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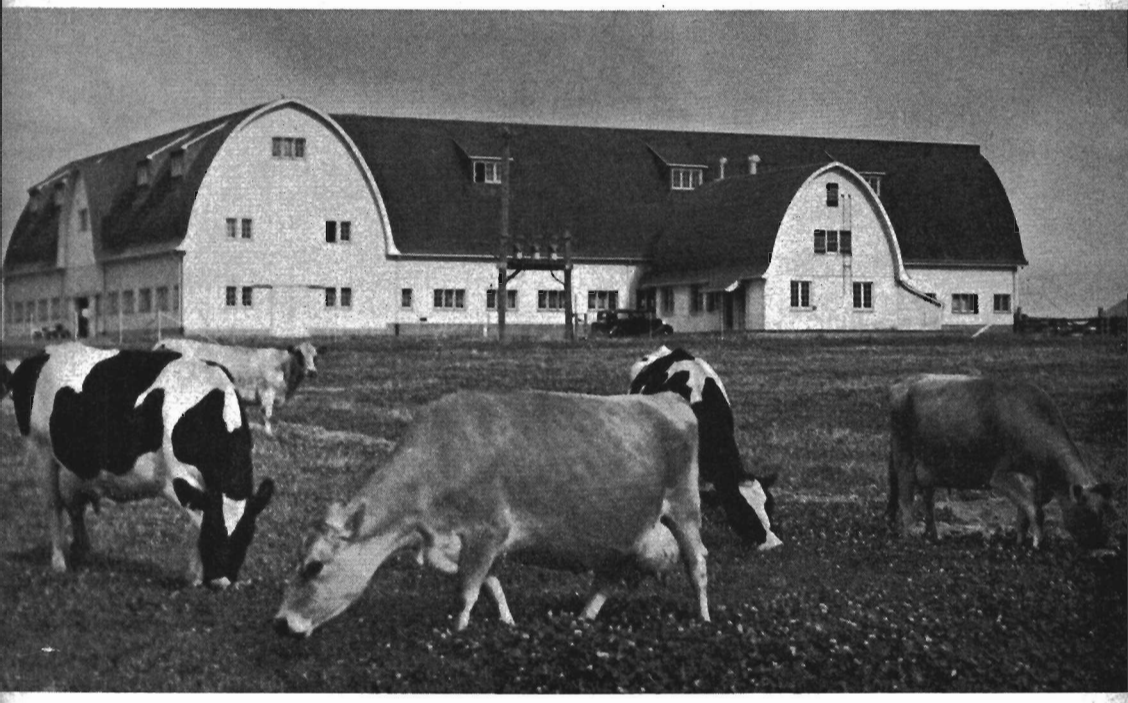

Feeding *for* MILK PRODUCTION

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FOREWORD

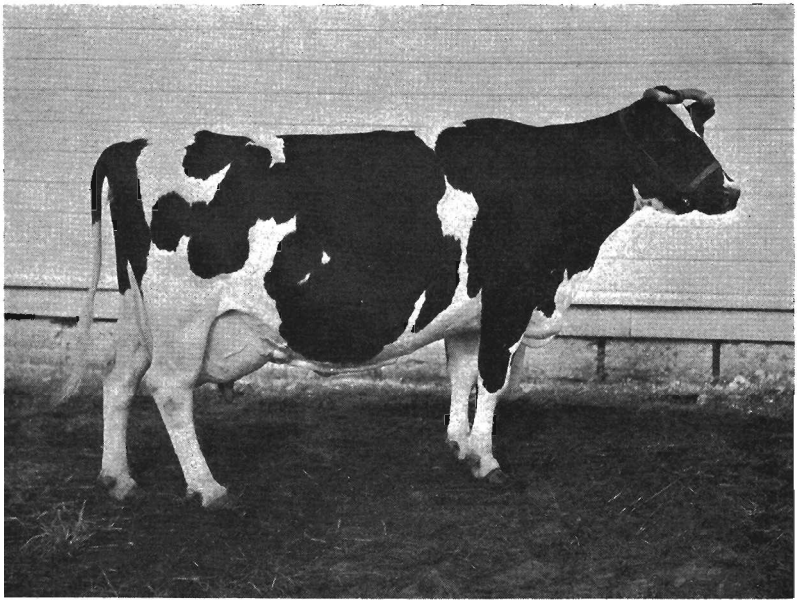
THE dairy cow has been developed through the efforts of man from an animal that produced barely enough milk to suckle her young until at the present time she is aptly referred to as the foster mother of the human race.

With the development of the milk-producing ability of the cow through careful selecting and breeding, it has become more essential for the dairy farmer to study and understand her feeding if maximum and profitable milk and butterfat production is to be obtained.

In this bulletin an attempt has been made to set forth in a fairly complete manner the important principles involved in the adequate feeding of the dairy cow so that Oregon dairymen may derive information that will make their enterprises more profitable.

Profitable dairying requires that attention be given, not only to feeding practices but also to principles of dairy management, including breeding practices, keeping and using production records, disease control, and the production of high-quality dairy products.

WM. A. SCHOENFELD, Director



THE FOSTER MOTHER OF THE WORLD

"The cow is a most wonderful laboratory. She takes the grasses of the pasture and roughage of the field and converts them into the most perfect food for man. In that food there is a mysterious something which scientists have found essential to the highest health of the human race, and which can be found nowhere else. Men have sought for centuries the fabled Fountain of Youth. The nearest approach to that fountain which has yet been discovered is the udder of the cow. Without her milk, children languish, the vigor of the adult declines, and the vitality of the human race runs low."

FRANK O. LOWDEN

TABLE OF CONTENTS

Feeding for Milk Production

By

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INTRODUCTION

THE importance of Oregon's dairy industry is indicated by the fact that it is Oregon's largest single agricultural income producer. About $21,000,000 cash income was received in 1940 from the sale of milk and milk products in Oregon. In addition, dairy products worth more than $3,000,000 were consumed in households on farms where produced. Also there is a considerable income from the sale of dairy animals for beef or veal and for breeding and milking purposes out of the state.

The 1940 Census shows a total of 61,829 farms in Oregon for the year 1939. Of these farms 46,203 reported keeping one or more milking cows and heifers, and 33,101 farms reported selling dairy products.

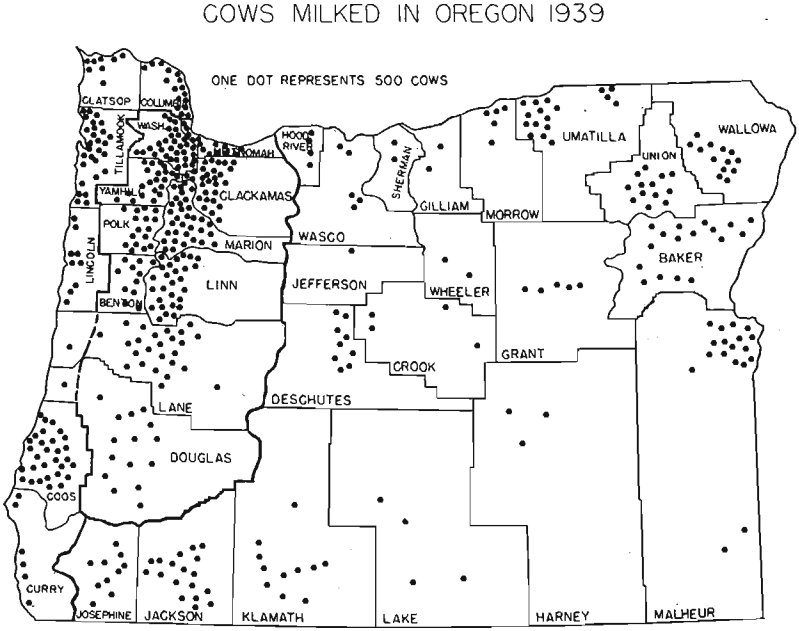

Figure 1. The distribution of the 241,079 cows in Oregon in 1939 according to the 1940 U. S. Census is graphically illustrated by the number of dots in the various counties and regions. It will be noted that the densest dairy cow population is found in the upper Willamette Valley and in Tillamook and Coos counties on the coast.

Figure 1 gives a graphic picture of the 241,079 milk cow population of Oregon by counties for the year 1939, as determined by the 1940 Census.

The actual census figures showing the cows milked and cows kept mainly for beef in Oregon by counties are given in Table 1. Also shown are the total pounds of milk produced and a computation giving the average production per cow in the respective counties. The average production in Oregon of 5,367 pounds of milk per cow in 1939 represents an increase of 794 pounds of milk per cow as compared to the 1934 Census.

Dairy regions. On the basis of climate, soil, and feed, Oregon may be divided into three main dairy regions: (1) the coast region, (2) the Willamette Valley, and (3) the irrigated regions of eastern, central, and southern Oregon. Oregon crop statistics by counties for 1939 are given in Table 2.

Table 1. DAIRY AND BEEF CATTLE STATISTICS FOR OREGON BY COUNTIES FROM 1940 CENSUS

County	Number of cows milked 1939	Milk produced	Average production per cow	Number of cows and heifers, 27 months and over kept mainly for beef production April 1, 1940
		Pounds	*Pounds*	
Marion	16,452	89,287,763	5,427	717
Washington	16,074	101,063,640	6,287	235
Coos	14,789	83,254,682	5,630	1,618
Tillamook	14,106	86,418,270	6,126	149
Clackamas	13,492	72,358,568	5,363	465
Linn	13,348	68,425,995	5,126	1,228
Lane	13,075	67,501,176	5,163	2,272
Yamhill	10,700	56,453,066	5,276	772
Jackson	8,951	48,193,213	5,384	7,677
Malheur	8,916	50,258,443	5,637	23,245
Umatilla	8,600	41,618,711	4,839	6,394
Baker	8,296	41,218,828	4,969	12,883
Polk	7,807	41,604,280	5,321	273
Columbia	7,762	43,182,354	5,563	687
Douglas	7,716	38,530,408	4,994	2,575
Multnomah	7,209	46,683,621	5,990	393
Union	6,716	34,807,614	5,183	5,060
Wallowa	6,520	32,056,139	4,917	7,707
Benton	5,697	28,773,975	5,051	624
Klamath	5,486	28,152,779	5,132	17,246
Josephine	4,989	26,700,248	5,352	1,241
Lincoln	4,455	21,969,784	4,931	644
Deschutes	4,254	23,740,145	5,581	1,291
Clatsop	4,090	21,998,293	5,379	667
Curry	2,827	13,959,374	4,938	629
Wasco	2,636	12,747,625	4,836	4,293
Grant	2,596	12,267,934	4,726	19,103
Morrow	2,429	10,364,797	4,267	2,787
Crook	2,248	11,538,224	5,133	10,734
Lake	2,059	8,726,592	4,238	30,693
Hood River	1,794	10,440,968	5,820	164
Harney	1,332	4,169,848	3,131	23,313
Gilliam	1,107	4,949,747	4,471	3,947
Wheeler	1,018	3,958,442	3,888	3,409
Sherman	1,005	4,285,466	4,264	2,294
Jefferson	528	2,203,518	4,173	3,628
OREGON	241,079	1,293,864,530	5,367	201,057

The coast region has a very equable climate with a mean temperature of about 50° F. and a range from about 20° F. in winter to 85° F. in summer. Rainfall is abundant, ranging from 60 to 120 inches, and largely comes between September 15 and June 1. The coastal region is noted for its natural pasture conditions, pastures furnishing good feed for about 7 months of the year.

Summer irrigation of pastures is rapidly developing. As indicated in Table 2 very little grain is grown in this region except for hay. Usually it is difficult to cure hay of good quality. A variety of grasses and clovers, vetch and oats, and peas and oats provide the main hay and silage crops. Both corn and peavines are important ensilage crops in some counties. Large yields of root crops are possible throughout the region.

The Willamette Valley comprises the territory between the Coast Range and the Cascade Mountains. The average temperature is about 52° F. with a usual range from 10° F. to 95° F. The average rainfall of 40 to 45 inches comes mostly during the winter months. The fact that the growing summer months are practically without precipitation has, within recent years, led to the development of supplementary irrigation, especially of pastures, by many progressive dairymen in the Willamette Valley. A great variety of hay, grain, and succulent feeds is produced on dairy farms in the Willamette Valley, as indicated in Table 2. The yields per acre, largely influenced by soil types and ground water, determine the crops grown on particular farms.

The irrigated regions of eastern, central, and southern Oregon for the most part show a considerably wider range in temperatures than do the Willamette Valley and coast regions. Dairying is carried on at elevations ranging from 500 to 5,000 feet. The rainfall is light, ranging from 10 to 20 inches. The growing season is quite variable and is shorter than in the other regions. Irrigation is practiced, with alfalfa and pasture plants the main crops irrigated on dairy farms. Grain crops are successfully grown with irrigation and in some sections under dry-land conditions.

Markets. About two-thirds of the total milk produced in the coast region is used in cheese manufacture. About 10 per cent of Oregon's butter is made in the coast section.

In the Willamette Valley about one-third of the farms produce market milk for city consumption, one-third produce churning cream, and the remainder condensery, creamery, and cheese factory milk and market cream. Of the butter made in Oregon, about 55 per cent is manufactured in the Willamette Valley.

About four-fifths of the milk produced in the irrigated regions is sold as churning cream. About 35 per cent of the butter made in the state is manufactured in the irrigated regions.

The coast region is a specialized dairy section with the major part of the total farm income being obtained from the dairy enterprise; whereas on the average dairy farm in the Willamette Valley and irrigated regions about half of the receipts are from the sale of dairy products and dairy cattle.

High production most profitable. The most important factor affecting the cost of producing milk and butterfat is the yield of milk and butterfat per cow. This relation between the amount of milk and butterfat produced and the economy of production is illustrated by cost of production studies, by a study of dairy herd improvement association records, and by a study of controlled experiments.

In a cost of production study conducted in Oregon for the 3 years, 1930-1932 as reported in Oregon Agricultural Experiment Station Bulletin 318, there was found to be a marked difference in the cost of producing butterfat on different farms, depending on the average yield per cow. With herds averaging

Table 2. FEED CROPS IN OREGON BY COUNTIES FROM 1940 CENSUS

(1939 Crop)

County	All hay exclusive of sorghums	Annual legumes saved for hay	Alfalfa	Clover or timothy hay alone or mixed	Small grain hay	All other hay	Corn other than for grain	Plowable pasture
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Acres*	*Acres*
Baker	125,388	.....	72,990	10,826	3,919	37,653	236	60,069
Benton	30,323	7,945	6,300	2,488	10,103	3,487	1,140	24,767
Clackamas	58,805	8,843	4,343	8,447	32,382	4,790	4,364	16,245
Clatsop	12,396	330	.....	1,792	2,265	8,009	8	7,369
Columbia	26,966	1,726	1,469	6,364	10,761	6,646	767	12,254
Coos	36,953	753	2,886	3,206	12,440	17,668	1,173	25,987
Crook	56,141	26	35,794	498	9,573	10,250	*	15,279
Curry	7,534	527	337	797	2,931	2,942	75	14,813
Deschutes	33,033	311	26,752	635	4,979	356	12	21,938
Douglas	44,142	2,325	12,858	1,329	22,242	5,388	659	79,736
Gilliam	7,913	.....	3,980	.....	3,933	*	14	28,202
Grant	71,514	.....	16,881	10,704	20,213	23,716	69	19,224
Harney	72,634	.....	9,229	2,416	3,646	57,343	.....	58,575
Hood River	8,603	10	5,175	1,485	1,003	930	113	3,809
Jackson	71,697	3,202	36,727	8,514	15,375	7,879	928	24,253
Jefferson	6,461	.....	3,963	53	2,332	113	*	5,692
Josephine	25,188	411	9,667	6,956	5,939	2,215	221	15,585
Klamath	103,989	.....	61,138	4,207	22,537	16,107	*	162,790
Lake	67,544	.....	10,614	1,620	5,282	50,028	*	88,802
Lane	69,525	13,969	16,803	4,651	24,553	9,549	1,290	52,193
Lincoln	12,433	119	86	1,402	5,435	5,391	105	12,202
Linn	65,370	24,079	11,468	4,924	16,656	8,243	2,608	51,327
Malheur	200,174	33	152,203	14,655	6,433	26,850	659	27,390
Marion	76,061	20,452	9,780	8,950	29,777	7,102	6,676	38,739
Morrow	25,128	*	17,180	*	7,697	251	93	60,017
Multnomah	20,669	1,072	3,406	5,674	7,072	3,445	1,489	10,146
Polk	41,272	11,110	7,701	4,850	15,138	2,473	1,944	17,800
Sherman	6,859	.....	372	.....	6,487	*	.....	32,719
Tillamook	25,076	*	*	701	4,695	19,680	28	17,563
Umatilla	88,250	.....	68,464	444	17,484	1,858	253	99,722
Union	62,277	*	41,341	3,249	7,619	10,068	212	25,056
Wallowa	69,679	*	35,591	5,906	20,921	7,261	502	25,888
Wasco	25,689	*	12,365	141	12,431	752	30	22,514
Washington	74,602	22,122	8,167	10,716	28,389	5,208	5,333	14,298
Wheeler	23,294	*	12,086	339	8,407	2,462	19	5,408
Yamhill	55,954	16,040	10,197	4,300	21,621	3,796	3,322	15,612
OREGON	1,809,536	135,592	728,317	143,254	432,670	370,140	34,364	1,213,983

* When less than three farms reported in the county, the tonnage is indicated only in the state total.

