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FEEDING *for* MILK PRODUCTION

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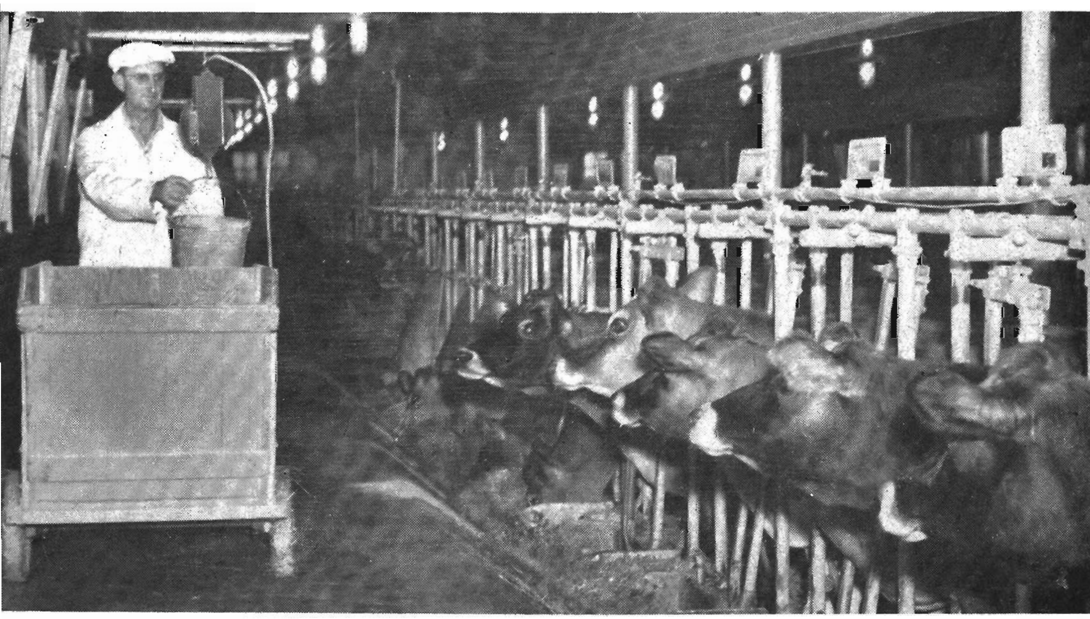

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Foreword

The dairy cow has been gradually improved through the efforts of man until she is aptly referred to as the foster mother of the human race. In the wild state, the cow produced only enough milk to suckle her young. By changing her inheritance through selection and controlled breeding, man has developed her into a veritable milk-producing factory.

A factory needs raw materials. For greater and more efficient output more and better materials must go into the factory. The cow is no exception. She needs large amounts of the right kind of raw materials, feed in her case, to produce at a high and profitable level.

This bulletin has been written to provide information that can make the dairy cow in Oregon more profitable through more skillful feeding. Mention is made of other factors that contribute to profitable dairy herd operation.

Wm. A. Schoenfeld

Dean and Director

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By

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Introduction

THE importance of Oregon's dairy industry is indicated by the fact that it is one of Oregon's largest agricultural income producers.

The value of farm marketings of dairy products from milk production in Oregon was estimated at $40,942,000 in 1945. The preliminary estimate for 1946 was $46,103,000. In addition, dairy products worth about $6,000,000 were consumed in households on farms where produced. Also, there is 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 reported selling dairy products.

The dairy and beef cattle distribution, by counties of Oregon from the 1945 Census, is given in Table 1. This table also shows the total pounds of milk produced and the average production per cow by counties. Approximately 70 per cent of the milk cows are located west of the Cascade Mountains, whereas nearly 90 per cent of the beef cows are in eastern Oregon.

The average milk production per cow of 5,538 pounds represents an increase of 171 pounds, as compared to the 1940 Census, and 965 pounds as compared to the 1935 Census. The average cow in Oregon in 1945 produced milk testing 4.5 per cent butterfat, which gave her a total average production of 249 pounds of butterfat annually. The high butterfat test contributes in making Oregon one of the leading states in average butterfat production per cow.

Dairy regions

On the basis of home-grown feed, as well as of climate and soil, Oregon may be divided into three main dairy regions: (1) the coast, (2) the Willamette Valley, and (3) the irrigated regions of eastern, central, and southern Oregon. Oregon crop statistics by counties for 1944 are given in Table 2.

Table 1. DAIRY AND BEEF CATTLE STATISTICS FOR OREGON BY COUNTIES FROM 1945 CENSUS.

County	Number of cows milked 1944	Milk produced	Average production per cow	Beef cows (2 years and over) January 1, 1944
		Pounds	*Pounds*	
Marion	18,714	104,772,166	5,599	1,500
Washington	16,164	96,247,038	5,954	350
Tillamook	16,082	106,795,445	6,641	200
Coos	15,221	95,478,791	6,273	2,200
Clackamas	14,760	81,835,054	5,544	2,000
Lane	13,268	66,608,170	5,020	3,600
Linn	13,100	69,274,376	5,288	2,100
Malheur	12,076	59,139,646	4,897	39,500
Yamhill	10,625	57,080,298	5,372	1,100
Jackson	9,573	52,132,908	5,446	10,000
Columbia	8,426	46,080,890	5,469	1,700
Douglas	7,507	42,375,115	5,645	3,600
Umatilla	7,507	35,593,216	4,741	9,600
Polk	7,286	43,417,298	5,959	400
Baker	6,809	37,167,712	5,459	18,500
Multnomah	6,637	42,305,593	6,374	600
Josephine	6,108	36,920,875	6,045	1,500
Union	5,428	26,668,591	4,913	8,000
Wallowa	5,428	25,552,982	4,708	9,700
Benton	5,355	28,231,151	5,271	750
Klamath	4,927	26,785,517	5,436	30,000
Lincoln	4,412	23,139,762	5,245	900
Clatsop	4,342	23,024,250	5,303	1,700
Deschutes	3,848	22,668,018	5,891	2,400
Hood River	2,270	12,984,951	5,270	300
Curry	2,232	12,275,305	5,500	1,100
Wasco	1,900	8,839,054	4,652	6,500
Grant	1,861	7,830,962	4,208	26,500
Crook	1,701	8,795,082	5,171	14,000
Lake	1,694	7,602,968	4,169	45,000
Morrow	1,546	7,316,355	4,616	5,600
Harney	1,054	5,360,062	5,085	35,000
Wheeler	788	3,313,219	4,205	6,400
Gilliam	718	3,210,784	4,472	6,300
Sherman	611	2,785,187	4,558	5,600
Jefferson	495	2,060,981	4,164	5,800
Oregon	240,446	1,331,519,488	5,538	310,000

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. Most of this falls between September 15 and June 1.

The coastal region is noted for its naturally good pasture conditions. Its pastures furnish good feed for about 7 months of the year. Summer irrigation of pastures is rapidly developing. Very little grain is grown in this region except for hay. A variety of grasses and clovers, vetch and oats, and peas and oats provide the main hay and silage crops.

Because of high humidity, it is usually difficult to cure hay of good quality. Consequently, more and more dairymen in this area are relying on grass silage for their winter feed. Recently developed field harvesters are proving satisfactory in putting up grass silage Large yields of root crops are possible.

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 summer months are practically without precipitation has, within recent years, led to the development of supplementary irrigation, especially of pastures, by many dairymen. A great variety of hay, grain, and succulent feeds is produced on dairy farms. 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 temperature than do the Willamette Valley and coast regions. Dairying is carried on at elevations ranging from 500 to 5,000 feet. Rainfall varies 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 being the main crops irrigated on dairy farms. Grain crops are successfully grown with irrigataion, and in some sections under dry-land conditions.

Markets

At the present time, dairymen in every county in which dairying is a major enterprise have the opportunity of marketing their product either through cooperative marketing associations or through private plants.

There have been many changes in the use of milk produced in Oregon since the start of World War II. Some of these changes will probably be permanent, particularly the diversion from selling churning cream to selling whole milk for manufacturing purposes. Also the increased use of milk in the state for consumption as milk decreases the amount available for manufacturing. If the dairy cow population of the state increases, some of these diversions in milk utilization will undoubtedly revert back to former practices. Others appear to be permanent, such as the increased percentage of the total milk used for human consumption as milk, especially that due to Oregon's increased population, and will probably continue at about 50 per cent of the total milk production.

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 relationship between the level and economy of production is demonstrated by cost of production studies, by a study of dairy herd improvement association records, and by controlled feeding experiments.

