University of Nebraska - Lincoln
DigitalCommons@University of Nebraska - Lincoln

Historical Materials from University of Nebraska-Lincoln Extension

Extension

5-1938

EC621 Revised 1938 Feeding Dairy Cattle

H. P. Davis

Follow this and additional works at: https://digitalcommons.unl.edu/extensionhist

Davis, H. P., "EC621 Revised 1938 Feeding Dairy Cattle" (1938). *Historical Materials from University of Nebraska-Lincoln Extension*. 2237.
https://digitalcommons.unl.edu/extensionhist/2237

This Article is brought to you for free and open access by the Extension at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Historical Materials from University of Nebraska-Lincoln Extension by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

AGRI
S
85
E7
#621

Extension Circular 621 -38 May 1938

FEEDING DAIRY CATTLE

RECEIVED
MAR 11 1970
COLLEGE OF AGRICULTURE
LIBRARY

THE UNIVERSITY OF NEBRASKA AGRICULTURAL COLLEGE EXTENSION SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING
W. H. BROKAW, DIRECTOR, EXTENSION SERVICE
LINCOLN, NEBRASKA

CONTENTS

Page

Feed Plenty 3
Feeds Required in Balanced Rations 4
Protein 4
Carbohydrates and fats 4
Minerals 5
Vitamins 6
Water 7
Summer Feeding with Pasture 7
Permanent pasture 7
Annual or biennial pastures 8
Cost of pasture 9
Soiling crops 10
Summer silos 10
Pasture supplements 10
Guide for feeding grain with pasture 10
Grain mixtures to be used with good pasture 11
Winter Feeding and Feeding without Pasture 11
High-protein roughage 12
Low-protein roughage 12
Root crops, root by-products, and tubers 14
Quantities of roughage to feed 14
Grain or concentrates 15
Balancing a ration by means of the grain mixture 16
Cheapest protein 18
Palatability 19
Effects of concentrates 19
Feeding Dry Cows 19
Feeding Cows at Calving Time 20
Feeding Herd Bulls 20
Feeding Heifers 21
Feeding Heavy-Milking Cows 21
Processing of Feeds 22
Practice in Making Grain Mixtures 22
Grain Mixtures for Different Roughages 24
High-protein roughage 24
Medium-protein roughage 25
Low-protein roughage 26
Accurate Balancing of Rations (Morrison Feeding Standard) 28

Feeding Dairy Cattle

H. P. DAVIS

Department of Dairy Husbandry

MILK is produced only from feed and water. Up to the limits of the inherent ability of the cow to produce milk, the production of milk is directly dependent upon the feed which the cow receives. Since dairy cows are kept primarily for their milk production it is essential that it be not limited because of insufficient or improper feeding. Successful feeding consists of getting the largest quantity of milk from the cow at the lowest cost and doing this year after year. For economical production the farmer and dairyman must always consider not only the present milking period but also those to come.

The dairy cow is the most efficient farm animal. For each 100 pounds of digestible organic matter which she is fed she produces in the form of edible solids in milk a total of 18 pounds. In producing milk a cow works hard. Anyone would admit that a horse doing full work for eight hours works hard, yet a cow producing daily 45 pounds of milk containing 4 per cent fat expends the same amount of energy that the horse does in working eight hours at full work. Milk production cannot be maintained unless the energy to produce it is supplied.

Feed Plenty

A cow, like an engine, uses fuel to produce work, which in the case of the dairy cow is making milk. Feed is the fuel for dairy cows. A certain quantity of feed is necessary to maintain the cow's body in proper running order, performing such duties as pumping blood, chewing and digesting food, making body repairs, and providing energy for moving about. The feed needed to keep the cow's body in good running order without any exercise or without gaining any weight or producing milk is called the "maintenance" requirement. It is never an efficient plan to try to feed a dairy cow only a maintenance ration, because if she is to be a profitable animal she must have the additional feed, above that necessary for running her body machine, to make any profit for the owner. The practice sometimes followed of "roughing" the dairy cow through the winter on poor feed at a maintenance or even a submaintenance level will almost certainly result in a future loss to the owner, since a cow can only produce milk profitably when she has adequate feed, not only during the milking period but during the dry period between lactations. A dairy cow is obliged to recuperate from a milking period during the time when she is dry; then, if feed is adequate, she replenishes any deficiencies that have resulted from a heavy milking period and stores nutrients in preparation for the succeeding lactation. A cow can be so fed that, if healthy, she can produce profitably for a half-dozen or more successive lactation periods with no "off years." The first principle of feeding is, plenty of feed.

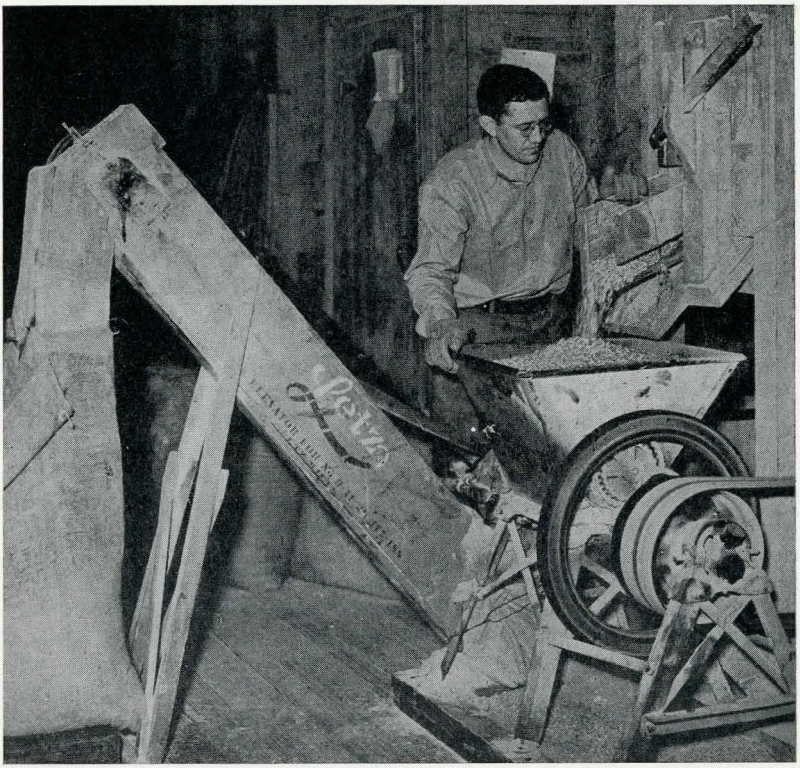
Feeds Required in Balanced Rations

A balanced ration is one that exactly meets the daily needs of a dairy cow both for the maintenance of her body and for the production of milk. Dairy cows require that a balanced ration shall contain protein, carbohydrates, fat, minerals, vitamins, and water. Each of these constituents is essential and in general no single one can be substituted for another. The quantities of these various constituents that are needed for the proper maintenance of health and the economical production of milk have been well established by the work of many experimenters.

Protein.—Protein is the name given to a very large number of substances all of which contain a rather definite proportion of nitrogen and are needed by the animal to make blood, muscle, and milk and to carry on the various body functions. Some proteins are much more useful to the animal than others and in practice it is desirable to have a number of different sources of protein in the ration in order to get as wide a variety as possible. There are some indications also that animal proteins are particularly useful for at least a part of the ration. There is no substitute for protein and its lack in the ration will not only definitely limit the milk production but will likely cause irregularity or failure to reproduce. Protein must not be limited or the cow's normal functions will be interfered with.

Grasses in the early stages of their growth contain enough protein to furnish a balanced ration for moderate milk production. As they mature the percentage of protein becomes much smaller, with the result that most dry roughages are very low in protein. Thus prairie hay, corn fodder, sorghum fodder, and corn silage are very low in protein. The legume hays such as alfalfa, the various clovers, soybeans, and cowpea hay are good sources of protein. The richest sources of protein are by-product feeds such as linseed oil meal, cottonseed meal, corn gluten meal, soybean meal, fish meal, etc.

Carbohydrates and fats.—Carbohydrates and fats are used by the cow to supply energy (power to do work), to eat, walk, produce milk, and to keep herself warm in winter and cool in summer. They are also useful for certain kinds of body repair and for the making of milk sugar and fat in the milk. A cow has certain requirements for carbohydrates and fats but since they are both used for much the same purpose they are often considered together. A cow must have a definite amount of fat in the ration and there are indications that when this quantity is reduced beyond certain limits there is a reduction in the percentage of butterfat and the total amount of butterfat produced. As a source of energy fats are two and one-fourth times as valuable as carbohydrates. For balancing rations, protein and total nutrients are used for ease of calculation. In the figures for total nutrients in Table 4 (page 30), the protein, which is equal to the carbohydrates as a source of energy, and the carbohydrates are added together and to that is added the fat, multiplied by 2¼. Thus the figure for total nutrients represents the energy in the protein, the carbohydrates, and the fats. Most roughages, corn, cereal grains, molasses,



Grinding grain is economical in feeding dairy cattle.

and roots are the chief sources of carbohydrates since they contain large proportions of that constituent. Most feeds contain a large enough proportion of fat so that that constituent does not have to be seriously considered except where the rations are very limited.

Minerals.—In most parts of the country mineral deficiency is not a problem, but there are a few inorganic substances that may be deficient, and the lack of these may cause physiological disturbances. Common salt (NaCl) is necessary for proper body functioning. When on pasture a cow may obtain enough of that substance, but even then, boxes which are protected from the weather and contain salt are advised. A milking cow needs from one to two ounces per day under most circumstances. A very satisfactory method of adding salt to the ration consists of adding one per cent of coarse salt to the grain mixture. Salt blocks are often so hard as to cause a sore tongue before a cow gets enough salt.

Since there are regions in the United States which have an iodine deficiency, goitre may develop in cows or calves unless iodine is given.

