ELEMENTARY TREATISE ON
STOCK FEEDS AND FEEDING.

Elementary Treatise

on

Stock Feeds and Feeding

By

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PREFACE.

This book has been written to furnish the readers with a knowledge of stock feeds, the principles of feeding and the care of farm animals. It is so arranged that it may be used as a text-book, or for farmers, or for those interested in commercial feeds.

Many of the American feeders waste a great deal of money through unwise selection of feeds; many do not properly supply the needs of their live stock; and many could improve their systems of feeding. This little book should acquaint the readers with suggestions along these lines, serve to solve many problems which confront the farmer and perhaps be a means of increasing his profits. The subject matter has been written in as simple and practical a way as possible so as to be within reach of all interested in the subject.

It is to be hoped that this little volume will fill a useful place in the libraries of farmers and students of animal feeding.

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Baton Rouge, La.

February 15, 1911. J. E. Halligan.

INTRODUCTION.

According to the Secretary of the United States Department of Agriculture, in the Yearbook of 1908: "The farmer who has averaged hardly twenty cents a pound for the butter that he has sold, between three and four cents a quart for his milk, and about one and a half cents for each egg, and even to the consumer who has paid prices much above these, it is a striking fact that the value of the farm products of the dairy cow are getting closer and closer to $800,000,000. Poultry and eggs produced on the farms of the United States are worth as much as the cotton crop, seed included, or the hay crop or the wheat crop."

Armsby says: "It is estimated by competent authority that over 45 per cent. of the food consumption of the better classes in the United States consists of animal products. Taking into account the relatively higher prices of these materials it seems safe to estimate that fully half the amount spent for food by the average well-to-do family goes for the purchase of meat, eggs and dairy products."

The following table gives statistics on farm animals in the United States.[1]

Kind of stock	Number on farms in the United States January 1, 1909	Average price per head January 1, 1909	Farm Value January 1, 1909
Horses	20,640,000	$ 95.64	$1,974,052,000
Mules	4,053,000	107.84	437,082,000
Milch cows	21,720,000	32.36	702,945,000
Other cattle	49,379,000	17.49	863,754,000
Sheep	56,084,000	3.43	192,632,000
Swine	54,147,000	6.55	354,794,000

These figures impress us with the vast expenditures and outlay of money in animals and animal products in the United States.

It is interesting to note that the animal manufactures foods such as fodders, hays, straws, grains, and wastes, many of which are not fit food for man, into products which are used for human consumption.

[1] 1908 Yearbook, U. S. Dept. of Agriculture.

It is also important on account of these facts that we learn the principles of feeds and feeding in order to more intelligently increase production with the least expenditure of time, labor and money.

The time has come when only those who understand feeding are in a position to realize the maximum profits from live-stock. The population of this country is rapidly increasing so that the human race is consuming more and more of the grain every year. The feeder of the future will perhaps find grain unprofitable for feeding live-stock and he will be forced to utilize the coarser foods, the by-products and the wastes. In order to do this profitably, the principles of feeds and feeding must be understood.

Contents.

SECTION I.

RELATION OF PLANT TO ANIMAL LIFE AND CHEMICAL ELEMENTS NEEDED BY PLANTS.

How Plants Feed.—Every seed is made up of a germ (embryo plant) surrounded by stored up food. When a seed is dropped into the warm soil it germinates and feeds on this stored up food material until it has put forth a root, stem and leaves. It is now able to gather its food from the air, water and soil. On the roots of plants are minute root hairs, composed of single cells, which absorb food materials from the soil water, by means of osmosis or diffusion. The leaves, on the under sides, have minute openings which permit the breathing of air which contains carbonic acid gas. The carbon is used in building up the plant and the excess of oxygen is given back to the atmosphere. This process requires the presence of light as does chlorophyll (green coloring matter of plants). Plants will grow without light as long as the food supply in the seed lasts, but they will be white and will not produce seed. By the aid of sunlight the materials gathered by the root hairs and leaves are manufactured into compounds and retained by the plants.

The Food of the Plant.—The plant keeps growing until it produces seed. It may continue its growth for years as is the case with trees. In this continual growing process we cannot see the plant feeding but we know its nourishment is obtained from the soil, water and air. The food of the plant, then, consists of the mineral substances, water and gases taken from the soil and air.

The Food of the Animal.—The plant takes its food from mineral substances, water and gases and changes these materials into many compounds. These compounds are stored in the plant and are in a form suitable for animals and constitute their food. The animal feeds on the plant and changes plant substances into bone, flesh and blood. If the animal is deprived of the plant it dies. Therefore we know that the plant is necessary for the existence of the animal and constitutes its food.

Action of the Plant on the Animal.—The plant is the animals' food. The plant builds them up, it keeps them warm and it furnishes substances which are changed into energy and motive power. No matter how cold it may be, we find that the plant enables the animal to maintain a constant body temperature. This temperature, in cold weather, is much warmer than the surrounding air, and in hot weather, it is cooler than the outside air. Take any young animal and feed it plant substances, such as grain and hay, and it continues to take on bone and flesh until it becomes large and heavy. As the animal requires for its existence, those substances which the plant stores up, we may properly call plant substances animals' food or feed stuffs.

Chemical Elements Needed by Plants.—All forms of matter in this world are made up of chemical elements in various combinations. There are about 81 chemical elements known to us, but only 15 of these are required for plant life so far as we know. In order to thoroughly understand this subject of feeds and feeding let us become acquainted with these fifteen elements.

The Fifteen Elements.—Hydrogen, oxygen, nitrogen, carbon, potassium, phosphorus, calcium, sulphur, silicon, iron, chlorine, magnesium, sodium, fluorine, and manganese are the elements used by plants. Some of these elements are used in much larger amounts than others. Hydrogen, oxygen, nitrogen and chlorine, in the pure state, generally occur as gases, while the other elements are solids.

Small amounts of oxygen are sometimes used by plants in the elementary state. Certain plants also use nitrogen in the free state. All the other elements, and generally oxygen and nitrogen, must be combined with other of these elements to be favorable for the support of plant life.

Hydrogen.—This element is generally found in combination with other elements. In the free state it occurs only in small quantities upon the earth. It is present in the gases of petroleum wells, around volcanic eruptions, and it is evolved by the fermentation and decomposition of some organic substances. It is abundantly found in combination with other elements. Water, hydrochloric acid, marsh gas, sulphuretted hydrogen, all acids and most organic (animal and vegetable) compounds contain this element. It is necessary for plant and animal life and it is used by animals in the form of water and as a constituent of feeds.

Oxygen.—About one-fifth of the atmosphere is made up of this element, in the free state, mechanically mixed with nitrogen. It is found in enormous quantities in combination with other elements. It constitutes about eight-ninths by weight of water and nearly one-half of the earth's crust. All combustion and decay require oxygen. The plant stores up oxygen in combination with other elements and it enters into many of the compounds of the animal body. Without oxygen plants and animals would die. The plant takes in oxygen in combination with carbon as carbonic acid gas, through the openings on the under sides of the leaves; the carbon is absorbed and the excess of oxygen given off. The animal inhales air which contains oxygen, which serves to purify the blood, and exhales carbonic acid which is thrown off by the blood through the lungs. So the supply of oxygen and carbon is continually being used and formed.

Nitrogen.—About four-fifths of the atmosphere is made up of nitrogen in the free state. In combination this element is found in many substances such as ammonia, sodium nitrate, potassium nitrate, and many organic compounds. Certain plants namely the legumes, of which the pea, bean, alfalfa, clovers, cowpea, soy bean, etc. are members, have the power of gathering nitrogen from the air, by means of certain growths (tubercles) on their roots. Our other plants are not capable of obtaining nitrogen in the free state. This element is one of the most important for us to consider. When in combination with other elements in plants, it is one of our most valuable compounds for animals' food. In fertilizers it is the most expensive and fugitive of essential elements. It tends to produce vigorous growth of plants.

Carbon is found in the free state in charcoal, graphite and diamonds. In combination with oxygen we find carbon as carbon dioxide (carbonic acid gas) in the air. It is given off by combustion and by respiration of animals. All carbonates (limestone, chalk, etc.) and all organic substances contain carbon. It is present in greater quantities in plant and animal life than any other element. Henry[1] says: "10,000 volumes of air contain about 3 volumes of carbonic acid gas; 32 cubic yards of air hold one pound of this gas. An acre of growing wheat will gather during four months, 2,000 pounds of carbonic acid gas, or an amount equal to all the air contains over the same area of land to a height of three miles." All of our farm crops use a great amount of carbon in the form of carbonic acid gas.

Potassium in combination is very common. It is mined in large quantities in the Stassfürt mines of Germany. The presence of this element in wood ashes is taken advantage of in making soft soap. Potassium is found in most rocks and in the soil. In plants it is associated with organic acids. This element is essential to plant growth and is found in the stems, leaves and fruits of plants. It is also present in the animal, mainly in the flesh, liver, blood corpuscles and also in bones, milk and other parts of the animal body.

Phosphorus is found in combination with oxygen and metals, as phosphates. Vast deposits of phosphates are found in Tennessee, South Carolina, Florida and some of the western states. It is present in many rocks and most soils and is an important element for plant food. It tends to produce early maturity in plants and helps to form the seed. It is also very important to the animal, where it is found in the hair, urine, muscles, nerve tissues, gland cells, milk, and bones. Bones contain about 60 to 65 per cent. of calcium phosphate which serves to strengthen them.

Calcium is an element which occurs in combination in many substances as in lime, marble, coral, and gypsum. Plants and animals require this element, sometimes in larger amounts than one would imagine. In animals it is found in the blood, milk, egg shells and bones. A deficiency of this element in the food of the animal often causes serious diseases of the bones.

[1] Feeds and Feeding.

Sulphur.—This is a yellow substance which is found in large deposits in Louisiana, California, the Rocky Mountains and Sicily. In combination it is present in gypsum, pyrites, galena, etc. It is also found in many natural waters and is generally present in sufficient quantities in soils for the needs of plants. In certain parts of the animal body, such as the hair and other nitrogenous tissues, it occupies an important place.

Silicon occurs in combination as sand, flint, quartz, etc. It is present in most rocks and soils. Plants require this element to support certain parts of their structure. The hulls and straws of plant substances are often comparatively rich in this element.

Iron.—We are all familiar with this element as in combination it is widely distributed. Although used in small amounts by plants and animals it is nevertheless very important. It is present in the blood and necessary to all cells of the animal body.

Chlorine is most commonly found as the chloride (common salt). It also occurs in combination with hydrogen, as hydrochloric acid, and in the gastric juice.

Magnesium.—This element is prevalent in most rocks and soils in sufficient amounts for the plant. Many natural waters contain magnesium. It is found associated as carbonate, with lime. Bones and muscles contain magnesium.

Sodium.—Chloride is the commonest compound of this element and is found in common salt, sea water, salt lakes and in many springs and waters. It occurs in sodium nitrate and sodium carbonate. As chloride, sodium is very important in animal life. It is present in blood serum, lymph and urine of animals. It is used a great deal in the fluids of the animal body and is a source of the acid in gastric juice.

Fluorine.—This element occurs in combination with calcium. It is present in some mineral waters, in bones and the enamel of teeth.

Manganese occurs in combination as manganese blend, manganese, spar, manganite, etc. Plants use this element in small amounts.

Suggestion: Secure an exhibit of substances containing the elements discussed in this section.

SECTION II.

COMPOSITION OF THE DRY MATTER OF PLANTS AND ANIMALS.

All plants and animals are made up of water and dry matter. The water is composed of hydrogen and oxygen while the dry matter contains many elements and combinations of elements.

Composition of the Dry Matter of Plants.—According to Jordan,[1] a German scientist, Knop, estimated: "That if all the species of the vegetable kingdom, exclusive of the fungi, were fused into one mass, the ultimate composition of the dry matter of this mixture would be the following:"

	Per cent.
Carbon	45
Oxygen	42
Hydrogen	6.5
Nitrogen	1.5
Mineral compounds (ash)	5.0

From the above analysis it is readily seen that carbon and oxygen make up the largest proportion of plants. Let us examine the analyses of some farm products that are familiar to us, and find out if this same predominance of carbon and oxygen exists.[1]

	Carbon Per cent,	Oxygen Per cent.	Hydrogen Per cent.	Nitrogen Per cent.	Ash Per cent.
Clover hay	47.4	37.8	5.0	2.1	7.7
Wheat kernel	46.1	43.4	5.8	2.3	2.4
Fodder beets	42.8	43.4	5.8	1.7	6.3
Fodder beet leaves	38.1	30.8	5.1	4.5	21.5
Wheat straw	48.4	38.9	5.3	0.4	7.0

There is some variation in the composition of these farm products but the carbon and oxygen constitute the largest amounts of the elements present.

This predominance of carbon and oxygen is due to the fact that about nineteen-twentieths of the plant's food is obtained from air and water, and the remaining one-twentieth is derived from mineral compounds of the soil and soil water.

[1] Jordan, "The Feeding of Animals."

Distribution of the Mineral Elements in Plants.—Let us see the proportions of mineral elements that the plant stores up in its period of growth. This table is figured on dry matter.[1]

	Potassium	Sodium	Calcium	Magnesium	Iron	Phosphorus	Sulphur
Apple	.43	.28	.04	.08	.01	.09	.04
Gooseberry	1.09	.25	.30	.12	.11	.29	.08
Strawberry	.59	.72	.35	..	.14	.21	.04
Orange	.93	.31	.54	.15	.03	.15	.05
Sugar beet	1.69	.25	.17	.18	.03	.20	.06
Sugar beet leaves	3.24	1.52	2.15	1.02	.06	.31	.32
Turnip	3.02	.59	.61	.18	.05	.44	.36
Turnip leaves	2.26	.82	2.74	.28	.13	.37	.44
Cabbage	3.57	.58	.84	.21	.03	.50	.53
Cauliflower	3.07	.37	.33	.19	.06	.74	.44
Onion	1.49	.10	.86	.15	.08	.40	.12

Composition of the Dry Matter of Animals.—The proportion of carbon to oxygen is greater in animals than in plants. The increase of carbon over oxygen is due to the presence of fats in the animal body. Fats are made up largely of carbon. As in plants, the elements carbon and oxygen are found in the greatest amounts. The following table[2] gives the composition of a fat ox and two steers.

	Fat ox Lawes & Gilbert Per cent.	Two steers 2 years old Maine Exp. Station Per cent.
Carbon	63.0	60.0
Oxygen	13.8	14.1
Hydrogen	9.4	9.0
Nitrogen	5.0	5.8
Mineral compounds (ash)	8.8	11.1

The above table is interesting because it shows that the animal body is composed so largely of carbon and oxygen. It also shows that the largest part of the elements required by animals does not have to be supplied to growing crops, as most of the animals' food is obtained by the plant from the air and water.

[1] Bul. 201, Ohio Experiment Station.

[2] Jordan, "The Feeding of Animals."

Mineral Elements in Animal Substances.—The following table[1] gives the distribution of the mineral elements in some animal substances.

	Potassium	Sodium	Calcium	Magnesium	Iron	Phosphorus	Sulphur	Chlorine
Hen's egg	.50	.59	.27	.02	.01	.57	.004	..
Swine's flesh	.94	.58	.03	.10	.02	.78	.75	..
Chicken's flesh	1.47	.30	.03	.12	.03	.80	.92	..
Steer's flesh	1.51	.27	.01	.10	.10	.70	.78	..
Wool scoured	.18	.02	.20	.04	.14	.02	..	..
Wool fleece	5.49	.26	.14	.03	.04	.04	.16	..
Cow's milk	.15	.07	.12	.01	.002	.08	..	.14

The distribution of the mineral elements in the body of the ox is as follows:[2]

	Per cent.
Phosphorus	.677
Calcium	1.281
Magnesium	.037
Potassium	.146
Sodium	.094
Iron	.017
Sulphur	.013
Live weight	1419 pounds
Age	4 years

Calcium, phosphorus and potassium predominate in the mineral compounds of the animal body. Although some of the other elements are present in only small amounts they are very important to the welfare of the animal.

[1] Bul. 201, Ohio Experiment Station.

[2] Bul. 201, Ohio Experiment Station.

SECTION III.

WATER AND DRY MATTER IN PLANTS.

The substances which the plant stores up in its period of growth are made up of the chemical elements previously described. These elements are not found in the free state in plants, but in various combinations, and may be classified as water and dry matter.

Kinds of Water in Plants.—All plants and parts of plants contain water. The water in plants is of two forms; physiological and hygroscopic.

1. **Physiological Water** is that which is contained in the plant structure. It is obtained from the soil. It is used to keep the leaf tissues and their cell walls moist so that carbonic acid gas may be absorbed, to transfer food materials, and to regulate the temperature of the plant by means of evaporation of water, just as the temperature of the animal body is regulated by the evaporation of perspiration.

2. **Hygroscopic Water** is that which is taken up from the air and may vary from day to day according to the humidity of the surrounding air. On rainy days more water would be taken up than on dry days. The writer has often determined the water content of the same samples of corn meal, wheat bran, cotton seed meal, hays, etc., on different days and found variations of two per cent. Sometimes there is an increase and at other times a decrease of hygroscopic water, depending upon the humidity of the surrounding air. The hygroscopic moisture also varies with different plant materials.

Amounts of Water Used by Plants.—According to Whitson,[1] the amount of water used by plants varies greatly with the kind of plant and with climatic conditions, but is always large. For instance, in the growth of one pound of dry matter of corn about 250 to 300 pounds of water are used; for potatoes, 350 to 400 pounds; for clover, 500 to 600 pounds.

Variation of Water in Plants.—Some species of plants contain much more water than others and the different parts of the

[1] Halligan, "Fundamentals of Agriculture."

same plant show a great variation in water content. We have all no doubt noticed that certain fruits like the apple, pear, lemon, plum, peach, strawberry, etc., and roots and tubers as the turnip, beet, radish, carrot, Irish potato, etc., contain a great deal of water. Perhaps some have not heretofore thought that substances like corn grain, wheat kernel, rice kernel, the several grain straws, etc., have water present. The following table gives us the percentage of water in some familiar plants and parts of plants.

Fruits	Per cent.	Forage Plants (green)	Per cent.
Apple	80.0	Alfalfa	71.8
Grape	83.0	Corn	79.3
Peach	88.4	Cowpea	83.6
Pear	83.1	Sorghum	79.4
Strawberry	90.2	Timothy	61.6
Roots and Tubers		**Cereals and Straws**	
Beet (mangel)	90.9	Corn (grain)	10.6
Carrot	88.6	Oats (grain)	11.0
Irish potato	78.9	Rice (rough)	10.9
Sweet potato	71.1	Rye straw	7.1
Turnip	90.5	Wheat straw	9.6

Water in Young and Mature Plants.—The percentage of water in young plants is greater than in mature plants. This is easily accounted for because the young plant uses a great deal of water in transferring food materials required for its growth. The Maine State College conducted an investigation on Timothy with the following results:[1]

	Water Per cent.		Water Per cent.
Nearly headed out	78.7	Out of blossom	65.2
In full blossom	71.9	Nearly ripe	63.3

The results on Timothy are similar to what would be found with other plants. It follows that the more mature a plant is, the easier it is to field cure.

Active cells in plants contain more water than do the older or less active cells and this may account for the larger percentage of water found in young plants.

[1] Jordan, "The Feeding of Animals."

Dry Matter of Plants.—As previously stated, the plant is made up of water and dry matter. When water is driven off from plants the dry matter is what remains. Now if we burn this dry matter a large proportion of it passes off in the form of invisible gases. This material which so disappears, in burning, is known as organic matter; that which is left is the ash or mineral matter.

The organic matter is composed of protein, fats, nitrogen free extract and fiber. The ash is made up of soda, phosphorus, sulphur, iron, potash, lime, sand, magnesia, etc.

Jordan[1] shows the relation of the fifteen elements to these compounds:

- All vegetable or animal matter
  - Incombustible or inorganic matter
    - Water
      - Oxygen
      - Hydrogen
    - Ash
      - Oxygen
      - Sulphur
      - Chlorine
      - Phosphorus
      - Silicon
      - Fluorine
      - Potassium
      - Sodium
      - Calcium
      - Magnesium
      - Iron
      - Manganese
  - Combustible or organic matter
    - Protein
      - Carbon
      - Oxygen
      - Hydrogen
      - Nitrogen
      - Sulphur (generally)
      - Phosphorus (sometimes)
      - Iron (in a few cases)
    - Carbohydrates and fats
      - Carbon
      - Oxygen
      - Hydrogen

Composition of Plants.—We may express the composition of plants and parts of plants (feed stuffs) in a condensed form as follows:

- Plant (feed stuff)
  - Water
  - Dry matter
    - Ash
    - Organic matter
      - Protein
      - Fats
      - Carbohydrates
        - Nitrogen free extract
        - Fiber

The chemist usually expresses the composition as:

Protein	Crude fiber
Fats (ether extract)	Water
Nitrogen free extract	Ash

[1] "The Feeding of Animals"

Water in Animals.—There is considerable water in the animal body. It is present in the blood, tissues, and digestive juices and secretions. About 80 per cent. of the blood is water; the per cent. of water in the tissues and digestive fluids varies according to their nature and in species.

The following data are the results of investigations by Lawes and Gilbert and the Maine Experiment Station.

	WATER Per cent.
Fat calf	63.0
Half-fat ox	51.5
Fat ox	45.5
Steer half fat, 17 months old	56.3
Steer half fat, 17 months old	59.0
Steer fat, 27 months old	52.2
Steer fat, 27 months old	51.9
Fat lamb	47.8
Sheep lean	57.3
Half-fat old sheep	50.2
Fat sheep	43.4
Extra fat sheep	35.2
Lean pig	55.1
Fat pig	41.3

From the above data we can see there is a wide variation in the water of animals, and that the per cent. of water is always large. The fat calf contains 63 per cent. of water while in the extra fat sheep the water is as low as 35.2 per cent. It is shown that the water content decreases with age; the fat calf contains 17.5 per cent. more water than the fat ox. The per cent. of water varies with species; the pig generally contains less water than sheep and cattle. The degree of fatness also influences the amount of water in the animal body; the fat ox and the fat sheep contain much less water than the half-fat ox and sheep. It may be safely said that about 50 per cent. of the body of the animal is made up of water.

Suggestion: Take one pound of green grass and dry it in the sun or else take some sliced potatoes and dry them below 212 degrees Fahrenheit and ascertain the loss in weight. What is the loss in weight due to?

SECTION IV.

ASH IN PLANTS.

The mineral elements that make up the ash are not present in the free state but in various combinations. A knowledge of the ash of plants and the combinations that make it up should be understood by the feeder.

Acids and Bases.—The acids and bases of the mineral elements of ash are:

ACIDS

Sulphuric (hydrogen, sulphur and oxygen) H_2SO_4
Hydrochloric (hydrogen and chlorine) HCl
Phosphoric (hydrogen, phosphorus and oxygen) $H_6P_2O_8$
Carbonic (carbon and oxygen) CO_2
Silicic (silicon and oxygen) SiO_2

BASES

Lime (calcium and oxygen) CaO
Soda (sodium and oxygen) Na_2O
Potash (potassium and oxygen) K_2O
Magnesia (magnesium and oxygen) MgO
Iron oxide (iron and oxygen) Fe_2O_3

The mineral elements do not exist as acids and bases in the ash, because in the burning of plant substances there is a rearrangement of the mineral elements and salts are formed.

Salts.—The elements exist in the ash of plants as salts. That is the acids and bases as united and form:

Phosphates Sulphates Chlorides and Carbonates	of	Calcium Magnesium Sodium Potassium

We are all familiar with some of these salts. A few of the combinations are:

Chloride of sodium (common salt)
Carbonate of lime (limestone)
Chloride of potash (muriate of potash)
Carbonate of soda (baking powder)
Sulphate of soda (Glauber's salts)
Sulphate of magnesia (Epsom salts)
Sulphate of calcium (gypsum)
Sulphate of potash (common sulphate of potash of commerce)

Variation of Ash.—The content of ash in different feeds varies a great deal as the following table shows:

GRAINS	ASH Per cent.	STRAW	ASH Per cent.
Corn	1.5	Oat	5.1
Oats	3.0	Rice	7.8
Rice	5.5	Rye	3.2
Wheat	1.8	Wheat	4.2
ROOTS AND TUBERS (fresh)		FORAGE PLANTS (hay)	
Beet (mangel)	1.1	Alfalfa	7.4
Carrot	1.0	Crimson clover	8.6
Irish potato	1.0	Orchard grass	6.0
Sweet potato	1.0	Timothy	4.4

Different parts of the same plant vary in ash content.

	ASH Per cent		ASH Per cent.
Corn grain	1.5	Corn stover (whole plant except ears)	4.9
Corn leaves	9.7	Corn shucks	3.4
Corn (whole plant)	4.3	Corn cob	1.4
Corn germ	4.0	Corn bran	1.3

There is also a variation in the amounts of compounds in the ash of different parts of the same plant. The percentages of the compounds in this table are figured on 100 per cent. ash of sugar cane.[1]

	Ash of leaves Per cent.	Ash of stalk Per cent.	Ash of roots Per cent.
Potash	31.25	38.23	17.39
Soda	1.17	1.30	0.85
Lime	5.90	5.19	3.45
Magnesia	5.11	5.76	2.61
Iron oxide	1.45	1.13	3.60
Alumina	1.03	0.25	4.70
Silica	30.32	15.70	49.52
Phosphoric acid	7.25	5.27	3.99
Sulphuric acid	11.29	18.47	9.15
Carbonic acid	1.10	2.70	0.45
Chlorine	3.08	4.52	0.98
Carbon	0.16	0.54	2.30
Ash	2.23	0.64	1.87

[1] Louisiana Experiment Station, Bul. 91.

From the figures given in the foregoing tables we find that the leaves of plants contain the most ash. The straws contain more ash than the grains.

Let us see the relation of the ash of roots to the leaves of the same plant.

	Roots Per cent. ash	Leaves Per cent. ash
Sugar beet	3.83	14.88
Stock turnip	8.01	11.64

The per cent. of ash in seeds is generally less than in the plant from which they are derived.

	Ash Per cent.		Ash Per cent.
Sorghum seed	2.1	Sorghum fodder	4.6
Cowpea seed	3.2	Cowpea hay	7.5
Soja bean seed	4.7	Soja bean hay	7.2

The per cent. of ash and the mineral elements that constitute the ash are given for several vegetable substances in the following table.[1]

Occurrence of Mineral Elements in Plants.—According to Forbes, Ohio Experiment Station Bul. 201: "Mineral substances of foodstuffs are present in four mechanical conditions: (1) in solution in the plant juices; (2) as crystals in the tissues; (3) as incrustations in cells and (4) in chemical combination with the living substance.

"The mineral content of any species of plant varies considerably as affected (1) by the composition of the soil and the soil water, (2) by the various factors controlling transpiration of water by the plant and (3) by the loss of mineral substances either through shedding of parts or through the leaching effect of dews and rains."

Distribution of Ash in Plants.—Roots and seeds generally contain much less ash than leaves because the mineral elements are carried to the leaves for the elaboration (manufacturing) of food and then the water evaporates and the ash remains. The ash present in roots and seeds is usually needed for supporting germination and early growth of the plant, while some of that in the leaves is in excess of what is really needed.

[1] Bul. 201, Ohio Experiment Station.

MINERAL ELEMENTS IN VEGETABLE SUBSTANCES (dry basis)

	Ash	Potassium	Sodium	Calcium	Magnesium	Iron	Phosphorus	Sulphur
Seeds								
Barley	1.99	.27	.06	.01	.15	.02	.29	.02
Bean (white)	3.22	1.18	.04	.15	.15	.01	.50	.05
Corn	1.45	.36	.01	.02	.14	.08	.29	.004
Oats	3.12	.46	.04	.08	.14	.03	.35	.02
Rice (clean)	.39	.07	.02	.01	.03	.003	.09	.001
Soy bean	3.14	1.16	.02	.12	.17	..	.50	.03
Winter wheat	1.96	.51	.03	.05	.14	.02	.40	.003
By-Products								
Corn meal	.68	.16	.02	.03	.06	.02	.13	..
Cotton seed meal	7.48	1.85	..	.24	.69	.07	1.50	.04
Linseed meal	5.84	1.18	.06	.35	.56	.11	.81	.08
Patent flour	.51	.15	.003	.03	.03	.002	.11	..
Rice bran (meal)	6.08	.56	.10	.09	.64	.23	1.14	.01
Wheat bran	6.16	1.46	.03	.13	.66	.03	1.35	.002
Roots and Tubers								
Potato	3.79	1.89	.08	.07	.11	.03	.28	.10
Radish	15.67	2.86	.44	.98	.35	.13	2.81	.48
Sugar beet	3.83	1.69	.25	.17	.18	.03	.20	.06
Turnip	8.01	3.02	.59	.61	.18	.05	.44	.36
Leaves								
Sugar beet leaves	14.88	3.24	1.52	2.15	1.02	.06	.31	.32
Turnip leaves	11.64	2.26	.82	2.74	.28	.13	.37	.44
Legumes								
Alfalfa in bloom	7.38	1.44	.10	2.15	.22	.10	.27	.17
Clover (red) in bloom	6.86	1.84	.10	1.71	.45	.05	.29	.09
Clover (white) in bloom	7.32	1.31	.39	1.58	.42	.11	.41	.22
Grasses								
Kentucky blue	5.18	1.81	..	.18	.10	..	.22	.10
Timothy	6.82	1.96	.09	.39	.13	.04	.35	.08
Straw								
Oat	7.17	1.72	.18	.36	.16	.06	.14	.09
Wheat	5.37	.61	.06	.22	.08	.02	.11	.05
Fodder								
Corn stover	5.33	1.61	.05	.41	.18	.09	.19	.11
Miscellaneous								
Cabbage	9.62	3.57	.58	.84	.21	.03	.50	.53
Cauliflower	8.35	3.07	.37	.33	.19	.06	.74	.44
Rape	8.10	2.23	.20	1.27	.19	.07	.39	.45

Phosphorus and potassium are present in the largest amounts in seeds, followed by magnesia. Silicon and potassium predominate in cereal grasses and straws, and the per cent. of calcium is usually larger than phosphorus or magnesium. The leguminous crops (alfalfa, clovers, cowpeas, soy beans, etc.) contain more calcium than phosphorus or potassium. Roots and legumes contain much less silicon than straws.

Ash of Young and Mature Plants.—According to Wolff the per cent. of ash of the dry matter of wheat, oats, rye, and clover decreases with the growth of the plant. The ash of healthful plants is generally higher in calcium than in sickly plants. The per cent. of calcium and potassium in the ash of grass plants decreases in the growing of the plant and the silicon increases. In the ash of the dry matter of clover, the magnesium and calcium increase while the potassium decreases.

Suggestion: Take a small quantity of hay and have the pupils approximate the weight of it. Burn this hay in a dish and show the students the remaining portion or ash. Ask them the loss in weight. Let them rub the ash between their fingers.

SECTION V.

ASH IN ANIMALS.

The ash in animals is small in amount but it is very important that animals receive sufficient of this constituent for the full development of their bodies.

Mineral Constituents must be supplied to build bones, teeth, and other hard parts of the animal body. The digestive fluids, blood, brain and other parts of the animal, require mineral substances to render them complete. In order that many parts of the animal body may carry on their functions, mineral compounds must be constantly furnished. To form bones and teeth, calcium, phosphorus, magnesium, carbonates, chlorides, and fluorides are necessary.

The gastric juice must be supplied with mineral elements to form hydrochloric acid and chlorides. Potassium is also present in the gastric juice as well as in the saliva. Iron is found in the blood and iodine in the thyroid gland. Sulphur and phosphorus are present in the brain, blood and many other organs, unoxidized.

Calcium and Phosphorus.—These are the most important mineral elements entering into animal life. Often the soil becomes depleted of calcium and phosphorus, and plants grown on such soil, when used for animal food, sometimes lack sufficient quantities of these elements for the production of bones, milk, eggs, flesh, wool, nerves, etc. and for the general welfare of the animal.

Malnutrition.—Again some of our feeding materials never do contain sufficient amounts of calcium and phosphorus for the animal, and serious diseases are sometimes brought about through malnutrition of bones. Corn grain or corn meal, for example, when fed alone as food for hogs in the pen, does not supply enough of the mineral elements to form rigid bones to support the body. An examination of the composition of the ash of the bones of an ox may be interesting.

COMPOSITION OF THE BONES OF AN OX.[1]

	Per cent.
Calcium phosphate	85.72
Calcium carbonate	11.96
Calcium chloride	0.30
Calcium fluoride	0.45
Magnesium phosphate	1.53
Iron oxide	0.13

The composition of the bones of other animals approximates that of the ox and we can readily see that animals must receive calcium and phosphorus in order that they may build up strong bones to support their bodies.

Ratio of Phosphoric Acid to Lime.—About 85 per cent. of the ash of bones is lime and phosphoric acid. These compounds usually exist in the following ratio; one of phosphoric acid to one and one-half of lime; or, 1:1.5. If the animal is receiving food that reaches or approximates this ratio, we may feel certain that the mineral compounds for building the bony structure are being properly supplied. The following table, the work of Warrington or Wolff, gives the ratio of phosphoric acid to lime in several feeds common to the feeder of live-stock.

Name of feed	Phosphoric acid		Lime
Corn (grain)	1	:	0.04
Oats (grain)	1	:	0.16
Wheat (grain)	1	:	0.07
Barley (grain)	1	:	0.06
Kafir corn (grain)	1	:	0.02
Peas (seed)	1	:	0.08
Wheat bran	1	:	0.09
Wheat plant	1	:	0.66
Oat hay	1	:	0.77
Potato (Irish)	1	:	0.15
Turnip	1	:	0.83
Corn fodder (dry)	1	:	1.35
Meadow hay	1	:	2.27
Cabbage	1	:	2.24
White clover (in bloom)	1	:	2.28
Red clover	1	:	3.60
Alfalfa	1	:	4.78
Pea straw	1	:	4.62

[1] Carnot.

The ratio of lime to phosphoric acid is very low in the grains, the oat hay and the wheat plant. Notice how high the ratio is in the legumes (clovers, alfalfa and pea straw). What an excellent combination the legumes and grasses make for the grains and their by-products in furnishing the mineral constituents so necessary for animal life. What a poor ration oat hay, wheat hay or other of the cereal straws, and the grains would make for supplying the needs of animals, because of the excess of phosphoric acid to lime.

Composition of Milk.—It is especially essential that the young animals receive adequate mineral constituents in order to get a good start in life. If we examine the composition of milk of various animals we learn that nature has provided for this.[1]

Species	Time in days for the new born animal to double its weight	100 parts of milk contain			
		Protein	Ash	Calcium	Phosphorus
Human	180	1.6	0.2	.021	.022
Horse	60	2.0	0.4	.086	.057
Cow	47	3.5	0.7	.114	.087
Goat	22	3.7	0.78	.143	.122
Sheep	15	4.9	0.84	.178	.127
Swine	14	5.2	0.80	.178	.135
Cat	9.5	7.0	1.02	...	...
Dog	9	7.4	1.33	.321	.223
Rabbit	6	10.4	2.50	.636	.437

It seems that the more rapid the growth of the animal the higher are the protein and ash contents. This is as it should be, for a fast growing animal must have rigid bones to support the body.

Composition of the Ash of Animals.—The following table[1] gives the composition of the ash of a few fat animals in per cent. The data is the work of Lawes and Gilbert.

[1] Bul. 201, Ohio Experiment Station.

	Ox	Calf	Sheep	Lamb	Pig
Phosphorus	.677	.670	.454	.492	.286
Calcium	1.281	1.177	.846	.915	.455
Magnesium	.037	.048	.029	.031	.019
Potassium	.146	.171	.123	.138	.115
Sodium	.094	.109	.072	.076	.054
Iron	.017	.015	.024	.018	.009
Sulphur	.013	.016	.012	.016	.012
Live weight lbs.	1419	258.8	127.2	84.4	185.0
Age	4 yrs.	9.5 wks.	1¼ yrs.	½ yr.	....

The results in this table show that calcium and phosphorus are present in the greatest amounts in the animal body. Although the mineral constituents are found in small amounts in the animal body, they are absolutely necessary for the health of the animal. Potassium is present in larger amounts than sodium; magnesium is found in larger amounts than iron and sulphur; iron and sulphur seem to be present in about equal amounts except in sheep, where iron predominates.

SECTION VI.

PROTEIN IN PLANTS AND ANIMALS.

Protein (nitrogenous compounds), includes all compounds of the plant and animal body containing nitrogen. Protein is made up of carbon, oxygen, hydrogen and nitrogen; generally sulphur; sometimes phosphorus; and in a few cases iron. About 16 per cent. of the protein is nitrogen. Protein is perhaps the most important constituent to consider in the feeding of animals.

The compounds of protein are classified by the Association of American Agricultural Colleges and Experiment Stations as follows:

- Protein, Total nitrogen compounds
  - Proteids
    - Albuminoids
      - Simple
        - Albumins
        - Globulins
        - and allies
      - Modified
        - Derived
        - Compound
    - Collagens or gelatinoids
  - Non-proteids
    - Extractives amides, amido acids, etc.

Protein in the Plant.—Protein is found in the plant as albuminoids and amides. The *albuminoids* are represented as legumin, the nitrogenous compound of legumes (peas, bean, alfalfa, clover, etc.), as gluten of the wheat grain, and as vegetable albumen resembling white of egg, which is found in the juices of plants. Crude gluten may be obtained by washing dough of wheat flour to a sticky mass. Most of the protein of feed stuffs is present as albuminoids. *Amides* are soluble in water and are considered more abundant in young plants and growing parts of plants. It is believed that the function of amides is to transfer nitrogen from one part of the plant to another. The nitrogen of roots, tubers, and cane molasses is more largely made up of amides than in other feeds. The grains and seeds contain less of such nitrogen compounds than other feeding stuffs. The flesh forming function of amides is doubtful and so the protein obtained from roots, tubers and cane molasses is not considered as valuable as that from grains and seeds.

PROTEIN IN PLANTS

	Protein Per cent.	Water Per cent.		Protein Per cent.	Water Per cent.
GRAIN			STRAW		
Barley	12.4	10.9	Oat	4.0	9.2
Corn	9.3	10.6	Rice	5.9	12.0
Oats	11.8	11.0	Rye	3.0	7.1
Wheat	11.9	10.5	Wheat	3.4	9.6
SEEDS			ROOTS & TUBERS		
Cotton	18.4	10.3	Beet (mangel)	1.1	90.9
Cowpea	20.8	14.8	Carrot	1.0	88.6
Flax	22.6	9.2	Irish potato	1.0	78.9
Soja bean	34.0	10.8	Turnip	1.1	90.5
LEGUMINOUS HAY			GRASS HAY		
Alfalfa	14.3	8.4	Kentucky blue	7.8	21.2
Cowpea	14.4	11.9	Meadow fescue	7.0	20.0
Crimson clover	15.2	9.6	Orchard	8.1	9.9
Red clover	12.3	15.3	Timothy	5.9	13.2

From the above results we can see that the protein in seeds is greater than in straws. In the woody or older parts of the plant very little protein is found. The legumes are richer in protein than the grasses. Grass hay and straw contain much more protein than roots. The protein in grains is found largely in the germ and that portion closely surrounding it.

DISTRIBUTION OF PROTEIN IN THE CORN PLANT

	Protein Per cent.	Water Per cent.
Corn grain	10.3	10.6
Corn bran	5.8	9.1
Corn germ	9.8	10.7
Corn cob	2.4	10.7
Corn (whole plant)	4.8	32.2
Corn leaves	11.8	8.9
Corn shucks	3.4	8.1

This distribution of protein in corn is interesting. The bran is the outer covering of the corn grain and is for protecting the seed, and is therefore low in protein. The outer coverings of other seeds as oats, rice, cotton, etc. also contain less protein than the other parts of the seed. The germ, or embryo plant, is comparatively rich in protein for it is this part of the seed that must be used for reproducing the plant. The leaves or growing parts, are rich in protein while the shucks, which protect the grain, are low in nitrogenous substances. The distribution of protein in corn is similar to the distribution of protein in other plants.

Protein in Animals.—Protein in animals is present as albuminoids, gelatinoids, and as horny substances.

Albuminoids are found in all the healthy organs and fluids of the animal body except the urine. The principal albuminoids are the albumen, such as white of egg, which is found in most animal fluids, the casein of milk, the fibrin of meat, and the fibrin of blood (present in the clotting of blood).

Gelatinoids.—The nitrogenous substances of bone and cartilage are gelatinoids. We have all no doubt noticed in the cooking of bones and tendons, the familiar substance gelatine which is derived from the gelatinoids perhaps by taking on water. The connective tissue, ligaments and the skin contain gelatinoids.

Horny Substances.—The protein in the hair, horns, hoofs, wool, etc. is somewhat similar to the albuminoids and gelatinoids.

PER CENT. PROTEIN IN ANIMAL BODIES.[1]

	Ox		Calf	Sheep				Lamb	Pig	
	Half fat	Fat	Fat	Thin	Half fat	Fat	Very fat	Fat	Thin	Fat
Protein ..	16.6	14.5	15.2	14.8	14.0	12.2	10.9	12.3	13.7	10.9
Live wt. lbs	1,232	1,419	258.8	97.6	105.1	127.2	239.4	84.4	93.9	185
Age	4 yrs.	4 yrs.	9.5 wk	1 yr.	3¼ yrs	1¼ yrs	1¾ yrs	½ yr.	....	....

Thin animals contain more protein than fat animals because the protein is present in lean meat in greater proportions than in fatty tissues.

There is a greater per cent. of protein in the animal body than in most plants or parts of plants.

Suggestion: Chop up some meat and extract it with cold water. Boil the extract and note the albumin that separates out. Treat this albumin with cold water again and see if it is soluble. Have the students state whether it is better to soak meat in cold

[1] Lawes and Gilbert, Bul. 201, Ohio Experiment Station.

water before cooking or to boil it at once to prevent losses. Take the white of egg and cook it in boiling water and note the result. Chop up some meat and extract it with about a 10 per cent. solution of common salt and boil the extract. Are there any more albuminoids extracted in this way than with cold water? Boil some fresh bones and obtain gelatine. Try to treat some wheat grain by extracting the starch with cold water and obtain a sticky mass which contains the gluten of the grain.

SECTION VII.

NITROGEN FREE COMPOUNDS.

The compounds we are about to study are made up of the elements carbon, oxygen and hydrogen, *i. e.* they are free from nitrogen, and are called the nitrogen free compounds. These compounds are nitrogen free extract, carbohydrates, crude fiber and fats.

Nitrogen Free Extract.—As previously stated the compounds of this group are made up of carbon, hydrogen and oxygen. There are a great many substances with which we are familiar that come under this group of substances, such as starches, various sugars, vegetable gums, and organic acids. The most important group of nitrogen free extract substances are the *carbohydrates* in which the hydrogen and oxygen are present in the proportion of water, namely, two parts of hydrogen and one of oxygen. The starches and sugars are the carbohydrates. Potato starch and corn starch are some of the common starches. Examples of the sugars are, the common white sugar (sucrose) used at the table and corn syrup which sugar content is mainly glucose, and manufactured from starch. Various mixtures of sucrose and glucose prevail among the sugars. Sucrose however is the most important sugar as it is found in many of our plants as sugar cane, sugar beet, sweet potato, corn plant, sorghum, roots and some grasses.

Vegetable Gums are found in beet pulp, gum arabic, wood gum of wood and straw, and in the stems and leaves of plants. Most, if not all, of our feed stuffs contain vegetable gums.

Organic Acids occur in fruits, silage, and sour milk. Examples of these acids are citric acid of lemons, acetic acid of vinegar, malic acid of apples, lactic acid of milk, and acetic and lactic acids of silage.

The nitrogen free extract is often termed carbohydrates although from the previous statements we know that such practice is not correct. The chemist determines nitrogen free extract by subtracting the sum of the protein, fats, crude fiber, water and ash from 100.

TABLE SHOWING NITROGEN FREE EXTRACT IN PLANT SUBSTANCES

	N. F. E. Per cent.	Water Per cent.		N. F. E. Per cent.	Water Per cent.
GRAIN			STRAW		
Barley	69.8	10.9	Oat	42.4	9.2
Corn	70.4	10.6	Rice	33.7	12.0
Oats	59.7	11.0	Rye	46.6	7.1
Wheat	71.9	10.5	Wheat	43.4	9.6
SEEDS			FORAGE PLANTS (hay)		
Cotton	24.7	10.3	Alfalfa	42.7	8.4
Cowpea	55.7	14.8	Crimson clover	36.6	9.6
Flax	23.2	9.2	Kentucky blue	37.8	21.2
Soja bean	28.8	10.8	Timothy	45.0	13.2
ROOT			TUBER		
Sweet potato	24.7	71.1	Irish potato	17.3	78.9

The grains run high in nitrogen free extract due to the large amount of starch present. The starch content also predominates in the dry matter of potatoes.

DISTRIBUTION OF NITROGEN FREE EXTRACT IN PARTS OF CORN

	N. F. E. Per cent.	Water Per cent.
Corn grain	70.4	10.6
Corn bran	62.2	9.1
Corn germ	64.0	10.7
Corn cob	54.9	10.7
Corn (whole plant)	37.2	32.2
Corn leaves	41.5	8.9
Corn shucks	51.6	8.1

The grain of corn is exceedingly high in carbohydrates (starch) and advantage of this is taken in fattening animals which we will speak of later. The starch of this grain is employed commercially in making corn starch and corn syrup.

Carbohydrates in Animals.—Glycogen which is found in the liver and muscles, and milk sugar found in the milk of mammals are the only carbohydrates in the animal body that we know of. The carbohydrates of plants are changed to fats in the animal body. Carbohydrates therefore do not occur in the animal body to such a large extent as in plants.

Crude Fiber.—The woody parts of plants are called crude fiber. Cotton lint is almost pure fiber. Crude fiber is made up principally of the cellulose of which the cell walls are mostly composed. It is really the framework or the structure of plants.

TABLE SHOWING CRUDE FIBER IN PLANT SUBSTANCES

	Fiber Per cent.	Water Per cent.		Fiber Per cent.	Water Per cent.
GRAIN			STRAW		
Buckwheat....	8.7	12.6	Oat	37.0	9.2
Corn..........	2.2	10.6	Rice	38.6	12.0
Oats	9.5	11.0	Rye............	38.9	7.1
Rye	1.7	10.5	Wheat	38.1	9.6
HULLS (seed coats)			FORAGE PLANTS (hay)		
Buckwheat....	44.5	10.0	Alfalfa	29.0	8.4
Cotton seed ...	45.1	11.1	Crimson clover .	20.2	9.6
Oat...........	29.7	7.3	Kentucky blue..	23.0	21.2
Rice..........	41.9	9.0	Timothy	29.0	13.2
LEAVES AND STEMS			ROOTS		
Beet	1.2	89.5	Beet............	0.9	90.9
Turnip........	1.6	84.0	Turnip	1.2	90.5

The fiber in the hulls or seed coats of grains and seeds is much higher than in the grains and seeds from which they are derived. The leaves and stems of the beet and turnip contain a great deal more fiber than their roots. The grasses contain less fiber than straws and more than roots. Stems of plants usually contain a comparatively large amount of fiber. Old plants contain more fiber than young plants because the cell walls of old plants are thicker than in young plants.

DISTRIBUTION OF FIBER IN PARTS OF CORN

	Fiber Per cent.	Water Per cent.
Corn grain........................	2.2	10.6
Corn bran	12.7	9.1
Corn germ........................	4.1	10.7
Corn cob	30.1	10.7
Corn (whole plant)	20.2	32.2
Corn leaves......................	24.7	8.9
Corn shucks	32.8	8.1

Fats.—These compounds are sometimes called ether extract because they compose those parts of the plant substance that the chemist dissolves out with ether. The substances that ether leaches out from plants are mainly fats or oils together with waxes, gums, chlorophyll (green coloring matter of plants) and other substances.

TABLE SHOWING FATS (ETHER EXTRACT) IN PLANT SUBSTANCES

	Fat Per cent.	Water Per cent.		Fat Per cent.	Water Per cent.
GRAIN			STRAW		
Corn	5.0	10.6	Oat	2.3	9.2
Oats	5.0	11.0	Rye	1.2	7.1
Rye	1.7	11.6	Soja bean	1.7	10.16
Wheat	2.1	10.5	Wheat	1.3	9.
SEEDS			FORAGE PLANTS (hay)		
Cotton (meats)	36.6	6.2	Alfalfa	2.0	8.4
Flax	33.7	9.2	Alsike clover	2.9	9.7
Peanut kernels	39.6	7.5	Orchard grass	2.6	9.9
Sunflower (whole)	21.2	8.6	Timothy	2.5	13.2

The grains contain more fat than straw or hay. Hay is usually higher in fat than straw. A certain class of seeds such as cotton seed, peanut, rape, sunflower, and flax seed are important for their high oil content. The oils from some of these seeds, notably the oils from cotton seed and flax seed, are expressed by hydraulic pressure or extracted with some solvent, and sold to us as cotton seed oil, cottolene, linseed oil and similar products.

THE DISTRIBUTION OF FATS (ETHER EXTRACT) IN PARTS OF CORN

	Fat Per cent.	Water Per cent.
Corn grain	5.0	10.6
Corn bran	5.8	9.1
Corn germ	7.4	10.7
Corn cob	0.5	10.7
Corn (whole plant)	1.3	32.2
Corn leaves	3.3	8.9
Corn shucks	0.9	8.1

There is quite a wide variation in the fat content of the different parts of the corn plant.

Fats in Animals.—Examples of animal fats are hog lard, mutton suet, beef tallow and milk fat. The fats of animals are different from the fats of plants.

TABLE SHOWING THE PER CENT. OF FAT IN ANIMALS[1]

	Calf	Ox		Sheep				Lamb	Pig	
Degree of fatness	Fat	Half fat	Fat	Lean	Half fat	Fat	Extra Fat	Fat	Lean	Fat
Fat per cent. ..	14.8	19.1	30.1	18.7	23.5	35.6	45.8	28.5	23.3	42.2
Live wt. lbs....	258.8	1,232	1,419	97.6	105.1	127.2	239.4	84.4	93.9	185
Age.....	9.5 wk	4 yrs.	4 yrs.	1 yr.	3¼ yrs	1¼ yrs	1¾ yrs.	½ yr.	....	....

Animals contain a great deal of fat. Especially is this true of fat animals. As previously stated the carbohydrates of plants are converted into fats in the animal body.

Suggestion: An exhibit of vegetable and animal fats, fiber, starches, and sugars should prove instructive to the student. Purchase a dilute solution of tincture of iodine from the drug store and put a drop of this on some broken kernels of corn and sliced potatoes. Note the blue color due to the presence of starch. A dilute solution of iodine is necessary to procure a delicate reaction.

[1] Lawes and Gilbert.

SECTION VIII.

COMPOSITION OF FARM ANIMALS.

In the preceding pages we have become familiar with the compounds that are contained in feed stuffs and animal bodies. We learned that the plant substances are changed to form body tissue, bones, blood, etc. by the animal. Let us now consider the animal body composition, or the proportions of the compounds in the animal body, to find out the food requirements, the differences in young and mature animals, lean and fat animals, species, increase and nature of increase during growth and fattening, and the relation of the ingredients of plants to the stored up materials of the animal.

We know that the compounds of plants and animals are:

Compounds of plants	Compounds of animals
Protein	Protein
Fat (ether extract)	Fat
Nitrogen free extract	Water
Crude fiber	Ash (mineral matter)
Water	
Ash (mineral matter)	

Or we may express animal body composition as:

Animal { Water; Dry matter { Ash; Organic matter { Protein; Fats

Dry Matter.—It is evident that there are many compounds somewhat similar in plant and animal life, but there is a great difference in the proportions of the compounds in the plant and the animal. The dry matter of plants is made up principally of carbohydrates and crude fiber, but in the animal carbohydrates are present in such small amounts as to be disregarded in stating animal body composition and crude fiber is not found in the animal body. The dry matter of the animal body is mostly fats. The percentages of fats and protein in animals are much greater than in most plant substances.

Composition of Farm Animals.—The most valuable experiments that have been conducted on animal body composition are those of Lawes and Gilbert. These investigators analyzed the whole bodies of ten animals of different ages, degrees of fatness and species. The results of these investigations are included in the table on page 33.

Water.—As already stated, the animal body contains a great deal of water, but perhaps many will be surprised to find that there is so much of this constituent in the animal. The water is present in the free state in the tissues and blood, and generally represents about 50 per cent. of the weight of the animal. Young animals contain more water than mature animals, as is shown in the water content of the calf and the ox. Active cells in animals contain more water than do the older or less active cells and this may account for the larger percentage of water found in young animals. It is also true that lean animals contain more water than fat animals, and the condition or degree of fatness influences the percentage of water in the animal body. The lean sheep contains 13.9 per cent. more water than the fat sheep; the fat sheep, 8.2 per cent. more than the extra fat sheep; the half-fat ox, 6 per cent. more than the fat ox; and the lean pig, 13.8 per cent. more than the fat pig. In fattening, animals store up fat, and the fatty substances do not replace the water, but an increase in fat in the animal body means an increase in dry matter. This accounts for fat animals containing less water than lean animals. It also explains why there is more meat in the fat animal than in the lean animal, and hence the preference given the fat animal at the markets.

Ash.—There is not a comparatively large amount of mineral matter in the animal body. As the animal matures there seems to be a decrease in the percentage of mineral matter. The half-fat ox contains 0.74 per cent. more ash than the fat ox; the lean sheep, 0.35 per cent. more than the fat sheep; and the lean pig, 1.02 per cent. more than the fat pig. There is also a variation of mineral matter in the species. The ox contains more mineral matter than the sheep and the sheep more than the pig. During fattening there is a difference in the increase of mineral matter in the different animals; pigs do not add as great a percentage as oxen, and oxen do not add as much as sheep.

PERCENTAGE COMPOSITION OF THE ENTIRE BODIES, THE CARCASSES AND THE OFFAL OF TEN ANIMALS OF DIFFERENT DESCRIPTIONS, OR IN DIFFERENT CONDITIONS OF MATURITY —LAWES AND GILBERT.[1]

Description of animal	Mineral matter (ash)	Nitrogenous substance (protein)	Fat	Total dry matter	Water	Contents of stomach and intestines (in moist state)
ENTIRE ANIMAL (fasted live wt.)						
Fat calf	3.80	15.2	14.8	33.8	63.0	3.17
Half-fat ox	4.66	16.6	19.1	40.3	51.5	8.19
Fat ox	3.92	14.5	30.1	48.5	45.5	5.98
Fat lamb	2.94	12.3	28.5	43.7	47.8	8.54
Lean sheep	3.16	14.8	18.7	36.7	57.3	6.00
Half-fat old sheep	3.17	14.0	23.5	40.7	50.2	9.05
Fat sheep	2.81	12.2	35.6	50.6	43.4	6.02
Extra fat sheep	2.90	10.9	45.8	59.6	35.2	5.18
Lean pig	2.67	13.7	23.3	39.7	55.1	5.22
Fat pig	1.65	10.9	42.2	54.7	41.3	3.97
Means of all	3.17	13.5	28.2	44.9	49.0	6.13
CARCASS						
Fat calf	4.48	16.6	16.6	37.7	62.3	....
Half-fat ox	5.56	17.8	22.6	46.0	54.0	....
Fat ox	4.56	15.0	34.8	54.4	45.6	....
Fat lamb	3.63	10.9	36.9	51.4	48.6	....
Lean sheep	4.36	14.5	23.8	42.7	57.3	....
Half-fat old sheep	4.13	14.9	31.3	50.3	49.7	....
Fat sheep	3.45	11.5	45.4	60.3	39.7	....
Extra fat sheep	2.77	9.1	55.1	67.0	33.0	....
Lean pig	2.57	14.0	28.1	44.7	55.3	....
Fat pig	1.40	10.5	49.5	61.4	38.6	....
Means of all	3.69	13.5	34.4	51.6	48.4	....
OFFAL (excluding contents of stomachs and intestines)						
Fat calf	3.41	17.1	14.6	35.1	64.9	....
Half-fat ox	4.05	20.6	15.7	40.4	59.6	....
Fat ox	3.40	17.5	26.3	47.2	52.8	....
Fat lamb	2.45	18.9	20.1	41.5	58.5	....
Lean sheep	2.19	18.0	16.1	36.3	63.7	....
Half-fat old sheep	2.72	17.7	18.5	38.9	61.1	....
Fat sheep	2.32	16.1	26.4	44.8	55.2	....
Extra fat sheep	3.64	16.8	34.5	54.9	45.1	....
Lean pig	3.07	14.0	15.0	32.1	67.9	....
Fat pig	2.97	14.8	22.8	40.6	59.4	....
Means of all	3.02	17.2	21.0	41.2	58.8	....

[1] Bul. 22, Office of Experiment Stations.

Protein is greater in lean animals than in those that are fat. The half-fat ox has 2.1 per cent. more protein than the fat ox; the lean sheep 2.6 per cent. more than the fat sheep; and the lean pig, 2.8 per cent. more than the fat pig. There is more protein in the ox than in the sheep and more in the sheep than in the pig.

Fat.—The fat calf has 14.8 pounds of fat per 100 pounds live weight; the half-fat ox 19.1 pounds, the fat ox 30.1 pounds, a difference of 15.3 pounds between the fat calf and the fat ox. The lean sheep contains 18.7 pounds of fat per 100 pounds live weight, the fat sheep 35.6 pounds and the extra fat sheep 45.8 pounds, or a difference of 27.1 pounds between the lean and extra fat sheep. The lean pig contains 23.3 pounds of fat per 100 pounds live weight and the fat pig 42.2 pounds, a difference of 18.9 pounds. It is shown that there is 2.5 per cent. more fat than protein in the half-fat ox and 15.6 per cent. more in the fat ox; in the lean sheep 3.9 per cent. more and in the fat sheep 23.4 per cent. more; in the lean pig 9.6 per cent. more and in the fat pig 31.3 per cent. more.

Nature of Gain in Fattening.—The findings of Lawes and Gilbert show that an increase in fattening means a great increase in the dry matter. The increase of fat is greater than protein. In fattening oxen the increase of live weight will approximate 1½ per cent. mineral matter, 7 to 8 per cent. of protein, 60 to 65 per cent. of fat and 70 to 75 per cent. of dry matter.

Should oxen be fattened while young and growing the increase may amount to about 2¼ per cent. of mineral matter, about 10 per cent. of protein and about 50 to 55 per cent. of fat. The fattening increase of mature animals amounts to about three quarters dry matter and one quarter water, while for young growing animals two-thirds dry matter and one-third water represents the proportion of increase.

The increase for sheep amounts to about 2 per cent. mineral matter, about 7 per cent. protein, from 65 to 70 per cent. fat, and 75 to 80 per cent. dry matter. The increase of mineral matter of sheep is greater than for mature oxen because of the growth of wool. In the final period of excessive fattening of sheep the increase may reach 70 to 75 per cent. of fat and 80 to 85 per cent. of dry matter.

The increase for highly fattened pigs amounts to 6½ to 7½ per cent. protein, 65 to 70 per cent. fat and 70 to 75 per cent. dry matter. The increase in mineral matter is so small as to be disregarded. If the pig is not highly fattened the increase will contain more protein and water and less fat and dry matter.

SECTION IX.

PHYSIOLOGY OF DIGESTION.[1]

In the preceding pages we have learned that the animals' food constitutes that which they eat and drink. We will now discuss the way the animal appropriates this food for nourishing its body and the processes necessary to prepare the food for digestion and assimilation.

Digestion.—This may be defined as the physiological process of preparing food or changing it into soluble substances that may be absorbed, or taken into the circulation.

Assimilation.—After the food is digested it is made use of by the cells of the several tissues of the body. The acquiring of the digested food for building up the several parts of the body is called assimilation.

Ferments.—In the processes of digestion foods are subjected to changes which are destructive and beneficial. Before taking up the several steps of digestion let us consider these changes which are caused by ferments.

A ferment is something which produces fermentation. When it comes in contact with any feed stuff, new compounds are formed and usually gas is given off. Examples of fermentation are; spoiling of butter, souring of milk, spoiling of fruits in jars, spoiling of canned vegetables, and the converting of apple juice to cider.

Ferments not Beneficial to Digestion.—The above changes are all due to the action of minute single celled organisms called bacteria. These bacteria are present in very large numbers in the alimentary canal and attack the food compounds, giving off water, marsh gas, carbonic acid, ammonia, sulphuretted hydrogen and other gases. In other words this kind of fermentation is destructive and is always accompanied by a loss of food nutrients.