Table 2. Feed Crops in Oregon—1945 Census
(1944 Crop)

County	All hay exclusive of sorghums	(Vetch) 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	126,944	....	46,027	31,470	6,216	43,231	139	4,514
Benton	25,735	5,562	3,253	3,438	8,294	5,188	516	11,564
Clackamas	62,188	12,517	4,511	22,445	17,623	5,092	3,235	21,437
Clatsop	15,551	701	....	1,793	1,119	11,938	82	2,896
Columbia	32,796	2,004	1,995	9,882	7,361	11,554	429	9,311
Coos	34,972	1,696	517	6,711	8,986	17,062	986	12,558
Crook	61,047	56	28,087	231	15,152	17,521	....	8,513
Curry	5,780	*	43	621	1,842	3,267	54	3,772
Deschutes	36,763	657	27,949	694	6,580	883	6	8,685
Douglas	45,493	5,726	11,683	2,427	14,163	11,494	496	73,178
Gilliam	12,476	....	4,979	*	5,045	2,107	....	7,440
Grant	64,140	....	10,769	8,589	20,968	23,814	....	5,879
Harney	94,888	....	6,499	3,243	3,620	81,526	....	49,733
Hood River	9,907	....	6,076	2,045	926	860	37	3,167
Jackson	72,154	5,573	30,376	14,486	12,891	8,828	716	17,512
Jefferson	12,414	....	6,723	266	5,130	295	....	4,245
Josephine	28,713	2,821	5,476	12,058	5,628	2,730	122	10,095
Klamath	111,193	*	50,725	4,814	27,619	28,031	*	26,036
Lake	117,292	....	14,947	1,390	14,086	86,869	....	3,547
Lane	60,513	14,653	7,559	7,445	11,838	19,018	614	32,268
Lincoln	13,522	*	....	1,526	2,827	9,098	24	4,216
Linn	54,038	18,680	5,914	11,160	9,264	9,020	1,446	33,006
Malheur	244,164	....	195,488	7,151	4,379	37,146	593	24,618
Marion	81,562	31,410	8,259	28,123	7,162	6,608	6,806	41,796
Morrow	23,384	....	14,952	28	8,095	309	48	18,334
Multnomah	18,066	413	3,159	6,419	4,889	3,186	689	5,935
Polk	31,877	11,335	4,186	5,798	6,438	4,120	548	10,525
Sherman	6,393	....	743	....	4,828	822	....	11,136
Tillamook	21,279	*	....	17	*	21,193	*	1,314
Umatilla	74,131	*	56,386	736	14,245	2,749	159	12,542
Union	59,662	....	37,256	3,507	6,424	11,755	52	18,970
Wallowa	66,048	....	22,438	6,675	20,349	16,586	25	4,643
Wasco	32,481	....	17,916	271	12,015	2,279	11	37,739
Washington	67,237	29,196	4,439	20,603	6,735	6,264	2,994	10,536
Wheeler	22,909	....	9,332	185	10,258	3,134	....	5,765
Yamhill	52,915	22,747	8,660	11,871	4,124	5,513	1,771	8,826
Oregon	1,909,906	165,888	657,322	238,463	317,144	530,318	22,601	566,251

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

Table 2. FEED CROPS IN OREGON—1945 CENSUS—(*Continued*)
(1944 Crop)

County	Woodland pasture	Other pasture	Oats	Barley	Wheat	Corn	Mixed grains
	Acres	*Acres*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Baker	21,542	706,474	118,003	517,433	434,455	1,306	6,123
Benton	39,014	59,536	399,521	183,852	102,122	652	229,626
Clackamas	80,159	28,454	783,149	246,850	290,411	54,632	198,170
Clatsop	15,273	15,616	7,045	1,369	*	....	4,492
Columbia	57,789	39,532	87,118	26,703	21,466	*	5,527
Coos	69,321	106,579	2,385	492	409	1,475	*
Crook	100,067	667,031	121,988	145,389	61,038	....	10,395
Curry	20,997	60,898	*	....	....	205	*
Deschutes	17,143	173,695	107,698	87,475	32,716	310	5,078
Douglas	308,818	144,297	293,877	116,599	84,326	49,276	110,582
Gilliam	4,535	508,343	10,910	119,644	2,891,871	674	*
Grant	73,899	934,440	22,251	43,612	41,737	....	7,225
Harney	22,095	963,428	28,269	106,979	30,437	....	....
Hood River	4,678	2,644	9,322	*	*	1,750	....
Jackson	87,071	138,206	106,392	134,947	80,831	27,913	27,474
Jefferson	22,362	448,289	6,376	22,937	570,343	....	*
Josephine	41,970	15,119	44,305	17,296	15,126	5,045	5,199
Klamath	581,642	557,174	610,226	1,051,858	282,861	....	6,987
Lake	151,910	804,666	241,413	148,237	235,060	....	5,169
Lane	140,205	130,605	557,897	177,923	143,343	20,760	218,342
Lincoln	32,291	38,096	1,204	....	*	147	*
Linn	114,059	63,718	1,110,888	581,791	228,950	28,475	354,859
Malheur	3,094	785,395	187,007	741,053	374,336	107,080	236,385
Marion	58,207	49,647	1,457,682	425,150	472,774	65,963	480,859
Morrow	24,307	633,931	7,833	53,338	2,883,943	2,990	19,078
Multnomah	17,976	13,606	55,420	64,244	9,684	3,010	4,705
Polk	34,466	39,662	482,756	435,405	176,166	7,635	286,526
Sherman	....	172,830	8,758	116,229	3,047,000	....	2,312
Tillamook	6,729	29,449	....	....	....	....	....
Umatilla	165,231	746,664	69,017	484,887	6,871,481	36,203	9,350
Union	105,351	191,626	200,833	404,818	1,291,640	170	17,176
Wallowa	56,784	501,329	122,571	363,423	621,544	840	29,013
Wasco	33,396	693,650	20,798	83,986	1,761,631	110	12,770
Washington	38,507	22,550	859,617	345,971	475,958	4,334	223,480
Wheeler	145,738	566,981	12,600	25,704	89,966	*	*
Yamhill	75,092	31,594	646,159	399,335	380,531	8,944	295,408
Oregon	2,771,718	11,085,754	8,802,088	7,675,268	24,007,980	430,219	2,817,600

* When fewer than three farms reported in the county, bushels indicated only in the state total.

In a cost-of-production study conducted in Oregon for the three years, 1930-32, 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, according to the average yield per cow. With herds averaging about 300 pounds of butterfat per cow each year, the cost of producing butterfat averaged 10 cents a pound less than when the average production was about 200 pounds each year. This difference would be greater with present prices.

With the increase in production per cow there is some increase in feed, labor, and other costs. Because these cost items increase at a slower rate than yield of the cow, the cost of producing 100 pounds of milk or a pound of butterfat decreases.

A cow producing 300 pounds of butterfat uses only 25 per cent more feed than a cow of the same size that produces 150 pounds. 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. First is the inherited ability of the cow to produce milk and butterfat; second, the feed and care given to the cow so she can produce to the optimum of her inheritance. Every cow inherits a certain maximum milk and butterfat-producing ability. She cannot go above that 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 impossible 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 seldom possible for even the best judge to distinguish between a 300-pound producer and a 400-pound producer.

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 cow. 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.

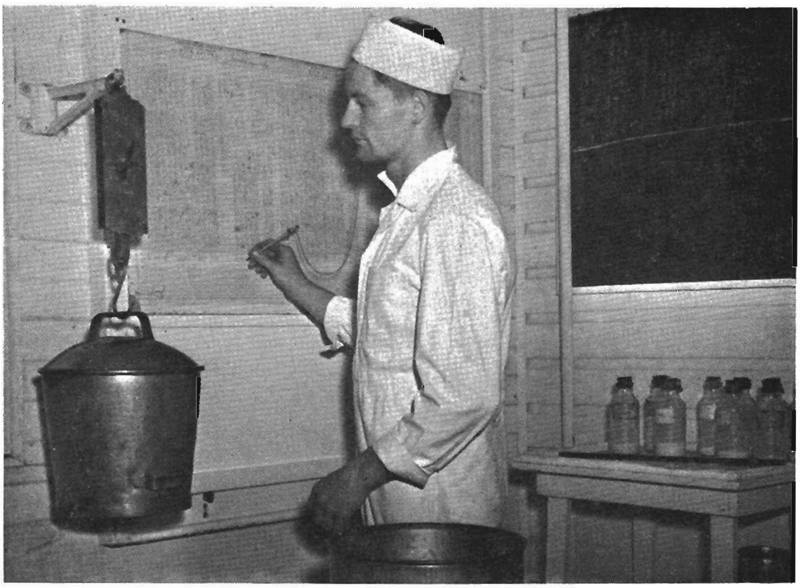

Figure 1. The amount of milk a cow produces at each milking should be determined by weighing on a scale graduated in pounds and tenths. The amounts should then be recorded on monthly milk sheets. Butterfat tests should be made one day each month and the total milk and butterfat produced monthly should be recorded in a permanent record book. Daily milk records enable the dairyman to do a much more intelligent job of feeding his herd.

Culling the dairy herd

After the production of individual cows in a herd is definitely known, the owner should decide on the culling standard. The minimum productive level for culling should be set reasonably high, be revised upwards at intervals, and animals failing to make the desired production should be sold to the butcher.

It should be kept in mind that immature cows should not be expected to make the production of cows 5 years of age or older. Conversion tables can be obtained from breed registry associations or the extension service. For practical purposes one can estimate that 2-year-old cows will produce about 70 per cent; 3-year-old cows about 80 per cent, and 4-year-old cows about 90 per cent of their mature production.

Usually the cow that proves to be a poor producer with her first calf will always remain a low producer unless there are special reasons for her production being low, such as sickness or calving in poor condition. With low producing cows culled from the herd, those remaining can be fed for more profitable production.

Good breeding program

The development of a high producing herd of cows goes hand in hand with good feeding practices in profitable dairy herd operation. Just as good cows cannot make profitable production unless well fed, the very best feeding program will not result in profitable returns when the dairy cows have not inherited the factors that make for high production of milk and butterfat.

The productive life of the average dairy cow is about 5 years. This rapid turnover gives the dairyman an opportunity to improve the production of his herd if he follows a definite breeding program based on raising his own replacements from the best cows in the herd and sired by meritorious dairy bulls. In many cases artificial insemination is extending the use of meritorious sires.