Table 2. FEED CROPS IN OREGON BY COUNTIES FROM 1940 CENSUS—(*Continued*)

(1939 Crop)

County	Woodland pasture	Other pasture	Oats	Barley	Wheat	Corn	Mixed grains
	Acres	*Acres*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Baker	37,565	585,637	164,739	215,692	249,214	11,705	13,802
Benton	46,875	74,734	326,208	148,958	127,825	26,260	155,072
Clackamas	65,748	96,787	756,583	165,430	315,138	138,029	212,428
Clatsop	20,896	13,831	14,032	*	1,663	.....	*
Columbia	35,058	63,129	83,140	22,814	29,836	1,838	2,822
Coos	84,726	149,224	3,901	9,566	657	3,900	618
Crook	4,211	741,631	82,280	82,234	67,825	.....	*
Curry	20,805	63,481	*	*	*	620	.....
Deschutes	10,265	112,183	89,690	63,526	40,687	207	3,085
Douglas	177,524	287,836	289,666	85,728	126,611	59,642	106,586
Gilliam	10,337	538,253	2,692	37,625	1,163,765	470	23,029
Grant	76,069	760,102	18,100	23,403	36,462	510	*
Harney	3,299	721,561	50,370	30,842	15,349	.....	*
Hood River	9,601	8,676	8,173	298	959	7,230	.....
Jackson	73,073	141,891	88,618	139,573	142,024	54,784	11,083
Jefferson	115,923	493,998	1,262	9,782	181,857	*	*
Josephine	60,643	23,995	13,861	7,429	14,932	18,277	18,235
Klamath	126,002	345,137	440,172	401,773	167,207	*	13,149
Lake	144,848	525,618	115,553	71,511	40,613	*	8,960
Lane	144,835	174,309	538,827	162,274	235,165	54,406	176,815
Lincoln	44,645	42,427	3,830	.....	261	1,089	.....
Linn	76,731	144,636	1,123,067	414,529	371,334	81,772	247,897
Malheur	219	702,536	115,395	369,659	245,800	215,439	42,165
Marion	64,368	79,116	1,324,624	230,269	512,079	246,307	151,994
Morrow	51,361	608,504	7,691	42,662	896,672	8,514	6,662
Multnomah	15,616	21,868	64,096	18,801	21,287	7,113	5,093
Polk	44,045	52,173	495,545	261,497	250,497	12,752	166,206
Sherman	971	166,952	20,658	74,788	1,900,326	.....	2,229
Tillamook	28,527	30,135	.....	.....	.....	.....	.....
Umatilla	90,966	870,082	133,365	398,844	4,904,104	39,753	3,042
Union	83,049	215,312	220,657	249,120	862,896	972	10,862
Wallowa	54,072	391,978	156,965	322,219	442,621	275	20,337
Wasco	30,596	645,134	17,541	76,857	1,152,087	529	16,433
Washington	46,421	58,628	794,967	184,975	435,971	25,296	235,056
Wheeler	135,240	600,885	20,058	16,151	52,738	465	2,180
Yamhill	46,777	98,554	580,720	244,244	351,479	43,252	218,782
OREGON	2,081,907	10,650,933	8,167,826	4,584,258	15,358,147	1,061,576	1,877,502

* When less than three farms reported in the county, the tonnage is indicated only in the state total.

about 300 pounds butterfat per cow annually, the cost of producing butterfat averaged 10 cents a pound less than when the average production was about 200 pounds annually.

A recent unpublished farm organization study by the Department of Farm Management of 71 dairy farms selected at random in the Willamette Valley indicated that farms having cows producing more than 300 pounds of butterfat per cow earned 4 per cent on the total farm investment and received in addition $690 as a wage for the labor and management of the operator. On the other hand farms having cows producing less than 300 pounds of butterfat per cow failed by $340 to earn 4 per cent on the investment and, furthermore, had absolutely nothing left as a wage for the labor and management of the operator.

With the increase in production per cow, there is some increase in feed, labor, and other costs, but the cost per pound of butterfat decreases because the cost items do not increase in proportion to the increased yield of the cow.

A cow producing 300 pounds of butterfat uses only 25 per cent more feed than is required to produce 150 pounds of butterfat by another cow of the same size but with the inheritance for low production. In other words, by the feeding of an additional 25 per cent of feed, the butterfat production is doubled and the unit cost of production is markedly decreased.

Main factors in high production. There are two main considerations in obtaining high milk and butterfat production. The first, and possibly more important, is the inherited ability of the cow to produce milk and butterfat; second, the feed and care given to the cow so that she can produce to the optimum of her inheritance. Every cow inherits a certain maximum milk- and butterfat-producing ability above which she will not go even though she is fed and cared for in the best possible way. If the cow is not fed a sufficient amount of the right kinds of feed, however, she cannot produce to the maximum of her inherited ability.

Testing for production. It is extremely difficult to judge accurately the producing ability of a cow from her appearance. A good dairyman can oftentimes tell the difference between a good and a poor cow, but it is almost impossible for even the best judge to pick out a 300-pound from a 400-pound cow.

A cow capable of producing 400 pounds of butterfat or more annually has the essential points of being a good producer of milk and butterfat and has inherited the characteristic of being persistent in her production. By persistency of lactation is meant the ability to continue to produce milk at a high level to within about 6 weeks of her next freshening. Many dairy cows are remarkably good producers for the first 5 or 6 months of their lactation period and then rapidly decline in production so that they are dry, or practically so, for a period of 3 or 4 months.

The only way to determine the annual milk and butterfat yield of cows in the herd is by some system of milk weighing, testing, and recording at intervals throughout the lactation. Dairy herd improvement associations furnish the most economical method of determining the production of the individual cows. In the case of purebred herds, some form of official testing, and especially the herd test under which all animals in the herd are tested, is desirable.

Culling the dairy herd. After the production of individual cows in a herd is definitely known, the owner should decide what his culling standard should be. The culling standard will depend on the variation and average production in a particular herd. It should be set reasonably high, revised at inter-

vals, and animals failing to make the desired production should be sold to the butcher. It should be kept in mind that young cows should not be expected to make the production of cows 5 years of age or older. Conversion tables can be obtained for different systems of testing and for the different breeds. It is likely the cow that proves to be a poor producer with her first calf will always remain a low producer, unless there is some special reason for her production being low.

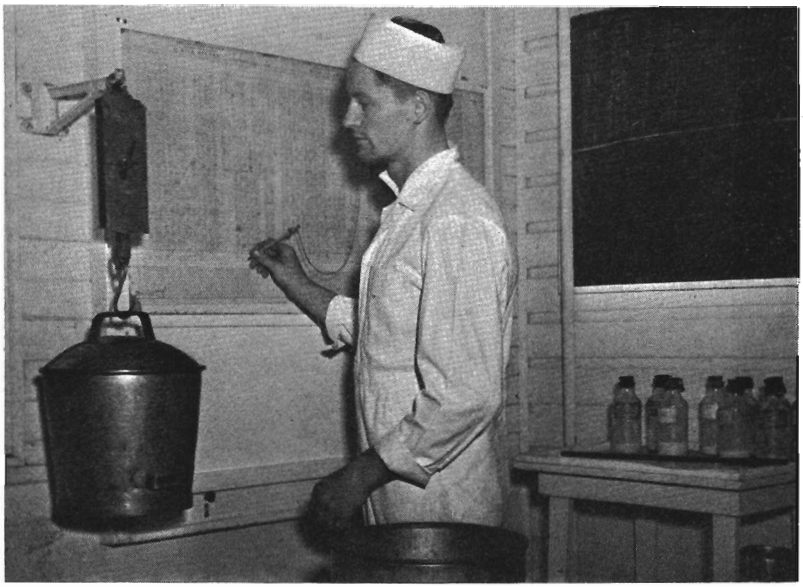

Figure 2. The amount of milk a cow produces at each milking should be determined by weighing on a scale graduated in pounds and tenths and the amount recorded on monthly milk sheets. Butterfat tests should be made one day each month and the total milk and butterfat produced monthly should be recorded in a permanent record book. Daily milk records enable the dairyman to do a much more intelligent job of feeding his herd.

Good breeding. After the culling standard in the herd has been established, the dairyman should decide whether the herd sire has the inheritance to increase low production or maintain high production in the herd. The best method of improving the dairy herd is by the use of a good sire and retention of daughters of the best cows in the herd. If possible, the herd sire should be used to only a limited extent until records are available on his first daughters. Good proved sires are difficult to locate if one desires to make a purchase. They should be kept in use in some herd as long as they are serviceable.

In case an unproved bull is selected as a future herd sire, the dairyman should be certain that he is backed by a good-producing family of ancestors. On the average, animals tend to transmit their own characteristics, and the good cow, just as the good bull, tends to transmit to her offspring her own characteristics for type and milk and butterfat production.

Healthy cows. Healthy cows are of importance to the dairyman for two main reasons. In the first place, cows must be healthy if good quality dairy

products are to be produced; and secondly, healthy cows are necessary for profitable production and reproduction.

USE OF FEED BY THE DAIRY COW

The dairy cow uses feed for two main purposes, for body maintenance and for production. The productive uses include the secretion of milk and butterfat, reproduction, fattening, and body growth in the case of the immature animal.

Maintenance. The dairy cow may be likened to a steam engine. A certain amount of the power furnished by the steam engine is used for running the machine itself and is not available for other use. This unproductive expense is termed the maintenance requirement of the cow, and it is that part of the feed consumed and used to perform body functions such as maintaining body temperature, locomotion, digestion, blood circulation, and tissue repair.

It should be stressed that the cow must be fed to meet the maintenance requirements before any feed is available for milk production and other uses. This is illustrated by Figure 3. The more milk a cow produces above the

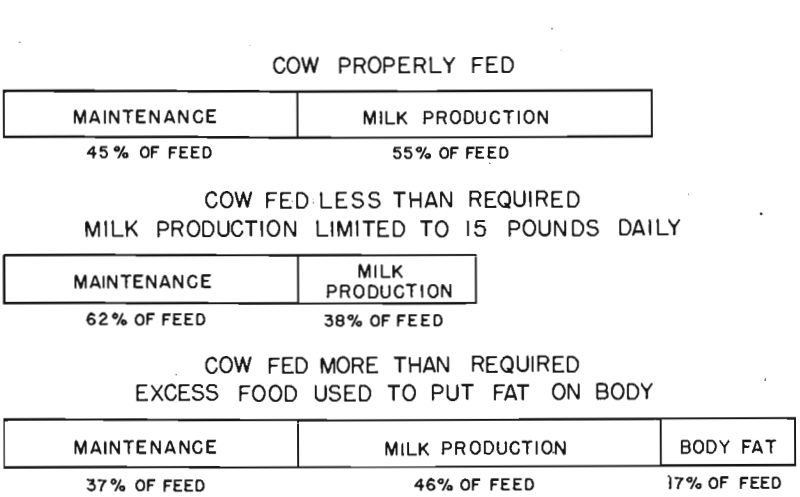

Figure 3. The cow uses feed first to meet her body maintenance requirement. Economical feeding requires that the cow be given all the feed she will need for maintenance and use for milk production. Feeding less than required results in a decline in milk production. Feeding too much is uneconomical as the cow will put on body fat but will not increase in production. Overfeeding in late lactation is desirable as it allows the cow to replenish her body reserves for the ensuing lactation.

amount necessary to offset the maintenance or overhead cost, the more profitable the cow is to the owner. Profitable production requires feeding the cow to her capacity, using feed furnishing low-cost nutrients. The maintenance requirements of dairy cows are given in Table 4, in the Appendix.

Milk production. If the dairy cow is fed only a maintenance ration, no nutrients are available for milk production. If she is fed twice the quantity necessary for maintenance, half of the feed can be used for producing milk. As the cow consumes more feed in proportion to her maintenance requirement, she has a higher percentage available for production. Highly specialized dairy cows will consume two or three times as much feed as that required for body maintenance, and such cows can produce a large amount of milk. However, it is uneconomical to feed cows beyond their inherited capacity to produce milk. These points are illustrated in Figure 3.

The feed required in addition to maintenance is determined by the amount and butterfat test of the milk produced as shown in Table 4. A good dairy cow usually will lose weight in early lactation due to the fact that it requires 3 to 4 weeks to get her on full feed, and in some cases she does not have the capacity to consume enough feed to meet her requirements. It is desirable to feed a cow so that she will put on flesh in late lactation and during the dry period so as to be in condition for the following lactation.

NUTRIENTS REQUIRED AND THEIR USES

Water. Water is very essential in the cow's ration, inasmuch as her body on the average contains about 55 per cent of water. Also milk contains 87 per cent water. Water is essential for the proper digestion of feeds and is the largest constituent of blood and lymph that carry nutrients to all parts of the body. Water assists in the elimination of waste products in the urine and feces. The body temperature is controlled by evaporation of water from the skin and through the lungs. The amount of water required by the dairy cow depends on the amount of milk she is producing, her body weight, the type of ration fed, and the temperature of the air.

As water is the cheapest ingredient that a cow requires for milk production, she should be provided with an adequate amount. Under moderate temperature conditions, the cow requires about 6 pounds of total water daily per 100 pounds of body weight, and about 1½ pounds of water for each pound of milk produced. A 1,000-pound cow producing 40 pounds of milk daily would require a total of 120 pounds of water. The provision of a convenient supply of pure, fresh water is necessary for economical production.

Feeds vary considerably in the amount of water they contain. Concentrates usually contain about 10 per cent water. Hays vary somewhat more, but usually contain a little more than 10 per cent water. In contrast to concentrates and hay, the succulent feeds are high in water. Pasture grasses and clovers contain from 75 to 85 per cent, the silages from 65 to 75 per cent, and the root crops from 80 to 90 per cent water. Naturally the free water requirement of a cow depends to a large extent on the type of ration fed.

In the example given above the cow requiring 120 pounds of water daily would obtain 20 to 25 pounds of water in the feed, if the ration consisted of 10 pounds of concentrates, 15 pounds of hay, and 30 pounds of silage, and would require 95 to 100 pounds of free water. In hot weather cows may drink 80 per cent more than in moderate weather. At freezing temperatures cows will drink about the same amount as in moderate weather if the water is not too cold.

It should be pointed out that the dairy cow requires a certain amount of dry matter in the ration. She is limited in her capacity to consume feeds. If

only feeds high in water are fed, she may not be able to consume enough dry matter to meet her requirements.