The easiest and safest way is to purchase iodized salt in barrels or sacks and feed it in boxes, add it to the grain mixture, or both.

Lime (CaO) and phosphoric acid (P_2O_5) are two essential mineral substances for cattle. Both are ingredients of the bone and teeth and are essential to proper physiological balance, which includes reproduction. Cows lacking in these minerals do not come in heat regularly, often fail to conceive, and may drop dead calves. A shortage of either of these substances in the soil will be likely to result in a deficiency in crops grown upon that land. Cereals, particularly the corn plant, are lacking in both these minerals. Alfalfa and other legume hays are high in lime as are several of the high-protein concentrates. Phosphoric acid or phosphates are found abundantly in bran, middlings, fish meal, tankage, etc. (Table 4). Since steamed bone meal and lime flour contain respectively phosphates and lime, a good practice is to add one per cent of each to the grain mixture. In addition a mineral mixture may be available in protected boxes. This may be composed of two or three parts of iodized salt and one part of steamed bone meal.

While deficiencies in other minerals are not likely to occur, there have been instances where the use of from 2 to 5 per cent of fish meal in the grain mixture has apparently helped the general physiological processes, especially reproduction. Iron has been found to be deficient in only a few places in the United States and the same is true of cobalt.

Vitamins.—The studies that have been made of the various vitamins have emphasized the importance of adequate quantities in the diets of dairy catle. Vitamin A, the lack of which inhibits or checks growth, may cause eye inflammation, night blindness, and reproductive difficulties, and may predispose animals to respiratory and gastro-intestinal infections. This vitamin is a very essential ingredient of the diet of dairy cattle. Vitamin A is usually found in abundance in green forages and in green hays, especially those artificially dried. Corn silage that is preserved with acids (A. I. V.) or with molasses contains a moderate quantity. Yellow corn and carrots are good sources of vitamin A. White corn, cereals, ordinary silage, and hay that has lost its color are poor sources of this vitamin.

Vitamin D, the lack of which causes rickets by failure to provide for the proper interaction of calcium and phosphorus in building up bone, is chiefly supplied to cattle by sunlight. The use of cod-liver oil with calves to supply both vitamins A and D has proved successful.

Vitamin E is the vitamin definitely connected with the reproductive processes. Since most green forage and many concentrates have adequate supplies of this vitamin, the average cow will probably not show any deficiency. A vitamin-E deficiency might occur where dry roughage of poor quality was fed and where the only concentrate was some cereal grain. Wheat-germ oil, corn oil, and cottonseed oil (when cold pressed) are excellent sources of vitamin E.

It does not appear necessary to consider either vitamin C or the B complex as far as dairy-cattle nutrition is concerned.

Water.—Since the animal body is more than one-half water and milk is 87 per cent water, it is important that there should be no lack of this vital substance. All feed given to the animals contains a certain quantity of water, but the dairy cow, on account of her production of milk, requires much more than can be supplied by feed. The quantity of water required in addition to the feed depends, of course, on the amount in the feed. The atmospheric temperature also has an important influence on the water requirements. Cows producing 100 pounds of milk a day have been known to drink as much as 350 pounds of water in a day. A 1,000-pound cow producing 30 pounds of milk a day will probably consume not less than 60 to 80 pounds of water daily if it is provided in a palatable form. A cow will consume from 3 to 6 pounds of water for each pound of milk produced. The character of the feed, the temperature of the air, the size of the cow, and the milk production all affect the quantity of water consumed. Certainly it is not sensible to limit a cow's production by failure to provide an adequate quantity of water in such a form that the cow can reach it without too much effort and at such a temperature that her consumption is not limited. The ideal water temperature is between 40° and 60° F. That will mean that in the winter, water must be warmed to 42° F., or 10 degrees above freezing.

Summer Feeding with Pasture

Permanent pasture.—Nature has provided an ideal assortment of food nutrients for the dairy cow in pasture grasses. They are succulent, nutritious, well balanced, palatable, rich in vitamins and minerals, and they stimulate milk production and promote good health. Unfortunately pastures of mixed grasses are available in this climate usually for but a short period each year, after which they must be supplemented by providing other feeds or the milk flow will not be maintained. It must be remembered that in the early stages of growth, most grasses contain a high enough percentage of protein to furnish a balanced ration for dairy cows producing moderate quantities of milk. As the grasses mature they develop a much higher percentage of carbohydrates and become in consequence unbalanced because of lack of protein. In the case of high-producing cows, even very good pastures will not furnish enough nutrients for maximum milk production, because of the inability of such cows to consume enough of such a bulky feed. To obtain maximum production some grain must be fed.

In summer the fundamental problem in feeding dairy cows is furnishing sufficient good pasture. Nebraska is a large state and pastures naturally vary greatly in different sections. In the eastern part of the state bluegrass and various other tame pasture grasses are abundant and furnish the bulk of the pasture. In central Nebraska mixed grasses such as little bluestem, side-oats grama, and blue grama are important, while the important grasses in the western part of the state are the short grasses such as blue grama, buffalo grass, and western wheat grass.

Wherever there is a good stand so that the native grasses furnish sufficient pasturage, it is unnecessary to consider other pasture crops. Many sections, however, have insufficient pasturage from native pastures, and in these cases other pasture crops are often a great improvement. Pasture reduces to the minimum the labor required to feed and care for cows, insures that the manure is applied directly to the soil, and if not too costly fits well into the farm plan. Care must be used not to overgraze pasture. The division of pastures into small fields with frequent changing of cattle will usually provide more pasturage. The grass should be at least six inches high before cattle are turned into pasture in the spring. A little dry feed to supplement pasture will be found advisable at this time.

Annual or biennial pastures.—Sweet clover has proved to be a very useful pasture crop in many sections of Nebraska. Seeded with an alfalfa drill, grain drill, or broadcast at the rate of from 10 to 15 pounds per acre as early in the spring as the ground can be put into condition, it furnishes considerable pasture under favorable weather conditions the first season. The first year it should be pastured lightly or the yield will likely be reduced for the following year. The second year the sweet clover should be pastured short throughout the season. Scarified seed of the biennial sweet clover should be used. By alternating pastures frequently, their carrying capacity can be increased. Of course it will be understood that rainfall will govern the growth and carrying capacity.

If sweet clover is not pastured fairly closely, especially the second year, it grows up very woody and is not very palatable. This crop stands dry weather well and usually responds with renewed growth to late-summer showers the first year. Practice has indicated that cattle should not be turned into sweet-clover pasture until the crop is six to eight inches high. While sweet clover is not especially palatable, cows usually learn to eat it after a short time.

Caution must be exercised in pasturing sweet clover to guard against bloating. The first week that cattle are to be turned into sweet clover pasture, it is a good plan to see that they are filled up on hay each morning before letting them on the sweet clover so as to prevent overeating and subsequent bloat. After the first two weeks there is usually no trouble. It is always well, however, to let a heavy dew dry off a little before turning animals into the pasture. If properly handled, sweet clover will make a fine pasture and may even be used for hay. For the latter purpose the stiff, hard stems are objectionable. Sometimes cows fed sweet-clover pasture or sweet-clover hay develop a condition in which their blood will not clot readily. Dehorning should, therefore, be avoided while cows are eating sweet clover in any form.

Sorghums of the forage and grain varieties are sometimes used for pasture. All of these are annuals and consequently must be seeded each year. Sudan grass stands dry, hot weather well and furnishes an abundance of feed. Usually Sudan grass is seeded with a grain drill after corn planting time at the rate of from 25 to 30 pounds per acre. Under

A trench silo furnishes economical storage for roughage.

favorable conditions it will be ready for pasture in a month to a month and a half. It should not be pastured until the growth is 10 to 12 inches high. Sudan, like all the sorghum family, may under unfavorable conditions develop a substance which in the stomach of the cow turns to prussic acid, a deadly poison. Hot, dry conditions that cause the plants to stop growing or frost may cause the development of this condition in the plants. Sudan that is not used for pasture may be allowed to grow up for hay.

Wheat or rye planted in the early fall is often very useful for late-fall pasture and again for early-spring pasture. Wheat, while it may not make quite so heavy a growth, is often better than rye because it does not flavor the milk so much and because it keeps coming up after grazing with finer stems and leaves. Barley and oats make a good pasture also and this combination supplies pasture in between the other crops.

Cost of pasture.—The cost of pasture depends upon the number of animals that can be properly carried, the value of the land, the price of labor, the length of pasture season, and the cost of preparing or caring for the land. In Nebraska few pastures that are not irrigated are capable of carrying one animal per acre for the pasture season and in some dry, sandy regions, ten acres or more are needed per cow. Under most circumstances it is not profitable to pasture cows on land where the monthly rental exceeds the cost of others feeds plus labor. There is much land that either because of the roughness of its surface or because of the character of its soil should always be in grass. Such cases and the plan of

soil conservation make it necessary to use certain land for pasture when other considerations might make it seem inadvisable.

Soiling crops.—Soiling crops or soilage is the practice of growing green crops, harvesting, and transporting them to a convenient place for feeding to animals. By this practice greater yields may be obtained from a given area of ground than by pasturing, since there is no waste of feed due to tramping or to covering by manure. On the other hand, soilage requires much labor, usually both horse and man labor, and unless these are available at low cost the system is not as economical as the use of pasture. It is also often difficult to arrange for a succession of crops that will be ready for feeding throughout the season. Probably a succession of crops beginning with wheat or rye, followed by sweet clover, oats, and then Sudan grass, will carry through the summer in Nebraska to good advantage. This same rotation will be satisfactory for pasture.

Summer silos.—Any silo may be used for feeding in summer but smaller silos are sometimes used for that purpose, not being opened until the early summer. The small diameter is desirable in order that there may be a smaller surface of silage exposed to the air, since silage spoils rather rapidly in summer. A small trench silo is very satisfactory.