Healthy cows

Cows must be healthy if high quality dairy products are to be produced and if the herd is to be continuously profitable. Brucellosis infected cows may be expected to milk about 20 per cent below normal. Mastitis may cause an even greater loss in milk flow. Extreme care should be exercised in bringing animals into a herd free of brucellosis, mastitis, and tuberculosis. Blood and other laboratory tests are useful in detecting infected animals.

Use of Feed by the Dairy Cow

The dairy cow uses feed 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 power is termed the maintenance requirement of the cow. 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.

The more milk a cow produces above the amount necessary to offset the maintenance or overhead cost, the more profitable the cow. Profitable production requires feeding the cow to her capacity but not overfeeding, and using feed furnishing low-cost nutrients. The maintenance requirements of dairy cows are given in Table 4.

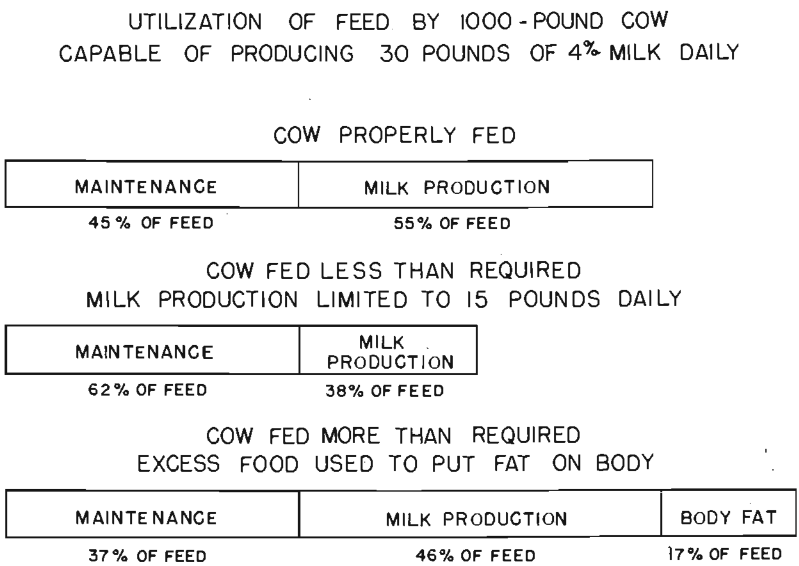

Figure 2. The cow uses feed first to meet her body maintenance requirement. Economical feeding requires that the cow be given all the feed she will need for maintenance and use for milk production. Feeding less than required results in a decline in milk production. Feeding too much is uneconomical as the cow will put on body fat but will not increase in production. Overfeeding in the late lactation is desirable as it allows the cow to replenish her body reserves for the ensuing lactation.

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 they require 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.

The feed required in addition to maintenance is determined by the amount and butterfat test of the milk produced as shown in Table 4. The requirements for maintenance and milk production do not include the additional feed necessary for continued growth of younger animals in milk. Cows in the second, third, and fourth lactations should, therefore, be fed at slightly higher levels to provide for their growth.

A good dairy cow usually will lose weight in early lactation because it requires two to four weeks to get her on full feed. Also, some cows may not have the capacity to eat enough feed to meet their requirements. The requirements for reproduction are not large until the last few months of the gestation period. It is economically sound to feed the cow well enough that she will put on flesh in late gestation, and particularly during the dry period, so that she will be in good condition for the following lactation.

Nutrients Required and Their Uses

Water

Water is essential in the cow's ration. Her body, on the average, contains about 55 per cent water, and her milk 87 per cent water.

Water is essential for the proper digestion of feeds. It 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. 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 weight, the type of ration fed, and the temperature of the air. As water is the cheapest material that a cow uses in producing milk, careful consideration should be given to providing an ample supply. Drinking fountains often pay for themselves in one season.

Under moderate temperature conditions, the cow requires about 6 pounds of water (from all sources) daily for each 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 needs 120 pounds of water daily from feed and drink together.

Feeds vary considerably in the amount of water they contain. Concentrates and hay usually contain about 10 per cent water. The succulent feeds are high in water. Thus pasture grasses and clovers and the root crops contain from 80 to 90 per cent water, and the silages from 65 to 75 per cent. Naturally, the drinking water needs of a cow depend to a large extent on the type of ration fed.

In the foregoing example, the cow requiring 120 pounds of water daily would obtain 20 to 25 pounds in the feed with the following ration: 10 pounds of concentrates, 15 pounds hay, and 30 pounds of silage. The rest must come from drinking water.

In hot weather, cows may drink 80 per cent more than in moderate weather. At freezing temperatures cows drink about the same amount as in moderate weather, if the water is not too cold.

The dairy cow requires a fairly definite 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 eat enough dry matter to meet her needs.

Protein

The protein content of feeds is very important in determining their value. Proteins make up about 18 per cent of the body of the mature cow. She 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. 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.

Until recent years it was thought that cows should be fed the 9 or 10 essential amino acids of the 22 or more which make up a complete protein. Recent studies show, however, that dairy cows are able to synthesize (manufacture) protein from nonprotein nitrogen with the help of micro-organisms growing in the paunch (rumen). This idea of protein synthesis receives confirmation from the fact that studies with ruminants have largely failed to show any significant differences in the biological value of protein from various plant and animal sources.

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 wastes; regulation of body temperature; milk (87 per cent water).
Proteins: Consisting of amino acids, the composition of about 22 of which are now known; cow can synthesize protein with aid of rumen micro-organisms, if adequate nitrogen and sulfur present.	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 Sulfur 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.

Table 3—Continued
Nutrients in Feeds and Their Uses

Nutrients	Important Uses
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; milk vitamin A and carotene.
B—a complex of many vitamins, several of which are now chemically known. Synthesized by cattle.	Growth in some species; prevents nervous disorders; stimulates appetite; B vitamins in milk.
C—chemically known as ascorbic acid, synthesized by cattle.	To prevent scurvy in species susceptible; in milk; (cattle do not require vitamin C).
D—antirachitic factor. Available from direct sunshine.	Necessary for proper calcium and phosphorus assimilation; normal growth and well-being; vitamin D in milk.
E—chemically known as alpha-tocophorol. Wheat germ oil rich source.	Reproduction in some species. Prevents muscular degeneration.
G—one of original vitamin B complex. Chemically known as riboflavin. Synthesized by cattle.	Growth, especially in poultry; (skim milk rich source).

From the standpoint of the practical feeding of dairy cattle, rumen synthesis of protein means that the *quantity* of nitrogen, and possibly the amount of sulfur supplied, are important considerations, but that the *quality* of protein (containing adequate amounts of essential amino acids) is not as significant as with nonruminants. Animals have only limited capacity to store protein, hence the cow must be supplied protein day by day. The fact that 25 per cent of the dry matter of milk is protein indicates the importance of feeding enough protein.

Fat

The fat or oil content of feeds is determined as the ether extract. Feeds commonly fed to the dairy cow are low in fat content. It is significant that one pound of digestible fat in a feed is worth $2\frac{1}{4}$ 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 as body fat.

Milk varies in its butterfat content within wide limits. Butterfat percentage of milk ranges from below 3 to above 7 per cent, in Oregon averaging about 4.5 per cent. The fat in feeds may considerably influence the physical and chemical composition of butterfat. 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.

Experimental investigations indicate that the dairy cow produces the greatest amount of milk and butterfat when the dry matter of the ration contains about 4 per cent of fat. If only $1\frac{1}{2}$ to 2 per cent of fat is present, the amount of milk and butterfat test may be diminished. The decreased fat content of the oil seed byproducts now available may tend to decrease the per cent of fat in dairy cow rations.

Carbohydrates

Usually about 75 per cent of the dry matter of plants is made up of carbonaceous material, hence the importance of carbohydrates in animal nutrition. The carbohydrate part of feeding stuffs contains a wide variety of compounds including cellulose, lignin, pectin, starch, pentosans, and sugars. In feed analysis tables, the carbohydrates are designated as crude fiber and nitrogen-free extract. The crude fiber is made up largely of cellulose and lignin with the percentage of lignin increasing as the plant becomes mature. The cellulose part of the crude fiber is almost as digestible as starches and sugar, whereas the lignin is almost completely indigestible.

Some investigators have suggested that the carbohydrate content of feeding stuffs be analyzed to show the percentages of lignin, cellulose, and other carbohydrates. This would give a much better indication of the feed value of the plant than the present crude fiber and nitrogen-free extract designation.

As forage plants become more mature, the percentage of lignin increases and the plant's digestibility decreases. Also, the easily digested constituents of feeds are soluble in water whereas lignin is not.

Hence, crops exposed to rain lose their most valuable constituents and retain the least digestible part.

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. Carbohydrates also provide energy for the muscular activity of the cow, including the work of digestion. Farm grains and hays contain practically the same amount of dry matter. Grains contain a much lower percentage of fiber than do the hays. This is the main reason for the high total digestible nutrient value of grains.

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 short time without them. 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 provide enough of them except for sodium and chlorine, the elements provided in common salt. In some regions the rations may be too low in calcium, phosphorus, and iodine for most favorable growth, lactation, and reproduction. 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 discovered when human beings and animals became sick or failed to grow well when their diets lacked them.

Most dairy cow rations, adequate in other respects, have enough vitamins for well-being. It should be pointed out 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.