Protein. The protein content of feeds is very important in determining their value for the dairy cow. Proteins make up about 18 per cent of the body of the mature cow. The dairy cow uses protein to maintain the tissues of the body such as the vital organs, muscles, tendons, blood, hoofs, and hair; to produce milk, which contains approximately 3½ per cent protein; and in the case of pregnant animals, to develop the growing fetus. It should be pointed out that the animal body cannot use carbohydrates and fats to build proteins, although an excess of protein can be broken down by the cow and used for energy. The protein requirements of the dairy cow that the feed consumed must provide are given in Table 4.

Within comparatively recent years it has been found that in addition to the requirement for a definite amount of protein, the quality of protein is also an important consideration. Proteins are very complex, nitrogenous compounds, containing various combinations and amounts of 22 or more different amino acids of which at least five or six are essential. Many feeds are low or lacking in some of these essential amino acids. It is desirable to use feeds from several plant sources in order to insure the quality of protein necessary. A deficiency in either amount or quality of protein is apt to be the cause of low milk production. This is emphasized by the fact that 25 per cent of the dry matter of milk is protein. Milk proteins are of high quality and contain all the known amino acids. The essential amino acids must be supplied in the ration if production is to be maintained.

Until more complete information on the amino-acid content of the proteins of feeds is available, it would seem that the best policy for the dairyman to follow is to provide the cow with as great a variety of feeds as possible and thereby compensate for the possible lack of some of the essential amino acids in one feed by supplying them in another. Both quality and quantity of protein must be considered in formulating the dairy cow's ration.

Fat. The fat or oil content of feeds is sometimes known as the ether extract. Feeds commonly fed to the dairy cow are low in fat content. It is significant that 1 pound of digestible fat in a feed is worth 2¼ pounds of digestible carbohydrates for heat and energy purposes. On the other hand, too much fat in ground feed is apt to cause rancidity to develop and is undesirable.

A dairy cow in average condition will have about 20 per cent of her body weight in the form of body fat. Milk varies in its butterfat content within wide limits. Average milk contains about 4 per cent butterfat, but may range from less than 3 to more than 7 per cent. The fat in feeds may considerably influence the physical and chemical composition of butterfat, but it does not ordinarily affect the per cent of fat in the milk. Recent experimental work has shown that if a cow is fed 2 or 3 pounds of supplementary fat daily, the butterfat test of the milk may be temporarily influenced but also the excessive fat may cause digestive disturbances.

Other investigations indicate that it is desirable for the dry matter of the ration to contain a minimum amount of about 4 per cent of fat. If only 2 per cent of fat is present, the amount of milk and total butterfat produced may be diminished. Care should be taken to feed rations that supply the minimum amount of fat suggested, particularly for high-producing cows.

Table 3. NUTRIENTS IN FEEDS AND THEIR USES

Nutrients	Important uses
Water Cow needs about 6 pounds daily per 100 pounds body weight and 1½ pounds for each pound of milk produced.	Body—50 to 60 per cent water; body fluids; digestion and absorption; removal of body waste; regulation of body temperature; milk—87 per cent water.
Proteins Consisting of amino acids, of which about 22 are known. Feeds may lack some of the essential amino acids.	Repair old and build new cells and tissues of vital organs, muscles, tendons, blood, hide, hoofs, horns, hair, etc.; milk proteins; growth of fetus; heat and energy if fed in excess.
Carbohydrates 1. Nitrogen-free extract including starches and sugars. Fairly digestible. 2. Fiber—of quite variable digestibility.	Heat to keep body warm; energy to do work of digestion, locomotion, etc.; milk fat and milk sugar; body fat; maintain life in fetus.
Fats Experiments indicate that 4 per cent fat in dry matter of ration may be desirable for best lactation results.	Heat; energy; milk fat; body fat.
Minerals Calcium Phosphorus Sodium and Chlorine (common salt) Iodine Iron and Copper Sulphur Potassium, etc.	Bone building, especially calcium and phosphorus; body fluids and tissues; minerals in milk; growth of fetus; iodine for prevention of goiter; iron and copper for prevention of anemia; sulphur essential part of some amino acids; digestion and metabolism.
Vitamins A—made in cow's body from carotene in feed.	Maintenance of normal health; growth and development of young; reproduction; prevention of body infections especially of eyes, lungs, intestinal tract.
B—a mixture of vitamins, several of which are now chemically known.	Growth in some species; prevents nervous disorders; stimulates appetite; synthesized by cattle.
C—chemically known as ascorbic acid.	Prevents scurvy in species susceptible; synthesized by cattle.
D—antirachitic factor. Replaced by direct sunshine.	Necessary for proper calcium and phosphorus assimilation; normal growth and well-being.
E—now chemically known. Wheat germ oil rich source.	Reproduction in some species.
G—one of original vitamin B complex. Chemically known as riboflavin.	Growth, especially in poultry; synthesized by cattle.

Carbohydrates. The starches, sugars, and crude fiber together form the main carbohydrate constituents of feeds. The total carbohydrates less the fiber are termed nitrogen-free extract. Carbohydrates are the main source of heat and energy in livestock feeds. The cow uses carbohydrates to maintain body temperature, to produce body fat, milk fat, and milk sugar, and to provide energy for the muscular activity of the cow, including the work of digestion.

Starches and sugars are highly digestible, whereas the fiber is usually the least digestible constituent of the feed. Farm grains and hays contain practically the same amount of dry matter. Grains contain a much lower percentage of fiber than do the hays, which is the main reason for the higher feeding value of the former.

In this bulletin the term "concentrates" will refer to feeds low in fiber content and high in total digestible nutrient value. Examples of concentrates are farm grains, mill feeds, and high protein feeds. The term "concentrate" does not indicate whether a feed is high or low in its protein content.

Minerals. The functions of minerals in the body are many and complex. It is needless to say that an animal could live but a limited time in their absence. About 5 per cent of the weight of a dairy cow's body consists of minerals, largely calcium and phosphorus in the bones. Milk contains about 0.7 per cent minerals, largely calcium and phosphorus.

While cattle need numerous mineral elements, it is probable that most rations are adequate except for sodium and chlorine, the elements provided in common salt. In some regions the rations fed may be too low in calcium, phosphorus, and iodine for optimum growth, lactation, reproduction, and well-being. A more complete discussion of the use of minerals will be found in another section of this bulletin.

Vitamins. Vitamins are complex compounds, the chemical compositions of which are becoming fairly well established. They were first discovered by the development of pathological conditions or failure of growth and well-being in animals when diets lacking them were fed.

Experimental evidence indicates that most dairy cow rations adequate in other respects are not apt to be deficient in sufficient quantities of vitamins for normal well-being. It might be mentioned that the vitamin A and vitamin D content of milk varies with the amount of these in the ration. A further discussion of vitamins will be found in later pages.

DIGESTIBILITY OF FEEDS

After the chemical analysis of a feed is determined, it is necessary to run digestion trials with livestock in order to determine how much of the protein, fat, fiber, and nitrogen-free extract is utilized. The difference between the amount of each nutrient fed and that voided in the feces represents the digested portion.

Digestion trials have been run with most of the common feeds, using dairy cows, steers, and sheep as the experimental animals. In case digestion trials have not been run with a particular feed, the digestion coefficients of a similar feed may be used to determine its digestible nutrients.

Total digestible nutrients. The total digestible nutrients in a feed are the sum of all the digestible constituents; namely, the digestible protein, the digestible fat times 2¼ (see explanation under fat), the digestible fiber, and the digestible nitrogen-free extract.

In feeding the dairy cow, the dairyman should be interested largely in the digestible value of feeds. The feed tag, as shown on mixed concentrates put out by feed manufacturers, shows the chemical analysis of the feed and not its digestible value. There is a great variation in the chemical analysis and digestibility of various feeds. Table 5 gives the chemical composition, the digestible protein, and total digestible nutrient value of Oregon's common feeds. It will be noted in Table 4 that the feeding standards giving requirements for maintenance and milk production are expressed in terms of digestible protein and total digestible nutrients.

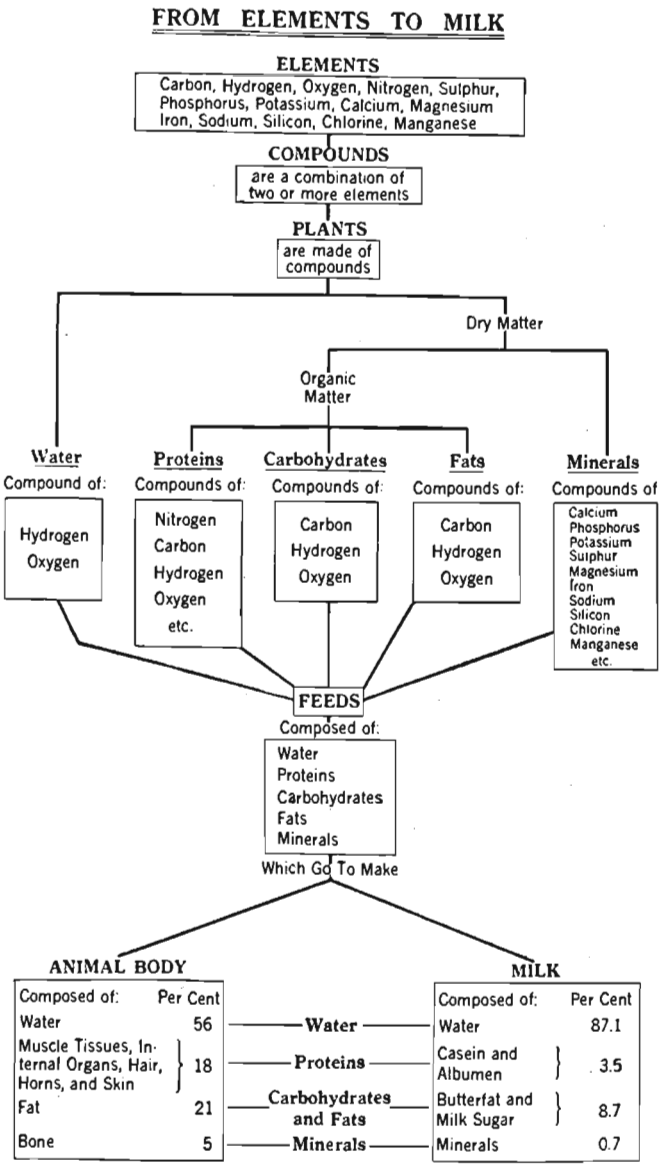

Figure 4. Chart showing interrelation of common component elements of plant and animal life which go to make up feed and finally milk. Reprinted by permission from *Dairy Cattle Feeding and Management* by Henderson, Larson, and Putney, published by John Wiley and Sons, Inc.

CHEAP FEEDS AND PROFITS WITH THE DAIRY HERD

On the average farm, approximately 50 per cent of the total cost of producing milk or butterfat is feed cost. The feed-cost item, however, varies quite markedly upon different farms and with different types of feeding conditions. The adaptability of a particular section to dairy farming depends to a large extent upon the cost of growing various feeds that are needed by the dairy cow. It is essential that a well-planned feed production program be practiced on every dairy farm.

Roughages cheapest feeds. Of the main classes of feeds that the dairy cow consumes, pasture usually furnishes the cheapest form of total digestible nutrients, or energy, followed by hay crops, succulent feeds, and lastly grains and other concentrates. The dairy cow is a highly specialized machine that requires an abundance of palatable feeds containing definite amounts of protein, energy constituents, minerals, and vitamins. A region is best adapted to dairying if high-quality roughages can be grown. If success is to be made in the dairy enterprise, the roughage required should be grown on the farm unless there is a special market for dairy products.

The results of the dairy cost survey* made in Oregon during the years from 1929 to 1932 show a marked variation in the kind of feeds used in different sections of the state and also in the feeds grown on farms in the same locality. Farms in those sections where cheap pasture and cheap hay of good quality were available had the lowest cost of production. There was a striking difference in the cost of production due to the type of feeds available and the feeding practices followed on farms in the same neighborhood.

The cow that will consume large amounts of roughage is usually the most economical producer. The proportion of concentrates to roughages offered the cow should depend largely upon the amount of milk given. High-producing cows will require more concentrates in proportion to roughage than will be necessary with the lower producers.

Legume hays best. Hay is the basis of a good dairy cow ration during the winter period. Hay can vary to a marked degree in its chemical composition, digestibility, quality, and palatability. The dairy cow is a hard-working animal, easily the hardest working animal on the farm, and thus it is important to supply her with the best possible feeds. It is poor economy to feed dairy cows poor-quality roughage, particularly poor hay.

The legume hays, such as alfalfa and clover, have special advantages in the dairy cow's ration as compared with the nonlegume hays, such as those made out of the cereal grains and grasses. The main advantage of a legume over a nonlegume hay is the considerably higher percentage of protein in the legume. The dairy cow must have a sufficient amount of the right kind of protein in her ration to maintain her body and to produce milk. The legume hays contain from two to three times as much protein as do the nonlegume hays as shown in Table 5. The dairyman who has legume hays available will be able to feed a much lower protein and lower priced concentrate mixture as indicated in Table 7, than the dairyman feeding grass or grain hay.

Quality of hay important. By quality in hay is meant those characteristics that determine its use and feeding value. Some of these characteristics

* Oregon Agricultural Experiment Station Bulletin 318.

are the presence or absence of weeds, the amount of leafiness, the color, soundness or freedom from mustiness or mold, and the fineness or coarseness of stems. A hay of high quality is sound and sweet, fine-stemmed, contains a large proportion of leaves to stems, has a natural green color, and is free from weeds. Such a hay has a markedly greater palatability and feeding value than a coarse-stemmed, weedy, musty, colorless hay from which the leaves have been shattered during curing. The difference in analysis and feeding value of leafy and stemmy alfalfa hay is given in Table 5.

There are localities in Oregon where it is difficult to grow good-quality legume hay. In other localities hay can be grown but is very difficult to cure, especially in the case of first-cutting alfalfa. Oats and vetch hay is grown and fed to dairy cows on a large number of dairy farms in the Willamette Valley. Oats and vetch for hay should be seeded quite heavily so that the plants do not grow too coarse and should be cut before it becomes ripe at which time the stems are woody. Practically any hay cut at an early stage of maturity has a higher feeding value than if cut when more mature. Many of the grasses in the early stages of growth contain almost as much protein as the mature legumes. Dairymen have not capitalized on the higher feeding value of the grasses when cut before becoming too mature.

Succulent feeds valuable. The succulent feeds, including silages, roots, fruits, kale, and soiling crops, are valuable feeds for dairy cows. The best production is obtained when succulent crops are fed to the animal as a part of the roughage ration at the rate of about 3 pounds daily per 100 pounds of live weight. A 1,000-pound cow would be fed about 30 pounds of succulent feed daily.

Most succulent feeds are palatable, and livestock will eat more total roughage and produce better when fed succulents along with hay or other dry forage than when receiving the dry forage alone. Thus the grain allowance can be lower with a hay and succulent ration than with hay alone. Possibly the only exception is when the hay is of very high quality, such as green, leafy alfalfa. In such cases, the addition of succulent feeds to the hay ration may not increase production, and their utilization depends upon the comparative cost of producing nutrients in the succulent crops and in hay. It is important to recognize that all the succulent feeds are comparatively low and quite variable in their dry-matter content and are usually low in protein. This is shown by a study of Table 5. In case a supply of clean, fresh water is not available to the cow at all times, however, succulent feeds are particularly valuable.

Silage crops. Feeding trials have shown that it requires about 3 pounds of silage to equal 1 pound of hay in total digestible nutrient value and even more silage in the case of digestible protein. Crops for silages are profitable to grow if the cost per ton of silage is not more than one-third that of palatable hay. Exceptions to this are the saving of crops that would otherwise be spoiled by bad weather and the utilization of poor-quality roughages by ensiling.