Ferments Beneficial to Digestion.—There is another class of ferments which are chemical compounds and have the power to change the composition of certain other substances simply by

[1] Adapted from Smith's Manual of Veterinary Physiology and from Dalrymple.

contact. The dissolving of starch, which is insoluble in water, by malt is an illustration of this kind of ferment. It is this class of ferments upon which the digestion of the food depends. These ferments change the insoluble compounds into compounds which are readily absorbed into the blood. All the changes of food in digestion are probably brought about by the action of ferments or dilute acids. Examples of these ferments are:

Solution	Ferment	Medium	Acts on	Forms
Saliva	Ptyalin	Alkaline	Starch	Maltose
Gastric Juice	Pepsin and Hydrochloric Acid	Acid	Proteids	Peptones
	Rennin	Acid	Coagulates	Milk
Bile	Glycocholic Acid	Alkaline	Emulsifies	Fats
	Taurocholic Acid	Alkaline	Accelerates	Action of the bowels
Pancreatic Juice	Trypsin	Alkaline	Proteids	Peptones
	Amylopsin	Alkaline	Starch	Sugar
	Steapsin	Alkaline	Emulsifies	Fats
Intestinal[1]	Intestinal	Alkaline	All carbohydrates	Glucose
Juice	Juice		Proteids	Peptones
			Emulsifies	Fats

The several steps of digestion follow:

1. **Prehension,** or conveying food to the mouth, differs according to species. The **horse** uses the lips a great deal in gathering food. In feeding in the stall, the horse collects the food with the lips and when grazing, cuts off the grass with the teeth, drawing the lips back so as to bite close to the ground.

The Ox has no teeth in the upper jaw and it seizes food with the tongue. In grazing the tongue is extended and curled around the grass, which is thus drawn into the mouth and taken off by a swinging motion of the head as it passes between the incisor teeth (teeth of the lower jaw) and the dental pad (pad of the upper jaw).

The Sheep has no teeth in the upper jaw. It has a divided upper lip which permits the use of the teeth and dental pad in grazing. Because of this divided lip the sheep can gather very

[1] Ellenberger (Herbivora).

short grass and live on pasture where the horse and ox would starve. The sheep like the horse uses the lips in gathering food.

The Hog uses the lower lip and teeth in prehending food.

Drinking.—In drinking, the animal uses the tongue as a piston and pumps up the water to the mouth; the lips are closed except a small opening, which permits the entrance of the liquid, which is placed under the liquid. The horse and ox use this method in drinking. The horse extends its head while drinking and draws the ears forward at each swallow and back between swallows.

The dog drinks with the tongue—laps water—by curling the tongue into the shape of a spoon.

Animals suck by forming a vacuum in the mouth when the lips are closed, increasing the size of the tongue behind and diminishing it in front, the dorsum being applied to the roof of the mouth.

2. **Mastication** or chewing is performed between the molar teeth, the large back teeth, or grinders, which reduce and grind the food. The lips, cheeks and tongue help to place and hold the food for grinding. The movements which the jaws undergo are somewhat different in species of animals. In the horse and ox the movement is not only up and down, but lateral. The herbivora (horse, sheep, goat and ox) can only masticate (chew) on one side at a time; when this side gets tired the process is reversed. The upper jaw of the herbivora is wider than the lower. It takes the horse from five to ten minutes to eat one pound of corn and fifteen to twenty minutes to eat one pound of hay. In the ox mastication is imperfectly performed to start with, but the material is eventually brought back to the mouth by the process of rumination and undergoes thorough re-mastication.

3. **Insalivation.**—While the food is chewed and reduced, small ducts and tubes on the sides of the mouth pour out a solution called saliva from the salivary glands. This saliva performs a chemical action on the food by converting the insoluble starch into soluble sugar (maltose), and otherwise prepares these carbohydrates for later digestion in the intestines, etc. Ptyalin, the ferment of saliva, does not change all the starch in the food

to sugar in the mouth, but it acts upon the starch in the œsophagus and until it reaches the true stomach when the conversion is arrested until the food reaches the small intestine. The ferments which change starch to sugar are alkaline and the gastric juice being acid, stops this conversion until the food reaches the small intestine where the alkaline ferment amylopsin completes this change of starch to sugar.

Colin places the daily secretion of saliva in the horse at 84 pounds and in the ox at 112 pounds, though the amount will depend upon the dryness of the food consumed. Hay absorbs more than four times its weight of saliva, oats rather more than their own weight, and green fodder half its own weight.

4. **Deglutition** or swallowing. This is brought about by means of the tongue, some of the muscles of the throat and by the wave-like contractions of the œsophagus (gullet), which ends at the stomach.

Some animals prepare their food into round masses, called boluses, before swallowing. The boluses of the ox are about two or three inches in diameter; those of the horse are one-half that size.

The construction of the œsophagus of the horse is different from that of the ox and sheep. It is very narrow and composed of a thick, rigid muscular coat at its termination. The œsophagus of the ox and sheep is coated with a thin muscular coat which stretches easily and because of this, these animals can swallow bulky material that would choke the horse.

5. **Stomachal Digestion** or chymification. This step refers to the food materials being converted into *chyme,* which is a liquid, or semi-liquid, mass into which the food in the stomach is changed by the action of the gastric juice, aided by the churning motion produced by the muscular wall of that organ. When in the stomach the food is not only rendered more liquid or poultaceous by the gastric juice as a whole, but, by the chemical ferment, *pepsin,* the insoluble *protein* is changed into soluble *peptone.*

The stomach of the ox always has food in it; that of the horse is too small even to hold one feed, so that the first food eaten is generally passed to the small intestine before the meal is finished.

LENGTH OF INTESTINES AND CAPACITY OF STOMACHS OF FARM ANIMALS[1]

Length of intestine				Capacity of stomach and intestine		
Animal	Average length	Ratio between large and small intestine	Ratio between body length and small intestine	Average capacity	Quarts	Ratio
	Feet					
HORSE				Horse		
Small intestine	73.6	3	1:12	Stomach	19.0	8.5
Large intestine	24.5	1		Small intestine	67.4	30.2
				Large intestine	137.4	61.3
				Total capacity	223.8	100.0
OX				Ox		
Small intestine	150.9	4.1	1:20	Stomach	266.9	70.8
Large intestine	36.3	1		Small intestine	69.7	18.5
				Large intestine	40.1	10.7
				Total capacity	376.7	100.0
SHEEP				SHEEP		
Small intestine	85.9	4	1:27	Rumen	24.7	52.9
Large intestine	21.4	1		Reticulum	2.1	4.5
				Manyplies	1.0	2.0
				Abomasum	3.5	7.5
				Small intestine	9.5	20.4
				Large intestine	5.9	12.7
				Total capacity	46.7	100.0
HOG				HOG		
Small intestine	60.0	3.5	1:14	Stomach	8.5	29.2
Large intestine	17.1	1		Small intestine	9.7	33.5
				Large intestine	10.8	37.3
				Total capacity	29.0	100.0

It generally requires from three to four days for the food to pass through the digestive tract of animals.

[1] Henry, Feeds and Feeding.

Stomach of the Ox and Sheep.—The stomachs of the horse and pig are simple and have one compartment while those of the ox and sheep are more complicated and have four compartments namely, the first compartment (rumen or paunch); the second compartment (honeycomb or reticulum); the third compartment

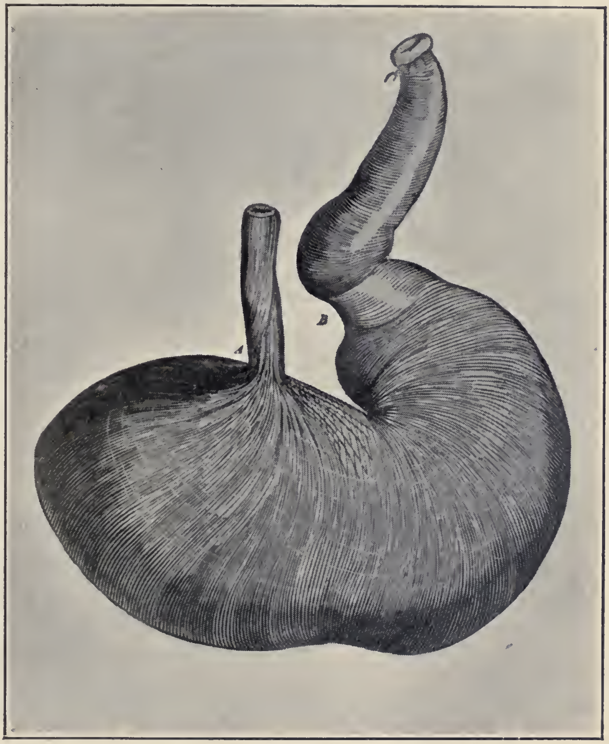

Fig. 1.—Stomach of the horse.
A—cardiac end of the oesophagus; B—pyloric end and ring—after Fleming.

(omasum or manyplies); and the fourth compartment (abomasum or rennet, or true digestive compartment). This last compartment corresponds to the stomach of the horse and pig.

Rumination.—In the ruminating animal, such as the ox, sheep and goat, which "chew the cud," the food, in a somewhat imperfectly masticated condition, passes into the large first compartment of the stomach, and then into the second. Then by a special arrangement of parts, it is forced back into the œsophagus and into the mouth for final preparation by the teeth and the saliva. When swallowed a second time, the mouthful of food passes into the third compartment and onto the fourth for final stomachal digestion. The first three compartments prepare the

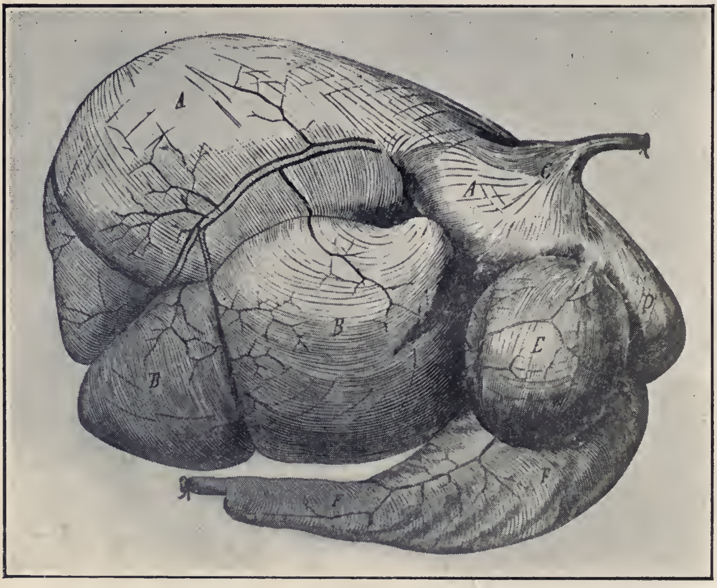

Fig. 2.—Stomach of the ox, seen on its right upper face, the abomasum being depressed. A—rumen, left hemisphere; B—rumen, right hemisphere; C—termination of the oesophagus; D—reticulum; E—omasum; F—abomasum—after Fleming.

food for the final digestion which takes place in the fourth compartment.

6. **Intestinal Digestion** or chylification. This step has reference to the food in the small intestine being converted into *chyle,* which is the nutritive materials, in liquid form, ready for absorption into the circulation. After reaching the small intestine, the food materials are again acted upon by ferments which have a somewhat similar action to those already spoken of in connection with the saliva and the gastric juice. These ferments are chiefly from the pancreas, or "sweetbread," and are conveyed to the intestine, as a part of the pancreatic juice, through the pancreatic duct or tube. These ferments alluded to are:

(a) **Amylopsin**, which changes the insoluble starch into soluble sugar.

(b) **Trypsin**, which converts insoluble protein into soluble peptone.

(c) **Steapsin**, which emulsifies the fats and oils in the food, and renders them more easy of absorption into the circulation.

7. **Absorption.**—This is the step by which the nutrient materials of the food, in liquid form, are taken from the alimentary canal into the circulation to be carried by the blood to all parts of the body to nourish the different tissues. And no food is capable of being absorbed until it has first been rendered soluble by the action of the different ferments.

Intestinal absorption takes place through the villi of the small intestines into the lacteals—small beginnings of the lymphatic system distributed to the small intestine—and through the bloodvessels into the venous system. The nutrients absorbed by the bloodvessels pass into the portal vein and are conveyed by this vein to the liver before entering into the circulation. Hence the nutrients either pass through the lymphatic glands to the blood or else are conveyed to the liver for further elaboration before entering the circulation.

Fats.—The fats are generally emulsified before being absorbed. The lacteals are considered as absorbing all the fats.

Sugar formed in the bowel reaches the circulation through the portal vein and liver. Some of it in the horse perhaps finds its way to the lacteals. We will learn in the next section that the excess of sugar in the blood is taken up by the liver and converted into starch (glycogen) and doled out in the form of sugar to the blood as required. Mineral salts in solution enter the blood as do the sugars.

Proteids.—As already stated the proteids are converted into peptones before being absorbed. It is said that the peptones are absorbed by the bloodvessels of the villi, and conveyed by the portal vein to the liver.

8. **Circulation.**—This step is accomplished by the blood in the arteries carrying the nutritive materials, absorbed from the food, to all parts of the body.

9. **Assimilation.**—This step is undertaken by the tissue-cells themselves, selecting from the blood, or lymph, the nutritive elements required for their maintenance and development.

10. **Defecation.**—This final step refers to the casting off from the body, in the form of excrementitious matter (manure), the inert indigestible parts of the food. Besides containing the undigested food, small portions of the residues of the juices employed in digestion and other waste matters are present.

Suggestion: Require the students to make a schematic drawing showing the passage of the food, the ferments and their properties, and the absorption of the nutrients, in the ruminant.

SECTION X.

THE CIRCULATION OF DIGESTED FOOD.[1]

The Blood.—After the food is digested it is absorbed and enters into the blood. The special functions of the blood are to nourish all the tissues of the body, and thus aid their growth and repair; to furnish material for the purpose of the body secretions, to supply the organism with oxygen without which life is impossible, and finally to convey from the tissues the products of their activity.

To enable all this to be carried out the blood is constantly in circulation, is rapidly renewed, is instantaneously purified in the lungs, and by means of certain channels it is placed directly in communication with the nourishing fluid absorbed from the intestines by which it is being constantly repaired.

Physical Characters of the Blood.—The color of the blood varies, depending upon whether it is drawn from an artery or a vein; in the former it is of bright scarlet color, while in the latter it is purplish red. Blood examined under the microscope is found to consist of an enormous number of red disk shaped bodies termed *corpuscles* floating in an almost clear liquid called *plasma*. These corpuscles are both red and white; the former are the more numerous and the latter the larger. These red corpuscles contain a pigment called *hæmoglobin* which gives blood its scarlet color. The scarlet or purplish color of the blood depends upon the amount of oxygen with which the hæmoglobin is combined. When hæmoglobin is charged with oxygen it is called *oxy-hæmoglobin*.

Arterial and Venous Blood.—Arterial blood contains more oxygen and less carbonic acid than venous blood. The dark color of venous blood is not due to the greater amount of carbonic acid it contains, but to the diminution of oxygen in the red blood cells.

Salts of the blood are divided between the plasma and the corpuscles. Sodium chloride is the most abundant salt of the blood, potassium chloride and sodium carbonate follow, and

[1] Adapted from Smith's Manual of Veterinary Physiology.

lastly phosphates of calcium, magnesium and sodium. Iron is found in the hæmoglobin.

Chemical Composition of Blood.—The composition of the blood as given is from various investigators.

100 parts venous blood of the horse contain:

	Per cent.
Corpuscles	32.6
Plasma	67.4

The corpuscles contain:

Water	56.5
Solid matter	43.5

The plasma contains:

Water	90.8
Solids	9.2

The solids consist of:

Fibrin	.4
Albumin	7.5
Fats	.1
Extractives	.4
Soluble salts	.6
Insoluble salts	.2

Average blood contains:

The plasma—	
Water	90.0
Proteids	8. to 9.
Fats	.1
Fibrin	.2 to .4
Extractives	.4
Salts	.8
The corpuscles—	
Water	56.0
Solids	43.0
consisting of 90 per cent. hæmoglobin and 8 per cent. proteids	
Salts	1.0

Taking the blood as a whole the following will approximately represent its composition.

	Per cent.		Per cent.
Water	80.		
Solids	20.	Hæmoglobin	10.
		Proteids	8.
		Salts	2.

Proteids constitute about 80 per cent. of the dry matter of the blood (hæmoglobin contains proteids). Fats and sugar are also present but generally in small amounts in the plasma.

The Heart.—The blood in the body has to be kept in constant motion, so that the tissues which are depending upon it for their vitality may be continually supplied, and also in order that the impure fluid resulting from these changes, may be rapidly and effectually conveyed to those organs where its purification is carried out.

Compartments of the Heart.—The heart is the organ which pumps the blood over the body, not only distributing it to the tissues but forcing it on from these back to the heart again to be prepared for redistribution. It may be described as a hollow muscle divided into two compartments, usually described as right and left, but in quadrupeds really anterior and posterior, each compartment being capable of division into an upper or auricle, and a lower or ventricle. Opening into the auricles are large veins which convey the blood back to the heart; from the ventricles other vessels, arteries, take their origin for the conveyance of blood from the heart; the two cavities are separated by a valvular arrangement.

Pure and Impure Blood.—Into the right heart the whole of the impure or venous blood in the body is brought for the purpose of being purified in the lungs; into the left heart the arterial or purified blood is brought back from the lungs for distribution over the body.

How the Nutrients Enter the Blood.—The absorbed nutritive materials reach the blood when it is returning to the heart. The blood is pumped out through the cavities into the arteries to be sent to all parts of the body, to furnish nourishment for building up the tissues.

Respiration.—The blood not only performs the function of supplying nutrient to the tissues, but it also takes up a great deal of the waste matter of the body. This elimination of waste matter by the blood is accomplished to some extent by means of the lungs. The blood is pumped to the lungs and renewed by taking on a fresh supply of oxygen from the inspired air, which is necessary for the life of the tissues. Some of the waste matters such as carbonic acid gas, water and organic substances, are passed off by the blood through the lungs in the expired air.

The changes the air undergoes in the lungs, on a water free basis, are as follows:

	Oxygen Per cent.	Nitrogen Per cent.	Carbonic acid Per cent.
Inspired air	20.96	79.01	.03
Expired air	16.00	79.60	4.40

The expired air contains about 5 per cent. less oxygen and 4 per cent. more carbonic acid than inspired air. Considerable water is also given off with the expired air.

The following table gives an idea of the extent of the elimination of wastes through the lungs of farm animals.

AMOUNTS OF OXYGEN CONSUMED AND CARBONIC ACID PRODUCED BY ANIMALS.[1]

	Live wt. lbs.	Amt. of air inspired in 24 hrs. cu. ft.	Amt. of oxygen consumed in 24 hrs., cu. ft	Amt. of carbonic acid produced in 24 hrs., cu. ft.
Horse	990	3373	150	151
Cow	990	2782	122	122.3
Pig	165	1216	54.7	55.1
Sheep	99	720	32.4	22.6

The Kidneys may be regarded as the filters of the body, and one of the channels by which waste and poisonous substances are removed or filtered from the blood, and passed off from the body in the urine. The amount of blood passing to the kidney is quite considerable; it has been calculated that in 24 hours, 146 pounds of blood will pass through the kidneys of a dog weighing 66 pounds.

The Composition of Urine depends upon the class of animal; in all herbivora, with certain minor differences, the urinary secretion is much the same.

[1] Boussingault.

COMPOSITION OF URINE OF SHEEP.[1]

	Per cent.
Water	86.48
Organic matter	7.96
Inorganic matter	5.56
The organic matter contained:	
Urea	2.21
Hippuric acid	3.24
Ammonia	.02
Other organic substances	2.07
Carbonic acid	.42
Total	7.96
The inorganic matter contained:	
Chlorine	1.05
Potassium chloride	1.84
Potassium	2.08
Lime	.07
Magnesia	.20
Phosphoric acid	.01
Sulphuric acid	.24
Silica	.07
Total	5.56

There is a considerable portion of nitrogenous matter in the urine which is present in the urea and hippuric acid. It must be understood that the composition of the urine is not always constant and it varies with the diet.

The Liver stores up an animal starch (carbohydrate) called glycogen. This is absorbed from the intestine as sugar and changed to starch. It is gradually passed out to the blood as sugar when required. The liver regulates the amount of sugar which should pass into the blood, so much and no more is admitted, the amount varying from 0.05 to 1.5 per cent.

The Skin gives off water and other substances by means of the sweat glands. Sweat exists in two forms: viz., the invisible vapor which is always rising from the surface of the skin, and distinguished as the "insensible perspiration," and the visible material, which is termed "sweat." The insensible per-

[1] Tereg.

spiration of a horse is probably about 14 pounds of water per 24 hours.

COMPOSITION OF HORSES' SWEAT.

	Per cent.		Per cent.
Water	94.3776	Serum albumin	.1049
Organic matter	.5288	Serum globulin	.3273
		Fat	.0020
Ash	5.0936	Chlorine	.3300
		Lime	.0940
		Magnesia	.2195
		Phosphoric acid	traces
		Sulphuric acid	traces
		Soda	.8265
		Potash	1.2135

The mineral matter in sweat is very high and exists principally as soda and potash. The nitrogenous matters (albumin and globulin) make up most of the organic matter. It will be observed that the mineral matter exceeds the organic matter; in horses which have sweated freely the hair mats, due to the nitrogenous substance, albumin, and is often covered with salty matter due probably to the salts excreted. The loss of albumin perhaps accounts for the weakening effect in animals produced by sweating freely.

Suggestion: Make a schematic drawing showing the entrance of the nutrients into the blood, the circulation of the blood and its functions.

SECTION XI.

CONDITIONS GOVERNING DIGESTIBILITY.

There are several factors which govern the digestibility of foods and brief mention will be given of some of the more important factors. The data submitted in this section are the results of investigations conducted by Europeans and Americans, and are of value in clearing up some points on feeding.

Quantity of Food.—It is said by some investigators that the quantity given, within certain limits, does not affect the digestibility of the same fodder. That is if the amount of fodder be great or small, provided the ration does not exceed the capacity of the animal, the fodder is digested in the same proportions. Other investigators have found that the larger the ration the less is the digestibility. It is probable that when an animal receives a large amount of food the digestibility is less because the ferments which act upon food are less concentrated than with a small ration.

Palatability.—The animal like man enjoys a food that is palatable (tastes good). Experiments have proven that palatability favors digestion by exciting the flow of gastric juice and by producing favorable action of the digestive organs. When a food is relished, more of it is eaten.

Chemical Composition.—The chemical composition of a food influences its digestibility. The same food grown on different soils, or fertilized differently, or grown at different seasons is changed in composition and digestibility.

Dry and Green Food.—It has been learned that dry fodder and green fodder are equally digestible when the dry fodder is carefully cured and saved. If fermentation sets in, or some of the leaves or other parts of the fodder are lost, of course the digestibility is lessened.

In hay-making, there are often losses which decrease the digestibility of the dried fodders. These losses may not be due to drying but to fermentation, leaching, decreases in soluble materials, and breaking off of the delicate parts.

Effect of Storage on Food.—The method of storing coarse fodders influences their digestibility. Experiments on hay when fed after recent harvesting showed 62 per cent. of its protein digestible, and three months later 54 per cent. of its protein was digested. The digestibility of the nitrogen free extract and crude fiber were practically the same in both trials. Other experiments have proven that there are losses in digestible protein in storing. There are also losses from breaking off of the dry, tender portions which generally contain the most protein.

There seems to be differences of opinion on the effect of storing fodders in the silo. Some experiments have been conducted that showed losses of digestibility in preserving fodders in this way and many believe that field cured corn fodder is less digestible than silage from the same corn. Of course there are many factors to be considered in determining this point. The method of field curing, the weather, handling, and thoroughness of curing and after preservation must be considered. In the silo the changes from fermentation and the neglect in siloing, sometimes cause losses.

Stage of Development.—The stage of growth of a plant effects its digestibility. Generally young plants are more digestible than the more mature, because the fiber is more tender. The protein of green clover before flowering is more digestible than that of mature clover. Hay cut at maturity is higher in fiber than the younger plant and less of it is digested.

The corn plant seems to be an exception to the rule. At maturity when the ears are fully ripe, there are more digestible nutrients than if cut before the ears are full grown. This is perhaps due to the increase of starch in the kernels of corn.

Preparation of Food.—It was formerly accepted that foods treated by cooking, steaming, scalding, roasting and fermenting were greatly improved, and rendered more digestible and favorable for the production of flesh, milk, etc. A great deal of attention was given to this system of feeding which entailed much expense, until experiments by Europeans and Americans proved conclusively that the digestibility of already palatable foods was lessened by such procedure. At the present time it is unusual to find feeders preparing rations by cooking, steaming, scalding, roasting and fermenting. The investigators found that the protein digestibility was most effected and as this was the most expensive nutrient the practice was discontinued. Sometimes scalding a food improves its palatability and thus serves to increase its consumption.

Grinding has considerable influence on the digestibility of certain foods when fed to certain animals. The smaller and

Fig. 3.—A coach horse—after Good.

harder the seed the more necessary it is to grind it. Many of our seeds such as flax, barley, peas, rye, sorghum, millet, etc., are so small as to escape mastication, or too hard, or too oily for the digestive fluids to penetrate and act upon. The harder the outer covering of the grain the more benefit is derived by grinding.

Imperfect mastication is greater with the horse or mule than with ruminating animals and therefore grinding is more necessary on certain foods when fed to the horse or mule. The digestibility of corn, wheat and oats is increased by grinding when fed to horses or mules. Grain when fed to calves should be ground, and grinding improves the digestibility of grain for swine. It is more necessary to grind the grain fed to the horse or mule when at work than when idle, because a working horse or mule has less time to properly masticate food. Hay, fodders, etc. are more completely consumed when ground. The cob can be utilized to advantage when the whole ear (corn and cob) is finely ground. Experiments have shown that corn and cob meal of this character is of about equal feeding value to pure corn meal. The bulkiness of corn and cob meal permits of thorough action of the digestive fluids.

Species of Animal.—With oxen, cows, sheep and goats the digestibility of forage is about the same. Sheep digest clover hay better than oxen, and oxen digest hay better than sheep. Horses and mules digest less hay than the ruminating animals, perhaps because of poorer mastication. The fat, carbohydrates and particularly the crude fiber, are digested in smaller amounts by horses and mules than ruminants. Experiments show that 20-25 per cent. less nitrogen free extract of hay is digested by the horse than by ruminants. The digestibility of grain is about the same with the horse and ruminants.

Individuality and Age.—Defective teeth, differences in age, and weakened digestion sometimes cause differences in digestibility with animals of the same species. Some claim that animals of the same species may show differences in digestive power ranging from 2 to 4 per cent. Experiments conducted on sheep and steers have shown variations in digestibility. Sometimes one animal gave the highest digestibility and at other times another. Young and old animals of the same species seem to digest equal amounts of food.

Work according to Wolff has no influence in causing a larger proportion of food substances to be digested. Excessive work perhaps causes a slight decrease in the amount digested.

Combinations.—Investigations show that the combination of the nutrients of a food exerts an influence on its digestibility. Corn added to hay produces no effect on the digestion of hay unless it is added in large amounts when it decreases the digestibility. Large amounts of carbohydrates tend to reduce the digestibility of the protein and crude fiber in hay. This decrease is not great until the carbohydrates amount to 25 to 30 per cent. of the total dry matter in the hay, although it is much larger if straw is included in the diet. This depression of digestibility can be removed by adding more protein. It is believed that if carbohydrates form 10 per cent. of the dry matter of a ration, or when roots or potatoes constitute more than 15 per cent. of the dry matter, the amount of digested substance decreases and becomes greater as the carbohydrates are increased. From these observations it is apparent that the excessive use of roots or tubers with hay or fodder, will decrease the digestibility of the ration unless the protein is increased. Experiments indicate that albuminoids and oil added to a ration do not increase the amount digested or do not alter the digestibility.

An Addition of Salt may improve the flavor of a food and thus cause an increase in the amount of food eaten, but it does not seem to be effectual in causing a larger per cent. of digestibility.

Time of Watering and Frequency of Feeding.—Experiments have been run to ascertain the effect of the time of watering, amount of water and frequency of feeding with the results that no alteration in digestion took place. It should be understood however that the ruminants should be fed and watered at least twice a day and horses and mules three times a day for the best results.

SECTION XII.

THE NUTRIENTS AND THEIR FUNCTIONS.

The previous sections explained the composition of plants and animals, how food is digested, absorbed and distributed over the body, but we must now learn about the nutrients and their functions.

The Nutrients.—Protein, fats, nitrogen free extract, crude fiber, water and ash serve to supply the needs of animals. Nitrogen free extract and crude fiber are classed as carbohydrates and the digestible amounts in both of these plant substances are regarded as of equal value and supply the same needs in the animal body. Water can be supplied in a cheaper form than in feed stuffs. Protein, fats, carbohydrates and ash therefore are considered as the nutrients. The nutrients and examples of each are:

Protein	Albumen (white of egg), legumin, casein of milk, washed lean meat, fibrin of blood, gluten of flour, gelatinoids (gelatin), amides, globulin, peptones, etc.
Fats	Linseed oil, cotton seed oil, sunflower seed oil, rape seed oil, olive oil, peanut oil, fat of milk, hog lard, mutton suet, beef tallow, fish oil, etc.
Carbohydrates	Starches, sugars (milk sugar, grape sugar, cane sugar, beet sugar, and glucose), glycogen, gums, dextrins, fiber, etc.
Ash	Sodium carbonate (baking powder), sodium chloride (table salt), carbonate of lime (limestone), magnesium sulphate (Epsom salts), sodium sulphate (Glauber's salts), etc.

Purpose of the Nutrients.—We want to know the purposes which the nutritive elements serve. In a general way it may be said that animals use food in two ways: 1. To build up the body and repair broken down tissues. 2. To produce energy to keep warm and to supply that which gives locomotion or movement to the animal body.

Functions of Ash or Mineral Matter.—All the bones which make up the framework of the animal body contain ash or mineral compounds, and the blood, tissues and the digestive fluids require these substances but to a less extent. Without lime and phosphoric acid it would be impossible to build up the bones to support the animal body. Soda and chlorine are required in the processes of digestion in the digestive juices and secretions. Iron is a necessary constituent of the blood. Nature has provided for the very young animal by furnishing the necessary mineral elements in milk. The young animal must have mineral compounds to reach full development and the mature animal requires ash for maintaining body functions. It is fortunate that nature has supplied sufficient mineral matter in most of the feeds that animals live on in this country. It is only necessary to furnish mineral compounds when a diet consisting chiefly of grain (such as corn) or prepared foods consisting of parts of grain are fed. Animals cannot live without mineral compounds. Such substances as common salt, wood ashes, and precipitated chalk are sometimes fed in conjunction with other feeds to supply the needs of growing animals.

Functions of Protein.—Protein as derived from plant substances is the main constituent of muscles, horn, hoof, hair, ligaments, the tissues of the organs used in digestive processes, and the working parts of the animal body. The protein compounds are in reality the flesh formers. Protein bodies repair the broken down tissues, help form blood, and milk. When animals are fed protein in the right proportions they possess vigor and look smart and lively. Without protein the animal cannot live. Sometimes protein can be made to take the place of fats and carbohydrates, but such substitution is not practicable, as protein generally costs more than fats and carbohydrates. Protein hardly ever performs the functions of fats and carbohydrates unless these latter nutrients are lacking in animal's food. The heat producing power of protein is about 1¼ times that of carbohydrates. As a heat producer fat is 2.25 times greater than protein. The amount of body fat that protein produces is equal to one-half that which the fat of plant substance produces.

Functions of Fats and Carbohydrates.—These nutrients perform the same functions and supply the fuel for the animal body. They are heat producers and furnish the substances that keep the animal warm. The fats and the carbohydrates also produce fat in the animal body. The fats are not always changed in forming fatty tissue but the carbohydrates are transformed into fats before being stored as such. Therefore in the animal body we have four classes of compounds namely, protein, fats, water and ash. As an energy and heat producer, fats have a greater value than carbohydrates. Fats are considered as being 2.25 times more valuable than carbohydrates in this respect. In other words, one pound of fat is worth 2.25 times as much as one pound of carbohydrates for animal fuel. One pound of fat is worth about two pounds of protein and one and three quarters pounds of carbohydrates in the production of animal fat. Fats and carbohydrates cannot form body tissue.

Summary.—The nutrients of the animal body serve the same purposes as furnished by the nutrients of feeds. When there is a deficiency in a diet, the protein and fats, or the fats of the animal body are used to help keep the animal going. A sufficiency of carbohydrates and fats in a ration prevents protein from being drawn upon, but a deficiency of carbohydrates and fats causes protein from the flesh of the animal to be used. Hence it is necessary that animals receive sufficient carbohydrates and fats to insure development and ample protection of the body.

CLASSIFICATION OF THE FUNCTIONS OF THE NUTRIENTS.[1]

Ash	Supplies materials for the bones, hard parts and framework of the body. Helps build up the blood, tissues, secretions and digestive fluids. A necessity for all animal life.
Protein	The flesh formers. Substances for the making of lean meat, muscles, skin, ligaments, horn, hair and milk. Sometimes used as fuel to give warmth and energy when there are deficiencies of fats and carbohydrates.
Fats	Furnish fuel to keep the animal warm. Help to produce energy. Aid in the production of fatty tissue.
Carbohydrates	Supply the fuel to keep the animal warm and to produce energy. Are transformed into fats for the production of fatty tissue.

1 The idea and some of the data in this classification came from Bul. 106, North Carolina Experiment Station.

Comparison of Protein, Fat and Carbohydrates

1 pound protein = 1¼ pounds carbohydrates for producing heat.
1 pound fat = 2.25 pounds carbohydrates for producing heat.
1 pound fat = 1¾ pounds carbohydrates for producing animal fat.
1 pound fat = 2 pounds protein for producing animal fat.
Protein can perform the offices of fats and carbohydrates.
Fats and carbohydrates cannot form body tissue (nitrogenous substances).

Suggestion:—Have the class examine some live animal and give the distribution of the nutrients and their functions.

SECTION XIII.

FEED STUFFS AS A SOURCE OF ENERGY.

We all know that when work is performed a certain amount of effort is put forth. This effort is proportional to the work done and energy is expended in the performance of the same. What is true for man in this respect applies for animals. The animal may be likened to the steam engine. It moves itself and also is capable of moving other things. The animal differs from the steam engine in that it never stops; it is continually at work. No matter how quiet the animal, the blood is pumped by the heart to all parts of the body, inspiration and expiration of air to and from the lungs is continuous, and the processes of digestion are being performed, so that energy is always being expended by the animal.

Sources and Uses of Energy.—In order that the animal may breathe, walk, run, trot, pull a load, plow, masticate, digest food, etc., it must be furnished with materials to enable it to perform these functions. The source of these substances is obtained from the compounds which the plant stores up as latent heat and is transformed by the animal into fats and flesh. We know that an animal deprived of plant substances soon wastes away. The animal therefore in performing work of any kind uses the substances, fats and flesh. The fats are used to furnish the fuel and the flesh to repair the tissues. Energy in animals is manifested by muscular movements. It is generally derived from the non-nitrogenous substances. The muscles are moved by the action of the non-nitrogenous substances. Let us represent the sources and uses of energy as follows:

Food compounds	Animal compounds	Functions
Carbohydrates and fats changed to	Animal fats	Used as fuel
Protein, water and ash changed to	Flesh, fluids and the body framework	Used as repair materials

Use of Compounds Furnishing Energy.—As previously mentioned the carbohydrates and fats comprise the fuel portion of the food. Should these compounds be fed in amounts just sufficient to do the work required, no excess will be stored in the body. Should they be fed in excess they are stored as fatty tissue (beef tallow, hog lard, mutton suet, etc.) with which we are all familiar. When protein is fed in larger quantities than needed for the building up and repair of the body tissues it may be used for fuel purposes. The use of protein as fuel is extravagant because it costs much more than carbohydrates and fats. The fat of the body is its storehouse of fuel. Animals fed insufficiently draw on their stored up fats and become lean. In the production of milk, growth, development of the young, etc., fuel and repair materials are reserved when the nutrients supplied are sufficient.

Potential and Kinetic Energy.—There are two kinds of energy manifested in the animal, namely, *potential* and *kinetic*. Potential energy is that which is in the food and stored up in the animal body. It may be likened to a bent spring. Kinetic energy is represented in the animal by work and heat. It is the energy represented in moving bodies and may be likened to the swinging of a pendulum.

EXAMPLES OF POTENTIAL AND KINETIC ENERGY IN THE ANIMAL[1]

Food Feces (manure) Urine Perspiration Combustible gases Storage of tissue	Potential Energy
Work Heat	Kinetic Energy

Measurement of Energy.—There is a great variation in the content of nutrients of the several feeds. In order to determine the amount of energy or heat units in feeds an apparatus is used called the *calorimeter*. This apparatus is so arranged that the heat given off by burning a feed completely is absorbed by water and the heat units measured or calculated. The principal units used in measuring heat are the *small calorie* (c), *large Calorie* (C) and the *therm* (t). The large Calorie (written with a capital C) is the amount of heat required to raise the temperature of 1 kilogram (2.2 lbs.) of water 1 degree Centigrade, or about 4 pounds of water 1 degree Fahrenheit. The

[1] Armsby, Principles of Animal Nutrition.

large Calorie is equal to 1,000 small calories (written with a small c). The Calorie is used more than calorie because of the smaller figures necessary. Armsby of the Pennsylvania Experiment Station, says: "For expressing the heat values of feeding stuffs, it is convenient to use a unit one thousand times as large as the Calorie, known as the *therm,* which accordingly is the amount of heat required to raise the temperature of 1,000 kilograms (2204.6 lbs.) of water 1 degree Centigrade, or of 4,000 pounds of water 1 degree Fahrenheit. The heat value of corn or any other fuel, as thus measured and expressed, would show its value as fuel to be burned to make steam."

These values are commonly called *heats of combustion.*

THE ENERGY VALUES OF SOME FEED STUFFS IN THERMS[1]

Feed stuffs	Amount pounds	Moisture Per cent.	Therms
Timothy hay	100	15	175.1
Clover hay	100	15	173.2
Oat straw	100	15	171.0
Wheat straw	100	15	171.4
Corn meal	100	15	170.9
Oats	100	15	180.6
Wheat bran	100	15	175.5
Linseed meal	100	15	196.7

Utilization of Energy.—It is no doubt surprising to you that wheat bran is not a great deal higher in chemical energy than timothy hay; and corn meal than oat straw. Armsby says in part: "Two causes combine to affect the utilization of the chemical energy contained in feed stuffs. First, more or less of the feed escapes from the body unburned. Much of even the best feeding stuff escapes digestion and is excreted in the dung, carrying with it a corresponding quantity of the chemical energy of the feed. More or less incompletely burned material is also contained in the urine, while ruminants, and to a certain extent horses, also give off combustible gases, arising from fermentations in the digestive tract. Thus about 22 per cent. of the chemical energy of corn meal and fully 55 per cent. of that of average hay has been found to escape in these ways.

[1] Farmers' Bul. 346, U. S. D. A.

"Second, as already pointed out, the animal body has to extract its real fuel material from its feed, separating it from the relatively large proportion of useless material which it excretes. To effect this separation requires work and consumes energy, and this energy, of course is not available for other purposes. Moreover, when the animal eats more feed than is required simply to furnish energy to run its machinery and hence is able to produce meat or milk, the process of converting the food into suitable forms to store up in the body seems to require a further expenditure of energy.

"**Total Chemical Energy not Always an Indication.**—It is not, then, the total chemical energy contained in a feeding stuff which measures its value as fuel material to the body, but what remains after deducting the losses in the unburned materials of the excreta and the energy expended in extracting the real fuel materials from the feed and transforming them into substances which the body can use or store up. For example, while 100 pounds of corn meal contain, as stated, about 170.9 therms of chemical energy, only about 88.8 therms remain, after all these deductions have been made, to represent the actual value of the corn meal as a source of energy to the organism."

Respiration Calorimeter or Respiration Apparatus.—The chemical energy of a feed stuff is easy to determine but in order to find out the amount utilized or the production value, the respiration calorimeter or respiration apparatus is used which is an airtight chamber in which man or animal is kept and food and air introduced. To determine the production value or the energy utilized, accurate data must be kept on the income and outgo of all materials. The income includes the food, composition and amount fed. The outgo includes feces, urine, perspiration, combustible gases, storage of tissue, heat and work. One must realize that an apparatus capable of measuring all these things (solids and gases) is complicated and expensive. To secure the energy values of feeds require considerable work and the expenditure of much time.

The respiration apparatus may be used for man as well as for animals.

THE RESPIRATION APPARATUS MEASURES THE

Income	Outgo
Food	Feces
	Urine
	Perspiration
	Combustible gases
	Storage of tissue
	Work
	Heat

SECTION XIV.

NATURAL STOCK FEEDS.

The natural feeds used for feeding stock include forage crops, root and tuber crops, and grains and seeds.

Forage Crops.—Under this head come green and cured leguminous plants, the grasses and the grain plants.

Leguminous Plants.—These plants differ from the grasses and

Fig. 4.—Cowpeas, a good leguminous crop.

the grain plants in that they contain more nitrogenous substances, namely, protein. Alfalfa, clovers, vetches, cowpeas and soja bean are some of our leguminous plants.

COMPOSITION OF SOME LEGUMINOUS PLANTS

Name of legume	Composition in per cent.					
	Water	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Ash
FRESH OR GREEN						
Alfalfa	71.8	4.8	1.0	12.3	7.4	2.7
Alsike clover	74.8	3.9	0.9	11.0	7.4	2.0
Cowpea	83.6	2.4	0.4	7.1	4.8	1.7
Crimson clover	80.9	3.1	0.7	8.4	5.2	1.7
Red clover	70.8	4.4	1.1	13.5	8.1	2.1
Soja bean	75.1	4.0	1.0	10.6	6.7	2.6
HAY						
Alfalfa	8.4	14.3	2.2	42.7	25.0	7.4
Alsike clover	9.7	12.8	2.9	40.7	25.6	8.3
Cowpea	11.9	14.4	2.5	41.2	21.5	8.4
Crimson clover	9.6	15.2	2.8	36.6	27.2	8.6
Red clover	15.3	12.3	3.3	38.1	24.8	6.2
Soja bean	11.3	15.4	5.2	38.6	22.3	7.2

Characteristics of Legumes.—The leguminous plants carry higher protein and ash contents, lower carbohydrates and fiber, and the fat is about the same as in grasses and grain plants. The grasses and grain plants tend to exhaust the soil of its fertility while the legumes have the habit of fixing nitrogen (the most fugitive and costly fertilizer constituent) in the soil. Like the other two classes of forage crops they use up phosphoric acid, potash and lime.

Grasses.—The principal grasses used for feeding are timothy, orchard, crab, red top, Johnson, Kentucky blue (June), and Bermuda.

The table on page 67 shows us that the grasses are much lower in protein than the legumes.

Grain Plants.—Corn, oats, barley, rye, rice and wheat are some examples of this class.

Husbanding of Forage Crops.—Forage crops are not always fed in their natural green state but are sometimes husbanded in other ways. For instance, our leguminous plants, grasses and grain plants are often dried in the field before harvesting. This field curing is done to permit the farmer to save these crops and feed at his pleasure.

COMPOSITION OF SOME GRASSES

Name of grass	Composition in per cent.					
	Water	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Ash
FRESH OR GREEN						
Kentucky blue	65.1	4.1	1.3	17.6	9.1	2.8
Orchard	73.0	2.6	0.9	13.3	8.2	2.0
Red top	65.3	2.8	0.9	17.7	11.0	2.3
Timothy	61.6	3.1	1.2	20.2	11.8	2.1
HAY						
Bermuda	21.2	7.8	3.9	37.8	23.0	6.3
Kentucky blue	9.9	8.1	2.6	41.0	32.4	6.0
Orchard	8.9	7.9	1.9	47.5	28.6	5.2
Red top	13.2	5.9	2.5	45.0	29.0	4.4
Timothy	10.6	10.2	2.2	48.3	22.4	6.4

COMPOSITION OF SOME GRAIN PLANTS

Name of grain plant	Composition in per cent.					
	Water	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Ash
GREEN FODDERS						
Barley	79.0	2.7	0.6	8.0	7.9	1.8
Corn	79.3	1.8	0.5	12.2	5.0	1.2
Oat	62.2	3.4	1.4	19.3	11.2	2.5
Rye	76.6	2.6	0.6	6.8	11.6	1.8

Losses in Field Curing.—When the leguminous plants and grasses are dried too much in the field, many of the leaves and delicate parts, which are rich in protein, fall off, thus decreasing the value of these classes of fodder; the palatability is lessened because of the loss of the aroma. Losses occur in all forage plants that are subjected to rain and cloudy weather. Fermentation often sets in under these conditions and some of the plant substances are lost. Rain often washes out some of the ash, nitrogen free extract and protein, and darkens the color of the product. Grasses suffer less than other plants in field curing. Plants like corn, with thick stalks, are practically impossible to field cure without losses from fermentation.

Time to Harvest Forage Plants.—It is generally considered best to cut grass before it fully matures as it is more palatable and the digestible nutrients probably amount to as much as in the fully mature plants. The legumes if allowed to mature suffer large losses in the breaking off of the leaves and other tender parts. With corn it is best to allow it to mature before harvesting as the fiber decreases and half of the carbohydrates increase with maturity. This increase in carbohydrates is to be expected as the ears amount to about one-half the weight of the crop. The dry matter of the mature corn plant is also more digestible than that of the immature plant.

Silage.—Often times feeds are preserved in the green state;

Fig. 5.—Filling a silo.

the resulting product being called silage or ensilage. To accomplish this an air-tight box called the *silo* is used. The fodder is best preserved by chopping into small pieces about one inch long. Corn is preserved more than any other crop in this way, although the sorghums and some of the legumes as peas, the clovers, cowpeas, soja bean, the vetches and velvet bean are sometimes used. Sometimes mixtures as oats and vetch, corn and cowpeas, corn and soja bean, etc. are used. Crops that can be quickly field cured are not generally made into ensilage. This method of preserving crops enables the feeder to furnish green, succulent feed at any time of the year, which is especially desirable to promote the appetite, excite digestion, and increase milk production. This method does away with the losses incurred in field curing because of unfavorable weather and loss of leaves, etc. It puts the coarse fodders in a good mechanical condition for handling. It is more completely consumed so that there is little waste. On the whole the preserving of forage crops in a silo is more profitable than field curing for crops with thick stems.

Composition of Silage

Name of silage	Composition in per cent.					
	Water	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Ash
Corn	79.1	1.7	0.8	11.0	6.0	1.4
Sorghum	76.1	0.8	0.3	15.3	6.4	1.1
Red clover	72.0	4.2	1.2	11.6	8.4	2.6
Soja bean	74.2	4.1	2.2	6.9	9.7	2.8
Cowpea	79.3	2.7	1.5	7.6	6.0	2.9

Silos are generally of the round (or circular) and square forms. The square form is used in barns because of the saving of space and the round form is the better for outside the barn. The latter form is to be preferred for a silo because the materials settle more quickly and more evenly. Silos may be constructed of wood, stone, brick, concrete, etc. Wood is very satisfactory for building the silo.

Losses in Silage are usually due to fermentation. Experiments show that the quicker the ensilage is packed and the air excluded the less will be these losses.

Well handled silage has about the same digestibility as corn fodder.

DIGESTIBILITY OF CORN SILAGE AND FODDER CORN[1]

Forage	Digestibility in per cent.					
	Dry matter	Ash	Protein	Fiber	Nitrogen free extract	Fat (ether extract)
Green fodder corn	68	35	61	61	74	74
Cured fodder corn	66	34	55	66	69	72
Corn silage	66	31	53	67	70	81

Straw is obtained in the threshing of grains and the securing of leguminous seeds. Stover from corn is the product left after field drying of corn grain and includes the whole plant except the ears. The straws from legumes, oats, rice and other cereal plants, and stover from corn are used for feeding. The straws from grain plants, other than oats and rice, are generally too poor for feeding and may be used for bedding.

COMPOSITION OF STRAWS AND STOVER

Name of feed	Composition in per cent.					
	Water	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Ash
Oat	9.2	4.0	2.3	42.4	37.0	5.1
Rice	12.0	5.9	2.1	33.7	38.6	7.8
Rye	7.1	3.0	1.2	46.6	38.9	3.2
Wheat	9.6	3.4	1.3	43.4	38.1	4.2
Soja bean	10.1	4.6	1.7	37.4	40.4	5.8
Corn stover	22.8	5.5	1.3	39.9	25.6	4.9

Roots and Tubers.—Turnips, carrots, rutabagas, mangel wurzels (a kind of beet) and beets are the principal root crops used for feeding. Potatoes (Irish and sweet) are sometimes fed but they are generally grown for human consumption and too expensive to be utilized for stock. Irish potatoes are known as tubers. The root and tuber crops contain a great deal of water; the average per cent. of water in these crops is about 90 per cent. That is for every 100 pounds of roots or tubers there are only 10 pounds of dry matter or actual feed. For making

[1] Woll, Henry's Feeds and Feeding.

milk or producing beef and mutton the feeding of root crops is satisfactory. On account of the tonic effect, roots give results far above what the chemical composition would indicate. In the South many crops can be grown on the same piece of land in a season; roots may be grown in the early fall and winter at a time when the land is often idle and harvested in time for the regular planting of the summer crops. Roots and tubers can be stored away and kept for feeding, provided the storehouse is well aired and kept at a low temperature. Bull. 243, Cornell, N. Y., Experiment Station, says: "If corn meal is worth $20 a ton or more in New York State, economy in the production of roots would be indicated."

COMPOSITION OF ROOTS AND TUBERS

Name of feed	Composition in per cent.					
	Water	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Ash
Carrot	88.6	1.1	0.4	7.6	1.3	1.0
Beet (sugar)	86.5	1.8	0.1	9.8	0.9	0.9
Beet (mangel)	90.9	1.4	0.2	5.5	0.9	1.1
Potato (Irish)	78.9	2.1	0.1	17.3	0.6	1.0
Potato (sweet)	71.1	1.5	0.4	24.7	1.3	1.0
Turnip	90.5	1.1	0.2	6.2	1.2	0.8

Grains and Seeds.—Some of our principal grains and seeds used for stock feeding are corn, cotton-seed, rice, oats, barley, rye, flaxseed, wheat, beans and peas. Most of our grains and seeds must be thoroughly dried before they are stored away. If they are not completely dried, they are liable to ferment and decompose. Such deterioration spoils them for feeding purposes. A full description of the grains, seeds and their by-products will be given in the following sections under commercial feed stuffs.

Production of Some Feeds.—The following table[1] gives the production of some farm crops for the year 1908. All of the seeds and more especially their by-products are used extensively for feeding farm animals and a study of the table should im-

[1] 1908 Yearbook, U. S. Dept. of Agriculture.

press the student with the great amount of these crops consumed each year by live-stock.

	Production, 1908	Farm value, Dec. 1, 1908
Corn	2,668,651,000 bu.	$1,616,145,000
Cotton	13,241,799 bales	588,814,828
Rice	21,889,620 bu.	17,771,281
Wheat	664,602,000 bu.	616,826,000
Oats	807,156,000 bu.	381,171,000
Barley	166,756,000 bu.	92,442,000
Rye	31,851,000 bu.	23,455,000
Hay	70,798,000 tons	635,423,000
Buckwheat	15,874,000 bu.	12,004,000
Flax	25,851,000 bu.[1]	
Cane sugar	365,000 long tons	
Beet sugar	380,254 long tons	

Suggestion:—The professor should try to secure exhibits of the various natural and commercial feeds in order to make the study of these few sections more interesting and instructive. Most of the natural feeds may be easily obtained at home. If you write to the following concerns and state that you wish ¼ to ½ a pound of each of their products for demonstration, I believe you will have no difficulty in collecting an elaborate exhibit, provided you are connected with a college or a high school. The student or the farmer cannot expect to receive these exhibits.

LIST OF CONCERNS.

Corn and its by-products—Corn Products Co., Chicago, Ill.

Wheat and its by-products—Washburn, Crosby Co., Minneapolis, Minn.

Oats and its by-products—Quaker Oats Co., Chicago, Ill.

Flaxseed and its by-products—American Linseed Co., Chicago, Ill.

Cotton-seed and its by-products—American Cotton Oil Co., New York City; Southern Cotton Oil Co., Atlanta, Ga.

Rice and its by-products—Louisiana Rice Exp. Station, Crowley, La.; Louisiana Rice Association, Crowley, La.

Packing House by-products—Swift & Co. or Armour & Co., Chicago, Ill.

[1] 1907.

Cane molasses (blackstrap)—Sugar Exp. Station, Audubon Park, New Orleans, La.

Beet molasses and dried beet pulp—The Experiment Stations of Michigan, Colorado, California, Utah and Wisconsin, or Michigan Sugar Co., Saginaw, Mich.; The Great Western Sugar Co., Denver, Col.; American Beet Sugar Co.; 32 Nassau St., New York City or 16 California St., San Francisco. California.

For other commercial feeds as dried brewers' grains, dried distillers' grains, malt sprouts, feed mixtures, molasses feeds, corn and oat feeds, wheat admixtures, poultry feeds, etc., consult the chemist in charge of feed stuff control in your state or go to the feed stores and obtain samples. Condimental feeds, condition powders, etc., may be obtained at feed stores, drug stores and occasionally at livery stables.

These samples may be preserved in museum bottles by adding a few drops of formalin and closing the tops with cotton or glass stoppers. The formalin is added in order to kill any insects that may be present or hatch out in the feed. Cotton is recommended when glass stoppers are not available because the weevils do not penetrate it as they do cork stoppers.

Have the students make a list of the natural feeds that are raised mostly in the state.

6

SECTION XV.

COMMERCIAL FEEDS.

Commercial feeds may be defined as those feeds made from the grains, seeds, their by-products, all products left after the preparation of human foods and beverages, the by-products left after oil extraction and animal and fish by-products.

Value of By-Products.—Many of these by-products are very valuable for feeding live-stock. Cotton-seed meal, wheat bran, wheat middlings, linseed meal, gluten feed, dried brewers' grains, distillers' grains, rice polish and hominy feeds are a few of the important by-products found on our markets. Others of these waste products such as inferior corn, oat hulls, rice hulls, buckwheat hulls, sweepings and elevator dust possess little feeding value and are sometimes injurious.

New By-Products.—Because of the high prices of grains and seeds, the increasing consumption of these by the human race, and the keen competition, almost all the by-products are being saved and disposed of in our commercial feeds. New by-products are continually being put on the American market, generally mixed with other materials but sometimes sold unmixed.

Sources of Commercial Feeds.—The following statement summarizes the sources of the by-products. These by-products are derived from:

1. The manufacture of cotton-seed oil, linseed oil and sometimes other vegetable oils.
2. The manufacture of whiskey, beer, alcohol, spirits, etc.
3. The manufacture of human cereals (breakfast foods).
4. The manufacture of glucose and starch.
5. The manufacture of products from grains, such as flour and rice.
6. The manufacture of cane-sugar, beet-sugar, sorghum cuite, etc.
7. The manufacture of animal and fish products.

Vegetable Oil By-Products.—The by-products from the manufacture of vegetable oils are principally cotton-seed meal, cotton-seed hulls, linseed meal and flax feed.

Importance of Cotton Products.—The yield of cotton in the United States is approximately 11,000,000 bales per year. It takes 1,500 pounds of seed cotton to make a bale and a bale weighs 500 pounds. This leaves 1,000 pounds for the manufacture of the by-products. The oil mills do not secure all of the seed, as many of the planters keep the seed for feeding and fertilizing at home. The price of seed is on the increase and a greater per cent. of the seed raised is being sold to the manufacturers every year than formerly. For the year 1908, 929, 287, 467 pounds of cotton-seed were manufactured.[1] The boll weevil, an insect that destroys a great many bolls of cotton, thus decreasing the yield, has been and is diminishing the yield and acreage of cotton in certain sections of the cotton belt. The figures cited, however, should impress the student with the importance of this industry and the large amount of cotton-seed meal and hulls which are used for feeding purposes.

Cotton-Seed Products.—Attached to the seed of cotton are long white fibers known to us as cotton. When the cotton is ginned all of these fibers or lint are removed except a few short fibers which adhere to the seeds. The seeds are then taken to a cotton-seed oil mill and treated as follows. First, the greater part of the lint is removed by a second ginning in a machine called the delinter, leaving the seed. The seed is composed of the hull, or hard outer covering, and the kernel or meat. The seeds are then put through a machine called the huller which removes the hulls from the seed. This process is called decorticating the seed. The whole mass (hulls and meats) is now subjected to a separating process by shaking in a revolving screen, the meats passing through the perforations of the screen. The hulls obtained in this process are known as *cotton-seed hulls*. The meats are conveyed from the shaker to special steam jacketed covered kettles and cooked. The cooked meats are transferred to a machine, called the cake former, where they are made up into cakes or forms of the proper size to fit the hydraulic press, and wrapped with camels' hair cloth. These hot forms are now subjected to enormous pressure in a hydraulic

[1] 1908 Yearbook, U. S. Dept. of Agriculture.

press and the oil is removed. The remaining product is ground

Fig. 6.—Cotton, the source of cotton-seed meal.

and sold as *cotton-seed meal,* although a great deal of it is shipped to foreign countries without being ground.

YIELDS OF PRODUCTS OF A TON OF COTTON-SEED[1]

	Pounds
Linters	23
Hulls	943
Crude oil (37.6 gals.)	282
Cake or meal	713
Waste	39
Total	2,000

This is about the average yield of the cotton oil mills although in many cases the production of oil approximates 40 to 45 gallons. The higher extraction of oil will of course reduce the amount of meal. In the past few years the oil mills have been securing a higher extraction of oil, averaging about 40 gallons per ton of seed. Dry, clean, mature seed yields more hulls than immature seed and produces a better grade of oil.

[1] Lamborn, Cotton Seed Products.

COMPOSITION OF COTTON-SEED, MEATS, MEAL AND HULLS

	Composition in per cent.					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
Cotton-seed	18.4	19.9	24.7	23.2	10.3	3.5
Cotton-seed meats	31.2	36.6	17.6	3.7	6.2	4.7
Cotton-seed meal	43.0	8.5	25.7	7.8	8.2	6.8
Cotton-seed hulls	4.2	2.2	33.4	46.3	11.1	2.8

The composition of these products varies a great deal. Sometimes the meal reaches 49 per cent. protein. Some mills have poor extraction and turn out meal that carries 10 to 13 per cent. fat. The feed sold as cotton-seed hulls varies with the amount of broken meats present. A poor separation of hulls and meats causes this product to occasionally contain as high as 10 per cent. protein and 2.5 to 3 per cent. fat. The composition of cotton-seed meal is apt to vary with the season, the nature of the soil it was raised on, the fertilizers applied and the climatic conditions.

COMPOSITION OF COTTON-SEED MEAL FROM HIGH AND LOW LAND SEED

Cotton-seed meal from	Composition in per cent.					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
High land	45.46	8.63	24.24	7.25	8.52	5.90
Low land	41.63	7.22	26.64	9.68	8.60	6.23

Cold Pressed Cake.—This is sometimes sold as Caddo cake and is the residue obtained from cotton seed from which most of the oil has been extracted by compression, without separating the kernels and the hulls and without heating.

COMPOSITION OF COLD PRESSED CAKE

Protein Per cent.	Fat (ether extract) Per cent.	Nitrogen free extract Per cent.	Fiber Per cent.	Water Per cent.	Ash Per cent.
21–28.5	5.8–13.5	26–33	17–26	7	5

Flax Products.—These materials are very common in certain sections of the West. They are derived from the flax plant which is grown for its valuable fiber.

The yearly production of flaxseed in the United States averages about 25,000,000 to 26,000,000 bushels. A bushel of flaxseed (56 lbs.) contains about 19 pounds of oil and 36 pounds of other material.[1] For the year 1908, 696,135,362 pounds of linseed cake was manufactured.[2].

1. **Linseed Meal.**—There are two classes of linseed meal found on the American market, namely, old process and new process meal. The old process meal is obtained by pressing out the oil from the cold or warmed crushed flax seeds. The new process consists of extracting the oil from the warmed crushed flax seeds by the use of naphtha. This new process is employed because it permits of a greater extraction of oil. The naphtha is driven off by steam before the product is placed upon the market.

2. **Flax Feed.**—This by-product is composed of the screenings from the flax seed, which contains inferior flax seeds, weed seeds, as well as part of the shell and fiber of the flax. It is usually ground and used to some extent in mixed feeds.

3. **Flax Bran** is a variable product which is used by manufacturers of commercial feeds as a filler and to furnish bulk and roughage to their feeds. It is generally made up of stems, pods and small flax seeds in varying proportions. The value of this product depends upon the amount of flaxseed present.

4. **Cold Pressed Linseed Cake.**—This is the residue obtained by pressing most of the oil from flaxseed by compression without heating. The process of obtaining this product is similar to that employed in manufacturing cold pressed cotton seed cake. Cold pressed linseed cake contains more fat (oil) and less protein than linseed meal.

[1] Jordan, "The Feeding of Animals,"

[2] 1908 Yearbook, U. S. Dept. of Agriculture.

COMPOSITION OF FLAX SEED AND ITS FEEDING BY-PRODUCTS

	Composition in per cent.					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
Flax seed	22.6	33.7	23.2	7.1	9.2	4.3
Old process meal	32.9	7.9	35.4	8.9	9.2	5.7
New process meal	33.2	3.0	38.4	9.5	10.1	5.8
Flax feed	15.9	11.6	41.9	14.6	8.1	7.9
Flax bran[1]	6.0	4.3	34.8	41.8	7.4	5.7
(Pods, 59 95 per cent.)	7.2	5.8	37.3	35.5	7.5	6.7
(Stems, 40.05 per cent.)	3.5	2.5	28.5	54.9	7.2	3.4

Value of Old and New Process Meal.—Woll found by artificial digestion that the protein of old process meal is 10 per cent. more digestible than the protein of the new process meal. This lower digestibility of protein in the new process meal is attributed to the use of steam to drive off the naphtha. We learned that the cooking of plant substances reduces the digestibility of protein.