FROM ELEMENTS TO MILK

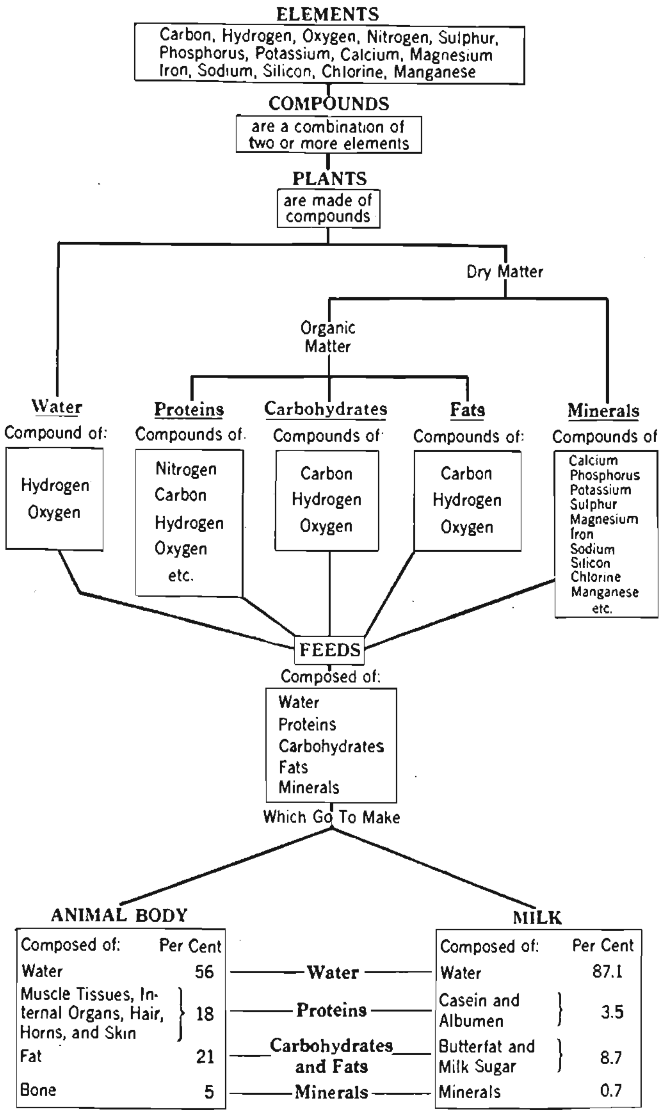

Figure 3. Chart showing interrelation of common component elements of plant and animal life which go to make up feed and finally milk. Reprinted by permission from *Dairy Cattle Feeding and Management* by Henderson, Larson, and Putney, published by John Wiley and Sons, Inc.

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 are utilized. The difference between the amount of each nutrient fed and that passed 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 have been used to estimate 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 $2\frac{1}{4}$ (see explanation under fat), the digestible fiber, and the digestible nitrogen-free extract.

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.

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 widely on 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. 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 eats, pasture usually furnishes the cheapest form of total digestible nutrients, or energy. Pasture is 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 that had cheap pasture and hay had the lowest cost of production. There was a striking difference in the cost of production due to the type of feeds available and to the feeding practices 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 lower producers.

Hay vs. silage

An important question relating to dairy herd profits that should be considered by every dairyman is whether the basis of his ration should be largely hay or silage. Most studies have shown that if a good quality of hay can be made, the cost of nutrients in such hay is less than if the same crop is put into the silo. However, weather conditions in Oregon west of the Cascade Mountains are often such that good quality hay cannot be made. This is particularly true of the coastal region.

If rainy or cloudy weather makes it impossible to cure hay, provisions should be made for making silage. Hay that is rained on loses a high percentage of its most valuable feed parts, particularly the carbohydrates that dissolve in water, its minerals, and vitamins. If weathering is severe enough, the hay may deteriorate to the feeding value of straw. If the forage is not cut until overly ripe, because of poor hay-making weather, its food value decreases. This loss is caused by an increase in fiber and a decrease in protein and carotene content. Usually there is a great loss of leaves with hay that is weathered or that becomes too mature.

A hay crop can usually be harvested as silage regardless of weather conditions without the leaching out of plant nutrients and the shattering of leaves. Cost studies indicate that with good weather conditions, the labor cost and the total cost of producing nutrients in

* Bulletin 318, Oregon Agricultural Experiment Station.

silage is somewhat greater than in hay. On the other hand, when weather conditions are not suitable for making good hay, feed nutrients can be preserved more cheaply and more completely in silage.

With the development of especially constructed machinery to handle forage crops in the green state, it is possible that the cost of harvesting and storing such forages in the form of silage will be no greater than if these are made into hay under good weather conditions. The artificial drying of hay is also a possibility. Air duct systems in the barn or artificial hay driers may be used. The comparative economy and practicability of ensiling and artificially drying forage crops in Oregon remain to be determined.

Legume hays best

In regions where good hay can be grown and cured, it 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 hard-working, easily the hardest working animal on the farm. It is important to supply her with the best possible feeds. It is poor economy to feed her poor quality roughage.

The legume hays, such as alfalfa and clover, have special advantages in the dairy cow's ration over the nonlegume hays, such as those made of the cereal grains and grasses. The main advantage of a legume over a nonlegume hay is that it normally contains 2 to 3 times as much protein (Table 5). The dairyman who has legume hays available will be able to feed less of a lower protein and lower priced concentrate mixture than the dairyman feeding grass or grain hay (Table 7).

Quality of hay important

The quality in hay is judged by the characteristics that determine feeding value. A hay of high quality is pleasing in aroma, sound and sweet, fine-stemmed, free of mustiness, 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 digestible value of leafy and stemmy alfalfa hay is given in Table 5. However, the difference in palatability makes the difference in feeding value much greater than is indicated in the table.

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. Where oats and vetch are grown for hay, they should be seeded quite heavily so the plants do not grow too coarse. They should be cut before becoming too ripe. Practically any hay cut at an early stage of maturity has a higher feeding value than later. Many of the grasses in the early stages of growth contain almost as much protein as the mature legume. Dairymen have not capitalized on the higher feeding value of the grasses when cut before becoming too mature.

Succulent feeds valuable

The succulent (juicy) feeds—silage, roots, fruits, kale, and soiling crops—are valuable feeds for dairy cows.

Most succulent feeds are palatable. Livestock will usually eat more total roughage and produce better when fed succulents along with hay or other dry forage than when receiving 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. 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 low and quite variable in their dry-matter content and, with some exceptions, such as green alfalfa, grass silage, and kale, are low in protein. This is shown by a study of Table 5. Where a supply of clean, fresh water is not available to the cow at all times, succulent feeds are particularly valuable.

Silage crops

About 3 pounds of silage are required to equal 1 pound of hay in total digestible nutrient value and even more of some kinds of 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 in favor of silage are the saving of crops that would otherwise be spoiled by bad weather, and the utilization of poor quality forages by ensiling.

The comparative yield per acre of total digestible nutrients and digestible protein in some hay, silage, and pasture crops is shown in Figure 5. The same figure shows the relative cost and man hours of direct labor necessary to produce 100 pounds of total digestible nutrients.

Corn silage is not usually a cheap crop in Oregon because of the low yield per acre. Vetch and oat silage normally costs a little more to produce than vetch and oat hay. Usually, however, the vetch and oat silage is more palatable than the hay. No conclusive data are yet available on the cost of producing grass silage. There has been much development in equipment to handle grass silage in recent years. With community ownership or custom use, this should materially reduce the cost of producing this crop.

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

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 common 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 reduced amount of hay, plus the concentrates necessary to meet the cow's requirements.

The moisture content of the forage crop at the time of ensiling is important. If it is too high in water, valuable plant juices will drain from the silo and the silage is apt to be very sour and not palatable. 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.

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.

It is fairly easy to make good silage with corn because this crop is high in sugar and low in protein. On the other hand, grasses, alfalfa, and clover are relatively high in protein and low in sugar. As a result the making of good-quality silage from these crops requires that attention be paid to certain details in their ensiling. Normally it is recommended that molasses at the rate of 3 or 4 per cent of the weight of the ensiled forage (60 to 80 pounds per ton) be added to provide additional sugar for proper fermentation. If not enough sugar is present for acid development, putrefactive fermentation due to protein breakdown (decomposition) is apt to occur. This makes a bad smelling, unpalatable silage.

If particular attention is paid to the amount of dry matter, good silage can be made from grasses and legumes without the addition of molasses. Normally this requires wilting the crop until the dry matter content increases to 35-40 per cent when put into the silo from the approximately 20-25 per cent found in the growing crop. With this increased dry matter content, it is necessary to do a good job of cutting, distributing, packing into the silo, and weighing down the ensiled material—otherwise airpockets will form and moldy silage will result.

Roots, kale, soiling crops, and fruits

Kale, where it can be grown, is a particularly valuable feed for the cow in milk. It is palatable and it stimulates milk 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. About 5 pounds of roots equal 1 pound of hay in feeding value. 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 them will eat large quantities at the expense of feeds higher in dry matter. This will result in a decline in milk flow due to the lack of sufficient protein and total digestible nutrients. A 1,000-pound cow producing 25 pounds of 4 per cent milk daily would have to eat 935 pounds of apples daily if her total required digestible protein were furnished by apples. Apples or pears fed at the rate of 20 to 30 pounds daily are a profitable supplement to a hay and grain ration.

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. Feeding too many may cause digestive disturbances.

Hay and grain crops can be cut when green and satisfactorily fed to dairy cows as soiling crops. Their dry-matter content is somewhat less than that of corn silage. It will be noted, however, that the legumes and immature grasses contain much higher percentages of digestible protein than corn silage (Table 5). The disadvantage of soiling crops is the high labor cost. 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.