Pasture supplements.—Since pasture is often short, especially in the latter part of the summer, supplements are often needed to supply proper nourishment. Pasture may be supplemented in many different ways—with soiling crops, silage, hay, and grain. If possible it is best to use a succulent feed, as a soiling crop or silage, since such a feed is stimulating to milk production. It must be remembered that pasture grass, especially in the early stages of its growth, contains a rather high percentage of protein and as it matures the percentage of protein becomes less because of the large increase in the carbohydrate content. When supplementing pasture with silage, especially in the later part of the summer, the ration may be lacking in protein because silage is low in that constituent. Good legume hay is useful as a supplement and will supply protein. Grain is very useful as a supplementary feed, either in addition to pasture for cows giving a large flow of milk or supplemental to poor or dried-up pastures. Naturally the quantity fed depends upon the milk flow and the quality of the pasture. Many dairymen who have high-producing cows feed some grain, even with good pasture.

Guide for Feeding Grain with Pasture

A guide that has proved useful when feeding grain with good pasture is as follows:

Jersey or Guernsey Cows producing	
Up to 20 lbs. milk daily	1 lb. grain to 7 lbs. milk
(If the pasture is very good, no grain is needed for 20 lbs. of milk or less.)	
20 to 25 lbs. milk daily	1 lb. grain to 6 lbs. milk
25 to 30 lbs. milk daily	1 lb. grain to 5 lbs. milk
30 to 35 lbs. milk daily	1 lb. grain to 4½ lbs. milk
35 lbs. or above daily	1 lb. grain to 4½ lbs. milk

Holstein, Ayrshire, Brown Swiss, or Shorthorn Cows producing

Up to 25 lbs. milk daily	1 lb. grain to 8	lbs. milk
(Many dairymen feed no grain under 25 lbs. of milk if pasture is very good.)		
25 to 30 lbs. milk daily	1 lb. grain to 7	lbs. milk
30 to 35 lbs. milk daily	1 lb. grain to 6	lbs. milk
35 to 40 lbs. milk daily	1 lb. grain to 5½	lbs. milk
40 lbs. or above daily	1 lb. grain to 5	lbs. milk

For cows of medium to low production it may not pay to feed grain with good pasture. For supplementing good pasture as indicated above, the following grain mixtures are suggested:

Grain Mixtures for Feeding with Good Pastures

Mixture No. 1—Digestible Protein 10.60%
100 lbs. barley (ground)
100 lbs. wheat bran
100 lbs. oats (ground)

Mixture No. 2—Digestible Protein 10.27%
100 lbs. corn (ground)
100 lbs. wheat bran
100 lbs. alfalfa meal

Mixture No. 3—Digestible Protein 12.17%
200 lbs. corn and cob meal
100 lbs. wheat bran
50 lbs. cottonseed meal [1]

Mixture No. 4—Digestible Protein 10.40%
100 lbs. milo (ground)
100 lbs. wheat bran
100 lbs. oats (ground)

For supplementing poor pastures use a grain ration such as would be used with medium-protein roughage. Do not depend too heavily for feed upon native pastures in Nebraska in the middle of the summer. Short pasture will slowly starve a milk cow.

Winter Feeding and Feeding without Pasture

Feeding dairy cows in the winter or when they are not on pasture is much more complicated than feeding in the summer. The principles involved are the same, namely, the furnishing of the proper nutrients to the cow at the least cost. The basis of the feeding should be the roughage produced on the farm, which usually consists of hay, silage, fodder, and straw. All of such feed is bulky and therefore costly to ship; consequently it should be fed on the farm. Hay, silage, and fodder furnish the basis of the ration and to them additional feeds are added to make a complete and balanced ration.

A ration may be made of roughage alone, but such a ration is likely to be unbalanced, and usually is lacking in protein if fed to cows of high production. When a balanced ration is fed composed solely of roughage, the good cow will produce upward of 75 per cent of her maximum production. If a cow is to be fed roughage alone, it is essential that good legume hay be available. She usually cannot produce much more because the bulkiness of roughage limits her ability to consume feed. If possible some succulent feed or a substitute for succulence should be furnished. For such a purpose, silage is the most common and easily obtained feed. Roots such as mangels, sugar beets, carrots, and turnips are splendid feed but are often more expensive. Beet tops when fed as a part of the ration are very useful, and wet beet pulp is a good feed when properly handled.

[1] Linseed meal, soybean meal, gluten meal, or other high-protein concentrate may be substituted.

Roughage is coarse feed that contains a relatively low quantity or percentage of nutrients. Roughage may be divided into two classes, namely dry roughage, which includes the hays, straws, and dry fodders, and succulent roughage, which includes green growing crops, silage, beet tops, wet beet pulp, etc. Often roots and tubers are classed as succulent roughage.

Roughage may be again divided, depending upon its protein content, into high-protein roughage and low-protein roughage.

High-protein roughage.—Plants that belong to the legume family produce hay that is high in protein. Since protein is one of the most expensive and essential parts of the ration for dairy cows, it is important to consider the quantity which can be obtained from the hay. The common legume hays are alfalfa, red clover, alsike clover, Japan clover or lespedeza, sweet clover, vetch, pea, cowpea, and soybean. While these hays are not of equal value for dairy-cattle feeding, they may well be grouped together. Alfalfa and red clover are usually preferred by feeders because of their palatability and high feeding value. Cowpea and soybean hay, although somewhat coarser with more stems, are usually relished by dairy cows. Sweet clover, unless cut while short and young, is likely to be stemmy and will not be eaten well. Under certain conditions there have been some ill effects from feeding that hay. Any young growing crop of grass or of the cereal grains if cut and quickly dried produces a hay of high-protein content. Color in hay is an indication of its vitamin content. Fine-quality hay has a large proportion of leaves to stems and is soft and not brittle.

Low-protein roughages—hays, straws, fodders, silage.—This includes the non-legume hays such as prairie, millet, timothy, grain and forage sorghums, Sudan grass, native grass, and cereal hays. The quality of such hay depends upon the kind, time of cutting, method of curing, and condition under which it was grown. None of these hays contains as much protein as legume hays and consequently are not as valuable for feeding to milk cows.

Dry fodders and straws vary greatly in quality, depending upon many conditions such as time of harvesting and method of storing. Corn stover, as cornstalks without the ears are called, makes an excellent feed if properly handled, but if allowed to be exposed to the weather for a considerable period, this feed loses much of its nourishment. Sorghum fodder from which the grain has been removed is similar to corn stover, except that being a little finer it is likely to be eaten more completely. It often pays to chop corn stover and sorghum fodder so as to get it in a better condition for feeding. The chopping does not increase the digestibility, but does prevent waste and increases consumption. In the case of straws of the cereal grains, oat straw and barley straw have more than twice the net energy that is contained in wheat straw. Alfalfa straw is a much better feed than soybean straw and both are much better than the cereal grain straws. While efforts should be made to utilize so far as

In mixing feeds spread the lightest on the floor first and the heavier feeds on top. Turning three times mixes effectively.

possible all farm roughages, it must be remembered that to do this may necessitate the purchase of high-protein concentrates to balance the ration. The chopping or grinding of roughage does not increase its digestibility but often does increase the quantity consumed.

A certain amount of juiciness or succulence is desirable in a ration for milking cows if maximum production is to be obtained economically. Silage consists of any finely cut green fodder packed in a container from which the air is excluded to be used out of season. Many crops are used for silage, but corn and the sorghums are probably the best adapted for this part of the country. Crops such as those mentioned can be preserved well as silage without any other treatment, since they contain available carbohydrates that can be acted upon by bacteria to form acid, which in turn stops the fermentation and preserves the material. Crops such as the legumes, grasses, cereal grains, etc. do not have enough available carbohydrates and consequently do not develop sufficient acid to properly

preserve the green material without considerable decomposition. To obviate this condition, mineral acids have been added to green fodders (A. I. V. process—patented). The acid acts as an immediate preservative and largely prevents fermentation. In some places whey has been used with success for the same purpose.

Another common method is to add common blackstrap cane feeding molasses to the green fodder as it is being run through the silage cutter. For crops that are low in available carbohydrates, the addition of 75 pounds of molasses for each ton of green fodder has given good results. This can easily be accomplished by diluting the molasses with water and allowing it to run into the blower of the silage cutter from an elevated tank. The addition of 50 pounds of molasses to the ton of green corn or sorghum has proved to be useful in furnishing a silage of higher feeding value and one in which the vitamin A content is higher than in ordinary silage. In addition to the crops mentioned, sunflowers, beet pulp, and beet tops have been put into silos with success. Good silage always depends upon a proper proportion of moisture, so that if the material is rather dry, water must be added. Silage should be fed out of doors if possible and after milking to prevent the possibility of silage odors or flavors in the milk.

Root crops, root by-products, and tubers.—Because of the cost of growing and storing, roots are chiefly used to supply succulence in the dairy ration. Mangels, half-sugar beets, sugar beets, red beets, turnips, rutabagas, and carrots are all common root crops that are used for feeding to cows. Roots must be sliced or chopped before feeding or there will be danger of choking. Mangels and half-sugar beets usually yield the greatest tonnage and thus are more largely used, although carrots are probably the most useful roots for feeding, because of their high vitamin-A content.

Roots are palatable, keep the animal body in good condition, and stimulate milk flow out of proportion to their analyzed feeding value. Because of their high sugar content, sugar beets should not be fed in as large quantities as other beets. Rutabagas and turnips should be fed after milking in order to prevent a flavor from being carried over into the milk. Sugar-beet pulp when wet is good feed for cows, but it must be handled carefully or it will spoil, and unless care is used in feeding it may cause undesirable flavors in the milk. Sugar-beet tops furnish much feed and can be used as part of the ration with good results. Too much beet top will cause difficulties.

Tubers, particularly potatoes, are good feed for dairy cows when they are cheap enough. Like sugar beets, potatoes should be fed in somewhat smaller quantities than ordinary beets. The use of cull potatoes for dairy cows has proved quite satisfactory, but for safety the potatoes should be chopped.