Other Vegetable Oil Feeds are peanut meal, sunflower seed meal, rape seed meal, cocoanut meal and palm-nut meal. These are not used extensively in this country for feeding stock. The whole peanuts of course are used for human and hog feed, but are not common as commercial feeds.

Alcoholic By-Products.—Brewers' grains, malt sprouts, and distillers' grains are examples of these by-products. They are rich in nitrogenous substances containing about ½ to ¾ as much protein as choice cotton seed meal, when dried.

1. **Brewers' Grains.**—These are the by-products from the manufacture of beer. They consist principally of barley grains from which the starch and other soluble matter have been extracted. When brewers' grains are used without drying, as wet brewers' grains, they must be fed near the brewery, as their high water content will not permit of shipping, because of the liability of fermentation setting in especially in warm locations, and the cost of transportation generally makes them unprofitable as feed.

[1] Bul. 141, Indiana Experiment Station.

Brewers' grains are kiln dried and sold as dried brewers' grains. In this form they are not perishable.

2. **Malt Sprouts.**—In the fermenting of barley for the manufacture of beer the barley begins to grow or sprout. When these barley sprouts have attained a height of about ¼ inch they are removed from the grain by machinery. They are then artificially dried and sold as malt sprouts. Feeders near the breweries often feed them in the wet state.

3. **Distillers' Grains.**—In the manufacture of whiskey and alcohol, etc., the starch and other soluble matter are removed from the several cereal grains. The remaining product is kiln dried and sold as dried distillers' grains. This product consists mostly of the germ, nitrogenous substances and outer coverings of the cereal grains.

COMPOSITION OF ALCOHOLIC BY-PRODUCTS

	Composition in per cent.					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
Wet brewers' grains	5.4	1.6	12.5	3.8	75.7	1.0
Dried brewers' grains.....	25.1	6.8	41.7	15.4	7.1	3.9
Malt sprouts (dried)......	27.6	3.0	47.1	10.9	5.0	6.4
Dried distillers' grains....	32.1	11.4	34.9	11.0	8.8	1.7

Breakfast Food By-Products.—In the manufacture of cereal foods, only the sound grains are used. Oats, wheat, corn, barley and rice are the principal grains from which breakfast foods are made. The hulls of the grains are usually removed and these hulls together with the inferior grains, and sometimes other parts of the grain, go to make up commercial stock feeds. Oat feeds and corn and oat feeds are stock feeds which are made up almost entirely of breakfast food by-products. The corn and oat feeds are sold to a large extent in this country and sometimes cost almost as much as the original grains from which they are derived.

COMPOSITION OF OAT AND CORN AND OAT FEEDS

	Composition in per cent.					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
Oat feed	7.2	2.1	53.1	23.4	8.6	5.6
Corn and oat feed	8.7	3.9	65.2	9.2	9.6	3.4
Oat hulls	3.3	1.0	52.1	29.7	7.2	6.7

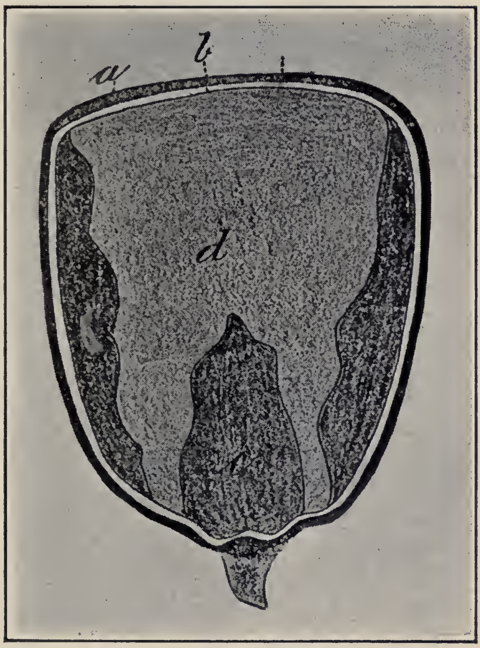

Fig. 7.—Corn kernel.

a—is the husk or skin covering the whole kernel; it consists of two distinct layers, the outer and inner, which when removed constitute the bran and contain practically all of the crude fiber of the whole grain; *b*—is a layer of gluten cells which lie immediately underneath the husk; it is, as a rule, yellow in color and cannot be readily separated from the remainder of the kernel; this part is richest in gluten; *c*—is the germ which is readily distinguished by its position and form; it also contains gluten though it is particularly rich in oil and mineral constituents; *d*—the large portion, is composed chiefly of starch; the dark color indicates the flinty part in which the starch cells are most closely compacted. Illustration after New Jersey Exp. Sta. Description after Mass. Exp. Sta.

COMPOSITION OF CORN AND OATS FOR COMPARISON

	Composition in per cent.					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
Corn	9.1	3.7	72.5	2.2	11.1	1.4
Oats	11.8	5.0	59.7	9.5	11.0	3.0

Glucose and Starch By-Products.—There are many by-products left from the manufacture of glucose and starch. These by-products usually come from the grain of corn. Gluten meal, gluten feed, corn bran, hominy feed, feed meal and corn germ meal are corn by-products. 1. Gluten meal is derived from the nitrogenous portion of the corn grain, known as the gluten layer. This feed is not so common on our markets as formerly. 2. Gluten feed is ground corn grain minus the starch. 3. Corn bran is made up of the outer husks or coverings of the corn grain. 4. Corn germ meal is generally the ground corn germs with more or less of the oil extracted. 5. Hominy feed and feed meal are the by-products from the manufacture of hominy grits and starch. They vary in composition and usually consist of the softer parts of the corn kernel and sometimes they contain corn bran.

COMPOSITION OF CORN, GLUCOSE AND STARCH BY-PRODUCTS

	Composition in per cent.					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
Corn grain	9.1	3.7	72.5	2.2	11.1	1.4
Gluten meal	29.3	11.8	46.5	3.3	8.2	0.9
Gluten feed	24.0	10.6	51.2	5.3	7.8	1.1
Corn bran	9.0	5.8	62.2	12.6	9.1	1.3
Corn germ meal	9.8	7.4	64.0	4.1	10.7	4.0
Hominy feed	9.9	7.1	64.4	7.1	9.0	2.5

Suggestion:—Require the students to bring as many different kinds of breakfast foods as possible to the classroom. Have them state the grains from which they were made and the part or parts that were eliminated in manufacture.

SECTION XVI.

COMMERCIAL FEEDS—Continued

Milling By-Products.—These consist of wheat by-products and rice by-products.

Wheat By-Products.—Of the 664,602,000 bushels of wheat harvested in the United States during 1908 about 11 per cent. was saved for seed and 25 per cent. of the remainder constituted the wheat by-products. According to Bessey the wheat kernel is made up as follows:[1]

	Per cent.		Per cent.
Coatings	5	Starch cells	84–86
Gluten layer	3–4	Germ	6

Wheat bran, wheat middlings, wheat screenings and flour are products derived from the wheat kernel. 1. Wheat bran consists mostly of the outer portions of the wheat kernel. 2. Wheat middlings is sometimes called shorts, and is made up of the inner layers of the outer covering of the wheat kernel. 3. Wheat screenings is a variable product obtained in screening wheat to prepare it for manufacturing into flour. It generally consists mostly of fine particles of the kernel, shrunken kernels, and may contain weed seeds and other foreign matter. It is used in mixed feeds and sometimes fed alone. 4. Flour is made from the starchy part of the wheat kernel, or the soft white interior portion. When flour contains middlings it is known as low grade flour, red dog flour, dark feeding flour and used for feeding live-stock.

COMPOSITION OF WHEAT AND ITS BY-PRODUCTS

	Composition in per cent.					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
Wheat kernel	11.9	2.1	71.9	1.8	10.5	1.8
Wheat bran	15.4	4.0	53.9	9.0	11.9	5.8
Wheat middlings (shorts)	16.1	4.5	58.7	5.7	10.4	4.6
Wheat mixed feed (bran and shorts)	15.5	4.3	56.8	7.4	10.9	5.1
Wheat screenings	12.5	3.0	65.1	4.9	11.6	2.9
Red dog flour	13.4	1.8	68.2	1.5	13.3	1.8
High grade flour	11.2	0.5	77.0	0.3	10.6	0.4

[1] Jordan, "The Feeding of Animals."

From the foregoing analyses of wheat and its by-products it is apparent that the by-products used for stock feed are higher in nitrogenous substances than the high-grade flour used for human consumption. The carbohydrates are higher in the flours than in the coarser products.

Rice By-Products.—The rice crop of the United States for 1908 was estimated as 21,889,620 bushels.[1] A bushel of rough rice weighs 45 pounds. A barrel of rough rice of 162 pounds contains approximately the following products:[2]

91.32 lbs.	head or clean rice (unbroken grains), No. 1 grade
15.30 lbs.	broken rice, No. 2 grade
6.28 lbs.	brewers' rice, very broken (grits)
20.00 lbs.	bran
8.00 lbs.	polish
21.10 lbs.	hulls
162.00 lbs.	Total

Rice hulls, rice bran, rice meal, rice grits and rice polish are the by-products obtained in the milling of rice. 1. Rice hulls are the outer protecting parts or hulls of the rice kernel. They are sometimes injurious when fed in large quantities, on account of their silicious or sandy structure. 2. Rice bran. This material comprises the outer layer of the rice kernel together with some of the germ. Most of the rice brans contain some rice hulls. The rice hulls cannot always be entirely eliminated in manufacturing but there will not be enough in this product to be injurious provided the hulls are not added. 3. Rice meal. This material is usually sold under the name of rice bran and is similar to rice bran except that it is practically free from hulls. 4. Rice grits or brewers' rice. This product is made up of the small hard particles which break off from the kernel in obtaining the rice polish or in handling rice. Grits are used by the brewers in making beer. Being small and hard they are apt to be of little feeding value unless ground. The brewers' are glad to pay a higher price than the feeder can afford for this article. 5. Rice polish. This consists of the flour, or white

[1] 1908 Yearbook, U. S. Dept. of Agriculture.

[2] Bul. 77, Louisiana Exp. Station.

powdery substance, which is removed from the rice kernel. The rice kernel is corrugated or rough, and in giving to it the smooth appearance and pearly lustre that the trade demands, the rough parts are smoothed down and brushed off with special machinery. Rice meal and rice polish are excellent feeds when sweet. Sometimes the meal contains a high content of fat (12-20 per cent.) which is objectionable because of its liability to turn rancid, in which case the feed is not fit for use. Rice polish is a good feed for fattening hogs and cattle.

COMPOSITION OF RICE AND ITS BY-PRODUCTS

	Composition in per cent.					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
Rice (rough)	7.4	2.6	64.3	9.3	10.9	5.5
Rice (clean)	7.5	0.4	78.1	0.5	12.8	0.7
Rice hulls	3.5	0.5	26.8	41.9	9.0	18.3
Rice bran (15 per cent. hulls)	9.9	9.9	44.5	14.5	9.9	11.3
Rice meal	13.3	10.7	49.8	8.7	8.6	8.9
Rice polish	11.1	5.8	64.3	3.8	11.5	3.5

Sugar By-Products.—About 20,000,000 gallons of cane molasses (blackstrap) are produced annually in the United States. A gallon weighs about 12 pounds. A great deal of this output is used for feeding live-stock. The demand for cane molasses for feeding is not satisfied by the Louisiana output so a great deal is being imported from the tropical countries, notably Porto Rico and Cuba. There is also a large quantity of beet molasses used for feeding. The amount used is hard to estimate because many factories work over their molasses so that there is none left for feeding. However, it is questionable at the present whether it is not more profitable to sell the molasses as stock feed than to work it over for its sugar content.

The sugar by-products used for stock feeds are cane molasses, beet molasses, beet pulp and sorghum cuite or molasses. 1. Cane molasses. The cane molasses sold for stock feed is usually the final product from the manufacture of cane-sugar.

It is called Blackstrap and is noted for its high content of digestible carbohydrates. It also contains 2.4 per cent. of protein which is considered to be in the form of amides, which have a doubtful flesh forming function. Therefore in using this for feeding, the protein is disregarded. 2. Beet molasses. This is the final product left from the manufacture of sugar from the sugar beet when the molasses is not worked over. Beet mo-

Fig. 8.—Sugar cane, the source of cane molasses.

lasses contains less carbohydrates than cane molasses and more ash. It has a bitter taste due to the large amount of potash present and for this reason is not used for human consumption. Like cane molasses, beet molasses is used a great deal for feeding purposes, although it is not so palatable as molasses from cane. 3. Beet pulp. This is the refuse or what remains of the sugar beet after the sugar has been extracted. It is often mixed with the molasses residues of the factory and is very wet. For this reason it cannot be used in the wet condition, except by feeders near the factory. Beet refuse is often kiln dried and sold as dried beet pulp. In this condition it is not perishable. 4. Sorghum molasses or cuite. This product is used to a limited extent in some sections for feeding live-stock.

COMPOSITION OF SUGAR BY-PRODUCTS

	Composition in per cent.					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
Cane molasses	2.4	....	65.9	....	22.4	9.3
Beet molasses	9.1	....	59.5	....	20.8	10.6
Beet pulp (wet)	0.9	....	6.3	2.4	89.8	0.6
Beet pulp (dried)	9.0	1.5	57.0	18.8	10.4	3.3

Animal and Fish By-Products.—The principal products of animal origin are milk and its by-products, and refuse from packing houses. The by-products from fish are classed as fish refuse.

Milk.—The composition of milk varies a great deal with the species of animal.[1]

	Composition in per cent.						
	Water	Dry matter	Ash	Casein	Albumen	Sugar	Fat
Bitch	75.44	24.54	.73	6.10	5.05	3.09	9.57
Ewe	79.46	20.56	.97	5.23	1.45	4.28	8.63
Sow	84.04	15.96	1.05	7.23		3.13	4.55
Goat	86.04	13.96	.76	3.49	.86	4.22	4.63
Cow	87.10	12.90	.70	3.20		5.10	3.90
Woman	88.20	11.80	.20	1.00	.50	6.80	3.30
Mare	89.80	10.20	.30	1.84		6.89	1.17

In all probability the nutrients are present in milk in the right proportions for supporting the young animal, as nature intended that it should be used to furnish the young animals' needs. The table shows that there is quite a difference in the dry matter of milk from the species. The milks containing

[1] Jordan, "The Feeding of Animals."

the higher dry matter are also higher in nitrogenous substances and ash, and lower in sugar than those lower in dry matter.

Milk By-Products.—Skim milk, buttermilk and whey are the principal milk by-products used for feeding live-stock. 1. Skim milk is obtained by allowing milk to stand skimming off the cream or by separating it by centrifugal force. 2. Buttermilk is what remains after making butter. It has about the same composition as skim milk. 3. Whey is the by-product obtained in making cheese. The fat and casein of the milk are removed in cheese making.

COMPOSITION OF MILK BY-PRODUCTS

	Composition in per cent.					
	Water	Fat	Casein and albumen	Milk sugar	Ash	Authority
Skim milk (gravity)......	90.43	0.87	3.26	4.74	0.70	Konig
Skim milk (centrifugal) ..	90.30	0.10	3.55	5.25	0.80	V'nSlyke
Buttermilk...............	90.12	1.09	4.03	4.04	0.72	Konig
Whey.....................	93.38	0.32	0.86	4.79	0.65	Konig

Skim milk and buttermilk run lower in water and higher in nitrogenous substances than whey. Therefore whey is more of a carbohydrate food than skim milk and buttermilk.

Packing House By-Products.—From the packing houses come tankage, dried blood, meat scraps, bone meal, and meat and bone meal. These products are sometimes fed to hogs and are excellent for poultry. Tankage is composed entirely of animal matter. It consists of meat and bone (from which the fat has been extracted) and more or less dried blood. It is variable in composition, but it usually contains a high content of protein. Dried blood is simply what the name signifies. It has a black brown color and is ground very fine. It is sold as red blood and black blood; the red blood being of higher protein composition. Bone meal is finely ground bone and is generally sold after the fat has been extracted because of its better keeping qualities.

Fish Refuse is the dried product from canneries, whale bone establishments and factories where glue is manufactured. The oil is generally extracted and the fish refuse dried and sold as fish scraps or dry ground fish.

COMPOSITION OF ANIMAL AND FISH BY-PRODUCTS

	Tankage Per cent.	Dried blood Per cent.	Meat scraps Per cent.	Dry gro'nd fish Per cent.	Bone meal Per cent.	Meat and bone meal Per cent.
Protein	46	84	55	53	26	40
Fat	....	2.5	14	6	3	10
Ash	....	4.7	20	31	67	40

All these products are highly nitrogenous and those that have bone present contain a large percentage of mineral compounds. Rations of cereals and these products, that contain high ash contents, are very satisfactory with hogs, as the cereals are generally deficient in the nutrients that these products are rich in. When corn is fed alone to hogs the addition of one of these by-products containing bone proves beneficial.

SECTION XVII.

CLASSES OF COMMERCIAL FEEDS.

In the previous three sections descriptions of the natural and commercial feeds were discussed; feeds are not always found on our markets unmixed, but in various mixed combinations. There are many manufacturers who use the natural and by-product feeds and mix them in varying proportions, often selling them under elaborate trade names. These manufacturers sell enormous quantities of stock feeds to our feeders.

We will now take up some of these mixtures. On page 91 are the principal feeds that the manufacturers offer to the trade with standards of protein, fat and fiber. A feed to be of standard quality should not exceed the fiber content and it should reach the protein and fat contents. The feed should also be clean, free from fermentation, mold, rancidity and be in good mechanical condition. Some of the data in this table is adapted from Bul. 120, Mass. Exp. Station, and represent averages.

A Discussion of the Table.—It must be remembered that many of these feeds are not sold under the names given in the above table. The manufacturers of mixed feeds usually employ attractive names which do not always reveal the nature of the products which make up the mixtures. For example, we may find a cotton-seed feed, or a corn and oat feed, or a wheat admixture, or a molasses feed, or a feed mixture being offered to the trade as Star Feed, Cracker Feed, Balanced Feed, Patchen Feed, Best Feed, Union Feed, Dixie Feed, etc. The straight feeds as wheat bran, wheat middlings (shorts), corn chops, dried brewers' grains, etc., usually carry names that distinguish their nature.

So this classification is not used on feeds by the manufacturer, but by the chemist who arranges them according to what they contain in the way of natural and by-products feeds. Some of the feeds in the table will not be taken up because we have already spoken sufficiently of them.

Cotton-Seed Meal.—In the past few years the manufacturers have not always put out this product in its pure state, but often

Name of feed	Protein Per cent.	Fat Per cent.	Fiber Per cent.
Cotton-seed meal (choice)	41.15–50	5–10	7
Cotton-seed meal (prime)	38.50–41.15	5–10	10
Cotton-seed meal (good)	36–38.50	6.5–10	11
New process linseed meal	38	2	9
Gluten meal	35	1	2
Dried distillers' grains	32	10	9.5
Old process linseed meal	32	6	9
Gluten feed	25	3	7.5
Malt sprouts (dried)	25	1	12.5
Dried brewers' grains	22	5	12
Cotton seed feed	22	5	22
Germ oil meal	22	10	9.5
Wheat middlings (flour)	18–20	5	3.5
Wheat middlings (standard)	17–19	5	7
Wheat mixed feed (bran and shorts)	16–18	4–5	8.5
Wheat bran	15–17	4–5	10
Oat middlings	17	7	2.5
Flax feed	15	10	15
Molasses dry dairy feed	14–18	4	14
Rye feed	15	3	4
Feed mixture (dairy)	14	4	15
Alfalfa meal (whole plant)	13.5–14	1.5	29–30
Fortified oat feed	12–14	3–5	..
Wheat admixture	12.5	4	13
Wheat screenings	12.5	3	5
Rice bran	12.5	7–10	10
Clover meal (whole plant)	12	2	25
Rice polish	11–12	8	2–4
Molasses dry horse or mule or ox feed	11–12	4–5	12–14
Feed mixture (horse or mule or ox)	11	3.5	14
Ground oats	11	4	10
Ground wheat	11	2	3
Barley meal	11	1.5	6
Rye meal	10	1.5	6
Hominy feed	10	7.5	4.5
Mixed oats and barley	10	3.5	10
Provender	10	3.5	6
Feed meal	9	6	5.5
Corn bran	9	5	10
Corn meal	9	3.5	2
Corn chops	8.5	3.3	2.5
Corn and oat feed	7.5–10	3–5	8–11
Oat feed	5–8	2	20–26
Dried beet pulp	8	0.3	18
POULTRY FEEDS			
Blood meal	85	0.2	..
Meat scraps	50	15	..
Meat and bone meal	40	10	..
Bone meal	25	..	..
Mash and meal	15	4–5	8
Hen, chick, scratching and pigeon feed	10–11	3	4

grind cotton-seed hulls and mix them with the meal and sell the product as cotton-seed meal. These hulls are ground so fine that it is impossible to detect the extent of their presence with the naked eye. Sometimes a meal is of high-grade (44-49 per cent. protein) and the hulls are added to bring down the protein content to the guarantee of say 41 per cent. protein.

Commercial Classification.—The Inter-State Cotton-Seed Crushers' Association composed of those interested or dealing in cotton-seed products, holds annual sessions and sets standards and regulations for these commodities. The following is the last standard classification adopted by this association for cotton-seed meal.

Choice Cotton-Seed Meal must be finely ground, perfectly sound and sweet in odor, yellow, free from excess of lint, and by analysis must contain 8 per cent. of ammonia, or 49 per cent. of combined protein and fat.

Prime Cotton-Seed Meal must be finely ground, of sweet odor, reasonably bright in color, yellow, not brown or reddish, free from lint, and by analysis must contain at least 7½ per cent. of ammonia, or 46 per cent. of combined protein and fat.

Good Cotton-Seed Meal must be finely ground, of sweet odor, reasonably bright in color, and by analysis must contain at least 7 per cent. of ammonia, or 43 per cent. of combined protein and fat.

Chemical Classification.—The writer uses the following classification. The protein equivalents of the ammonia standards are taken instead of combining the protein and fat. The color, odor and fat contents are not considered because the purchaser can easily distinguish a meal that is off in color and odor and most of the meal contains enough fat for feeding purposes.

Choice Cotton-Seed Meal calls for 8 per cent. ammonia, which is equivalent to 41.15 per cent. of protein; that is, all meals carrying 41.15 per cent. protein or over are called choice.

Prime Cotton-Seed Meals are those carrying 7.5 per cent. ammonia, which is equivalent to 38.5 per cent. protein. Hence all meals between 38.5 and 41.15 per cent. protein are prime.

Good Cotton-Seed Meal carries 7 per cent. ammonia, which is equivalent to 36 per cent. protein. Meals between 36 and 38.5 per cent. protein are good.

For feeding purposes a bright yellow meal free from an excess of lint and hulls, and sweet in odor, should be selected. The dark color of cotton-seed meal may be due to careless handling and storage, fermentation before the seed is treated in the oil mill, or to overheating in cooking. These causes tend to lower the digestibility or palatability of the feed.

The manufacturers sell these three classes as cotton-seed meal and not as choice, prime and good. The chemist makes these distinctions.

COMPOSITION OF COTTON-SEED MEAL

Class	Composition in per cent.						
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash	No. of samples
Choice	43.12	8.92	25.69	8.08	7.62	6.57	1192
Prime	39.87	8.58	27.23	9.86	7.81	6.65	651
Good	37.26	9.28	28.13	11.14	7.50	6.69	116

A decrease in protein is accompanied by an increase in nitrogen free extract and fiber.

Cotton-Seed Feed.—Those cotton-seed meals falling below 36 per cent. protein are classed as cotton-seed feeds. These feeds are made up of varying quantities of cotton-seed meal, lint and hulls. If such a feed is desired it is perhaps cheaper for the feeder to purchase the meal and hulls separately and mix them himself. Cotton-seed feeds are, as a class, more expensive than cotton-seed meal, for the amount of protein received. The range of the feeds of this class is generally from 18 to 36 per cent. protein, 4 to 10 per cent. fat and 11 to 26 per cent. fiber.

AVERAGE COMPOSITION OF COTTON-SEED FEED

	Composition in per cent.						
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash	No. of Samples
Cotton-seed feed	28.50	6.81	32.71	18.32	8.06	5.60	48

There are some feeds sold that have the following approximate composition.

	Protein Per cent.	Fat (ether extract) Per cent.	Nitrogen free extract Per cent.	Fiber Per cent.	Water Per cent.	Ash Per cent,
Cotton-seed feed	22	5	36	24	8	5

Rice Bran.—Sometimes rice hulls are introduced into this feed and the resulting product is sold as rice bran. The presence of rice hulls, when unground, is easy to detect with the naked eye, and when the per cent. of hulls is high, the feed should not be used, as the rice hulls may be injurious to the digestive organs of the animal to which the mixture is fed. A rice bran should smell sweet and one that has a rancid odor should be avoided. A high fat content, which is usually the cause of rancidity, is thought to retard digestion. Good rice bran should contain 12.50 per cent. protein and not over 10 per cent. fiber or ash.

COMPOSITION OF RICE BRAN AND HULLS

	Composition in per cent.					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
Rice bran (standard).....	12.50	....	....	10	....	10
Rice bran (673 samples) ..	11.91	10.83	44.06	12.95	10.27	9.98
Rice hulls................	3.50	0.49	26.86	41.89	8.97	18.29

Rice Polish.—The best rice polish is a pure white powdery substance free from grits and rice hulls. The rice hulls are easily detected, and the grits when present may be found by rubbing a small portion between the fingers. The grits are not very objectionable as they are never present in great amounts, as a higher price is obtained for grits from the brewers. The only objection to grits is that they are small and hard and are apt to escape mastication and digestion. Rice hulls are only occasionally present in polish and then only in small amounts. Sometimes rice polish has a red cast due to the presence of red rice, a weed which grows in the rice field, but the amount

Fig. 9.—Honduras and Japan rice.

present does not materially lower the feeding value of this product.

COMPOSITION OF RICE POLISH

	Composition in per cent.						
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash	No. of samples
Rice polish.......	11.94	8.30	63.01	1.90	10.33	4.52	386

In the above samples of rice polish the protein varied from 10 to 15.5 per cent., the fat from 4.5 to 14.3 per cent. and the fiber from 0.4 to 5.0 per cent.

Wheat Mixed Feed is a mixture of wheat bran and wheat middlings in varying proportions and it should contain 16 per cent. of protein. This feed is sometimes called shipstuff, although this latter name is applied to any wheat feed, ground fine.

ANALYSES OF SOME PURE WHEAT PRODUCTS

Class	Composition in per cent.						
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash	No. of samples
Wheat bran.......	16.21	4.10	53.96	9.06	10.25	6.42	2538
Wheat middlings..	17.57	4.52	57.27	5.60	10.50	4.54	506
Wheat mixed feed.	17.08	4.01	55.59	7.61	10.30	5.41	52

Wheat Admixtures are made up of wheat products, corn, ground corn cobs, corn bran, rice products, oat hulls, ground peanut hulls, etc. A wheat admixture is not sold under this name but as mixed feed, shipstuff, or under some trade name as Dixie Feed, etc., and for example may contain wheat screenings, ground wheat bran, corn bran and rice bran.

In purchasing this class of feed the consumer generally pays almost as much as for the genuine wheat products. Most of these feeds are so finely ground that it is almost impossible to distinguish them from wheat shorts, unless the purchaser is very familiar with the physical appearance of wheat products. There is no doubt that many of these feeds are sold as pure wheat products. These feeds are too expensive for the economical feeder. Wheat feeds should be avoided that are guaranteed to contain less than 15 per cent. protein.

AVERAGE ANALYSIS OF WHEAT ADMIXTURE

	Composition in per cent.						
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash	No. of samples
Wheat admixture .	13.06	4.06	53.89	12.34	9.85	6.80	506

SECTION XVIII.

CLASSES OF COMMERCIAL FEEDS—Continued

Corn Chops, as found on the American market, are the cracked grains of corn. Some of this feed is made up of inferior corn and sometimes may contain ground corn cobs. To be of good standard quality this feed should contain 9 per cent. protein, should be free from fermentation and adulteration, should smell sweet and look clean, and be made from sound grains of corn. A close physical examination will reveal the quality of this material to a great extent.

AVERAGE ANALYSIS OF CORN CHOPS

	Composition in per cent.						
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash	No. of samples
Corn chops	9.19	3.79	72.20	2.16	11.28	1.38	6329

Mixed Oats and Barley.—On account of the high price of oats, barley (which is cheaper and heavier) is often mixed with oats and sold as No. 2 oats or as mixed oats and barley. Much of this class of goods is made of inferior oats, 5 to 40 per cent. of barley, and sometimes contains weed seeds. The barley grain is smaller than the oat grain and can be easily detected. The off grade oats may be distinguished by their color or their shrunken or shriveled appearance. The presence of weed seeds is easily noticed.

ANALYSES OF OATS, BARLEY AND MIXED OATS AND BARLEY

	Composition in per cent.						
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash	No. of samples
Oats	11.8	5	59.7	9.5	11.0	3.0	....
Barley...........	12.4	1.8	69.8	2.7	10.9	2.4	....
Mixed oats and barley..........	10.84	3.68	64.06	9.8	8.1	3.52	414

Corn and Oat Feeds.—These feeds, sometimes called chop feeds, are made up of factory products or waste products, with corn and oats. Many of these feeds contain oat hulls and most of them carry 1 to 2 per cent. salt to make them more palatable.

Provender is a name used in the New England States for feeds composed of ground corn and oats.

Fortified Oat Feed.—A feed is said to be fortified when some protein concentrate (highly nitrogenous feed) is added to it. Hence fortified oat feed is made up of oat feed and some protein concentrate.

ANALYSES OF OATS, CORN, OAT HULLS AND CORN AND OAT FEED

	Composition in per cent.						
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash	No. of samples
Oats	11.8	5	59.7	9.5	11.0	3.0	....
Corn	10.3	5	70.4	2.2	10.6	1.5	....
Oat hulls	3.3	1	52.1	29.7	7.3	6.7	....
Corn and oat feed	8.57	3.82	64.63	9.77	9.69	3.52	1,256

Molasses Feeds are sometimes called sugar feeds or molasses grains. There are many combinations of materials introduced in these feeds, governed principally by the intelligence and honesty of the manufacturers. The location, demand, ease of obtaining, and price of the feeding materials that go to make up the finished product are also important considerations in the selection.

Products Used.—Cotton-seed meal, linseed meal, malt sprouts, dried brewers' grains, distillery products, rice products, corn products, ground corn cobs, ground corn stalks, corn pith, wheat products (generally wheat screenings), dried beet pulp, oats (generally off grade), oat hulls, barley products, buckwheat products, finely ground or chopped hay (usually leguminous hays, such as alfalfa, clover, etc.), straw, flax feed, elevator dust (including grain smut, all sorts of brushings and cleanings, such as dust, grain rust, etc.), sweepings, grain screenings, refuse from flouring mills, cockle seeds and bran, ground peanut hulls, weed seeds (ground and unground), chaff from pipe factories and similar products together with beet, cane and sorghum molasses are used in these feeds in varying proportions. Some of the molasses feeds contain beet or cane molasses entirely. When beet molasses is used it is generally accompanied with a small amount of cane molasses and occasionally sorghum molasses, to give the feed a pleasant aroma. In most of these feeds, especially those manufactured in the North, beet molasses predominates. The quantity of molasses employed in these feeds varies from 10 to 60 per cent. About 1 per cent. of salt is added to improve the palatability.

Classes of Molasses Feeds.—Those feeds carrying 25 per cent. or more of molasses are usually classed as wet feeds (provided they are not artificially dried), and those containing less than 25 per cent. of molasses are termed dry feeds. There are many feeds that contain more than 25 per cent. of molasses which are subjected to a drying process and these are classed as dry feeds.

Wet Molasses Feeds are generally sticky and of darker color than other molasses feeds, due to the large amount of molasses present.

ANALYSES OF WET MOLASSES FEEDS IN PER CENT.

	I	II	III	IV	V
Protein	11.69	12.88	15.95	6.52	15.60
Ether extract (fat)	0.54	0.74	2.75	1.79	3.82
N. free extract	43.33	36.94	49.45	51.92	45.32
Fiber	19.23	21.16	10.86	14.97	12.01
Water	16.41	18.47	16.10	14.20	16.65
Ash	8.80	9.81	4.89	10.60	6.60

Note the high water content in all of these feeds. The ether extract is low in all but sample No. 5.

Horse and Dairy Feeds.—There are two general classes of molasses feeds sold to our feeders, namely, horse feeds and dairy feeds. Molasses feeds for other classes of live stock are also manufactured, but these are exceptional.

The dry molasses dairy feeds found on the American market usually contain from 14 to 18 per cent. protein, 3 to 7 per cent.

fat, 8 to 20 per cent. fiber, 7 to 12 per cent. water and 44 to 54 per cent. nitrogen free extract. In other words these feeds run high in protein. The dry molasses horse or mule feeds carry more nitrogen free extract and less protein than the dry dairy feeds. The protein generally varies from 8.5 to 14 per cent., fat 1.5 to 8 per cent., fiber 6 to 20 per cent., water 8 to 13 per cent., and nitrogen free extract 40 to 62 per cent.

APPROXIMATE AVERAGE COMPOSITION OF AMERICAN DRY MOLASSES FEEDS

	Composition in per cent,					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
Dairy	16.38	4.31	49.26	12.33	10.50	7.20
Horse	11.95	4.80	51.40	13.03	11.62	7.22

There are many excellent molasses feeds on our markets free from adulteration, but the molasses offers an excellent chance for the use and concealment of inferior products.

Feed Mixtures.—Under this head come those feeds which are made up of mixtures of alfalfa, dried brewers' grains, corn products, oat products, gluten feed, wheat products, rice products, barley products, cotton seed products, flaxseed products, etc. Most of these feeds have alfalfa, corn products and oat products present and may contain one or more other ingredients. As in molasses feeds, the best grades of primary products are not always used, and materials as oat hulls, off grade oats and off grade corn are sometimes found in these feed mixtures. They are sometimes called proprietary feeds because the name of the feed does not indicate the ingredients present. The principal classes of feed mixtures are, horse or mule or ox feeds and dairy feeds. A few calf feeds are also on our markets. The horse, mule and ox feeds are the most common, and usually run from 9 to 13 per cent. protein, 3 to 6 per cent. fat and 6 to 18 per cent. fiber The dairy feeds generally vary from 13.5 to 20 per cent. protein, 3.5 to 5.5 per cent. fat and 10 to 15 per cent. fiber.

APPROXIMATE AVERAGE COMPOSITION OF FEED MIXTURES

	Composition in per cent.					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
Dairy	14.0	4.0	52.8	15	9	5.2
Horse	11.0	3.5	57.7	14	9	4.8

The protein, fat and fiber contents are generally less and the nitrogen free extract more in the horse than the dairy feeds. Most of these feeds contain salt in small amounts and are sold under trade names.

Poultry Feeds are composed of mixtures of corn (whole or cracked), Kaffir corn, wheat, wheat by-products, broken rice, oats, oat refuse, cotton seed meal, linseed meal, ground leguminous hay (usually alfalfa and sometimes clover), peas, millet seeds, rye, sunflower seeds, barley, flax seeds, molasses, weed seeds, animal by-products, sweepings, shells, grit, charcoal, sometimes salt and other products and waste products.

These feeds should be purchased on the protein content, as this nutrient is generally what poultry require. Eggs are made up largely of protein and the common food given to poultry is generally lacking in this constituent. Shells, grit, and charcoal are present in some of these feeds and usually these materials can be purchased cheaper by themselves than in a poultry food. The per cent. of ash is an indication of the shell and grit content, and these feeds should not carry over 6 per cent. ash. Unground weed seeds are sometimes found in these feeds. Such material should not be used in these mixtures, as they are a means of scattering weeds all over the country. Some brands contain sweepings and the consumer should not purchase such adulterated feeds, but should demand a cleaner article.

A close physical examination will reveal a great deal as to the character of these feeds. Avoid feeds which contain sweepings, grit, and an excess of shells, and purchase only those feeds which smell sweet and show a good clean appearance.

Most of our poultry foods are sweet and clean but a few always carry sweepings, shells and charcoal.

Classes of Poultry Feeds.—The principal classes of poultry feeds are; 1. Hen feed. 2. Chick feed or scratching grains. 3. Pigeon feed. 4. Mash.

Hen feed is usually composed of cracked corn, some of the coarser parts or whole seeds and may contain shells, grit and charcoal. Chick feeds are similar to hen feeds except the product is in a finer mechanical condition. Pigeon feed is generally not so coarse as chick feed and may contain the same materials. Mash is a variable product depending upon the materials of which it is composed. It usually contains alfalfa or clover meal, corn product, oat product, meat scraps or other animal by-product, weed seeds, etc. It may contain some of other materials as linseed meal, flax feed, wheat products, etc. The mash is characterized by carrying more protein than the other mentioned feeds.

APPROXIMATE AVERAGE COMPOSITION OF POULTRY FEEDS

	Composition in per cent.					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
Hen	11	3	67	4	10	5
Chick	11	3	67	4	10	5
Pigeon	11	3	67	4	10	5
Mash	15	4.5	52.5	8	10	10

The animal by-products mentioned previously are used a great deal in poultry feeding.

Alfalfa and Clover Meal.—The cured hays of alfalfa and clover are ground and put upon the market as alfalfa and clover meal. They may be very finely ground but generally the hay is cut in ⅛ to ½ inch lengths. The manufacturers usually buy these hays baled and grind them at their mills. A great deal of alfalfa is consumed as chopped alfalfa and alfalfa meal in mixed commercial feeds. Alfalfa seems to be very popular with the American feeders and they often demand that it be present in the feeds they purchase.

COMPOSITION OF ALFALFA AND CLOVER MEAL

	Composition in per cent.					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
Alfalfa	14	2	36	29	10	9
Clover	12	2	40.5	27	10	8.5

SECTION XIX.

FEED STUFF LAWS AND FEED ADULTERANTS

Importance of State Feed Laws.—On account of the adulteration of commercial feed stuffs many of our states have passed laws to protect the consumers of these commodities. The enforcement of these laws is generally controlled by the Experiment Stations or the State Boards of Agriculture, through a staff of chemists and inspectors. The inspectors draw samples of the various feeds and the chemists analyze them to find out if they are as represented. The results of the chemists' findings are published in bulletins which are sent out to the farmers, manufacturers and other interested parties.

These laws require the manufacturers and dealers in these materials "to state what they sell and sell what they state." In other words they are forced to guarantee their products. Example, John Doe is manufacturing and selling cotton seed meal. Before he is allowed to sell his cotton seed meal he must have printed on the sacks, or on tags attached to the sacks, the composition of the cotton seed meal, the weight of the package, the name, brand, or trade mark, and the manufacturer's or dealer's name and address. Let us suppose that John Doe has printed on his sacks the following; protein 40 per cent., fat 9 per cent., carbohydrates 24 per cent. and fiber 10 per cent.; weight 100 lbs.; cotton seed meal; manufactured by John Doe, Memphis, Tenn. Such a statement is the guarantee. The weight of the package is a good requirement in such laws because the purchaser is enabled to tell just the amount contained in the package. Some feeds are put up in 90 pound sacks, for most purchasers will take it for granted that all feeds are sold in lots of 75 or 100 pounds or more. Feeds put up in irregular weights are generally sold per sack and not by weight. The guarantee then protects the consumer.

Comparison of Some of the Requirements of Feed Laws.—Harris in a discussion of feed stuff laws says: "Suppose we take, for instance, the main feature of every feed law—the guaranteed chemical analysis—and see if any uniformity exists here. Certainly not. One state requires a guarantee of protein and fat; a sister state, the minimum per cent. of protein and fat, and adds the maximum per cent. of crude fiber; another state will add to this carbohydrates; another starch and sugar, and Michigan adds nitrogen free extract.

"So it seems that there is not even an attempt at uniformity in the main feature of these laws. Some states require a license tax (*i.e.* a stipulated amount per brand per year). One state requires a license and a tonnage tax (*i. c.* a brand tax and a tax on every ton or part of a ton sold in the state). Some states exempt certain feeds from a license fee or tonnage tax; others do not. Some states require standard weight bags; others do not. Where standard weight bags are required, they differ in different states (a 75 pound bag of feed can be sold in Tennessee, but not in North Carolina). Some states require the ingredients to be registered with the state authorities enforcing the law. Some states have a standard analysis for different feeds; others do not. The state of Mississippi, for example, requires that a feed must contain at least 13.5 per cent. of crude fat and protein together; no feed carrying less than 3.5 per cent. fat can be sold; all ordinary feeds must not contain over 12 per cent. crude fiber except when branded "Cow & Ox Feed," if such feeds contain cotton seed or its by-products. Some states have a provision in the law that where a feed is found misbranded or adulterated it can be siezed, pending an investigation; other states have no provision of this kind. There are a number of states that impose a fine of from $200 to $500 on a manufacturer whose feed fails to come up to the guarantee claimed for it, and fine him $25 to $100 for adulterating." Some states prohibit the sale of feeds containing oat hulls, rice hulls, peanut hulls, corn cobs, and similar materials. Many states do not eliminate these substances.

Uniform Feed Stuff Law.—On account of the lack of uniformity of the several state feed stuff laws there has been a great deal of agitation among those interested in feed stuff trade, and a movement has been started to pass a standard feed stuff law. The American Feed Manufacturers' Association and state control officials met in Washington, D. C., in Sept. 1909 to discuss and if possible draw up a uniform feed stuff law satisfactory to all parties concerned in this business. The results of this meeting brought out the following, that the purchaser should know:—

1. The name, brand or trade mark.

2. The weight of the package.

3. The principal address and name of the manufacturer or jobber responsible for placing the feed on the market.

4. The chemical analysis as,

   Minimum per cent. of crude protein.
   Minimum per cent. of crude fat.
   Maximum per cent. of crude fiber.

5. If a compounded or mixed feed, the specific name of each ingredient of which it is made up.

Tentative Definitions of Feed Stuffs Recommended by the Feed Control Officials

Meal is the clean, sound, ground product of the entire grain, cereal or seed which it purports to represent. Provided, that the following meals, qualified by their descriptive names are to be known as, viz: Corn germ meal is a product in the manufacture of starch, glucose and other corn products and is the germ layer from which a part of the corn oil has been extracted. Cotton-seed meal is the meal obtained from the cotton-seed kernel after extraction of part of the oil and contains not less than 38.50 per cent. of crude protein. Linseed meal is the ground residue after extraction of part of the oil from ground flaxseed. Bolted corn meal is the entire ground product of corn, bolted.

Grits are the hard, flinty portions of Indian corn.

Hominy meal, feed or chop is the bran coating and germ of the corn kernel and may contain a part of the starchy portion of the kernel.

Corn feed meal is the sifting obtained in the manufacture of cracked corn and table meal made from the whole grain.

Gluten meal is a product obtained in the manufacture of starch and glucose from corn and is the flinty portion of the kernel which lies in its outer circumference just beneath the hull. If the meal is derived from any other cereal, the source must be designated.

Corn bran is the outer coating of the corn kernel.

Gluten feed is a product obtained in the manufacture of starch and glucose from corn and is a mixture of gluten meal and corn bran to which may be added the residue resulting from the evaporation of the so-called "steep-water." If derived from any other cereal, the source must be designated.

Wheat bran is the coarse outer coating of the wheat berry.

Shorts or standard middlings are the fine particles of the outer bran as well as the inner or "bee-wing" bran separated from the bran and white middlings.

Shipstuff or wheat mixed feed is a mixture of the by-products from the milling of the wheat berry.

White wheat middlings are that part of the offal from wheat left after separating it from the bran and the shorts or standard middlings.

Red dog is a low-grade wheat flour containing the finer particles of bran.

Oat Groats are the kernels of the oat berry with the hulls removed.

Oat shorts or oat middlings are the starchy portion of the oat groats obtained in the milling of rolled oats.

Oat hulls are the outer covering of the oat grain.

Oat clippings are the small hairs, dust and ends of oats separated from the oats in the clipping process and may contain light oats and oat hulls.

Rice bran is the inner cuticle of the rice hull.

Rice polish is the flour secured from the surface of the rice kernels in polishing.

Rice meal or flour is the clean ground rice.

Rice hulls are the outer covering of the rice grain.

Flaxseed meal is the entire flaxseed ground.

Flax plant refuse is the flax shives, flax pods, inferior flax seeds and the woody portion of the flax plant or any of the above materials.

Buckwheat shorts or middlings are that portion of the buckwheat grain immediately inside of the hull after separation from the flour.

Blood meal is finely ground dried blood.

Meat meal is finely ground beef scraps. If it bears a name descriptive of its kind, composition or origin, it must correspond thereto.

Cracklings are the residue after extracting the fats and oils from the animal tissue. If it bears a name descriptive of its kind, composition or origin, it must correspond thereto.

Digester tankage is meat scraps from edible carcasses which have been inspected and passed as satisfactory for human consumption, especially prepared for feeding purposes through tanking under live steam, drying under high heat and suitable grinding.

Distillers' dried grains are the dried residue from cereals obtained in the manufacture of alcohol and distilled liquors. The product shall bear a designation indicating the cereal predominating.

Brewers' dried grains are the dried residue from cereals obtained after "mashing and sparging" the malt.

Malt sprouts are the sprouts of the barley grain. If the sprouts are derived from any other malted cereal, the source must be designated.

Cotton-seed feed shall be a mixture of cotton-seed meal and cotton-seed hulls containing less than 38.50 per cent. of crude protein and shall be plainly marked "mixture of cotton-seed meal and cotton-seed hulls."

Alfalfa meal is the entire alfalfa hay ground and does not contain an admixture of ground alfalfa straw or other foreign materials.

Chop is a ground or chop feed composed of one or more different cereals or by-products thereof.

Screenings are the smaller imperfect grains, weed seeds and other foreign materials having feeding value, separated in clean-ing the grain. They shall be designated by the name of the seed from which they are derived.

Barley bran is a misnomer.

Cotton-seed bran is a misnomer.

Elevator feed is a misnomer.

Cotton-seed meal feed is a misnomer.

Cotton-seed feed meal is a misnomer.

Oat feed is a misnomer unless applied to whole ground oats.

Flax feed is a misnomer unless applied to whole ground flax-seed.

Flax bran is a misnomer.

Oat nubbins is a misnomer.

Buckwheat feed, consisting of buckwheat middlings and hulls, is a misnomer.

Gluten feed as applied to distillers' grains is a misnomer.

The Federal Law.—The national pure food law also protects the purchaser of feeds. All feeds that enter into interstate trade are subject to the requirements of this law. The manufacturers of feeds are required to sell goods as represented to satisfy this law. Example, a manufacturer cannot sell a feed manufactured in Texas, in Arkansas, labelled pure wheat bran that contains any thing other than wheat bran, nor can he sell a feed of a stated chemical analysis and have it fall materially below it.

Low Grade By-Product Feeds.—Some states, as heretofore stated, do not permit the sale of feeds below certain standards. There is considerable difference of opinion as to the advisability of such prohibition. Some claim such feeds should be eliminated so as to furnish all purchasers with feeds of a so-called high or standard grade. Others claim that a manufacturer should be permitted to sell low grade feeds provided the ingredients that make up the feed are stated and there are no injurious or poisonous materials present. We all know that oat hulls, corn cobs, screenings, cotton seed hulls, etc., contain some nutritious material and many claim that should the consumer wish to buy feeds containing any of these substances it is his own privilege and legitimate, when they are stated as being present. Other points that are worth considering are, that the prices of grains are getting higher and the population of this country is increasing so that the feeder may be forced in the future to utilize the wastes and low grade by-products to a certain extent.

Adulteration of Feeds.—If it were not for the protection our feed laws give us, we would find it hard to purchase good standard products. A manufacturer could easily adulterate his feed and sell it for the genuine article if he knew it would not be subject to inspection and analysis. For instance, a manufacturer could easily introduce ground cotton seed hulls into his cotton seed meal and sell the product with any guarantee he pleased. He could sell this mixed product under the name of cotton seed meal, when in reality it is cotton seed meal and ground cotton seed hulls (cotton seed feed). Of course the manufacturer could afford to sell the mixed product at a lower price than pure cotton seed meal, but for the nutrients received the purchaser would perhaps pay much more than for cotton seed meal. Many of the laws permit manufacturers to sell low grade products provided they are not injurious, but require that the true name or a trade name be employed. Perhaps the manufacturer would not care to put out a mixture of cotton seed meal and cotton seed hulls and label it so, but he would rather give it a trade or brand name, as Cracker Feed.

Values of Low Grade Feeds.—The purchasers of low grade feeds should know their values. The Experiment Stations or the State Boards of Agriculture are continually sending out bulletins which comment and set forth the values of commercial feeds so there is no excuse for a feeder, in states having feed laws, allowing a spurious article to be sold to him. In all feeds the principles as cited are true. It is unfortunate but possible, for manufacturers to put out feeds that resemble standard products, which are badly adulterated. These adulterated feeds are generally ground so fine that the casual observer would not notice the adulteration.

Feed Adulterants.—In some of our molasses feeds, wheat admixtures, corn and oat feeds, feed mixtures, cotton seed feeds, mixed oats and barley, and similar mixtures, materials are often added which are inferior. These inferior materials are called adulterants. As a general rule adulterants are added to feeds that command high prices and so are disposed of for more than they would bring if sold unmixed.

COMPOSITION OF FEED ADULTERANTS

Name of adulterant	Composition in per cent.					
	Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
Ground corn cobs	2.40	0.50	54.90	30.10	10.70	1.40
Corn bran	9.00	5.80	62.20	12.70	9.00	1.30
Oat hulls	3.30	1.00	52.10	29.70	7.30	6.70
Flax bran[1]	5.63	3.58	....	41.86	....	....
Wheat screenings	12.50	3.00	65.10	4.90	11.60	2.90
Cotton seed hulls	6.10	2.06	32.91	45.10	11.06	2.77
Rice hulls	3.50	0.49	26.86	41.89	8.97	18.29
Peanut hulls	4.54	0.78	14.36	66.12	10.76	3.44
Flax feed (screenings)	15.85	11.57	41.91	14.60	8.18	7.89
Buckwheat hulls	3.60	0.90	38.21	45.30	10.01	1.98
Weed seeds[2]	13.30	7.00	53.90	11.60	10.00	4.20

These materials are generally ground very fine so that they are not easily detected by a physical examination. Sweepings, elevator dust, brushings, grain screenings and other wastes are used to some extent in our feeds, but there is such variation in the composition of these materials that the analyses are not given in the table. Corn pith, corn stalks, straws, corn husks, etc., are sometimes used. Weed seeds are objectionable because they sometimes injure the palatability of the feed to which they are added, and they are a source of disseminating objectionable weeds when they are added to a feed unground. Unground weed seeds often pass through the animal undigested. Some states do not permit the use of adulterants as previously explained.

Suggestion: Require the students to secure a copy of the State Feed Stuff Law and if your state has no law have them obtain the law from some other state. The students should read it thoroughly and write a criticism of it.

[1] Bul. 141, Kentucky Exp. Station.
[2] Bul. 131, Indiana Exp. Station.

SECTION XX.

A FEW REMARKS ABOUT FEED STUFFS

Valuation of Feed Stuffs.—It is impossible to arrive at money values of feed stuffs as we can with fertilizers. The constituents in mixed fertilizers, namely, nitrogen, phosphoric acid and potash may be purchased singly, but when we purchase feed stuffs we get protein, fats and carbohydrates and cannot purchase any one of these nutrients alone, except occasionally carbohydrates from cane molasses. There are products on the market as sugar, starch, oils, protein substances, etc., which may contain single nutrients but these products are too expensive to feed live stock.

There have been many attempts made to secure a money valuation for protein, fats and carbohydrates but so far all have been unsuccessful. Should corn be taken as a basis and values established, these values when applied to the nutrients in cotton seed meal are all out of proportion to the selling price of this feed. The same principle applies with the nutrients of other feeds. If we calculate on the digestible nutrients or dry matter in feeds, the results secured have no comparative relation. The heat values of feed stuffs may be determined but a money value cannot be placed on the heats of combustion, because the nutrients act in another capacity as repair material, which value cannot be ascertained in this way.

Rebates and Comparative Unit Values.—In some sections of the country the purchaser buys feed stuffs on the chemical analyses and when they fail to reach the guarantee, rebates are demanded to make up for the deficiencies. In Louisiana the writer received so many communications requesting the settlement of rebates on feeds failing to reach their guarantees, that the following method was worked out and is used in the calculation of rebates.

The nutrients considered are protein, fat and carbohydrates (nitrogen free extract). To secure a basis of comparison of values, according to composition, one pound of protein is considered of the same value as two and one-half pounds of carbohydrates, and one pound of fat is considered to be worth as much as two and a quarter pounds of carbohydrates. Therefore, to secure the total number of units on which the value is based, we multiply the protein content by 2.50 and the fat content by 2.25 and add these products to the carbohydrate content.

Example.—Let us suppose a commercial feed is sold for $32 per ton and guaranteed to contain 14 per cent. of protein, 4 per cent. of fat and 60 per cent. of carbohydrates. By analysis we find 12.30 per cent. of protein, 3.80 per cent. of fat and 62 per cent. of carbohydrates. Then the percentages of protein, fat and carbohydrates as guaranteed, multiplied by their respective unit values will give the unit values guaranteed of each of these nutrients. The addition of these will give us the total unit value guaranteed. In other words, 14 (the per cent. of protein guaranteed) multiplied by 2.50 (the unit value for protein) gives us 35.00 (or the unit value of protein guaranteed).

4 (the per cent. of fat guaranteed) multiplied by 2.25 (the unit value of fat) gives us 9.00 (or the unit value of fat guaranteed).

60 (the per cent. of carbohydrates guaranteed) multiplied by 1.00 (the unit value of carbohydrates) gives us 60.00 (or the unit value of carbohydrates guaranteed).

That is:

$$14 \times 2.50 = 35.00$$
$$4 \times 2.25 = 9.00$$
$$60 \times 1.00 = 60.00$$

Total unit value guaranteed.......... = 104.00

In a similar manner we arrive at the total units found.

Example:

$$12.30 \times 2.50 = 30.75$$
$$3.80 \times 2.25 = 8.55$$
$$62.00 \times 1.00 = 62.00$$

Total unit value found.................. = 101.30

That is, the purchaser was guaranteed 104 units for $32 a ton, but he received only 101.30 units.

Then 104 (the unit value guaranteed) is to 101.30 (the unit value found) as 32 (the contract price per ton) is to (the actual price to be paid per ton).

In other words:

$$104 : 101.30 = 32 : X \qquad 104\,X = 3241.60$$

$X = 31.17$, or the actual price that should be paid per ton.
\$32 — \$31.17 = \$0.83, the rebate per ton.

Impossible to Consider Digestibility.—It is impossible to consider the digestibilities of the nutrients in the several mixed feeds, because of the enormous expenditure of money and work necessary to determine these percentages. Again the primary products that go to make up these feeds are often changing. For example, a mixed feed will be inspected that is made up of corn, rice bran, rice polish, cotton seed meal, and cane molasses. In a month from the above inspection, the same company will change the ingredients of this same brand of feed, so that it consists of corn, wheat bran, alfalfa and cane molasses, and the guarantee and the name of the brand will remain unchanged. Under such conditions it is impossible to consider anything except the chemical analysis. The market prices, demand, ease of obtaining, location, etc. of the available primary products seem to determine the ingredients that are used in mixed feeds.

No Other Feed Should be Considered in Settlement.—Some agents have tried to settle rebates by figuring a mixed feed as valuable as some other feed as oats for example. Oats may be selling for \$36 per ton and his feed for \$32 per ton, and yet the per cent. of protein, fat and carbohydrates may be about the same in the two feeds. When a feed is sold to contain a given per cent. of protein, fat and carbohydrates for a fixed price, the rebate should be calculated on this basis and no other feed should be considered in the settlement.

Values Only Approximate.—The student should understand that the unit values for protein, fat and carbohydrates as given are only approximate, but are used by the trade in certain sections, in settling rebates, and seem to give general satisfaction.

Overages and Deficiencies.—The student may wish to know why allowance is made for overage in certain nutrients and deficiencies in others. It may be said that such is permissible within reasonable limits. The manufacturers of feeds intend to guarantee their products as true to the actual composition as possible. Most of the manufacturers try to give a little more nutrients than guaranteed, so that the feed will meet the guarantee under reasonable conditions. Sometimes a feed will run above the guarantee in one nutrient and low in the other two, or it may run above in two nutrients and low in one; but it hardly ever falls below the guarantee in all three nutrients. If the chemical analysis approximates the guarantee, the system as laid down for figuring rebates is permissible. The composition of the feed stuffs found on the American market will usually come within reasonable limits of their guarantees.

How to Buy a Feed.—You have learned that many of our feeds vary considerably in composition and therefore do not buy cotton seed meal, linseed meal, wheat bran, etc. just because they are so named. In purchasing feed stuffs consult the standards as given for the several feeds in the previous sections, and send for a bulletin from your State Experiment Station or from the State Board of Agriculture, which may contain analyses of the products you intend to buy. After familiarizing yourself with what the feed should contain, ask your feed dealer for the guarantee, *i. e.* the chemical analysis and weight of the package. If the feed or feeds you want to purchase are below the standards as set forth in your state bulletin or in the table of standards in this book, do not purchase. There are many dealers and merchants who purchase the cheapest feeds possible, regardless of their value, and sell these inferior feeds to their customers for nearly as high a price as high class feeds bring. They do this to make greater profits.

Before purchasing any feed the purchaser should know the kind of feed that is needed for his economical use. If considerable molasses, corn, roughage (native hay, corn stover, etc.) are on hand, a feed rich in protein should be secured. For example, if plenty of carbohydrate feeds are on hand, as corn and grass hay, it would be a waste of money to purchase a feed rich in carbohydrates and in all probability the results of feeding such combinations would be unsatisfactory. The selling price and the name of a feed do not indicate its suitability for the needs of the purchaser. Often the cheapest feeds are the most expensive for the nutrients received and sometimes the reverse is true.

Classes of Feeds.—The table following shows the principal feeds found on the American market arranged in classes according to their protein content.

Class I	Cotton-seed meal Linseed meal Gluten meal Dried distillers' grains	30-50 per cent. protein 23-49 per cent. carbohydrates
Class II	Gluten feed Malt sprouts Cotton-seed feed Dried brewers' grains Germ oil meal	20-30 per cent. protein 35-55 per cent. carbohydrates
Class III	Wheat middlings (flour) Wheat middlings (standard) Wheat mixed feed (bran and shorts) Oat middlings Wheat bran Flax feed Molasses dry dairy feed Rye feed Feed mixture (dairy) Alfalfa meal (whole plant)	14-20 per cent. protein 35-65 per cent. carbohydrates
Class IV	Wheat admixture Rice bran Clover meal (whole plant) Fortified oat feed Rice polish Molasses dry horse feed Feed mixture (horse and mule) Ground oats Ground wheat Barley meal Rye meal Hominy feed Mixed oats and barley Provender	10-14 per cent. protein 35-65 per cent. carbohydrates
Class V	Feed meal Corn bran Corn meal Corn chops Corn and oat feed Oat feed Dried beet pulp Beet molasses	8-10 per cent. protein 50-75 per cent. carbohydrates

The hays from grasses, dry fodders, straws, and cane molasses would probably be considered as carbohydrate feeds although it must be remembered that they do not contain as much protein as the feeds included in Class V.

This table may be found useful in the selection of feeds. Classes I and II are especially rich in protein and may be classed as protein feeds. Classes III and IV may be termed protein and carbohydrate feeds. Class V includes the carbohydrate feeds.

Conversion Factors.—Some products are used for fertilizer and feed, and when sold may be guaranteed to contain only nitrogen or ammonia. The following factors will be useful in obtaining equivalents of nitrogen, ammonia and protein:

One per cent. nitrogen = 1.2154 per cent. ammonia = 6.25 per cent. protein.

One per cent. ammonia = .823 per cent. nitrogen = 5.14 per cent. protein.

One per cent. protein = .16 per cent. nitrogen = .1945 per cent. ammonia.

Per cent.	Per cent.	Per cent.
5.44 nitrogen =	6.61 ammonia =	34 protein
5.60	6.81	35
5.76	7.00	36
5.91	7.19	37
6.08	7.40	38
6.24	7.59	39
6.40	7.78	40
6.56	7.98	41
6.72	8.17	42

EXAMPLE.—Cotton-seed meal, carrying 6.58 per cent. of nitrogen, is equivalent to cotton-seed meal containing 6.58 × 1.2154 or 8.00 per cent. ammonia and 6.58 × 6.25 or 41.12 per cent. protein. A feed containing 15 per cent. protein is equivalent to a feed containing 15 × .1945 or 2.92 per cent. ammonia and 15 × .16 or 2.40 per cent. nitrogen.

Condimental Feeds.—There are a great many of these feeds sold in this country. They are made up of mixtures of sulphur, salt, saltpeter, Epsom salts, Glauber's salts, sodium bicarbonate, fenugreek seeds, fennel seeds, ginger, turmeric, gentian powder, charcoal, red and black peppers, ground bone, venetian red, anise, oyster shells and similar products, generally with some feed as a basis, in varying proportions. These feeds generally carry attractive names and the manufacturers make great claims regarding their curative properties.