In Oregon the possibility of making silage out of grasses and legumes when weather conditions do not allow the making of good-quality hay is receiving more and more attention. In case a large amount of silage is available and the hay is of poor quality, or out of line in cost of growing or purchase price, it may be economical to feed much more silage than would follow from the rule of 3 pounds daily per 100 pounds of body weight. Good results have been obtained by feeding 60 to 80 pounds of good-quality silage daily along with a limited amount of hay and the concentrates necessary to meet the cow's requirements.

The average costs of producing hay, silage, and kale in various regions of Oregon are discussed in Oregon Agricultural Experiment Station Bulletins 241, 248, and 251.

There are certain fundamental requirements in making good silage. The silo must be airtight and of a diameter commensurate with the size of the herd so that at least 1½ inches of silage can be removed daily to prevent spoilage. The capacity of silos of different sizes is shown in Table 10.

The moisture content of the forage crop at the time of ensiling is important. If it is too high in water, the silage is apt to be very sour and not palatable to dairy cattle. If the forage is too dry, it is difficult to pack well in the silo and the presence of air allows mold to grow. With hollow-stemmed forage, it is particularly essential to cut the crop into short lengths, to distribute it evenly, and to pack it well at the time of ensiling.

With crops high in protein and low in sugar content, such as immature grasses, alfalfa, clovers, and vetch, it is important to supply additional sugar for the proper acid fermentation or to prevent putrefactive fermentation by the direct addition of acids. The addition of molasses at the rate of 3 or 4 per cent of the weight of the ensiled material will provide enough additional sugar for a good quality of silage to be produced. Good silage has been reported to have been made from the legume and grass crops without the addition of molasses, providing the crop is allowed to dry so that the moisture content is about 35 per cent at the time of ensiling and extreme care is taken in packing the chopped forage.

If the forage to be ensiled is dry, water should be added to make it pack well. This can be done by running the water through a spray nozzle into the silo or into the blower fan case or the blower pipe.

Roots, kale, soiling crops, and fruits. Experiments have shown that kale, where it can be grown, is a particularly valuable feed for the cow in milk, being very palatable and stimulating production. The high protein content of kale is shown in Table 5.

Common beets, carrots, rutabagas, mangels, and turnips are about equal in feeding value and can be profitably utilized in many sections of Oregon. Pumpkins and squash are comparable in feeding value to the root crops.

Apples and pears can be fed to the dairy cow, but in addition to being quite low in dry matter, they are very low in protein. Since apples are palatable, cows having free access to this fruit will consume large quantities, resulting in a decline in milk flow due to a lack of sufficient protein and total digestible nutrients. For example, a 1,000-pound cow producing 25 pounds of 4 per cent milk daily would have to consume 935 pounds of apples daily if her total required digestible protein were furnished by apples.

Potatoes in amounts up to 30 pounds daily are a satisfactory feed for dairy cows, being worth about 80 per cent as much as well-eared corn silage. They should be chopped before feeding. Excessive amounts may cause digestive disturbances.

Hay and grain crops can be cut when green and satisfactorily fed to dairy cows. Their dry-matter content as shown in Table 5 is about the same as that of corn silage. It will be noted, however, that the legumes and immature grasses particularly contain much higher percentages of digestible protein than corn silage. The disadvantage of soiling crops is the high labor cost required for their utilization. Pasture crops furnish similar nutrients and the grazing cow eliminates this labor cost.

Pastures. Pasture plants are the natural feed of livestock. The countries of the world that have the rainfall and climate conditions essential for the growing of pasture and other forage are the leaders in livestock production. As values increase on the more productive land, there is a tendency for the dairy cow to replace the meat- and wool-producing animals.

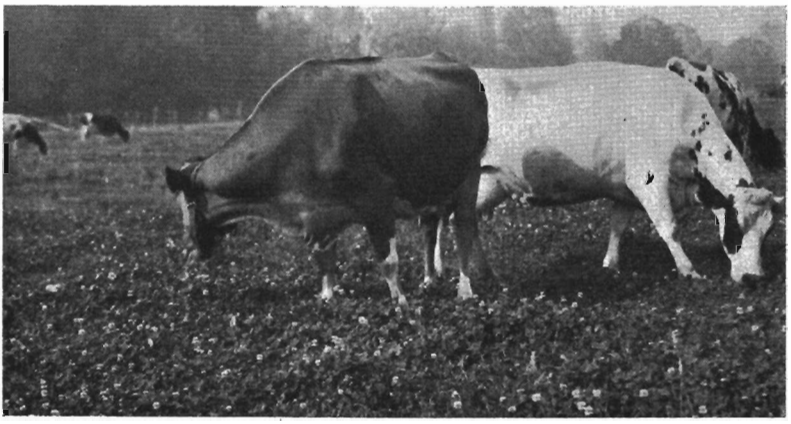

Figure 5. A close-up view of cows pasturing on Ladino clover. Note absence of grass after three and one-half months of pasturing.

Good pasture usually furnishes feed for the dairy cow at a lower price than any other farm crop. It is more economical than the other roughages, such as hay, silage, roots, and soiling crops, because of the higher yield and greater digestibility of the dry matter of pastures and because there are no harvesting costs and comparatively low seeding and tillage costs. In addition to supplying a low-cost feed, the barn labor cost of producing milk or butterfat is lower when cows have good pasture than when stall feeding of roughage is necessary.

In addition to supplying nutrients cheaply, pasture furnishes the right kind of nutrients for the good health, milk and butterfat production, and reproduction of the cow. Immature plants are much more palatable and the dry matter is higher in protein, minerals, and vitamins than are the same plants when more mature.

Pasture plants as eaten by the cow usually contain from 15 to 25 per cent dry matter. The high feeding value of pasture plants is indicated by the analysis of clippings made from an irrigated Ladino clover and grass pasture at the Oregon Agricultural Experiment Station throughout the entire pasture seasons from 1935 to 1938 inclusive.* The average analysis is given in Table 5. The pasture furnished from 4 to 5 tons of dry matter per acre, of which more than 3 tons were digestible and would be equivalent to about 6½ tons of alfalfa hay per acre or 284 bushels of oats per acre.

The growing season in the Willamette Valley is from 7½ to 8 months, along the coast of Oregon from 8½ to 9 months, and in the irrigated regions

* Oregon Agricultural Experiment Station Bulletin 366.

from 5 to 7 months. The limiting factor in realizing results from pastures during the entire growing season in most sections of the state is the lack of rainfall. To offset this deficiency, it is possible on many farms to utilize water from streams or wells in irrigating pastures and thereby realize greater returns from dairy herd operations.

Every dairyman in Oregon should consider carefully the possibilities of irrigated pasture crops for the dairy herd. He should compare the necessary cash outlay for an irrigation system with the expected returns.

Experimental results at the Oregon State College and actual results by dairymen in the state indicate that good irrigated pastures will carry two milking cows per acre for a season of at least 6 months when the cows are obtaining 75 to 85 per cent of their total feed requirements from the pasture. If 1 acre of pasture provides all the roughage the two cows can eat for 6 months and enables each of them to produce ¾ of a pound of butterfat daily, the returns per acre of pasture would be 6,750 pounds of 4 per cent milk or 270 pounds of butterfat. The annual gross returns per acre of pasture for butterfat at 25, 35, and 45 cents per pound would be $67.50, $94.50 and $121.50 respectively.

The annual total of all irrigation costs will usually range between $15 and $30 per acre of pasture. These costs include interest on the land and the irrigation system, depreciation, taxes, fertilizers, labor of irrigation, and fencing.

The annual returns above feed costs on pasture with good cows would thus be from $40 to $80 per acre of good irrigated pasture, depending upon the pasture costs and the selling price of butterfat.

The economy of feeding concentrates to dairy cows on pasture is a question that should be considered by every dairyman. It depends upon the level of production of the cows in the herd, the condition of the pasture, the price for which concentrates can be purchased, and the selling price of milk or butterfat.

On good pasture alone the dairy cow can maintain her body and produce about 0.8 pound of butterfat daily. Beyond this production concentrates should be fed at the rate of about 1 pound for each 0.1 pound of butterfat (2 pounds of 5 per cent milk or 2.5 pounds of 4 per cent milk). If the feeding of 8 pounds of concentrates daily will enable the cow to produce 40 pounds of milk testing 4 per cent butterfat instead of declining to 20 pounds daily without concentrates, then it pays to feed concentrates even at low butterfat prices. The concentrates fed will cost from 10 to 15 cents daily and the extra butterfat will be worth 20 cents with butterfat selling at 25 cents a pound.

A mixture of home-grown grains and wheat bran or mill run is economical and provides sufficient protein for cows producing more than 1 pound of butterfat daily on good pasture. As production increases to about 40 pounds of milk daily, it is necessary to add high protein feeds to the concentrate mixture. The dairyman and feed manufacturer should study feed prices and utilize those concentrates that furnish digestible nutrients at the lowest cost. Concentrate mixtures suitable for use with different types of pastures are given in Table 7 and a schedule for feeding in Table 8.

In times of low butterfat prices it is more than ever essential to keep accurate production records on individual cows in the herd and feed only those cows that have the ability to maintain high production or to respond to concentrate feeding by increasing production. When butterfat prices are high, even the poor cow may show a profit from concentrate feeding.

The dairy cow that freshens in good condition will produce for a limited time on pasture alone above the minimum indicated in Table 8 by taking the balance of the requirements from her body. The response to concentrate feed-

ing may not be immediately noticeable, but when considered on a lactation basis it is found to be profitable. Also, good-producing cows that receive concentrates on pastures calve for their next lactation in better condition and consequently start lactation at a much higher level of production. Cows will often increase in production when first turned on pasture even though the amount of concentrate is reduced. This increase in production is of short duration unless the nutritive requirements of the cow are met. Once the cow declines in production due to lack of feed, it is very difficult to restore the flow to the original amount.

Turning cattle on pasture too early in the spring tends to lower the returns from the pasture for the season. Likewise, pasturing too closely for any period during the year is not conducive to the largest returns. Pasture plants can grow only by having leaves above the ground in contact with the air and sunshine. If the grass is grazed too closely, its recovery is slow, and the yield of nutrients is considerably reduced. It pays to have pastures divided into three or more areas so that the dairy herd can be rotated, allowing the plants in each area to have a period of recovery.

Investigations with irrigated pastures at Oregon State College indicate that 3 or 4 weeks' growth between grazings gives the highest returns in nutrients per acre. If a pasture is grazed too frequently, it will not produce as much forage, and that produced will be lower in dry matter.

Most Oregon pastures can be markedly improved by fertilization. This is well indicated by the results obtained from an irrigated Ladino clover and grass pasture at the Oregon Experiment Station for the 5 years from 1934 to 1938 inclusive. On this particular pasture the addition of 300 pounds of 16 per cent superphosphate per acre increased the average yield of dry matter about 85 per cent over check areas. In terms of alfalfa hay equivalent on a total digestible nutrient basis, the increase was from 3.7 tons to 6.4 tons per acre. The addition of nitrate of soda, or nitrate of soda and potash with superphosphate, gave only slightly greater yields of dry matter than when phosphate alone was applied.

Concentrate feeds. The concentrate feeds are, as a group, considerably higher in energy value than are the roughages. Both concentrates and hay contain about the same amount of dry matter, but the concentrates are much lower in fiber and are higher in starches and sugars than are the hays. Upon feeding to livestock, it has been found that the starches and sugars are much more digestible than is fiber. As a result the concentrates contain 70 to 80 per cent total digestible nutrients, or energy value, as compared to about 50 per cent for hays. It is this difference in value that classifies feeds into concentrates and roughages.

The concentrates, including the farm grains, mill feeds, protein concentrates, and byproducts of various industries, show a considerable variation in their digestible protein and total digestible nutrient values. Those concentrates that are comparatively high in fiber, such as wheat bran, mill run, oats, and dried beet pulp, have total digestible nutrient values around 70 per cent, which is low for concentrates. Barley, corn, wheat, coconut meal, and the high protein concentrates, such as linseed, soybean, and peanut meal, usually have about 80 per cent total digestible nutrients.

Some feeds have a low total digestible nutrient value because they are very high in mineral ash content. The mineral matter in a feed is not considered in calculating its total digestible nutrient value. Fish meals, meat meals, and tankage usually have a high mineral content, which results in the total digestible

nutrient value being reduced to about the same level as that of oats and wheat bran.

If a particular feed is very high in fat, then the total digestible nutrient value is correspondingly increased. Thus some of the fat-bearing seeds, such as cottonseed and flaxseed, may have a total digestible nutrient value above 100 per cent due to the fact that their fat values are allowed 2¼ times as much energy as any of the other digestible constituents. (See explanation under "Fat.")

If a concentrate mixture of four or more feeds is made up, it will usually contain from 72 to 75 per cent of total digestible nutrients. The total digestible nutrient values of the mixtures recommended in Table 7 are indicated. The inclusion of minerals will reduce the total digestible nutrient value of the mixture. From what has been said, it is seen that 1 pound of hay of good quality is equal in total digestible nutrient value to about 0.7 of a pound of a concentrate mixture containing minerals.

The concentrates vary even more in the protein they carry than in their total digestible nutrient content. This variation is in amount, digestibility, and quality of protein.

The farm grains as a group are low in digestible protein, ranging from 7 to 10 per cent. Wheat bran and mill run contain 12 or 13 per cent, coconut meal about 20 per cent, and the high protein concentrates from 30 per cent for linseed oil to 35 or 40 per cent for soybean, cottonseed and peanut meals, and skim milk powder. Some of the proteins of animal origin, such as fish meal, meat meal, and tankage contain from 40 to 55 per cent digestible protein. Blood meal shows the very high digestible protein content of 70 to 80 per cent.

As previously discussed, the quality of protein in an individual feed depends upon the completeness with which it carries essential amino acids. Studies show a considerable variation in the value of different proteins for growth, maintenance, and lactation. These differences are often expressed as the biological value of the protein. The highest biological values are at present assigned to proteins of animal origin, with intermediate values for the legume seeds, and the lowest values for some of the cereal grains, peanut meal, and linseed meal.

Two feeds, when fed alone, may each have low biological values. However, if these two feeds are fed together, it is possible for the deficiencies of one to be supplemented by the other so that the mixture has a much higher biological value than either fed alone. For example, when corn and milk powder are fed together, the biological value of the two is much greater than would be expected by averaging the biological values when fed singly. The practical recommendation is to supply a variety of feeds in the mixture from different plant sources and thereby tend to supplement the deficiencies of one with another.

Inasmuch as the dairy cow is limited in the production she can make on roughages alone, it is very essential to provide concentrate feeds to balance the ration for high milk production. The basis of the concentrate ration should be the farm grains, barley, oats, wheat, corn, and the wheat milling byproducts. The grains usually provide nutrients at a comparatively low cost. Usually in formulating a concentrate mixture, farm grains are used in as large amounts as possible, but some of the high protein concentrates must be added when low protein roughages are fed in order to meet the cow's requirements. Suggested mixtures using amounts of the different concentrates for feeding with different roughages are given in Table 7.

FEEDING STANDARDS FOR DAIRY COWS

Previous to about 1870, almost nothing was known concerning the chemical analysis of plants and animals. The man feeding livestock previous to that time did not know what it was in the feed that satisfied their nutritive requirements. With the development of chemical and biochemical methods, science has been able to determine the composition of plants and indicate the usage the animal body makes of these plants in the form of body growth, fattening, maintenance, and in the case of the dairy cow, the production of milk and butterfat.

Most of our present-day feeding standards are based upon the digestible protein and total digestible nutrient requirements for various classes of livestock. Some standards, instead of using pounds of total digestible nutrients, use therms of net energy which, for practical purposes, are equivalent to total digestible nutrients.

Morrison feeding standard. At the present time the standard most commonly used in computing rations for dairy cows is that developed by Morrison.* According to this standard, definite amounts of digestible protein and total digestible nutrients are required by the cow daily, varying with the size of the cow and the amount and butterfat test of the milk.