Quantities of roughage to feed.—The quantity of roughage eaten by a milking cow depends upon the individuality and size of the cow, the quantity of milk she is producing, the weather, the temperature, the water supply, palatability, and the quantity and quality of the roughage and of

the other feeds that she is eating. Since all these factors may operate, only approximate quantities can be indicated for feeding.

When hay or other dry roughage is fed alone, a cow will consume from 2.5 to 4.0 pounds per day for each 100 pounds of live weight. In other words a 1,000-pound cow will consume between 25 and 40 pounds of dry roughage daily. Obviously a palatable roughage will be consumed in greater quantities than a coarse, unpalatable one.

When hay or other dry roughage and silage are fed together without other feeds a cow will consume from 1.5 to 2.5 pounds of dry roughage daily per 100 pounds of live weight when she is receiving between 3.0 and 4.5 pounds of silage daily per 100 pounds of live weight. If the quantity of either kind of roughage exceeds the quantities given, then the other roughage will be consumed in proportionately smaller quantities.

A cow fed dry roughage and roots or tubers will consume between 1.8 and 3.0 pounds of dry roughage and from 3.5 to 6.0 pounds of roots or tubers daily per 100 pounds of live weight. Sugar beets and potatoes should not be fed in quantities exceeding 40 pounds daily.

When silage is fed alone a cow will eat from 4.5 to 6.0 pounds per day for each 100 pounds of live weight. This is not a desirable practice and will likely result in an unbalanced ration unless a legume crop is used.

When fed roots or tubers alone, a cow will eat from 5.5 to 7.5 pounds daily per 100 pounds of live weight. Sugar beets and potatoes should be fed in quantities not exceeding 40 pounds daily.

When grain is fed in proportion to milk yield, namely, one pound of grain for each three to four pounds of milk produced daily, then a cow will consume between 0.6 and 1.8 pounds of dry roughage daily per 100 pounds of live weight when she is receiving between 2 and 4 pounds of silage per 100 pounds of live weight. This is a general guide only and may have to be varied for individual cases.

With grain fed in proportion to milk yield, a cow will consume daily between 2.0 and 3.5 pounds of dry roughage daily for each 100 pounds of live weight.

If grain is fed in proportion to milk yield, a cow will consume between 4.0 and 6.0 pounds of roots or tubers daily for each 100 pounds of live weight.

With grain fed in proportion to milk yield, a cow will eat between 0.6 and 1.8 pounds of dry roughage daily and between 2.5 and 5.0 pounds of roots or tubers for each 100 pounds of live weight.

While in general it is not desirable to depend upon silage as the sole source of roughage, it can be done without any harmful results when adequate protein is furnished in the grain. With grain fed in proportion to milk yield, a cow will consume daily from 4.0 to 5.5 pounds of silage for each 100 pounds of live weight.

Grain or concentrates.—Grain of various kinds and various by-products of milling, oil extraction, and other industries are often collectively designated as concentrates, since in comparison with roughage they contain a much higher feeding value for each unit of weight. While the primeval

cow obtained enough nutrients in grazing, with the development of more specialized cows whose milk-producing function has been greatly increased, it has been necessary to supply feed in more concentrated form if the maximum production is to be obtained, since there is an actual limit to the quantity of feed that a cow can handle in a day. While in many parts of the country roughage can be depended upon to furnish, very largely, if not entirely, the nutrients for milk production, roughage supplies a balanced ration only when it supplies adequate protein. Only when legume hay is available or when pasture grass or other green material cut in the early stages of growth forms a part of the ration can roughage alone furnish a balanced ration for milking cows, growing young stock, or bulls. When a balanced ration can be obtained from roughage it is likely that milk produced on such a ration will cost less per quart than when concentrates are used. Since in many instances it is difficult if not impossible to obtain a balanced ration from roughage sources alone, the use of concentrates to supplement the roughage is usually a desirable and economical practice.

Concentrates are commonly more expensive than roughage and consequently should be fed carefully so as to obtain the maximum benefits. It must be remembered that there is an exceedingly wide variation in the food nutrients of different concentrates, so that the substitution of one for another cannot be made in a haphazard manner, but the digestible nutrients which each contains must be considered. The chemical analysis does not always indicate the true feeding value of feeds. Thus according to Armsby[1] there is a great difference between gross energy and net energy as is shown below.

Feeds	Total carbohydrate, fat, and protein	Total digestible nutrients	Gross energy	Net energy
	Lbs.	*Lbs.*	*Therms*[1]	*Therms*[1]
Corn meal	88.77	80.6	201.49	92.58
Timothy hay	86.70	46.9	204.94	48.63
Wheat straw	83.77	35.7	201.58	11.07

[1] A thousand large calories.

Compared on the basis of total gross nutrients or total gross energy, it will be apparent that the three feeds are approximately equal. But compared on the basis of total digestible nutrients, there is a great difference with corn being worth more than twice as much as wheat straw. Probably the most accurate comparison is in net energy, in which comparison corn is approximately twice as valuable as timothy and eight times as valuable as wheat straw.

Balancing a ration by means of the grain mixture.—In general the roughage can be supplied by the farm. The furnishing of a balanced ration, therefore, consists first in selecting roughage that has the highest feeding value if that can be done. In any event, the second step is to

[1] H. P. Armsby, The Nutrition of Farm Animals, Macmillan Co.

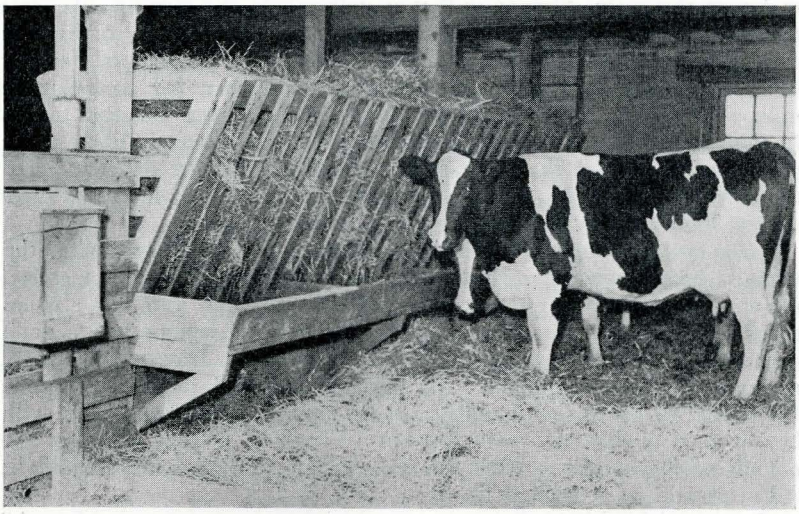
make up the grain mixture so that it will supply the nutritive elements that are lacking in the roughage and in proper proportions so that the cows may receive a balanced or complete ration. For practical feeding it is possible to make up a grain mixture that, when fed according to milk yield and the roughage fed *ad libitum,* will supply a balanced ration. In this part of the country the most important constituent is likely to be protein, since that is the food element that is ordinarily deficient. For the purpose of balancing rations, the roughages may be divided into three classes: high protein, medium protein, and low protein.

High-protein roughage consists of legume hays, such as alfalfa, the various clovers, cowpea, soybean, etc. Cereal grasses or ordinary grasses if cut early and dried rapidly in a drier will also fall into this class of roughages. Thus if the entire roughage consists of a legume hay, a grain mixture to supply the proper nutrients should contain between 10 and 12 per cent of digestible protein. To obtain a balanced ration the legume hay should be fed in such quantities as the cow will consume, which, with hay of good quality, will vary between 1.5 and 2.5 pounds daily per 100 pounds of live weight. With the hay, such a grain mixture should be fed in proportion to milk yield.

In general for low-testing cows, one pound of grain for each 3.5 to 4.0 pounds of milk is the rule, while for higher-testing cows, one pound of grain for each three pounds of milk is suggested. A more accurate guide for feeding grain is given in the following table:

Daily milk production range	Ratio of grain to milk produced—one pound of grain to each of the quantities of milk listed below		
	Milk testing 3 to 4% fat	Milk testing 4 to 5% fat	Milk testing 5 to 6% fat
Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
Up to 25	4.0	3.5	3.0
25 to 40	4.0	3.5	3.0
40 to 60	3.5	3.0	3.0
60 or above	3.0	3.0	3.0

Medium-protein roughage consists of a mixture of approximately equal parts of legume roughage and non-legume or low-protein roughage. Only when there are nearly equal parts of both kinds should the roughage be considered as belonging to this class. If there is a doubt as to whether they are approximately equal, it is well to consider the roughage belonging to the class from which the predominant quantity of roughage comes. Alfalfa hay and corn silage, prairie hay with alfalfa, and clover hay and corn stover are good examples of medium-protein roughage. Used with medium-protein roughage, the grain mixture should contain between 12.5 and 16.0 per cent of digestible protein. If alfalfa hay of good quality forms the major part of the roughage, the percentage of digestible protein in the grain mixture may be 12.5, while if corn silage, corn stover, sorghum



A rack is a convenient method of feeding hay.

fodder, or prairie hay forms the bulk of the roughage, then the percentage of protein in the grain mixture should approach 16.0.

Low-protein roughage consists of prairie, native, timothy, millet, sorghum, and Sudan hays, cereal hays and straws, straws of various crops, silages, roots, tubers, beet by-products, etc. In fact it includes practically all roughages except the legume hays. Low-protein roughage requires a high percentage of protein in the grain mixture, the percentage of digestible protein varying between 16.5 and 21.0 per cent. A grain mixture to balance with low-protein roughage requires such a large proportion of some high-protein concentrate to supply sufficient protein that it sometimes upsets the physiological balance. Rather than use too large a proportion of one concentrate, it is better to use two or three. It is desirable, therefore, to use roughage that will fall in either the high-protein or medium-protein group.