The following is taken from Bul. 106, Mass. Exp. Station.

"**Cost and Selling Price Compared.**—None of the mineral drugs used in these feeds except nitre, cost much over a cent a pound, and the vegetable drugs vary in price from 3 to 12 cents a pound. The cost of condimental feeds rarely exceeds 2 to 3 cents a pound. The retail prices vary from 6 to 25 cents a pound, depending on the brand and quantity purchased. Condition powders are much higher priced, from 30 cents to $1 a pound.

Value.—"The food value of these feeds has been shown by experiments to be no greater than that of ordinary grains of which they are largely composed. Their medicinal value depends largely upon the aromatic seeds and roots used as a tonic for the stomach, on charcoal as an absorbent, and on the purgative effect of the Epsom or Glauber's salts. The quantity recommended to be fed daily is usually so small (one ounce or less) that very little effect can be expected unless the material is fed for a considerable length of time. While it is probably true that some of these stock foods may prove beneficial under certain conditions, it is also true that most of them are heterogeneous mixtures and evidently put together by parties quite ignorant of the principles of animal physiology, pathology and veterinary medicine.

"Dr. Paige, very pointedly expresses the most advanced views of the veterinary profession when he says, animals in a state of health do not need condition powders or tonic foods. There is in the body of a healthy animal a condition of equilibrium of all body functions. The processes of digestion and assimilation are at their best. All that is required to maintain this condition of balance, is that the animal be kept under sanitary conditions and receive a sufficient supply of healthful nutritive food and pure water. While tonics may improve the appetite so that the animal will temporarily consume and digest more food, should this increased quantity of nutrients consumed not be appropriated by the tissues of the body, harm may result from thus over-loading the lymphatic system, or from an increased action of the excreting organs."

Treatment.—Bartlett of the Maine Experiment Station recommends the following when a tonic is required. "Pulverized gentian, one pound; pulverized ginger, ¼ pound; pulverized saltpeter, ¼ pound; pulverized iron sulphate, ½ pound. Mix and give one tablespoonful in the feed once a day for ten days, omit for three days, then give ten days more. The cost of this tonic is 20 cents a pound."

If animals are sick it is cheaper to consult a veterinarian than to take any chances with tonics.

Experiments conducted at other Experiment Stations on condimental feeds and condition powders have demonstrated that the economical feeder cannot afford to purchase them.

Suggestion: Take the class to a feed store or feed stores, and have the students examine the commercial feeds on sale. Require them to copy the guarantees, selling prices, names of the feeds and addresses of the manufacturers or jobbers. Have them compare the data obtained with the standards as set forth in the state bulletin or in this book. Let them figure the cost of the feeds per ton and classify them. Take the class around to the feed and drug stores and see what condimental feeds are for sale. Make a list of them and ascertain their prices. Have them figure the ton prices of these feeds.

Require the students to make a physical examination of all the feeds stating their ingredients.

SECTION XXI.

COMPOSITION AND DIGESTIBLE NUTRIENTS OF FEED STUFFS AND THE NUTRITIVE RATIO.

Composition of Feeds.—We have already stated the meaning and functions of the nutritive elements contained in plants and animals. The next thing is to become more familiar with the composition and digestibility of feeds. The chemist has already worked out these for us and he expresses the composition as follows:

COMPOSITION OF CORN (GRAIN) IN PER CENT.

Protein	Fat (ether extract)	Nitrogen free extract	Fiber	Water	Ash
10.3	5.0	70.4	2.2	10.6	1.5

The above analysis is very simply translated. It means that in every 100 pounds of corn grain, there are 10.3 lbs. of protein, 5 lbs. of fat, 70.4 lbs. of nitrogen free extract, 2.2 lbs. of fiber, 10.6 lbs. of water and 1.5 lbs. of ash. Or there are 10.6 lbs. of water and 89.4 lbs. of dry matter.

Digestibility of Feeds.—Knowing the composition of feeds, it is now necessary to become acquainted with the actual amounts of the nutrients (protein, fat, nitrogen free extract and fiber), that the animal can assimilate. The digestibility of any food is determined by analyzing and finding its chemical composition, namely the per cent. of protein, ether extract, nitrogen free extract, fiber, water and ash, and feeding weighed portions of this food to animals for a given period and at regular intervals. The feces or manure is collected, weighed and analyzed. The difference between the dry matter fed and the dry matter cast off as manure, is taken as digestible. This procedure seems very simple but it requires a great deal of work, and the results received are not always satisfactorily accurate.

Digestibility not Always Accurate.—The true digestibility of the protein and fats is the most difficult to ascertain. We know that nitrogenous compounds present in wastes that are passed off in the processes of digestion, such as the wastes from mucus, bile, digestive juices, etc., have no connection with the protein of the food in the experiment. It seems that the smaller the per cent. of protein in the food, as in hay or straw for example, the greater are the amounts of these waste products in the manure. The writer conducted some digestion experiments on Bermuda and lespedeza (Japan clover) hays of low quality, and found in some cases when other feeds as cotton-seed meal, corn chops and molasses were fed with these hays, a negative digestibility for the protein of these hays. It is reasonable to suppose that some of the protein in these hays was digested. The digestibility of fat is difficult to arrive at because the wastes from the bile, which are present in the feces, are soluble in ether, which extracts matter that is calculated as fat. The digestibility of the same kind of feed is perhaps influenced by several factors such as season, climate, fertilizer, curing, handling, etc., so that the digestibility of a feed may vary with these conditions.

From the foregoing we can readily understand that the digestibilities as given in Table I are perhaps not always accurate, yet they serve in giving us an approximate value of feed stuffs.

The Per Cent. Digestible is often spoken of as the coefficient of digestibility. In order to acquaint the student with a full understanding of digestibility let us take the digestibility of corn for example.

COEFFICIENT OF DIGESTIBILITY OR DIGESTIBILITY OF CORN IN PER CENT.

Protein	Ether extract (fat)	Nitrogen free extract	Fiber
76	86	93	58

That is, in 100 lbs. of the grain of corn, 76 per cent. of the 10.3 lbs. of protein is digestible, 86 per cent. of the 5 lbs. of fat is digestible, 93 per cent. of the 70.4 lbs. of nitrogen free extract is digestible and 58 per cent. of the 2.2 lbs. of fiber is digestible. We can represent this in another way by stating the total pounds of digestible nutrients in 100 lbs. of corn grain.

Fig. 10.—Lespedeza (Japan clover).

TOTAL POUNDS DIGESTIBLE NUTRIENTS IN 100 LBS. of CORN GRAIN

Protein	Ether extract (fat)	Nitrogen free extract	Fiber
7.8	4.3	65.5	1.3

The digestible fiber is generally added to the digestible nitrogen free extract and called digestible carbohydrates. In this case then the digestible carbohydrates of corn grain would be $65.5 + 1.3 = 66.8$ lbs. As mentioned previously the water is not considered a nutrient as it can be supplied so much cheaper by itself. The ash is also omitted because most of our feeds contain enough of this substance for the needs of the animal.

Necessity of Composition and Digestibility.—There are several feeds which have practically the same chemical composition but different percentages of digestibility. Therefore to ascertain the real feeding value of a feed the composition and digestibility should be known.

Nutritive Ratio.—The ratio between the digestible protein and the digestible carbohydrates + the digestible fats, is called the nutritive ratio. This ratio is obtained in the following manner. The per cent. of digestible fat is multiplied by 2.25, to reduce it to terms of carbohydrates. It was previously explained that the fuel value of fat is 2.25 times that of carbohydrates. This product is then added to the per cent. of digestible carbohydrates which gives us the total carbohydrates. This sum is divided by the per cent. of digestible protein,

Example: $$\frac{(\text{digestible fat} \times 2.25) + \text{digestible carbohydrates}}{\text{digestible protein}}$$

= nutritive ratio.

To explain this more clearly let us take the digestibility of corn grain, as just cited in this section.

Digestible fat (4.3) $\times$ fuel value (2.25) = Carbohydrate equivalent (9.675).

Digestible carbohydrates (66.8) + 9.675 = Total digestible carbohydrates (76.475).

TABLE I.—AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS OF AMERICAN FEED STUFFS

Name of feed	Percentage Composition							Per cent. of digestible nutrients		
	Dry matter	Water	Ash	Protein	Nitrogen free extract (carbohydrates)	Crude fiber	Fat (ether extract)	Protein	Carbohydrates	Fat
CONCENTRATES										
Barley	89.1	10.9	2.4	12.4	69.8	2.7	1.8	8.7	65.6	1.6
Beet pulp (dried)	92.0	8.0	5.4	9.5	61.3	15.4	0.4	6.1	68.7	..
Beet pulp (wet)[1]	10.2	89.8	0.6	0.9	6.3	2.4	..	0.6	7.3	..
Brewers' grains (dried)	91.8	8.2	3.6	19.9	51.7	11.0	5.6	15.7	36.3	5.1
Brewers' grains (wet)	24.3	75.7	1.0	5.4	12.5	3.8	1.6	3.9	9.3	1.4
Broom corn seed	87.3	12.7	3.4	10.2	63.6	7.1	3.0	7.4	48.3	2.9
Buckwheat	87.4	12.6	2.0	10.0	64.5	8.7	2.2	7.7	49.2	1.8
Buckwheat bran	89.5	10.5	3.1	12.4	38.8	31.9	3.3	7.4	30.4	1.9
Buckwheat shorts	88.9	11.1	5.1	27.1	40.8	8.3	7.6	21.1	33.5	5.5
Buckwheat middlings	86.8	13.2	4.8	28.9	41.9	4.1	7.1	22.0	33.4	5.4
Cocoanut meal	89.7	10.3	5.9	19.7	38.7	14.4	11.0	15.6	38.3	10.5
Corn, all analyses	89.4	10.6	1.5	10.3	70.4	2.2	5.0	7.8	66.8	4.3
Corn meal	85.0	15.0	1.4	9.2	68.7	1.9	3.8	5.5	64.5	3.5
Corn, flint	88.7	11.3	1.4	10.5	70.1	1.7	5.0	8.0	66.2	4.3
Corn, sweet	91.2	8.8	1.9	11.6	66.8	2.8	8.1	8.8	63.7	7.0
Corn and cob meal	84.9	15.1	1.5	8.5	64.8	6.6	3.5	4.4	60.0	2.9
Corn bran	90.9	9.1	1.3	9.0	62.1	12.7	5.8	7.4	59.8	4.6
Corn and oat feed (Victor)	90.0	10.0	3.5	8.6	62.9	11.3	3.7	6.1	57.6	3.2
Cotton seed (raw)	89.7	10.3	3.5	18.4	24.7	23.2	19.9	12.5	30.0	17.3
Cotton seed (roasted)	93.9	6.1	5.5	16.8	23.5	20.4	27.7	7.9	25.5	19.9
Cotton seed meal (choice)	91.8	8.2	7.2	42.3	23.6	5.6	13.1	37.2	16.9	12.2

[1] Not a concentrate; included for comparison.

TABLE I.—AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS OF AMERICAN FEED STUFFS.—(*Continued*)

Name of feed	Percentage Composition							Per cent. of digestible nutrients		
	Dry matter	Water	Ash	Protein	Nitrogen free extract (carbohydrates)	Crude fiber	Fat (ether extract)	Protein	Carbohydrates	Fat
CONCENTRATES (Continued)										
Cotton seed feed[1]	92.0	8.0	4.6	24.9	37.0	18.0	7.5	18.2	32.0	6.8
Cotton seed feed[2]	89.0	11.0	3.1	10.5	35.9	36.0	3.5	5.4	36.4	3.0
Cowpea seed	85.2	14.8	3.2	20.8	55.7	4.1	1.4	18.3	54.2	1.1
Distillers' dried grains	92.0	8.0	1.7	31.7	34.2	12.3	12.1	23.1	39.4	11.5
Flax seed	90.8	9.2	4.2	22.6	23.2	7.1	33.7	20.6	17.1	29.0
Flour (dark feeding)	90.3	9.7	4.3	19.9	56.1	3.8	6.2	13.5	51.3	2.0
Flour (high grade)	87.8	12.2	0.6	14.9	70.0	0.3	2.0	8.9	62.4	0.9
Flour (low grade)	88.0	12.0	2.0	18.0	63,3	0.9	3.8	8.2	62.7	0.9
Germ meal	91.9	8.1	1.3	11.1	62.5	9.9	7.1	9.0	61.2	6.2
Gluten meal	91.8	8.2	0.9	29.3	46.5	3.3	11.8	25.8	43.3	11.0
Gluten feed	91.5	8.5	1.7	26.2	53.3	7.2	3.1	22.3	52.9	2.6
Grano-gluten	94.2	5.8	2.8	31.1	33.4	12.0	14.9	26.7	38.8	12.4
Hominy chops	88.9	11.1	2.5	9.8	64.5	3.8	8.3	7.5	55.2	6.8
Hominy meal	89.0	11.0	2.5	10.4	64.1	4.2	7.8	6.8	59.8	7.2
Horse bean	88.7	11.3	3.8	26.6	50.1	7.2	1.0	22.4	49.3	0.9
Kafir corn	90.7	9.3	1.5	9.9	74.9	1.4	3.0	7.8	57.1	2.1
Linseed meal (old process)	90.8	9.2	5.7	32.9	35.4	8.9	7.9	29.3	32.7	7.0
Linseed meal (new process)	89.9	10.1	5.8	33.2	38.4	9.5	3.0	28.2	40.1	2.8
Malt sprouts	89.8	10.2	5.7	23.2	48.5	10.7	1.7	18.6	37.1	1.7
Millet seed	86.0	14.0	3.3	11.8	57.4	9.5	4.0	8.9	45.0	3.2
Molasses (beet)	79.2	20.8	10.6	9.1	59.5	..	..	..	59.5	..

[1] Mixture of cotton seed meal and cotton seed hulls. [2] Some cotton seed meal, but mostly cotton seed hulls.

TABLE I.—AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS OF AMERICAN FEED STUFFS.—(*Continued*)

Name of feed	Percentage Composition							Per cent. of digestible nutrients		
	Dry matter	Water	Ash	Protein	Nitrogen free extract (carbohydrates)	Crude fiber	Fat (ether extract)	Protein	Carbohydrates	Fat
CONCENTRATES (Continued)										
Molasses, (cane, blackstrap)	77.6	22.4	9.3	2.4	65.9	..	..	..	65.9	..
Oats	89.0	11.0	3.0	11.8	59.7	9.5	5.0	9.3	47.6	3.5
Oat dust	93.5	6.5	6.9	13.5	50.1	18.2	4.8	8.9	38.4	3.1
Oat feed (shorts)	92.3	7.7	3.7	16.0	59.4	6.1	7.1	12.5	46.9	2.8
Oat meal	92.1	7.9	2.0	14.7	67.4	0.9	7.1	11.5	52.1	5.9
Palm-nut meal	89.6	10.4	4.3	16.8	35.0	24.0	9.5	16.0	52.6	9.0
Pea meal	90.0	10.0	2.6	18.9	49.4	17.5	1.6	15.7	51.0	0.9
Peanut meal	89.3	10.7	4.9	47.6	23.7	5.1	8.0	42.9	22.8	6.9
Peanut feed (largely husks)	90.0	10.0	2.6	8.9	16.6	56.4	5.5	6.3	14.3	5.0
Rape seed meal	90.0	10.0	7.9	31.2	30.0	11.3	9.6	25.2	23.7	7.5
Rice (clean)	87.2	12.8	0.7	7.5	78.1	0.5	0.4	4.8	72.2	0.3
Rice (rough)	89.1	10.9	5.5	7.4	64.3	9.3	2.6	..	..	..
Rice bran (15 per cent hulls)	90.1	9.9	11.3	9.9	44.5	14.5	9.9	6.4	36.7	5.4
Rice meal (pure bran)	91.4	8.6	8.9	13.3	49.8	8.7	10.7	8.6	40.0	5.9
Rice polish	88.5	11.5	3.5	11.1	64.3	3.8	5.8	7.3	60.4	4.3
Rye	88.4	11.6	1.9	10.6	72.5	1.7	1.7	9.9	67.6	1.1
Rye bran	88.4	11.6	3.6	14.7	63.8	3.5	2.8	11.5	50.3	2.0
Rye shorts	90.7	9.3	5.9	18.0	58.9	5.1	2.8	11.9	45.1	1.6
Soja (Soy) bean seed	89.2	10.8	4.7	34.0	28.8	4.8	16.9	29.6	22.3	14.4
Sorghum seed	87.2	12.8	2.1	9.1	69.8	2.6	3.6	7.0	52.1	3.1
Sunflower seed	91.4	8.6	2.6	16.3	21.4	29.9	21.2	12.1	20.8	19.0

TABLE I.—AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS OF AMERICAN FEED STUFFS.—(*Continued*)

Name of feed	Percentage Composition							Per cent. of digestible nutrients		
	Dry matter	Water	Ash	Protein	Nitrogen free extract (carbohydrates)	Crude fiber	Fat (ether extract)	Protein	Carbohydrates	Fat
CONCENTRATES (Continued)										
Sunflower cake	89.2	10.8	6.7	32.8	27.1	13.5	9.1	31.2	19.6	8.8
Wheat (grain)	89.5	10.5	1.8	11.9	71.9	1.8	2.1	10.2	69.2	1.7
Wheat admixture	90.0	10.0	4.3	12.3	54.6	15.5	3.3	7.7	43.1	3.0
Wheat bran (all analyses)	88.1	11.9	5.8	15.4	53.9	9.0	4.0	12.1	39.2	2.7
Wheat bran (spring wheat)	88.5	11.5	5.4	16.1	54.5	8.0	4.5	12.9	40.1	3.4
Wheat bran (winter wheat)	87.7	12.3	5.9	16.0	53.7	8.1	4.0	12.3	37.0	2.6
Wheat middlings	87.9	12.1	3.3	15.6	60.4	4.6	4.0	12.8	53.0	3.4
Wheat screenings	88.4	11.6	2.9	12.5	65.1	4.9	3.0	9.8	51.0	2.2
Wheat shorts	88.2	11.8	4.6	14.9	56.8	7.4	4.5	12.2	50.0	3.8
WASTE PRODUCTS—(Low Grade)										
Buckwheat hulls	86.8	13.2	2.2	4.6	35.3	43.6	1.1	2.1	27.9	0.6
Corn cob	89.3	10.7	1.4	2.4	54.9	30.1	0.5	0.4	52.5	0.3
Cotton seed hulls	88.9	11.1	2.8	4.2	33.4	46.3	2.2	0.3	33.1	1.7
Oat chaff	85.7	14.3	10.0	4.0	36.2	34.0	1.5	1.5	33.0	0.7
Oat hulls	92.7	7.3	6.6	3.3	52.1	29.7	1.0	1.3	40.1	0.6
Rice hulls	91.0	9.0	18.3	3.5	26.8	41.9	0.5	0.8	14.2	0.2
Wheat chaff	85.7	14.3	9.2	4.5	34.6	36.0	1.4	0.3	23.3	0.5
FODDERS										
Corn fodder (leaves)	91.1	8.9	9.8	11.8	41.5	24.7	3.3	5.3	43.3	2.0
Corn fodder (whole plant)	67.8	32.2	4.3	4.8	37.2	20.2	1.3	2.6	37.5	0.9
Corn fodder (green)	20.7	79.3	1.2	1.8	12.2	5.0	0.5	0.9	12.0	0.3

TABLE I. —AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS OF AMERICAN FEED STUFFS.—(*Continued*)

Name of feed	Percentage Composition							Per cent. of digestible nutrients		
	Dry matter	Water	Ash	Protein	Nitrogen free extract (carbohydrates)	Crude fiber	Fat (ether extract)	Protein	Carbohydrates	Fat
FODDERS (Continued)										
Corn husks (shucks)	91.9	8.1	3.3	3.3	51.6	32.8	0.9	1.0	64.7	0.3
Corn stover (whole plant except ears)	77.2	22.8	4.9	5.5	39.9	25.6	1.3	2.8	42.3	0.7
Kafir corn stover (field cured)	86.6	13.4	9.3	5.5	42.2	27.9	1.7	2.3	44.8	0.8
Sorghum (cane)	94.3	5.7	8.2	5.8	55.5	23.3	1.5	2.5	44.3	0.9
Spanish moss	30.5	69.5	1.6	3.7	15.9	8.2	1.1	..	....	..
FRESH GRASS										
Barley (green)	21.0	79.0	1.8	2.7	8.0	7.9	0.6	1.9	10.2	0.4
Barley and vetch	20.0	80.0	1.2	2.8	9.0	6.5	0.5	2.1	9.5	0.3
Kentucky blue grass	34.9	65.1	2.8	4.1	17.6	9.1	1.3	3.0	19.8	0.8
Meadow fescue (in bloom)	30.1	69 9	1.8	2.4	14.3	10.8	0.8	1.5	16.8	0.4
Millet (barnyard)	20.0	80.0	1.7	1.9	9.4	6.6	0.4	1.2	11.5	0.2
Millet (common)	20.0	80.0	1.0	1.5	10.5	6.5	0.5	0.9	11.6	0.3
Millet (Hungarian grass)	28.9	71.1	1.7	3.1	14.2	9.2	0.7	2.0	16.0	0.4
Millet (Japanese)	20.0	80.0	1.1	1.2	10.2	7.1	0.4	0.6	11.2	0.3
Oats (in bloom)	37.8	62.2	2.5	3.4	19.3	11.2	1.4	2.5	18.8	1.0
Oats (in milk)	25.0	75.0	1.5	2.7	11.5	8.6	0.7	2.0	11.8	0.5
Orchard grass	27.0	73.0	2.0	2.6	13.3	8.2	0.9	1.5	11.4	0.5
Pasture grasses (mixed)	20.0	80.0	2.0	3.5	9.7	4.0	0.8	2.5	10.2	0.5
Peas and oats	20.0	80.0	1.7	2.9	8.8	6.0	0.6	2.1	10.1	0.4
Peas and barley	20.0	80.0	1.6	2.8	8.2	6.8	0.6	2.1	9.1	0.4
Red top (in bloom)	34.7	65.3	2.3	2.8	17.7	11.0	0.9	2.1	21.2	0.6

TABLE I.—AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS OF AMERICAN FEED STUFFS.—(*Continued*)

Name of feed	Percentage Composition							Per cent. of digestible nutrients		
	Dry matter	Water	Ash	Protein	Nitrogen free extract (carbohydrates)	Crude fiber	Fat (ether extract)	Protein	Carbohydrates	Fat
FRESH GRASS (Continued)										
Rye (green)	23.4	76.6	1.8	2.6	6.8	11.6	0.6	2.0	14.1	0.4
Sorghum (green)	20.6	79.4	1.1	1.3	11.6	6.1	0.5	0.6	12.2	0.4
Timothy (different stages)	38.4	61.6	2.1	3.1	20.2	11.8	1.2	1.2	19.1	0.6
Vetch and oats (1—1)	20.0	80.0	1.8	3.0	8.4	6.3	0.5	2.3	10.0	0.2
Wheat and vetch	20.0	80.0	1.6	3.4	8.1	6.4	0.5	2.6	10.3	0.3
GRASS HAY										
Bermuda grass[1]	89.4	10.6	6.3	10.2	48.3	22.4	2.2	4.6	39.1	0.9
Canada blue grass	86.0	14.0	4.8	5.9	42.1	32.3	0.9	2.5	48.7	0.3
Crab grass	89.7	10.3	7.3	6.9	41.0	32.9	1.6	2.2	42.8	0.6
English hay (mixed grasses)	86.0	14.0	5.3	7.9	42.8	27.7	2.3	3.7	43.3	1.0
Johnson grass	89.8	10.2	6.1	7.2	45.9	28.5	2.1	3.2	41.3	0.8
Kentucky blue grass	78.8	21.2	6.3	7.8	37.8	23.0	3.9	4.8	37.3	2.0
Marsh grass	88.4	11.6	6.7	7.2	45.9	26.6	2.0	2.4	29.9	0.9
Meadow fescue grass	86.0	14.0	7.1	5.8	39.3	32.2	1.6	3.0	44.8	0.9
Millet (barnyard)	86.0	14.0	7.3	8.2	40.4	28.4	1.7	5.2	38.6	0.8
Millet (cat tail)	89.5	10.5	10.2	9.9	36.6	30.8	2.0	6.2	42.1	0.9
Millet (Hungarian grass)	92.3	7.7	6.0	7.5	49.0	27.7	2.1	4.5	51.7	1.3
Mixed grass and clover	87.1	12.9	5.5	10.1	41.3	27.6	2.6	5.9	40.9	1.2
Oat hay (cut in milk stage)	85.0	15.0	5.2	9.3	39.0	29.2	2.3	5.0	33.0	1.4
Orchard grass	90.1	9.9	6.0	8.1	41.0	32.4	2.6	4.9	42.3	1.4
Prairie grass	93.2	6.8	8.1	6.0	46.3	30.1	2.7	3.7	43.6	0.9

[1] Approximate.

TABLE I.—AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS OF AMERICAN FEED STUFFS.—(*Continued*)

Name of feed	Percentage Composition							Per cent. of digestible nutrients		
	Dry matter	Water	Ash	Protein	Nitrogen free extract (carbohydrates)	Crude fiber	Fat (ether extract)	Protein	Carbohydrates	Fat
GRASS HAY (Continued)										
Red top	91.1	8.9	5.2	7.9	47.5	28.6	1.9	4.8	46.9	1.0
Rowen (mixed)	83.4	16.6	6.8	11.6	39.4	22.5	3.1	7.9	40.1	1.5
Salt hay (mixed)	84.0	16.0	8.4	5.5	45.5	22.5	2.1	2.3	36.8	0.6
Swamp or swale hay	86.0	14.0	5.8	7.1	44.5	26.7	1.9	2.4	29.3	0.8
Tall oat grass	86.0	14.0	4.7	6.4	42.1	30.9	1.9	3.3	41.4	1.1
Timothy	86.8	13.2	4.4	5.9	45.0	29.0	2.5	2.8	43.4	1.4
White daisy	89.7	10.3	6.6	7.7	42.0	30.0	3.4	3.8	40.7	1.2
CEREAL STRAW										
Barley	85.8	14.2	5.8	3.5	39.0	36.0	1.5	0.7	41.2	0.6
Oat	90.8	9.2	5.1	4.0	42.4	37.0	2.3	1.2	38.6	0.8
Rice	88.0	12.0	7.8	5.9	33.7	38.6	2.0	2.7	32.8	1.0
Rye	92.9	7.1	3.2	3.0	46.6	38.9	1.2	0.6	40.6	0.4
Wheat	90.4	9.6	4.2	3.4	43.4	38.1	1.3	0.4	36.3	0.4
FRESH LEGUMES										
Alfalfa	28.2	71.8	2.7	4.8	12.3	7.4	1.0	3.9	12.6	0.5
Alsike clover (in bloom)	25.2	74.8	2.0	3.9	11.0	7.4	0.9	2.7	13.1	0.6
Canada field pea	13.0	87.0	1.2	2.8	4.8	3.8	0.4	2.3	5.3	0.2
Cowpea	16.4	83.6	1.7	2.4	7.1	4.8	0.4	1.8	8.7	0.2
Crimson clover	19.1	80.9	1.7	3.1	8.4	5.2	0.7	2.4	9.1	0.5
Lespedeza (Japan clover)[1]	30.0	70.0	3.0	2.7	14.4	9.3	0.6	1.9	15.1	0.3
Red clover (different stages)	29.2	70.8	2.1	4.4	13.5	8.1	1.1	2.9	14.8	0.7

[1] Approximate.

TABLE I.—AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS OF AMERICAN FEED STUFFS.—(*Continued*)

Name of feed	Percentage Composition							Per cent. of digestible nutrients		
	Dry matter	Water	Ash	Protein	Nitrogen free extract (carbohydrates)	Crude fiber	Fat (ether extract)	Protein	Carbohydrates	Fat
FRESH LEGUMES (Continued)										
Soja (Soy) bean	24.9	75.1	2.6	4.0	10.6	6.7	1.0	3.2	11.0	0.5
Vetch (spring)	15.0	85.0	1.4	2.7	6.0	4.5	0.4	1.9	6.6	0.2
Vetch (winter)	15.0	85.0	2.1	3.4	4.7	4.4	0.4	2.8	6.4	0.3
LEGUME HAY										
Alfalfa	91.6	8.4	7.4	14.3	42.7	25.0	2.2	10.6	38.9	0.9
Alsike clover	90.3	9.7	8.3	12.8	40.7	25.6	2.9	8.4	42.5	1.5
Cowpea	88.1	11.9	8.5	14.4	41.2	21.5	2.5	9.3	38.4	1.2
Crimson clover	90.4	9.6	8.6	15.2	36.6	27.2	2.8	10.5	34.9	1.2
Lespedeza (Japan clover)[1]	89.7	10.3	4.1	11.7	43.8	26.5	3.6	7.6	42.2	1.8
Peanut vine (without nuts)	92.4	7.6	10.8	10.7	42.7	23.6	4.6	6.7	42.2	3.0
Red clover (medium)	84.7	15.3	6.2	12.3	38.1	24.8	3.3	6.8	35.8	1.7
Red clover (mammoth)	78.8	21.2	6.1	10.7	33.6	24.5	3.9	5.7	32.0	1.9
Soja (Soy) bean	88.7	11.3	7.2	15.4	38.6	22.3	5.2	10.9	40.2	1.5
Vetch hay	88.7	11.3	7.9	17.0	36.1	25.4	2.3	12.9	37.5	1.4
Vetch and oats (1—1)	85.0	15.0	7.4	12.8	35.8	26.7	2.3	8.3	34.2	1.4
White clover	90.3	9.7	8.3	15.7	39.3	24.1	2.9	11.5	42.2	1.5
LEGUME STRAW										
Pea vine	86.4	....	....	....	....	....	....	4.3	32.3	0.8
Soja (Soy) bean	89.9	10.1	5.8	4.6	37.4	40.4	1.7	2.3	40.0	1.0

[1] Approximate.

TABLE I.—AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS OF AMERICAN FEED STUFFS.—(*Continued*)

Name of feed	Percentage Composition							Per cent. of digestible nutrients		
	Dry matter	Water	Ash	Protein	Nitrogen free extract (carbohydrates)	Crude fiber	Fat (ether extract)	Protein	Carbohydrates	Fat
SILAGE										
Alfalfa	27.5	....	..	..	..	..	..	3.0	8.5	1.9
Apple pomace	15.0	85.0	0.6	1.2	8.8	3.3	1.1	..	9.7	0.5
Barnyard millet and soy bean	21.0	79.0	2.8	2.8	7.2	7.2	1.0	1.6	9.2	0.7
Red clover	28.0	72.0	2.6	4.2	11.6	8.4	1.2	2.0	13.5	1.0
Corn	20.9	79.1	1.4	1.7	11.0	6.0	0.8	0.9	11.3	0.7
Corn and soy bean	24.0	76.0	2.4	2.5	11.1	7.2	0.8	1.6	13.0	0.7
Cowpea vine	20.7	79.3	2.9	2.7	7.6	6.0	1.5	1.5	8.6	0.9
Grass	32.0	....	..	..	..	..	..	1.9	13.4	1.6
Sorghum	23.9	76.1	1.1	0.8	15.3	6.4	0.3	0.6	14.9	0.2
Soy (Soja) bean	25.8	74.2	2.8	4.2	6.9	9.7	2.2	2.7	8.7	1.3
ROOTS AND TUBERS										
Artichoke	20.5	79.5	1.0	2.6	15.9	0.8	0.2	2.0	15.8	0.2
Carrots	11.4	88.6	1.2	1.2	7.5	1.3	0.2	1.0	8.1	0.2
Beet (common)	11.5	88.5	1.0	1.5	8.0	0.9	0.1	1.2	8.8	0.1
Beet (sugar)	13.5	86.5	0.9	1.8	9.8	0.9	0.1	1.1	10.2	0.1
Beet (Mangel Wurzel)	9.1	90.9	1.1	1.4	5.5	0.9	0.2	1.1	5.4	0.1
Parsnip	13.7	86.3	0.7	1.6	10.2	1.0	0.2	1.6	11.2	0.2
Potato (Irish)	21.1	78.9	1.0	2.1	17.3	0.6	0.1	0.9	16.3	0.1
Potato (sweet)	28.9	71.1	1.0	1.5	24.7	1.3	0.4	0.9	22.2	0.3
Rutabaga	11.4	88.6	1.2	1.2	7.5	1.3	0.2	1.0	8.0	0.2
Turnip (flat)	9.5	90.5	0.8	1.1	6.2	1.2	0.2	1.0	7.2	0.2

TABLE I.—AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS OF AMERICAN FEED STUFFS.—(*Continued*)

Name of feed	Percentage Composition							Per cent. of digestible nutrients		
	Dry matter	Water	Ash	Protein	Nitrogen free extract (carbohydrates)	Crude fiber	Fat (ether extract)	Protein	Carbohydrates	Fat
MISCELLANEOUS										
Acorns (fresh)	44.7	55.3	1.1	2.5	34.8	4.4	1.9	2.1	34.4	1.7
Buttermilk	9.9	90.1	0.7	4.0	4.0	..	1.2	3.9	4.0	1.1
Cabbage	9.5	90.5	1.4	2.3	3.9	1.5	0.4	1.8	4.2	0.4
Cow's milk	12 8	87.2	0.6	3.6	4.9	..	3.7	3.6	4.9	3.7
Cow's milk (colostrum)	25.4	74.6	1.5	17.6	2.7	..	3.6	17.6	2.7	3.6
Dried blood	91.5	8.5	4 7	84.3	..	..	2.5	52.3	..	2.5
Dried fish	89.2	10.8	29.2	48.4	..	..	11.6	44.1	..	10.3
Meat scrap	89.3	10.7	4.1	71.2	0.3	..	13.7	66.2	0.3	13.7
Prickly comfrey	11.6	88.4	2.2	2.4	5.1	1.6	0.3	1.4	4.6	0.2
Pumpkin (field)	9.1	90.9	0.5	1.3	5.2	1.7	0.4	1.0	5.8	0.3
Pumpkin (garden)	13.2	86.8	0.9	1.8	7.9	1.8	0.8	1.4	8.3	0.8
Rape	15.5	84.5	2.0	2.2	8.3	2.5	0.5	1.5	8.1	0.2
Skim milk (centrifugal)	9.4	90.6	0.7	3.1	5.3	..	0.3	2.9	5.2	0.3
Skim milk (gravity)	9.6	90.4	0.7	3.3	4.7	..	0.9	3.1	4.7	0.8
Spurry	24.4	75.6	4.0	2.0	12.7	4.9	0.8	1.5	9.8	0.3
Sugar-beet leaves	12.0	88.0	2.4	2.6	4.4	2.2	0.4	1.7	4.6	0.2
Tankage	93.0	7.0	18.7	44.1	9.4	7.2	13.6	31.7	15.3	13.6
Whey	6.2	93.8	0.4	0.6	5.1	..	0.1	0.6	4.7	0.1

Total digestible carbohydrates (76.475) ÷ digestible protein (7.8) = 9.8.

Nutritive ratio in this case is 1 : 9.8.

Table of Composition and Digestible Nutrients.—The composition and digestible nutrients of feed stuffs are given in Table I. The results in this table are the work of Foreign and American investigators.

Suggestion: Make the students determine the coefficients of digestibility of several feeds. Assume some percentages of digestibility for protein, fat and carbohydrates and have the students work out the nutritive ratios. If a cow is fed 6 lbs. of corn and cob meal a day what per cent. of protein, fat, and carbohydrates does it digest?

SECTION XXII.

FEEDING STANDARDS.

The amount of digestible protein, digestible fat and digestible carbohydrates required per day for animals of 1,000 lbs. live weight, for different purposes, is called the "Feeding Standard."

The table of feeding standards is based on the work of foreign investigators and is arranged after Armsby. American investigators think that these standards call for more protein than is required for our conditions and hence a reduction is sometimes recommended to secure the best results. However, the prices of protein and carbohydrates, which will be taken up later, have a great deal to do with the make up of a ration.

Henry in his valuable book on "Feeds and Feeding," says: "Standards are arranged to meet the requirements of farm animals under normal conditions. The student should not accept the statements in the standards as absolute, but rather as data of a helpful nature, to be varied in practice as circumstances suggest.

"The statements in the column headed "Dry Matter" should be regarded as approximate only, since the digestive tract of the animal readily adapts itself to variations of 10 per cent. or more from the standard of volume.

"The standards are for animals of normal size. Those of small breeds will require somewhat more nutrients, amounting in some cases to 0.3 of a pound of nitrogenous and 1.5 pounds of non-nitrogenous digestible nutrients daily for 1,000 pounds of live weight of animals.

"Narrowing the nutritive ratio in feeding full grown animals is for the purpose of lessening the depression of digestibility, to enliven the temperament, or to increase the production of milk at the expense of laying on fat.

"The different standards given for the same class of animals according to performance illustrate the manner and direction in which desirable changes should be made.

"In considering the fattening standards the student should bear in mind that the most rapid fattening is usually the most economical, so that the standard given may often be profitably increased.

"Standards for milch cows are given for the middle of the lactation period with animals yielding milk of average composition.

"The standards for growing animals contemplate only a moderate amount of exercise; if much is taken, add 15 per cent.,—(mostly non-nitrogenous nutrients)—to the ration. If no exercise is taken, deduct 15 per cent. from the standard."

Explanation of Table II.—The table on feeding standards is divided into two parts, A and B. Table A gives the amounts of dry matter and digestible nutrients required per day for farm animals under all conditions of work and rest. This table is based on 1,000 lbs. live weight. Table B is similar to Table A, except that the standards are based on the weights of the animals as mentioned. To make this clearer, the first standard in Table A is for "oxen at rest in stall." The standard reads 17.5 lbs. dry matter, 0.7 lbs protein, 8.3 lbs. carbohydrates and fat, 9.0 lbs. total, with a nutritive ratio of 1 : 11.9. This standard is for oxen, weighing 1,000 lbs., at rest in the stall. The first standard in table B is for growing cattle 2-3 months old weighing 150 lbs. The standard reads 3.3 lbs. dry matter, 0.6 lbs. protein, 2.8 lbs. carbohydrates and fat, 3.4 lbs. total, with a nutritive ratio of 1 : 4.6. This standard is figured on growing cattle weighing 150 lbs.

The digestible carbohydrates, fiber and fat are included in the column, carbohydrates and fat. The fat is reduced to terms of carbohydrates and the digestible fiber is added to the carbohydrates because it is considered of equal value.

A study of the table reveals a difference in the standards for the same class of animal according to the purpose for which the animal is fed. These standards therefore may be called feed requirements. The feed requirements may be considered for maintenance, growth, work, milk production and fattening.

Maintenance Requirements.—We learned that no matter how still an animal might be, a supply of food is necessary to keep the animal alive. The amount of dry matter and digestible nutrients

TABLE II.—FEEDING STANDARDS

A—Per day and 1,000 pounds live weight.[1]

	Dry matter pounds	Digestible Protein pounds	Digestible Carbohydrates and fat pounds	Digestible Total pounds	Nutritive ratio
Oxen at rest in stall	17.5	0.7	8.3	9.0	1:11.9
Wool sheep, coarser breeds	20.0	1.2	10.8	12.0	1: 9.0
Wool sheep, finer breeds	22.5	1.5	12.0	13.5	1: 8.0
Oxen, moderately worked	24.0	1.6	12.0	13.0	1: 7.5
Oxen, heavily worked	26.0	2.4	14.3	16.7	1: 6.0
Horses, lightly worked	20.0	1.5	10.4	11.9	1: 6.9
Horses, moderately worked	21.0	1.7	11.8	13.5	1: 6.9
Horses, heavily worked	23.0	2.3	14.3	16.6	1: 6.2
Milk cows, Wolff's standard[2]	24.0	2.5	13.4	15.9	1: 5.4
Milk cows, Wisconsin standard[2]	24.5	2.2	14.9	17.1	1: 6.8
Fattening oxen, preliminary period	27.0	2.5	16.1	18.6	1: 6.4
Fattening oxen, main period	26.0	3.0	16.4	19.4	1: 5.5
Fattening oxen, finishing period	25.0	2.7	16.2	18.9	1: 6.0
Fattening sheep, preliminary period	26.0	3.0	16.3	19.3	1: 5.4
Fattening sheep, main period	25.0	3.5	15.8	19.3	1: 4.5
Fattening swine, preliminary period	36.0	5.0	27.5	32.5	1: 5.5
Fattening swine, main period	31.0	4.0	24.0	28.0	1: 6.0
Fattening swine, finishing period	23.5	2.7	17.5	20.2	1: 6.5
Breeding ewes with lambs	25.0	2.9	16.2	19.1	1: 5.6
Brood sows	22.0	2.5	16.4	18.9	1: 6.6
Age Months — Average live weight per head					
GROWING CATTLE:					
2- 3 — 150 lbs.	22.0	4.0	18.3	22.3	1: 4.6
3- 6 — 300 lbs.	23.4	3.2	15.8	19.0	1: 4.9
6-12 — 500 lbs.	24.0	2.5	14.9	17.4	1: 6.0
12-18 — 700 lbs.	24.0	2.0	13.9	15.9	1: 7.0
18-24 — 850 lbs.	24.0	1.6	12.7	14.3	1: 8.0
GROWING SHEEP:					
5- 6 — 56 lbs.	28.0	3.2	17.4	20.6	1: 5.4
6- 8 — 67 lbs.	25.0	2.7	14.7	17.4	1: 5.4
8-11 — 75 lbs.	23.0	2.1	12.5	14.6	1: 6.0
11-15 — 82 lbs.	22.5	1.7	11.8	13.5	1: 7.0
15-20 — 85 lbs.	22.0	1.4	11.1	12.5	1: 8.0
GROWING FAT PIGS:					
2- 3 — 50 lbs.	42.0	7.5	30.0	37.5	1: 4.0
3- 5 — 100 lbs.	34.0	5.0	25.0	30.0	1: 5.0
5- 6 — 125 lbs.	31.5	4.3	23.7	28.0	1: 5.5
6- 8 — 170 lbs.	27.0	3.4	20.4	23.8	1: 6.0
8-12 — 250 lbs.	21.0	2.5	16.2	18.7	1: 6.5

[1] The fattening rations are calculated for 1,000 pounds live weight at the beginning of the fattening.

[2] For standards for milk cows see Section XXVII.

B—Per day and per head.

GROWING CATTLE:						
2- 3	150 lbs..............	3.3	0.6	2.8	3.4	1: 4.6
3- 6	300 lbs..............	7.0	1.0	4.9	5.9	1: 4.9
6-12	500 lbs..............	12.0	1.3	7.5	8.8	1: 6.0
12-18	700 lbs..............	16.8	1.4	9.7	11.1	1: 7.0
18-24	850 lbs..............	20.4	1.4	11.1	12.5	1: 8.0
GROWING SHEEP:						
5- 6	56 lbs..............	1.6	0.18	0.974	1.154	1: 5.4
6- 8	67 lbs..............	1.7	0.18	0.981	1.161	1: 5.4
8-11	75 lbs..............	1.7	0.16	0.953	1.113	1: 6.0
11-15	82 lbs..............	1.8	0.14	0.975	1.115	1: 7.0
15-20	85 lbs..............	1.9	0.12	0.955	1.075	1: 8.0
GROWING FAT SWINE:						
2- 3	50 lbs..............	2.1	0.38	1.50	1.88	1: 4.0
3- 5	100 lbs..............	3.4	0.50	2.50	3.00	1: 5.0
5- 6	125 lbs..............	3.9	0.54	2.96	3.50	1: 5.5
6- 8	170 lbs..............	4.6	0.58	3.47	4.05	1: 6.0
8-12	250 lbs..............	5.2	0.62	4.05	4.67	1: 6.5

required to keep the animal alive, which is producing and doing nothing, without a loss or gain in weight, is called the maintenance requirement. It is then the amount of nutrients required to maintain the animal body. The feeding standard for "oxen at rest in stall" is an example of a maintenance requirement.

Growth Requirements.—In the composition of farm animals we found that the young animal contains a larger percentage of water than the mature animal, and a gain in weight of the young animal shows less dry matter and more water than with the mature animal. We also learned that the dry matter of the young animal contains more protein and less fat than that of the mature animal. Hence the requirements for growth show a larger proportion of protein to carbohydrates than for the older animals. The following standards per 1,000 lbs. live weight, illustrate this point.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds	Nutritive ratio
Cattle, 3–6 months old............	23.4	3.2	15.8	1:4.9
Oxen, moderately worked....	24.0	1.6	12.0	1:7.5

Work Requirements.—A working animal requires protein to repair the broken down tissues and carbohydrates and fats to produce energy. Therefore the harder an animal has to work the more protein and carbohydrates are needed. The protein

Fig. 11.—Saddle horse; a moderately worked animal—after Good.

is usually increased in greater proportion than the carbohydrates. The standards for horses illustrate this:

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds	Nutritive ratio
Horses, lightly worked	20	1.5	10.4	1:6.9
Horses, moderately worked	21	1.7	11.8	1:6.9
Horses, heavily worked	23	2.3	14.3	1:6.2

Milk Production Requirements.—The protein requirements for milk production are not entirely satisfactory for all parts of this country, and this will be discussed later. Suffice it to say that milk contains nitrogenous compounds, and enough protein must be supplied to produce a good flow of milk and perform the necessary functions of the animal body.

Fattening Requirements.—In the production of fat, carbohydrates and fat of feed stuffs are mainly used. Hence the ration for fattening animals should contain a considerable proportion of non-nitrogenous substances. Too much of an excess of carbohydrates and fats is undesirable as such excess interferes with digestion. A small proportion of the ration should consist of digestible protein which aids in the digestion and consumption of fattening rations. Kellner recommends 1 pound of digestible protein to 8-10 pounds of carbohydrates and fat.

SECTION XXIII.

HOW TO BALANCE A RATION AND TERMS OF A NUTRITIVE RATIO.[1]

Trial Ration.—Referring to Table I (Composition and Digestible Nutrients) and Table II (Feeding Standards) and knowing the meaning of the terms as set forth in the preceding pages, it will now be a simple matter of arithmetic and judgment to compute or balance any ration.

Let us suppose, for example, that we have a horse or a mule at home ploughing. Ploughing all day is hard or heavy work. Now if we turn to Table II we find that the standard for a horse weighing 1,000 lbs. heavily worked is as follows:

Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds	Nutritive ratio
23	2.3	14.3	1:6.2

This means that if our horse at home doing heavy work, weighs 1,000 lbs., the requirement will be 23 lbs. of dry matter, 2.3 lbs. of digestible protein, and 14.3 lbs. of digestible carbohydrates to satisfy its needs for a day of 24 hours.

Let us suppose we have the following feed stuffs at home: Cotton-seed meal, corn (shelled), wheat bran and timothy hay. To figure our ration let us try 2 lbs. of cotton-seed meal, 6 lbs. of shelled corn, 6 lbs. of wheat bran and 10 lbs. of timothy hay. We must now find the total dry matter, digestible protein, digestible carbohydrates and fat, in each of the above feeds that make up our ration. Referring to Table I we find that 100 lbs. of cotton-seed meal contain 91.8 lbs. of dry matter, 37.2 lbs. of digestible protein, 16.9 lbs. of digestible carbohydrates and 12.2 lbs. of digestible fat. Then as 2 lbs. of cotton-seed meal are included in our trial ration we get the amounts of digestible nutrients as stated.

[1] Adapted from Halligan's Fundamentals of Agriculture.

2 lbs. × 0.918 = 1.836 lbs. of dry matter.
2 lbs. × 0.372 = 0.744 lbs. of digestible protein.
2 lbs. × 0.169 = 0.338 lbs. of digestible carbohydrates.
2 lbs. × 0.122 = 0.244 lbs. of digestible fats.

In the same way we arrive at the digestible amounts contained in 6 lbs. of shelled corn, 6 lbs. of wheat bran and 10 lbs. of timothy hay. Then we add together the dry matter and digestible nutrients in the cotton-seed meal, shelled corn, wheat bran and timothy hay and compare the result with the standard.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds	Digestible fat pounds
2 lbs. cotton-seed meal	1.836	0.744	0.338	0.244
6 lbs. shelled corn	5.364	0.468	4.008	0.258
6 lbs. wheat bran	5.286	0.726	2.352	0.162
10 lbs. timothy hay	8.680	0.280	4.340	0.140
24 lbs. total	21.166	2.218	11.038	0.804

To reduce the fat to terms of carbohydrates we must multiply by 2.25. 0.804 × 2.25 = 1.809. 11.038 + 1.809 = 12.847 lbs. total digestible carbohydrates. 12.847 (total digestible carbohydrates) ÷ 2.218 (digestible protein) = 5.8. That is, the nutritive ratio is 1 : 5.8. This trial ration is stated as follows:

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds	Nutritive ratio
Ration	21.166	2.218	12.847	1:5.8
Standard	23.	2.3	14.3	1:6.2

Balancing the Ration.—This trial ration is not entirely satisfactory. It is almost correct for dry matter and near enough to the standard in protein. It is too low in carbohydrates. We must correct the ration to make it more nearly approximate the standard. Let us add 3 lbs. of timothy hay and see what effect it has on balancing the ration.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds	Digestible fat pounds
2 lbs. cotton-seed meal	1.836	0.744	0.338	0.244
6 lbs. shelled corn	5.364	0.468	4.008	0.258
6 lbs. wheat bran	5.286	0.726	2.352	0.162
13 lbs. timothy hay	11.284	0.364	5.642	0.182
27 lbs. total	23.770	2.302	12.340	0.846

The ration as it now stands.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds	Nutritive ratio
Ration	23.77	2.302	14.244	1:6.2
Standard..........................	23.	2.3	14.3	1:6.2

It is practically impossible to get the exact amounts as laid down in the standard. The above ration is perhaps nearer the standard than one will ordinarily approximate.

Rations for Animals Weighing More or Less Than 1,000 Lbs.—If animals weigh more or less than 1,000 lbs. it is necessary to increase or decrease the amounts of the feed proportionately. The nutritive ratio, however, should remain the same. In the above example suppose the horse weighs 1,200 lbs., then we would increase the amounts of feed one-fifth. That is, instead of feeding 2 lbs. of cotton-seed meal, 6 lbs. of shelled corn, 6 lbs. of wheat bran and 13 lbs. of timothy hay we would feed 2.4 lbs. of cotton-seed meal, 7.2 lbs. shelled corn, 7.2 lbs. of wheat bran and 15.6 lbs. of timothy hay. If the animal weighed less than 1,000 lbs. the ration should be proportionately reduced. Sometimes the individuality of the animal must be considered. Dairy cattle weighing 700 lbs. giving 25 lbs. of milk need more feed than dairy cattle weighing the same but only giving 15 lbs. of milk.

Terms of Nutritive Ratio.—Narrow, wide and medium are the terms applied to nutritive ratios.

Narrow Ration.—A narrow ration is one in which the proportion of protein is large as compared to the carbohydrates. A ration having a nutritive ratio less than 1 : 5.5 is considered narrow.

A narrow ration.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds	Digestible fat pounds
3 lbs. cotton-seed meal	2.754	1.116	0.507	0.366
10 lbs. wheat bran	8.810	1.210	3.920	0.270
15 lbs. crimson clover hay	13.560	1.575	5.235	0.180
28 lbs. total	25.124	3.901	9.662	0.816

Nutritive ratio 1:2.9

The protein in the above ration is high as compared to the carbohydrates. Nitrogenous ration is another name sometimes applied to a narrow ration because of the predominance of nitrogenous substances (protein).

Wide Ration.—A wide nutritive ratio is one where the proportion of carbohydrates is large as compared to the protein. Such a ration has a nutritive ratio of more than 1 : 8.0

A wide ration.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds	Digestible fat pounds
5 lbs. oats	4.450	0.465	2.380	0.175
10 lbs. corn and cob meal	8.490	0.440	6.000	0.290
15 lbs. timothy hay	13.020	0.420	6.510	0.210
30 lbs. total	25.960	1.325	14.890	0.675

Nutritive ratio 1:12.4

This style of ration is sometimes called carbonaceous on account of the high proportion of carbohydrates, but the term is incorrect because protein as well as carbohydrates contains carbonaceous compounds.

Medium Ration.—A ration with a nutritive ratio between 1:5.5 and 1: 8.0 is called a medium ration.

A medium ration.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds	Digestible fat pounds
3 lbs. dried brewers' grains	2.754	0.471	1.089	0.153
6 lbs. wheat middlings	5.274	0.768	3.180	0.204
15 lbs. corn stover	11.580	0.420	6.345	0.105
5 lbs. alfalfa hay	4.580	0.530	1.945	0.045
29 lbs. total	24.188	2.189	12.559	0.057

Nutritive ratio 1:6.3

SECTION XXIV.

AMOUNTS OF ROUGHAGE AND CONCENTRATES TO FEED.

Amounts of Roughage and Concentrates to Feed.—In compounding rations for live stock it is necessary that the proper amounts of roughage and concentrates accompany each other. It is practically impossible to state just the amounts of roughage and grain to furnish animals for different purposes, as available feeds and prices influence the make up of the ration. The following considerations therefore are only approximate.

Milch Cows.—In rations for milch cows we should aim to supply 12-14 lbs. of dry matter from roughage and the balance with 8-12 lbs. of grain. Sometimes as high as 50 lbs. of silage are fed to milch cows but usually 30 to 40 lbs. are sufficient.

Fattening Cattle do well on 2 lbs. of grain to 1 lb. of roughage. 8 to 10 lbs. of roughage and 15 to 18 lbs. of grain per 1,000 lbs. live weight are perhaps sufficient for this class of animal.

Horses or Mules.—For horses or mules 10 to 12 lbs. of hay are usually enough. 1 lb. of roughage to 100 lbs. live weight is a crude method of estimating the quantity of roughage for a horse or mule. A horse or mule weighing 1,200 lbs. would therefore receive, according to this method, 12 lbs. of hay.

When the concentrates of a ration are carbohydrate in character, the roughage should be nitrogenous (legumes for example) and should the concentrates be nitrogenous the roughage should be relatively high in carbohydrates (grass hay for example). In other words the roughage and concentrates should be complements of each other.

1. A few illustrations perhaps will make these points clearer. The standard for a horse weighing 1,000 lbs., doing hard work, is according to Table II:

Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds	Nutritive ratio
23	2.3	14.3	1:6.2

A ration to meet the protein standard using red top hay alone would take 48 lbs.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds
48 lbs. red top hay	43.728	2.304	23.592
Standard	23.	2.3	14.3

There is an excess of 20.7 lbs. of dry matter and a waste of 9.29 lbs. of carbohydrates in such a ration. A horse could not perform hard work with this ration as it would be impossible for this class of animal to consume such a large quantity of hay.

2. Using 15 lbs. of corn (grain), it will take 40 lbs. of timothy hay to approximate the protein requirement.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds
15 lbs. corn	13.410	1.170	11.471
40 lbs. timothy hay	34.720	1.120	18 620
55 lbs. total	48.130	2.290	30.091

This combination is unsatisfactory because it exceeds the dry matter standard by 25 lbs. and there is a waste of 15.7 lbs. of carbohydrates. Both of these feeds are proportionately high in carbohydrates.

3. Substituting alfalfa hay (which is nitrogenous) for the timothy it will take 10 lbs. of the former to satisfy the protein standard with 15 lbs. of corn.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds
15 lbs. corn	13.410	1.170	11.471
10 lbs. alfalfa hay	9.160	1.060	4.093
Ration	22.570	2.230	15.564
Standard	23.	2.3	14.3

This combination practically balances the ration although the carbohydrates are slightly in excess. In this ration the corn is proportionately high in carbohydrates and the alfalfa is relatively high in protein. These feeds are then complements of each other. This ration should prove satisfactory as the total feed is not too large in amount and the roughage is within the limit of the requirements for a horse.

4. Using oats alone would require 25 lbs. to approximate the standard.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds
25 lbs. oats	22.25	2.325	13.869
Standard	23.	2.3	14.3

A ration of oats alone is not suitable because of the excess of concentrate. Roughage is required for the best results. Such a ration would prove too expensive for the economical feeder.

5. If we reduce the amount of oats to 15 lbs. and add enough red top hay to meet the protein requirement, 18 lbs. will be needed.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds
15 lbs. oats	13.350	1.395	8.321
18 lbs. red top hay	16.398	0.864	8.847
33 lbs. total	29.748	2.259	17.168

This ration contains 6.7 lbs. too much of dry matter and 2.8 lbs. excess of carbohydrates.

6. It is evident that a nitrogenous roughage must be added and the amount of red top hay reduced.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds
15 lbs. oats	13.350	1.395	8.321
7 lbs. red top hay	6.377	0.336	3.441
6 lbs. alfalfa hay	5.496	0.636	2.456
Ration	25.223	2.367	14.218
Standard	23.	2.3	14.3

The ration as it now stands is properly balanced. It is not enough too high in dry matter to affect its usefulness and the protein and carbohydrates are sufficiently close.

7. Generally a variation from the standard shows a predominance of carbohydrates and dry matter but sometimes an excess of protein is employed. The following ration illustrates a predominance of protein:

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds
12 lbs. oats	10.680	1.116	6.657
2 lbs. cotton-seed meal	11.836	0.744	0.887
15 lbs. alsike clover hay	13.545	1.260	6.881
Ration	26.061	3.120	14.425
Standard	23.	2.3	14.3

This ration shows a waste of 0.8 of a pound of protein which is generally the most expensive nutrient in feed stuffs. The roughage in this ration is also a little high. The carbohydrates agree with the standard.

Feeding Standards are Guides.—It must be understood that the feeding standards are only guides and the intelligent feeder will often find it necessary to change the standard to suit his conditions. In other words the feeder must use the feeding standards to approximate the requirements of his live-stock from the feeds that are available and cheapest.

The following table is given to enable the feeder to compound rations easily. In making rations for animals, large amounts of the grain portion can be mixed at one time. This saves the trouble of mixing and calculating at every feeding. The measure of roots, molasses, hay, fodder and ensilage can be determined once and fed accordingly without any inconvenience.

Suggestion:—Compute a ration for a moderately worked horse weighing 1,000 lbs. from cotton-seed meal, wheat bran and molasses (cane). Criticize this ration.

How much hay are the horses or mules receiving per day in your community? Is this too much? Are not some feeders allowing their horses all the roughage they wish? Is this good practice?

WEIGHT AND MEASURE OF FEED STUFFS[1]

	One quart weighs pounds	One pound measures quarts
Alfalfa meal	1.0	1.0
Barley meal	1.1	0.9
Barley (whole)	1.5	0.7
Brewers' dried grains	0.6	1.7
Corn and cob meal	1.4	0.7
Corn and oat feed	0.7	1.4
Corn bran	0.5	2.0
Corn meal	1.5	0.7
Corn (whole)	1.7	0.6
Cotton-seed meal	1.5	0.7
Cotton-seed hulls	0.26	3.8
Distillers' dried grains	0.5-0.7	1.0-1.4
Germ oil meal	1.4	0.7
Gluten feed	1.3	0.8
Gluten meal	1.7	0.6
Hominy meal	1.1	0.9
Linseed meal (new process)	0.9	1.1
Linseed meal (old process)	1.1	0.9
Malt sprouts	0.6	1.7
Molasses (cane, blackstrap)	3.0	0.3
Oats (ground)	0.7	1.4
Oats (whole)	1.0	1.0
Rice bran	0.8	1.3
Rice polish	1.2	0.8
Rye bran	0.6	1.8
Rye meal	1.5	0.7
Rye (whole)	1.7	0.6
Wheat bran	0.5	2.0
Wheat (ground)	1.7	0.6
Wheat middlings (flour)	1.2	0 8
Wheat middlings (standard)	0.8	1.3
Wheat mixed feed (bran and shorts)	0.6	1.7
Wheat (whole)	2.0	0.5

[1] The data on wheat mixed feed was taken from Bul. 112, Massachusetts Experiment Station; the data on alfalfa meal, cotton-seed hulls, molasses and rice products were worked out by the writer; the remaining data came from Farmers' Bul. 222.

SECTION XXV.

HOW TO IMPROVE AND REDUCE THE COST OF RATIONS.[1]

A Common Ration.—A herd of milch cows is receiving the following ration per day of 24 hours, per 1,000 lbs. live weight; 5 lbs. of cotton-seed meal, 3 lbs. of wheat bran, 10 lbs. of red clover hay (medium) and 15 lbs. of corn stover. Let us figure this ration and find out if it is properly balanced for the herd of dairy cows. Turn to Table I and find that the following amounts of digestible nutrients are present in 100 lbs. of each feed stuff.

	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
Cotton-seed meal	91.8	37.2	16.9	12.2
Wheat bran	88.1	12.1	39.2	2.7
Red clover hay	84.7	6.8	35.8	1.7
Corn stover	77.2	2.8	42.3	0.7

Then as 5 lbs. of cotton-seed meal are in the ration, we multiply the amounts of dry matter, digestible protein, digestible carbohydrates and digestible fat as given above for cotton-seed meal, by 5. Or

$5 \times 0.918 = 4.590$ lbs. of dry matter in 5 lbs. of cotton-seed meal.

$5 \times 0.372 = 1.860$ lbs. of digestible protein in 5 lbs. of cotton-seed meal.