In calculating the cow's ration, the first step is to determine the daily maintenance requirements by referring to Table 4, using the actual or estimated weight of the animal. To the digestible protein and total digestible nutrients needed for maintenance are added the amounts required according to the quantity and butterfat test of the milk the cow is producing as determined from Table 4.

As an illustration, let us assume that a cow weighs 900 pounds and is producing daily 34 pounds of milk testing 5 per cent butterfat. According to Table 4, this cow needs 0.59 pound of digestible protein and 7.23 pounds of total digestible nutrients for maintenance. From this table it is further noted that the cow needs 0.056 pound of digestible protein and 0.373 pound of total digestible nutrients for each pound of 5 per cent milk produced. For the 34 pounds of milk she requires 1.90 pounds of digestible protein and 12.68 pounds of total digestible nutrients. The figures for maintenance and milk production are usually set down in the following form and added together:

Requirements	Digestible protein	Total digestible nutrients
	Pounds	*Pounds*
For maintenance, 900-pound cow	0.59	7.23
For 34 pounds 5 per cent milk	1.90	12.68
Total daily requirement	2.49	19.91

Selection of the ration. In selecting the ration, one must know the amount of digestible protein and total digestible nutrients in feeds. As previously indicated, the total digestible nutrient content of a feed is the sum of the digestible protein, the digestible fiber, the digestible nitrogen-free extract, and the digestible fat. Inasmuch as fat gives 2¼ times as much energy value on being utilized by the animal body, the digestible fat is multiplied by 2¼ before being added to the remainder of the total digestible nutrients. The digestible

* *Feeds and Feeding*, 20th Edition 1938, F. B. Morrison.

protein and total digestible nutrient values of most commonly used feeds are given in Table 5.

In selecting a ration for the cow for which the requirements were determined above, let us assume that red clover hay, corn silage, barley, and oats are available on the farm. It is economical to feed all of the good-quality roughage the cow will consume and enough concentrates to balance the ration. In the case of the above cow, 15 pounds of clover hay and 30 pounds of corn silage would be about the expected consumption. This roughage supplies the following nutrients:

Feeds	Digestible protein	Total digestible nutrients
	Pounds	*Pounds*
15 pounds red clover hay	1.05	7.79
30 pounds corn silage	.39	5.61
Total supplied in roughage	1.44	13.40
To be supplied in concentrates	1.05	6.51

The roughage supplies enough nutrients to take care of the cow's maintenance requirements and to enable her to produce about 16 pounds of 5 per cent milk daily. The requirements for the remaining 18 pounds of milk must be met by concentrate feeding. In Table 7 will be found various concentrate mixtures suggested for feeding with different roughages. Those listed under Group C should provide the right amount of protein in the above example. Nine pounds of mixture Number 9 would balance this cow's ration as shown below:

BALANCED RATION

Feeds	Digestible protein	Total digestible nutrients
	Pounds	*Pounds*
15 pounds red clover hay	1.05	7.79
30 pounds corn silage	.39	5.61
9 pounds mixture No. 9, Table 7	1.20	6.62
Total supplied	2.64	20.02
Total required	2.49	19.91

In case the hay available is of poor quality such as bleached out, stemmy oats and vetch hay, the consumption may decrease to 10 to 14 pounds daily for a 1,000-pound cow. Such a cow would have to receive a much higher proportion of nutrients from concentrates than in the case of the cow fed high-quality alfalfa hay. If only a poor grade of hay is available, it should be fed liberally to cows in milk. Another means of aiding the consumption of low-quality roughage is to improve its palatability by sprinkling molasses diluted with water over it.

Most of the succulent feeds, such as good silages, most root crops, pastures, soiling crops such as green corn and alfalfa, and kale, are very palatable and if economical to grow may well form a part of the dairy cow's ration.

Some of the concentrate feeds are more palatable than others. Cows will become accustomed to most concentrates gradually included in their ration, however, provided they are free from mold, mustiness, and rancidity. Less palatable concentrates should be used in limited amounts in a mixture.

Cows like frequent changes in the ration, especially of the roughages. It has been a common experience that cows will show an increase in production when one roughage is substituted for or included with another that has been rather monotonously fed.

The ration selected should allow the cow in question to maintain the level of production indicated. In actual feeding practice the rations of individual cows are seldom calculated. Ordinarily the cows are allowed all the roughage they will consume, the concentrate mixture is made up to balance the protein content of the roughages for the average cow in the herd, and the cows are fed an amount of concentrates according to their level of production as shown in Table 8.

OTHER CHARACTERISTICS OF A GOOD RATION

In the formulation of a ration that has the proper amount of digestible protein and total digestible nutrients, there are certain other factors that should be taken into consideration.

Palatability. The ration fed should be palatable to the cow if profitable production is to be obtained. If unpalatable the cow will limit her feed consumption, resulting in reduced milk production. Particularly the roughages should be palatable, as they form the most economical part of the ration. Cows fed the finest quality of alfalfa hay as the only roughage will consume about 3 pounds daily per 100 pounds of live weight, or about 30 pounds daily for a 1,000-pound cow. If the cow is fed 30 pounds of palatable silage daily, the alfalfa hay consumption will decrease to about 20 pounds daily.

Variety. As discussed under the topics of proteins, minerals, and vitamins, it is desirable to have as many good feeds in the ration as economically possible. Each feed differs in composition and a variety gives greater assurance of providing adequate amounts of essential amino acids, minerals, and vitamins. It is desirable to make the concentrate mixture from at least four plant sources. A ration containing a variety of feeds is usually more palatable to the cow.

Bulk. Nature has provided the cow and other ruminants with a digestive system adapted to utilizing large amounts of bulky feeds. In order to insure proper functioning of the digestive tract, the ration must contain sufficient bulk. Too heavy a concentrate mixture is apt to cause cows to go off feed. The grinding of farm grains too finely is not desirable if they are to form a high percentage of the concentrate mixture. The weight per quart of some of the common concentrates is given in Table 9.

It should be pointed out that the ration may be too bulky for the best results. This would be true if the roughage were more or less limited to succulent feeds, such as the root crops, apples, kale, squash, and early spring pasture, which are low in dry-matter content. A cow might eat to her capacity of 100 to 150 pounds daily of the succulent feeds high in water content, but because of the low dry matter and digestible nutrient value, she would decline in production. For the best results succulent feeds high in water should be limited to about 3 pounds daily per 100 pounds body weight. As previously discussed, silage crops may be fed in larger amounts.

Physiological effects. The dairy cow's ration should keep her in good physical condition. Some feeds are laxative and some constipating in effect.

Rations causing either extreme are not desirable. Overfeeding on some of the succulent feeds, linseed oil meal, molasses, and other laxative feeds is not desirable. A ration of dry hay and heavy grain may cause constipation. Linseed oil meal in the ration is a good conditioner and causes the cow's hair to become soft and glossy and enables her to place soft fat on the body when not milking. The complete ration should be mildly laxative. This is especially true at calving time.

Cost of the ration. Studies made in Oregon* show that feed cost is about one-half of the total cost of milk and butterfat production. In many cases the feed cost can be reduced by utilizing available information on the most profitable feeds to grow in different localities, on different soil types, and under various climatic conditions. Usually roughages and farm grains can be more economically grown than purchased. Legume hays grown on the farm are desirable because it is then not necessary to purchase a large amount of high-priced protein concentrates. This is illustrated by a study of the mixtures given in Table 7. The availability of good pastures either with or without irrigation is closely related to low production costs.

A study of Table 5 will give an understanding of the comparative value of feeds. This should be carefully considered in determining the crops to grow and the feeds to purchase.

The costs per pound of digestible protein and total digestible nutrients of some of the common feeds are given in Table 6. *For reasons of simplicity, all feeds are valued at the same price basis of $1.00 per ton.* In making a comparison of the cost of nutrients provided by various feeds it is only necessary to multiply the figures given by the actual price per ton of the feeds being considered.

MINERALS FOR DAIRY CATTLE

The question as to whether or not dairy cows need supplementary minerals in their feed is one upon which there has been much discussion within recent years. It is known that dairy farmers of the state spend many thousands of dollars annually for complex mineral mixtures, some of which sell for exorbitant prices without their use being based upon positive experimental evidence.

While it is true that the dairy cow requires a very large number of the known mineral elements for body maintenance, milk production, and reproduction, there are only five likely to be deficient in practical farm rations of dairy cattle; namely, sodium and chlorine (common salt), iodine, calcium, and phosphorus.

Undoubtedly with the early domestication of dairy cattle, there were sufficient minerals in the feed to take care of the requirements of the cow. However, with the large increase in the amount of milk given by the highly developed dairy cow of today, the question of supplementary mineral feeding does have some basis for discussion. Not only has there been a tremendous increase in the average milk production per cow, causing a greater mineral requirement, but the feeds supplied the cow today are, in many cases, grown on soils depleted in some of the essential mineral elements, thereby resulting in a deficiency of minerals in the crop grown on such soils. No investigation to date, except in certain restricted regions, has shown, however, that mineral elements

* Oregon Agricultural Experiment Station Bulletin 318.

other than those indicated above are necessary beyond that found in the average dairy cow's ration.

Common salt. The feeding of common salt to dairy cattle is almost a universal practice. Salt is a compound made up of sodium and chlorine, both of which are needed in the blood and body cells. Chlorine is also used in making hydrochloric acid in digestive juices especially needed in the digestion of the roughage-type feeds. Milk contains a high percentage of sodium and chlorine, thus the cow in milk has a higher requirement than the dry cow. On the average, the dairy cow needs about ¾ of an ounce of salt daily per 1,000 pounds live weight, and about ⅓ of an ounce in addition for each 10 pounds of milk produced. The average producing cow would, therefore, require 30 to 35 pounds of supplementary salt in a year.

Salt should be put in a box in the exercise lot or pasture where the cows have free access to it, even though it is also mixed with the feed. A good method is to include 1 per cent of salt in the concentrate mixture and allow the cows to have free access to any additional salt that they require. If cows do not receive adequate salt for a long period of time, a complete breakdown is likely to occur. This will be marked by a rapid decline in live weight and in yield of milk, a loss of appetite or a depraved appetite, a rough coat, and low vitality in general. If salt is gradually supplied, recovery is rapid.

Iodine. A small amount of iodine is necessary in the ration of dairy cattle for the proper functioning of the thyroid gland. If a ration deficient in iodine is fed to pregnant dairy cows, it is evidenced by the appearance of goiter in the calves. There are some areas in Oregon where goiter has been observed. Where an iodine deficiency is evidenced by the appearance of goiter, it can be overcome by the feeding of iodized salt (1 ounce potassium iodide in 300 pounds salt). Some people prefer to feed the potassium iodide in solution form. This can be prepared by dissolving 3 ounces of potassium iodide in 1 gallon of water and feeding 1 tablespoonful of the solution to all pregnant animals in the herd once a week. The solution is best fed by sprinkling on the grain.

Calcium and phosphorus. Calcium and phosphorus make up about 90 per cent of the minerals of the body and constitute nearly 50 per cent of the minerals in milk. If these elements are not supplied in or assimilated from the ration, the cow in heavy milk will take them from her skeleton for a time, but eventually the bones become depleted and milk production decreases. The assimilation of calcium and phosphorus is dependent upon an adequate supply of vitamin D in the ration or its equivalent in direct sunshine (see discussion under Vitamin D).

According to the analyses of feeds grown in Oregon, the element most likely to be deficient is phosphorus. In those areas where it is known that soils are lacking in phosphorus, as evidenced by a large increase in yield when phosphate fertilizer is applied, it is possible that crops grown are relatively low in this element.

A study of Table 5 will show that the roughages are comparatively low in phosphorus regardless of the type of soil upon which they are grown. This is also true of the cereal grains, such as barley and oats. The best sources of phosphorus in the average ration as fed under Oregon conditions are wheat bran or mill run and the high protein concentrates, such as cottonseed, linseed, soybean, peanut, and fish meals.

If the ration fed consists almost entirely of home-grown roughages, regardless of what these may be, and limited amounts of the cereal grains, such as barley, oats, and corn, there may be a phosphorus deficiency. In case the concentrate mixture fed contains a liberal amount of wheat bran or mill run or the high protein feeds, there is probably little need for additional phosphorus in the form of a mineral supplement.

If the ration gives indications from its analysis or feeding that it is deficient in either calcium or phosphorus, or both, sterilized bone flour especially prepared for cattle feeding is recommended. A good bone flour is usually light colored, palatable, and free from any disease germs. If it has a bad odor, it is unpalatable and not suitable for dairy cattle feeding. Raw rock phosphate is not recommended, because experiments have shown that it contains fluorine that is detrimental to the health of animals consuming it.

Dicalcium phosphate preparations have been fed experimentally and found satisfactory. Likewise, in areas where phosphorus alone is deficient, disodium phosphate has been fed with good results. Spent bone black, a bone meal by-product of the sugar-refining industry, is comparable to sterilized bone flour. The cost of the phosphorus supplied is usually the best guide as to which mineral supplement to purchase.

There is no conclusive evidence that dairy rations in widespread areas of Oregon are deficient in calcium. Ground limestone is high in calcium, but does not contain phosphorus. Its use might be indicated in areas where the ration consists solely of grass hays or cereal straws and the farm grains. In case legume hays are fed, there is never likely to be a calcium deficiency.

If it is decided that the feeding of a calcium and phosphorus supplement is desirable on a particular dairy farm, it is believed that this is best fed by placing sterilized bone flour in a box protected from rain and wind in the exercise yard or corral where the cows have free access to it. If the product is of good quality the cow's appetite is probably a helpful guide in determining the need for additional calcium and phosphorus. The rather common practices of mixing bone flour with salt or including it as 1 or 2 per cent of the concentrate mixtures may be acceptable in high-producing herds fed legume hays and home-grown grains. In other herds of lower producing ability or where large amounts of mill feeds and high protein concentrates are used, the forced consumption of additional calcium and phosphorus supplements has not been demonstrated as necessary or economical.

Complex mineral mixtures. Many mineral mixtures of unknown composition are being offered for sale to dairymen. They are often low in their guaranteed phosphorus content. The cost per pound of phosphorus in these mixtures should be compared with that of bone meal. Such mixtures may contain a combination of various minerals including bone meal, limestone, common salt, copperas, sulphur, Glauber's salt, potassium iodide, wood ashes, and charcoal. Studies at some of the experiment stations have shown that such mixtures may be detrimental to the health of animals consuming them over a long period of time. Thus, the Michigan Agricultural Experiment Station* recommends that "Mineral mixture containing Glauber's salt, Epsom salts, copperas, and sulphur should never be fed to dairy cattle as part of their daily ration. These minerals are medicines and should be used accordingly."

* Michigan Experiment Station Circular Bulletin 95.

VITAMINS FOR DAIRY CATTLE

From the information available, it would seem that good dairy cattle rations are not apt to be deficient in the vitamins essential for normal nutrition. The functions of the vitamins have been studied for many species and their occurrence in many feeds determined.

Vitamin A. Vitamin A is essential for growth, well-being, and reproduction of dairy cattle. A deficiency of vitamin A allows the development of infections of the mucous membranes of the body.

Vitamin A is colorless. Dairy cows change more or less of the carotene, precursor of vitamin A, found in green feeds, silage, carrots, etc., into colorless vitamin A. The vitamin A and carotene content of milk and butterfat increases with an increase in the amount of carotene in the ration fed. The amount of carotene changed over to vitamin A is greater with some breeds than with others. The carotene in milk can be converted into vitamin A in the animal or human body with varying degrees of efficiency.

Vitamin A and carotene are easily destroyed by oxidation. Feeds exposed to sun and rain lose much of their vitamin A and carotene. If vitamin A supplements, such as cod liver oil, are mixed with feeds, the vitamin A is largely destroyed by oxidation in a period of about 4 weeks. Hay stored in the barn, and especially loose hay, may lose from 50 to 75 per cent of its carotene in a storage period of 5 to 6 months.