Good pasture furnishes feed for the dairy cow at a lower price than any other farm crop. It is more economical than the other

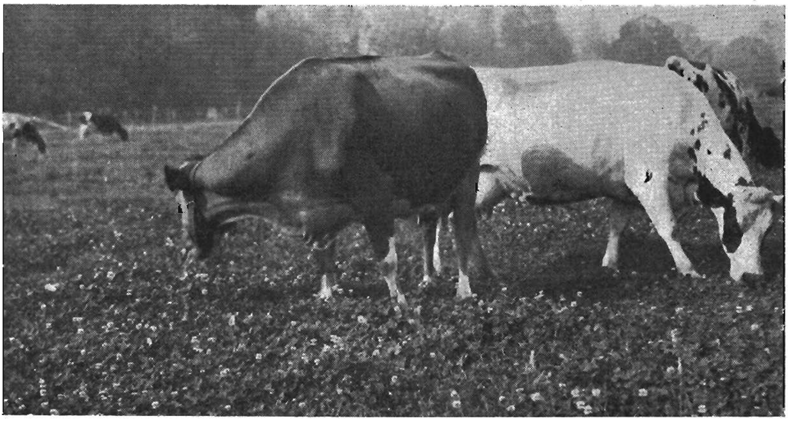

Figure 4. A close-up view of cows pasturing on Ladino clover. Note absence of grass after three and one-half months of pasturing.

roughages such as hay, silage, roots, and soiling crops, (1) because of the higher yield and greater digestibility of the dry matter of pastures and (2) 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 and/or butterfat is lower when cows have good pasture than when they are stall-fed on roughage.

Pasture furnishes the right kind of nutrients for good health, production, and reproduction. Forages at the pasture stage of maturity are more palatable than the same plant when mature. Also the dry matter is more digestible and contains a higher percentage of protein, minerals, and carotene. Reports from several experiment stations indicate that there is as yet some unknown factor in grasses usually designated as the grass juice factor which stimulates lactation, and also promotes growth in young animals beyond the level expected with known nutritive elements.

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 season from 1935 to 1938, inclusive.* (Table 5). The pasture furnished 4 to 5 tons of dry mat-

* Oregon Agricultural Experiment Station Bulletin 366.

ter per acre, of which more than 3 tons were digestible. This 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 7½ to 8 months, along the coast of Oregon 8½ to 9 months, and in the irrigated regions outside western Oregon 5 to 7 months. In much of the state high-yielding pastures cannot be developed without irrigation. Often streams or wells can be utilized to irrigate pastures, and thereby provide more income from dairying.

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. (Figure 5.)

Experimental results at the Oregon State College and 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 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 50¢, 75¢, and $1.00 per pound would be $135.00, $212.50, and $270.00, respectively.

The cost of irrigating pastures shows a wide range from farm to farm. In most cases this range is between $30.00 and $60.00 yearly per acre. In some cases, costs of about $100.00 per acre have proved profitable.

The availability and method of obtaining water is the main factor in cost variation. The cost may include the drilling of deep wells, installation of expensive centrifugal pumps, and lifting the water many feet for irrigation. This method is much more expensive than use of flowing streams where conditions permit.

Usually gravity irrigation costs less than sprinkler irrigation if the land lies so that water can be applied without too much leveling. On the other hand, sprinkler irrigation is more conservative of water and it is not necessary to disturb the more fertile top soil as is often necessary for gravity irrigation.

The annual returns above feed costs from good irrigated pasture with good dairy cows would thus be from $100.00 to $200.00 per acre. The application of irrigation water to tame grass and clover pastures increases the yield from approximately 1,000 pounds total digestible nutrients per acre to approximately 4,000 pounds of total digestible nutrients. With present land values, dairymen can afford to invest in irrigation equipment and pay all other irrigation costs if the cost per acre is less than the cost of purchasing an additional acre of crop-producing land. The costs that have been considered in determining pasture costs under irrigation include interest on the land, interest and depreciation on the irrigation system, taxes, fertilizers, labor of irrigation, and fencing.

Grain feeding on pasture

The economy of feeding concentrates to dairy cows on pasture is a question that should be considered by every dairyman. It depends on 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 and 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.

A mixture of home-grown grains and wheat bran or mill run is economical. It will provide sufficient protein for cows producing more than 1 pound of butterfat daily on good pasture. 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 accurate production records on individual cows in the herd are especially important. Feed should not be wasted on cows that do not 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 feeding may not be immediately noticeable, but when considered on a lactation basis it will be profitable. Also, good-producing cows that receive concentrates on pastures, calve for their next lactation in better condition. Consequently, they start the lactation at a much higher level of production. Cows will often

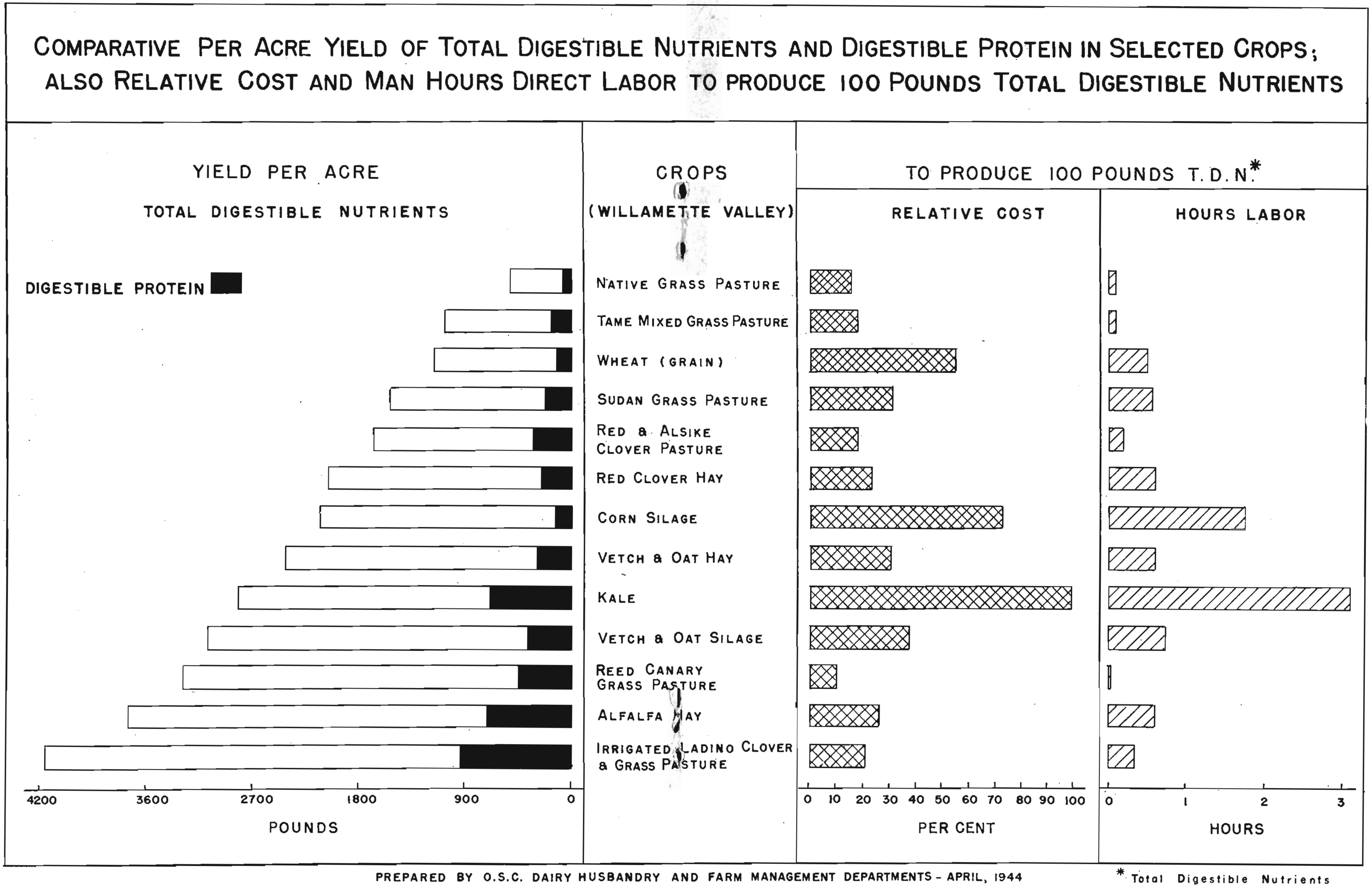

Figure 5. Reprinted from Oregon Station Circular 165.

increase in production when first turned on pasture even though the amount of concentrate is reduced. This increase in production does not last long unless the nutritive requirements of the cow are met. Once the cow declines in production because of lack of feed, it is very difficult to get her back to her previous production.

Pasture management

Turning cattle on pastures 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 will reduce 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 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 time to recover.

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 greatly improved by fertilization. The value of phosphate fertilization was proved on an irrigated Ladino clover and grass pasture at the Oregon Experiment Station for the 5 years from 1934 to 1938, inclusive. On this 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 similar but unfertilized areas. In terms of alfalfa hay equivalent on a total digestible nutrient basis, the yield was increased from 3.7 tons to 6.4 tons per acre. The addition of nitrate of soda and potash with superphosphates gave only slightly greater yields of dry matter than phosphate alone.

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 higher in starches and sugars than are the hays. Starches and sugars are much more digestible than is fiber. Thus 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, vary greatly 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 matter (ash). 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. This reduces their total digestible nutrient value to about the same level as that of oats and wheat bran. The inclusion of salt, bonemeal or other minerals will reduce the total digestible nutrient value of a mixture by the percentage of minerals added.