$5 \times 0.169 = 0.845$ lbs. of digestible carbohydrates in 5 lbs. of cotton-seed meal.

$5 \times 0.122 = 0.610$ lbs. of digestible fat in 5 lbs. of cotton-seed meal.

In the same way we compute the digestible nutrients in the wheat bran, red clover hay and corn stover.

[1] Adapted from Halligan's Fundamentals of Agriculture.

	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
5 lbs. cotton-seed meal	4.590	1.860	0.845	0.610
3 lbs. wheat bran	2.643	0.363	1.176	0.081
10 lbs. red clover hay	8.470	0.680	3.580	0.170
15 lbs. corn stover	11.580	0.420	6.345	0.105
33 lbs. total	27.283	3.323	11.946	0.966

With the fat reduced to carbohydrates the ration reads:

				Nutritive ratio
Ration	27.283	3.323	14.1195	1:4.2
Standard	24.	2.5	13.4	1:5.4

The ration is too high in dry matter, digestible protein and digestible carbohydrates. The ration is also too narrow.

Improving the Ration.—Let us try to improve this ration by supplying less of the nutrients and particularly less protein. By consulting Table I we learn that cotton-seed meal has more digestible protein than any of the other feeds in this ration. Suppose then we reduce the amount of cotton-seed meal to 3 lbs. Then the ration will be as follows:

	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
3 lbs. cotton-seed meal	2.754	1.116	0.507	0.366
3 lbs. wheat bran	2.643	0.363	1.176	0.081
10 lbs. red clover hay	8.470	0.680	3.580	0.170
15 lbs. corn stover	11.580	0.420	6.345	0.105
31 lbs. total	25.447	2.579	11.608	0.722
				Nutritive ratio
Improved ration	25.447	2.579	13.232	1:5.1
Standard	24.	2.5	13.4	1:5.4

The ration as it now stands approximates the standard. It is close enough to the standard for all practical purposes.

How to Reduce the Cost of a Ration.—John Smith has a large farm and he is feeding his 15 horses which weigh 1,000 lbs., that are doing hard work, the following ration.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds	Digestible fat pounds
8 lbs. oats	7.120	0.736	3.784	0.336
4 lbs. shelled corn	3.576	0.312	2.672	0.172
6 lbs. wheat bran	5.286	0.726	2.352	0.162
10 lbs. timothy hay	8.680	0.280	4.340	0.140
28 lbs. total	24.662	2.054	13.148	0.810
				Nutritive ratio
Ration	24.662	2.054	14.9705	1:7.3
Standard	23.	2.3	14.3	1:6.2

Cost of the Ration.—Let us learn what it is costing John Smith to feed his horses. The following are the market prices of some of the feeds which are available to John Smith.

	Per ton of 2,000 pounds
Oats	$35.00
Shelled corn	28.00
Wheat bran	25.00
Timothy hay	18.00
Crab grass hay	15.00
Cotton-seed meal	26.00
Corn and cob meal	22.00

Oats cost $35 per ton of 2,000 lbs. One pound of oats costs $0.0175. Then 8 lbs. will cost 8 × 0.0175 = $0.14. In a similar way the cost of the shelled corn, wheat bran and timothy hay are calculated.

	Cost
8 lbs. oats	$ 0.14
4 lbs. shelled corn	0.056
6 lbs. wheat bran	0.075
10 lbs. timothy hay	0.090
Total cost per day's ration	= $ 0.361

It is costing John Smith $0.361 per day per horse. Or it is costing him 15 × $0.361 = $5.415 for his 15 horses per day. We will now substitute some other feeds and see if we cannot reduce John Smith's feed bill.

A Cheaper Ration.—Oats, shelled corn and timothy hay are the expensive feeds in this ration, considering the nutrients they furnish. By perusing Table I we find that cotton-seed meal contains a high per cent. of digestible protein. We can substitute this feed for oats. Shelled corn and corn and cob meal contain about the same amounts of dry matter and digestible carbohydrates, so we may substitute corn and cob meal for shelled corn. The shelled corn is richer in digestible protein than the corn and cob meal but we can get this nutrient cheaper from our wheat bran. The crab grass hay is of about the same nutritive value as timothy hay. It is also cheaper so we will use crab grass hay in place of timothy hay. A balanced ration from these feeds would be as stated.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds	Digestible fat pounds
2 lbs. cotton-seed meal	1.836	0.744	0.338	0.244
7 lbs. corn and cob meal	5.943	0.308	4.200	0.203
8 lbs. wheat bran	7.048	0.968	3.136	0.216
12 lbs. crab grass hay	10.764	0.264	5.136	0.072
29 lbs. total	25.591	2.284	12.810	0.735
				Nutritive ratio
Ration	25.591	2.284	14.464	1:6.3
Standard	23.	2.3	14.3	1:6.2

Compared to the Standard.—This ration is better than the one John Smith is feeding. It comes nearer the standard. The dry matter and carbohydrates in John Smith's ration approximate the standard but the protein is too low and his ration is too wide. The dry matter in this second ration is a little high, but animals can take care of an excess of dry matter within certain limits as previously explained. The protein and carbohydrates in the balanced ration are very close to the standard. The nutritive ratio very closely approximates the standard nutritive ratio.

The Saving.—At the market prices the new ration will cost,

2 lbs. cotton-seed meal	$0.026
7 lbs. corn and cob meal	0.077
8 lbs. wheat bran	0.100
12 lbs. crab grass hay	0.090
Total cost per ration	$0.293

In other words this ration will cost John Smith $0.293 per day per horse. The ration of John Smith's costs $0.361 per day per horse. This new ration will save John Smith $0.361 — $0.293 = $0.068 per day per horse. On 15 horses the saving will be 15 × $0.068 = $1.02 per day. In a year the saving will amount to 365 × $1.02 = $372.30. This example just cited is not exceptional. There are many farmers, livery men and other feeders who throw away money every year because of a poor selection of feeds and still they do not always get the best returns. This second ration, as it more closely approximates the standard, is indeed a better one, besides being cheaper than John Smith's ration.

Suggestion:—Select a few rations fed in the county and have the students ascertain the market values of the feeds and reduce the cost and improve these rations as much as possible.

SECTION XXVI.

TABLE OF AMOUNTS OF DRY MATTER AND DIGESTIBLE NUTRIENTS IN FEED STUFFS.

Table III which follows, is given to save the student considerable work in figuring rations. It gives the dry matter and the digestible nutrients in 1, 2, 3, 4, 5, 7, and 10 pounds of several feed stuffs commonly used.

In Table I the composition and digestible nutrients of feed stuffs are given but in figuring rations from Table I a great deal of work is necessary. The figures in Table I are based on 100 lbs. of material so in obtaining data for any amount less than 100 lbs. involves a chance for error.

Use of Table III.—Let us suppose we wish to feed a ration composed of 5 lbs. of oats, 10 lbs. of alfalfa hay and 4 lbs. of corn (grain) per day. By referring to Table III we find that these quantities of the stated feeds carry the following amounts of dry matter and digestible nutrients.

	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds	Digestible fat pounds
5 lbs. oats	4.450	0.465	2.380	0.175
4 lbs. corn	3.576	0.312	2.672	0.172
10 lbs. alfalfa hay	9.160	1.060	3.890	0.090
Total	17.186	1.837	8.942	0.437
Ration	17.186	1.837	9.925	

The digestible fat as given in the table must be reduced to carbohydrates to get the total carbohydrates. It is only necessary to do this once, however, after the amounts for the ration have been added, as was done above.

If amounts other than those given in the table are desired it is only necessary to multiply, divide or add some of those given. For example, if the amounts of dry matter and digestible nutrients for 6 lbs. are wished we would multiply the amounts given for 3 lbs., by 2. If 9 lbs. are wanted, add the amounts

TABLE III.—DRY MATTER AND DIGESTIBLE NUTRIENTS IN 1, 2, 3, 4, 5, 7 AND 10 POUNDS OF FEED STUFFS.

Feed	Weight pounds	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
Barley (grain)	1	0.891	0.087	0.656	0.016
	2	1.782	0.174	1.312	0.032
	3	2.673	0.261	1.968	0.048
	4	3.564	0.348	2.624	0.064
	5	4.455	0.435	3.280	0.080
	7	6.237	0 609	4.592	0.112
	10	8.910	0.870	6.560	0.160
Beet pulp (dried)	1	0.920	0.061	0 687	.....
	2	1.840	0.122	1.374	.....
	3	2.760	0.183	2.061	.....
	4	3.680	0.244	2.748	.....
	5	4 600	0.305	3.435	.....
	7	6.440	0.427	4.809	.....
	10	9.200	0.610	6.870	.....
Brewers' grains (dried)	1	0.918	0.157	0.363	0.051
	2	1.836	0.314	0.726	0.102
	3	2.754	0.471	1.089	0.153
	4	3.672	0.628	1.452	0.204
	5	4.590	0.785	1.815	0.255
	7	6.426	1.099	2.541	0.357
	10	9.180	1.570	3.630	0.510
Buckwheat (grain)	1	0.874	0.077	0.492	0.018
	2	1.748	0.154	0.984	0.036
	3	2.622	0.231	1.476	0.054
	4	3.496	0.308	1.968	0.072
	5	4.370	0.385	2.460	0.090
	7	6.118	0.539	3.444	0.126
	10	8.740	0.770	4.920	0.180
Corn (grain)	1	0.894	0.078	0.668	0.043
	2	1.788	0.156	1.336	0.086
	3	2.682	0.234	2.004	0.129
	4	3.576	0.312	2.672	0.172
	5	4.470	0.390	3.340	0.215
	7	6.258	0.546	4.676	0.301
	10	8.940	0.780	6.680	0.430
Corn meal	1	0.850	0.055	0.645	0.035
	2	1.700	0.110	1.290	0.070
	3	2.550	0.165	1.935	0.105
	4	3.400	0.220	2.580	0.140
	5	4.250	0.275	3.225	0.175
	7	5.950	0.385	4.515	0.245
	10	8.500	0.550	6.450	0.350
Corn and cob meal	1	0.849	0.044	0.600	0.029
	2	1.698	0.088	1.200	0.058
	3	2.547	0.132	1.800	0.087

TABLE III.—DRY MATTER AND DIGESTIBLE NUTRIENTS IN 1, 2, 3, 4, 5, 7 AND 10 POUNDS OF FEED STUFFS.—(*Continued*)

Feed	Weight pounds	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
Corn and cob meal (cont'd).	4	3.396	0.176	2.400	0.116
	5	4.245	0.220	3.000	0.145
	7	5.943	0.308	4.200	0.203
	10	8.490	0.440	6.000	0.290
Cotton-seed (raw)	1	0.897	0.125	0.300	0.173
	2	1.794	0.250	0.600	0.346
	3	2.691	0.375	0.900	0.519
	4	3.588	0.500	1.200	0.692
	5	4.485	0.625	1.500	0.865
	7	6.279	0.875	2.100	1.211
	10	8.970	1.250	3.000	1.730
Cotton-seed hulls	1	0.889	0.003	0.331	0.017
	2	1.778	0.006	0.662	0.034
	3	2.667	0.009	0.993	0.051
	4	3.556	0.012	1.324	0.068
	5	4.445	0.015	1.655	0.085
	7	6.223	0.021	2.317	0.119
	10	8.890	0.030	3.310	0.170
Cotton-seed meal	1	0.918	0.372	0.169	0.122
	2	1.836	0.744	0.338	0.244
	3	2.754	1.116	0.507	0.366
	4	3.672	1.488	0.676	0.488
	5	4.590	1.860	0.845	0.610
	7	6.426	2.604	1.183	0.854
	10	9.180	3.720	1.690	1.220
Distillers' dried grains	1	0.920	0.231	0.394	0.115
	2	1.840	0.462	0.788	0.230
	3	2.760	0.693	1.182	0.345
	4	3.680	0.924	1.576	0.460
	5	4.600	1.165	1.970	0.575
	7	6.440	1.627	2.758	0.805
	10	9.200	2.310	3.940	1.150
Flour (dark feeding)	1	0.903	0.135	0.513	0.020
	2	1.806	0.270	1.026	0.040
	3	2.709	0.405	1.539	0.060
	4	3.612	0.540	2.052	0.080
	5	4.515	0.675	2.565	0.100
	7	6.321	0.945	3.591	0.140
	10	9.030	1.350	5.130	0.200
Gluten feed	1	0.915	0.223	0.529	0.026
	2	1.830	0.446	1.058	0.052
	3	2.745	0.669	1.587	0.078
	4	3.660	0.892	2.116	0.104
	5	4.575	1.115	2.645	0.130
	7	6.405	1.561	3.703	0.182

TABLE III.—DRY MATTER AND DIGESTIBLE NUTRIENTS IN 1, 2, 3, 4, 5, 7 AND 10 POUNDS OF FEED STUFFS.—(*Continued*)

Feed	Weight pounds	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
Gluten feed (continued)....	10	9.150	2.230	5.290	0.260
Gluten meal..............	1	0.918	0.258	0.433	0.110
	2	1.836	0.516	0.866	0.220
	3	2.754	0.774	1.299	0.330
	4	3.672	1.032	1.732	0.440
	5	4.590	1.290	2.165	0.550
	7	6.426	1.806	3.031	0.770
	10	9.180	2.580	4.330	1.110
Hominy chops	1	0.889	0.075	0.552	0.068
	2	1.778	0.150	1.104	0.136
	3	2.667	0.225	1.656	0.204
	4	3.556	0.300	2.208	0.272
	5	4.445	0.375	2.760	0.340
	7	6.223	0.525	3.864	0.476
	10	8.890	0.750	5.520	0.680
Hominy meal.............	1	0.890	0.068	0.598	0.072
	2	1.780	0.136	1.196	0.144
	3	2.670	0.204	1.794	0.216
	4	3.560	0.272	2.392	0.288
	5	4.450	0.340	2.990	0.360
	7	6.230	0.476	4.186	0.504
	10	8.900	0.680	5.980	0.720
Kaffir corn	1	0.907	0.078	0.571	0.021
	2	1.814	0.156	1.142	0.042
	3	2.721	0.234	1.713	0.063
	4	3.628	0.312	2.284	0.084
	5	4.535	0.390	2.855	0.105
	7	6.349	0.546	3.997	0.147
	10	9.070	0.780	5.710	0.210
Linseed meal (old process) .	1	0.908	0.293	0.327	0.070
	2	1.816	0.586	0.654	0.140
	3	2.724	0.879	0.981	0.210
	4	3.632	1.172	1.308	0.280
	5	4.540	1.465	1.635	0.350
	7	6.356	2.051	2.289	0.490
	10	9.080	2.930	3.270	0.700
Linseed meal (new process).	1	0.899	0.282	0.401	0.028
	2	1.798	0.564	0.802	0.056
	3	2.697	0.846	1.203	0.084
	4	3.596	1.128	1.604	0.112
	5	4.495	1.410	2.005	0.140
	7	6.293	1.974	2.807	0.196
	10	8.990	2.820	4.010	0.280
Malt sprouts	1	0.898	0.186	0.371	0.017

TABLE III.—DRY MATTER AND DIGESTIBLE NUTRIENTS IN 1, 2, 3, 4, 5, 7 AND 10 POUNDS OF FEED STUFFS.—(*Continued*)

Feed	Weight pounds	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
Malt sprouts (continued)...	2	1.796	0.372	0.742	0.034
	3	2.694	0.558	1.113	0.051
	4	3.592	0.744	1.484	0.068
	5	4.490	0.930	1.855	0.085
	7	6.286	1.302	2.597	0.119
	10	8.980	1.860	3.710	0.170
Molasses (beet)............	1	0.792	.....	0.595	.....
	2	1.584	.....	1.190	.....
	3	2.376	.....	1.785	.....
	4	3.168	.....	2.380	.....
	5	3.960	.....	2.975	.....
	7	5.544	.....	4.165	.....
	10	7.920	.....	5.950	.....
Molasses (cane, blackstrap).	1	0.776	.....	0.659	.....
	2	1.552	.....	1.318	.....
	3	2.328	.....	1.977	.....
	4	3.104	.....	2.636	.....
	5	3.880	.....	3.295	.....
	7	5.432	.....	4.613	.....
	10	7.760	.....	6.590	.....
Oats	1	0.890	0.093	0.476	0.035
	2	1.780	0.186	0.952	0.070
	3	2.670	0.279	1.428	0.105
	4	3.560	0.372	1.904	0.140
	5	4.450	0.465	2.380	0.175
	7	6.230	0.651	3.332	0.245
	10	8.900	0.930	4.760	0.350
Peanut meal	1	0.893	0.429	0.228	0.069
	2	1.786	0.858	0.456	0.138
	3	2.679	1.287	0.684	0.207
	4	3.572	1.716	0.912	0.276
	5	4.465	2.145	1.140	0.345
	7	6.251	3.003	1.596	0.483
	10	8.930	4.290	2.280	0.690
Rice (clean)	1	0.872	0.048	0.722	0.003
	2	1.744	0.096	1.444	0.006
	3	2 616	0.144	2.166	0.009
	4	3.488	0.192	2.888	0.012
	5	4.360	0.240	3.610	0.015
	7	6.104	0.336	5.054	0.021
	10	8.720	0.480	7.220	0.030
Rice bran (15 per cent. hulls)	1	0.901	0.064	0.367	0.054
	2	1.802	0.128	0.734	0.108
	3	2.703	0.192	1.101	0.162
	4	3.604	0.256	1.468	0.216

TABLE III.—DRY MATTER AND DIGESTIBLE NUTRIENTS IN 1, 2, 3, 4, 5, 7 AND 10 POUNDS OF FEED STUFFS.—(*Continued*)

Feed	Weight pounds	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
Rice bran (15 per cent. hulls) (continued)	5	4.505	0.320	1.835	0.270
	7	6.307	0.448	2.569	0.378
	10	9.010	0.640	3.670	0.540
Rice meal (pure bran)	1	0.914	0.086	0.400	0.059
	2	1.828	0.172	0.800	0.118
	3	2.742	0.258	1.200	0.177
	4	3.656	0.344	1.600	0.236
	5	4.570	0.430	2.000	0.295
	7	6.398	0.602	2.800	0.413
	10	9.140	0.860	4.000	0.590
Rice polish	1	0.885	0.073	0.604	0.043
	2	1.770	0.146	1.208	0.086
	3	2.655	0.219	1.812	0.129
	4	3.540	0.292	2.416	0.172
	5	4.425	0.365	3.020	0.215
	7	6.195	0.511	4.228	0.301
	10	8.850	0.730	6.040	0.430
Rye (grain)	1	0.884	0.099	0.676	0.011
	2	1.768	0.198	1.352	0.022
	3	2.652	0.297	2.028	0.033
	4	3.536	0.396	2.704	0.044
	5	4.420	0.495	3.380	0.055
	7	6.188	0.693	4.732	0.077
	10	8.840	0.990	6.760	0.110
Wheat (grain)	1	0.895	0.102	0.692	0.017
	2	1.790	0.204	1.384	0.034
	3	2.685	0.306	2.076	0.051
	4	3.580	0.408	2.768	0.068
	5	4.475	0.510	3.460	0.085
	7	6.265	0.714	4.844	0.119
	10	8.950	1.020	6.920	0.170
Wheat bran	1	0.881	0.121	0.392	0.027
	2	1.762	0.242	0.784	0.054
	3	2.643	0.363	1.176	0.081
	4	3.524	0.484	1.568	0.108
	5	4.405	0.605	1.960	0.135
	7	6.167	0.847	2.744	0.189
	10	8.810	1.210	3.920	0.270
Wheat middlings	1	0.879	0.128	0.530	0.034
	2	1.758	0.256	1.060	0.068
	3	2.637	0.384	1.590	0.102
	4	3.516	0.512	2.120	0.136
	5	4.395	0.640	2.650	0.170
	7	6.153	0.896	3.710	0.238

TABLE III.—DRY MATTER AND DIGESTIBLE NUTRIENTS IN 1, 2, 3, 4, 5, 7 AND 10 POUNDS OF FEED STUFFS.—(*Continued*)

Feed	Weight pounds	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
Wheat middlings (cont'd) ..	10	8.790	1.280	5.300	0.340
Corn fodder (whole plant)..	1	0.678	0.026	0.375	0.009
	2	1.356	0.052	0.750	0.018
	3	2.034	0.078	1.125	0.027
	4	2.712	0.104	1.500	0.036
	5	3.390	0.130	1.875	0.045
	7	4.746	0.182	2.625	0.063
	10	6.780	0.260	3.750	0.090
Corn fodder (leaves)	1	0.911	0.053	0.433	0.020
	2	1.822	0.106	0.866	0.040
	3	2.733	0.159	1.299	0.060
	4	3.644	0.212	1.732	0.080
	5	4.555	0.265	2.165	0.100
	7	6.377	0.371	3.031	0.140
	10	9.110	0.530	4.330	0.200
Corn husks (shucks).......	1	0.919	0.010	0.647	0.003
	2	1.838	0.020	1.294	0.006
	3	2.757	0.030	1.941	0.009
	4	3.676	0.040	2.588	0.012
	5	4.595	0.050	3.235	0.015
	7	6.433	0.070	4.529	0.021
	10	9.190	0.100	6.470	0.030
Corn stover (whole plant except ears)................	1	0.772	0.028	0.423	0.007
	2	1.544	0.056	0.846	0.014
	3	2.316	0.084	1.269	0.021
	4	3.088	0.112	1.692	0.028
	5	3.860	0.140	2.115	0.035
	7	5.404	0.196	2.961	0.049
	10	7.720	0.280	4.230	0.070
Corn fodder (green)........	1	0.207	0.009	0.120	0.003
	2	0.414	0.018	0.240	0.006
	3	0.621	0.027	0.360	0.009
	4	0.828	0.036	0.480	0.012
	5	1.035	0.045	0.600	0.015
	7	1.449	0.063	0.840	0.021
	10	2.070	0.090	1.200	0.030
Sorghum (green)	1	0.206	0.006	0.122	0.004
	2	0.412	0.012	0.244	0.008
	3	0.618	0.018	0.366	0.012
	4	0.824	0.024	0.488	0.016
	5	1.030	0.030	0.610	0.020
	7	1.442	0.042	0.854	0.028
	10	2.060	0.060	1.220	0.040
Barley (green).............	1	0.210	0.019	0.102	0.004

TABLE III.—DRY MATTER AND DIGESTIBLE NUTRIENTS IN 1, 2, 3, 4, 5, 7 AND 10 POUNDS OF FEED STUFFS.—(*Continued*)

Feed	Weight pounds	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
Barley (green) (continued)	2	0.420	0.038	0.204	0.008
	3	0.630	0.057	0.306	0.012
	4	0.840	0.076	0.408	0.016
	5	1.050	0.095	0.510	0.020
	7	1.470	0.133	0.714	0.028
	10	2.100	0.190	1.020	0.040
Oats in bloom (green)	1	0.378	0.025	0.188	0.010
	2	0.756	0.050	0.376	0.020
	3	1.134	0.075	0.564	0.030
	4	1.512	0.100	0.752	0.040
	5	1.890	0.125	0.940	0.050
	7	2.646	0.175	1.316	0.070
	10	3.780	0.250	1.880	0.100
Rye (green)	1	0.234	0.020	0.141	0.004
	2	0.468	0.040	0.282	0.008
	3	0.702	0.060	0.423	0.012
	4	0.936	0.080	0.564	0.016
	5	1.170	0.100	0.705	0.020
	7	1.638	0.140	0.987	0.028
	10	2.340	0.200	1.410	0.040
Bermuda hay	1	0.894	0.046	0.391	0.009
	2	1.788	0.092	0.782	0.018
	3	2.682	0.138	1.173	0.027
	4	3.576	0.184	1.564	0.036
	5	4.470	0.230	1.955	0.045
	7	6.258	0.322	2.737	0.063
	10	8.940	0.460	3.910	0.090
Crab grass hay	1	0.897	0.022	0.428	0.006
	2	1.794	0.044	0.856	0.012
	3	2.691	0.066	1.284	0.018
	4	3.588	0.088	1.712	0.024
	5	4.485	0.110	2.140	0.030
	7	6.279	0.154	2.996	0.042
	10	8.970	0.220	4.280	0.060
Johnson grass hay	1	0.898	0.032	0.413	0.008
	2	1.796	0.064	0.826	0.016
	3	2.694	0.096	1.239	0.024
	4	3.592	0.128	1.652	0.032
	5	4.490	0.160	2.065	0.040
	7	6.286	0.224	2.891	0.056
	10	8.980	0.320	4.130	0.080
Kentucky blue grass hay	1	0.788	0.048	0.373	0.020
	2	1.576	0.096	0.746	0.040
	3	2.364	0.144	1.119	0.060
	4	3.152	0.192	1.492	0.080

TABLE III.—DRY MATTER AND DIGESTIBLE NUTRIENTS IN 1, 2, 3, 4, 5, 7 AND 10 POUNDS OF FEED STUFFS.—(*Continued*)

Feed	Weight pounds	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
Kentucky blue grass hay (continued)	5	3.940	0.240	1.865	0.100
	7	5.516	0.336	2.611	0.140
	10	7.880	0.480	3.730	0.200
Marsh or swamp hay	1	0.884	0.024	0.299	0.009
	2	1.768	0.048	0.598	0.018
	3	2.652	0.072	0.897	0.027
	4	3.536	0.096	1.196	0.036
	5	4.420	0.120	1.495	0.045
	7	6.188	0.168	2.093	0.063
	10	8.840	0.240	2.990	0.090
Meadow fescue hay	1	0.860	0.030	0.448	0.009
	2	1.720	0.060	0.896	0.018
	3	2.580	0.090	1.344	0.027
	4	3.440	0.120	1.792	0.036
	5	4.300	0.150	2.240	0.045
	7	6.020	0.210	3.136	0.063
	10	8.600	0.300	4.480	0.090
Millet hay (cat tail)	1	0.895	0.062	0.421	0.009
	2	1.790	0.124	0.842	0.018
	3	2.685	0.186	1.263	0.027
	4	3.580	0.248	1.684	0.036
	5	4.475	0.310	2.105	0.045
	7	6.265	0.434	2.947	0.063
	10	8.950	0.620	4.210	0.090
Mixed grass and clover hay	1	0.871	0.059	0.409	0.012
	2	1.742	0.118	0.818	0.024
	3	2.613	0.177	1.227	0.036
	4	3.484	0.236	1.636	0.048
	5	4.355	0.295	2.045	0.060
	7	6.097	0.413	2.863	0.084
	10	8.710	0.590	4.090	0.120
Oat hay (cut in milk stage)	1	0.850	0.050	0.330	0.014
	2	1.700	0.100	0.660	0.028
	3	2.550	0.150	0.990	0.042
	4	3.400	0.200	1.320	0.056
	5	4.250	0.250	1.650	0.070
	7	5.950	0.350	2.310	0.098
	10	8.500	0.500	3.300	0.140
Orchard grass hay	1	0.901	0.049	0.423	0.014
	2	1.802	0.098	0.846	0.028
	3	2.703	0.147	1.269	0.042
	4	3.604	0.196	1.692	0.056
	5	4.505	0.245	2.115	0.070
	7	6.307	0.343	2.961	0.098

TABLE III.—DRY MATTER AND DIGESTIBLE NUTRIENTS IN 1, 2, 3, 4, 5, 7 AND 10 POUNDS OF FEED STUFFS.—(*Continued*)

Feed	Weight pounds	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
Orchard grass hay (cont'd)	10	9.010	0.490	4.230	0.140
Red top hay	1	0.911	0.048	0.469	0.010
	2	1.822	0.096	0.938	0.020
	3	2.733	0.144	1.407	0.030
	4	3.644	0.192	1.876	0.040
	5	4.555	0.240	2.345	0.050
	7	6.377	0.336	3.283	0.070
	10	9.110	0.480	4.690	0.100
Rowen hay (mixed)	1	0.834	0.079	0.401	0.015
	2	1.668	0.158	0.802	0.030
	3	2.502	0.237	1.203	0.045
	4	3.336	0.316	1.604	0.060
	5	4.170	0.395	2.005	0.075
	7	5.838	0.553	2.807	0.105
	10	8.340	0.790	4.010	0.150
Timothy hay	1	0.868	0.028	0.434	0.014
	2	1.736	0.056	0.868	0.028
	3	2.604	0.084	1.302	0.042
	4	3.472	0.112	1.736	0.056
	5	4.340	0.140	2.170	0.070
	7	6.076	0.196	3.038	0.098
	10	8.680	0.280	4.340	0.140
Oat straw	1	0.908	0.012	0.386	0.008
	2	1.816	0.024	0.772	0.016
	3	2.724	0.036	1.158	0.024
	4	3.632	0.048	1.544	0.032
	5	4.540	0.060	1.930	0.040
	7	6.356	0.084	2.702	0.056
	10	9.080	0.120	3.860	0.080
Rice straw	1	0.880	0.027	0.328	0.010
	2	1.760	0.054	0.656	0.020
	3	2.640	0.081	0.984	0.030
	4	3.520	0.108	1.312	0.040
	5	4.400	0.135	1.640	0.050
	7	6.160	0.189	2.296	0.070
	10	8.800	0.270	3.280	0.100
Rye straw	1	0.929	0.006	0.406	0.004
	2	1.858	0.012	0.812	0.008
	3	2.787	0.018	1.218	0.012
	4	3.716	0.024	1.624	0.016
	5	4.645	0.030	2.030	0.020
	7	6.503	0.042	2.842	0.028
	10	9.290	0.060	4.060	0.040
Wheat straw	1	0.904	0.004	0.363	0.004

TABLE III.—DRY MATTER AND DIGESTIBLE NUTRIENTS IN 1, 2, 3, 4, 5, 7 AND 10 POUNDS OF FEED STUFFS.—(*Continued*)

Feed	Weight pounds	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
Wheat straw (continued)...	2	1.808	0.008	0.726	0.008
	3	2.712	0.012	1.089	0.012
	4	3.616	0.016	1.452	0.016
	5	4.520	0.020	1.815	0.020
	7	6.328	0.028	2.541	0.028
	10	9.040	0.040	3.630	0.040
Alfalfa (green)	1	0.282	0.039	0.126	0.005
	2	0.564	0.078	0.252	0.010
	3	0.846	0.117	0.378	0.015
	4	1.128	0.156	0.504	0.020
	5	1.410	0.195	0.630	0.025
	7	1.974	0.273	0.882	0.035
	10	2.820	0.390	1.260	0.050
Canada field pea (green) ...	1	0.130	0.023	0.053	0.002
	2	0.260	0.046	0.106	0.004
	3	0.390	0.069	0.159	0.006
	4	0.520	0.092	0.212	0.008
	5	0.650	0.115	0.265	0.010
	7	0.910	0.161	0.371	0.014
	10	1.300	0.230	0.530	0.020
Cowpea (green)	1	0.164	0.018	0.087	0.002
	2	0.328	0.036	0.174	0.004
	3	0.492	0.054	0.261	0.006
	4	0.656	0.072	0.348	0.008
	5	0.820	0.090	0.435	0.010
	7	1.148	0.126	0.609	0.014
	10	1.640	0.180	0.870	0.020
Alfalfa hay	1	0.916	0.106	0.389	0.009
	2	1.832	0.212	0.778	0.018
	3	2.748	0.318	1.167	0.027
	4	3.664	0.424	1.556	0.036
	5	4.580	0.530	1.945	0.045
	7	6.412	0.742	2.723	0.063
	10	9 160	1.060	3.890	0.090
Alsike clover hay	1	0.903	0.084	0.425	0.015
	2	1.806	0.168	0.850	0.030
	3	2.709	0.252	1.275	0.045
	4	3.612	0.336	1.700	0.060
	5	4.515	0.420	2.125	0.075
	7	6.321	0.588	2.975	0.105
	10	9.030	0.840	4.250	0.150
Cowpea vine hay...........	1	0.881	0.093	0.384	0.012
	2	1.762	0.186	0.768	0.024
	3	2.643	0.279	1.152	0.036
	4	3.524	0.372	1.536	0.048

TABLE III.—DRY MATTER AND DIGESTIBLE NUTRIENTS IN 1, 2, 3, 4, 5, 7 AND 10 POUNDS OF FEED STUFFS.—(*Continued*)

Feed	Weight pounds	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
Cowpea vine hay (cont'd) ..	5	4.405	0.465	1.920	0.060
	7	6.167	0.651	2.688	0.084
	10	8.810	0.930	3.840	0.120
Crimson clover hay	1	0.904	0.105	0.349	0.012
	2	1.808	0.210	0.698	0.024
	3	2.712	0.315	1.047	0.036
	4	3.616	0.420	1.396	0.048
	5	4.520	0.525	1.745	0.060
	7	6.328	0.735	2.443	0.084
	10	9.040	1.050	3.490	0.120
Lespedeza (Japan clover) hay	1	0.897	0.076	0.422	0.018
	2	1.794	0.152	0.844	0.036
	3	2.691	0.228	1.266	0.054
	4	3.588	0.304	1.688	0.072
	5	4.485	0.380	2.110	0.090
	7	6.279	0.532	2.954	0.126
	10	8.970	0.760	4.220	0.180
Peanut vine hay (without nuts)	1	0.924	0.067	0.422	0.030
	2	1.848	0.134	0.844	0.060
	3	2.772	0.201	1.266	0.090
	4	3.696	0.268	1.688	0.120
	5	4.620	0.335	2.110	0.150
	7	6.468	0.469	2.954	0.210
	10	9.240	0.670	4.220	0.300
Soja (soy) bean hay.	1	0.887	0.109	0.402	0.015
	2	1.774	0.218	0.804	0.030
	3	2.661	0.327	1.206	0.045
	4	3.548	0.436	1.608	0.060
	5	4.435	0.545	2.010	0.075
	7	6.209	0.763	2.814	0.105
	10	8.870	1.090	4.020	0.150
Vetch hay	1	0.887	0.129	0.375	0.014
	2	1.774	0.258	0.750	0.028
	3	2.661	0.387	1.125	0.042
	4	3.548	0.516	1.500	0.056
	5	4.435	0.645	1.875	0.070
	7	6.209	0.903	2.625	0.098
	10	8.870	1.290	3.750	0.140
Vetch and oats (1–1) hay...	1	0.850	0.083	0.342	0.014
	2	1.700	0.166	0.684	0.028
	3	2.550	0.249	1.026	0.042
	4	3.400	0.332	1.368	0.056
	5	4.250	0.415	1.710	0.070
	7	5.950	0.581	2.394	0.098

TABLE III.—DRY MATTER AND DIGESTIBLE NUTRIENTS IN 1, 2, 3, 4, 5, 7 AND 10 POUNDS OF FEED STUFFS.—(*Continued*)

Feed	Weight pounds	Dry matter pounds	Protein pounds	Carbohy-rates pounds	Fat pounds
Vetch and oats (1–1) hay (continued)	10	8.500	0.830	3.420	0.140
Corn silage	1	0.209	0.009	0.113	0.007
	2	0.418	0 018	0.226	0.014
	3	0.627	0.027	0.339	0.021
	4	0.836	0.036	0.452	0.028
	5	1.045	0.045	0.565	0.035
	7	1.463	0.063	0.791	0.049
	10	2.090	0.090	1.130	0.070
Cowpea vine silage	1	0.207	0.015	0.086	0.009
	2	0.414	0.030	0.172	0.018
	3	0.621	0.045	0.258	0.027
	4	0.828	0.060	0.344	0.036
	5	1.035	0.075	0.430	0.045
	7	1.449	0.105	0.602	0.063
	10	2.070	0.150	0.860	0.090
Soja bean silage	1	0.258	0.027	0.087	0.013
	2	0.516	0.054	0.174	0.026
	3	0.774	0.081	0.261	0.039
	4	1.032	0.108	0.348	0.052
	5	1.290	0.135	0.435	0.065
	7	1.806	0.189	0.609	0.091
	10	2.580	0.270	0.870	0.130
Sorghum silage	1	0.239	0.006	0.149	0.002
	2	0.478	0.012	0.298	0.004
	3	0.717	0.018	0.447	0.006
	4	0.956	0.024	0.596	0.008
	5	1.195	0.030	0.745	0.010
	7	1.673	0.042	1.043	0.014
	10	2.390	0.060	1.490	0.020
Carrots	1	0.114	0.010	0.081	0 002
	2	0.228	0.020	0.162	0.004
	3	0.342	0.030	0.243	0.006
	4	0.456	0.040	0.324	0.008
	5	0.570	0.050	0.405	0.010
	7	0.798	0.070	0.567	0 014
	10	1.140	0.100	0.810	0.020
Beet (mangel wurzel)	1	0.091	0.011	0.054	0.001
	2	0.182	0.022	0.108	0.002
	3	0.273	0.033	0.162	0.003
	4	0.364	0.044	0.216	0.004
	5	0.455	0.055	0.270	0.005
	7	0.637	0.077	0.378	0.007
	10	0.910	0.110	0.540	0.010
Potato (Irish)	1	0.211	0.009	0.163	0.001
	2	0.422	0.018	0.326	0.002

TABLE III.—DRY MATTER AND DIGESTIBLE NUTRIENTS IN 1, 2, 3, 4, 5, 7 AND 10 POUNDS OF FEED STUFFS.—(*Continued*)

Feed	Weight pounds	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
Potato (Irish) (continued)..	3	0.633	0.027	0.489	0.003
	4	0.844	0.036	0.652	0.004
	5	1.055	0.045	0.815	0.005
	7	1.477	0.063	1.141	0.007
	10	2.110	0.090	1.630	0.010
Potato (sweet)............	1	0.289	0.009	0.222	0.003
	2	0.578	0.018	0.444	0 006
	3	0.867	0.027	0.666	0.009
	4	1.156	0.036	0.888	0.012
	5	1.445	0.045	1.110	0.015
	7	2.023	0.063	1.554	0.021
	10	2.890	0.090	2.220	0.030
Rutabagas...............	1	0.114	0.010	0.081	0.002
	2	0.228	0.020	0.162	0.004
	3	0.342	0.030	0.243	0.006
	4	0.456	0.040	0.324	0.008
	5	0.570	0.050	0.405	0.010
	7	0.798	0.070	0.567	0.014
	10	1.140	0.100	0.810	0.020
Buttermilk...............	1	0 099	0.039	0.040	0.011
	2	0.198	0.078	0.080	0.022
	3	0.297	0.117	0.120	0.033
	4	0.396	0.156	0.160	0 044
	5	0.495	0.195	0.200	0.055
	7	0.693	0.273	0.280	0.077
	10	0.990	0.390	0.400	0.110
Skim milk (centrifugal)....	1	0.094	0.029	0.052	0.003
	2	0.188	0.058	0.104	0.006
	3	0.282	0.087	0.156	0.009
	4	0.376	0.116	0.208	0.012
	5	0.470	0.145	0.260	0.015
	7	0.658	0.203	0.364	0.021
	10	0.940	0.290	0.520	0.030
Skim milk (gravity).......	1	0.096	0.031	0.047	0.008
	2	0.192	0.062	0.094	0.016
	3	0.288	0.093	0.141	0.024
	4	0.384	0.124	0.188	0.032
	5	0.480	0.155	0.235	0.040
	7	0.672	0.217	0.329	0.056
	10	0.960	0.310	0.470	0.080
Whey....................	1	0.062	0.006	0.047	0.001
	2	0.124	0.012	0.094	0.002
	3	0.186	0.018	0.141	0.003
	4	0.248	0.024	0.188	0.004
	5	0.310	0.030	0.235	0.005

TABLE III.—DRY MATTER AND DIGESTIBLE NUTRIENTS IN 1, 2, 3, 4, 5, 7 AND 10 POUNDS OF FEED STUFFS.—(*Continued*)

Feed	Weight pounds	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
Whey (continued)	7	0.434	0.042	0.329	0.007
	10	0.620	0.060	0.470	0.010
Cabbage	1	0.095	0.018	0.042	0.004
	2	0.190	0.036	0.084	0.008
	3	0.285	0.054	0.126	0.012
	4	0 380	0.072	0.168	0 016
	5	0.475	0.090	0.210	0.020
	7	0.665	0.126	0.294	0.028
	10	0.950	0.180	0.420	0.040
Rape	1	0.155	0.015	0.081	0.002
	2	0.310	0.030	0.162	0.004
	3	0.465	0.045	0.243	0.006
	4	0.620	0.060	0.324	0.008
	5	0.775	0.075	0.405	0.010
	7	1.085	0.105	0.567	0.014
	10	1.550	0.150	0.810	0.020

for 4 and 5 lbs. or multiply the amounts for 3 lbs., by 3. If ½ lb. is needed, take 1/10 of 5 lbs. or divide the amounts for 1 lb., by 2. For 50, 100, 200, 300 lbs., etc., a simple multiplication will give the amounts required.

A Ration Computed by Using Table III.—Let us figure a ration by using this table. Supposing we have some cattle we wish to fatten for the market. The standard, Table II, for the preliminary period for fattening cattle of 1,000 lbs. live weight is:

Dry matter pounds	Protein pounds	Carbohydrates pounds	Nutritive ratio
27	2.5	16.1	1:6.4

If corn and cob meal, alfalfa hay and cotton-seed meal should be available, we could try the following amounts which are given in Table III.

	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
10 lbs. corn and cob meal..........	8.490	0.440	6.000	0.290
15 lbs. alfalfa hay	13.740	1.590	5.835	0.135
1 lb. cotton-seed meal	0.918	0.372	0.169	0.122
26 lbs. total..........................	23.148	2.402	12.004	0.547
				Nutritive ratio
Ration..............................	23.148	2.402	13.235	1:5.5
Standard..............................	27.	2.5	16.1	1:6.4

Our ration is too low in carbohydrates to be satisfactory. Corn and cob meal contains a larger percentage of carbohydrates than the other feeds included in this ration. Therefore we will use 15 lbs of corn and cob meal. The protein in our trial ration is almost equal to that of the standard and by using 15 lbs. of corn and cob meal the protein will be too high. Let us try reducing the amount of alfalfa hay to 14 lbs. and compare our ration to the standard.

	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
15 lbs. corn and cob meal	12.735	0.660	9.000	0.435
14 lbs. alfalfa hay	12.824	1.484	5.446	0.126
1 lb. cotton-seed meal	0.918	0.372	0.169	0.122
30 lbs. total..........................	26.477	2.516	14.615	0.683
				Nutritive ratio
Ration..............................	26.477	2.516	16.15	1:6.4
Standard..............................	27.	2.5	16.1	1:6.4

This ration is very close to the standard.

Suggestion:—Compute a ration for farm work horses averaging 1,200 lbs., doing heavy farm work, from oats, linseed meal, corn and cob meal and timothy hay. How much of each concentrate would be required to last 15 horses of this weight for a month?

SECTION XXVII.

STANDARDS FOR MILCH COWS.

Wolff's standard for milch cows, which has been generally used, has been found to be unsatisfactory for American feeders. Many investigations have been conducted to determine the requirements for milch cows in this country.

Adjust the Ration to the Cow's Needs.—Haecker in Minnesota Bul. 79, says: "It has long since been recognized that because of the difference in composition of the various kinds of feed stuffs no single standard of composition for all feeds would be practical, and yet, while there is as great a difference in the composition of milks as there is in feed stuffs, there has been no adjustment of the nutrients in the ration to the quantity and character of the solids contained in the milk yielded, though such an adjustment is simple and practicable. If in formulating a ration it is deemed necessary in economic milk production, to take note of the fact that one feed stuff contains 12 per cent. protein and another 20 per cent., is it not equally important in our attempt to adjust the ration to the needs of the cow in milk production to also take into account the fact that one cow may give milk containing 3 per cent. fat while that of another may contain twice as much? It would seem quite as consistent to feed an animal food regardless of its composition as to feed an assumed balanced ration regardless of the composition of the product which is to be elaborated from the nutrients in the food.

"Great stress has been placed upon the fact that the nutrients in milk have a nutritive ratio of approximately one to five, and that therefore the ration for a milch cow should have a similar nutritive ratio; apparently overlooking the fact that only 50 per cent. of the ration is used in milk production and the balance for maintenance of body. If note is taken of the fact that about half the ration is used for maintenance and that the maintenance ration has a nutritive ratio of one to ten, it becomes apparent that for the production of milk of average quality by an animal of average milk producing powers the nutritive ratio of the ration should be approximately 1 : 7.5. But since animals vary in productive powers, and since this variation is not in proportion to weight of body, it follows that if rations are adjusted to the actual requirements of animals the nutritive ratio of the rations will also vary."

A New World Record.

"It remained for the Missouri College of Agriculture at Columbia, Missouri, to raise and develop the Champion Dairy Cow of all the world. Missouri Chief Josephine, a Holstein-Friesian cow

Fig. 12.—Missouri Chief Josephine.
(Courtesy Missouri Experiment Station.)

finished her six months test on July 18th, producing 17,008.8 pounds, an average of 93.4 pounds of milk daily for 182 days. This is equivalent to 46.7 quarts, or 11.6 gallons every day. Her highest record for one day was 110.2 pounds. This record is the more remarkable because no special preparation had been made for this test and Josephine has done her full duty in the regular dairy herd of the University, having had five calves in five and one-half years.

Not only has this record smashed all previous worlds records for milk production, but the per cent. of butter fat is increasing daily, so that, barring accidents this cow will undoubtedly produce more butter during a period of twelve months than any other cow that has ever been tested in the world.

This cow is but one of a number of remarkable cows owned by the University of Missouri and maintained solely for the instruction of its students in Agriculture and for investigational purposes. Only twenty Jersey cows in the history of the world have produced more than 700 pounds of butter in one year. Five of these cows, or 25 per cent. of the total number are owned and were bred by this Missouri institution. The College owns more than 300 pure bred and registered animals, belonging to 17 distinct breeds.

Josephine's record exceeds the present world's record for six months by 1,458 pounds."

The table on page 176 of standards for milch cows has been compiled from Haecker's work, giving the requirements for cows weighing 1,000 lbs. producing the stated quantities of milk of stated butter fat.

Maintenance and Milk Production Requirements.—The standards in the table include the requirements for maintenance and milk production and are based on 1,000 lbs. live weight. Investigations have demonstrated that the maintenance per 100 lbs. live weight, namely, 0.07 of a pound of digestible protein, 0.7 of a pound of digestible carbohydrates and 0.01 of a pound of digestible fat, which is given at the head of the preceding table, are ample for maintaining the average cow.

To compute the maintenance requirements for any live weight, say 600, 700 or 800 lbs., simply multiply the maintenance for 100 lbs. by 6, 7 or 8 as the case may be. For milk production requirements, divide the production of milk by 10 and multiply the standard for each additional 10 lbs. by this result. The standard required would be the sum of the maintenance and milk production requirements.

	Per cent. butter fat	Protein pounds	Carbohydrates pounds	Fat pounds	Nutritive ratio
Maintenance per 100 lbs. live weight		0.07	0.7	0.01	
10 pounds of milk	3	1.10	8.81	0.24	1:8.5
10 “ “ “	4	1.17	9.14	0.26	1:8.3
10 “ “ “	5	1.24	9.48	0.28	1:8.2
15 “ “ “	3	1.30	9.715	0.31	1:8.0
15 “ “ “	4	1.405	10.21	0.34	1:7.8
15 “ “ “	5	1.51	10.72	0.37	1:7.6
20 “ “ “	3	1.50	10.62	0.38	1:7.6
22 “ “ “	4	1.64	11.28	0.42	1:7.5
20 “ “ “	5	1.78	11.96	0.46	1:7.3
25 “ “ “	3	1.70	11.525	0.45	1:7.4
25 “ “ “	4	1.875	12.35	0.50	1:7.2
35 “ “ “	5	2.05	13.20	0.55	1:7.0
30 “ “ “	3	1.90	12.43	0.52	1:7.2
30 “ “ “	4	2.11	13.42	0.58	1:7.0
30 “ “ “	5	2.32	14.44	0.64	1:6.8
35 “ “ “	3	2.10	13.335	0.59	1:7.0
35 “ “ “	4	2.345	14.49	0.66	1:6.8
40 “ “ “	5	2.59	15.69	0.73	1:6.7
40 “ “ “	3	2.30	14.24	0.66	1:6.8
40 “ “ “	4	2.58	15.56	0.74	1:6.7
50 “ “ “	5	2.86	16.92	0.82	1:6.6
For each additional 10 lbs...	3	0.40	1.81	0.14	....
“ “ “ “ “	4	0.47	2.14	0.16	....
“ “ “ “ “	5	0.54	2.48	0.18	....

Use of the Table.—Let us make this clearer by computing the standard for a cow weighing 850 lbs. producing 23 lbs. of milk daily, testing 5 per cent. butter fat.

Since 850 is 8.5 × 100, we must multiply our maintenance (0.07 lb. protein; 0.7 lb. carbohydrates and 0.01 fat) by 8.5.

$0.07 \times 8.5 = 0.595$ lb. of protein
$0.7 \times 8.5 = 5.950$ lbs. of carbohydrates
$0.01 \times 8.5 = 0.085$ lb. of fat
} Maintenance requirement for a cow weighing 850 lbs.

Since our cow is producing 23 lbs. of milk, we divide 23 by 10 which gives us 2.3. Multiply the standard for each additional 10 lbs. of 5 per cent. butter fat milk (0.54 lb. protein, 2.48 lbs., carbohydrates and 0.18 lb. fat) by 2.3 which gives us the milk production requirement.

$0.54 \times 2.3 = 1.182$ lbs. of protein
$2.48 \times 2.3 = 5.704$ lbs. of carbohydrates
$0.18 \times 2.3 = 0.414$ lb. of fat
} Milk production requirement for a cow producing 23 lbs. of milk daily testing 5 per cent. butter fat.

The sum of the maintenance and the milk production requirements is the amount required.

	Requirement for maintenance		Requirement for milk production		Standard required
Pounds of protein	0.595	+	1.182	=	1.777
Pounds of carbohydrates	5.950	+	5.704	=	11.654
Pounds of fat	0.085	+	0.414	=	0.499

As previously stated the standards in the table are on the basis of 1,000 lbs. live weight. Therefore to compute the standard for a cow of this weight (1,000 lbs.) it is not necessary to figure the maintenance and milk production requirements, as this work has already been done and is included in the table.

A Ration.—The following ration for a cow weighing 1,000 lbs. producing 25 lbs. of milk daily, testing 4 per cent. butter fat, illustrates how feed stuffs may be compounded to meet the standards as laid down in this table.

	Dry matter pounds	Protein pounds	Carbohydrates pounds	Fat pounds
2 lbs. linseed meal (new process)	1.80	0.56	0 80	0.06
6 lbs. corn and cob meal	5.09	0.26	3.60	0.17
2½ lbs. dried brewers' grains	2.30	0.40	0.90	0.13
40 lbs. corn silage	8.40	0.36	4.40	0.28
6 lbs. red top hay	5 47	0.29	2.81	0.06
Ration	23.06	1.87	12.51	0.70
Standard		1.875	12.35	0.50

The carbohydrates and fat are a little high but the ration approximates the standard close enough for all practical purposes.

A Narrow Nutritive Ratio is Sometimes Economical.—Dairymen have learned by practical experience that Haecker's standards are too wide (that is there is too high a proportion of carbohydrates and fat to protein) for the most economical production of milk where protein is cheap and carbohydrates relatively expensive. In all probability Haecker's table is suitable for the Northwest and other sections where protein is expensive and carbohydrates comparatively cheap. Prof. E. L. Jordan of the Louisiana State University and the writer adapted the following table from Haecker's work to meet the demands of feeders who wish to employ narrow rations for milch cows.

	Per cent. butter fat	Protein pounds	Carbohydrates pounds	Fat pounds	Nutritive ratio
10 pounds of milk..........	4	1.3	9.14	0.26	1:7.5
10 " " "	5	1.4	9.48	0.28	1:7.2
15 " " "	4	1.6	10.21	0.34	1:6.9
15 " " "	5	1.75	10.72	0.37	1:6.6
20 " " "	4	1.9	11.28	0.42	1:6.4
20 " " "	5	2.1	11.96	0.46	1:6.2
25 " " "	4	2.2	12.35	0.50	1:6.1
25 " " "	5	2.45	13.20	0.55	1:5.9
30 " " "	4	2.5	13.42	0.58	1:5.9
30 " " "	5	2.8	14.44	0.64	1:5.7
35 " " "	4	2.8	14.49	0.66	1:5.7
35 " " "	5	3.15	15.68	0.73	1:5.5
40 " " "	4	3.1	15.56	0.74	1:5.6
40 " " "	5	3.5	16.92	0.82	1:5.4
For each additional 10 lbs...	4	0.60	2.14	0.16	....
" " " " "	5	0.70	2.48	0.18	....

Woll of the Wisconsin Experiment Station says: "At the prices of feeding stuffs in the North Central States it will not, as a general rule, pay to feed a narrower ratio to dairy cows than 1: 6.0 and we find that the cows in our University herd fed according to our best judgment receive on the average rations with a nutritive ratio of about 1 :6.5 to 7.0. The heavier producers in the herd naturally receive more grain feed than the low producers and their rations, therefore, have a narrower nutritive ratio, but it is very rarely that we find it necessary to go below 1 :6.0. The starchy feeds are cheaper than the protein feeds with us and unless the cow has an exceptional productive capacity a medium or somewhat wide nutritive ratio is more economical than a narrow one."

Suggestion: A gallon of milk weighs 8.6 lbs. Compute two rations for a cow weighing 825 lbs. producing 2½ gallons of milk a day, testing 4 per cent. butter fat, according to the standards in the two tables in this section, from mixed hay, corn meal, linseed meal and wheat bran.

SECTION XXVIII.

COMPUTATION OF RATIONS ACCORDING TO ENERGY VALUES.

The tables given in the foregoing pages on composition, digestible nutrients and standards are those commonly used in compounding rations. Armsby of the Pennsylvania Experiment Station and G. Kuhn and Kellner of the Mockern Experiment Station of Germany have been conducting investigations as to the protein and energy values of feeds, and the requirements of animals, by means of the respiration apparatus.

The following table of digestible protein and energy values is taken from Farmers' Bul. 346. The energy value represents the production value, or the value of the feed stuffs cited for the production of gain in fattening animals. The protein represents what is available for repair material.

TABLE IV.—DRY MATTER, DIGESTIBLE PROTEIN, AND ENERGY VALUES PER 100 POUNDS.[1]

Feeding stuff	Total dry matter pounds	Digestible protein pounds	Energy value therms
GREEN FODDER AND SILAGE			
Alfalfa	28.2	2.50	12.45
Clover—crimson	19.1	2.19	11.30
Clover—red	29.2	2.21	16.17
Corn fodder—green	20.7	0.41	12.44
Corn silage	25.6	1.21	16.56
Hungarian grass	28.9	1.33	14.76
Rape	14 3	2.16	11.43
Rye	23.4	1.44	11.63
Timothy	38.4	1.04	19.08
HAY AND DRY COARSE FODDERS			
Alfalfa hay	91.6	6.93	34.41
Clover hay—red	84.7	5.41	34.74
Corn forage, field cured	57.8	2.13	30.53
Corn stover	59.5	1.80	26.53
Cowpea hay	89.3	8.57	42.76
Hungarian hay	92.3	3.00	44.03
Oat hay	84.0	2.59	36.97
Soy bean hay	88.7	7.68	38 65
Timothy hay	86 8	2.05	33.56

[1] Farmers' Bul. 346.

TABLE IV.—DRY MATTER, DIGESTIBLE PROTEIN, AND ENERGY VALUES PER 100 POUNDS.—(*Continued*)

Feeding stuff	Total dry matter pounds	Digestible protein pounds	Energy value therms
STRAWS			
Oat straw	90.8	1.09	21.21
Rye straw	92.9	0.63	20.87
Wheat straw	90.4	0.37	16.56
ROOTS AND TUBERS			
Carrots	11.4	0.37	7.82
Mangel wurzels	9.1	0.14	4 62
Potatoes	21.1	0.45	18.05
Rutabagas	11.4	0.88	8.00
Turnips	9 4	0.22	5.74
GRAINS			
Barley	89.1	8.37	80.75
Corn	89.1	6.79	88.84
Corn-and-cob meal	84.9	4.53	72.05
Oats	89 0	8.36	66.27
Pea meal	89.5	16.77	71.75
Rye	88.4	8.12	81.72
Wheat	89.5	8.90	82.63
BY-PRODUCTS			
Brewers' grains—dried	92 0	19.04	60.01
Brewers' grains—wet	24.3	3.81	14.82
Buckwheat middlings	88 2	22.34	75.92
Cotton-seed meal	91.8	35.15	84.20
Distillers' grains—dried			
Principally corn	93.0	21.93	79.23
Principally rye	93.2	10.38	60.93
Gluten feed—dry	91.9	19.95	79.32
Gluten meal—Buffalo	91.8	21.56	88.80
Gluten meal—Chicago	90.5	33.09	78.49
Linseed meal—old process	90.8	27.54	78.92
Linseed meal—new process	90.1	29 26	74.67
Malt sprouts	89.8	12.36	46.33
Rye bran	88.2	11.35	56.65
Sugar-beet pulp—fresh	10.1	0.63	7.77
Sugar-beet pulp—dried	93.6.	6.80	60.10
Wheat bran	88 1	10.21	48.23
Wheat middlings	84.0	12.79	77.65

The Feed Requirements given in Table V may not be absolutely accurate but they are perhaps as near to the true requirements as those we are accustomed to using. The intelligent feeder can compound rations from this table that will meet the requirements of his animals. The requirements for swine have not been worked out. The per cent. of digestible protein, being true protein (crude protein minus the amides) will be smaller in amount than the digestible protein of the standards given in Table II.

TABLE V.—FEED REQUIREMENTS[1]

	Age months	Live weight pounds	Digestible protein[4] pounds	Energy value therms
Cattle maintenance	—	150	0.15	1.70
	—	250	0.20	2.40
	—	500	0.30	3.80
	—	750	0.40	4.95
	—	1000	0.50	6.00
	—	1250	0.60	7.00
	—	1500	0.65	7.90
Growing cattle[2]	3	275	1.10	5.0
	6	425	1.30	6.0
	12	650	1.65	7.0
	18	850	1.70	7.5
	24	1000	1.75	8.0
	30	1100	1.65	8.0
Horse maintenance	—	150	0.30	2.0
	—	250	0.40	2.8
	—	500	0.60	4.4
	—	750	0.80	5.8
	—	1000	1.00	7.0
	—	1250	1.20	8.15
	—	1500	1.30	9.2
Horse[3] for light work[2]	—	1000	1.0	9.8
Horse[3] for medium work[2]	—	1000	1.4	12.4
Horse[3] for heavy work[2]	—	1000	2.0	16.0
Sheep maintenance	—	20	0.03	0.30
	—	40	0.05	0.54
	—	60	0.07	0.71
	—	80	0.09	0.87
	—	100	0.10	1.00
	—	120	0.11	1.13
	—	140	0.13	1.25
Growing sheep[2]	6	70	0.30	1.30
	9	90	0.25	1.40
	12	110	0.23	1.40
	15	130	0.23	1.50
	18	145	0.22	1.60

[1] Farmers' Bul. 346.
[2] Including the maintenance requirements.
[3] After Kellner.
[4] True protein, amides not included.

TABLE V.—(*Continued.*)

ESTIMATED ENERGY VALUE OF 1 POUND OF GAIN IN WEIGHT

	Age months	Live weight pounds	Digestible protein pounds	Energy value therms
Growing cattle and growing sheep ...	3	——	——	1.50
	6	——	——	1.75
	12	——	——	2.00
	18	——	——	2.50
	24	——	——	2.75
	30	——	——	3.00
Fattening cattle 1 lb. gain live weight	——	——	——	3.5
One lb. milk production requirement.	——	——	0.05	0.3

How to Compute the Requirement.—Let us compute a ration for a dairy cow weighing 875 lbs., producing 25 lbs. of milk daily.

Referring to Table V we find the maintenance requirements for cows weighing 750 lbs. and 1,000 lbs. are:

	750 lb. cow	1,000 lb. cow
Digestible protein, pounds........	0.40	0.50
Energy, therms	4.95	6.00

The difference between 875 and 1,000 is the same as the difference between 750 and 875. Therefore the maintenance requirement for a cow weighing 875 lbs. is:

Digestible protein..............................	0.45 pound
Energy	5.475 therms

For the production of 25 lbs. of milk we would need according to Table V:

Digestible protein ....(25 × 0.05)	= 1.25 pounds
Energy ....(25 × 0.3)	= 7.50 therms

The total requirement then is:

	Digestible protein pounds	Energy value therms
Maintenance..........................	0.45	5.475
Milk production	1.25	7.500
Total requirement.................. =	1.70	12.975

How to Compute the Ration.—Let us suppose cotton-seed meal, corn meal, wheat middlings, oat hay and rye straw are available. Our previous study has taught us that we should endeavor to supply 12 to 14 pounds of dry matter from roughage, as roughage generally is our cheapest source of feed. We have been taught that the amount of roughage should be limited because an animal can only properly consume a certain amount of roughage. Rye straw and oat hay are the feeds which are available as roughage.

In Table IV we find that 100 lbs. of rye straw and oat hay contain:

	Dry matter pounds	Digestible protein pounds	Energy value therms
Rye straw	92.9	0.63	20.87
Oat hay	84.0	2.59	36.97

Let us see what 8 lbs. of rye straw will furnish:

$92.9 \times 0.08 = 7.432$ pounds dry matter
$0.63 \times 0.08 = 0.0504$ pound digestible protein
$20.87 \times 0.08 = 1.6696$ therms of energy value

Eight pounds of rye straw furnish 7.432 lbs. of dry matter. By a simple calculation we find that 6 lbs. of oat hay will furnish the remaining dry matter required from roughage. The amounts for oat hay are arrived at in the same way as for rye straw.