If the dairy herd has access to green pasture during the summer months and is fed a good quality of green, leafy hay or silage made from green plants during the winter months, there will not be a vitamin A deficiency. On the other hand, if the dairy cow is stall-fed throughout the year with hay that is coarse, stemmy, and lacking in leaves and color, there may be a deficiency of vitamin A sufficient to cause poor reproductive behavior and lactation and difficulties in growing calves. The milk produced by such cows would not have a high vitamin A value.

Vitamin B complex. The original vitamin B has been found to consist of a number of different vitamins with distinct functions. At least three of these have been chemically identified and are known as thiamin, nicotinic acid, and riboflavin. Whole grains, pasture, silage, and well-cured hay are good sources of the vitamin B complex. Cows also have the ability to synthesize at least some of the B vitamins in the rumen. The vitamin B complex apparently presents no problem in the adequate nutrition of dairy cows.

Vitamin C. Vitamin C has been chemically identified and is known in its pure form as ascorbic acid. Green forages are good sources of vitamin C, but it is largely destroyed during the curing process. The cow can synthesize vitamin C from other substances in the feed. There is no conclusive evidence that cows fed normal rations require supplementary vitamin C.

Vitamin D. Vitamin D, usually known as the antirachitic vitamin, or its equivalent in direct sunshine is necessary in the rations of dairy cattle. Its presence in feed enables animals to assimilate properly calcium and phosphorus. The requirement for vitamin D is large during the growing period, and therefore it is especially important in the rations of dairy calves. There is an increased need for vitamin D in the ration of the pregnant cow to enable her to supply the growing fetus. During lactation there is a heavy demand for this vitamin, inasmuch as milk is high in both calcium and phosphorus.

Vitamin D is directly related to light. Most common feeds contain a compound known as ergosterol, which upon exposure to sunshine or ultraviolet radiation is converted into vitamin D. The effect of exposing animals to direct sunlight is to change traces of ergosterol in the body tissues to vitamin D. Summer sunshine is much more effective than that of winter. Livestock will be amply provided with vitamin D by exposure to direct sunshine in the summer, but in the northern latitudes this may not be adequate during the winter.

Growing plants do not contain vitamin D. The same plants cured in the sun, however, will contain vitamin D. The cereal grains, other seeds, roots, and tubers contain practically no vitamin D. The main place of vitamin D storage in the body is in the liver and one of the main supplementary sources is fish liver oil.

There has been considerable interest in recent years in the production of vitamin D milk. This milk can be prepared by several methods, such as by feeding irradiated yeast to cows, by the direct irradiation of milk with ultraviolet light, and by adding a potent vitamin D concentrate directly to milk. The reception of vitamin D milk by consumers and the medical profession indicates its value, especially for children.

If the ration fed to cows contains some sun-cured forage, there will be no particular advantage to the animals themselves from the feeding of vitamin D supplements. Recent experiments indicate that the heavy feeding of cod liver oil to dairy cattle may not be desirable. Excess feeding of such oil results in a decrease in butterfat test and may cause heart lesions, particularly in young animals. It would seem that if vitamin D deficiency is suspected, the feeding of hay cured in the sun would be more desirable than the feeding of large amounts of cod liver oil. Limited amounts of fish liver oils have been fed to dairy calves with good results.

Vitamin E. Vitamin E is a fat-soluble vitamin, the chemical composition of which is now known. It is essential for reproduction in some species. It is widely distributed in feeds, being abundant in whole grains, green grass, and good hay. Wheat germ oil is a rich source. The need for supplementary vitamin E in the rations of dairy cattle has not been clearly demonstrated.

GENERAL CONSIDERATIONS IN FEEDING

Grinding grains. Experimental evidence shows that it pays to grind grain for dairy cows to a medium fineness. Cows fail to masticate properly whole grains, such as barley and oats, so that there is a loss of 10 to 20 per cent in feeding unground grains. Medium fine grains are more palatable and digestible to cows than finely ground grains. Limited experimental evidence indicates that medium fine ground grain is superior to rolled grain for livestock feeding. Ground grains are more palatable in a concentrate mixture than whole grains and result in greater milk production. It is ordinarily economical to grind grain for dairy cows at a cost equal to 10 per cent of the cost of the grain.

Chopping or grinding hay. The chopping, or grinding, of a good quality hay is not economical. Hay is not made more digestible by chopping and the amount of waste is small with good hay. Also, chopped hay is dusty and is objectionable to feed in a milking barn.

Cows will eat more of a coarse, stemmy hay and waste less if it is chopped. Chopping may be advisable if hay prices are high and the cost of chopping low.

Inasmuch as considerably less storage space is required, it may be desirable to chop hay under certain conditions.

Processing feeds. Various systems of cooking, processing, and predigesting feeds, especially hays, have been tried. In no case has such processing proved economical. The expense and labor involved are entirely too great to be offset by the small increase in palatability and roughage consumption.

Addition of molasses. If the hays or other forages available for feeding are coarse and of poor quality, their palatability and consumption may be increased by sprinkling them with a mixture of about 1 part of molasses to 3 or 4 parts of water.

Regularity in feeding. The dairy cow is a creature of habit and does best when fed at regular intervals. A system of feeding that gives good results is to feed the concentrates before or at the time of milking, any succulent feed such as silage, roots, or kale immediately after milking, and hay after the succulent feeds are cleaned up. If milking is done three or four times daily, concentrates should be fed at the same time. It may be desirable to feed a heavy concentrate mixture on top of the silage.

FEEDING AND CARE OF THE DAIRY COW BEFORE AND FOLLOWING CALVING

It pays to give the dairy cow a rest period of 6 weeks to 2 months between lactations. The actual length of time necessary will depend upon the condition of the cow and the amount of milk she is producing. Two months should be allowed a cow in poor flesh or a heavy producer, so that she will have plenty of time to replenish body reserves of fat, minerals, and vitamins for the ensuing lactation. Investigations have shown that a cow will produce more milk in the subsequent lactation as the length of the dry period is increased, up to approximately two months providing she is well fed during the dry period.

Feeding the dry cow. Ordinarily cows lose weight for 3 to 6 weeks after calving because they cannot consume enough feed to meet the requirements for body maintenance and milk production. It is necessary, therefore, that the cow be fed so as to put on considerable flesh previous to calving. Also, cows that calve in good condition will start at and maintain a higher level of production than cows that calve in a thin condition. The stimulus to produce milk is much more pronounced in early lactation and unless the cow starts milking at a fairly high level, the total production for the year will be low.

Dry cows can be fed the same roughages as if in milk. The amount of concentrates to feed will depend on the quality of the available roughages and the condition of the cow. With good roughage, such as alfalfa or clover hay and silage, or good pasture, the cow will put on considerable flesh if 5 or 6 pounds of concentrates are fed daily. The ordinary farm grains or the low protein concentrate mixtures indicated in Table 7 under Group A are entirely satisfactory regardless of the kind of roughage available. About 1 week before calving the concentrate allowance should be reduced to 1 or 2 pounds daily of the bulky feeds such as wheat bran and ground oats.

Feeding the cow after calving. A mash of bran and warm water is recommended for a few days at calving time. Along with this she can be

allowed all the hay she wants and a small amount of silage. The drinking water should be warmed slightly if the weather is cold. For a few days following calving the concentrate allowance should be limited to 1 or 2 pounds of a laxative mixture. A mixture of 200 pounds ground oats, 200 pounds bran, and 100 pounds linseed oil meal meets these requirements.

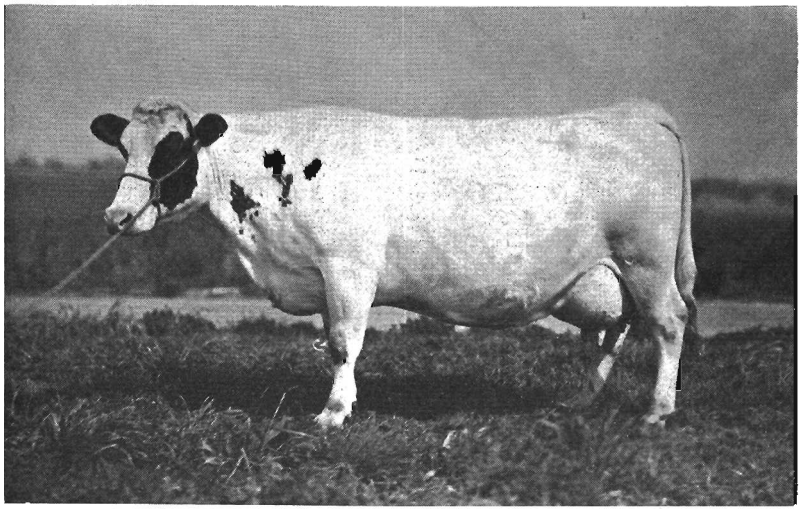

Figure 6. A high producing 5-year-old Ayrshire cow 4 days before calving showing good condition following a dry period of 7 weeks when she was fed all the good hay and corn silage she would eat and about 6 pounds of grain daily. Her production of 14,132 pounds of milk and 686 pounds of butterfat in the ensuing lactation indicates the value of her adequate feeding during the dry period.

The calf is usually left with the cow until the end of the second or the beginning of the third day. It is desirable not to remove all the milk from the udder for a day or two following calving as this may help to prevent milk fever.

Needless to say, the cow that calves during the winter months should be placed in a well-bedded stall. Normally, she can be returned to her stanchion on about the third day after calving. In any case, the calf should receive the colostrum or first milk of the mother.

Getting the cow on full feed. The cow can be fed as much roughage as she will eat at any time following calving, but the amount of concentrates given should be increased very gradually. It is impossible to say just how long one should take in getting a particular cow on full feed because it will vary with the individual cow. With a good cow it may take a period of about 3 weeks to get her on full feed and with a heavy-producing cow even 1 month. It is much better to go too slowly in increasing the concentrate allowance than to cause digestive disturbances by increasing it too rapidly. It is to be expected that a good cow will lose weight for several weeks following calving, and this is the main reason that the cow should have received concentrates during the dry period in sufficient amount for her to put considerable flesh on her body.

SCHEDULE OF CONCENTRATE FEEDING WITH EXCELLENT ROUGHAGE

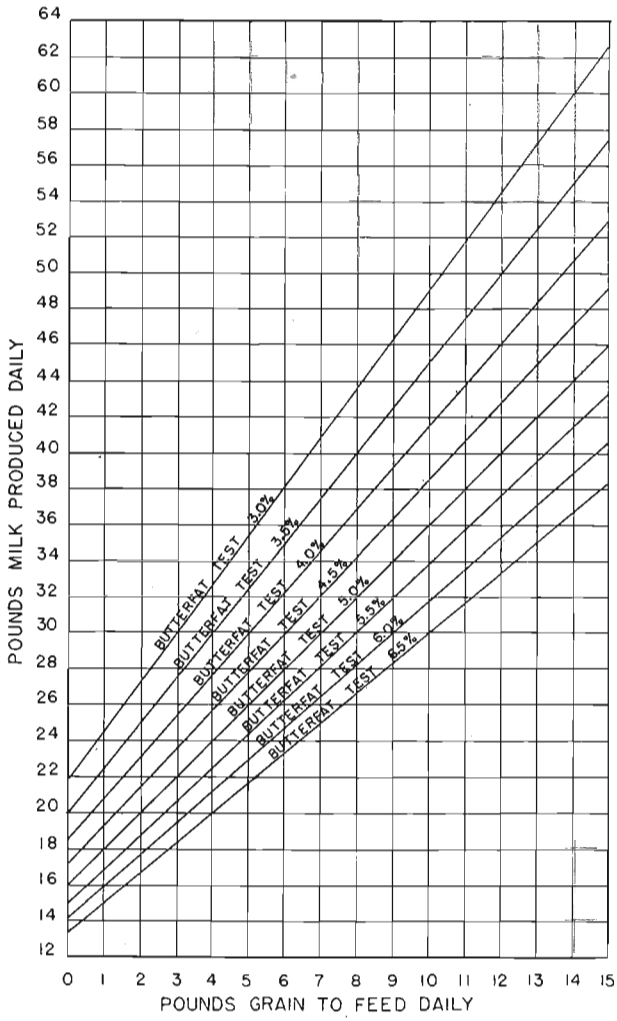

Figure 7. The point of intersection of the lines indicating the POUNDS OF MILK PRODUCED DAILY and the BUTTERFAT TEST of the milk will give the POUNDS OF GRAIN TO FEED DAILY along with all the excellent quality roughage (hay or pasture) the cow will eat. For example a cow producing 32 pounds of 5 per cent milk or 40 pounds of 3.5 per cent milk would need 8 pounds of concentrates daily.

Ordinarily, one can feed 3 or 4 pounds of a concentrate mixture on about the fifth day following freshening, and this can be increased at the rate of about 1 pound every 2 or 3 days until the cow reaches her maximum production. Some cows are very good feeders and will be able to consume more concentrates than they actually require for the amount of milk they are producing. Other cows will not be able to consume a sufficient quantity to meet their productive requirements.

CONCENTRATE FEEDING

Schedule. Too often dairymen follow the practice of feeding all cows in milk the same amount of concentrates when for most economical results each cow should be fed as an individual. When cows are not fed as individuals the low-producing animal is usually overfed and the high producer underfed. The low producer in such cases will ordinarily reduce the consumption of roughages or put on body fat, which is uneconomical during the lactating period. The high producer will of necessity decline in production due to insufficient nutrients for maximum production.

In feeding practice the dairyman should consider both the production and condition of the individual cows. Cows vary in their ability to consume roughages and may require a larger or smaller amount of concentrates to maintain production and good condition than is indicated by average feeding schedules. Some cows do not have the capacity to consume the necessary amount of concentrates to balance their ration. In no case should more concentrates be fed a cow than she can eat and digest without going off feed regardless of the amount required. It is preferable to keep the cow a little hungry than to overfeed her. In case she does go off feed all concentrates should be withheld for two or three feedings, laxative roughages should be supplied, and the concentrates replaced in her ration very gradually.

The concentrate allowance can only be accurately determined by weighing. The additional time required for weighing is negligible considering the advantages. If the concentrate is fed by measure, the weight of a definite measure such as 1 or 2 quarts should be determined and the cow fed accordingly. The weight per quart of some of the commonly fed concentrates is given in Table 9.

A schedule of concentrate feeding is given in Table 8 for cows receiving excellent and fair roughages. The schedule of feeding with excellent roughages is graphically shown in Figure 7. Excellent roughage might consist of luxuriant pasture either irrigated or on subirrigated bottom lands, or fine stemmed, leafy, legume hay such as U. S. No. 1 alfalfa or clover. The ration might include a limited amount of succulent feeds. It may be expected that the cow will consume from 2½ to 3 pounds of hay, or hay equivalent, daily per 100 pounds of live weight of so-called excellent roughage.

Fair roughage might consist of average pasture or U. S. No. 2 alfalfa or clover, or U. S. No. 1 grass hay with limited amounts of succulent feeds. A cow may be expected to consume about 2 pounds of such hay, or hay equivalent, daily per 100 pounds of live weight. It will be noted in Table 8 that a cow fed fair roughage rather than excellent roughage requires the feeding of 4 additional pounds of concentrates daily to produce the same amount of milk.

Economy of concentrate feeding. It is evident from a study of Table 8 that an increase in the amount of concentrate fed is expected to result in increased milk flow with good cows, the rate of increase being greater with cows

of low butterfat test than with high test. It is further evident that the economy of concentrate feeding is directly related to the quality and quantity of the roughage and the cost of the concentrate, as well as the selling price of the milk or butterfat.