Cheapest protein.—Since low cost is of great importance in economical feeding, it is essential to know which grains or concentrates will furnish protein at the lowest cost. Table 4 shows how to figure the cost of 100 pounds of digestible protein as supplied by different feeds. The cost may be determined for any feed by dividing the cost of 100 pounds of feed by the protein content in percentage. For example, when wheat bran, which on the average has a digestible protein content of 13.1 per cent (0.131), is worth $25.00 per ton, or $1.25 per 100 pounds, the cost of 100 pounds of digestible protein is 1.25÷0.131, or $9.54 per 100 pounds of protein in wheat bran. Factors are given in Table 4 which when multiplied by the cost of 100 pounds of feed will give the cost in dollars of 100 pounds of digestible protein in that feed. In this way it is possible

to determine the cost of protein in a number of different feeds and select those in which protein can be obtained at the lowest cost. Factors are also given for determining the cost of total nutrients in the same manner. By comparing the cost of protein in several feeds, it will be evident which furnishes that material cheapest.

Palatability.—Palatability as a factor in feeding is often underestimated by many feeders. It is, nevertheless, of much importance since the more a good cow eats, up to her producing limit, the greater will be the production. At least one-half the grain mixture should be of concentrates that are listed as palatable. The use of cane feeding molasses is suggested as a means of improving palatability of either the roughage or the grain mixture. Molasses will in addition add materially to the nutrients in the ration, since it contains a rather high percentage of carbohydrates.

Effects of concentrates.—Feeds have various effects upon the animal body. Some are laxative, some constipating, some affect the color, texture, and composition of the butterfat. Some feeds are high in vitamins and some contain a high percentage of minerals. The effects of these various feeds must be considered in making up a ration. In general it is best to include at least four concentrates in the grain mixture. Since some feeds are rather lacking in certain essential kinds of protein, the dairyman can, by the use of a number of concentrates, make up any deficiency in one feed likely to be lacking in another. If possible the grain mixture should be so balanced that it does not contain an undue proportion of either highly laxative or highly constipating feeds or feeds that are derivatives of one plant. Some feeds such as rye tend to produce a hard, crumbly butter, while others such as soybeans will be likely to produce a soft butter. A good rule is to use only moderate quantities of any feed that may cause a marked effect upon either the cow or her milk.

Feeding Dry Cows

Usually little attention is paid to the feeding of dry cows. Since they are not producing, it is the all too common practice to feed them lightly on hay or other roughage. The interval between the time a cow is dried off and before she calves again should be from four to six weeks. This is the time when the cow should be *well fed* in order to have some reserve stored up in her body to use after freshening. The fat that is stored in the body and the glycogen that is stored in the liver are an insurance that a cow can produce to her capacity after she freshens. Cows that are starved or half-starved will not produce well the following lactation. With the proper feed, cows should, barring accidents and disease, produce to their maximum year after year. Just before freshening dry cows should weigh from 100 to 250 pounds more than their average weight at the middle of the lactation.

In the season when pasture is not available, dry cows should have an abundance of good legume hay, some succulent feed, and with such roughage a grain mixture that contains between 12 and 14 per cent of digestible protein. The amount of grain to be fed will depend upon the

condition of the cow. As a fair rule, about one pound daily for each 300 to 400 pounds of live weight is a good guide. If grain is cheap, up to two pounds daily for each 300 to 400 pounds of live weight may be fed. On good pasture it may not be necessary to feed anything additional although a little grain two or three weeks before calving is useful. Liberal feeding of dry cows before calving pays better returns for feed than at any other time.

Feeding Cows at Calving Time

About a week before a cow is due to calve, the regular grain mixture should be changed to a mixture of three parts wheat bran and one part ground oats. This mixture may be fed in quantities of two to six pounds daily. Right after calving the cow should be given four to six pounds of a mixture of equal parts of whole oats and wheat bran made up with hot water into a warm mash. Then the grain mixture of bran and oats may be resumed and continued for four or five days after calving or until the swelling has largely left the udder, after which the switch may be made to the regular grain mixture.

Feeding Herd Bulls

All too often the herd bull gets little attention in the matter of feeding. He is fed the odds and ends and leavings on the theory that since he does not work so hard as the cows, he does not need much attention.

A common custom is to feed the bull an abundance of hay of poor quality and little or nothing else. A bull in service needs a balanced ration and that generally means some grain. It is not a good plan to give a bull all the hay or other roughage that he will eat since that will tend to make him paunchy and will likely make him slow in service. A moderate quantity of hay, preferably legume hay, about a half to a full pound for each 100 pounds of live weight, is enough for a daily feed if he is given from a half to three-quarters of a pound of grain for each 100 pounds of live weight. This grain mixture should contain not less than 14 per cent digestible protein.

Protein is necessary for the proper production of sperm and its lack may prevent satisfactory breeding by the bull. Silage may be fed to bulls but not in large quantities, the suggested rule being not to exceed one pound for each 100 pounds of live weight. Green grass and other feeds high in vitamins A and E are likely to keep the bull in good serviceable condition.

A young bull should have special attention and every effort should be made to grow him out well. Plenty of the right kind of feed between six months and eighteen months will usually pay good dividends later. From eight months of age until two years of age a young bull should receive about 10 pounds daily of a grain mixture containing at least 14 per cent digestible protein.

Separator-bowl feeding pans are useful for grain feeding.

Feeding Heifers

After the heifers are weaned there is a tendency to let them shift for themselves. As a result heifers are often stunted. Animals that are stunted seldom make normal growth at a later time and if they do, this growth is made at greater feed cost. At six months of age heifers should receive 1.5 to two pounds of silage and from two to 3.5 pounds of alfalfa or other legume hay for each 100 pounds of live weight. In addition it is a good practice to feed them one to two pounds daily of a grain mixture containing at least 10 per cent digestible protein. This feeding practice may continue until the heifers have been bred and are near to freshening. About three months before calving the heifer should receive at least a half pound daily of the grain mixture mentioned for each 100 pounds of live weight and the roughage may be continued at the same rate of feeding.

Feeding Heavy-Milking Cows.

The larger the production of milk and butterfat, the more the skill required to feed a dairy cow efficiently, sufficiently, and economically. Lack of proper feed or unskilled feeding undoubtedly limits the pro-

duction of many good cows. The first requisite for good feeding is to know how much the cow is producing in milk and butterfat. This necessitates the weighing of the milk at each milking and a monthly test for butterfat. While the suggested guides for feeding grain are useful, the skillful feeder will study his cow and her reaction to feed and then plan his feeding. For high-producing cows it is desirable to use roots since that feed helps materially to keep the body functioning properly. If roots are not available, dried beet pulp soaked between feeds with water to which molasses has been added is very useful. Molasses used in moderate quantities, two to four pounds daily, is a very useful feed and helps keep animals in good health. A selection of concentrates so that there are at least six in the grain mixture, with part of the mixture containing some animal protein, is to be advised. Special efforts should be made to see that high-producing cows get green, high-quality roughage and as much green pasture as possible.

Processing of Feeds

The cutting or grinding of dry roughage has the advantage that it prepares the feed so that coarse, stemmy portions are likely to be consumed. Grinding or cutting does not increase the digestibility of the feed. If the cost is not excessive, it may be advisable to process roughage, but the value of the feed, the cost of grinding and the cost of other feeds must be considered. It pays to grind grains for dairy cattle because if that is not done, much of the grain passes through the animal undigested.

There appears to be no added value in cooking feeds for dairy cows, although the practice is sometimes followed. Soaking grain for cows may be advisable when feeding high-producing cows in individual feed containers. The practice is most useful if some dried beet pulp is mixed with grain.

Practice in Making Grain Mixtures

For general farm use, it is not practical to obtain great accuracy in the quantities of protein, carbohydrates, and fat needed to make an exact balance. Since there is seldom a deficiency in either carbohydrates or fat in this section of the country, when the cow has all the roughage that she can eat, a roughly balanced ration may be obtained by balancing the digestible protein of the grain mixture to fit the roughage available, and disregarding the total nutrients and fat.

For low- to medium-producing cows good alfalfa hay and corn meal make up a reasonably good ration. It is better to make up a grain mixture of at least four concentrates and thus insure a better physiological balance of protein. As an example to go with alfalfa hay, a high-protein roughage, a grain mixture of corn meal, ground oats, wheat bran, and linseed meal might be made up.

By referring to Table 4 the percentage of digestible protein may be obtained, which is the number of pounds of protein in 100 pounds of feed. Digestible protein is that which can be digested and used by the animal and will not be the same figure that appears on the sack of bran or linseed

meal. The difference between total protein and digestible protein may vary from one to nearly ten per cent. There is a variation in composition in feeds; the figures quoted represent the average of many analyses. In a previous section (page 17) it was mentioned that when alfalfa hay was the roughage, the grain mixture should contain between 10 and 12 per cent of digestible protein. Suppose, therefore, that a gram mixture is made up as follows:

Quantity of feed	Kind of feed	Digestible protein
Lbs.		*Lbs.*
200	Cornmeal	14.2
100	Oats (ground)	9.4
100	Wheat bran	13.1
50	Linseed meal	15.3
450		52.0

52.0 ÷ 450 = 0.1155, or 11.55 per cent of protein.

This quantity would fall within the limits suggested. In making up a grain mixture, cost, palatability, physiological effects, vitamins, minerals, and the number of concentrates involved must be kept in mind. Table 4 will prove helpful in checking some of these features, as for instance cost of protein and the mineral and vitamin content. The mixture suggested will be palatable, it will have a slightly laxative effect, if yellow corn is used it will contain a reasonable quantity of vitamin A, it contains fair quantities of phosphorus and calcium. In fact it is a very good ration if it can be made up at reasonable cost. By referring to Table 4 the cost of the protein and total nutrients, but more particularly the protein, can be calculated for each feed and comparison made with other feeds.