	Dry matter pounds	Digestible protein pounds	Energy value therms
8 pounds rye straw	7.432	0.0504	1.6696
6 pounds oat hay	5.040	0.1554	2.2182
Total	12.472	0.2058	3.8878

We must supply the difference between what we have figured for roughage and the requirement (1.7 lbs. digestible protein and 12.975 therms of energy value) with the available concentrates (cotton-seed meal, corn meal and wheat middlings).

Addition of Concentrates.—Let us try 3 lbs. of cotton-seed meal, 3 lbs. of corn meal and 2 lbs. of wheat middlings and add these to our roughage. The amounts for the concentrates are calculated in a similar manner from Table IV as illustrated for rye straw.

	Dry matter pounds	Digestible protein pounds	Energy value therms
8 pounds rye straw	7.432	0.0504	1.6696
6 pounds oat hay	5 040	0 1554	2.2182
3 pounds cotton-seed meal	2.754	1.0545	2.5260
3 pounds corn meal	2.673	0.2037	2.6652
2 pounds wheat middlings	1.680	0.2558	1.5530
Ration	19.579	1.7198	10.6320
Requirement		1.70	12.975

Our ration meets the protein requirement but it is deficient in therms of energy value.

Balancing the Ration.—In order to bring the energy value to the requirement we must add some corn meal, as this feed stuff contains a relatively larger proportion of therms than the other available concentrates. We must reduce the quantity of cotton-seed meal because an addition of corn meal will make the protein too high. We will try 6 lbs. of corn meal and 2 lbs. of cotton-seed meal and compare the ration to the requirement.

	Dry matter pounds	Digestible protein pounds	Energy value therms
8 pounds rye straw	7.432	0.0504	1.6696
6 pounds oat hay	5.040	0.1554	2.2182
2 pounds cotton-seed meal	1 836	0.7030	1 6840
6 pounds corn meal	5.346	0.4074	5.3304
2 pounds wheat middlings	1.680	0.2558	1.5530
Ration	21.334	1.5720	12 4552
Requirement		1.70	12.975

The ration is slightly deficient in digestible protein and energy value. Let us add 1 lb. of wheat middlings to the ration.

	Dry matter pounds	Digestible protein pounds	Energy value therms
8 pounds rye straw	7.432	0 0504	1.6696
6 pounds oat hay	5.040	0.1554	2.2182
2 pounds cotton-seed meal	1.836	0.7030	1.6840
6 pounds corn meal	5.346	0.4074	5.3304
3 pounds wheat middlings	2.520	0.3837	2.3295
Ration	22.174	1.6999	13.2317
Requirement		1.70	12.975

The ration as it now stands approximates the requirement, although the energy value is a little high; the ration is close

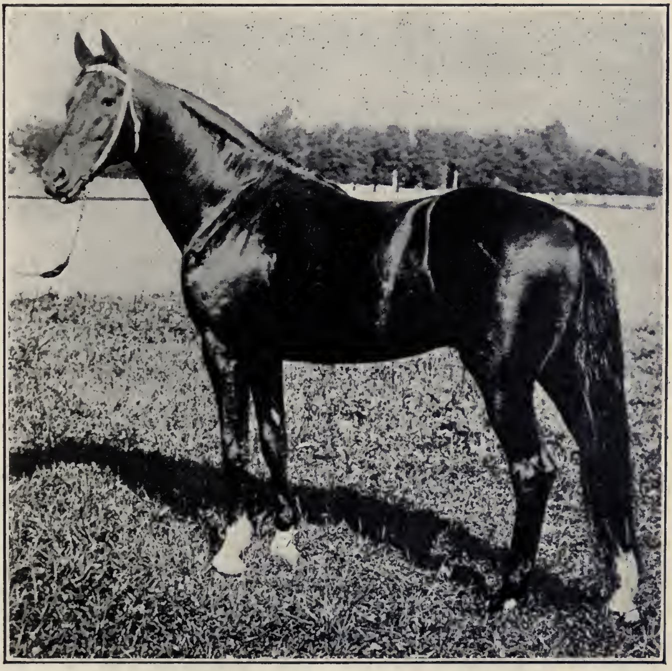

Fig. 13.—A typical roadster—after Good.

enough when we consider that all standards are not absolutely correct but merely guides for the intelligent feeder.

A Ration for a Horse.—It is a simple matter to figure a ration for a horse by the use of energy values. A ration for a horse doing medium work, weighing 1,200 lbs. computed from timothy hay, oats, corn and wheat bran would be calculated as follows. Table V gives maintenance and work requirement for a horse doing medium work weighing 1,000 lbs. as,

Digestible protein	1.4 pounds
Energy value	12.4 therms

As our horse weighs 1,200 lbs. we must increase this requirement one-fifth, since 200 is one-fifth of 1,000.

	Live weight pounds	Digestible protein pounds	Energy value therms
	1,000	1.4	12.4
	200	0.28	2.48
Requirement	1,200	1.68	14.88

We must aim to allow a limited amount of roughage to a horse because this class of animal is not capable of consuming large amounts of this kind of feed stuff. The following ration approximates the requirement.

	Dry matter pounds	Digestible protein pounds	Energy value therms
12 pounds timothy hay	10.416	0.2460	4.0272
7 pounds oats	6.230	0.5852	4.6389
4 pounds corn	3.564	0.2716	3.5536
5½ pounds wheat bran	4.8455	0.56155	2.65265
Ration	25.0555	1.66435	14.87235
Requirement		1.68	14.88

Rations for Fattening Cattle.—In computing rations for fattening cattle the maintenance requirement should be added to the average gain in live weight per day. Example: A farmer has a bunch of cattle weighing 1,000 lbs. which he wishes to fatten for the market. These cattle should make an average gain of 2 lbs. a day and weigh about 1,500 lbs. when ready for sale.

According to Table V, 1 pound gain in live weight for fattening cattle requires 3.5 therms of energy value. The cattle gain 2 lbs. a day, hence $(2 \times 3.5) = 7$ therms, or the requirement of energy value. The maintenance should be calculated on the average live weight of the cattle for the period, namely 1,250 lbs.

	Digestible protein pounds	Energy value therms
Maintenance for 1,250 pounds	0.60	7.00
Fattening requirement for 2 pounds, gain	—	7.00
Total requirement	0.60	14.00

The digestible protein requirement is not given for 1 pound gain live weight, so that in computing a ration of this nature it will be necessary to balance the energy value. The digestible protein will then be much higher than is included in the requirement, but if the energy value is balanced by the employment of the proper amounts of roughage and concentrates the digestible protein will be near enough for good results.

Suggestion: Require the class to compute a ration for a flock of sheep averaging 135 lbs. live weight and 16 months of age, from potatoes, gluten feed, corn, clover hay and oat straw, according to energy values.

SECTION XXIX.

FEED AND CARE OF DAIRY COWS.

Requirements.—The ration for a dairy cow should supply the proper amounts of nutrients for good milk production and for the needs of the animal body. It should be palatable and adaptable. The ration should be as cheap as possible and should not contain enough feed to disturb the digestive equilibrium of the animal.

Amount of Feed.—As already stated the amount of nutrients should be controlled by the quantity of milk produced, and its butter fat content. A cow producing 15 lbs. of milk should not receive as much digestible feed as one giving 25 lbs. of milk, and of two cows producing equal quantities of milk, the one producing the higher fat content should receive the more non-nitrogenous food.

The dairy cow when producing a good flow of milk is a hard working animal. Hence the larger the yield of milk the greater should be the proportion of concentrates to roughage. A dry cow is a lightly worked animal and a suitable ration may consist of much less grain and more roughage than for a cow in milk. A pregnant cow needs nitrogenous food to support the calf in utero and a suitable ration may be furnished with some well cured leguminous hay and carbohydrate roughage as corn stover, good grass hay, or straw. When the roughage is inferior, grain should be supplied in small amounts. A ration for a dairy cow should be made up of more than two feeds as an animal does better and enjoys variety just as people do.

Cows usually prefer their feed in a dry condition and by supplying the feed in this way, the mangers are easily kept clean. The general practice is to feed dairy cows in the morning and late afternoon, with a little roughage, such as hay, at noon time. The cows should be fed and milked regularly. With some cows (usually fresh young cows) uniformity in the milking time is necessary for the best returns.

Conditions Which Influence the Ration.—The size of the cow, the milk produced and the market price of the milk will necessarily influence the amount of grain that should be fed per day. For cows weighing 800 lbs. producing 20 to 22 lbs. of milk testing 5 per cent fat, 7 to 8 lbs. of grain should suffice. When the price of grain is high it is sometimes economical to reduce the grain portion of the ration to 5 to 6 lbs. When the grain is reduced the feeds grown on the farm may be fed to advantage. Cows weighing 1,100 to 1,200 lbs. should receive sometimes as high as 11 to 12 lbs. of grain, depending upon their ability to consume it to good advantage. Whenever heavy feeds such as corn meal, middlings, etc. form a part of the ration, bulky feeds such as wheat bran, dried brewers' grains, corn and cob meal, etc. should be included.

Some of the most important feeds suitable for dairy cows will be considered.

Corn (Grain).—This grain is used very extensively in American dairy rations because it may be successfully grown in most all sections of the United States. It is relished by cattle. It is relatively high in carbohydrates and when supplemented with another feed to complete the ration, the latter must necessarily supply roughage and be nitrogenous in character. When whole corn grain is fed some of it passes through the animal undigested and for this reason it is well to grind it and feed it as corn meal.

Corn and Cob Meal, when ground fine, is very satisfactory for dairy cattle. When the expense of grinding is not too great it may be used profitably. It is practically equal to corn meal in feeding value for dairy cows because of its bulkiness and looseness, which permits of its being readily acted upon by the digestive juices.

Ground Corn, Cob and Shuck Meal is also a good dairy feed. By grinding the corn with the husk, the expense of shucking is eliminated.

Corn By-Products.—Corn bran, corn germ meal, gluten feed, gluten meal, grano-gluten and hominy meal are used a great deal by feeders of dairy cattle. Gluten feed and gluten meal are very popular with the eastern feeders as a source of protein.

Wheat and Its By-Products.—Ground wheat may sometimes be fed when the price is not too high. It is of equal feeding value to corn meal and should be mixed with other grain in forming a ration, because it is sticky when masticated. The by-products are superior to ground wheat for dairy cows.

Wheat bran, wheat middlings or shorts and red dog flour are the wheat by-products fed in dairy rations. Wheat bran is especially desirable. This feed runs high enough in fiber to give bulk and it contains a high ash content and a fair protein percentage for a concentrate. Wheat bran is used in more dairy rations perhaps than any other concentrate. With heavy corn meal it makes a good combination as corn is rather deficient in ash and fiber. Bran seems to aid digestion, has a cooling effect, and is a mild laxative. It is one of the best feeds for dairy cows just after calving, because at that time the cow is generally constipated and feverish.

Middlings are much heavier than bran so they are not as good a complement for corn meal as bran. Middlings are more suitable than bran for animals of small capacity.

Six to eight pounds of bran and from four to six pounds of middlings may be fed daily to dairy cows. Dark feeding flour (red dog) is excellent dairy feed when the price is within the limit of the feeder. It is a heavy feed and therefore should be accompanied with some light concentrate.

Barley.—Ground barley may be fed profitably to dairy cows, at the rate of 3 to 5 lbs., in certain sections when the price is low. Barley should always be ground. It has about the same feeding value as corn. It is often fed with oats. It contains more digestible protein than corn and less than oats. Wheat bran, or roots, or oats, should accompany barley as this latter feed counteracts the laxative effect of these feeds.

Buckwheat By-Products.—Buckwheat bran and middlings are satisfactory milk producing feeds.

Rice Meal, pure rice bran, may be fed to dairy cows when the market value is not too high. Four pounds of this feed a day are sufficient.

Rye Meal should be fed in conjunction with ground oats, wheat bran, corn meal, etc., and should never be supplied in quantities of more than 3 pounds a day. An excess of this feed affects the quality of butter and for this reason it is customary to feed less than 3 pounds a day.

Oats.—Ground oats make excellent feed for cows in milk. The selling price regulates the extent of its use in dairy feeding. It may form the whole grain part of the ration and when mixed with corn meal, wheat bran, ground barley or rye meal, an excellent ration may be completed with hay and stover. Oats is easily digested and bulky and may be fed economically when the price is slightly higher than corn.

Pea Meal and ground oats when mixed together offer a suitable feed. About ⅓ pea meal together with ⅔ oats or bran is an ideal feed. This concentrate is fed in far northern sections with good success

Vegetable Oil By-Products.—Linseed meal, cotton-seed meal and cotton-seed hulls are used considerably for dairy herds. Cotton-seed is sometimes fed but at the present prices it is more advisable to sell it to the oil mills. It is a good feed. Linseed meal and cotton-seed meal are both used to furnish protein in rations. A study of Table I shows these feeds to contain high protein contents. Practical feeders advise that not over 4 pounds of cotton-seed meal be furnished per day and that some other grain accompany it in a ration.

Linseed meal is very popular in the foreign countries where it is used a great deal for feeding. This foreign demand has caused the employment of this feed to be too expensive for supplying the protein of dairy rations in some sections. Three to four pounds of this concentrate give excellent results with dairy cows.

Cotton-seed hulls, which are very light and bulky, furnish excellent roughage in dairy rations. Too much hulls are not desirable and 12 to 14 pounds a day are enough. The price of this feed must be considered by the feeder. There is a great variation in the composition of this feed, depending on the amount of broken kernels present. They are generally fed near the oil mills.

Alcoholic By-Products.—Malt sprouts, dried brewers' grains, and dried distillers' grains are protein concentrates of value for dairy cattle. About 25 pounds of wet brewers' grains may be fed successfully at points near the breweries. Their large water content and liability to ferment prohibit transportation and storage. Malt sprouts, dried brewers' grains and dried distillers' grains are used to supply protein and may make up 2 to 5 pounds of a day's ration.

The Massachusetts Agricultural Experiment Station, Bul. 94 says, "After taking into consideration the digestible nutrients contained in the several by-products (alcoholic), the mechanical condition and palatability, together with the results of different trials with dairy animals, the following general statements may be made with regard to the relative value of the several feed stuffs.

"1. Distillers' dried grains with 32 per cent. or more protein are fully equal if not rather superior to gluten feed in feeding value.

"2. Distillers' grains and gluten feed are worth fully one-half as much again as wheat bran.

"3. Brewers' dried grains and malt sprouts do not vary greatly in feeding value; the former will generally be given preference.

"4. Brewers' grains and malt sprouts are rather superior in feeding value to wheat bran, probably 10 per cent."

Sugar By-Products.—Cane, beet and sorghum molasses and beet pulp are used in feeding dairy cows. Cane molasses is especially palatable and digestible and 4 to 5 pounds a day may be fed with good results to furnish carbohydrate concentrate. Beet molasses is not so palatable as cane molasses but may be used to the extent of 2 pounds mixed with other feed per day. Sorghum molasses is used in mixed feeds and may be fed in sections where available at the rate of 2 to 4 pounds a day. Molasses is a good tonic and conditioner and may often be used to advantage in disposing of unpalatable roughage. The wet beet pulp may be fed in close proximity to the sugar factory, but it will not stand storing and becomes too expensive when transported. The New York (Geneva) Experiment Station estimates that pound for pound, the dry matter of beet pulp is equal to that of corn silage, or approximately, 2 tons of wet beet pulp equal 1 ton of corn silage. Wet beet pulp seems to give results far above what its chemical composition shows. In other words it has a beneficial physiological effect for milk production. The Colorado Experiment Station recommends 50 pounds as a maximum in daily rations. In their investigations the following ration was used:

24 pounds wet beet pulp
20 pounds alfalfa
4 pounds corn chops
4 pounds wheat chops.

Dried beet pulp seems to be more suitable for fattening animals than for dairy cows.

Corn Fodder and Stalks.—Corn stover, the whole corn plant, corn leaves, etc., furnish desirable feed that may be used to make up part of the ration for milch cows. On account of the wide distribution of the corn plant, this roughage is found in dairy rations of many sections. These feeds are comparatively high in carbohydrates so that leguminous hays are excellent to complete the roughage portion of rations containing any of them.

Grass Hays.—Timothy, Kentucky blue grass, meadow fescue, red top, Hungarian grass and other millets, orchard grass, prairie grasses, tall oat grass, Bermuda, crab, Canadian blue grass, Italian rye grass, rescue grass, teosinte, velvet grass, Russian broom, Western rye grass, Texas blue grass, oat, etc., are fed as roughage to dairy cattle. These furnish relatively large proportions of carbohydrates and when fed should be accompanied with grains rich in protein to form a balanced ration.

Timothy hay commands such a high market price that it is only occasionally that the feeder can economically use it. It is usually more profitable to sell this hay as the market price is generally far above its feeding value for dairy cows. Oats and vetch, oats and peas, wheat and vetch, oats, peas and vetch and similar combinations are grown and furnish good roughage for cows in milk.

Great care should be exercised in harvesting grasses. They should be cut before they become too woody and lose color. In curing, the green color and aroma should be maintained as much as possible.

Straws.—The straws from rye, barley, buckwheat, wheat, oats and rice are sometimes used in furnishing part of the roughage of dairy rations. Oat straw when bright, may be used to advantage. Many feeders use a small amount of oat straw to furnish a part of the roughage. As a general rule straws are too woody and stiff to be used to any considerable extent for feeding dairy cows in milk.

Legumes.—Alfalfa, clovers, Canada field pea, cowpea, soy bean and peanut vine are the principal leguminous plants used in dairy rations. Alfalfa and the clovers are par excellence for supplying roughage. Cowpea, peanut vine, soy bean and Japan clover (lespedeza) are fed in the South where they are easily grown. All the legumes are nitrogenous and make excellent roughage for carbohydrate concentrates. Clover hay is fed more in dairy rations than any other leguminous hay. It is greatly relished by dairy cattle.

Legumes should be harvested before they are mature to have the best feeding value. They are usually highest in feeding value just when in blossom. Great care should be taken in curing these natural feeds as the shattering of the leaves and other fine parts, results in large losses of protein. Rain and dew also injure these feeds.

Methods of Curing.—There are different methods employed in the successful curing of these crops. Some farmers cut this class of forage late in the afternoon so that very little wilting takes place before the dew falls. The next day the hay is cured as rapidly as possible and stored away before night. Another system requires that the forage be cut in the morning just after the dew has dried off. It should not be disturbed until afternoon when it is cocked before the dew falls. The cocks should be covered with caps to prevent rain injury, and allowed to stand until the sweating process is over. The cocks are then opened up and allowed to dry a short while until the water passes off and stored away before the dew falls.

Silage.—This is one of the best fodders for dairy cows. It furnishes succulent feed that exerts a beneficial physiological effect which tends to increase milk production. In winter it is very acceptable when green feeds are not to be had. It is variable in composition depending upon the nature of the crop or crops used, the condition of growth, and with corn the maturity of the ears. When corn is harvested at too early a stage it contains a great deal of water which tends to produce the so-called sour silage. Sweet silage is obtained from the more mature corn and may be fed in larger quantities than sour silage. As high as 50 pounds per day are sometimes fed but 30 to 40 pounds are usually sufficient. Some dry roughage as leguminous hay should be fed with it.

Corn and Legumes Make Valuable Silage.—The following from Bul. 101, Illinois Experiment Station is valuable data relative to silage. "Corn not only produces a large quantity of nutritious feed that is easily placed in the silo, but it is of such a nature as to pack readily and keep well. The large southern varieties of ensilage corn, which give enormous yields in tons per acre, have been recommended for silage; but such varieties do not produce much grain and the total nutrients are usually less than from ordinary field corn. The best results are obtained with some variety that will give a good yield of grain, and by planting somewhat thicker than for a grain crop. Under average conditions a larger tonnage of feed can usually be obtained per acre by combining corn, sorghum and cowpeas or soy beans, but even with this combination the greater part of the crop should be corn. When either peas or beans are grown with corn and the entire crop is put into the silo, the feeding value is greater, ton for ton, than that of corn alone. This is a much more economical method of obtaining protein than by purchasing it in high priced concentrates, as gluten feed, cotton-seed meal, linseed meal, etc.

Harvesting Corn and Cowpeas.—"If cowpeas are planted at the same time as the corn and in the rows with it, they will usually make a fair growth. Since the vines will run up the corn stalks, the entire crop can be cut with the binder the same as corn alone, making practically no extra work in filling the silo. The only difficulty in harvesting corn and cowpeas with the corn binder is that, if the corn is missing for a rod in the row,

Fig. 14.—Corn and cowpeas.

there is nothing to carry the peas back into the binder and it is likely to clog. Where there is a fairly uniform stand of corn, all can be readily bound together. As the stalks of soy beans are much stiffer than those of cowpeas, no difficulty is experienced in cutting them with corn."

Weight of Silage.—The following table gives the weight of corn silage at different depths two days after filling.[1]

[1] Bul 59, Wisconsin Exp. Station.

Depth of silage feet	Weight of silage at different depths pounds	Mean weight of silage per cu. ft. pounds	Depth of silage feet	Weight of silage at different depths pounds	Mean weight of silage per cu. ft. pounds	Depth of silage feet	Weight of silage at different depths pounds	Mean weight of silage per cu. ft. pounds
1	18.7	18.7	13	37.3	28.3	25	51.7	36.5
2	20.4	19.6	14	38.7	29.1	26	52.7	37.2
3	22.1	20.6	15	40.0	29.8	27	53.6	37.8
4	23.7	21.2	16	41.3	30.5	28	54.6	38.4
5	25.4	22.1	17	42.6	31.2	29	55.5	39.0
6	27.0	22.9	18	43.8	31.9	30	56.4	39.6
7	28.5	23.8	19	45.0	32.6	31	57.2	40.1
8	30.1	24.5	20	46.2	33.3	32	58.0	40.7
9	31.6	25.3	21	47.4	33.9	33	58.8	41.2
10	33.1	26.1	22	48.5	34.6	34	59.6	41.8
11	34.5	26.8	23	49.6	35.3	35	60.3	42.3
12	35.9	27.6	24	50.6	35.9	36	61.0	42.8

According to King:[1] "The weight of corn silage increases with the depth below the surface, with the amount of water in the silage, and with the diameter of the silo. In silos of small diameters the amount of surface in the wall is so much greater in proportion to the silage contained that the friction on the sides has more influence in preventing the settling of the silage.

"**Capacity of Silos.**—The capacities of silos increase more rapidly than do their depths, so much that a silo 36 feet deep will contain nearly five times as much silage as one only one-third that depth; and when it is remembered that there is less necessary loss with deep silage the importance of depth will be appreciated.

"Doubling the diameter of the silo increases its capacity a little more than four times, while trebling its diameter increases its capacity nine-fold. It is evident, therefore, that the cost of storage decreases rapidly with increase in the size of the silo."

The following tables give the approximate capacities of round silos in tons of corn silage.

[1] Bul. 59, Wisconsin Exp. Station.

TABLE A.[1]

Depth in feet	Inside diameter in feet											
	15	16	17	18	19	20	21	22	23	24	25	26
	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons
20	58.84	66.95	75.58	84 74	94.41	104.6	115.3	126.6	138.3	150.6	163.4	176.8
21	62.90	71.56	80.79	90.57	100.9	111.8	123.3	135.3	147.9	161.0	174.7	189.0
22	67.35	76.52	86.38	96.84	107.9	119.6	131.8	144.7	158.1	172.2	186.8	202.1
23	71.73	81.61	92.14	103.3	115.1	127.5	140.6	154.3	168.7	183.6	199.3	215.5
24	76.12	86.61	97.78	109.6	122.1	135.3	149.2	163.7	179.0	194.9	211.5	228.7
25	80.62	89.64	103.6	116.1	129.3	143.3	158.0	173.4	189.5	206.4	223.9	242.2
26	85.45	97.23	109.8	123.0	137.1	151.9	167.5	183.8	200.9	218.8	237.4	256.7
27	90.17	102.6	115.8	129.8	144.7	100.3	176.7	194.0	212.0	230.8	250.5	270.9
28	94.99	108.1	122.0	136.8	152.4	168.9	186.2	204.3	223.3	243.2	263.9	285.4
29	99.92	113.7	128.3	143.9	160.3	177.6	195.8	214.9	234.9	255.8	277.6	300.2
30	105.0	119.4	134.8	151.1	168.4	186.6	205.7	225.8	246.8	268.7	291.6	315.3
31	109.8	124.9	141.1	158.2	176.2	195.2	215.3	236.3	258.2	281.8	305.1	330.0
32	115.1	135.9	147.8	165.7	184.6	204.6	225.5	247.5	270.5	294.6	319.6	345.7

[1] Bul. 59, Wisconsin Exp. Station.

TABLE B.[1]

(The diameter is shown at the top of the columns and depth at the left.)

Height of silo	Inside diameter of silo in feet and the capacity in tons (2,000 lbs.).										
	10 ft.	11 ft.	12 ft.	13 ft.	14 ft.	15 ft.	16 ft.	17 ft.	18 ft.	19 ft.	20 ft.
feet	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons
20	26										
21	28										
22	30	36									
23	32	39									
24	34	41	49								
25	36	43	52								
26	38	46	55	64							
27	40	49	58	68							
28	42	51	61	71	83						
29	44	54	64	75	87						
30	47	56	67	79	91	105					
31	49	59	70	83	96	110					
32	51	62	74	86	100	115	131				
33	53	65	77	90	105	121	138				
34	56	68	80	94	109	126	143	162			
35	58	70	84	98	114	132	149	169			
36	61	73	87	102	118	136	155	176	196		
37	63	76	90	106	123	142	161	183	204		
38	66	79	94	110	128	148	167	191	212	237	
39	68	82	97	115	133	154	174	198	221	247	
40	70	85	101	119	138	160	180	205	229	256	280

The Horizontal Feeding Area.—Silage must be removed from the top and not sliced or cut down vertically as is often practiced in feeding hay from the mow or stack, because the entrance of air will rapidly spoil it. It is considered that at least 1.2 inches should be removed per day from the top to prevent molding. Two inches of corn silage weigh 5 lbs. per square foot at the top and 10 lbs. at the bottom, or an average of 7.5 lbs. for the silo. The daily requirement for a cow, at this rate, would be about 5 square feet surface area. The feeding area should not be so large that enough cannot be fed per day to prevent deterioration.

[1] Bul. 21, *Concrete Review.*

The table[1] which follows gives the diameters and depths of silos of two types which hold enough silage for 180 days, feeding 2 or 3.2 inches a day, allowing each cow 40 lbs.

No. of cows	Silo 30 ft. deep without partition					Silo 24 ft. deep without partition				
	Contents		Round diam. in feet	Square sides in feet	Mean depth fed daily inches	Contents		Round diam. in feet	Square sides in feet	Mean depth fed daily inches
	tons	cu. ft.				tons	cu. ft.			
30	108	4091	15.	12x14	2	108	5510	17.	16x16	3.2
40	144	6545	16.75	14x16	2	144	7347	20.	18x18	3.2
50	180	8182	18.75	16x18	2	180	9184	22.	20x20	3.2
60	216	9818	20.5	18x18	2	216	11020	24.	22x22	3.2
70	252	11454	22.	20x20	2	252	12857	26.	22x26	3.2
80	288	13091	23.5	20x22	2	288	14691	28.	24x26	3.2
90	324	14727	25.	22x24	2	324	16531	29.75	26x28	3.2
100	360	16364	26.5	24x24	2	360	18367	31.25	28x28	3.2

This table[2] gives the number of cows in herd and tonnage of silage for both 180 and 240 days of feeding of 40 pounds of silage per cow, also acreage of corn estimated to fill the silo and the dimensions of the silo itself. The diameters given are such that at least 2 inches in depth of silage will be taken off daily.

Number of cows in herd	Feed for 180 days				Feed for 240 days			
	Estimated tonnage of silage consumed	Size of silo		Corn acreage required at 15 tons to acre	Estimated tonnage of silage consumed	Size of Silo		Corn acreage required at 15 tns to acre
		Diameter	Height			Diameter	Height	
	tons	feet	feet	acres	tons	feet	feet	acres
10	36	10	25	2½	48	10	31	3½
12	43	10	28	3	57	10	35	4
15	54	11	29	4	72	11	36	5
20	72	12	32	5	96	12	39	6½
25	90	13	33	6	120	13	40	8
30	108	14	34	7½	144	15	37	10
35	126	15	34	8½	168	16	38	11
40	144	16	35	10	192	17	39	13
45	162	16	37	11	216	18	39	14½
50	180	17	37	12	240	19	39	16
60	216	18	39	14½	288	20	40	19
70	252	19	40	17	336	—	—	—

[1] Bul. 59, Wisconsin Exp. Station.
[2] Bul. 21, *Concrete Review.*

Roots and Tubers.—Carrots, beets, sweet potatoes, Irish potatoes, turnips, rutabagas, etc., are feeds that exert a beneficial effect on dairy cows. Irish and sweet potatoes usually command too high a price to warrant using them as feed. However, when the market price is low it sometimes pays to feed them. Beet (mangel) sugar-beet, rutabagas, carrots, and turnips are often fed with profit. These feeds increase milk pro-

Fig. 15.—Roots (mangels), a good succulent feed.

duction far above what would be expected from their chemical composition. In northern sections where corn is easily grown it is perhaps more economical to make silage than to grow roots for feeding. The Nebraska Experiment Station found sugar beets to have about the same feeding value as corn silage. The Colorado Experiment Station found that one ton of beets is equivalent to two tons of beet pulp. A great deal more dry matter may be produced on the same area by growing corn, than roots. In southern localities roots may be grown in the winter when land is often idle, and harvested in time to plant corn and other summer crops. Roots should be sliced before feeding. They seem to exert a cooling effect on animals. The mangel is probably the most profitable root crop to feed.

Pasturage.—When dairy cows are receiving plenty of green pasture grass, the production of milk generally increases and under such conditions it is not necessary to feed any roughage. Sometimes a small amount of grain (2 lbs.) fed occasionally at the afternoon feeding is beneficial. If the pasturage is scant the cows will require sufficient feed to supplement it.

Soiling.—Some farms have not the acreage to support the number of cows the dairyman wishes to keep by pasturing. On other farms the pastures become poor at certain times. On such farms green crops are cut and fed fresh to the animals. There is a great deal of labor involved in handling green crops in this way and for this reason soiling is not popular in some sections. In furnishing green crops to cows, the dairyman must arrange so that green feed may be furnished continuously. Oats, rye, alfalfa, clovers, oats and peas, sorghum, corn, etc., are popular soiling crops.

Salt.—This should be allowed the cows regularly. If the cows are on pasture a sheltered box containing rock salt or pulverized salt is helpful. Some feeders mix a little pulverized salt or common salt in the feed, but care must be taken not to add too much and make the feed unpalatable. About ¾ to 1 ounce of salt a day should be given regularly.

Water.—A good artesian well or other pure water should be supplied the animals at a place near or in the barn, so that the cows will not be forced to go a long distance in severe weather. They should be allowed all they wish as milk requires a great deal of water for a good production. If the water is not at the animals' disposal it should be supplied regularly two or three times a day. If a trough or other vessel is used, the feeder should make sure that it is kept clean.

Shelter.—In the summer, flies annoy the cows and effect milk production. Some dairymen keep their cows in dark, cool places during the day and pasture them at night, feeding green crops during the day. All pastures should have some trees to furnish shade during the hot days.

Exercise.—In the cold winters cows should get several hours of exercise daily, to keep up milk production. Often it is too disagreeable to exercise the cows outside, and a change to some roomy, well ventilated, covered enclosure, which is bedded with straw and horse manure and sprinkled with some material such as land plaster, makes a desirable place for the animals to rest and exercise.

Kindness.—The dairy cow is generally a nervous animal and should always be treated gently for best results. Dairy cattle like people do not enjoy harsh and abusive treatment. To keep up a good flow of milk the cows should be quiet and contented and any treatment that tends to make them nervous, results in lessening milk production.

Rations for Dairy Cows.—In the Wisconsin Experiment Station Bul. 38, Woll gives statistics on 100 American dairy rations. Some of the data from this bulletin is given for the student because it represents actual practice of some of the leading American dairymen.

In all, 2,921 cows in milk were represented as receiving these rations. A few of these rations may prove of interest.

Colorado—20 lbs. alfalfa hay, 10 lbs. corn fodder, 3 lbs. cotton-seed meal, 4 lbs. corn meal, 13 lbs. bran, 35 lbs. mangolds.

Connecticut—35 lbs. corn silage, 10 lbs. hay, 3 lbs. bran, 3 lbs. corn and cob meal, 2 lbs. Chicago gluten meal, 2 lbs. cotton-seed meal.

Illinois—7½ lbs. clover hay, 7½ lbs. timothy hay, 12 lbs. corn and cob meal, 8 lbs. bran, 1¼ lbs. linseed meal, 1¼ lbs. cotton-seed meal.

Indiana—30 lbs. corn silage, 5 lbs. clover hay, 3 lbs. corn fodder, 1 lb. oat straw, 1 lb. wheat straw, 5 lbs. bran, 2 lbs. oil meal, 2 lbs. cotton-seed meal.

Iowa—50 lbs. corn silage, 5 lbs. hay, 5 lbs. corn fodder, 1 lb. oat straw, 1 lb. barley straw, 5 lbs. ear corn, 2½ lbs. ground oats and barley.

Kansas—50 lbs. sorghum fodder, 7½ lbs. hay, 3.2 lbs. bran, 3.2 lbs. corn meal, 1½ lbs. oil meal.

Kentucky—32.5 lbs. corn silage, 6 lbs. clover hay, 3 lbs. corn fodder, 5 lbs. corn meal, 4 lbs. shipstuff, 2 lbs. oil meal.

Louisiana[1]—11 lbs. lespedeza hay, 3.5 lbs. cotton-seed meal, 13.5 lbs. cotton-seed hulls, 4.5 lbs. corn meal.

Massachusetts—40 lbs. corn silage, 5 lbs. English hay, 5 lbs. clover hay, 2 lbs. bran, 2 lbs. gluten meal, 1 lb. cotton-seed meal, 1 lb. linseed meal.

Michigan—27½ lbs. corn silage, 3½ lbs. clover hay, 3½ lbs. timothy hay, 3.6 lbs. bran, ½ lb. oats, 1 lb. rye, ½ lb. linseed meal.

Minnesota—8 lbs. corn fodder, 7 lbs. clover and timothy hay, 5 lbs. sheaf oats, 3 lbs. rutabagas, 2 lbs. bran, 3 lbs. oats, 3 lbs. corn meal, 2 lbs. oil cake.

Nebraska—20 lbs. prairie hay, 10 lbs. corn fodder, 5.7 lbs. corn meal, 2.9 lbs. bran, 1.4 lbs. oil meal.

New Hampshire—11.7 lbs. clover and witch grass hay, 3.3 lbs. oat straw, 10 lbs. meadow hay, 2 lbs. shorts, 2 lbs. corn and cob meal, 1 lb. ground pease, 1 lb. oats, 1 lb. barley

New Jersey—24 lbs. corn silage, 4 lbs. corn meal, 2 lbs. bran, 6 lbs. oats, 2 lbs. oil meal.

New York—9 lbs. clover hay, 9 lbs. timothy hay, 5 lbs. corn fodder, 5 lbs. oat and pea straw, 1 lb. oats, 1 lb. buckwheat middlings, 1 lb. corn, 1 lb. rye bran, 1 lb. wheat bran, 1.6 lbs. cotton-seed meal.

North Carolina—30 lbs. corn silage, 8 lbs. fodder corn, 3 lbs. corn meal, 3 lbs. bran, 1 lb. cotton-seed meal.

Ohio—10 lbs. clover hay, 20 lbs. corn stalks, 8 lbs. corn meal, 3 lbs. corn and cob meal, 1 lb. bran, 8 lbs. roots.

Pennsylvania—10 lbs. clover hay, 5 lbs. timothy hay, 2½ lbs. corn fodder, 6½ lbs. corn meal, 2 lbs. oats, 3.2 lbs. bran, 1½ lbs. oil meal, 15 lbs. carrots.

Texas—30 lbs. corn silage, 13½ lbs. sorghum hay, 1.3 lbs. corn meal, 2.6 lbs. cotton-seed meal, 2.2 lbs. cotton-seed, 1.3 lbs. wheat bran.

[1] Not included in average, supplied by the writer.

Utah—35 lbs. alfalfa hay, 6⅔ lbs. wheat bran, 3⅓ lbs. barley.

Vermont—35 lbs. corn silage, 10 lbs. mixed hay, 2 lbs. bran, 3.2 lbs. corn meal, 1 lb. linseed meal, 0.8 lb. cotton-seed meal.

West Virginia—48 lbs. corn silage, 2½ lbs. corn and cob meal, 2½ lbs. ground wheat, 2½ lbs. oats, 2½ lbs. barley meal.

Washington—15 lbs. alfalfa hay, 7 lbs. bran, 7 lbs. shorts, 2 lbs. malt sprouts.

Wisconsin—22 lbs. corn silage, 4 lbs. clover hay, 4 lbs. timothy hay, 2 lbs. oat straw, 2 lbs. corn stalks, 6 lbs. wheat screenings, 2 lbs. malt sprouts, 2 lbs. oil meal, 1 lb. wheat bran.

Canada—30 lbs. corn silage, 7½ lbs. hay, 6½ lbs. straw, 25 lbs. turnips, 1.3 lbs. pea meal, 2.5 lbs. oats, 1.3 lbs. barley.

In the 100 rations were included 3 succulent feeds, 18 coarse dry fodders, 27 concentrates, 6 kinds of roots and tubers, and 1 miscellaneous (skim milk). Of these 55 feeds several were used in many rations. The list that follows shows the number of times the most popular feeds were employed.

	times		times
Wheat bran	73	Oat straw	16
Corn silage	64	Corn and cob meal	14
Mixed hay	42	Barley	13
Corn meal	42	Roots	13
Clover hay	40	Wheat shorts	13
Linseed meal	37	Wheat middlings	11
Cotton-seed meal	35	Gluten meal	8
Oats	35	Pea meal	6
Corn fodder and stalks	35	Wheat	3
Timothy hay	21	Malt sprouts	3

NUTRIENTS IN THE 100 RATIONS IN POUNDS

	No. of rations	Dry matter	Digestible matter			Nutritive ratio
			Protein	Carbohydrates	Fat	
New England States	11	24.28	2.10	13.19	0.75	1:7.1
Middle States	31	24.65	2.27	13.68	0.82	1:6.8
Central States	20	22.97	1.97	12.78	0.72	1:7.3
North Central States	21	25.79	2.08	13.79	0.68	1:7.3
Southern States	2	23.48	2.00	12.14	1.05	1:7.2
Rocky Mountain States	5	30.81	3.12	15.39	0.79	1:5.5
Pacific States	1	21.60	2.68	10.54	0.55	1:4 4
Canada	9	21.57	1.76	11.69	0.63	1:7.4

Alfalfa was the principle roughage used in the western rations which accounts for the narrow nutritive ratio.

Dr. Woll gives the average nutritive ratio for 128 herds from the different sections of the United States and Canada as:

AMERICAN STANDARD RATION FOR DAIRY COWS.

Average for	Dry matter pounds	Digestible protein pounds	Digestible carbohydrates pounds	Digestible fat pounds	Nutritive ratio
128 herds.........	24.51	2.15	13.27	0.74	1:6.9

As previously stated the width of a profitable dairy ration depends upon the cost of the feeds locally. In some sections wider or narrower rations than the above may be best for certain conditions. The feeds that go to make up a ration are influenced by market prices of those that are available. Hence it is impossible to state the best ration for dairy cows. The nutritive ratio of most of the dairy rations fed in America is much wider than the Wolff standard given in Table II. From the foregoing data the student should experience little trouble in selecting feeds and compounding a ration suitable to the conditions of his home.

Suggestion:—Is there any objection to feeding a ration to a milch cow composed of linseed meal, wheat bran, gluten feed and alfalfa hay? Require the students to make a list of the available feeds in the locality; their prices; and require them to compute the cheapest rations possible for milch cows.

Have one of the students explain the construction of a silo, the way the crop is prepared for siloing and the appearance of the silage after it has been in the silo for some time. Examine some silage and allow the students to taste it. If there is a silo in the vicinity a trip to it may prove profitable.

SECTION XXX.

FEED AND CARE OF FATTENING CATTLE.

Requirements.—We have learned that fattening animals require enough protein to repair the wastes, and carbohydrates must be supplied to increase body weight. Hence the carbohydrates should predominate in rations for fattening animals.

The amount of protein required will depend upon the age of the animal. Mature animals require very little protein and a wide nutritive ratio is satisfactory for the laying on of fat. The width of the ration will be influenced by the available feeds and market values, and the cost per pound of increase in live weight. In some sections where alfalfa is cheap and abundant, a suitable ration would necessarily be narrower than one where carbohydrate roughage and grains are economical. The addition of protein from some nitrogenous concentrate as linseed meal, gluten feed, cotton-seed meal, etc., tends to increase the efficiency of fattening rations and makes them more palatable. Sometimes it is cheaper to supply most of the protein from some protein roughage.

A fattening ration should not only be palatable but should be easily digestible, hence rough fodders are not suitable. A variety of materials should make up the ration.

Cattle should average 2 lbs. gain in live weight per day during the fattening period. The gain of course depends upon the age of the animals. Experiments have shown that young animals gain faster than those more mature. During the first part of the fattening period cattle gain more than at the latter part and the longer the fattening period the more feed is required to produce a given gain in weight. It is considered that 12 to 13 lbs. of dry matter are required for 1 pound of gain. The animals should be allowed all the roughage they will eat.

Corn is the best grain feed for fattening cattle. In this country it is used more than any other single grain for this purpose. Because of its high content of starch it is admirably suited for producing fat.

Snapped Corn.—This is the unhusked ear which is snapped or broken from the stalk. It is the most popular feed in the West and produces excellent results. Some feeders fatten their cattle on this feed alone, claiming that the husk and cob furnish sufficient roughage. Farmers who practice this method of feeding often leave the stalks in the field allowing the cattle to eat what they wish of them. It is better to harvest the stalks and use them as roughage, for there is a great deal of waste and loss of nutrients by allowing the stalks to remain in the field. Cattle fed snapped corn sometimes become troubled with sore mouths. In such cases the animal should be fed a mixture of corn and cob meal and wheat bran or some other easily masticated grain mixture until the soreness disappears. In feeding snapped corn the cattle should receive some leguminous roughage such as clover, alfalfa, cowpea, soy bean, etc.

Shocked Corn.—This is a very satisfactory feed for fattening cattle. The harvester cuts and ties the fodder corn into bundles and the corn is then put in shock at a small expense. It is well preserved for winter feeding by this procedure and the husk prevents the ear corn from becoming too hard for cattle to masticate. Shocked corn is more easily preserved than snapped corn because in storing the latter it is hard to keep up a free circulation of air. This shocked corn is placed in sheltered feed racks with enough space between the racks to permit the animal free use of the head. Sometimes the bundles are scattered over a field. The cattle eat some of the fodder in this method. Pigs should follow cattle to pick up the wastes and droppings as some of the corn kernels pass through the animal undigested. One pig to one steer is sufficient. This indirect method of selling corn is profitable. The cattle often pay for the corn and the profits are derived from selling the pigs.

Protein is Desirable.—It is often profitable to limit the amount of shocked corn in a steer's ration and supplement it with corn and cob meal, shelled corn, and some protein concentrate as linseed meal, gluten feed, gluten meal, cotton-seed meal, etc. Sometimes wheat bran may be used instead of a protein concentrate when the market value is low. When nitrogenous roughage as alfalfa, clover, etc., is profitable to feed, the nitrogenous concentrates may be reduced.

Husked Corn is sometimes fed. It is cheaper and more desirable to feed snapped or shocked corn than husked corn. Husked corn becomes exceedingly dry and hard and has the tendency to produce sore mouths and gums when fed in large quantities. It is often practical to crush corn to make it more easily masticated.

Corn Meal seems to be favored by Eastern feeders. Larger gains are made with meal than with unground grain. Of course corn meal is a heavier feed than the whole ear and care must be exercised in its use. For Western and Southern feeders it is no doubt cheaper to feed the whole unground ear because of the expense of grinding.

Corn and Cob Meal.—Experiments have demonstrated that corn and cob meal is equal in feeding value to corn meal. This feed is more bulky than corn meal and hence it is easily attacked by the digestive fluids.

Corn Stover is always a cheap roughage on the farm. It should supply at least one-half the roughage when available. Alfalfa or clover make excellent complements of stover to complete the roughage of a ration. It is often desirable to cut up the stover or shred it to insure a larger consumption. The cost of course will determine the practicability of such practice.

Corn Silage.—When the farm is equipped with a silo it pays to allow the cattle about 10 to 15 lbs. a day during the preliminary and middle periods of fattening. Silage seems to help the cattle in the preliminary and middle periods of fattening by supplying water and bulk, by increasing the appetite and by producing a cooling and laxative effect. It is perhaps unprofitable to construct a silo just for feeding fattening cattle.

The Indiana Experiment Station produced good gains by feeding the following ration to fattening steers:

2.5 pounds cotton-seed meal
4.4 pounds clover hay
14.4 pounds shelled corn
27.7 pounds corn silage

With silage the cost of gain was ½ cent a pound less than with dry feed and the increase in profits amounted to $3-$8 per steer. The cotton-seed meal gave better results than oil meal and tended to produce a firmer flesh with silage.

Wheat Bran.—When the market price permits, wheat bran may be utilized for giving bulk to a ration. It seems to produce a slight laxative action and possess cooling properties which are desirable. When corn meal is fed, wheat bran is especially valuable in the ration.

Protein Concentrates.—Linseed meal, gluten feed, gluten meal, cotton-seed meal, etc., may often be used to advantage in furnishing protein to fattening animals. A little protein especially from linseed meal seems to give a finish to beef and often reduces the fattening period. This is helpful on a declining market. Linseed meal or oil cake at the rate of 2 to 4 lbs. a day is exceedingly beneficial for the finishing period. Cotton-seed and cotton-seed meal are good beef producing feeds. 3 to 4 lbs. of cotton-seed meal is sufficient per day.

Roots are valuable in the preliminary period of fattening, but should not be fed during the finishing period, because they produce soft flesh. 10 to 20 lbs. of roots per day are ample. Roots should always be sliced or pulped before feeding. In fattening rations the feeds are generally heat producing and roots seem to exert a cooling effect which is beneficial. In the corn belt it is cheaper to feed silage because twice as much dry matter can be obtained from equal areas by growing corn than roots. The mangel is the best root crop for steers and it produces a higher tonnage than the other roots.

Beet pulp has been shown by experiments to be a good feed for fattening cattle. With alfalfa as an adjunct, in sections where alfalfa is cheap, beet pulp may be fed profitably for fattening cattle.

Straw.—Flax straw, when flaxseed is present, may be used in fattening cattle. Oat straw is sometimes profitably utilized for supplying half the roughage. If hay is available it is perhaps better to feed the hay. Wheat straw has been found to be unsatisfactory because as much energy is expended in preparing it for digestion as is digested. Barley and rye straw do not furnish sufficient nutriment to warrant their use.

Molasses.—When the price of this feed is low it may be used to furnish part of the carbohydrates of a ration. On account of its increasing price it is not within the reach of many of our feeders.

Kaffir Corn may be successfully fed in the arid regions where corn is not profitably grown, for feeding steers. The Kansas Experiment Station found that Kaffir corn was a little below corn in feeding value. Where Kaffir corn is available, the stover may be fed as is practiced in feeding corn. Kaffir corn should be ground or soaked before feeding because of the hardness of the grains.

Sorghum Hay is sometimes used to furnish roughage in feeding steers. The smaller the stems, the more suitable is this feed.

Leguminous Hays.—Alfalfa, clover, cowpea, soy bean, etc., may often be used to advantage in furnishing the greater part of the nitrogenous portion of a fattening ration. It is often very profitable to utilize these hays in this way. Of course the market value will influence the extent of their use.

Grass Hays.—Most of the grass hays are suitable for fattening cattle. When corn stover is available it is cheaper to feed the stover and sell or save the hay for other live stock. Sometimes a part of the roughage may be profitably supplied in the form of hay. In Western sections prairie hay is often cheap and can most profitably be utilized as roughage for fattening cattle. Timothy hay is more profitable to sell than to feed cattle at the present market value. It is low in digestible nutrients and cattle cannot use it economically at the present price it carries.

Oats is sometimes used in fattening cattle. It is not high enough in carbohydrates to furnish the whole of the grain and should be supplemented with corn. The market value often makes the use of oats unprofitable.

Wheat.—Ground wheat is about equal to corn for fattening purposes. On account of its stickiness, bran, oil meal or some other concentrate helps with this feed. The price of wheat will not always permit its use, but when it sells for the same price as corn it may be fed.

Barley should always be ground before being fed. It is perhaps a little below corn for fattening value and not so well liked. When accompanied with corn is perhaps the better way of feeding it.

Summer Pasturing.—Cattle fed on grain and hay during the winter cannot be pastured on green grass entirely without causing shrinkage. For this reason some farmers make the change from hay to grass gradually. There are two methods used in turning steers to grass. One is to wait until the grass gets a good growth and accustom the steers to the change by allowing them a few hours a day on pasture, gradually increasing the period until they become used to it. By following this method the heavy feeding of grain is still followed and may be reduced when the cattle are on full pasture.

Another method is to turn the cattle to pasture when the first blades appear. By doing this the cattle cannot gorge themselves with grass and by the time the grass is abundant the cattle will be accustomed to it. The objection to this method of turning to pasture is that the grass does not have a chance to get a good start because of the continual cropping.

Size of Pasture.—Most American feeders prefer one large pasture to several small pastures. One large pasture does away with the trouble of changing the steers, offers a greater variety of grasses for grazing, and gives the animals more freedom and contentment.

Grain on Grass.—The kind of grain to feed on grass depends upon the grasses that make up the pasture. If clovers, alfalfa, or other nitrogenous legumes predominate, corn may make up the entire grain portion. If timothy, Kentucky blue grass, meadow fescue, or other grasses relatively high in carbohydrates are abundant, a little oil meal, cotton-seed meal, gluten feed, gluten meal, etc., should be mixed with the corn for the best results. Cattle fed in this way should be ready for market in the summer.

Preparing for the Fall Market.—When cattle are to be marketed in the fall it is not necessary to feed grain in the early summer. In the fall when the corn is ripe, shocked or snapped corn may be distributed over the pasture or fed in a rack in the field. It is desirable to feed a small quantity, 3 to 4 lbs., of corn at first, gradually increasing to a full feed of 15 lbs. a day. The cattle may be fed in this way until ready for market which will usually be sometime before the winter sets in. An addition of a protein concentrate is desirable in this system of fattening.

Water and Salt.—A plentiful supply of pure water should be supplied to cattle in the lot twice a day. In pastures a good spring will often furnish the water for range feeders. In cold weather it is beneficial to take the chill from water with some form of heater to cause cattle to drink enough water.

As with dairy cattle, rock salt or pulverized salt should be placed in a sheltered box in the feed lot. When the steers are kept in barns or feed lots, ¾ to 1½ ounces a day will be enough. Some feeders add common salt to the grain but it is necessary not to supply too much and make the feed unpalatable.

Shelter.—In the summer when the flies are troublesome fattening cattle often fail to gain unless they are taken to some dark, cool enclosure for a short time each day during the worst periods and fed some grain. Every pasture should have some trees to furnish shade. When cattle are fattened for the fall market a shelter should be provided in the pasture to protect the cattle during the cold fall rains.

Bedding induces the cattle to rest when they are kept in a feed lot or barn. Often a feed lot becomes muddy and a liberal supply of straw as bedding provides comfort and contentment.

Rations for Fattening Cattle.—There are many rations that may be computed for fattening cattle. The feeder should aim to utilize the cheap coarser feeds, by-products and wastes. By so doing, feed stuffs that ordinarily would go to waste or bring low prices on the market, may be profitably converted into beef. The amount of feed in a fattening ration will depend upon the age, weight, appetite and capacity of the animal. A feeder must use his judgment and regard the fattening standards merely as guides.

Suggestion:—Make a list of feeds that could be profitably fed in fattening cattle in your section of the country. Compute

Fig. 16.—A Shorthorn bull—after Good.

some cheap rations from these feeds. What differences would be made in feeding cattle during the different periods of fattening? What could be done to economize an animal's food during cold weather?

SECTION XXXI.

FEED AND CARE OF HORSES.

Requirements.—A horse or mule requires digestible nutrients to furnish the energy required for walking, pulling loads, trotting, etc., and for the repair of the tissues. The degree of work determines the amount of digestible nutrients needed. A horse or mule doing light, medium or heavy work will require different amounts and proportions of digestible nutrients. See Table II.

According to Massachusetts Experiment Station Bul. 99, the requirements of food for horses may be summed up as follows:

"1. The amount of food required is proportional to the amount of work performed.

"2. The amount of food required is also proportional to the speed with which work is done.

"3. More energy and consequently more food are required by a horse when drawing a load at a trot, than at a walk.

"4. Worry, confusion, fast driving and much stopping, sudden, short and severe labor, all consume much energy and require extra food.

"5. Generally speaking it is believed that truck horses drawing heavy loads slowly over good roads, require less food than express or cab horses.

"6. Horses doing severe work require more protein than those engaged in light work.

"7. The proportion of protein to carbohydrates (nutritive ratio) required by horses doing moderate work should be about 1 : 7 or 8, and for horses doing heavy work as 1 : 5 or 6."

It has been previously remarked that a horse or mule cannot consume as much roughage as ruminants. The stomach of a horse is small and 10 to 14 lbs. of roughage is enough for a day's ration.

Oats is the best grain for horses. This feed is used to a large extent in this country. The high cost of oats has sometimes induced feeders to substitute other feeds. Oats may make up the whole grain portion of the ration, or it may be used with corn, wheat, bran, barley and similar feeds.

There is no food that will take the place of oats for horses. The presence of the hull makes the feed light enough for the digestive juices to permeate freely. Oats should be ground for horses with poor teeth. Oats is a well balanced feed.

Barley is sometimes mixed with oats, or fed alone. On the Pacific slope, barley is fed a great deal to horses. Crushing or grinding barley helps in the mastication. Sometimes linseed meal or wheat bran is mixed with barley when fed to horses.

Wheat.—Ground wheat, mixed with oats or bran, is sometimes used as horse feed. Wheat requires some bulky feed to supplement it, because when fed alone it becomes sticky in the mouth. The market value of wheat generally prohibits its use as a horse feed.

Corn is fed extensively in the South and West. It is fed on the ear, shelled, or ground fine. Corn and cob meal because of its bulk is better for horses than corn meal when fed alone. When corn meal is fed it should be diluted with some bulky feed like wheat bran. Corn is more of a fattening feed than oats and it causes the animal to sweat freely, but may be used to good advantage as part of a ration. Corn is a very satisfactory feed in cold weather for horses because of its heat producing power. Corn runs low in ash and protein and must be supplemented with feeds running high in these constituents.

Kaffir Corn.—When this feed is ground it may be used for horses. This feed is not as valuable as corn but may be often profitably fed in semi-arid sections where corn cannot be grown successfully.

Cotton-Seed Meal.—As much as 2 lbs. of this feed per day may be fed to a horse or mule weighing 1,000 lbs. doing hard work. It is not desirable to feed too much cotton-seed meal to horses although a moderate daily amount, 1 to 2 lbs., mixed with other grains, seems to give good results. There is a great variation in the chemical composition of cotton-seed meal as manufactured and the feeder should try to secure meal carrying 40 per cent. protein, as the high grade meals are usually cheaper per unit of protein.

Linseed Meal, or oil meal, may be used to supply some of the protein of the grain ration. One-fourth to one pound per day is generally ample.

Dried Brewers' Grains.—Experiments have shown this product to be a more economical feed for horses than oats at the present prices, in some sections, and of equal feeding value. This feed is not as palatable as oats and corn but may be successfully fed with mixtures as bran and corn.

Wheat Bran is often used to lighten rations composed of heavy concentrates. It has a slight laxative effect. Some feeders use it daily in their rations while others feed it two or three times a week.

Molasses.—Cane and beet molasses are both fed to furnish carbohydrates. Cane molasses is more palatable than that from the beet and is used considerably in feeding horses in some sections. The amount of cane molasses to feed per day depends upon the feeds that make up the ration and the market price of this carbohydrate feed. As high as 12 to 14 lbs. a day have been fed with satisfaction but a smaller quantity, 4 to 8 lbs., is perhaps sufficient. This feed is used in sections of the South where it is available, and is increasing in popularity in the East where it is imported from tropical countries, notably Porto Rico.

Beet molasses is bitter and not so palatable as cane molasses but may be used when mixed with other feeds.

Timothy Hay is the best roughage for horses. The feeding value is not as high as some other hays, but this feed is usually free from dust and objectionable weeds, is easily handled without loss of nutrients, is relished, is well cured and seems to give better results than any other roughage on the American market for horses. On account of its bulk it serves as a good roughage for concentrates. Timothy hay is for roughage what oats is for grain in horse feeding.

Clover Hay is not very popular with horse feeders. Often it contains dust which is objectionable because it is apt to produce heaves. Well cured clover hay, however, is a good source of roughage and when used the protein supplied by the grain should be reduced. It is a good complement of starchy concentrates. Clover hay is liable to lose some of its leaves and other fine parts, which are rich in protein, when carelessly handled.

Alfalfa Hay.—The same objections are raised to alfalfa hay as to clover hay. Well cured alfalfa hay is fed successfully in limited quantities to horses. Corn or some other carbohydrate feed should supplement alfalfa in the ration. Alfalfa is liked by horses and they are liable to eat too much unless the supply is limited. The Utah Experiment Station has used alfalfa hay for supplying the entire roughage of rations for horses.

Oat Hay cut in the milk stage and well cured furnishes satisfactory roughage for moderately worked horses.

Corn Fodder is a valuable and cheap roughage for horses. It may be fed with corn and bran, corn and oats, and other combinations. It should be harvested before the leaves die because this part of the corn plant is relished by horses. For hard working horses the stalk should be cut or shredded to render mastication more easy. It may be used to supply the whole or part of the roughage and on account of its cheapness is worthy of consideration by all horse feeders.

Corn Silage may be fed to idle horses. When used for feeding working horses the amount should be small. It is a succulent feed and increases the appetite. It is somewhat bulky for the hard working horse.

Millet Hay.—The exclusive use of millet as roughage has been claimed to increase the action of the kidneys, produce lameness and swelling of the joints, and render bones soft. For these reasons millet is not a safe feed for horses, although it may sometimes furnish a part of the ration.

Grass Hays.—As previously stated, timothy hay is the best grass hay for horses. Sometimes other grass hays are available and when well cured and free from dust may economically furnish the roughage for horses.

Leguminous Hays.—Besides alfalfa and clover, other of the legumes are successfully fed to horses. Cowpea, lespedeza, etc.

may be fed when free from dust and well cured. The supplementing of any leguminous hay with grain of course offers a chance of reducing the protein in the grain portion.

Straw in good condition may be used for idle horses, but when fed to working horses only a small amount should be given. It is not so valuable as hay and therefore a larger quantity of grain should accompany its use. Oat straw is the best. Barley, rice and wheat straws may also be utilized but rye straw is of little value.

Cotton-Seed Hulls.—In the South this material is sometimes used in feeding idle horses. On account of its bulk, a working horse has not time to thoroughly masticate it, and when fed to hard working horses it should be used in small amounts to furnish a part of the roughage. The feed cannot generally be fed profitably at points far from the oil mills.

Roots are not generally fed in America to horses and mules. Sweet potatoes are sometimes used in the South at the rate of 3 lbs. to 1 lb. of grain. Horses are especially fond of carrots. They are excellent feed for horses fed dry feed. They seem to keep the digestive organs in good tone and increase the appetite. Not over 10 to 15 lbs. a day should be allowed and they should be sliced or pulped.

Watering.—Horses should be watered regularly with pure water. In the winter it is good practice to warm the water when it is too cold. Horses require different quantities of water depending on the atmospheric conditions, the work performed and the nature of the feed.

For horses of 1,200 lbs., 60 to 70 lbs. of water are considered average daily amounts, with variations of 30 to 100 lbs. There is some difference of opinion as to the best time to water the horse. It has been found that it makes no difference as long as the horses are watered regularly and with judgment. Hard working horses may be watered to advantage before feeding. Some advocate watering before and after feeding.

Bedding.—It is almost needless to say that horses to be kept in good condition should have a good clean bed of straw to rest on. Horses, like people, require a comfortable bed in order to sleep and feel well. An unclean bed is liable to produce sickness.

Salt.—A little salt occasionally is required by horses to keep the body in good tone. This may be supplied in the rock or pulverized form.

Wintering Working Horses.—In the winter when there is practically no work for the horse comfortable quarters should be provided. Coarse roughage as corn stover, straw, etc. may be

Fig. 17.—Draft type: Clydesdale—after Good.

used to advantage until spring time. About 6 or 7 weeks before the working period sets in the horses should be given a light grain ration and exercised to fit them for work.