It will be noted from Table 8 that on the average an increase of 1 pound of concentrate is expected to bring about an increase of about 0.1 pound of butterfat, or 10 pounds of concentrates per pound of butterfat. If the concentrate costs as much as $40 a ton, or 2 cents a pound, and the selling price of butterfat is only 20 cents a pound, the increase in butterfat will just pay for the feed. If the concentrate-butterfat price ratio is very favorable such as with concentrates worth $20 a ton, or 1 cent a pound, and with butterfat selling at 40 cents a pound, heavy concentrate feeding is very profitable inasmuch as every dollar expended for concentrate would bring a return of $4 in additional butterfat.

The fact that a good dairy cow can consume on the average only enough excellent quality roughage to maintain her body and produce, for example, 16 pounds of 5 per cent milk, indicates the economy of feeding 10 pounds of concentrates daily so that she has the necessary nutrients to produce 36 pounds of 5 per cent milk. The additional production of 20 pounds of milk and 1 pound of butterfat should be credited to the 10 pounds of concentrates alone.

Concentrate feeding is economical if the cost of concentrates in dollars per ton is a little less than twice the selling price of butterfat in cents per pound. This means that when butterfat sells for 30 cents a pound, it would be economical to feed concentrates costing almost up to $60 a ton. As previously indicated, an additional pound of butterfat should result from each 10 pounds of concentrate consumed by a good cow in the early part of her lactation. Ten pounds of concentrates at $34 a ton would cost 17 cents and the return in butterfat would be 30 cents, indicating that it pays well to feed concentrates to good cows to the limit of their inherited capacity.

COMMERCIAL DAIRY FEEDS

The manufacture of commercial mixed feeds is an important industry in the United States as a whole and in Oregon. The largest tonnages of such feed are made for dairy cattle and poultry consumption.

Oregon commercial feeding stuffs law. The Oregon Commercial Feeding Stuffs Law regulates all feeds used for feeding livestock and poultry, except the whole seeds or grains and the unmixed meals made from the same. It also does not include the roughage type of feeds, such as hay and straw, or the succulent feeds.

Any mixed feed offered for sale in Oregon must be registered with the State Department of Agriculture along with a bona fide sample of the feed to be sold. In addition, the product offered for sale or distributed within the state must be labeled or have a tag fastened to the sack giving the following information: the net weight of the contents of the sack; the name, brand, or trademark; the name and address of the manufacturer; the minimum percentage of crude protein and of crude fat; the maximum percentage of crude fiber and ash; and the specific name of each ingredient used in the manufacture of the feed.

It is the duty of the State Department of Agriculture to sample and analyze each brand of commercial mixed feed offered for sale, and any manufacturer selling feeds not meeting the requirements as set by law is subject to

fine. It should also be pointed out that the Department of Agriculture may refuse to register any feed under a brand name that tends to mislead or when all the ingredients indicated as being used in its manufacture are not present.

The Oregon Commercial Feeding Stuffs Law prohibits the sale of adulterated feeds, such as buckwheat hulls, corn cobs, ground straw, moldy or decayed feed, mill or elevator sweepings or dust, or any deleterious or worthless ingredients.

Furthermore, the law requires that no manufacturer shall offer for sale any feeds containing more than 12 per cent crude fiber unless the manufacturer shall designate the percentage of each ingredient of the mixed feed contained in the sack.

Dairymen should acquaint themselves with the provisions of the Oregon Commercial Feeding Stuffs Law by requesting a copy of the law from the State Department of Agriculture, Salem, Oregon. Dairymen may also request that their names be placed on the mailing list to receive the Oregon State Department of Agriculture monthly bulletin, which includes the results of commercial feed analyses.

Buying commercial mixed feeds. Most of the commercial mixed feeds on the market are made of good ingredients by honest and intelligent manufacturers and give good results when properly chosen by the dairyman for his dairy herd.

There is probably no one best commercial mixed dairy feed. There are many mixtures that give excellent results when fed with the type of roughage for which they are fitted. In actual practice most feed manufacturers vary the amount of different ingredients from time to time as prices vary, because in this way they can sell the feed at a lower price and still retain a high-quality mixture.

Figure 8. Each cow's concentrate allowance should be weighed at each feeding.

Commercial mixed feeds will have more variety than the dairyman will usually have in a mixture he might make on the farm. This variety usually means greater palatability and a better possibility of supplementary protein values.

The main consideration as to whether dairy feeds should be purchased as mixed feeds or mixed on the farm is that of price. If the herd is small and all the feed has to be purchased, there is a question as to whether or not it pays to mix the feed at home unless labor is plentiful and no reliable commercial mixed feed is available. In the case of the large herd when practically all the feeds have to be purchased, there is probably no great advantage in home mixing because the feed manufacturer buys in large quantities and is able to sell to the dairymen at only a small profit above the mixing cost. On the other hand, if a considerable amount of home-grown grains is available and facilities for grinding are at hand, the careful selection of the ingredients necessary to balance the ration and the mixing at home is desirable.

The feed mill usually does a better job of mixing than can possibly be done on the farm where a feed mixer is not available. When one realizes that such feeds as oats and barley containing about 9 per cent of crude protein are mixed with high protein concentrates, such as cottonseed or soybean meal with 43 per cent of protein, it is easy to appreciate that these should be well mixed before being fed to the dairy cow. Many dairymen take their own grains to feed mills for grinding and mixing with the mill feeds and high protein concentrates necessary for feeding with the roughages available.

What to look for on the feed tag. The dairyman should carefully study the feed tags of mixtures he is contemplating purchasing. In the first place he should buy feed based on its crude protein content. The crude protein content of a concentrate mixture is the most expensive part for the manufacturer to furnish and must be taken into consideration by the dairyman in determining the proper ration for his cows. The amount of protein necessary for feeding with various types of roughages is discussed elsewhere in this bulletin. (See page 13). *There is no necessity to pay more money to buy a higher percentage protein mixture than required.*

The fat content of feed is very important. A pound of digestible fat furnishes 2¼ times as much energy as a pound of digestible starch or sugar. The value of fat in the ration of dairy cows in maintaining production has been previously discussed. (See page 14).

Usually the lower the fiber content of a feed, the higher is its total digestible nutrient value. Any mixed feed carrying as much as 10 per cent crude fiber should be studied carefully and the ingredients noted before purchasing. Some manufacturers use a large amount of beet pulp or alfalfa meal, which may cause the mixture to be fairly high in fiber even though the balance of the ingredients may be of high grade. However, it should be remembered that alfalfa meal is not classed as a concentrate but is a roughage.

The ash or mineral content of mixed feeds should be compared. If the mixture includes salt and bone flour, the mineral content will be increased by the percentage of these added.

There are some concentrates that are not desirable to include in mixed feeds. The dairyman should acquaint himself with the digestibility of feeds. Cocoa meal and hemp seed meal are examples of undesirable additions to a concentrate mixture because of their low digestibility. Only 37 per cent of the

protein in cocoa meal and 40 per cent of the nitrogen-free extract are digestible. In the case of hemp seed meal only 12 per cent of the fiber and 15 per cent of the nitrogen-free extract are digestible. Therefore, the total digestible nutrient value of hemp seed meal is 45 per cent, which is about 5 per cent lower than that of the average hay.

It would seem that a man feeding dairy cows should acquaint himself with the Oregon Commercial Feeding Stuffs Law, with the average analysis and digestibility of feeds, and with what he should look for on the feed tag before buying commercial mixed dairy feeds. If it is decided that in the particular case it is wise to buy mixed feeds rather than to prepare the mixture on the farm, then the product of a reliable manufacturer should be selected, keeping in mind that it is not always the cheapest feed that is the most economical to purchase.

Appendix

Table 4. MORRISON FEEDING STANDARDS FOR DAIRY COWS*

	Digestible protein	Total digestible nutrients
	Pounds	*Pounds*
A. *For Maintenance* (Per head daily)		
700-pound cow	0.476	5.81
800-pound cow	.536	6.53
900-pound cow	.593	7.23
1,000-pound cow	.650	7.93
1,100-pound cow	.706	8.61
1,200-pound cow	.762	9.29
1,300-pound cow	.817	9.97
1,400-pound cow	.872	10.63
1,500-pound cow	.925	11.28
B. *For milk production per pound of milk* (To be added to maintenance requirement)		
For 2.5-per-cent milk	0.040	0.251
For 3.0-per-cent milk	.043	.276
For 3.5-per-cent milk	.046	.300
For 4.0-per-cent milk	.049	.324
For 4.5-per-cent milk	.052	.349
For 5.0-per-cent milk	.056	.373
For 5.5-per-cent milk	.059	.397
For 6.0-per-cent milk	.062	.422
For 6.5-per-cent milk	.065	.446
For 7.0-per-cent milk	.068	.470

* Taken by special permission of the Morrison Publishing Company, Ithaca, New York, from *Feeds and Feeding,* 20th Edition, by F. B. Morrison.

Table 5. AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS OF FEEDS

Feeds	Digestible protein	Total digestible nutrients	Calcium	Phosphorus	Dry matter	Crude protein	Fat	Fiber	Nitrogen-free extract	Ash
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Concentrates										
Babassu meal	18.6	74.7	.....	.....	89.7	22.4	6.4	11.8	44.2	4.9
*Barley	7.5	78.8	0.05	0.36	90.0	9.5	2.0	6.0	69.9	2.6
Beet pulp, dried, molasses	6.1	74.3	.52	.07	91.8	9.9	0.7	15.9	60.1	5.2
Blood meal	70.7	75.9	.33	.26	91.2	82.2	1.2	1.3	2.7	3.8
Brewers' grains, dried	20.7	65.3	.25	.47	92.8	25.6	6.7	14.8	42.0	3.7
Buttermilk	3.3	9.1	.18	.10	9.4	3.5	.6	.....	4.5	.8
Cocoa meal	9.0	60.7	.....	.....	96.0	24.3	17.1	5.1	43.7	5.8
Coconut meal	18.7	80.8	.21	.62	90.7	20.8	8.2	10.4	45.0	6.3
*Corn, dent, No. 2	7.2	81.5	.02	.27	86.0	9.5	4.0	2.2	69.0	1.3
Corn, gluten meal	36.5	81.8	.03	.38	91.5	42.9	2.3	2.5	42.0	1.8
Cottonseed meal, 41 per cent protein	33.9	73.6	.20	1.19	92.8	41.9	7.0	10.8	27.2	5.9
*Fish meal, herring	56.4	74.3	4.20	2.80	92.5	69.6	6.4	1.2	4.0	11.3
*Fish meal, pilchard	54.4	72.0	4.20	2.80	92.5	67.1	5.4	.9	6.9	12.2
*Fish meal, salmon	44.5	73.1	5.37	2.98	92.0	54.9	11.3	.8	4.1	20.9
*Hempseed meal	26.2	45.1	.....	.....	92.0	31.2	6.6	22.1	24.8	7.3
*Linseed meal, domestic	28.9	76.9	.34	.92	91.4	33.2	5.8	9.0	37.9	5.5
*Milk, cows'	3.4	17.7	.12	.09	13.6	3.6	4.3	.....	5.0	.7
Molasses, beet	2.5	58.8	.05	.02	80.6	7.7	.....	.....	62.6	10.3
Molasses, cane	.9	56.6	.56	.06	74.1	2.8	.....	.....	61.9	9.4
*Oats	7.5	71.3	.09	.35	91.0	9.6	5.5	11.5	60.7	3.7
Orange meal	6.1	78.4	.....	.....	87.9	7.7	1.5	8.0	67.3	3.4
Pea seed, field	20.2	79.6	.07	.40	90.5	23.8	1.2	6.2	56.2	3.1
Peanut meal	35.9	81.8	.17	.55	93.0	40.3	8.6	8.3	29.2	6.6
*Sesame meal	37.2	73.7	2.00	1.60	93.0	40.9	10.2	5.6	24.2	12.1
Skim-milk, dried	33.1	84.1	1.24	.96	93.8	34.8	.9	.....	50.1	8.0
Soybean meal, average	37.7	82.2	.28	.66	91.7	44.3	5.7	5.6	30.3	5.7
Wheat, Pacific Coast states	8.5	83.6	.....	.....	89.1	9.9	2.0	2.7	72.6	1.9
*Wheat bran	12.0	68.3	.12	1.32	90.0	14.5	3.7	10.0	56.0	5.8
*Wheat feed (mill run)	12.9	69.7	.10	1.00	90.0	15.5	4.0	8.5	57.0	5.0

* Oregon analyses. All other analyses taken by special permission of the Morrison Publishing Company, Ithaca, New York, from *Feeds and Feeding,* 20th Edition, by F. B. Morrison.

Table 5. AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS OF FEEDS—(*Continued*)

Feeds	Digestible protein	Total digestible nutrients	Calcium	Phosphorus	Dry matter	Crude protein	Fat	Fiber	Nitrogen-free extract	Ash
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Roughages										
Alfalfa hay, average	10.6	50.3	1.43	.21	90.4	14.7	2.0	29.0	36.4	8.3
Alfalfa hay, very leafy	12.4	53.7	1.69	.24	90.0	16.5	2.7	22.6	39.5	8.7
Alfalfa hay, stemmy	8.2	47.5	1.01	.19	90.4	12.1	1.4	36.0	33.1	7.8
*Alfalfa hay, (Oregon average)	9.2	49.7	1.27	.20	90.0	12.8	1.6	29.9	37.2	8.5
Alfalfa leaf meal, good	16.2	57.4	1.90	.22	91.9	21.1	2.8	16.1	39.8	12.2
Alfalfa meal, good	10.8	53.9	1.31	.17	91.9	15.2	1.9	28.4	37.9	8.5
Bent grass hay, creeping	3.6	53.6	.....	.....	90.0	5.8	1.8	26.9	49.9	5.6
Bluegrass hay, Kentucky, average	4.7	53.3	.30	.22	89.4	8.2	2.8	29.8	42.1	6.5
Cheat hay	2.9	40.4	.33	.25	91.7	6.9	2.1	29.2	46.1	7.4
Clover hay, alsike, average	7.7	49.0	.76	.23	89.0	12.0	2.2	27.1	39.8	7.9
Clover hay, red, average	7.0	51.9	1.21	.18	88.2	11.8	2.6	27.3	40.1	6.4
Clover and grass hay	5.2	50.5	.83	.17	89.7	9.6	2.7	28.8	42.4	6.2
Corn fodder, medium dry	3.5	54.6	.21	.14	82.5	6.7	2.1	21.7	46.9	5.1
Corn stover, medium dry	2.1	46.2	.41	.08	81.0	5.7	1.2	27.7	40.9	5.5
Marsh or swamp hay	2.9	40.6	.....	.....	90.2	7.7	2.3	28.2	44.3	7.7
Mesquite grass hay	2.3	31.5	.....	.....	90.0	4.9	1.6	26.9	40.8	15.8
Native hay, mt. region, good	4.9	52.0	.....	.....	90.0	8.1	2.1	29.8	43.3	6.7
Native hay, mt. region, poor	1.6	36.6	.26	.21	90.0	3.9	1.4	33.6	43.6	7.5
Oat hay	4.5	46.3	.22	.17	88.0	8.3	2.7	28.4	41.7	6.9
Oat straw	.9	44.1	.36	.13	89.6	4.0	2.3	36.1	41.2	6.0
Pasture grasses and clovers, mixed, from closely-grazed, fertile pasture, dried	13.1	64.7	.66	.29	90.0	18.0	3.5	20.1	40.1	8.3
Pea hay, field	11.6	56.9	1.36	.22	89.2	14.9	3.2	24.5	38.9	7.7
Pea and oat hay	8.9	52.2	.80	.20	89.0	12.2	2.8	27.3	38.9	7.8
Reed Canary grass hay	3.5	46.6	.....	.23	90.8	7.5	2.4	29.1	44.4	7.4
Ryegrass hay, native	3.6	44.7	.....	.....	87.4	7.8	2.1	33.5	37.6	6.4
Sudan grass hay, average	4.3	48.5	.....	.....	89.2	8.8	1.6	27.9	42.9	8.0
*Vetch and oat hay, average	6.3	52.8	.62	.22	89.9	8.7	2.8	29.4	42.6	6.4
Wheat hay	3.2	46.5	.18	.21	89.0	5.9	1.7	26.1	48.9	6.4
Wheat straw	.8	35.7	.22	.07	90.1	3.8	1.5	35.7	40.9	8.2

* Oregon analyses. All other analyses taken by special permission of the Morrison Publishing Company, Ithaca, New York, from *Feeds and Feeding,* 20th Edition, by F. B. Morrison.