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 because their fat values are allowed 2¼ times as much energy as any 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. (See Table 7.) One pound of a concentrate mixture without added minerals is equal in total digestible nutrient value to about 1½ pounds of good quality hay.

Concentrate feeds show a greater variation in protein than they do in total digestible nutrients. This protein variation is in amount, digestibility, and quality. As previously discussed, protein quality need not be a major consideration in ruminant nutrition as recent studies show that the cow, with help of micro-organisms, can synthesize in the rumen, from the nitrogen and sulphur supplied by feeds, at least part of the essential amino acids needed to meet her protein requirement.

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, and coconut meal about 20 per cent. The high protein concentrates vary from about 30 per cent for linseed 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 and blood meal from 70 to 80 per cent digestible protein.

A cow cannot make high production on roughages alone. Some of her ration must be provided in more digestible concentrates. Barley, oats, wheat, corn, and wheat milling or other byproduct feeds, the percentage of each depending upon the price, will make up the bulk of the concentrate mix. When low-protein roughages are fed, some high-protein concentrates must be included in the concentrate mixture for high producing cows.

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 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.

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 starch values or therms of net energy.

The standard that has been most widely used in the United States in computing rations for dairy cows is that developed by Morrison.* In 1945 a committee on animal nutrition of the National Research Council published a report titled "Recommended Nutrient Allowances for Dairy Cattle." This committee evaluated available experimental data, and suggested minimum allowances of nutrients for various classes of dairy cattle. The minimum requirements recommended (see Table 4) furnish a safe margin above the true minimum. In comparison with the Morrison standard, the recommended allowances for maintenance and for lactation are a little lower in digestible protein and a little higher in total digestible nutrients.

In calculating a ration for a cow in milk, the first step is to determine the daily maintenance requirement. Next, to the digestible protein and total digestible nutrients needed for maintenance are added the amounts required for the quantity and butterfat test of the milk the cow is producing. Table 4 provides the information for these calculations.

As an example, let us assume a cow weighs 1,000 pounds and is producing daily 45 pounds of milk testing 4 per cent butterfat. According to Table 4, this cow needs 0.60 pound digestible protein and 8.10 pounds of total digestible nutrients for maintenance. She also needs 0.045 pound of digestible protein and 0.32 pound of total digestible nutrients for each pound of 4 per cent milk produced. For

* *Feeds and Feeding,* 21st edition 1948, F. B. Morrison.

the 45 pounds of milk, she requires 2.03 pounds of digestible protein and 14.40 pounds of total digestible nutrients. The figures for maintenance and milk production are usually set down in the following form and added:

Requirements	Digestible protein	Total digestible nutrients
	Pounds	*Pounds*
For maintenance, 1,000-pound cow	0.60	8.10
For 45 pounds 4 per cent milk	2.03	14.40
Total daily requirement	2.63	22.50

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. On being utilized by the animal body, fat gives $2\frac{1}{4}$ times more energy value per unit than the other components. The digestible fat is, therefore, multiplied by $2\frac{1}{4}$ before being added to the remainder of the total digestible nutrients.

In selecting a ration for the cow for which the foregoing requirements were determined, let us assume that red clover hay, 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. For the above cow, 25 pounds of average quality clover hay would be about the expected consumption. This roughage (Table 5) supplies enough nutrients to take care of the cow's maintenance requirements and to enable her to produce about 15 pounds of 4 per cent milk daily. The requirements for the remaining 30 pounds of milk must be met by feeding grain. In Table 7 will be found various concentrate mixtures suggested for feeding with different roughages. Thirteen pounds of mixture (1) will approximately balance this cow's ration as shown below:

Balanced Ration

Feeds	Digestible protein	Total digestible nutrients
	Pounds	*Pounds*
25 pounds red clover hay	1.75	12.98
Total required	2.63	22.50
Balance needed in grain mixture	0.88	9.52
13 pounds mixture (1) Table 7	0.98	9.76

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. (Refer to Figure 7 and Table 8.)

Other Characteristics of a Good Ration

In the formulation of a ration more than the digestible protein and the total digestible nutrients should be considered.

Palatability

The different feedstuffs making up the ration fed should be palatable to the cow. If unpalatable feeds are supplied, the cow will eat less and produce less milk. Particularly the roughages should be palatable, as they form the most economical part of the ration. Cows fed high-quality alfalfa hay as the only roughage will eat about 3 pounds daily for each 100 pounds of live weight, or about 30 pounds daily for a 1,000-pound cow. If a cow of this body weight is fed 30 pounds of palatable silage daily, the alfalfa hay consumption will decrease to about 20 pounds daily. If the hay available is of low quality due to mustiness, high proportion of stems to leaves, and presence of weeds, the amount consumed by a 1,000-pound cow may amount to only 15 to 20 pounds daily.

Most of the succulent feeds, such as good silages, root crops, pastures, soiling crops such as green corn and alfalfa, and kale are very palatable. If economical to grow, they may well form a part of the dairy cow's ration. Moldy and improperly fermented silage is not palatable.

Some of the concentrate feeds are more palatable than others. However, cows will become accustomed to almost any feed gradually included in their ration, provided it is free from mold, mustiness, and rancidity. Molasses is often used to make unpalatable feeds more palatable.

Cows like frequent changes in the ration, especially of the roughages. They often show an increase in production when one roughage is substituted for or included with another that has been monotonously fed.

Variety

A ration containing a variety of feeds gives greater assurance of providing the dairy cow with needed nutrients. This is particularly true of mineral elements and vitamins. A ration containing a variety of feeds is usually more palatable to the cow.

Bulk

Nature has provided the cow and other ruminants with digestive systems that will handle large amounts of bulky feeds. 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 farm grains should not be ground too finely for cows. 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 watery for the best results. This would be true if the ration consisted largely of succulent feeds, such as the root crops, apples, kale, squash, and early spring pasture. A cow might eat to her capacity of 100 to 150 pounds daily of the 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, feeds high in water should be limited to about 3 pounds daily per 100 pounds body weight.

As previously indicated, silage crops, particularly grass silage, are sufficiently high in dry matter and protein to give good production results when fed at considerably higher levels than would be indicated by the rule of three pounds daily per one hundred pounds body weight. This is also true of later pastures.

Physiological effects

The dairy cow's ration should allow her to keep 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 should be guarded against. A ration of dry hay and heavy grain may cause constipation. Linseed oil meal in the ration is a good conditioner. It 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 normally 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.

*Oregon Agricultural Experiment Station Bulletin 318.

The comparative per acre yield of total digestible nutrients and digestible protein in certain crops grown in the Willamette Valley is shown in Figure 5. The relative cost and man hours of direct labor to produce 100 pounds of total digestible nutrients are shown in the same chart.

The two most important steps the dairyman can take toward profitable feeding is to provide good pasture for the dairy herd throughout the pasture season, and sufficient legume hay for winter feeding. Usually roughages and farm grains can be more economically grown than purchased. If legume hay is provided, a lower protein and lower priced concentrate mixture can be fed. This is illustrated by a study of the mixtures given in Table 7.

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 reason 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 with no experimental proof of their value.

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

With the large amount of milk given by the highly developed dairy cow of today, the question of supplementary mineral feeding does have some basis for discussion. The additional mineral need comes not only because of the increase in milk production per cow, but also because some of her feeds may be grown on soils low in essential minerals. No investigation to date, except in certain restricted areas of the United States and other countries, has shown, however, that mineral elements other than those indicated 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 needs more than the dry cow. On the average, the dairy cow needs about $\frac{3}{4}$ of an ounce of salt daily per 1,000 pounds live weight, and about $\frac{1}{3}$ of an ounce in addition for each 10 pounds of milk produced. The average producing cow would, therefore, require 30 to 35 pounds of 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). Iodized stock salt is now available on the market. 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 mineral of the body and 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. Eventually, however, the bones become depleted and milk production decreases. The assimilation of calcium and phosphorus depends on an adequate supply of vitamin D in the ration, or its equivalent in direct sunshine. (See discussion under Vitamin D.)

In Oregon-grown feeds 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 meal.

If the ration is made up entirely of home-grown feeds, there may be a lack of phosphorus. If the concentrate mixture 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 legume hay or pasture is provided there will be no deficiency of calcium.

If the ration gives indications from its analysis of feeding that it lacks 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 disease germs. If it has a bad odor it is unpalatable and not suitable for dairy cattle. Raw rock phosphate is not recommended, because it contains fluorine which is toxic. Rock phosphate which has been defluorinated to meet specified state standards may be satisfactorily used.

Dicalcium phosphate preparations have been fed experimentally and found to be satisfactory. Likewise, in areas where phosphorus alone is lacking, disodium phosphate has been fed with good results. Spent bone black (a bone meal byproduct 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 buy.

There is no conclusive evidence that dairy rations in widespread areas of Oregon lack calcium. Ground limestone is high in calcium, but it 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.

Calcium and phosphorus may be provided by placing sterilized bone flour in a box protected from rain and wind in the corral where cows have free access to it. If the product is of good quality, the cow's appetite is 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 mixture may be acceptable in high-producing herds fed legume hays and home-grown grains. In herds of lower producing ability or where large amounts of mill feeds and high protein concentrates are used, the forced consumption of calcium and phosphorus supplements may not be 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 harmful to the health of animals consuming them over a long period. The Michigan Agricultural Experiment Station* has recommended that: "Mineral mixtures 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."