System in Feeding.—Dalrymple in Louisiana Experiment Station, Bul. 115, says:

"A feeder may have all the information necessary concerning feeding standards, balanced rations, nutritive ratios, etc., and yet he cannot possibly secure the maximum of good results from the possession of such knowledge unless he employs a rational and intelligent system in the feeding of his animals.

"Animals under domestication, such as the live stock of the farm, and more particularly the work horses and mules, are living under artificial conditions in respect to their feeding, and are solely at the mercy of the intelligence, or otherwise, of their owners for the manner, or system, in which their food is supplied to them.

"Under natural conditions, the horse, or mule, owing to the anatomical arrangement of its digestive organs, and its physiological requirements, feeds quite often, but partakes of little at a time. The main reason for this is, the relatively small capacity of its stomach—not more, perhaps, than from 14 to 17 quarts—the short time it takes for the stomach to empty itself, and hence the necessity for frequent replenishment.

In order to obtain the most satisfactory results, under domestication, or during work, it is reasonable to presume that the animal's natural method of feeding should be approximated as closely as practicable. During the working season on the plantation or farm this would suggest that the day's ration, or the amount of food required by the animal in twenty-four hours, should be divided into at least three feeds. Some animals may, and do, become habituated to a lesser number of feeds per day with, apparently, satisfactory results. But it is a risky method, because, instead of getting as close as practicable to the animal's natural way of feeding, it is getting further away from it.

"After an opportunity, during the past twenty years, of studying and observing the conditions under which many of our work animals are fed, we have no hesitancy in saying that lack of system in feeding is responsible for the major portion of the loss of valuable animals from colic, inflammation of the bowels, etc.

"Many who lose valuable horses and mules on the plantations and farms from digestive troubles are wont to place the blame on the kind or class of feed the animals have been given; while, in reality, the blame properly belongs to the unnatural and unintelligent manner in which they receive their feed. A properly-balanced ration of the very best quality of oats, when fed intelligently and systematically, may not induce a case of colic during the natural lifetime of the animal. But if the entire day's ration of oats is fed at one time, instead of its being divided into three parts, it is liable to so derange the digestive apparatus as to set up a fatal case of flatulent colic, because the digestive organs in the horse or mule are not constructed, nor prepared, to "handle" such an excessive quantity of food material all at once. In such a case, are we to blame the oats for the trouble, or the unintelligent manner in which they were fed to the animal? And so it is with other kinds and classes of concentrated feeds; they require system in their administration to prevent indigestion, colic, etc., and to produce the best results in the capacity of the animal for work.

"A point of very great importance for the owner or feeder to bear in mind, therefore, is, that an animal's food may be properly balanced as to its digestible nutrients; it may be correct as to quantity and nutritive ratio; in fact, be perfect in every particular, so far as supplying the needs of the animal is concerned; and yet, if an intelligent system is not employed in the feeding of it, the otherwise perfect requirements may be altogether vitiated."

Rations for Horses and Mules.—A few rations fed in different parts of the country are given below. These rations are given to illustrate the several concentrates and roughage employed by practical feeders. Many combinations may be compounded into balanced rations for horses and mules doing different kinds of work. Of course the make up of a ration is controlled by the market values of the available feeds. By studying the text in this section the student should have no trouble in compounding rations for all classes of horses and mules, no matter what degree of work they may be required to perform. A variety of feeds in a ration is satisfactory.

TABLE OF RATIONS.[1]

New Hampshire Experiment Station, Live Weight 1,200-1,300 Pounds—Farm Horses.

6 pounds gluten feed	7 pounds bran	8 pounds corn
2 pounds bran	8 pounds corn	4 pounds linseed meal
6 pounds corn	10 pounds timothy hay	10 pounds timothy hay
10 pounds timothy hay		

Iowa Experiment Station—Farm Horses.

Live weight 1,500-1,600 pounds, heavy work	Live weight 1,300 pounds, ordinary work
15 pounds (oats, corn, bran, 3:2:1)	7½ pounds oats
15 pounds hay	7½ pounds corn
	10 pounds oat straw

Live weight 1,200 pounds		Live weight 1,300 pounds, severe work
6 pounds oats	5 pounds oats	9 pounds oats
4 pounds corn	5 pounds corn	6 pounds corn
2 pounds bran	2 pounds bran	10 pounds oat straw
12 pounds hay	12 pounds hay	

California Experiment Station, Live Weight 1,000 Pounds

7 pounds crushed barley	7 pounds cracked corn
11 pounds wheat hay	12 pounds barley hay
12 pounds alfalfa hay	10 pounds alfalfa hay

Truck Horses, Live Weight 1,500 Pounds, Severe Work

15–20 pounds oats	15–20 pounds equal parts corn and oats
12–20 pounds hay	12–20 pounds hay

Army Horses, Live Weight 1,100 Pounds

12 pounds oats	12 pounds corn	12 pounds barley
14 pounds hay	14 pounds hay	14 pounds hay

Express Horses, Live Weight 1,325 Pounds

2 pounds corn	1.5 pounds bran
19 pounds oats	9.5 pounds hay

Carriage Horses, Live Weight 1,050 Pounds

10 pounds oats	12 pounds hay

[1] Farmers' Bul. 170.

Rations Adapted from Various Sources.—The following are rations that are being fed in different sections of this country and represent practical rations.

MODERATE WORK, 1,000–1,200 POUNDS, LIVE WEIGHT

4 pounds dried brewers' grains	2 pounds wheat bran
4 pounds wheat bran	6 pounds hominy meal
3½ pounds corn	4 pounds oats
11 pounds hay	12 pounds hay
13 pounds oats	7 pounds oats
12 pounds hay	7 pounds corn
2 pounds straw	12 pounds corn stover
2 pounds cotton-seed meal[1]	4 pounds dried brewers' grains
8 pounds wheat bran	8 pounds oats
16 pounds cotton-seed hulls.	10 pounds hay
3½ pounds linseed meal	2 pounds wheat bran
8 pounds corn	6 pounds corn
10 pounds hay	6 pounds gluten feed
	11 pounds corn stover
6 pounds oats	10 pounds corn
5 pounds barley	15 pounds corn silage
11 pounds hay	14 pounds hay

HEAVY WORK, 1,000 POUNDS, LIVE WEIGHT

2 pounds cotton-seed meal	2 pounds cotton-seed meal
7 pounds shelled corn	10 pounds corn and cob meal
6 pounds molasses (cane, blackstrap)	2 pounds wheat bran
12 pounds cowpea hay	5 pounds corn stover
	12 pounds mixed lespedeza and crab grass hay
5 pounds rice bran	7 pounds shelled corn
5 pounds rice polish	2 pounds cotton-seed meal
2 pounds cotton-seed meal	4 pounds wheat bran
5 pounds molasses (blackstrap)	5 pounds molasses (blackstrap)
12 pounds lespedeza hay	12 pounds lespedeza and crab grass hay

Suggestion: Make a list of concentrates that may replace each other for feeding a horse. Why should not a horse in the stable doing no work be fed the same as when working? What will be the result if the horse's ration is not cut down when idle? What is the cheapest balanced ration that can be fed to a horse in your locality? How many times a day are the horses fed in your county? Do you think you could improve upon the system of feeding as practiced in your town?

[1] Sales stable horses and mules.

SECTION XXXII.

FEED AND CARE OF SHEEP.

Requirements.—The natural food of sheep is plants. They have four stomachs as is the case with cattle and therefore they are able to consume comparatively large quantities of roughage. They seem to be able to digest and assimilate the nutrients in roughage quite completely as is noticed by the fineness of the

Fig. 18.—Wool type.

particles in their manure. The requirements of sheep are somewhat similar to the requirements of cattle. Sheep require a little more protein per pound of live weight than cattle, perhaps because of wool production. Fattening lambs also require protein to produce growth. As a rule sheep require more digestible nutrients per pound live weight and make larger gains per unit of digestible nutrients than steers.

Weed Destroyers.—Sheep may be used to destroy weeds in pastures and are sometimes called weed destroyers. When grazing is scant sheep crop the grass very close to the ground and sometimes injure pastures in this way, but when good pasturage is allowed them no injury is done. Sheep will eat weeds that other classes of live-stock refuse. By turning a flock of sheep on a pasture containing noxious weeds, the pasture is improved by the destruction of such weeds and the land is made richer and better, and the pasture becomes covered with a smooth growth of grass.

Pasturing.—In the spring when the grass begins to come up the ewes and lambs should be put on pasture for a few hours a day, gradually lengthening the period until they become accustomed to the change from dry to green feed. Alfalfa, clover, rape, and rape and corn, make fine pastures for sheep.

Alfalfa Pasture.—By pasturing on alfalfa in the fall after two or three cuttings have been harvested good gains may be made for preparing lambs for the early winter market. Good gains are made on alfalfa alone but the addition of shelled corn increases the rapidity of gain. Alfalfa is nitrogenous in character and corn makes an excellent grain to feed with it. In feeding corn a little should be supplied at first, ¼ of a pound, and gradually increased until 1 pound a day is supplied. When oats and bran are cheap they may be fed in place of some of the corn.

Clover Pasture.—After the hay has been harvested and the second growth has a good stand the crop may be pastured by lambs. As with alfalfa grain should be supplied lambs that are to be sold in the late fall or early winter.

Rape Pasture.—This plant is becoming popular for pasturing sheep. It may be pastured the whole summer or for preparing lambs for fall shipment. Sometimes it is cut green and fed in racks. The Wisconsin Experiment Station considers rape as worth $14.48 to $20 per acre depending on the season. As with alfalfa and clover, grain is desirable for preparing lambs for the fall market. On account of the fondness sheep have for alfalfa and rape they sometimes eat too much when first turned to pasture and become bloated. If fed some hay and turned to pasture partly filled, bloating should not take place.

Rape and Corn.—In the West rape is sometimes drilled between the rows of corn, when the corn is laid by. When the corn is mature, the lambs are turned into the field and allowed to eat both crops. In this way many of the lambs are fattened quickly. The lambs should be watched and as soon as they become fat they should be taken from the pasture. Sometimes a few lambs have to be finished in the feed lot.

Wintering Fattening Quarters.—Sheep because of their heavy coat of wool do not require as warm quarters as cattle. Therefore a shelter should be provided that offers plenty of fresh air and protection from severe weather. A southern exposure is to be preferred. Plenty of bedding is desirable which should be renewed and supplied in sufficient quantities to keep the animals comfortable. The quarters should be well drained and kept as dry as possible to prevent disease such as foot rot.

Feeding Racks.—The roughage and grain should be supplied daily and separately. The hay should be placed in racks large enough so that all the sheep may feed at the same time. It should only be furnished in quantities sufficient for a feed as sheep do not relish hay that remains in the hayrack. Grain should be placed in troughs wide enough so that the feed cannot be eaten rapidly. This may be accomplished by providing a wide bottom to the grain trough thus distributing the grain. As with hay only grain enough for a feed should be given.

Salt.—Sheep require salt and there should always be a supply on hand. This may be furnished by nailing several boxes about the feed lot or by a separate trough which should be kept for this purpose.

Water.—Sheep do not drink as much water as other classes of live-stock. The amount of water consumed varies with the nature of the feed and temperature. From 4 to 6 quarts daily are considered average amounts. A supply of pure fresh water in suitable watering troughs should be in the feed lot.

Fattening Winter Lambs.—When the lamps are taken from the pasture to the feed lot only a moderate amount of grain should be given. This may be increased gradually until they are on a full ration. The kind of roughage will determine the amount and character of grain to use. Should straw, corn stover, or grass hay be the roughage, a protein concentrate must be provided as part of the grain ration. If alfalfa, clover, or some other nitrogenous hay be the roughage, shelled corn alone may supply the grain. It is not necessary to grind grain for sheep, because they are so constructed that they can easily masticate hard grains. When their teeth become poor it is best to fatten them on ground grains and market them.

Dorset the Best Breed for Hot-House Lambs.—In the East many fattened lambs are sold at fancy prices at the age of about 3

Fig. 19.—Dorset ewes—after Wing.

months for February trade. These lambs are called hot-house lambs or winter lambs and usually weigh about 45 lbs. The Dorset is considered the best breed for supplying early lambs, because of the hereditary tendency towards liberal milk production which fattens lambs early. The Dorset-Merino crossbreed and Hampshire are also used for producing hot-house lambs, the former being more desirable because of heavier milk production.

It is usually more profitable to fatten lambs for the spring and fall markets than for summer trade. Lambs gain more per pound of feed than mature sheep and there is more money made in fattening lambs than mature sheep.

Corn is the best fattening feed for lambs. Experiments have shown that about 500 lbs. of corn and 400 lbs. of clover hay produced 100 lbs. of gain in live weight. Shelled corn is the form in which this material is utilized for sheep. The amount of shelled corn in a ration depends upon the character of the roughage and the market value of corn.

Shock Corn.—In some sections the whole stalk of corn is fed to sheep. Enough shocked corn for a day's ration is placed in the feed rack. The lambs eat the grain, leaves, and more tender parts of the stalk. Some nitrogenous roughage as alfalfa, clover, cowpea, etc., makes an excellent fattening food with shocked corn. If nitrogenous hay is not available some protein concentrate should be used.

Oats produce growth in lambs and for a fattening ration corn should be added. It is not always profitable to feed oats but this is an excellent feed when the market price is low.

Barley is often fed in sections where corn is hard to grow. It may be used in fattening lambs. Barley is not as valuable as corn for sheep feeding but may be fed unground with other feeds.

Wheat is not as good as corn for fattening and an addition of corn helps a ration containing wheat. Wheat is a better feed for producing growth than corn because of its higher content of protein.

Wheat Screenings may often be fed at a profit to sheep. This material contains shrunken grains of wheat, weed seeds and other wastes obtained in preparing wheat, as it comes from the farm, for manufacturing flour. This feed is usually sold at a low price and sheep seem to be fond of it. The feeding value of this by-product is variable.

Wheat Bran is not a profitable sheep feed. It is too bulky for so small an animal and does not possess sufficient fattening qualities to be of material value for fattening lambs. It is sometimes fed in small quantities mixed with other grains.

Speltz or Emmer grows well in semi-arid regions and it has about the same composition as barley. Alfalfa hay fed with speltz makes a good sheep feed. The Colorado Experiment Station got better returns by feeding speltz than barley and found it to be as valuable as corn in that section. The South Dakota Experiment Station found barley to be more valuable than speltz and a mixture of barley or corn and speltz to be better than speltz alone.

Protein Concentrates.—Linseed meal, gluten meal, gluten feed and cotton-seed meal may often be used in rations deficient in protein. When grass hay, stover, etc., are used as roughage a mixture of a protein concentrate with shelled corn gives good results. The proportion of protein concentrate to corn or other carbohydrate concentrate should depend to some extent on the prices of these grains, although too large a proportion of protein concentrate should be avoided.

Protein Roughage.—Clover, alfalfa and cowpea hays are suitable roughage to supplement corn in completing a sheep ration. These crops can be grown on the farm and the necessary protein for the growth and repair of the animal body may be supplied much more cheaply than from protein concentrates. Should the supply of protein roughage be limited it could be used with straw, corn stover or grass hay. Some protein concentrate would be necessary under such conditions but not so much as if no protein roughage were utilized.

Cotton-Seed Hulls are fed to sheep in sections near oil mills. This feed makes a good roughage for sheep when the price is low.

Corn Leaves are eaten by sheep with great relish. They are not so valuable as the leguminous hays. Sheep do not eat the coarser parts of the corn stalk very much even when shredded or ground.

Corn Silage fed in limited quantities tends to keep sheep in good health and is excellent during the early period of fattening. It would not pay to build a silo just to furnish ensilage to sheep but on dairy farms the available silage may be furnished to lambs in daily amounts of 1 to 2 lbs. together with about

½ to 1 lb. of dry roughage. As corn silage contains some grain, the dry grain may be reduced when it is fed.

Grass Hays.—Lambs fed on grass hays should receive some protein concentrate to balance the ration. Most of the grass hays are suitable. Millet hay is not favored by sheep feeders because it sometimes produces scours.

Roots like silage furnish succulence, keep the digestive tract in good condition, and increase the appetite. In the European countries and Canada roots are used a great deal in feeding sheep. The feeding of roots in the United States is not as profitable as feeding silage in sections where corn may be grown extensively. In the South it ought to prove profitable to raise roots in the winter for sheep feeding, as the land is often idle during the winter and roots are off the land in time to plant the summer crops. Some dry roughage should be fed with roots. Roots are especially desirable during seasons when sheep are off from pasture. Mangels and sugar beets are popular roots for feeding sheep. Two to 4 lbs. a day are sufficient.

Wet Beet Pulp may be utilized at points near sugar factories. The laxative effect of beet pulp may be eliminated by using a little dry roughage as straw or stover. On account of the large amount of water in beet pulp it is not desirable in large quantities when finishing lambs.

Dried Beet Pulp is a fattening food suitable for sheep. The market price of this feed will determine whether or not it can be profitably used. It is not as valuable as corn.

Straw.—When other roughage is scarce, straw may be fed as part of the roughage. Straw is inferior to hay as feed and when other roughage is available straw is undesirable. Sometimes a feeder may use straw entirely to furnish roughage, in which case the grain must be increased to balance the ration. Oat straw is better than wheat, rye, or barley straw.

Feeding Period, Rate of Gain, Etc.—Lambs fed grain on pasture should be ready for market in 5 to 8 weeks after being placed in the feed lot. The total feeding period for sheep and lambs when preparing for market should not last over 15 weeks and often in 12 to 14 weeks they are ready. Lambs

EXPERIMENT STATION RATIONS FOR LAMBS.[1]

Rations by lots	Michigan Bulletin 113[2]				Wisconsin Bulletin, 32[3]		Colorado Bulletin 75[4]		
	Corn Clover	Corn, 80 % Oil meal, 20 % Clover	Corn, 50 % Bran, 50 % Clover	Corn, 50 % Wheat, 50 % Clover	Corn, 66⅔ % Oil meal, 33⅓ % Pasture	Corn, 66⅔ % Cotton-seed meal, 33⅓ % Pasture	Corn Alfalfa	Barley Alfalfa	Speltz Alfalfa
Average weight at the beginning	82.	83.	80.	81.	55.	53.	53.8	57.4	53.8
Average weight at the close	115.	118.	106.	111.	88.	82.	78.4	76.8	78.2
Daily gain	0.31	0.34	0.25	0.28	0.47	0.42	0.27	0.21	0.27
Grain consumed per day	1.49	1.65	1.62	1.40	0.83	0.66	0.88	0.88	0.95
Hay consumed per day	1.04	1.10	1.07	1.07	pasture	pasture	1.78	1.97	1.96
Grain consumed per pound of gain	4.81	4.86	6.38	5.03	—	—	3.09	3.43	3.03
Hay consumed per pound of gain	3.35	3.23	4 20	3.80	—	—	6.07	7.59	6.26
Cost of 100 pounds of gain	$4.60	$5.10	$5.30	$5.40	$2.00	$3.31	$5.25	$4.95	$4.28

[1] Smith's Profitable Stock Feeding.

COST OF FEEDS

[2] Corn, $14.20 per ton; 40 c. per bush.
Wheat, $17.70 per ton; 53 c. per bush.
Bran, $13.75 per ton.
Oil meal, $25.00 per ton.
Clover, $7.00 per ton.

[3] Corn, $14.00 per ton; 39 c. per bush.
Oil meal, $20.00 per ton.
Cotton-seed meal, $25.00 per ton.
Pasture, not counted.

[4] Corn, $26.00 per ton; 63 c. per bush.
Barley, $20.00 per ton.
Speltz, $20.00 per ton.
Alfalfa, $4.00 per ton.

EXPERIMENT STATION RATIONS FOR LAMBS.[1]—(*Continued*)

Rations by lots	Utah Bulletin 78[5]			Wyoming Bulletin 47[6]		Nebraska Bulletin 66[7]		Nebraska Bulletin, 71[8]		Average for the seven tests
	Wheat and alfalfa	Good wheat screenings Alfalfa	Poor wheat screenings Alfalfa	Prairie hay Corn, 95 % Oil cake, 5 %	Alfalfa hay Corn, 95 % Oil cake, 5 %	Prairie hay Corn	Alfalfa hay Corn	Sorghum Corn	Alfalfa Corn	
Average weight at the beginning.....	47.	47.	47.	46.	45.	52.4	53.5	62.	62.	58.93
Average weight at the close..........	64.	66.	68.	72.	78.	72.	85.	82.	94.3	79.81
Daily gain	0.19	0.24	0.20	0.25	0.32	0.20	0.34	0.21	0.32	0.28
Grain consumed per day.............	0.85	0.90	1.08	0.76	0.76	0.86	1.00	1.25	1.27	1.06
Hay consumed per day	1.24	1.4	1.27	1.07	1.47	0.85	1.36	1.68	1.65	1.37
Grain consumed per pound of gain...	4.54	3.96	5.32	3.00	2.4	4.3	3.06	6.11	4.23	4.22
Hay consumed per pound of gain ...	6.57	6.22	6.23	4.3	4.6	4.24	4.11	8.18	5.18	5.25
Cost of 100 pounds of gain..........	$4.88	$3.58	$3.27	$4.48	$3.89	$2.73	$2.20	$4.91	$3.82	$4.10

[1] Smith's Profitable Stock Feeding.

COST OF FEEDS

[5] Wheat, $15.00 per ton; 45 c. per bush.
Good screenings, $11.00 per ton.
Poor screenings, $7.00 per ton.

[6] Corn, $30.00 per ton; 84 c. per bush.
Alfalfa, $11.00 per ton.
Prairie hay, $12.00 per ton.

[7] Corn, $8.80 per ton; 25 c. per bush.
Alfalfa, $4.00 per ton.
Prairie hay, $4.00 per ton.

[8] Corn, $10.70 per ton; 30 c. per bush.
Alfalfa, $6.00 per ton.
Sorghum, $4.00 per ton.

average about ¼ of a pound daily gain. According to Lawes and Gilbert: "Sheep on good fattening food, such as oil cake or corn, with chaff and roots, will consume weekly about 4.75 lbs. oil cake, 4.75 lbs. of hay, and about 70 lbs. of roots, for every 100 lbs. of their live weight.

"When fed as above, they will consume every week about $^1/_7$ of their own weight of the dry substance of food; that is, after deducting the moisture it contains.

"Sheep well fed and under cover will increase about 2 per cent. upon their weight; that is to say, 100 lbs. live weight will increase from 1.75 lbs. to 2 lbs. per week.

"To increase 100 lbs. in live weight, sheep will consume about 225 lbs. of oil cake, or corn, 225 lbs. of hay (chaff), and from 3,000 to 3,750 lbs. of roots.

"The increase of a fattening sheep is at the rate of about one pound live weight to eight or nine pounds of the dry substance of the food consumed."

SECTION XXXIII.

FEED AND CARE OF SWINE.

Swine like horses have but one stomach, therefore they are not adapted to consuming as large quantities of roughage as the ruminants, cattle and sheep. Grain is very desirable for pigs and from equal weights of such feed pigs will gain more than

Fig. 20.—Grand champion Poland-China sow—after Dietrich.

the ruminants. Swine generally are made to utilize the wastes from the kitchen and the dairy and because of the many wastes that would ordinarily be thrown away, the raising of pork is usually very profitable.

Requirements.—The requirements for pork production include plenty of bone making material (ash) and a fair supply of protein. It was formerly customary to feed very wide rations and market the animals very fat at the age of about 15 months, weighing 300 to 400 lbs. Such hogs are suitable for the packing houses. Local demand at present often calls for pigs of

150 to 250 lbs. of rather lean pork, which may be produced in a few months, the age depending upon whether they are grain or pasture fed. For lean pork a narrower nutritive ratio is required than for fat pork. A nutritive ratio of 1 : 6.5 or 7 is suitable for the production of lean pork. As with other animals the gain in live weight from feed is greater in the earlier stages of the fattening period and so it is more profitable to market pigs when 5 to 8 months old than when 15 months old. This early marketing also gives quicker returns. The following table from Henry's "Feeds and Feeding" illustrates this point:

Weight of pigs	Average weight	No. of stations	No. of trials	No. of animals fed	Average amount of feed eaten per day	Feed eaten per 100 lbs. live wt.	Average gain per day	Feed per 100 lbs. gain
pounds	pounds				pounds	pounds	pounds	pounds
15– 50	38	9	41	174	2.23	5.95	0.76	293
50–100	78	13	100	417	3.35	4.32	0.83	400
100–150	128	13	119	495	4.79	3.75	1.10	437
150–200	174	11	107	489	5.91	3.43	1.24	482
200–250	226	12	72	300	6.57	2.91	1.33	498
250–300	271	8	6	223	7.40	2.74	1.46	511
300–350	320	3	19	105	7.50	2.35	1.40	535

The average weight of 34,400,000 market hogs for the year ending March 1, 1908 was 226.58 lbs., costing the packers $5.52 per 100 lbs.[1] This shows that 225-230 lbs. is about the average weight of the market hog of to-day.

Corn is the most common feed for swine. It is high in carbohydrates and low in protein and ash, and is suited for the quick production of fat.

Shelled corn, corn meal and corn on the cob are about of equal feeding value for swine; corn meal being perhaps slightly superior. If shelled corn is very hard, causing sore mouths, it should either be soaked in water for a day or so or else ground to a meal. Sometimes grinding is too expensive but is preferable when practicable. Corn meal should always be soaked with

[1] Coburn, "Swine in America."

water just before feeding to render it more palatable. Corn is often profitably fed without the addition of any other grain when pigs are on good leguminous pasture or rape. The amount of corn to use in the ration depends upon the age of the pigs. Young pigs require more protein and ash, to supply nutrients to furnish growth, than mature animals. Corn alone does not contain enough protein and ash to supply the needs of young pigs, therefore it is necessary to supplement it with materials rich in protein and ash, and use it in smaller proportions for young pigs. Wood ashes, bone meal, etc., are often fed pigs that are kept in pens, to furnish sufficient ash to form strong bones, especially when corn is the only grain fed. Swine on pasture do not generally require to be supplied bone forming materials as they secure an ample supply from the pasture.

Wheat should always be ground for pigs. It meets the requirements of young pigs better than corn because of its higher percentage of protein and mineral compounds. It is considered of equal feeding value to corn and produces pork of fine flavor. When the price is low this feed is very profitable for pork production. A mixture of wheat and corn meal or wheat and barley, is better than when fed alone. A combination of wheat and skim milk makes an excellent food for young pigs. Sometimes wheat is soaked for a day before feeding but this is not as satisfactory as wheat meal. Experiments show an increase of one pound gain from about 5 lbs. of wheat.

Wheat Middlings or Shorts is a suitable feed for all ages of swine. A mixture of shorts and corn, shorts and barley, or shorts and skim milk, produces firm pork. This feed should never compose the whole grain of the ration as when fed alone the pork is liable to be soft. This by-product seems to be especially adapted for pork production and should be used with other feeds and when the market price will permit. For young pigs middlings gives fine results.

Wheat Bran is not adapted to young pigs because it is too bulky and coarse and contains too much fiber. It is sometimes fed in small amounts to brood sows but it is not generally popular.

Wheat Screenings when cheap may sometimes be profitably utilized for pigs. The composition of this material is variable. It should be soaked before feeding.

Barley is considered the best cereal for the production of firm, well flavored pork. There are two varieties grown in this country, namely, the bald and common. The bald variety is preferable because of the smaller amount of hull. It should be ground or soaked and makes a good combination with leguminous hay and skim milk before fattening. A mixture of barley and corn makes a good fattening ration although sometimes the barley is used alone.

Rye is considered of about equal feeding value to barley in the production of pork. It is best to feed rye ground and in the form of a slop. It should not constitute more than ⅓ of the ration as swine seem to tire of it. An addition of corn is of material value in furnishing a palatable ration with rye.

Kaffir Corn.—This feed should be soaked or ground on account of its small hard seed. It is not the equal of corn meal for fattening. It also has the tendency of producing constipation. From experiments conducted at the Kansas Experiment Station, Georgeson concludes that: "Red Kaffir corn meal did not prove quite equal to corn meal as a fattening food. A mixture of ⅔ Kaffir corn meal and ⅓ soy bean meal produced excellent gains. The soy bean meal apparently corrected the defects of the Kaffir corn meal in such a way as to make the mixture a desirable feed. A mixture of ⅔ corn meal and ⅓ soy bean meal gave slightly better results than Kaffir corn meal and soy bean meal. The conclusion to be drawn from this is that red Kaffir corn meal is not as good a feed for hogs as corn meal, but that when either Kaffir corn meal or corn meal is mixed with soy bean meal the results are highly satisfactory."

Millet Seed.—Experiments conducted at the South Dakota Experiment Station with ground millet seed proved this feed to be less valuable as a feed for swine than wheat or barley. Twenty per cent. more millet seed was required to produce one pound of gain than barley and it seemed to produce a softer pork than barley or wheat. Millet seed is relished by swine and in certain localities it should prove a profitable feed. It may be fed with corn but in such a mixture the corn should predominate.

Oats give better returns when fed ground or crushed. Sometimes oats are soaked before feeding. As a general rule oats are too expensive to feed hogs. They are not satisfactory for young pigs on account of their bulk, but may be fed if the hulls are removed. A mixture of wheat and oats (when the hulls are sifted out) forms a good ration for growing pigs. Oats are inferior to corn for fattening and therefore should be cheaper than corn to feed profitably.

Canada Field Peas are rich in protein and in sections where they are easily grown are a valuable hog feed. They should never be fed alone. They may be fed unground, ground or soaked. Mixed with corn, wheat, barley or rye they complete a good fattening ration. Before the fattening period they are considered better than corn.

Linseed Meal should not form over 5 per cent. of the grain portion of the ration as large amounts of this feed seem objectionable. As a supplement in limited amounts, it proves beneficial in that it aids digestion and produces laxativeness.

Cotton-Seed Meal is not considered entirely safe as a food for swine when continually fed or when supplied in large quantities. Bul. 85 of the Arkansas Experiment Station says: "According to our experience, any economic advantages to be derived from feeding this material will be secured by amounts well within the danger limit, and that independent of its effects on health. For the benefit of those who may wish to take the chances on feeding cotton-seed meal or cotton-seed to hogs continuously, the following allowances appear to be well within the danger limit:

Pigs under 50 pounds	1/4 pound per day
Pigs from 50–75 pounds	1/3 pound per day
Pigs from 75–100 pounds	2/5 pound per day
Pigs from 100–150 pounds	1/2 pound per day

"If fed a full grain allowance, the dosage may be obtained by properly proportioning the cotton-seed meal to the other components of the ration, namely: one to five, six, seven, or eight, according to the stage of growth. A meal ration containing cotton-seed meal should also contain at least an equal amount of wheat bran to supply bulk. For the remainder, corn appears to be the only choice."

Bul. 78 of the Texas Experiment Station says:

"For animals on heavy feed, that not more than one-fourth the weight of the grain ration consists of cotton-seed meal.

"That this feeding continue not more than 50 days, or that the proportion of meal be reduced if feeding is to be continued longer.

"That the meal be mixed with the other feed and all soured together."

"That as much green feed as possible be supplied to the hogs."

"That a close watch be kept and the meal taken from any animals not eating or not gaining well.

"One pound of cotton-seed meal to five of corn furnishes the nutrients in the most desirable proportions for fattening, while one or two of corn are more nearly correct for young stock."

It is understood that the United States Department of Agriculture have been endeavoring to eliminate the toxic or poisonous principle in cotton-seed meal and if they successfully accomplish this, it will render this material much safer and more valuable for a feed for animals of all kinds.

Rice Polish is especially adapted for fattening hogs. It contains more protein than corn and sufficient carbohydrates to make it a good fattening food. The Alabama Experiment Station found that 373 lbs. of rice polish produced 100 lbs. of gain as compared with 474 lbs. of corn meal. Or 78.6 lbs. of rice polish were equal to 100 lbs. of corn meal. This feed is not generally in the American markets except in a few sections and where it can be purchased at a reasonable price it may be used to good advantage in fattening hogs. The Louisiana rice polish is usually of good quality.

Rice Meal.—This product is pure rice bran. The South Carolina Experiment Station found that rice meal was superior to corn meal as a fattening food for swine. The Massachusetts Experiment Station found that equal weights of corn meal and rice meal when fed with skim milk were of equal feeding value.

This by-product, like rice polish, is hard to purchase at a reasonable price, outside of certain localities. The experienced feeder of rice by-products should have no difficulty in securing rice meal instead of rice bran adulterated with hulls.

Packing House By-Products.—Digester tankage and dried blood are fed to furnish protein to supplement corn in rations for hogs. These by-products should be fed in limited quantities because they are very concentrated. Tankage should not make up more than 10 per cent. of a ration and dried blood in quantities of a tablespoonful is sufficient. These concentrates should be thoroughly mixed with the grain portion of the ration so that each pig will not secure any more than its share. For young pigs these amounts should be reduced. The use of these feeds seems to shorten the fattening period and keep up the appetite. It must be understood that the value of these by-products depends upon their composition and quality which is sometimes variable.

Dairy By-Products.—Skim milk, buttermilk and whey are the dairy by-products fed to swine.

1. Skim milk may be fed to swine of all ages. Experiments show that 3 lbs. of skim milk to 1 lb. of meal give the best returns. Skim milk develops strong bones and produces good body tissue.

2. Buttermilk, when not diluted, has about equal value to skim milk. It is perhaps not so valuable as skim milk for feeding young pigs. Skim milk and buttermilk are rich in protein and ash, and as corn meal is rather deficient in these constituents, they are complementary feeds.

3. Whey. The value of this by-product for feeding depends upon its source. Experiments gave best results when whey was fed with ground corn, barley, rye, or wheat. Whey is a bulky food and can be utilized to better advantage by old than young animals. According to Henry in averages of results of the Wisconsin and Ontario Experiment Stations, 785 lbs. of whey will equal 100 lbs. of grain.

Molasses.—The results of experiments in feeding hogs with beet molasses have not been favorable for using this by-product for swine feed. The large amount of potash salts in the ash of beet molasses is liable to produce scouring when fed in other than limited quantities. In Louisiana cane molasses is fed to hogs. Hogs are extremely fond of it and seem to thrive on it. The writer believes a limited quantity, when the market price is low, will prove a profitable fattening food. Cane molasses is high in digestible carbohydrates and when corn is fed, the roughage should be nitrogenous. Cane molasses is in such demand by manufacturers of mixed feeds, syrup mixers, and as a feed for mules and horses, that it is questionable whether it can be used by the economical feeder.

Leguminous Hays.—Clover and alfalfa are excellent roughage to feed with concentrates as corn, barley, rye, wheat, rice polish, etc. It should be the aim of every feeder to harvest these crops when the stems are small and tender, and prevent the loss of the leaves and finer parts, to furnish them in the best condition for hogs. These hays should be ground, scalded and added to the grain and fed about once a day. These nitrogenous hays are not satisfactory to feed during the finishing period but supply protein in a cheap form for the early periods of fattening.

Peanuts are used a great deal in the Gulf States to fatten hogs. The vines are first harvested or grazed with cattle or sheep and then the swine are turned on to harvest the peanuts. It has been found profitable to allow the swine either a field of corn or to supply corn to them while they are on peanuts, as peanuts alone do not make firm pork. It is estimated that an acre of Spanish peanuts will furnish sufficient food for 8-10 hogs depending upon the grain supplied and the length of time they are kept on the pasture. Peanuts are considered more profitable than corn for pigs, as 3 lbs. of peanuts make 1 lb. of pork, while it takes 5 lbs. of corn to produce a pound of gain.

Roots are too bulky and contain too much water to be considered favorably as fattening feed. They may be used for brood sows' suckling pigs as they tend to increase milk production. The local conditions will determine whether to raise roots for swine feeding.

Corn Silage may be fed to brood sows' suckling pigs as this feed exerts the same influence on milk production as roots. On farms where this feed is available it may be utilized.

Following the Cattle.—In those sections where corn is extensively grown and fed to cattle, it is common to have shotes weighing 90-150 lbs. follow the cattle and glean the droppings. About

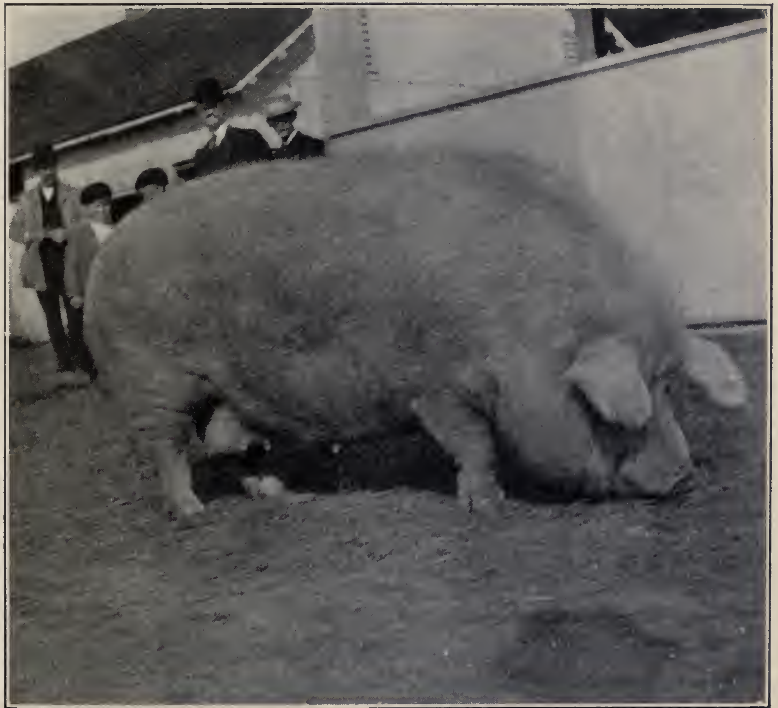

Fig. 21.—Chester white sow—after Plumb.

15 shotes are allowed to 10 steers. Sometimes the number of shotes is increased when a large amount of grain is fed or scattered. Two feeding lots are often provided and the hogs are turned into the lot that the steers occupied the previous day. In the fall and early winter the shocked or snapped corn is scattered about the pasture and the steers eat all they wish. Considerable

grain is left about and this and whatever is undigested is eaten by the hogs. By keeping the steers and hogs separated, the corn is not trampled so badly, and the animals are more contented. The more shotes put on the pasture the more grain must be fed. As soon as a hog becomes fat another should replace it. This method of feeding hogs is considered the cheapest in the corn sections. All the gain from hogs so fattened is usually profit because what the steers waste and void would ordinarily be lost. Again the land is made richer by fattening cattle and hogs in this way. Should more hogs be used than there is feed for, it is necessary that some feed be supplied the hogs.

Pasturing.—Pigs do well when pastured on clover, alfalfa, cowpeas, rape, field peas, barley, rye, wheat, etc. When pigs root they should be rung to prevent them from injuring the plants. Experiments have shown that alfalfa is the best pasture crop for pigs. Feeding corn on pasture is profitable when corn is cheap and the crop is nitrogenous. On barley, rye, etc., a supplement of tankage, dried blood, oil meal, or skim milk is desirable. In the absence of corn, other grains as wheat, barley, rye, etc., may be substituted. The Wisconsin Experiment Station found rape superior to clover as a pasture crop for swine.

Wet Meal Better Than Dry Meal.—The experiments generally show that larger gains were made by feeding wet instead of dry meal and that larger quantities were consumed of wet meal.

Exercise.—Of course the young pigs require more exercise than those that are mature. Exercise tends to keep away disease. Pigs on pasture or in lots do better than those in pens. Exercise seems beneficial and experiments have been conducted to prove this point.

Water.—Fresh water should be supplied to pigs in convenient and clean troughs or fountains. In winter the warming of it is beneficial.

Cleanliness.—In order to keep swine in good health the feeding troughs should be kept clean. If dairy by-products, slop, or refuse such as swill are fed, it is not long before the feeding pen becomes filthy unless proper care is given to it. In pens the pigs should be allowed fresh clean bedding and the pens should be disinfected once in a while with a weak solution of carbolic acid, zenoleum or other disinfectant. A dipping tank is advisable on every farm to wash off those pigs that become infected with lice and so prevent the spread of disease. Many farmers think that pigs ought to do well when the food becomes mixed with manure and filth, as is the case in filthy pens, but for the greatest profits filth should be avoided and cleanliness is necessary. In clean pens pigs fatten more rapidly and are generally free from disease. When kept in a feed lot dry situations should be selected and bedding provided to make them comfortable.

Rations for Fattening Swine

Per 1,000 pounds, live weight[1]

9 pounds cowpeas	8 pounds cowpeas
10 pounds corn meal	12 pounds middlings
30 pounds sweet potatoes	21 pounds corn
12 pounds rice meal	20 pounds corn
22 pounds corn	40 pounds middlings
37 pounds skim milk (gravity)	

Rations from Various Sources—Experiment Stations

Ground peas, Ground barley, Ground rye — equal parts	2 parts corn meal 1 part shorts
Corn meal Bran Gluten meal Skim milk or buttermilk	Shorts Chopped wheat Oats Bran

2 parts corn meal	Corn meal	1 part chopped wheat
2 parts shorts	Gluten meal	1 part shorts
2 parts oil meal	Skim milk	1 part ground oats

4 parts whole wheat	Wheat meal	Corn meal	2 parts corn meal
1 part bran	Buttermilk	Wheat meal	1 part ground oats

1 pound corn meal	2 parts Kaffir corn meal
3 pounds skim milk or buttermilk	1 part soy bean

Suggestion: Why is it that the gains made by the young pig during the first months of life, are more profitable than later gains? Have the student make suitable rations for hogs for the different periods of fattening. What differences should be made in feeding, breeding and fattening stock? Why?

[1] Bul. 115, Louisiana Experiment St tion.

SECTION XXXIV.

FEED AND CARE OF YOUNG FARM ANIMALS.

Requirements.—In supplying the needs of young animals the nutrients should be furnished in such proportions as to produce a strong healthy growth. The ration must furnish nutrients to build up and strengthen the bones; it must supply digestible nutrients so necessary for the rapid formation of body tissue. The feeding of the young animal influences to a great extent the efficiency of the animal for its purpose in future life. Many animals are ruined by improper feeding when young.

Composition of Animal Bodies.—In order to understand the requirements of young animals let us find out the composition of the bodies of the young and more mature animals. The analyses of the whole body of a calf made by Lawes and Gilbert, and of a steer made by the Maine Experiment Station, show the following composition:

	Protein per cent.	Fat per cent.	Ash per cent.	Water per cent.	Dry matter per cent.
Calf	16.5	14.1	4.8	64.6	35.4
Steer, 17 months	17.5	20.2	5.2	57.1	42.9

These analyses correspond to those of young and mature animals of other species. A study of these analyses shows that the young animal body contains more water and a greater proportion of protein to fat than that of the more mature animal. Therefore we should aim to furnish nutrients in such proportions that will have a narrow nutritive ratio.

Nature has fortunately provided, in mothers' milk, the food requirements of young animals. We cannot improve upon this food, but it is often profitable and sometimes necessary to wean the animal as early as possible. To accomplish this, substitutes for mothers' milk must be provided to satisfy the nutrients essential to good healthy growth.

1. **Feeding the Beef Calf.**—If the most rapid gain is desired in raising the calf it should be allowed all the mother's milk

it can consume, but sometimes the calf gets too much in this way, which brings about indigestion. In such cases the calf should only receive a limited amount and the excess in the cow's udder should be stripped twice a day. Sometimes a cow giving a generous supply of milk may feed two calves in which case stripping will not be necessary.

Experiments show that a calf on mother's milk will gain faster during the first month than for the following months. A gain of about 2½ to 3 lbs. a day for the first month and about 2 lbs. for the following days may be expected, Hunt found that calves fed whole milk from a pail gained 1.77 lbs. daily from 8.7 lbs. of whole milk and one pound of grain and one pound of hay per pound of growth. About 6 to 10 lbs. of whole milk produces one pound of gain.

Generally calves are allowed milk for four to six months, the latter period being preferable when possible, because whole milk puts on good flesh.

After Weaning, the calf should be allowed pasture or green crops in the summer, and roots or silage in the winter, to furnish the succulence so necessary to keep the calf in a healthy growing condition. At this stage grain should be furnished in addition to whole milk. Oats, shelled corn, oil meal, gluten feed and bran are adapted for feeding calves. Calves become very fond of corn, but this grain should never be fed alone because it contains too high a content of carbohydrates to be a growing food. It may be amended with whole oats and oil meal, or gluten feed, or with oats and wheat bran. Either of these combinations furnish sufficient protein to balance the ration. Bran and oil meal serve to regulate the digestive organs.

After the calf is weaned the feeder must try to prevent the loss of weight and endeavor to produce gain. The feeding of grain while the calf is on mother's milk tends to lessen shrinkage when the calf is weaned. Protein from some roughage should supplement the grain. This may be furnished in winter by clover, alfalfa, cowpea or other nitrogenous hay and in the summer by good pasturage.

2. **Feeding the Dairy Calf.**—The practice of allowing the calf practically all the milk it desires is not profitable in dairying. Hence the calf must be weaned as soon as possible and substitutes furnished to take the place of the whole milk. The calf should stay with the mother for two or three days as the colostrum (first milk) fits the digestive tract for later reception of food. On the third or fourth day the calf may be separated from the mother and fed 10 lbs. of whole warm milk daily, from a pail. This amount should be gradually increased until 15 lbs. are fed. The old fashioned way of placing the fingers in the pail is the best way to teach the calf to drink. There are many arrangements on our market to serve this purpose but they are not satisfactory as they are hard to keep clean, and therefore harbor germs. The calf should receive the whole warmed milk at least three times a day and it should always be warmed. At the expiration of two and one-half to three weeks, warm skim milk may be partially substituted for some of the whole milk. Just a little skim milk should be used at first and the amount gradually increased. The changing from whole to skim milk should take one and one-half to two weeks. When the calf is on skim milk entirely, 18 lbs. should suffice, although sometimes a larger amount is beneficial. Often feeders give calves too much skim milk and the result is sickness. It should be understood that calves fed on skim milk are not so fleshy as those fed on whole milk, because skim milk is deficient in fat, but skim milk produces growth for about ⅓ of what it costs with whole milk.

Grain and Skim Milk.—Some feeders utilize skim milk entirely but an addition of cooked flaxseed meal or cooked oil meal is more satisfactory. Cooked flaxseed meal is especially to be recommended. It contains high percentages of protein and fat, a low percentage of carbohydrates, and is easily digestible. It is laxative and tends to keep the young animal in good condition. At the beginning, about a spoonful of cooked flaxseed meal or oil meal may be placed in the warm skim milk. This amount should be gradually increased until the calf is consuming ⅓ to ½ lb. a day. Feeds as corn meal, shorts, bran, gluten feed, oats, etc., may be used. Frequent feeding is essential for the welfare of the calf and care should be taken not to overfeed. The calf may be taught to eat grain by placing a little in the mouth after it has finished drinking the milk. When grain is fed there should not be any left over after a meal. If so reduce the amount and never let grain remain in the feeding trough after a meal. A little nitrogenous hay as alfalfa, clover, etc., or when this is not available, corn stover or well cured grass hay, should be continually supplied. According to Henry a dairy calf should not gain over one and one-half pounds a day during the first four months and less thereafter.

All feeding utensils should be kept thoroughly clean and it is important that the feeding pails be frequently scalded.

Care of Calves.—Calves are not so rugged as cows and should be well protected from the cold of winter and the extreme heat and flies of summer. When flies are troublesome the calf may be pastured at night. On favorable winter days the calf may be turned into a sunny enclosure for exercise. In the summer, when it is very hot, the calf may be pastured early in the morning and late in the afternoon, which will allow of sufficient exercise and sunshine. A few minutes spent each day in brushing the calf will be found beneficial.

3. **Feeding the Colt.**—When the colt is born, the dam and foal should be kept in the barn for a few days. Easily digested food, in small amounts, is desirable at this time. A bran mash is relished once a day. The mare with a colt should be regarded as a milch animal and foods that tend to produce a good flow of milk should be supplied. To bring this about in summer the dam and foal may be turned on pasture, and in winter, succulent feeds as roots or silage should be fed. If the dam and foal are turned on pasture they should be looked after every day to be sure they are in good health. As with cows, some mares give too much milk and this must be regulated by drawing the last of the milk and changing the food so as to reduce the milk production. In case the mare is on pasture the time of pasturing may be limited and a little dry feed fed. Should the mare not furnish enough milk, succulent

feeds that tend to increase milk giving are helpful. Should this fail, the colt may be fed whole cows' milk which may be gradually supplanted with skim milk. Intelligent feeders are very successful with this manner of feeding colts when such is necessary. A colt may be reared on cows' milk.

Sometimes a mare must be worked. If so the colt should be allowed to run with its mother for two or three weeks so as to receive a sufficient supply of nourishment. At the end of this time the colt may be kept in the barn and put with the mother three times a day.

Grain for the Colt.—In order to produce flesh that will not shrink greatly after weaning, grain is essential. A feed box in the stall or feed lot should be placed low enough so that the colt can conveniently reach it and ground oats, whole oats, shelled or cracked corn, bran, shorts and oil meal may be placed in it. The colt will soon learn to relish the grain. If the colt is on pasture a separate enclosure may be built that will permit of the colt's entrance but not of the mare's, where oats and other grain food may be supplied.

Food After Weaning.—At the end of five months the colt may be weaned. Easily digested foods in limited quantities such as ground oats, cracked corn, bran, shorts and oil meal are good. Oats is the best grain for the colt, but a mixture of other grains is desirable. Sometimes soft foods as mashes, crushed oats, corn meal, etc., are relished and necessary when the teeth are being cut. Roughage, as well cured hay, straw, corn stover, etc., helps to increase the efficiency of the digestive organs and accustoms the animal to eating such feed as will be supplied when it is more mature. Colts are apt to eat more roughage than is good for them unless the supply is limited. Plenty of exercise is about as important as furnishing the proper amount of food. Many colts are ruined by overfeeding and lack of exercise.

4. **Feeding the Lamb.**—When the lamb is born it is often necessary to help it secure its first food. Sometimes the ewe must be held for the first day or so. In some cases it becomes necessary to place the ewe and lamb in a pen away from the rest

of the sheep, when the mother refuses to own her lamb, and in a few days the mother will claim it.

In case the mother dies, the lamb may be reared on cows' milk by feeding with a bottle. At first the lamb must be fed about 15 times a day and when two weeks old, feeding may be cut down to three times a day.

Feed for Ewes' Suckling Lambs.—The lamb is most always fed through its mother; therefore a milk producing ration is necessary. In the summer the ewes' suckling lambs will get along nicely on good pasturage, without grain. In the winter, roots or silage, clover or alfalfa hay, and some grains as oats, corn, shorts, bran, peas, oil meal and gluten feed are adapted for producing a good milk supply. In the absence of nitrogenous hay, well cured grass hay, straw or corn stover may be utilized. Timothy hay is not desirable for sheep. Many good rations may be fed depending upon the feeds available and their market prices. The ration should always be such as to produce a liberal flow of milk. A mixture of ¾ to 1 pound of the following feeds are satisfactory for the grain portion of a day's ration:

Oil meal	1 part	Corn	2 parts
Corn meal	2 parts	Oats	2 parts
Bran	2 parts	Shorts	1 part
Grass hay	2 pounds	Clover or alfalfa hay	2 pounds
Roots or silage	2 pounds	Roots or silage	2 pounds

Corn	2 parts	Bran	3 parts
Bran	2 parts	Oil meal	1 part
Gluten feed	1 part	Sliced roots or silage	2 pounds
Grass hay	2 pounds	Nitrogenous hay	2 pounds
Roots or silage	2 pounds		

If the ewe gives too much milk the feed should be changed. If on pasture the ewe may be taken off for a certain length of time each day and supplied a little dry feed. If in the barn the succulent feeds may be reduced.

Grain for Lambs.—Lambs should be supplied with a little grain to produce the best growth. Experiments show that lambs fed grain in addition to mothers' milk, gain faster than those that do not receive grain. Sometimes it may not prove profitable to feed grain to lambs on pasture unless they are to be sold in the fall. If kept for winter or spring markets they may be fed grain for marketing at that time. When grain is fed to lambs a separate feeding trough not accessible to the mothers should be in every pen or pasture to provide the grain. No feed should be left over from time to time.

Fig. 22.—Mutton type.

The Wisconsin Experiment Station found that one pound of ewe's milk produced 0.15 lb. gain; a daily gain of 0.4 to 0.6 of a pound per lamb was made; lambs before weaning required 4 lbs. of grain for a gain of 1 lb. The Maine Experiment Station found that 5¾ lbs. of grain produced 1 lb. gain.

5. **Feeding the Pig.**—In rearing pigs it is desirable to produce rapid gain and a strong bony structure to support the body. When they are born they may be kept away from the sow except at feeding time, because they are liable to be killed or injured by the sow laying on them. When they become lively this separation will be unnecessary. At the age of two weeks the pig may be supplied with a mixture of skim milk and middlings in feeding troughs not accessible to the sow. At four weeks a little corn meal may be substituted for part of the middlings, which may be gradually increased until equal parts of corn meal and middlings are fed. Ground oats, barley, and peas are suitable and may be used instead of corn meal and middlings. Soaking or wetting feed for young pigs seems to be beneficial; hence it is good practice to add the dry feed to the skim milk.

The pig is generally weaned at the age of 7 to 12 weeks. The Wisconsin Experiment Station found that late weaning at the age of 10 to 12 weeks is profitable. Just as rapid gains were made by feeding through the mother as to the pigs. The advantage of late weaning is that it affords the utilization of cheaper feeds than can be fed to the young pig. The practice of gradually drying off a sow by weaning the strongest pigs first is a good one.

The following table from Henry's "Feed and Feeding," is the work of the Wisconsin Experiment Station and was conducted to determine the gain of young pigs:

Age of pigs	Weight of pigs pounds	Gain in 7 days per cent.
At birth	2.5	——
First week	4.4	76.
Second week	7.0	59.
Third week	9.8	40.
Fourth week	12.5	28.
Fifth week	15.6	25.
Sixth week	18.6	19.
Seventh week	22.6	22.
Eighth week	27.8	23.
Ninth week	33.1	19.
Tenth week	38.5	16.

Exercise.—Young pigs should be forced to exercise as they are liable to become very fat. Feed may be scattered about the litter which will give the young pigs some work, or they may be driven about a yard for a few times every day.

Suggestion:—What are the bone producing elements and what feeds contain these in the most suitable proportions? Why should young stock be fed narrower nutritive ratios than mature animals?

SECTION XXXV.

FEED AND CARE OF POULTRY.

The Importance of feeding poultry properly may be realized when we become acquainted with the extent of this industry in the United States. For the year 1908[1] the value of poultry and eggs in this country was as much as the cotton crop, seed included, or the hay crop, or the wheat crop. The hay crop for 1908[1] was valued at $635,423,000.

Requirements.—The requirements of poultry are somewhat different than for horses, cattle and sheep in that poultry require both animal and vegetable food. The vegetable food may be low in ash in which case animal food as bone should be supplied to furnish phosphate of lime. When the vegetable portion of the ration is deficient in protein the animal food should make up for this deficiency. In fattening mature fowls vegetable food may predominate and animal food may be added to increase the palatability of the ration. A variety of foods seems to give the best results, because of the increase in palatability and beneficial influence in keeping the fowls in good condition.

Foods should make up the ration to supply the nutrients in the right proportions. A different ration is required for fattening fowls than for those producing eggs or breeding. Some breeds used for egg production take on fat more readily than others and the feed should be administered so that they will have to exercise to keep them laying. Other breeds like the Leghorns, may be fed differently because they are not prone to fatten rapidly.

Composition of Fowls and Eggs.—Before taking up the feeds and amounts of nutrients needed for fowls, let us study the composition of the body and the egg. The New York Experiment Station made several analyses of fowls and some of the results of this work are given in the following table, which was compiled from Jordan's "The Feeding of Animals:"

[1] 1908 Yearbook, United States Dept. of Agriculture.

	Protein per cent.	Fat per cent.	Water per cent.	Ash per cent.
Mature Leghorn hen[1]	21.6	17.0	55.8	3.8
Leghorn pullet (laying)	21.2	18.0	55.4	3.4
Mature capon (Plymouth Rock)	19.4	33.9	41.6	3.7
Egg (dry matter, minus shell)	49.8	38.6	——	3.5
Hen (dry matter)	48.9	38.5	——	8.6
Egg (total dry matter)	38.5	25.9	——	35.6
Fresh egg (11.4 % shell)	13.2	8.9	65.7	0.8

Discussion of the Table.—The analyses of the fowls include the whole body (bones, feathers, blood, etc.) and not the clean fowl of the market. Of the ash of eggs, 53.7 per cent. is phosphoric acid and 0.2 per cent. of that portion which is eaten, is phosphoric acid. As in animals, a great deal of water is present in the body. Eggs are also made up largely of water. This fact indicates the necessity for furnishing fowls with a continual and fresh supply of pure water. The large amount of ash in eggs shows us that laying fowls require comparatively large amounts of this material for the construction of good eggs. Poultry kept in houses closely confined must be supplied with mineral constituents in some form.

The table also shows that fowls contain considerable protein in their bodies and that eggs are largely composed of this compound. Often the food of poultry consists of the wastes from the kitchen and dairy and may sometimes be deficient in this nutrient for the welfare of laying and breeding fowls.

Some of the principal feeds suitable for poultry will now be discussed.

Corn.—This feed is found in many poultry rations and hens relish this grain. It is a fattening food and should not be fed alone. For laying hens it should be fed in limited quantities and some fowls like the general purpose and Asiatics, which easily fatten, will get so fat on this grain that they will not lay. The Mediterraneans (Leghorns and other egg breeds) are not

[1] Female more than one year old is called a hen.
Female less than one year old is called a pullet.
Male more than one year old is called a cock.
Male less than one year old is called a cockerel.
A castrated male chicken is called a capon.

prone to get fat and may consume more of it than the Asiatics without injuring their egg production. Corn may be fed in larger amounts in cold weather because of its heat producing power. Corn tends to give the yolk of eggs a yellow color. Corn is fed whole, cracked and as corn meal.

Kaffir Corn is somewhat similar to corn in composition and should make up only a part of a laying hen's ration. This feed is very popular in certain sections and is found in many commercial poultry feeds.

Oats contain sufficient protein to be of value for young fowls. Poultrymen favor heavy oats for feeding and declare that it is one of the best grains to feed alone when other feed is scarce.

Rye is sometimes fed, but poultry do not seem to relish this grain.

Wheat is especially desirable for poultry because it is rich in protein and ash and is valuable in grain mixtures.

Barley is fed whole or ground and it is often used for fattening. For laying hens barley, like corn, should only form a part of the ration.

Buckwheat contains considerable carbohydrates and is a favorable fattening food when the price is reasonable. It forms fine white skin which is a good factor for market fowls.

Millet Seed is often fed in poultry rations. It is somewhat similar in composition to oats and may be used in furnishing variety to the ration. It is not so fattening as barley or corn.

Rice.—Broken rice is often fed and on account of its high content of carbohydrates it is very fattening.

Peas are good for furnishing protein to the ration. When the market value will permit, the feeding of this grain as a part of the ration is profitable.

Sunflower Seeds are rich in protein and fat, but their nutritive ratio is narrow enough to consider them a protein feed. These seeds are found in most commercial hen feeds and should be desirable in furnishing variety.

Flax Seeds are very rich in oil and a small amount in a ration may be fed during the molting season when the oil tends to help in the shedding of feathers. It is perhaps more economical to eliminate this feed unless it can be purchased cheap. Unground it is not a satisfactory feed for poultry.

Linseed Meal is high in protein and is very desirable in the molting season on account of the presence of oil which tends to loosen the feathers. It may be used to furnish protein to a ration.

Cotton-Seed Meal is a dangerous poultry feed when fed in large quantities. It seems to produce sickness and if fed must be used in very limited amounts. It is perhaps safer to supply protein from some other source. It is understood that the United States Dept. of Agriculture have been endeavoring to eliminate the toxic or poisonous principle in cotton-seed meal and if they successfully accomplish this it will render this feed much safer and more valuable for a feed for poultry and farm animals generally.

Gluten Feed and dried brewers' grains are used in some sections to bring up the protein content of poultry rations and are very suitable.

Wheat Screenings of good quality is sometimes an economical poultry feed. The quality of this material is variable and the poultryman should use his judgment in purchasing this by-product.

Wheat Bran.—Bran is used in mashes and it gives bulk to a ration. It is rich in protein and mineral compounds which make it a valuable feed.

Wheat Shorts and low grade flour are sometimes used in a dry mash and when the price is reasonable may be profitably utilized.

Meat Scrap sometimes called beef scrap, is either fed alone or mixed with other feeds to form a dry mash. This animal food varies in protein but is always rich in this constituent. It also contains considerable fat and ash. Poultry are very fond of animal food and especially of meat scrap.

Fresh Cut Bone.—Fresh or green cut bone is perhaps the best animal food for poultry. It is rich in protein, fat and ash. The elements that make up the ash are principally in the form of calcium phosphate which is used in building up a strong body and in producing eggs of good quality. It is sometimes difficult to grind fresh bone on the farm. This material should never be fed when in a spoiled condition as it causes sickness.

Dry Cracked Bone is easier to keep in good condition than fresh cut bone and for this reason may be purchased at feed stores. It is not as valuable as fresh cut bone but nevertheless it is an exceedingly desirable poultry food. Bone in some form should be kept before poultry at all times to furnish the nutrients for making firm and fine flavored eggs.