If the roughage were prairie hay instead of alfalfa the requirement for protein in the grain mixture would be between 16.5 and 21.0 per cent. The mixture suggested is as follows:

Quantity of feed	Kind of feed	Digestible protein
Lbs.		*Lbs.*
100	Cornmeal	7.1
100	Oats (ground)	9.4
100	Wheat bran	13.1
50	Linseed meal (old process)	15.3
350		44.9
200	Linseed meal (old process)	61.2
550		106.1

106.1 ÷ 550 = 0.1929, or 19.29 per cent digestible protein in the mixture.

In other words, a grain mixture to balance with prairie hay must contain more protein, and since linseed meal is the only high-protein concentrate of the four, it is necessary to add more linseed meal to the grain mixture since prairie hay is of the low-protein roughage group.

This emphasizes the importance of a legume roughage, lack of which makes necessary the purchase of a considerable proportion of the mixture in the form of some high-protein concentrate. It will be found to be comparatively easy to balance a ration in this manner for any roughage combination that may be available. The grain mixture will have to be adjusted according to the roughage. This method of balancing a ration is not exact, but is accurate enough for all practical feeding purposes.

Grain Mixtures for Different Roughages

A suggestive series of grain mixtures for use with different classes of roughage is given for convenience.

HIGH-PROTEIN ROUGHAGE

High-protein roughage consists of legume hays, such as alfalfa, the clovers, cowpea, soybean, etc.

Protein in Grain Mixtures, 10 to 12 per cent

	Digestible protein
	Lbs.
MIX 1—Protein 11.55%	
200 lbs. Corn meal	14.2
100 lbs. Oats (ground)	9.4
100 lbs. Wheat bran	13.1
50 lbs. Linseed meal (O. P.)	15.1
450 lbs. mixture	51.8
MIX 2—Protein 11.39%	
500 lbs. Barley (ground)	46.5
100 lbs. Oats (ground)	9.4
100 lbs. Wheat bran	13.1
50 lbs. Soybeans (ground)	16.4
750 lbs. mixture	85.4
MIX 3—Protein 10.49%	
300 lbs. Snap corn (ground)	17.7
100 lbs. Oats (ground)	9.4
100 lbs. Wheat bran	13.1
50 lbs. Cottonseed meal (43%)	17.5
550 lbs. mixture	57.7
MIX 4—Protein 10.95%	
400 lbs. Hominy feed	31.2
100 lbs. Oats (ground)	9.4
100 lbs. Wheat bran	13.1
50 lbs. Cottonseed meal (43%)	17.5
650 lbs. mixture	71.2
MIX 5—Protein 11.38%	
200 lbs. Corn meal	14.2
100 lbs. Oats (ground)	9.4
100 lbs. Alfalfa meal	10.6
100 lbs. Gluten feed	22.7
500 lbs. mixture	56.9

	Digestible protein
	Lbs.
MIX 6—Protein 10.90%	
400 lbs. Corn meal	28.4
100 lbs. Alfalfa meal	10.6
100 lbs. Wheat bran	13.1
50 lbs. Soybean meal	18.8
650 lbs. mixture	70.9
MIX 7—Protein 11.48%	
500 lbs. Milo grain (ground)	43.5
100 lbs. Alfalfa meal	10.6
100 lbs. Wheat bran	13.1
50 lbs. Soybean meal	18.9
750 lbs. mixture	86.1
MIX 8—Protein 11.16%	
200 lbs. Barley (ground)	18.6
200 lbs. Beet pulp (dried) (Mol.)	12.2
100 lbs. Wheat bran	13.1
50 lbs. Cottonseed meal (43%)	17.5
550 lbs. mixture	61.4
MIX 9—Protein 10.95%	
400 lbs. Milo grain (ground)	34.8
100 lbs. Alfalfa meal	10.6
100 lbs. Oats (ground)	9.4
50 lbs. Soybeans (ground)	16.4
650 lbs. mixture	71.2
MIX 10—Protein 10.03%	
500 lbs. Corn & cob meal	30.0
200 lbs. Oats (ground)	18.8
100 lbs. Wheat bran	13.1
50 lbs. Meat scraps (50%)	23.4
850 lbs. mixture	85.3

MEDIUM-PROTEIN ROUGHAGE

In medium-protein roughage approximately one-half of the roughage is of a high protein group and the remainder is of the low protein group. Examples: alfalfa hay and silage; alfalfa hay and corn stover; prairie hay and alfalfa hay.

Protein in Grain Mixtures, 12.5 to 16.0 per cent

	Digestible protein *Lbs.*
MIX 11—Protein 15.01%	
200 lbs. Corn meal	14.2
100 lbs. Oats (ground)	9.4
100 lbs. Wheat bran	13.1
150 lbs. Linseed meal (O. P.)	45.9
550 lbs. mixture	82.6
MIX 12—Protein 14.33%	
300 lbs. Barley (ground)	27.9
100 lbs. Oats (ground)	9.4
100 lbs. Corn gluten feed	22.7
50 lbs. Soybeans (ground)	18.8
550 lbs. mixture	78.8
MIX 13—Protein 15.37%	
200 lbs. Snap corn (ground)	11.8
100 lbs. Oats (ground)	9.4
200 lbs. Wheat bean	26.2
150 lbs. Cottonseed meal (43%)	52.5
650 lbs. mixture	99.9
MIX 14—Protein 14.18%	
200 lbs. Hominy feed	15.6
100 lbs. Oats (ground)	9.4
300 lbs. Wheat bran	39.3
100 lbs. Cottonseed meal (43%)	35.0
700 lbs. mixture	99.3
MIX 15—Protein 14.66%	
300 lbs. Corn (ground)	21.3
100 lbs. Oats (ground)	9.4
100 lbs. Alfalfa meal	10.6
100 lbs. Meat scraps (50%)	46.7
600 lbs. mixture	88.0

	Digestible protein *Lbs.*
MIX 16—Protein 14.05%	
200 lbs. Corn (ground)	14.2
200 lbs. Alfalfa meal	21.2
300 lbs. Wheat bran	39.3
100 lbs. Soybean meal	37.7
800 lbs. mixture	112.4
MIX 17—Protein 15.00%	
200 lbs. Milo grain (ground)	17.4
100 lbs. Alfalfa meal	10.6
300 lbs. Wheat bran	39.3
100 lbs. Soybean meal	37.7
700 lbs. mixture	105.0
MIX 18—Protein 15.32%	
100 lbs. Barley (ground)	9.3
100 lbs. Beat pulp (dried) (Mol.)	6.1
200 lbs. Wheat bran	26.2
100 lbs. Cottonseed meal (43%)	35.0
500 lbs. mixture	76.6
MIX 19—Protein 14.30%	
200 lbs. Milo grain (ground)	17.4
100 lbs. Alfalfa meal	10.6
300 lbs. Wheat bran	39.3
100 lbs. Soybeans (ground)	32.8
700 lbs. mixture	100.1
MIX 20—Protein 13.31%	
400 lbs. Corn and cob meal	24.0
100 lbs. Oats (ground)	9.4
100 lbs. Wheat bran	13.1
100 lbs. Meat scraps (50%)	46.7
700 lbs. mixture	93.2

LOW-PROTEIN ROUGHAGE

Low protein roughage consists of all non-legume hays, the straws, and fodders.

Protein in Grain Mixtures, 16.5 to 21.0 per cent

	Digestible protein *Lbs.*
MIX 21—Protein 18.16%	
100 lbs. Corn meal	7.1
100 lbs. Oats (ground)	9.4
100 lbs. Wheat bran	13.1
200 lbs. Linseed meal (O. P.)	61.2
500 lbs. mixture	90.8
MIX 22—Protein 18.43%	
100 lbs. Barley (ground)	9.3
200 lbs. Oats (ground	18.8
300 lbs. Corn gluten feed	68.1
100 lbs. Soybeans (ground)	32.8
700 lbs. mixture	129.0
MIX 23—Protein 18.58%	
100 lbs. Snap corn (ground)	5.9
100 lbs. Oats (ground)	9.4
200 lbs. Wheat bran	26.2
200 lbs. Cottonseed meal (43%)	70.0
600 lbs. mixture	111.5
MIX 24—Protein 18.07%	
100 lbs. Hominy feed	7.8
100 lbs. Oats (ground)	9.4
300 lbs. Wheat bran	39.3
200 lbs. Cottonseed meal (43%)	70.0
700 lbs. mixture	126.5
MIX 25—Protein 18.20%	
250 lbs. Corn meal	17.8
200 lbs. Oats (ground)	18.8
100 lbs. Cottonseed meal (43%)	35.0
100 lbs. Meat scraps (50%)	46.7
650 lbs. mixture	118.3

	Digestible protein *Lbs.*
MIX 26—Protein 18.56%	
100 lbs. Corn meal	7.1
200 lbs. Alfalfa meal	21.2
200 lbs. Gluten feed	45.4
100 lbs. Soybean meal	37.7
600 lbs. mixture	111.4
MIX 27—Protein 18.71%	
200 lbs. Milo grain (ground)	17.4
300 lbs. Wheat bran	39.3
150 lbs. Linseed meal (O. P.)	45.9
100 lbs. Soybean meal	37.7
750 lbs. mixture	140.3
MIX 28—Protein 19.75%	
100 lbs. Barley (ground)	9.3
100 lbs. Beet pulp (dried) (Mol.)	6.1
300 lbs. Corn gluten feed	68.1
100 lbs. Cottonseed meal (43%)	35.0
600 lbs. mixture	118.5
MIX 29—Protein 19.35%	
100 lbs. Milo grain (ground)	8.7
300 lbs. Alfalfa meal	31.8
150 lbs. Cottonseed meal (43%)	52.5
100 lbs. Soybeans (ground)	32.8
650 lbs. mixture	125.8
MIX 30—Protein 19.39%	
100 lbs. Corn and cob meal	6.0
400 lbs. Wheat bran	52.4
100 lbs. Linseed meal (O. P.)	30.6
100 lbs. Meat Scraps (50%)	46.7
700 lbs. mixture	135.7

The grain mixtures given are suggestive but numerous other combinations can be made which are just as satisfactory. In general, corn meal, corn and cob meal, ground snapped corn, and the grain sorghums (ground) can be interchanged. These feeds are not of exactly equal feeding value but the differences are not great. Oats and barley can often be interchanged, although oats possess some conditioning qualities that are not found in barley. To some extent alfalfa meal and wheat bran may be interchanged, although it must be remembered that wheat bran is higher in protein and in phosphorus. Among the high-protein concen-

trates linseed and cottonseed meal may be interchanged, always remembering that the former has better conditioning qualities and less protein. It is suggested that soybean products be kept in proportions under 20 per cent in the grain mixture.