Vitamins for Dairy Cattle

Good dairy cattle rations are not apt to be deficient in the vitamins needed for normal nutrition.

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, particularly of the eyes and lungs.

Cows convert some of the yellow pigment carotene of green feeds, well-cured hays, silage, carrots, etc., into vitamin A, which is colorless. Therefore carotene is called the precursor of vitamin A. The amount of carotene changed to vitamin A varies with breeds and individual cows and is reflected by the color of milk and body fat. The carotene in food or milk can be converted into usable vitamin A in the animal or human body with varying degrees of efficiency.

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* Michigan Experiment Station Circular Bulletin 95.

The carotene and vitamin A content of whole milk (they are carried in the butterfat) increase with an increase in the amount of carotene in the ration fed. Feeds exposed to the sun and rain lose much of their carotene. If vitamin A supplements, such as cod liver oil, are mixed with feeds, the vitamin A is largely destroyed by oxidation in about 4 weeks. However, it is possible to stabilize vitamin A in dry carriers by the use of anti-oxidants. Hay stored in the barn, and especially loose hay, may lose from 50 to 75 per cent of its carotene within 5 or 6 months.

If the dairy herd is on green pasture during the summer, there will be no carotene deficiency. Neither will there be any deficiency in the winter if the cows are fed good quality, green, leafy hay or silage made from green plants. If the cows are stall-fed throughout the year on hay that is coarse, stemmy, and lacking in leaves and color, there may be a deficiency of carotene sufficient to cause poor lactation, reproduction disorders, or difficulties in raising calves. The milk produced by cows thus fed would not have a high vitamin A value.

Vitamin B complex

The original water soluble vitamin B has been found to consist of many different vitamins distinctive in function. The chemical composition of several are now definitely known. These include thiamin or B_1, riboflavin or G, niacin, pyridoxine, pantothenic acid and biotin. Other factors commonly included in the B group are choline, inositol, folic acid, and para-aminobenzoic acid. Whole grains, pasture, silage, and well-cured hay are good sources of most of the B group vitamins.

There is no evidence of a deficiency of B group vitamins in cattle rations. With the assistance of micro-organisms, cows are known to synthesize some of the B vitamins in the rumen. The level of these vitamins in the ration may affect the amount in the milk. The vitamin B complex apparently presents no problem in the adequate nutrition of the dairy cow.

Vitamin C

Vitamin C has been chemically identified and some of its functions clearly established. It 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. Cows can synthesize ascorbic acid in their normal metabolism. There is no conclusive evidence that cows fed normal rations are benefited by supplementary vitamin C.

Vitamin D

Vitamin D, known for its action in preventing rickets, is often called the antirachitic vitamin. Vitamin D, or its equivalent in direct sunshine, is necessary in the rations of dairy cattle.

Vitamin D makes it possible for animals to assimilate calcium and phosphorus properly. The requirement is large during the growing period, and therefore it is especially important in the rations of calves. There is an increased need for it in the ration of the pregnant cow. During lactation there is a heavy demand for vitamin D, 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 other sterols 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.

While growing plants do not contain vitamin D, they take on vitamin D properties when cured in the sun. However, there is little, as yet, definite information available on the optimum length of time of sun exposure and the relation of the kind and quality of forage to the vitamin D content. There is practically no vitamin D in the cereal grains, other seeds, roots and tubers. The main place of vitamin D storage in the body is in the liver. Common supplementary sources for animals are fish liver oils and irradiated yeast.

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 sun-cured hays, there probably will be no particular advantage to the animals themselves from the feeding of vitamin D supplements. Excess feeding of cod liver oil may decrease the butterfat test and cause heart lesions, particularly in young animals. If vitamin D deficiency is suspected, the provision of sun-cured hay, irradiated yeast or other dry vitamin D concentrates 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, chemically known as alpha-tocopherol. It is essential for reproduction and in preventing muscular dystrophy 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 value of supplementary vitamin E in controlling reproductive failure in dairy cattle has not been definitely demonstrated in controlled experiments.

General Considerations in Feeding

Grinding grains

It pays to grind grain for dairy cows to a medium fineness; gritty, not floury. Cows fail to chew properly the 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.

Experimental evidence indicates that there is little difference in the value of medium-fine ground, crushed, or rolled grain for cows. Ground grains are more palatable in a concentrate mixture than whole grains and result in greater milk production. It is ordinarily profitable to grind grains 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. With good hay it does not prevent much waste. Also, chopped hay is dusty and objectionable to feed in a milking barn.

Cows may eat more of a coarse, stemmy hay and waste less if it is chopped. If a hay contains unpalatable weeds, chopping is apt to decrease the hay consumption. 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 pre-digesting feeds, especially hays, have been tried. In no case has such processing proved profitable. 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 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 are usually fed at each milking. It is preferable to feed a heavy concentrate mixture (weighing more than one pound per quart) on top of silage or moistened beet pulp.

Feeding and Care of the Dairy Cow Before and Following Calving

Rest period

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 age and condition of the cow and her producing ability. Two months should be allowed an immature cow or one in poor flesh or a heavy producer, so that she will have opportunity to continue growth or 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, provided 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 both body maintenance and milk production. It is necessary, therefore, that the cow be fed so as to put on considerable flesh before calving. Also, cows that calve in good condition will start at and maintain a higher level of production than cows that are thin at calving. The cow's inherent stimulus to produce milk is most pronounced in early lactation, so unless the cow starts and maintains a fairly high milk flow 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 under Group A in Table 7, 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.

The calf is usually left with the cow until the end of the second or the beginning of the third day. It is best not to milk the cow

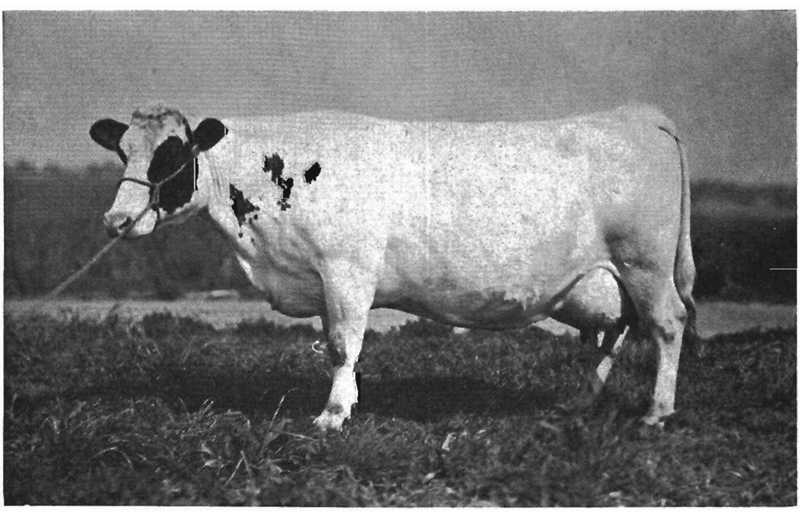


Figure 6. A high producing 5-year-old Ayrshire cow 4 days before calving showing good condition following a dry period of 7 weeks when she was fed all the good hay and corn silage she would eat and about 6 pounds of grain daily. Her production of 14,132 pounds of milk and 686 pounds of butterfat in the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

completely dry for 2 or 5 days following the calving, as incomplete milking may help 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 a portion of the first few days milk (colostrum) 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 should be increased very gradually. It is impossible to say just how long one should take in getting cows on full concentrate allowance 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. 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.

Ordinarily, one can feed 3 or 4 pounds of a concentrate mixture on about the fifth day following freshening. 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 decline in production because of insufficient nutrients.

In feeding practice the dairyman should consider both the production and condition of the individual cow. 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.

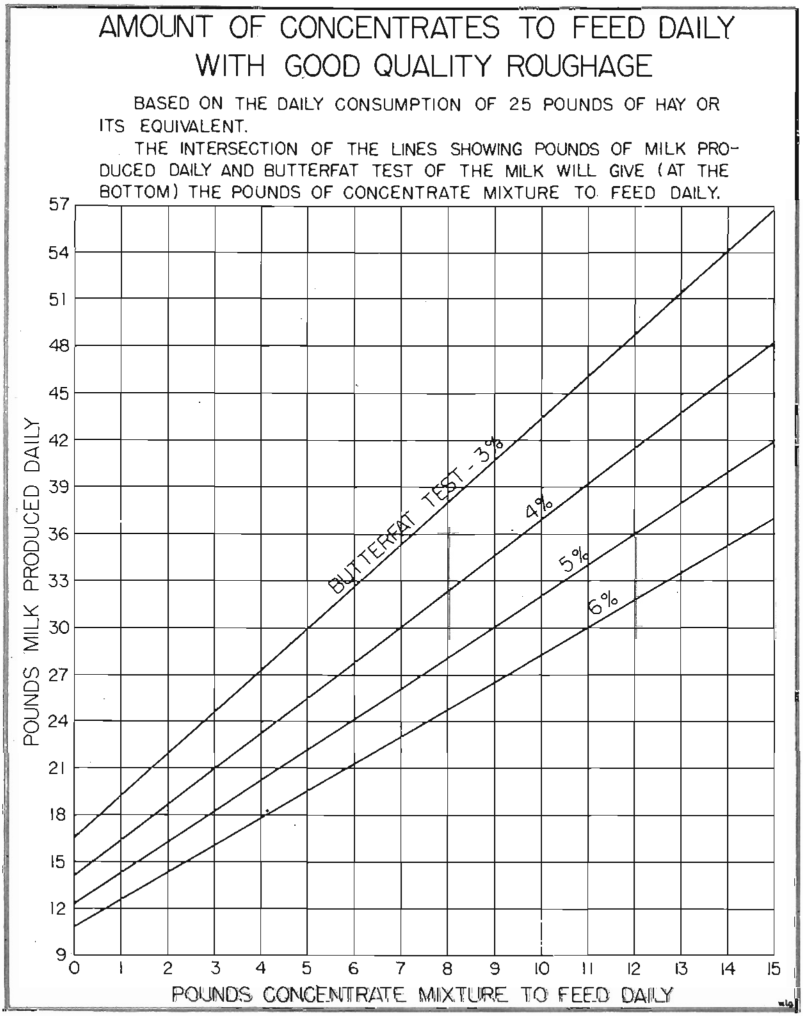


Figure 7. **Examples of using chart. A cow producing 54 pounds of 3.0 per cent milk daily requires 14 pounds of concentrates; a cow producing 30 pounds of 4.0 per cent milk requires 7 pounds of concentrates; and a cow producing 36 pounds of 5.0 per cent milk requires 12 pounds of concentrates.**