Table 5. AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS OF FEEDS—(*Continued*)

Feeds	Digestible protein	Total digestible nutrients	Calcium	Phosphorus	Dry matter	Crude protein	Fat	Fiber	Nitrogen-free extract	Ash
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Succulents										
Alfalfa, green	3.4	14.7	.40	.06	25.4	4.6	1.0	7.0	10.4	2.4
*Alfalfa, molasses silage	3.0	17.2	.46	.08	31.1	4.2	1.6	6.0	16.7	2.6
Apples	.2	14.4	.01	.01	17.9	.5	.4	1.3	15.3	.4
Artichokes, tubers	1.0	16.1	.....	.06	20.5	2.0	.1	.8	15.9	1.7
Beets, roots, common	1.2	10.2	.03	.04	13.0	1.6	.1	.9	8.9	1.5
Beets, roots, sugar	1.2	13.8	.03	.04	16.4	1.6	.1	1.0	12.6	1.1
Beet tops, sugar	1.9	7.4	.15	.04	11.4	2.6	.3	1.2	5.3	2.0
Bluegrass, Kentucky, average	2.4	18.6	.16	.08	31.8	4.2	1.2	8.7	14.9	2.8
Carrots, roots	.8	9.6	.06	.06	11.9	1.2	.2	1.1	8.2	1.2
Clover, red, average	2.6	15.4	.43	.07	25.0	4.0	.9	6.8	11.2	2.1
Clover, sweet	3.0	14.0	.32	.10	22.0	3.9	.7	6.4	9.2	1.8
Corn fodder, dent, average	1.2	16.3	.06	.05	24.0	2.0	.6	5.6	14.5	1.3
Corn silage, dent, average	1.3	18.7	.07	.06	28.3	2.3	.9	6.9	16.5	1.7
Kale	1.9	7.8	.19	.06	11.8	2.4	.5	1.6	5.5	1.8
Mangels	1.0	7.3	.01	.03	9.4	1.4	.1	.8	6.1	1.0
*Pasture, mostly Ladino clover	2.8	12.9	.26	.08	19.3	3.6	.6	4.9	7.2	2.0
*Pasture, irrigated grasses and clover	2.4	14.5	.22	.08	20.6	3.1	.6	4.9	9.8	2.3
Pasture, grasses and clover	2.6	16.1	.24	.19	24.4	3.7	.8	6.5	10.8	2.6
Pea and oat silage	2.7	19.2	.09	.07	30.0	3.6	1.2	9.4	13.0	2.8
Pea vine silage	2.6	17.8	.....	.....	27.9	3.5	1.0	7.8	13.1	2.5
Potatoes	1.1	17.3	.01	.05	21.2	2.2	.1	.4	17.4	1.1
Pumpkins, field	1.3	9.0	.....	.04	10.4	1.7	1.0	1.6	5.2	.9
Reed Canary grass silage	1.8	18.0	.17	.10	30.5	2.8	.7	11.8	15.3	2.3
Rutabagas	1.0	9.3	.07	.05	11.1	1.3	.2	1.4	7.2	1.0
Sudan grass, average	1.4	17.7	.14	.06	25.7	2.0	.6	8.5	12.8	1.8
Sugar beet top silage	1.8	11.8	.31	.09	27.0	3.5	.7	3.0	11.3	8.5
Turnips	1.3	8.5	.06	.04	9.5	1.4	.2	1.1	5.9	.9
Vetch and oats, green	2.9	17.1	.....	.07	26.5	3.8	.9	7.5	12.0	2.3
*Vetch and oat silage	2.4	19.4	.26	.07	30.1	3.2	1.1	9.5	12.9	2.2

* Oregon analyses. All other analyses taken by special permission of the Morrison Publishing Company, Ithaca, New York, from *Feeds and Feeding,* 20th Edition, by F. B. Morrison.

Table 6. Comparative Costs of Digestible Protein and Total Digestible Nutrients in Feeds All Priced at $1.00 per Ton. To Obtain the Cost at Any Price per Ton Multiply by that Price.*

Feed	Cost per pound of digestible protein	Cost per pound of total digestible nutrients
Alfalfa hay (average analyses)	$0.0047	$0.0010
Alfalfa hay (very leafy)	.0040	.0009
Alfalfa hay (stemmy)	.0061	.0011
Clover hay, red (average analyses)	.0071	.0010
Oat hay	.0111	.0011
Corn silage, dent, well-eared	.0333	.0024
Kale	.0263	.0064
Carrots	.0625	.0052
Barley	.0067	.0006
Beet pulp, dried	.0104	.0007
Corn, dent	.0069	.0006
Oats	.0067	.0007
Wheat	.0059	.0006
Mill run (wheat mixed feed)	.0039	.0007
Wheat bran	.0042	.0007
Coconut meal	.0027	.0006
Cottonseed meal (43 per cent protein)	.0014	.0007
Fish meal (average analyses)	.0010	.0007
Linseed meal	.0017	.0006
Peanut meal	.0013	.0006
Skim milk, dried	.0015	.0006
Soybean meal	.0014	.0006
Alfalfa molasses feed	.0064	.0009
Molasses, beet	.0200	.0009
Molasses, cane	.0556	.0009

* For example, to get the cost of a pound of digestible protein and total digestible nutrients in oats at $30 a ton, multiply the figures given above by 30, and we find the cost per pound of digestible protein to be $0.201 and of total digestible nutrients to be $0.021. In comparison, if wheat bran can be purchased for $25 a ton, it would supply a pound of digestible protein for $0.105 and a pound of total digestible nutrients for $0.0175 and would be the cheaper feed to purchase.

Table 7. CONCENTRATE MIXTURES FOR FEEDING WITH VARIOUS ROUGHAGES

Group A: Mixtures recommended for feeding with leafy alfalfa hay or with luxuriant pastures.

(1)

	Pounds
Ground barley	300
Ground oats	300
Mill run	400
	Per cent
Crude protein	11.9
Digestible protein	9.7
Total digestible nutrients	72.9

(2)

	Pounds
Ground barley	200
Ground oats	250
Ground wheat	250
Wheat bran	300
	Per cent
Crude protein	11.1
Digestible protein	9.1
Total digestible nutrients	75.0

(3)

	Pounds
Ground barley	400
Ground oats	400
Mill run	150
Linseed oil meal	50
	Per cent
Crude protein	11.6
Digestible protein	9.4
Total digestible nutrients	74.3

(4)

	Pounds
Ground barley	150
Ground oats	150
Ground corn	250
Wheat bran	350
Molasses beet pulp	100
	Per cent
Crude protein	11.1
Digestible protein	8.5
Total digestible nutrients	72.7

Group B: Mixtures recommended for feeding with average-quality alfalfa hay or good clover hay with or without kale, or with good pasture.

(5)

	Pounds
Ground barley	300
Ground oats	300
Mill run	300
Linseed oil meal	50
Cottonseed meal	50
	Per cent
Crude protein	14.1
Digestible protein	11.5
Total digestible nutrients	73.4

(6)

	Pounds
Ground barley	300
Ground oats	100
Ground corn	150
Mill run	300
Cottonseed meal	50
Molasses beet pulp	100
	Per cent
Crude protein	14.4
Digestible protein	11.2
Total digestible nutrients	73.1

(7)

	Pounds
Ground oats	350
Ground wheat	250
Wheat bran	300
Cottonseed meal	50
Peanut meal	50
	Per cent
Crude protein	14.3
Digestible protein	11.8
Total digestible nutrients	74.1

(8)

	Pounds
Ground barley	300
Ground oats	200
Mill run	300
Coconut meal	200
	Per cent
Crude protein	13.6
Digestible protein	11.4
Total digestible nutrients	75.0

Group C: Mixtures recommended for feeding with good legume hay and a succulent feed such as silage, root crops, fruits, vegetables, or wet beet pulp; also recommended for average pasture.

(9)

	Pounds
Ground barley	250
Ground oats	250
Mill run	350
Linseed oil meal	50
Cottonseed meal	50
Soybean meal	50
	Per cent
Crude protein	16.2
Digestible protein	13.3
Total digestible nutrients	73.6

(10)

	Pounds
Ground barley	200
Ground oats	200
Ground wheat	200
Wheat bran	250
Cottonseed meal	50
Soybean meal	50
Peanut meal	50
	Per cent
Crude protein	15.7
Digestible protein	13.1
Total digestible nutrients	75.7

Table 7. CONCENTRATE MIXTURES FOR FEEDING WITH VARIOUS ROUGHAGES—(*Continued*)

(11)

	Pounds
Ground barley	100
Ground oats	100
Ground corn	100
Ground wheat	100
Mill run	350
Cottonseed meal	100
Soybean meal	50
Molasses beet pulp	100

	Per cent
Crude protein	16.4
Digestible protein	13.1
Total digestible nutrients	73.3

(12)

	Pounds
Ground barley	250
Ground oats	250
Wheat bran	300
Molasses beet pulp	100
Cottonseed meal	50
Fish meal (67 per cent)	50

	Per cent
Crude protein	16.7
Digestible protein	13.1
Total digestible nutrients	71.4

Group D: Mixtures recommended for feeding with a mixed legume and nonlegume hay such as oats and vetch and a succulent feed.

(13)

	Pounds
Ground barley	100
Ground oats	100
Ground corn	100
Ground wheat	100
Wheat bran	300
Linseed oil meal	100
Cottonseed meal	50
Soybean meal	50
Peanut meal	50
Coconut meal	50

	Per cent
Crude protein	18.9
Digestible protein	15.9
Total digestible nutrients	75.7

(14)

	Pounds
Ground oats	200
Ground barley	200
Mill run	300
Orange meal	100
Linseed oil meal	50
Cottonseed meal	50
Peanut meal	50
Fish meal (67 per cent)	50

	Per cent
Crude protein	19.7
Digestible protein	16.2
Total digestible nutrients	74.2

(15)

	Pounds
Ground oats	350
Mill run	350
Cottonseed meal	100
Soybean meal	100
Coconut meal	100

	Per cent
Crude protein	19.5
Digestible protein	16.2
Total digestible nutrients	73.1

(16)

	Pounds
Ground barley	150
Ground wheat	100
Wheat bran	300
Molasses beet pulp	100
Cottonseed meal	100
Peanut meal	100
Ground field peas	150

	Per cent
Crude protein	19.3
Digestible protein	15.8
Total digestible nutrients	74.0

Group E: Mixtures recommended for feeding with nonlegume hays, such as oat or rye grass, with or without succulent feeds.

(17)

	Pounds
Ground barley	100
Ground oats	100
Ground corn	100
Ground wheat	100
Wheat bran	300
Linseed oil meal	100
Cottonseed meal	100
Peanut meal	50
Fish meal	50

	Per cent
Crude protein	21.1
Digestible protein	17.5
Total digestible nutrients	74.8

(18)

	Pounds
Ground barley	150
Ground oats	100
Mill run	300
Cottonseed meal	100
Soybean meal	100
Peanut meal	50
Molasses beet pulp	100
Ground field peas	100

	Per cent
Crude protein	21.6
Digestible protein	17.7
Total digestible nutrients	73.1

(19)

	Pounds
Ground barley	350
Mill run	400
Cottonseed meal	100
Soybean meal	50
Peanut meal	50
Fish meal	50

	Per cent
Crude protein	21.3
Digestible protein	17.6
Total digestible nutrients	74.7

(20)

	Pounds
Ground oats	200
Ground wheat	100
Wheat bran	300
Cottonseed meal	100
Soybean meal	150
Coconut meal	150

	Per cent
Crude protein	21.2
Digestible protein	17.9
Total digestible nutrients	75.0

Table 8. SCHEDULE OF CONCENTRATE FEEDING TO COWS RECEIVING EXCELLENT OR FAIR QUALITY ROUGHAGE, EITHER PASTURE OR HAY, WITH OR WITHOUT SUCCULENT FEEDS

Amount of concentrates to feed		Pounds milk produced daily							
With excellent roughage	With fair roughage	3.0 per cent	3.5 per cent	4.0 per cent	4.5 per cent	5.0 per cent	5.5 per cent	6.0 per cent	6.5 per cent
None	2	16.5	15.0	14.0	12.5	12.0	11.0	10.5	10.0
None	3	19.0	17.5	16.0	15.0	14.0	13.0	12.0	11.5
None	4	22.0	20.0	18.5	17.0	16.0	15.0	14.0	13.5
1	5	24.5	22.5	21.0	19.5	18.0	17.0	16.0	15.0
2	6	27.0	25.0	23.0	21.5	20.0	19.0	17.5	16.5
3	7	30.0	27.5	25.5	23.5	22.0	20.5	19.5	18.5
4	8	32.5	30.0	27.5	25.5	24.0	22.5	21.0	20.0
5	9	35.5	32.5	30.0	28.0	26.0	24.5	23.0	21.5
6	10	38.0	35.0	32.5	30.0	28.0	26.5	24.5	23.5
7	11	41.0	37.5	34.5	32.0	30.0	28.0	26.5	25.0
8	12	43.5	40.0	37.0	34.5	32.0	30.0	28.0	26.5
9	13	46.0	42.5	39.0	36.5	34.0	32.0	30.0	28.5
10	14	49.0	45.0	41.5	38.5	36.0	34.0	32.0	30.0
11	15	52.0	47.5	44.0	40.5	38.0	35.5	33.5	31.5
12	16	54.5	50.0	46.0	43.0	40.0	37.5	35.5	33.5
13	*17	57.0	52.5	48.5	45.0	42.0	39.5	37.5	35.0
14	*18	60.0	55.0	50.5	47.5	44.0	41.5	39.0	36.5
15	*19	62.5	57.5	53.0	49.5	46.0	43.0	41.0	38.5
*16	*20	65.5	60.0	55.0	51.5	48.0	45.0	42.5	40.0

* No more concentrates should be fed than the cow can eat and digest without going off feed regardless of the amount required to maintain production.

Examples of use of table: A cow fed excellent-quality alfalfa hay and corn silage and producing 30 pounds of 5 per cent milk daily would receive 7 pounds of concentrates daily. If this roughage were low quality oats and vetch hay for this same cow, 11 pounds of concentrates should be fed.

Table 9. WEIGHTS OF COMMON FEEDS*

Feed	One quart weighs	One pound measures
	Pounds	*Quarts*
Barley, whole	1.5	0.7
Barley, ground	1.1	.9
Beet pulp, dried	.6	1.7
Coconut meal	1.5	.7
Corn, dent, whole	1.7	.6
Corn, dent, ground	1.5	.7
Cottonseed meal	1.5	.7
Linseed meal, old process	1.1	.9
Molasses	3.0	.3
Oats, whole	1.0	1.0
Oats, ground	.7	1.4
Peas, field	2.1	.5
Wheat, whole	1.9	.5
Wheat, ground	1.7	.6
Wheat bran	.5	2.0
Wheat feed (mill run)	.6	1.7

* Taken by special permission of the Morrison Publishing Company, Ithaca, New York, from *Feeds and Feeding*, 20th Edition, by F. B. Morrison.

Table 10. CAPACITY OF SILOS WITH VARIOUS DIMENSIONS

Depth of silage	Capacity with inside diameter of					
	10 feet	12 feet	14 feet	16 feet	18 feet	20 feet
Feet	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
20	27	.....	.....	.....	.....	.....
24	34	49	.....	.....	.....	.....
28	43	61	84	.....	.....	.....
32	51	74	100	131	.....	.....
36	.....	86	117	153	194	.....
40	.....	100	135	177	224	276
44	.....	.....	174	198	251	310