Better mixtures from the physiological standpoint can be constructed by using from six to eight different concentrates to insure a more complete balance of some of the proteins. The addition of one per cent each of iodized salt, lime flour, and steamed bone meal to each grain mixture is suggested to insure adequate minerals. Dried beet pulp may be added to the grain mixture and the mixture moistened to give a semblance of succulence.

TABLE 1.—*Weight of feeds.*

Feed	One quart weighs	One pound measures	Feed	One quart weighs	One pound measures
	Lbs.	*Qts.*		*Lbs.*	*Qts.*
Barley (ground)	1.1	0.9	Molasses (cane)	3.0	0.3
Beans (field)	1.7	0.6	Oats (ground)	0.7	1.4
Beet pulp (dried)	0.6	1.7	Peas (field)	2.1	0.5
Coconut meal (O.P.)	1.5	0.7	Rye (ground)	1.5	0.7
Corn dent (ground)	1.5	0.7	Soy beans	1.8	0.6
Corn and cob meal	1.4	0.7	Tankage	1.6	0.6
Corn gluten feed	1.3	0.8	Wheat (ground)	1.7	0.6
Corn gluten meal	1.7	0.6	Wheat bran	0.5	2.0
Cottonseed meal	1.5	0.7	Wheat standard middlings	0.8	1.3
Hominy feed	1.1	0.9			
Linseed meal (O.P.)	1.1	0.9	Alfalfa meal	0.6	1.7

Listed below is a grain mixture that has proved satisfactory for feeding high-producing cows when the roughage consists of alfalfa hay and corn silage:

Mix 31	Digestible protein	Total digestible nutrients
	Lbs.	*Lbs.*
250 lbs. Corn meal	17.75	201.50
100 lbs. Oats (ground)	9.40	71.50
300 lbs. Wheat bran	39.30	210.60
100 lbs. Cottonseed meal (43%)	35.00	75.50
100 lbs. Linseed meal (O. P.)	30.60	78.20
100 lbs. Corn gluten feed	22.70	77.40
20 lbs. Fish meal	9.50	13.50
10 lbs. Bone meal (steamed)	...	....
10 lbs. Lime flour	...	....
10 lbs. Iodized salt	...	....
1000 lbs. mixture	164.25	728.20
1 lb. contains	0.1642	0.72820

Accurate Balancing of Rations (Morrison Feeding Standard)

For the more accurate balancing of rations, either for individual cows or for the herd, the total nutrients as well as the digestible protein should be included. If the average of the herd is used when balancing for the herd, the results will prove satisfactory. It must be remembered that the analyses given in Table 4 represent averages of many analyses but that feeds may vary materially from such figures.

TABLE 2.—*Daily requirements for dairy cows.*

	Digestible protein [1]	Total digestible nutrients
	Lbs.	*Lbs.*
Maintenance 1,000 lb. cow	0.650	7.93
Maintenance per 100 lbs. of live wt.	0.065	0.793
For each 1 lb. of 3.0% milk	0.043	0.276
For each 1 lb. of 3.5% milk	0.046	0.300
For each 1 lb. of 4.0% milk	0.049	0.324
For each 1 lb. of 4.5% milk	0.052	0.349
For each 1 lb. of 5.0% milk	0.056	0.373
For each 1 lb. of 5.5% milk	0.059	0.397
For each 1 lb. of 6.0% milk	0.062	0.422
For each 1 lb. of 6.5% milk	0.065	0.446

[1] Digestible crude protein.

TABLE 3.—*Daily requirements for growing dairy cattle (average figures).*

Maintenance and Growth	Digestible protein [1]	Total digestible nutrients
	Lbs.	*Lbs.*
Weight 100 lbs.	0.320	1.600
Weight 200 lbs.	0.570	3.650
Weight 300 lbs.	0.725	5.200
Weight 400 lbs.	0.850	6.350
Weight 500 lbs.	0.925	7.300
Weight 600 lbs.	1.000	8.200
Weight 700 lbs.	1.065	9.050
Weight 800 lbs.	1.130	9.900
Weight 900 lbs.	1.190	10.750
Weight 1000 lbs.	1.245	11.500

[1] Digestible crude protein.

To balance a ration first determine the weight of the individual cow, growing animal or milking cow, or the average of the herd. Then calculate the quantity of digestible protein and total digestible nutrients needed for maintenance and growth in growing cattle, depending upon the weight. For milking cows the quantity of digestible protein and total digestible nutrients needed for maintenance must first be calculated. Then the additional requirements for milk production depending on the quantity

of milk produced and the percentage of fat in the milk must be calculated. To the maintenance requirements must be added those for the quantity of milk produced. Thus the protein needed for milk production must be added to that needed for maintenance and the total nutrient requirements for milk production added to those for maintenance to give the total requirements.

For example, let us consider a 1,200-pound cow producing 48 pounds of 4.0 per cent milk daily. Available for feeding are alfalfa hay, corn silage, corn meal, ground oats, wheat bran, and oil meal. Consulting the figures given and Table 4 the problem may be solved as follows:

	Digestible protein		Total digestible nutrients	
	Lbs.		*Lbs.*	
1200 lb. cow–maintenance.....	0.780		9.516	
48 lbs. of 4.0% milk.....	2.352		15.552	
Total daily requirements...		3.132		25.068
55 corn silage.....	0.715		10.285	
10 alfalfa hay.....	1.060		5.030	
Nutrients supplied by roughage		1.775		15.315
Needed from grain.....		1.355		9.753
12 lbs. mix.....		1.702		9.068
		+.347		–.685

To balance a ration exactly it is easier to make up a grain mixture with the same ratio between the protein and total nutrients that exists after the nutrients in the roughage have been subtracted from the requirements.

TABLE 4.—*Analyses and characteristics of feeds—from F. B. Morrison's Feeds and Feeding, 20th edition, by special permission of the Morrison Publishing Company, Ithaca, New York.*

Feeding stuff	DIGESTIBLE		Nutritive ratio 1:	Calcium or lime (CaO in 100 lbs.)	Phosphates (P_2O_5 in 100 lbs.)	VITAMINS			Coefficients for cost of 100 lbs. of protein and total nutrients. Multiply coefficient by cost per 100 lbs. feed. Digestible	
	Protein	Total nutrients				A	D	E	Protein	Total nutrients
CONCENTRATES	*Per cent*	*Per cent*		*Per cent*	*Per cent*					
Barley	9.3	78.7	7.5	0.05	0.38	0 to +	0	++	10.75	1.269
Beans (field)	19.9	75.6	2.8	0.14	0.45	0	0	—	5.02	1.322
Beet pulp (dried)	4.8	71.8	14.0	0.68	0.07	0	0	0	20.83	1.392
Beet pulp (dried molasses)	6.1	74.3	11.2	0.52	0.07	..	..	..	16.39	1.345
Beet pulp (wet)	0.8	8.9	10.1	0.09	0.01	..	..	..	125.00	11.235
Bone meal (steamed)	...	...	...	32.61	15.17	..	..	..	..	..
Brewers grain (dried)	20.7	65.3	2.2	0.25	0.47	..	..	..	4.83	1.531
Brewers grain (wet)	4.6	16.6	2.6	0.07	0.12	..	..	..	21.73	6.024
Buttermilk (dried)	32.1	85.5	1.7	1.36	0.74	+	0	+	3.11	1.169
Coconut meal (O. P.)	18.7	80.8	3.3	0.21	0.62	..	..	..	5.35	1.237
Corn (dent No. 2) yellow	7.1	80.6	10.3	0.01	0.27	++	0	++	14.08	1.240
Corn (snapped)	5.9	70.6	11.0	...	...	..	..	..	16.95	1.416
Corn and cob meal	6.0	75.9	11.2	...	0.23	..	..	..	16.66	1.317
Corn germ meal	14.5	79.5	4.5	...	...	..	..	..	6.90	1.257
Corn gluten feed	22.7	77.4	2.4	0.14	0.55	++[1]	0	0	4.40	1.291
Corn gluten meal	36.5	81.8	1.2	0.03	0.38	+++[1]	0	0	2.74	1.222
Corn oil meal (O. P.)	16.7	78.7	3.7	0.05	0.57	.	..	..	5.99	1.270
Cottonseed meal (43%)	35.0	75.5	1.2	0.24	1.11	0	0	—	2.86	1.324
Cottonseed meal (41%)	33.9	73.6	1.2	0.20	1.19	..	..	..	2.95	1.358
Distillers dried grains (corn)	23.3	85.0	2.8	0.05	0.31	..	..	..	4.48	1.176
Feterita grain	10.1	79.7	6.9	...	...	..	..	..	9.90	1.254
Fish meal	47.5	67.6	0.4	5.37	2.98	0 to +	0 to +	—	2.10	1.481
Hegari grain	7.9	81.2	9.3	...	...	..	..	..	12.66	1.231
Hominy feed	7.8	85.2	9.9	0.03	0.57	++[1]	0	++	12.82	1.173
Kafir grain	9.1	80.1	7.8	0.04	0.30	..	..	..	10.99	1.248
Linseed meal (O. P.)	30.6	78.2	1.6	0.33	0.86	0	0	+	3.27	1.278
Malt sprouts	20.3	70.6	2.5	0.24	0.71	..	..	..	4.92	1.416
Meat scraps (50%) or dry-rendered tankage with bone	46.7	71.2	0.5	10.96	5.16	..	..	..	2.14	1.404
Milo grain	8.7	79.9	8.2	...	0.34	..	..	..	11.49	1.251
Molasses (beet)	2.5	58.8	22.5	0.05	0.02	..	..	..	40.00	1.700
Molasses (cane)	0.9	56.6	61.9	0.56	0.06	0	0	++	111.11	1.766
Oats	9.4	71.5	6.6	0.09	0.33	0	0	++	10.64	1.398

[1] Chiefly from yellow corn.