Meat and Bone Meal.—As the name implies this feed is composed of meat and very fine ground bone. This is a very desirable poultry food as it furnishes a great deal of protein, fat and ash.

Skim Milk is a splendid food for fattening or growing chickens, whether sweet or sour. It may be fed alone or with a mash. When utilized care must be taken to keep the feeding vessels thoroughly clean.

Green Food.—Like animals, poultry do well when supplied green food. In the spring when tender grass is furnished, an increase in egg production is noticeable. Therefore it should be the aim of every poultryman to supply pasture or green grass or legumes to the poultry in summer and in the winter cut clover, alfalfa, and immature cured grasses are beneficial. Clover and alfalfa meal are found on our markets but the farmer should raise enough of these hays so that he will not be forced to buy them. Alfalfa and clover are better than grass hays because they run higher in protein and ash and are excellent for the needs of laying hens. The finer parts that are found about the barn may be saved for the poultry. The coarse stems are not generally consumed but so little of this material is required that what is left will not amount to much. Lettuce, cabbage and onions are also sometimes fed and poultry are very fond of these vegetables. Cabbage twice a week is sufficient and onions once in a while. If these feeds are fed continually they are liable to spoil the flavor of the eggs.

Other Succulent Feed.—Roots such as potatoes, beets, etc., are excellent. They may be hand fed or stuck on nails about the yard or house. Silage is also beneficial and may be furnished two or three times a week. Apples when plentiful are splendid.

The fresh vegetable wastes from the kitchen are relished by poultry and may be utilized advantageously in this way. Succulent food is laxative and too much therefore should not be supplied.

Grit.—The hen grinds its food in the gizzard. In order that hens may grind food, grit in some form must be furnished them. When grit is lacking digestive troubles take place. Ground broken glass or mica crystal grit are needed even if sand is supplied. Shells do not take the place of grit. As soon as the stones in the gizzard become round they are passed off.

Lime.—As the shell of eggs contain a great deal of lime it must be furnished poultry in some form easily assimilated. Ground oyster shells seem to furnish lime in a splendid form. Limestone is also used. Lime in some form should be before hens at all times.

Charcoal should be accessible to hens continually. It absorbs objectionable gases and tends to keep the digestive system in good condition.

Salt in small quantities is desirable. This mineral should not be supplied in large quantities. About 5 ounces to 100 lbs. of feed are considered safe.

Exercise.—Most birds are naturally very active and require a great deal of exercise to keep the body in good health. Laying hens and breeding cocks especially must have exercise. This can be provided in summer by allowing them liberty or by furnishing a yard. In winter the hens should be made to exercise to get their food. This may be accomplished by providing a heavy litter of straw and scattering the grain over it so that the hens will be forced to scratch for their food.

Palatability of Feed.—Experiments have demonstrated that hens are not all alike in their fondness for certain food. Their tastes should be catered to in compounding rations and the best way to do this is to furnish variety. Musty, sour, or unclean food is not desirable for meat or egg production.

Mash is fed wet or dry and experiments have shown that dry mash is the better. Advantages in feeding dry mash are; the production of more fertile eggs, the feeding receptacles are easily kept clean and sanitary, and time is saved in furnishing food.

SECTION XXXVI.

STANDARDS AND RATIONS FOR POULTRY.

Points to be Observed in Compounding Rations.—Rice in Reading Course for Farmers, No. 18, gives the following points to be observed in making rations for poultry:

1. "It should be composed of foods every one of which the fowls like.

2. "It should contain a sufficient quantity of digestible nutrients to supply the needs of rapid growth and large production.

3. "It should have enough bulk to enable the digestive secretions to act quickly upon it.

4. "It should not contain an excess of indigestible fiber, which must be thrown off by the system, thus causing a waste of energy.

5. "A certain portion of the feed should be of whole grain in order to provide muscular activity of the digestive organs. This is made necessary in grinding the grain.

"Under certain conditions a quantity of the ration should be of soft ground food. This is for the purpose of providing quickly available nutrients to supply the immediate demands of rapid growth or heavy continuous egg yield.

6. "It must provide a good variety of foods in which are included grain, green food, meat and mineral matter, in proper proportions.

7. "The age of the fowl, the breed and kind of product which it is desired to produce, must be taken into consideration, as to whether the food is intended to grow muscle and bone, or to produce eggs, or to fatten.

8. "The ration must provide two classes of food nutrients, the protein and carbohydrates, in such proportions that they will supply the daily need of the fowl's system; it must also provide sufficient digestible protein to repair the waste of tissue with new growth and to produce eggs, and provide the proper amount of digestible carbohydrate food to furnish heat, energy and lay by a little surplus fuel in the form of fat.

9. "The ration must consist of foods which furnish the nutrients at the lowest possible cost.

10. "The food in the ration must not have an injurious effect on the color or the flavor of the product.

11. "It is not how much a fowl eats, but how much it can digest, that determines the value of the food. Various classes of animals differ in their power to digest the same kind of food. Foods also vary in their digestibility when used by the same animal. Unfortunately the proportion of each poultry food which fowls can ordinarily digest, has not yet been determined, therefore we are obliged to use the standards of digestibility which are used in compounding rations for other animals."

POULTRY STANDARDS—PER 100 POUNDS, LIVE WEIGHT.[1]

	Weight pounds	Dry matter	Ash	Protein	Carbohydrates	Fat	Nutritive ratio
MAINTENANCE							
Capons	9-12	2.3	0.06	0.30	1.74	0.20	1:7.5
Hens	5- 7	2.7	0.10	0.40	2.00	0.20	1:6.2
Hens	3- 5	3.9	0.15	0.50	2.95	0.30	1:7.4
HENS IN FULL LAYING							
Hens	5- 8	3.3	0.20	0.65	2.25	0.20	1:4.2
Hens	3- 5	5.5	0.30	1.00	3.75	0.35	1:4.6
CHICKS' AGE							
First 2 weeks	——	10.1	0.50	2.00	7.20	0.40	1:4.1
From 2–4 weeks	——	9.6	0.70	2.20	6.20	0.50	1:3.4
From 4–6 weeks	——	8.6	0.60	2.00	5.60	0.40	1:3.3
From 6–8 weeks	——	7.4	0.50	1.60	4.90	0.40	1:3.7
From 8–10 weeks	——	6.4	0.50	1.20	4.40	0.30	1:4.3
From 10–12 weeks	——	5.4	0.40	1.00	3.70	0.30	1:4.4
DUCKLINGS							
First 2 weeks	——	17.2	1.60	4.00	11.20	1.40	1:3.7
From 2–4 weeks	——	17.0	1.50	4.10	10.10	1.30	1:3.2
From 4–6 weeks	——	11.2	0.80	2.70	7.00	0.70	1:3.3
From 6–8 weeks	——	8.0	0.60	1.70	5.20	0.50	1:3.8
From 8–10 weeks	——	7.0	0.50	1.40	4.70	0.40	1:4.1
From 10–15 weeks	——	4.6	0.30	0.90	3.20	0.20	1:4.1

Use of the Table.—Rations for fowls may be figured in a similar way as for farm animals by the use of Table 1 and this table of poultry standards. In making up rations for fowls, large amounts of feed may be mixed at one time, as it would not be

[1] Wheeler, in Jordan's, "The Feeding of Animals."

practical to compound feed enough for a few days. Supposing we had enough laying hens, weighing 5-8 lbs., to make a total live weight of 200, 300, 400 or 500 lbs. Our standard for laying hens of this weight would be multiplied by 2, 3, 4, or 5 as the case would be and the feed balanced accordingly. Example; the standard for laying hens weighing 5-8 lbs., is, dry matter 3.3 lbs., ash 0.20 lb., digestible protein 0.65 lb., digestible carbohydrates 2.25 lbs., and digestible fat 0.20 lb. Let us suppose all our laying hens total 300 lbs. live weight. Then to find the standard for 300 lbs. we must multiply the standard for 100 lbs. by 3.

Standard for 100 pounds		Standard for 300 pounds
3.3	× 3 =	9.9 pounds dry matter
0.20		0.60 pound ash
0.65		1.95 pounds digestible protein
2.25		6.75 pounds digestible carbohydrates
0.20		0.60 pound digestible fat

These standards are figured for daily requirements.

Chick Rations.—Chicks should not be allowed to eat too much. Some of the methods of feeding chicks used in the Maine Experiment Station taken from Farmer's Bul. 357, follow:

1. "Infertile eggs are boiled for a half an hour and then ground in an ordinary meat chopper, shells included, and mixed with about six times their bulk of rolled oats, by rubbing both together. This mixture is fed for two or three days, until the chicks have learned how to eat. It is fed with chick grit, on the brooder floor, on short cut clover or chaff.

"About the third day the chicks are fed a mixture of hard, fine broken grains, as soon as they can see to eat in the morning. The mixture is:

	Parts by weight
Cracked wheat	15
Pinhead oats (granulated oat meal)	10
Fine screened cracked corn	15
Fine cracked peas	3
Broken rice	2
Chick grit	5
Fine charcoal (chick size)	2

"It is fed on the litter, care being taken to limit the quantity, so they shall be hungry at 9 A. M. at which time the rolled oats and egg mixture is fed in tin plates with low rims. The feed is kept before them for five minutes. At 12.30 the hard grain mixture is fed again, as in the morning, and at 4.30 or 5 P. M. they are fed all they will eat in a half an hour of the rolled oats and egg mixture. Sharp grit, fine charcoal, and clean water are always before the chicks."

When the chicks are about 3 weeks old the Maine Experiment Station displaces the rolled oats and egg mixture with the following:

	Parts by weight
Wheat bran	2
Corn meal	4
Middlings or red dog flour	2
Linseed meal	1
Screened beef scrap	2

This mixture is slightly moistened with water before feeding.

2. Another method employed by the Maine Experiment Station is to supply fine beef scrap very early in the morning instead of boiled eggs, and feed dry. At 9 o'clock the following is fed:

	Parts by weight
Rolled oats	2
Wheat bran	2
Corn meal	2
Linseed meal	½
Screened beef scrap	1

The same order of feeding as in the first method is followed.

The Kansas Experiment Station, Bul. 164, uses the following method:

"When a chick is newly hatched, it is allowed to dry off in the incubator and then put into the brooder which has been heated to 100 degrees. When 48-60 hours old the chicks are fed some boiled, tested-out eggs. Following this, they have placed before them in a shallow pan a dry mash made as follows:

2 pounds corn meal
2 pounds shorts
2 pounds bran
2 pounds beef scrap
½ pound charcoal

"This is kept before them practically all the time, from the time they are large enough to eat it until they have obtained a good growth.

"Scattered in the litter, five times daily thereafter, is a grain mixture as follows:

2 pounds corn chop (sifted)
2 pounds cracked Kaffir corn
2 pounds cracked wheat
1 pound millet

"Before them at all times are pans of fresh water and clean grit. Absolute cleanliness and sanitation are ever present.

"When the chicks are large enough to eat whole grain, the cracked is taken away. If the chicks are early hatched and have attained a good growth early in the summer the beef scrap and possibly all the mash should be cut out of the ration. This prevents premature development with early chicks and consequent fall molting. The ration above mentioned produced 3 lb. White Plymouth Rock cockerels in 10 weeks from date of hatch."

Fattening Rations.—Experiments at the Maine Experiment Station, given in Farmers' Bul. 357, state that the following grain mixture was used in fattening cockerels and was fed wet with good success:

100 pounds corn meal
100 pounds wheat middlings
40 pounds meat meal

The wetting of the above mixture with skim milk improved its efficiency for fattening.

The following fattening ration has been successfully used in preparing cockerels for market by the Kansas Experiment Station:

2 pounds ground oats
2 pounds shorts
2 pounds corn meal
1 pound beef scrap

Pearl in Farmers' Bul. 357, says: "An experiment with 150 birds when they were four months old showed that they required 4.9 lbs. of grain to produce 1 pound of gain, while birds from the same stock, when they were six months old, required 7.4 lbs. of grain to produce 1 pound of gain." He further concludes that:

1. "As great gains are made just as cheaply and more easily when the chickens are put into small houses and yards as when they are fed in small lots in lattice coops just large enough to hold them.

2. "Four weeks is about the limit of profitable feeding, both individually and in flocks.

3. "Chickens gain faster while young. Birds that are from 150-175 days old have uniformly given comparatively small gains.

4. "The practice of successful poultrymen selling chickens at the earliest marketable age is well founded.

"The experiments clearly indicate that it is profitable to fatten chickens in cheaply constructed sheds or in large coops with small runs for about four weeks and then send them to market dressed. In quality the well covered, soft fleshed chickens are so much superior to the same birds not specially prepared that the former will be sought for at a higher price. The dairy farmer is particularly well prepared to carry on this work, as he has the skim milk which these experiments show to be of so great importance in obtaining cheap rapid growth and superior quality of flesh."

Laying Rations.—According to Farmers' Bul. 357, the method followed at the Maine Experiment Station in feeding laying hens is as follows:

"Early in the morning for each 100 hens (Plymouth Rocks), 4 quarts of whole corn are scattered on the litter, which is 6 to 8 inches deep on the floor. This is not mixed into the litter, for the straw is dry and light, and enough of the grain is hidden so the birds commence scratching for it almost immediately. At 10 o'clock they are fed in the same way, 2 quarts of wheat and 2 quarts of oats. This is all the regular feeding that is done.

"Besides the dry whole grain a dry mash is kept always before the birds. Along one side of the room is the feed trough with its slatted front, and in it is kept a supply of dry meals mixed together. This dry meal mixture or mash has the following composition:

	Parts by weight
Wheat bran	2
Corn meal	1
Middlings	1
Gluten meal or dried brewers' grains	1
Linseed meal	1
Beef scrap	1

"The dry meal mixture is constantly within reach of all the birds and they help themselves at will.

"Oyster shell, dry cracked bone, grit, and charcoal are kept in slatted troughs, and are accessible at all times. A moderate supply of mangolds and plenty of clean water are furnished. About 5 lbs. of clover hay cut into ½ inch lengths is fed dry daily to each 100 birds in winter.

"The average amounts of the materials eaten by each hen during the year are about as follows:

	Pounds
Grain and the meal mixture	90.0
Oyster shell	4.0
Dry cracked bone	2.4
Grit	2.0
Charcoal	2.4
Clover	10.0

The following ration has been used by the Kansas Experiment Station, Bul. 164, in feeding White Leghorns and White Plymouth Rocks:

Grain	Mash
10 pounds wheat	6 pounds shorts
10 pounds corn	3 pounds bran
5 pounds oats	6 pounds corn meal
	5 pounds beef scrap
	1 pound alfalfa meal

"Between February 1, 1909, and November 1, 1909, one White Plymouth Rock produced 201 eggs and another 196 eggs, at a cost for feed of 90 cents each. The Leghorns averaged 166.1 eggs for the same nine months at a slightly less cost.

"The above ration is best suited to fowls which are confined and have no chance to obtain food on the range. A very practical way to feed it, is to put 25 lbs. of the grain in a bucket and 21 lbs. of the mash in a hopper. The feed in these two vessels should disappear at the same time. Fowls will naturally eat more grain than they will the dry mash, so it is sometimes necessary to cut down on the grain in order to make them consume the mash. The grain should be fed scattered in the litter."

SECTION XXXVII.

THE IMPORTANCE OF RAISING LIVE-STOCK AND THE FERTILIZER CONSTITUENTS IN FEEDS.

Farm Crops Have a Double Value.—Nitrogen, phosphorus and potassium are the elements which are generally present in small amounts in the soil and often become deficient when farm crops are sold. The other elements used by plants are usually found in sufficient quantities so that we need not consider them, except occasionally calcium. The fertility that is taken away from the soil in the form of crops may best be restored by feeding these crops to live-stock and applying the manure to the soil. It should be understood that when farm crops are sold the fertilizing value is lost and the price received represents only the feeding value.

Effects of Farm Manure.—The chemical composition of farm manure is not a true indication of its value. It serves to improve the texture and condition of the soil. It makes the plant food that is stored in the soil available. When manure is put upon the land it decomposes very rapidly on account of its already partially decayed condition and fermentation sets in and acids are formed which act upon unavailable plant food and renders it available. During the process of decay humus is formed which has a tendency of making heavy soils (like clay soils) loose, and light sandy soils more binding. It increases soil warmth and it renders the moisture conditions of the soil more satisfactory.

The Fertilizing Value of manure depends upon the species of animal, age of animal, kind of feed, bedding employed, and care in husbanding. Highly nitrogenous feeds as cotton-seed meal, linseed meal, etc. produce a more valuable manure than coarser feeds.

Lasting Qualities of Farm Manure.—Manure is one of the most efficient fertilizers for the farmer to use. It has wonderful lasting qualities; one good application will last for many years. The Rothamstead Experiment Station of England has made valuable experiments with manure as a fertilizer on grass and barley to show its almost permanent effect. A plot of grass land received 14 tons of farm manure per acre for 8 years and was then left unmanured. For the two years following the discontinuance of manure the crop was double that of the unmanured plot; yet the yield has slowly declined from year to year but has averaged 15 per cent. more than the unmanured plot. The barley experiment is as follows: The first plot received an application of 14 tons of farm manure per acre for 20 years (1852-71) and since that time has been left unmanured. Another plot has been left unmanured during the entire period since 1852. The yield on the first plot for twenty years after the application of manure was discontinued, was 30 bushels per acre per year, while the unmanured plot where nothing was applied gave an average yield of 13 bushels per acre per year.

Amount of Manure Voided by Animals.—It is estimated by Heiden that for every 100 lbs. of dry matter fed there are,

210 pounds of fresh manure voided by the horse,
380 pounds of fresh manure voided by the cow, and
180 pounds of fresh manure voided by the sheep.

Snyder[1] estimates that a well fed horse will produce about 50 lbs. of manure per day of which one quarter will be urine. A horse will produce about 6 tons of manure per year in the stable. A milch cow will produce from 60-70 lbs. of total manure of which 20-30 lbs. are liquid. He estimates that a well fed cow will produce about 80 lbs. of manure per day including absorbents.

Composition of Manure.—The following table gives the composition of solid and liquid manure from some farm animals:

	Water		Nitrogen		Phosphoric acid		Potash	Lime[2]
	Solids per cent.	Liquids per cent.	Solids per cent.	Liquids per cent.	Solids per cent.	Liquids per cent.	Solids per cent.	Total per cent.
Cows....	76.	89.	0.50	1.20	0.35	——	0.30	0.31
Horses ..	84.	92.	0.30	0.86	0.25	——	0.10	0.21
Pigs.....	80.	97.	0.60	0.80	0.45	0.12	0.50	0.08
Sheep ...	58.	86.5	0.75	1.40	0.60	0.05	0.30	0.33

The above table shows that the liquid portion is richest in

[1] "Soils and Fertilizers."

[2] Approximate.

nitrogen and this fact should impress one with the necessity of absorbing and saving the urine. The phosphoric acid is only present in traces in the urine of horses and cattle but is quite considerable in the liquid portions from sheep and swine.

Value of Manure.—The following are average values of farm manures when nitrogen is valued at 15 cents a pound, phosphoric acid at 7 cents and potash at 4½ cents:[1]

	Value per ton
Horse	$ 2.49
Cow	2.43
Sheep	4.25
Pig	3.20

Continued Cropping Exhausts the Soil.—In the New England States the continual selling of farm crops has exhausted the soil on many of the farms of a great deal of its fertility. In some localities, 150-200 lbs. of commercial fertilizer formerly produced as good returns as 1000-1200 lbs. do now. Because of the continual selling of farm crops without maintaining soil fertility, we have many abandoned farms in the older sections of this country.

Now in order to get this valuable fertilizer, farm manure, to keep up the fertility of the soil, we must raise live-stock or purchase manure.

If live-stock are kept on the farm and fed the farm products, 80-90 per cent. of the fertilizer value of the crops may be saved and put back on the land and the full feed value may be realized.

Idle Lands may be Made Profitable.—The feeding of live-stock makes it profitable to pasture lands that are too poor for the growing of the ordinary cultivated crops. In this way the land that is ordinarily idle may be utilized.

Reducing Freight Charges.—Live-stock create a market for selling farm crops in a more condensed form. It takes about 7-12 lbs. of farm products to produce a pound of gain and by feeding the farm products to live-stock the weight of these products is reduced 1/7 to 1/12, which is a great saving in the freight charges of marketing.

[1] Roberts, "The Fertility of the Land."

A Market for Cheap and Coarse Feed Stuffs.—Around every farm there are many coarse farm products and other materials which would ordinarily be wasted if live-stock are not kept. Corn stover, straw, damaged and shrunken grain, and other similar farm products do not bring much on the market but may be utilized to good advantage in feeding stock. Often certain

Fig. 23.—Hay should be raised at home.

hays hardly pay the cost of marketing and may be profitably used in such cases for feeding live-stock.

Growing of Legumes.—When live-stock are kept on the farm the growing of legumes is very profitable as they increase the soil fertility and serve as cheap feed for furnishing the protein so necessary in animal production. Many of the leguminous crops will not bring their real value when sold but when utilized for feeding live-stock become very profitable crops for the farmer to raise.

Roots and Tubers.—In the South roots as mangels and turnips may often be profitably raised during the winter when the land is ordinarily idle. These crops do not interfere with the raising of cotton, corn, etc., because they may be harvested in time to plant the summer crops. When the market prices for Irish and sweet potatoes are low these crops may be fed to live-stock.

Labor.—The raising of live-stock furnishes employment for the hands throughout the year. By being able to keep labor the year round is usually more satisfactory and cheaper than to employ hands for a part of the year.

Mixed Husbandry the Most Profitable.—Because of the maintaining and often increasing of soil fertility, and the utilization of cheap feeds that would ordinarily be thrown away, it is readily seen that the raising of live-stock in conjunction with general farm crops is perhaps the most profitable. We have only to look to the older farming sections to learn that mixed husbandry has proved to be the most profitable. Of course on new lands the farmer often realizes a good profit by raising single crops, but such lands invariably deteriorate and it is only a question of time when such single crop farming will have to be abandoned.

Raise Products at Home.—The farmer of to-day should realize the economy of raising animal products and feed stuffs for home consumption. It seems strange to know that in some sections, where single crop farming is practiced, that farmers purchase a great deal of food from the merchant, often at exorbitant prices, that could be easily and cheaply raised at home. Some of these products that are purchased are, butter, milk, cheese, eggs, meat, vegetables, fruits, feed stuffs for live-stock, and similar products. The farmer should always aim to have something to sell and not be forced to continually buy if he wishes to be prosperous and happy. Some products of course must be purchased but anything that the farm will produce should be grown at home.

The following table, the work of American and foreign investigators will acquaint the student with the fertilizer constituents in feed stuffs:

FERTILIZING CONSTITUENTS IN AMERICAN FEED STUFFS

Name of feed	Water per cent.	Ash per cent	Nitrogen per cent	Phosphoric acid per cent.	Potassium oxide per cent.
CONCENTRATES					
Barley	14.30	2.48	1.51	0.79	0.48
Beet pulp (dried)	8.00	5.40	1.60	0.16	1.47
Brewers' grains (dried)	6.98	6.15	3.05	1.26	1.55
Brewers' grains (wet)	75.01	1.00	0.89	0.31	0.05
Broom corn seed	14.10	3.40	1.63	——	——
Buckwheat	14.10	2.00	1.44	0.44	0.21
Buckwheat middlings	14.70	1.40	1.38	0.68	0.34
Corn (grain)	10.88	1.53	1.82	0.70	0.40
Corn bran	9.10	1.30	1.63	1.21	0.68
Corn and cob meal	8.96	1.50	1.41	0.57	0.47
Cotton-seed (raw)	10.30	3.50	3.13	1.27	1.17
Cotton-seed meal	9.90	6.82	6.64	2.68	1.79
Cowpea seed	14.80	3.20	3.33	——	——
Distillers' dried grains	8.00	1.70	4.50	0.61	0.31
Flax-seed	9.20	4.20	3.61	1.39	1.03
Flour (dark feeding)	9.70	4.30	3.18	2.14	1.09
Flour (high grade)	12.20	0.60	1.89	0.22	0.15
Flour (low grade)	12.00	2.00	2.89	0.56	0.35
Germ meal	8.10	1.30	2.65	0.80	0.50
Gluten meal	8.59	0.73	5.03	0.33	0.05
Gluten feed	8.50	1.70	3.84	0.41	0.03
Grano-gluten	5.80	2.80	4.98	0.51	0.15
Hominy chops	11.10	2.50	1.63	0.98	0.49
Hominy meal	11.00	2.50	1.66	1.25	0.78
Horse bean	11.30	3.80	4.07	1.20	1.29
Linseed meal (old process)	8.88	6.08	5.43	1.66	1.37
Linseed meal (new process)	7.77	5.37	5.78	1.83	1.39
Malt sprouts	10.38	5.72	3.55	1.43	1.63
Millet seed	14.00	3.30	2.04	0.85	0.36
Molasses (beet)	20.80	10.60	1.46	0.05	5.63
Molasses (cane, blackstrap)	22.40	9.30	0.47	0.14	3.70
Oats	11.00	3.00	2.06	0.82	0.62
Oat dust	6.50	6.90	2.16	——	——
Oat feed (shorts)	7.70	3.70	1.72	0.91	0.53
Oat meal	7.90	2.00	2.35	——	——
Peanut meal	10.70	4.90	7.56	1.31	1.50
Peas	10.50	2.60	3.08	0.82	0.99
Rape-seed meal	10.00	7.90	4.96	2.00	1.30
Rice (clean)	12.80	0.70	1.08	0.18	0.09
Rice bran (impure)	9.90	13.00	0.71	0.29	0.24
Rice polish	10.30	3.50	1.97	0.30	0.71
Rye	11.60	1.90	1.76	0.82	0.54
Rye bran	11.60	4.60	2.32	2.28	1.40
Rye shorts	9.30	5.90	1.84	1.26	0.81
Soja (soy) bean	10.80	4.70	5.30	1.87	1.99
Sorghum seed	12.80	2.10	1.48	0.81	0.42
Sunflower seed	8.60	2.60	2.28	1.22	0.56
Sunflower seed cake	10.80	6.70	5.55	2.15	1.17

FERTILIZING CONSTITUENTS IN AMERICAN FEED STUFFS.—(*Continued*)

Name of feed	Water per cent.	Ash per cent.	Nitrogen per cent.	Phosphoric acid per cent.	Potassium oxide per cent.
CONCENTRATES—(Continued)					
Wheat (grain)	10.50	1.80	2.36	0.79	0.50
Wheat bran	11.90	6.30	2.67	2.89	1.61
Wheat middlings	12.10	3.30	2.63	0.95	0.63
Wheat screenings	11.60	2.90	2.44	1.17	0.84
Wheat shorts	11.80	4.60	2.82	1.35	0.59
WASTE PRODUCTS (low grade)					
Buckwheat hulls	13.20	2.20	0.49	0.07	0.52
Corn cob	10.70	1.40	0.50	0.06	0.60
Cotton-seed hulls	11.10	2.80	0.69	0.25	1.02
Oat hulls	7.30	6.60	0.52	0.24	0.52
Rice hulls	9.00	18.30	0.58	0.17	0.14
GREEN FODDERS					
Alfalfa	75.30	2.25	0.72	0.13	0.56
Apple pomace silage	75.00	1.05	0.32	0.15	0.40
Canada field pea	85.00	1.20	0.50	0.12	0.38
Clover (alsike)	81.80	1.47	0.44	0.11	0.20
Clover (red)	80.00	1.45	0.53	0.13	0.46
Clover (scarlet)	82.50	1.42	0.43	0.13	0.49
Clover (white)	81.00	——	0.56	0.20	0.24
Corn silage	79.10	1.40	0.28	0.11	0.37
Corn and soy bean silage	76.00	2.40	0.79	0.42	0.44
Cowpea	78.81	1.47	0.27	0.10	0.31
Flat pea	71.60	1.93	1.13	0.18	0.58
Horse bean	84.20	——	0.68	0.33	1.37
Italian rye grass	74.85	2.84	0.54	0.29	1.14
Lupine (white)	85.35	——	0.44	0.35	1.73
Lupine (yellow)	83.15	0.96	0.51	0.11	0.15
Millet (common)	62.58	1.20	0.61	0.19	0.41
Millet (Hungarian grass)	71.10	1.70	0.39	0.16	0.55
Millet (Japanese)	80.00	1.10	0.53	0.20	0.34
Millet (silage)	74.00	——	0.26	0.14	0.62
Millet and soy bean silage.	79.00	2.80	0.42	0.11	0.44
Oat fodder	83.36	1.31	0.49	0.13	0.38
Oats and vetch (1–1)	80.00	1.80	0.43	0.14	0.30
Orchard grass	73.14	2.09	0.43	0.16	0.76
Pasture grasses (mixed)	63.12	3.27	0.91	0.23	0.75
Perennial rye grass	75.20	2.60	0.47	0.28	1.10
Prickly comfrey	84.36	2.45	0.42	0.11	0.75
Rape	85.00	——	0.34	0.10	0.78
Rye fodder	76.60	2.10	0.33	0.15	0.73
Serradella	82.59	1.82	0.41	0.14	0.42
Soja (soy) bean	75.10	2.60	0.29	0.15	0.53
Sorghum fodder	79.40	1.10	0.23	0.09	0.23
Timothy	66.90	2.15	0.48	0.26	0.76
Vetch (common)	84.50	1.94	0.59	1.19	0.70
HAY AND DRY COARSE FODDERS					
Alfalfa	8.40	7.40	2.19	0.51	1.68

FERTILIZING CONSTITUENTS IN AMERICAN FEED STUFFS.—(*Continued*)

Name of feed	Water per cent.	Ash per cent.	Nitrogen per cent	Phosphoric acid per cent.	Potassium oxide per cent.
HAY AND DRY COARSE FODDERS—(Continued)					
Branch grass	16.00	——	1.06	0.19	0.87
Broom corn stalks (waste)	10.00	——	0.87	0.47	1.87
Blue melilot	8.22	13.65	1.92	0.54	2.80
Carrot tops (dry)	9.76	12.52	3.13	0.61	4.88
Clover (alsike)	9.94	11.11	2.34	0.67	2.23
Clover (Bokhara)	7.43	7.70	1.98	0.56	1.83
Clover (crimson)	9.60	8.60	2.05	0.40	1.31
Clover (mammoth red)	15.00	6.30	2.14	0.52	1.80
Clover (red)	15.00	6.20	2.07	0.48	2.20
Clover (white)	——	——	2.75	0.52	1.81
Corn fodder (with ears)	7.85	4.91	1.76	0.54	0.89
Corn fodder (without ears)	9.12	3.74	1.04	0.29	1.40
English hay (mixed grasses)	14.00	5.30	1 34	0.32	1.61
Fox grass	16.00	——	1.18	0.18	0.95
Italian rye grass	8.71	6.40	1.19	0.56	1.27
Japanese buckwheat	5.72	——	1.63	0.85	3.32
Kentucky blue grass	10.35	4.16	1.19	0.40	1.57
Meadow fescue grass	8.89	8.08	0 99	0.40	2.10
Meadow foxtail	15.35	5.24	1.54	0.44	1.99
Millet (common)	9.75	——	1.28	0.49	1.69
Millet (Hungarian grass)	7.69	6.18	1.20	0.35	1.30
Millet (Japanese)	10.45	5.80	1.11	0.40	1.22
Mixed grasses	11.99	6.34	1.41	0.27	1.55
Oat fodder	15.00	5.20	1.90	0.65	1.90
Orchard grass	8.84	6.42	1.31	0.41	1.88
Oxeye daisy	9.65	6.37	0 28	0.44	1.25
Perennial rye grass	9.13	6.79	1.23	0.56	1.55
Red top	7.71	4.59	1.15	0.36	1.02
Rowen (mixed)	16.60	6.80	1.61	0.43	1.49
Sainfoin	12.17	7.55	2.63	0.76	2.02
Serradella	7.39	10.60	2.70	0.78	0.65
Spanish moss	15.00	1.40	0.61	0.07	0.56
Soy bean (whole plant)	11.30	7.20	2.32	0.67	1.08
Sulla	9.39	——	2.46	0.45	2.09
Tall meadow oat grass	15.35	4.92	1.16	0 32	1.72
Teosinte	6.06	6.53	1.46	0.55	3.70
Timothy	13.20	4.40	1.26	0.53	0.90
Vetch and oats (1–1)	15.00	7.40	1.80	0.60	1.27
White daisy	10.30	6.60	0.26	0.41	1.18
STRAW					
Barley straw	14.20	5.80	1.31	0.30	2.09
Barley chaff	13.08	——	1.01	0.27	0.99
Millet straw	15.00	——	0.68	0.18	1.73
Oat straw	9.20	5.10	0.62	0.20	1.24
Rye straw	7.10	3.20	0.46	0.28	0.79
Soja bean	10.10	5.80	1.75	0.40	1.32

FERTILIZING CONSTITUENTS IN AMERICAN FEED STUFFS.—(*Continued*)

Name of feed	Water per cent.	Ash per cent.	Nitrogen per cent.	Phosphoric acid per cent.	Potassium oxide per cent.
STRAW—(Continued)					
Wheat straw	9.60	4.20	0.59	0.12	0.51
Wheat chaff	14.30	9.20	0.79	0.70	0.42
ROOTS, TUBERS, ETC.					
Artichoke	78.00	1.00	0.26	0.14	0.47
Beet (mangel)	90.9	1.10	0.19	0.09	0.38
Beet (red)	88.50	1.00	0.24	0.09	0.44
Beet (sugar)	86.50	0.90	0.22	0.10	0.48
Beet (yellow fodder)	89.00	——	0.23	0.11	0.56
Carrot	88.60	1.20	0.15	0.09	0.51
Mangold	88.00	——	0.15	0.14	0.34
Parsnip	86.30	0.70	0.18	0.20	0.44
Potato (Irish)	78.90	1.00	0.21	0.07	0.29
Radish (Japanese)	93.00	——	0.08	0.05	0.40
Rutabaga	88.60	1.20	0.19	0.12	0.49
Turnip (flat)	90.50	0.80	0.18	0.10	0.39
DAIRY PRODUCTS					
Butter	12.50	——	0.19	——	——
Buttermilk	90.10	0.70	0.48	0.17	0.16
Colostrum (cows' milk)	74.60	1.50	2.82	0.66	0.11
Skim milk (centrifugal)	90.60	0.70	0.56	0.20	0.19
Skim milk (gravity)	90.40	0.70	0.56	0.20	0.19
Whey	93.80	0.40	0.15	0.14	0.18
Whole milk	87.20	0.60	0.53	0.19	0.18
MISCELLANEOUS					
Apples	78.00	——	0.12	0.01	0.17
Cabbage	90.50	1.40	0.38	0.11	0.43
Dried blood	8.50	4.70	13.50	1.35	0.77
Dried fish	10.80	29.20	7.75	12.00	0.20
Meat scrap	10.70	4.10	11.39	0.70	0.10
Pumpkin (garden)	86.80	0.90	0.11	0.16	0.09
Spurry	75.60	4.00	0.38	0.25	0.59
Sugar beet leaves	88.00	2.40	0.41	0.15	0.62

Suggestion: Have the students figure the values of the fertilizer constituents in one ton of several feed stuffs, valuing nitrogen at 17 cents a pound, and phosphoric acid and potash at 5 cents a pound. Have them observe the amount of fertility removed from an acre of land by some of the popular crops grown in the locality. Assume a few common rations fed to different classes of live-stock in the locality and let the students calculate the yearly values of the manure obtained.

SECTION XXXVIII.

CROPPING SYSTEMS FOR STOCK FARMS.

All over this country there are certain farmers who manage their lands better than others and thus make greater profits. These farmers are not plentiful but are scattered about and give us practical examples of farming systems best adapted to their localities. The cropping systems for stock farms vary of course with the nature of stock, nature of the crops grown, locality of the farm, nature of the land, size of the farm, price of labor, results desired, etc.

Cropping systems are well illustrated by Spillman in the 1907 Year-book of the United States Dept. of Agriculture, from which the following is taken:

"**Rotation Defined.**—A rotation of crops is a succession of crops, one following another on the same land. If these crops continually recur in a fixed order, the rotation is a definite one. If they recur at regular intervals, the rotation is said to be a fixed rotation. A definite rotation may not be a fixed rotation; for example, in many parts of the country it is customary to leave grass lands down from three to six or more years, the length of time depending on the condition of the sod, the supply of labor, feed requirements of stock, etc. When the sod is plowed up, the land is planted in corn, then wheat is sown, and grass follows. This rotation is perfectly definite as to the crops grown and the order in which these crops follow each other, but it is not fixed as to the number of years it occupies.

"Fixed rotations are not objectionable on farms that grow crops for sale, provided, of course, the crops are such as bring a satisfactory profit and proper measures are taken to conserve the fertility of the soil. We shall later see also that fixed rotations are practically necessary on certain types of stock farms where one or more of the crops in the rotation are used for pasture, and where, consequently, the fields must be separately fenced. But a single fixed rotation practically never produces crops in the needed proportions on the stock farm. Hence, the stockman who runs a single fixed rotation covering his whole farm practically always has a surplus of some kinds of feed or a shortage of others. For this reason he is compelled to keep less stock than his farm would support with a properly planned cropping system unless he is in a position to buy feed that may be lacking.

"**Examples of Simple and Complex Rotations.**—While a single fixed rotation produces crops in fixed proportions, except for variations in yield, and is thus inflexible, two rotations can nearly always be so arranged as to produce any given crops in any desired proportion. Suppose, for instance, that a dairy farmer desires to produce annually 15 acres of corn for silage, 20 acres of corn for grain, 25 acres of oats for grain, and 60 acres of hay. He can do this by arranging two three-year rotations as follows:

A SYSTEM OF TWO SIMPLE ROTATIONS ON A DAIRY FARM

First series		Second series	
First year....	35 acres corn	First year..	5 acres pea and oat hay
Second year	25 acres oats 10 acres pea and oat hay	Second year.	5 acres timothy and clover hay
Third year ..	35 acres timothy and clover	Third year...	5 acres timothy and clover hay

"This gives the exact acreage of each crop desired. If, in the above cropping system, the area of oats exceeds that of corn, the requirements being, say, 20 acres of corn, 25 acres of oats, and 60 acres of hay, we can arrange the rotations as follows:

A SECOND SYSTEM OF TWO SIMPLE ROTATIONS ON A DAIRY FARM.

First series		Second series	
First year....	20 acres in corn for grain 5 acres in a hay crop	First year.......	10 acres in peas and oats for hay
Second year....	25 acres in oats for grain	Second year....	10 acres in timothy and clover for hay
Third year.....	25 acres in timothy and clover for hay	Third year.....	10 acres in timothy and clover for hay

"The general plan in the foregoing scheme of two rotations is to fill in the vacancies of the first and more usual rotation by putting in some other crop which is grown mainly in the second rotation. The scheme is therefore an elastic one, well suited especially to dairy farms on which the pasture is provided outside of the regular rotations.

"There is always a way of planning a single complex rotation which has the same elasticity as the two-rotation systems before outlined and which is even better than the two-rotation system on most farms. The two systems given before may be arranged as follows:

COMBINATION OF THE FOREGOING TWO-ROTATION SYSTEMS INTO SINGLE COMPLEX ROTATIONS

	First system		Second system
First year	35 acres in corn for grain 5 acres in peas and oats for hay	First year	20 acres in corn 15 acres in peas and oats for hay
Second year	25 acres in oats for grain 10 acres in peas and oats for hay 5 acres in timothy and clover for hay	Second year	25 acres in oats 10 acres in timothy and clover for hay
Third year	40 acres in timothy and clover for hay	Third year	35 acres in timothy and clover for hay

"The first of these complex rotations gives the same acreage of each crop as the first set of two rotations previously given, and the second the same as the second set of two rotations. While these last two rotations are technically called complex rotations, they form systems which are really simpler than the two-rotation scheme, and we generally use rotations of this type in planning cropping systems for dairy farms.

"This type of rotation is exceedingly elastic. It not only permits each crop to be grown in exactly the proportion needed, but it can be varied in many ways by substituting other crops for those shown in the outlines above. For instance, in the first of these complex rotations, instead of plowing up the whole 40 acres of timothy and clover, we may leave 5 acres to take the place of the peas and oats in the first year. This 5 acres may remain down indefinitely, as long as the yield is satisfactory, and when necessary it may be plowed up and sown to peas and oats, to be followed by timothy and clover again without losing a crop of hay.

"Again, we may sow 10 acres of timothy and clover in the corn-field of year 1 to take the place of the 10 acres of peas and oats in year 2. Similar modifications may be made in the second complex rotation. This is exactly the type of cropping system that has been developed by the shrewd New England dairy farmer whose small holdings will not permit him to grow a fixed, inelastic rotation that does not produce the crops in the proportion in which he wants them. Such a system enables the farmer to keep a maximum herd on his farm.

"It is, of course, recognized that variations in yield from year to year will cause considerable variation in the quantity of each crop produced. This variation is especially likely to occur on poor soils; it is much less on farms that have exceedingly rich soil. Nevertheless, the farmer is compelled to lay some kind of plan for meeting such variations in yield. Any scheme has value if it enables the farmer to approach more nearly to the ideal of his plans, and cropping systems like the complex rotations outlined will do this."

How to Plan a Cropping System.—The following is taken from Spillman's article in the 1907 Year-book United States Dept. of Agriculture:

"The method of managing hogs assumed in the following is adapted to the latitude of Virginia, North Carolina, Kentucky, Tennessee, Southern Missouri, and Northern Arkansas. It assumes that winter grain can be made available for pasture practically throughout the winter. When pasture is not available, some clover hay cut from the summer pasture is fed. A small area of soy-bean hay may also be grown for winter feed for the hogs. Fixed rotations are necessary in this type of farming, because each field must be permanently fenced. Experience has shown that with good pasture 10 bushels of corn will, on the average, make a fall pig weigh about 170 pounds by July. The same quantity of corn, with good clover or alfalfa pasture, will carry a spring pig to 190 or 200 pounds by December or January. The pigs are supposed to be fed about all the corn they will eat up clean once a day—late in the afternoon. It will require about 25 bushels of corn to feed a sow on pasture for a year. The sows are supposed to run on pasture with the pigs until the pigs are about ten weeks old. The sows are then removed to their own special pasture, where they are bred, and remain till the next litter of pigs is farrowed. Good winter wheat pasture will carry about 6 pigs to the acre. Good clover pasture will carry 12 pigs to the acre till July, after which it will carry half as many. By sowing wheat and clover in corn in August we get our winter and summer pasture on the same land, so that 1 acre of pasture suffices for 6 fall and 6 spring pigs.

"Estimating corn at 60 bushels per acre, 3 horses will require 4½ acres of corn. If hay yields 1½ tons per acre, the horses will require 5½ acres of hay. If a sow produces on the average 14 pigs a year in two litters, then for each sow kept the requirements are as follows:

AMOUNT AND ACREAGE OF CORN AND ACREAGE OF PASTURE NEEDED TO SUPPORT ONE SOW WITH PIGS FOR A YEAR.

	Acres
FEED FOR 1 SOW	
Corn, 25 bushels	0.42
Special pasture	0.20
FEED FOR 14 PIGS	
Corn, 140 bushels	2.33
Pasture	1.17
Total	4.12

"Deducting 10 acres required to raise feed for the horses, we have on a 60-acre farm 50 acres to be devoted to hog raising. This divided by 4.12 gives 12.11; *i. e.*, we can keep 12 sows and raise 168 pigs.

The approximate acreage of each crop would be as follows:

TOTAL ACREAGE OF EACH CROP NEEDED ON A HOG FARM IN A REGION A LITTLE SOUTH OF MIDDLE LATITUDE

Crop	For 3 horses	For 12 sows	For 168 pigs	Total
	acres	acres	acres	acres
Corn	4.5	4.85	28.24	37.50
Hay	5.5	——	——	5.50
Pasture	——	2.40	14.13	16.53

Scheme of Rotation for a Hog Farm in a Region a Little South of Middle Latitude

First rotation		Second rotation	
First year...	14 acres in corn and cowpeas	First year..	6 acres of corn
Second year.	14 acres in corn, wheat and clover	Second year .	3.6 acres of corn 2.4 acres of hay
Third year..	14 acres in wheat and clover	Third year...	3.6 acres of hay 2.4 acres of sow pasture

"By feeding a good deal of corn stover to horses, there ought to be hay enough to feed a cow on this farm. A fair crop of hay may be cut from the pig pasture about the first of July. This hay will contain a good deal of wheat straw, but will answer very well for pig feed in winter. The sow pasture will have to be fenced off each year with a temporary fence.

"On account of the variation in yields, in some years there will be more corn than can be utilized, while in other years there will be less than is needed. This is true in all forms of live-stock farming. Some men meet this difficulty by keeping fewer animals than the farm would support with average yields, and thus in good years have some crops for sale. Others meet it by changing the number of animals from year to year to suit conditions. Still others keep a maximum number of animals and buy feed when needed. As before stated, everyone must be his own judge in matters of this kind.

"In the system of hog management outlined it is clear that in a section where corn can be bought at a price that permits it to be fed to hogs with a profit, the limit to the number of hogs that can be kept on the farm is the area of pasture that can be provided. With a winter cereal and clover furnishing this pasture, it would be possible to keep half the land in pasture by growing a two-year rotation of corn followed by wheat and clover, these being sown together in August in the corn.

"To ascertain the number of hogs 60 acres may be made to support under this last rotation, we deduct the 10 acres required to raise feed for the horses and divide the remaining 50 acres by a divisor obtained as follows:

ACREAGE FOR ONE SOW AND PIGS

	Acres
Special pasture for 1 sow	0.20
Regular pasture for 14 pigs	1.17
Corn in rotation with pasture	1.17
Total	2.54

"For each sow and her two litters of pigs there is therefore required 2.54 acres. Dividing 50 by this we get 19.7. Retaining the fraction of this number as a factor of safety, the area of the special pasture for the sows is 4 acres. The area of wheat and clover pasture is 23, and the area of corn 23 acres.

"If increasing the area of pasture and buying corn to feed the hogs on this pasture is more profitable than raising the corn, it would also be more profitable to buy feed for the horses. If this is done, to find the number of sows that can be kept we divide 60 acres by 2.54, the result being 23.6. This gives the area of special pasture for the sows as 4.72 acres, leaving 55.28 acres to divide into two fields of 27.64 acres each for the rotation.

"Twenty-three sows would produce 322 pigs annually. The amount of corn and hay that must be bought under this system, assuming that the corn raised yields 60 bushels per acre, would be: Hay for 3 horses, 8½ tons; corn for three horses, 270 bushels; for 23 sows and 322 pigs, in addition to corn raised, 2,138 bushels.

"In the system of hog farming just outlined difficulty sometimes arises from the fact that when wheat begins to shoot up in the spring it has a deleterious effect on the intestinal canal of the hog. If trouble of this kind is experienced, rye may be substituted for wheat. Along the extreme southern edge of the belt to which this type of farming is adapted winter oats may be used, and these are better than either wheat or rye for hog pasture."

Cropping System for Illinois Hog Farm.—According to Farmers' Bul. 272, the following cropping system has been used on a hog farm in Illinois with good success for 10 years:

First year, corn, 4/5 and soy bean 1/5
Second year, corn
Third year, oats
Fourth year, clover

Four equal fields of 20 acres each were used in this rotation. The soy beans were harvested and used as hay for winter feeding; the clover was pastured; the oats were used for feeding the hogs and work horses; and the corn stover, sheaf oats or oat straw were also used for feeding. A little hay was purchased. Besides the 80 acres used in the rotation, 10 acres were in blue grass, 31 acres in timber and 10 acres were used for the orchard, garden, barn lot and yards, making a total for the farm of 131 acres.

Five horses, two cows, fifteen Duroc-Jersey brood sows which averaged eight pigs to the litter, and 120 yearling hogs were kept. The yearling hogs were pastured on 12 acres of the clover and grain fed, at the rate of 2½ to 4 lbs. a day depending upon the pasture, during the summer and were sent to market about August 1-10 weighing 325-350 lbs.

The sows and young pigs were put on 8 acres of clover and turned on the remaining 12 acres when the yearling hogs were marketed. The sows and pigs were grain fed and by fall the pigs weighed about 100-125 lbs.

In the winter the pigs were fed 5 lbs. of the following mixture:

3½ pounds corn
¾ pound shorts
¾ pound oil meal

Soy bean hay was also fed. By spring these pigs weighed 200-225 lbs.

The sows were fed clover hay, enough of which was cut from the pasture for this purpose, and 4 lbs. of grain, consisting of ground rye or bran, oil meal, shorts, and corn.

The owner of this hog farm says: "We think now we shall change our rotation and have one division in alfalfa, running a rotation of corn, corn, clover on three fields; or we may use soy beans and omit the clover."

Cropping Systems for New England Dairy Farms.—According to Dodge in Farmers' Bul. 337.

"New England is preeminently a section of small farms, due largely to the generally broken character of the country, the farming land being located in small areas scattered among the hills. Since the farms are small, some type of intensive farming must be followed to make them profitable. Since the land has already been tilled longer than good land will bear an exploitive system of farming, some type of live-stock farming is a necessity on most farms. As the most intensive form of stock farming is dairying, this latter industry is naturally the leading one on New England farms. Dairying, in the main, has been a profitable business in New England, but in recent years conditions have changed, and the outlook is not so satisfactory as it has been at various times in the past.

"Some of the difficulties which are at present most evident are the high prices of concentrated feeds and of labor. Some sections of New England, furthermore, feel the pressure of unsatisfactory market conditions, especially those sections which ship milk to the large cities, where the farmers are offered a price for their milk on which they can hardly make a profit.

"Outside of the milk-shipping sections the difficulties mentioned do not appear, on careful observation, to be the most fundamental, although they are the most obvious. Taking the Northeastern States of the Union as a whole, owing to climate and topography the land is in general adapted to the growth of grass and trees. The fact that grass is so much at home in those States has led to a serious fault in New England dairy farming, namely, the mismanagement of grass lands. This consists in the main of a lack of proper treatment for permanent grass lands and of suitable rotations for other land, as well as the use for grass growing of land which does not give profitable returns from grass and which should rightfully be devoted to tree growth, either as woodland or orchards. Another frequent and wide-spread fault is the habit of cutting the hay crop entirely too late in the season, which of itself shortens the life of the meadow and results in an inferior quality of hay for dairy feeding.

"Closely associated with poor management of grass lands is the failure to utilize other crops available for this section, especially corn. In southern New England there is little difficulty in growing good silage corn, but as one travels northward there is evidence of a lack of suitable varieties of corn for silage. This difficulty is not insuperable. There are varieties of corn that can be grown for silage in all but the most northern counties in New England. What is most needed is that sufficient attention be given to the selection of seed in order to develop strains of corn fitted to the requirements of the different sections.

"Some of the best dairy farms of the country are to be found in New England. They are scattered here and there all over the New England States. A careful study has been made of the cropping systems on a large number of these farms." The results of this study are tabulated in the following table.

The following table shows the acreage, live-stock and seed required on several New England dairy farms:[1]

TABLE I.—ACREAGE OF NEW ENGLAND FARMS, AND NUMBER OF LIVE-STOCK ON EACH

Farm	System		Tilled land	Pasture	Number of cattle		Tillable land per animal[2]	Pasture per animal
					Cows	Young stock		
			acres	acres			acres	acres
Jones	Silage	Grain pur'd	40	40	25	15	[3]1.09	1.00
Sanborn	Silage	Grain pur'd	[4]200	225	140	100	1.05	0.9
Noyes	Silage	Grain pur'd	18	150	11	3	0.95	([5])
Smith	Silage	Grain pur'd	75	75	55	25	1.10	0.935
Chittenden	Silage	Grain pur'd	175	100	110	25	[6]1.40	0.7
Davis	Silage	Grain pur'd	28	36	25	15	0.83	0.92
Holt	Silage	Grain pur'd	74	40	70	25	0.89	0.4
Sadd	Silage	Grain pur'd	80	——	45	——	1.77	([7])
Wilson	Silage	Grain rais'd	65	60	35	12	1.56	1.28
Ames	No silage	Grain pur'd	16	40	11	3	1.23	2.85
Avery	No silage	Grain pur'd	18	——	20	——	0.90	——

[1] Farmers' Bul. 337.

[2] On most of these farms 2 horses are kept for each 18 or 20 cattle. The horses do not use any pasture, but must be counted in connection with the crops raised. In reckoning tillable land or pasture per animal, 2 young cattle or 5 sheep are considered the equivalent of 1 cow.

[3] In reckoning tillable land per cow only that used for raising feed is counted.

[4] Figures on the Sanborn farm refer only to the part used to supply dairy feeds.

[5] On the Noyes farm 32 sheep are kept in addition to the cattle, and so the surplus pasture is partly utilized.

[6] Considerable hay is sold annually from the Chittenden farm.

[7] There is no pasture on the Sadd farm. Cows are stall fed the year around.

TABLE II.—ACREAGE OF THE SEVERAL CROPS ON NEW ENGLAND FARMS, AND PERCENTAGE OF LAND IN EACH CROP

Farm	Tilled land	Approximate number of acres[1] in—			Tillable land		
		Corn	Other cereals[2]	Grass and clover	In corn	In other cereals[2]	In grass and clover hay
	acres				per cent.	per cent.	per cent.
Jones	40	12	10	14	30.	25.	[3]35.
Sanborn	200	50	100	[4]150	25.	50.	25.
Noyes	18	4.5	4.5	9	25.	25.	50.
Smith	75	22	22	31	30.	30.	40.
Chittenden	175	58	17	100	32.	10.	58.
Davis	28	6	2	20	21.5	7.5	71.
Holt	74	25	20	29	34.	25.	31.
Sadd	80	30	—	50	37.5	—	62.5
Wilson	65	16	[5]16	32	25.	25.	50.
Ames	16	—	4	11	—	25.	[3]70.
Avery	18	[6]2	—	16	11.	—	89.

TABLE III.—QUANTITY OF SEED REQUIRED AND DATES OF PLANTING AND HARVESTING FOR THE LATITUDE OF CONCORD, N. H.[7]

Crop	Quantity of seed per acre	Date of planting	Date when fit for soiling	Date when fit for silage or hay
Corn	12 quarts	May 18-25	August 10	Sept. 10
Oats } mixed	1 bushel	April 25 to May 10	July 5	July 25
Peas } mixed	1 bushel			
Barley } mixed	1½ bush.			
Barley	3 bushels	July 1	September 1	Sept. 20.
Winter rye	3 bushels	Sept. 1-20	May 20	June 10
Winter wheat } mixed	2 bushels	Sept. 1-20	June 10	July 1-5
Winter vetch } mixed	½ bushel			
Japanese millet	30 pounds	June 1-30	July 5-30	Aug. 1-30
Hungarian millet	30 pounds	June 1-30	July 20 to August 20	Aug. 1-30
Clover	12 pounds	April 10–30; August 1-25	June 15	June 25-30

[1] These figures are only approximate, for the acreages vary slightly from year to year.

[2] Includes either Japanese or Hungarian millet on a few farms.

[3] On the Jones and the Ames farms, respectively, a small area out of the tilled land is used for potatoes.

[4] Includes 50 acres of permanent pasture.

[5] On all except the Wilson farm other cereal crops than corn are used for hay or silage. On the Wilson farm they are cut for grain.

[6] All corn raised is for silage except on the Avery farm, where corn is raised for grain, and figures there apply only to winter feeding.

[7] The dates given are for a normal season. For points to the north or south of Concord or in higher altitudes some allowance needs to be made, but the differences will be rather slight.

"The essentials of the New England dairyman, according to Farmers' Bul. 337, in growing feed for his cows appear to be the use of a short rotation wherever possible; all the clover

Fig. 24.—Sorghum; a succulent feed.

hay and corn silage that can be grown; liming the land for clover if need be; better management, especially in the use of manure, of land which is not fit for short rotations; and the utilizing of the various other crops that have been mentioned to fill the gaps with succulent feed or add in quantity and quality to the ordinary hay crop."

Cropping System for Dairy Farm in Michigan.—Farmers' Bul. 280, gives a description of a dairy farm in Michigan run on the tenant basis which has been successful. This farm is of 120 acres, and 60 cows, 43 calves and yearlings, 2 bulls and 9 horses were on the place at the time of these observations. All the roughage was grown on the farm, and the oil meal, bran and cotton-seed meal were purchased.

SYSTEM OF CROPPING FOR 1905, 1906 AND 1907[1]

Field number	Acreage	Crop, 1905	Crop, 1906	Crop, 1907
1	17	Timothy hay	Pasture	Corn
2	24	Pasture	Corn, sowed to rye	Rye, to be cut for hay and followed by corn
3	32	Corn	13 acres corn	13 acres corn
			18 acres oats, seeded to alfalfa	19 acres alfalfa
			1 acre rye, seeded to alfalfa	
4	13	Oats, cut for hay; seeded to alfalfa	Alfalfa	Alfalfa
5	10	Oats, cut for grain; seeded to rye	Rye, followed by corn, seeded to rye	Rye, to be cut for hay and seeded to alfalfa
6	10	Alfalfa	Alfalfa	Alfalfa

In addition there was a pasture of 2½ acres, which was never plowed.

Enough manure was produced on this farm to cover the whole form with 6-8 tons per acre. No commercial fertilizer was used.

The corn for silage was a large ensilage corn planted on well manured land. The corn stubble was seeded with rye which proved to be very successful as a hay crop. From 10 acres, 4 big loads of rye hay and 15 tons of silage to the acre were harvested for 1906.

[1] Farmers' Bul. 280.

Cropping Systems with Alfalfa.—Wing[1] suggests the following rotations using alfalfa in Ohio, Indiana, and Illinois:

First year, corn
Second year, corn
Third year, alfalfa and barley
Fourth year, alfalfa
Fifth year, alfalfa
Sixth year, alfalfa

The alfalfa may be sown in the fall on barley stubble or in the spring with barley as a nurse crop. Permanent pasture is kept for cows, work horses, and pigs.

A shorter rotation is suggested by the same authority as follows:

First year, corn
Second year, wheat
Third year, alfalfa
Fourth year, alfalfa

The alfalfa may be sown on the plowed wheat stubble. Permanent pasture is provided for live-stock.

Cropping Systems for North Central States.—The following cropping system is popular in these states:

First year, corn
Second year, oats
Third year, clover and timothy
Fourth year, clover and timothy

It is possible to plant Irish potatoes or oats after the corn. Rye may be planted in the fall after the corn, oats or potatoes and this crop will be off by July 1st. The clover may be sowed at the last snowfall or early in the spring, and a crop of hay should be secured from this by early fall. The mammoth red clover is popular.

Cropping Systems for the Gulf States.—In the Gulf states it is possible to raise many crops during the summer and winter, and so the stock farmer is not always limited in his choice of crops. The following are a few crops that are successful for this region:

[1] Alfalfa in America.

Summer	Winter
Corn and cowpeas	Beets, turnips or carrots
Sorghum	Oats
Sweet potatoes	Red or crimson clover
Lespedeza (Japan clover)	Italian rye grass
Peanuts	Bur clover
Alfalfa	Irish potatoes
Bermuda	

In some sections of the Gulf States it is too cold in the winter for mangels, and carrots or turnips may be substituted, but mangels are preferred.

Alluvial lands well seeded in alfalfa may remain until the crop is unprofitable. On certain lands this crop may last for years. Lespedeza and Bermuda are excellent for pasture or for hay and will usually reseed themselves. Besides these, there are innumerable grasses, legumes and other forage crops that may be successfully grown..

Suggestion:—Figure cropping systems for stock farms in your locality. The yearly requirements for live-stock may be easily ascertained by computing rations from the feeds you can raise. It may be necessary to purchase small amounts of protein concentrates for some classes of live-stock, but most and sometimes all of the feed may be raised at home.

THE STATE AGRICULTURAL EXPERIMENT STATIONS.

Alabama—
  College Station; Auburn.
  Canebrake Station; Uniontown.
  Tuskegee, Tuskegee.
Arizona—Tucson.
Arkansas—Fayetteville.
California—Berkeley.
Colorado—Fort Collins.
Connecticut—
  State Station, New Haven.
  Storrs Station, Storrs.
Delaware—Newark.
Florida—Gainesville.
Georgia—Experiment.
Idaho—Moscow.
Illinois—Urbana.
Indiana—Lafayette.
Iowa—Ames.
Kansas—Manhattan.
Kentucky—Lexington.
Louisiana—
  State Station, Baton Rouge.
  Sugar Station, Audubon Park, N. O.
  North La. Station, Calhoun.
  Rice Station, Crowley.
Maine—Orono.
Maryland—College Park.
Massachusetts—Amherst.
Michigan—East Lansing.
Minnesota—St. Anthony Park, St. Paul.
Mississippi—Agricultural College.
Missouri—
  College Station; Columbia.
  Fruit Station; Mountain Grove.
Montana—Bozeman.
Nebraska—Lincoln.
Nevada—Reno.
New Hampshire—Durham.
New Jersey—New Brunswick.
New Mexico—Agricultural College.
New York—
  State Station; Geneva.
  Cornell Station; Ithaca.
North Carolina—
  College Station; West Raleigh.
  State Station, Raleigh.
North Dakota—Agricultural College.
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Oklahoma—Stillwater.
Oregon—Corvallis.
Pennsylvania—State College.
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