TABLE 4.—*Analyses and characteristics of feeds—(Continued).*

Feeding stuff	DIGESTIBLE		Nutritive ratio 1:	Calcium or lime (CaO in 100 lbs.)	Phosphates (P_2O_5 in 100 lbs.)	VITAMINS			Coefficients for cost of 100 lbs. of protein and total nutrients. Multiply coefficient by cost per 100 lbs. feed. Digestible	
	Protein	Total nutrients				A	D	E	Protein	Total nutrients
	Per cent	*Per cent*		*Per cent*	*Per cent*					
Oat, mill feed	4.0	42.6	9.7	0.26	0.18	..	..	..	25.00	2.347
Peas field (culls)	21.0	79.4	2.8	0.07[2]	0.40[2]	..	..	..	4.76	1.259
Peanut meal (O. P.)	38.0	82.1	1.2	0.17	0.55	0	0	++	2.63	1.218
Rye	10.3	80.1	6.8	0.04	0.37	0	0	++	9.71	1.248
Skimmilk	3.5	8.6	1.5	0.14	0.12	0	0	+	28.57	11.627
Skimmilk (dried)	33.1	84.1	1.5	1.24	0.96	0	0	+	3.02	1.189
Sorghum grain sweet	5.6	74.3	12.3	...	0.36	..	..	..	17.86	1.345
Soybean meal, expelled process	37.7	82.2	1.2	0.28	0.66	0	0	—	2.65	1.216
Soybeans	32.8	86.2	1.6	0.20	0.60	0	0	—	3.05	1.160
Tankage (55%) digester	51.5	74.2	0.4	7.21	3.85	0	0	—	1.94	1.347
Wheat	11.3	83.6	6.4	0.03	0.43	0	0	++	8.85	1.196
Wheat bran	13.1	70.2	4.4	0.12	1.32	0	0	++	7.63	1.424
Wheat standard middlings	14.4	78.4	4.4	0.08	0.94	0	0	+++	6.94	1.275
Wheat gray shorts	15.0	78.9	4.3	...	...	..	..	..	6.67	1.267
Whey	0.9	6.4	6.1	0.05	0.04	0	0	+	111.11	15.625
GREEN ROUGHAGE, ROOTS, ETC.										
Alfalfa	3.4	14.7	3.3	0.40	0.06	+++	0	+++	29.41	6.802
Beets, sugar	1.2	13.8	10.5	0.03	0.04	0	0	—	83.33	7.246
Beet tops	1.9	7.4	2.9	0.15	0.04	..	..	..	52.63	13.513
Blue grass (KY)	2.4	18.6	6.8	0.16	0.08	..	..	..	41.67	5.376
Brome grasses (misc.)	3.0	20.8	5.9	...	0.10	..	..	..	33.33	4.854
Clover (red)	2.6	15.4	4.9	0.43	0.07	+++	0	+++	38.46	6.493
Clover (sweet)	3.0	14.0	3.7	0.32	0.10	..	..	..	33.33	7.142
Corn fodder (dent) (green)	1.2	16.3	12.6	0.06	0.05	..	..	..	83.33	6.135
Grama grass	2.0	20.6	9.3	...	...	..	..	..	50.00	4.854
Kafir fodder	1.3	15.5	10.9	0.06	0.04	..	..	..	76.92	6.451
Milo fodder	1.0	15.1	14.1	...	0.07	..	..	..	100.00	6.622
Oats (8 in. high)	3.9	9.2	1.4	...	...	..	..	..	25.64	10.869
Peas (field misc.)	2.6	11.9	3.6	...	0.05	..	..	..	38.46	8.403
Peas and oats	2.4	14.1	4.9	0.07	0.07	..	..	..	41.67	7.092
Potatoes	1.1	17.3	14.7	0.01	0.05	0	0	—	90.91	5.780
Rye fodder all analyses	2.3	16.2	6.0	...	0.07	..	..	..	43.48	6.172
Sorghum sweet fodder	0.8	17.3	20.6	0.12	0.05	..	..	..	125.00	5.780
Soybean fodder	3.2	15.1	3.7	0.29	0.09	..	..	..	31.25	6.622
Sudan grass	1.4	17.7	11.6	0.14	0.06	..	..	..	71.43	5.649
Wheat fodder (not over 10 in.)	4.3	13.5	2.1	...	...	..	..	..	23.25	7.407

[2] Figures for field peas.

TABLE 4.—*Analyses and charteristics of feeds—(Concluded).*

Feeding stuff	DIGESTIBLE		Nutritive ratio 1:	Calcium or lime (CaO in 100 lbs.)	Phosphates (P_2O_5 in 100 lbs.)	VITAMINS			Coefficients for cost of 100 lbs. of protein and total nutrients. Multiply coefficient by cost per 100 lbs. feed. Digestible	
	Protein	Total nutrients				A	D	E	Protein	Total nutrients
	Per cent	*Per cent*		*Per cent*	*Per cent*					
SILAGES										
Alfalfa (high in water)	1.9	12.7	5.7	0.38	0.06	..	..	..	52.63	7.874
Clover (sweet)	3.5	16.1	3.6	0.41	0.13	..	..	..	28.57	6.211
Corn (dent well mature)	1.3	18.7	13.4	0.07	0.06	+ to ++	0 to +	+	76.92	5.347
Corn (dent without ears)	0.8	13.6	16.0	0.11	0.02	..	..	..	125.00	7.352
Sorghum (grain)	1.1	17.8	15.2	...	...	..	..	..	90.91	5.617
Sorghum (sweet)	0.8	15.1	17.9	0.07	0.04	+ to ++	0 to +	+	125.00	6.622
DRY ROUGHAGES										
Alfalfa hay or meal (all analyses)	10.6	50.3	3.7	1.43	0.21	++[3]	++[3]	+++[3]	9.43	1.988
Alfalfa straw	4.5	42.6	8.5	...	...	..	..	..	22.22	2.347
Barley straw	0.9	44.5	48.4	0.32	0.09	0	—	—	111.11	2.247
Bean straw (field)	3.0	45.2	14.1	1.67	0.13	..	..	..	33.33	2.212
Clover red (all analyses)	7.0	51.9	6.4	1.21	0.18	++	++	+++	14.28	1.926
Clover sweet (2d yr.)	10.5	49.9	3.8	0.95	0.19	..	..	..	9.52	2.004
Corn stover (no ears)	2.1	46.2	21.0	0.41	0.08	+	+	0	47.62	2.164
Cow pea hay	12.6	49.4	2.9	1.13	0.25	..	..	..	7.94	2.024
Feterita stover	1.8	49.3	26.4	...	...	..	..	..	55.55	2.028
Kafir fodder (dry)	4.6	54.1	10.8	0.47	0.17	+	+	—	21.74	1.848
Kafir stover (med)	1.7	47.7	27.1	0.37	0.13	..	..	..	58.82	2.096
Millet hay (common)	5.2	51.5	8.9	0.30	0.17	..	..	..	19.23	1.941
Milo fodder dry	4.3	53.0	11.3	...	...	..	..	..	23.25	1.886
Milo stover dry	1.1	48.8	43.4	...	...	..	..	..	90.91	2.049
Native hay (good)	4.9	52.0	9.6	...	...	..	..	..	20.41	1.923
Native hay (weathered)	1.6	36.6	21.9	0.26	0.21	..	..	..	62.50	2.732
Oat hay	4.5	46.3	9.3	0.22	0.17	..	..	..	22.22	2.159
Oat straw	0.9	44.1	48.0	0.36	0.13	..	..	..	111.11	2.267
Pea (field) hay	11.6	56.9	3.9	1.36	0.22	..	..	..	8.62	1.757
Pea (field) straw	3.2	51.8	15.2	1.58	0.10	..	..	..	31.25	1.930
Peas and oats hay	8.9	52.2	4.9	0.80	0.20	..	..	..	11.23	1.915
Prairie hay (good)	2.6	49.2	17.9	0.49	0.10	..	..	..	38.46	2.032
Rye straw	0.7	41.2	57.9	0.28	0.11	..	..	..	142.86	2.427
Sorghum sweet fodder (dry)	3.6	52.7	13.6	0.49	0.14	..	..	..	27.78	1.897
Soybean hay	11.1	50.6	3.6	0.96	0.25	..	..	..	9.01	1.976
Soybean straw	0.9	36.5	39.6	...	0.13	..	..	..	111.11	2.739
Sudan grass hay	4.3	48.5	10.3	...	...	..	..	..	23.25	2.061
Wheat hay	3.2	46.5	13.5	0.18	0.21	..	..	..	31.25	2.150
Wheat straw	0.8	35.7	43.6	0.22	0.07	..	..	..	125.00	2.801

[3] Good quality.

Distributed in furtherance of Acts of May 8 and June 30, 1914. Extension Service, University of Nebraska College of Agriculture, and U. S. Department of Agriculture cooperating. W. H. Brokaw, Director, Nebraska Agricultural Extension Service.

[1925—5M (Exp. Sta. Circ. 25)]
[1-26-20M 6-33-6M 4-38-10M]