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 rather 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 be accurately determined only 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, good, and fair roughages. *Excellent quality roughage* might consist of luxuriant pasture such as on either irrigated or on sub-irrigated 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 3 pounds of hay, or hay equivalent, daily per 100 pounds of live weight if the roughage is excellent. (Three pounds of silage or five pounds of roots is equivalent to one pound of hay.)

Good quality roughage such as good pasture, average alfalfa, clover or vetch hay should be consumed daily at the rate of about 2½ pounds of hay or hay equivalent feeds per 100 pounds of live weight. The schedule of concentrate feeding with good roughage is graphically shown in Figure 7.

Fair quality 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 quality 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, or Figure 7, 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 direcly 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 mixture costs $70 per ton, or 3½¢ per pound, it would require 35¢ of the selling price of each pound of butterfat to pay for the additional feed required to produce it.

Concentrate feeding is profitable if the cost of concentrates in dollars per ton is a little less than twice the selling price of butterfat in cents per pound. From Figure 7 it will be noted that a cow producing 36 pounds of 5 per cent milk needs 10 pounds of concentrates in addition to the roughage ration. The roughage eaten will take care of body maintenance and 16 pounds of 5 per cent milk. The additional production of 20 pounds of 5 per cent milk should be credited to the 10 pounds of concentrate. If the 10 pounds of concentrates cost less than the selling price of the additional 20 pounds of 5 per cent milk, or 1 pound of butterfat, then the feeding of concentrates is profitable. Ordinarily 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 sack 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 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. Any manufacturer selling feeds not meeting the requirements as set by law is subject to penalty. The Department of Agriculture may refuse to register any feed under a brand name that tends to mislead or when 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 harmful 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. They can get a copy by request from the State Department of Agriculture, Salem. Dairymen may also request that their names be placed on the mailing list to receive the Oregon State Department of Agriculture quarterly bulletins, which include the results of commercial feed analysis.

Buying commercial mixed feeds

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

There is 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.

The main consideration as to whether dairy feeds should be bought 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, it may not pay 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. With careful selection of the ingredients necessary to balance the ration, mixing at home may be profitable, if home-grown grains and labor are available and facilities for grinding are at hand.

The feed mill will do 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 farm-grown grains to feed mills for grinding and mixing with the mill feeds and high protein concentrates necessary.

What to look for on the feed tag

The dairyman should study carefully 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. The amount of protein necessary for feeding with various types of roughages is discussed elsewhere in this bulletin. (See page 35.) *There is no necessity to pay more money to buy a higher percentage protein mixture than required.*

The fat content of the feed mixture is important. A pound of digestible fat furnishes $2\frac{1}{4}$ 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.

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. If manufacturers use a large amount of beet pulp or alfalfa meal, the mixture will be fairly high in fiber even though low fiber ingredients make up the balance of the mixture. It should be remembered that alfalfa meal is not classed as a concentrate but as a roughage.

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

The dairyman should consider the reliability of the feed manufacturer whose name appears on the feed tag. It should be kept in mind that the cheapest feed is not necessarily the most economical to purchase.

Appendix

TABLES 4-10

Table 4. DAILY NUTRITIONAL ALLOWANCES FOR DAIRY CATTLE (BASED ON RECOMMENDATIONS OF COMMITTEE ON ANIMAL NUTRITION, NATIONAL RESEARCH COUNCIL, AUGUST 1945).

	Digestible protein	Total digestible nutrients	Calcium	Phosphorus
	Pounds	*Pounds*	*Grams**	*Grams**
A. Maintenance				
700-pound cow	0.45	6.0	7	7
800-pound cow	0.50	6.7	8	8
900-pound cow	0.55	7.4	9	9
1,000-pound cow	0.60	8.1	10	10
1,100-pound cow	0.65	8.8	11	11
1,200-pound cow	0.70	9.5	12	12
1,300-pound cow	0.75	10.2	13	13
1,400-pound cow	0.80	10.9	14	14
1,500-pound cow	0.85	11.6	15	15
B. Pregnancy (per 1,000 pounds)				
Last 6 to 12 weeks	1.20	14.0	22	17
C. Lactation (per pound milk)				
2.5 per cent butterfat	0.037	0.26	1	0.7
3.0 per cent butterfat	0.040	0.28	1	0.7
3.5 per cent butterfat	0.043	0.30	1	0.7
4.0 per cent butterfat	0.045	0.32	1	0.7
4.5 per cent butterfat	0.048	0.35	1	0.7
5.0 per cent butterfat	0.050	0.37	1	0.7
5.5 per cent butterfat	0.053	0.40	1	0.7
6.0 per cent butterfat	0.055	0.42	1	0.7
6.5 per cent butterfat	0.058	0.45	1	0.7

* 454 grams equal 1 pound.

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	Phos- phorus	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. SUGGESTED CONCENTRATE MIXTURES FOR FEEDING WITH VARIOUS ROUGHAGES.*

Group A: With good alfalfa or clover hay or silage or good Ladino clover and grass pastures.

(1)		(2)	
	Pounds		*Pounds*
Ground oats	500	Wheat mixed feed (mill run)	500
Ground barley	500	Ground barley	500
	Per cent		*Per cent*
Crude protein	9.6	Crude protein	12.5
Digestible protein	7.5	Digestible protein	10.2
Total digestible nutrients	75.1	Total digestible nutrients	74.3

Group B: With low quality alfalfa or clover hay, or good oat and vetch hay or silage, or grass silage, or good grass pasture.

(3)		(4)	
	Pounds		*Pounds*
Ground oats	300	Wheat mixed feed	500
Ground barley	300	Ground barley	350
Wheat mixed feed	300	Coconut meal	150
Linseed meal	100		
	Per cent		*Per cent*
Crude protein	13.7	Crude protein	14.2
Digestible protein	11.3	Digestible protein	12.9
Total digestible nutrients	73.6	Total digestible nutrients	74.6

Group C: With grass or oat hay alone or with silage or roots, or sudan grass pasture.

(5)		(6)	
	Pounds		*Pounds*
Ground oats	250	Wheat mixed feed	500
Ground barley	250	Ground barley	350
Wheat mixed feed	350	Cottonseed meal	50
Soybean meal	150	Linseed meal	100
	Per cent		*Per cent*
Crude protein	16.8	Crude protein	16.5
Digestible protein	13.9	Digestible protein	13.7
Total digestible nutrients	74.2	Total digestible nutrients	73.8

* In these mixtures barley, wheat and corn can be used interchangeably, price being the governing factor. Oats have the same protein content but like wheat mixed feed (mill run) have about 10 per cent lower total digestible nutrient value than have barley, wheat and corn. Oats are very palatable and give desirable bulk to a grain mixture. Linseed meal, soybean meal, cottonseed meal and peanut meal can be used interchangebly in mixtures. The addition of one per cent iodized salt to the grain mixture will usually add to its palatability. If the mixture consists largely of home-grown grains, the addition of one per cent sterilized bone meal is desirable.

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

Pounds Milk Produced Daily				Amount of Concentrate to Feed Daily		
3.0 *Per cent*	4.0 *Per cent*	5.0 *Per cent*	6.0 *Per cent*	With *Excellent* Roughage	With *Good* Roughage	With *Fair* Roughage
16.5	14.0	12.0	10.5	None	None	2
19.0	16.0	14.0	12.0	None	1	3
22.0	18.5	16.0	14.0	None	2	4
24.5	21.0	18.0	16.0	1	3	5
27.0	23.0	20.0	17.5	2	4	6
30.0	25.5	22.0	19.5	3	5	7
32.5	27.5	24.0	21.0	4	6	8
35.5	30.0	26.0	23.0	5	7	9
38.0	32.5	28.0	24.5	6	8	10
41.0	34.5	30.0	26.5	7	9	11
43.5	37.0	32.0	28.0	8	10	12
46.0	39.0	34.0	30.0	9	11	13
49.0	41.5	36.0	32.0	10	12	14
52.0	44.0	38.0	33.5	11	13	15
54.5	46.0	40.0	35.5	12	14	16*
57.0	48.5	42.0	37.5	13	15	17*
60.0	50.5	44.0	39.0	14	16*	18*
62.5	53.0	46.0	41.0	15	17*	19*
65.5	55.0	48.0	42.5	16*	18*	20*

* 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 the roughage fed were low quality oats and vetch hay for this same cow, 11 pounds of concentrates should be fed.

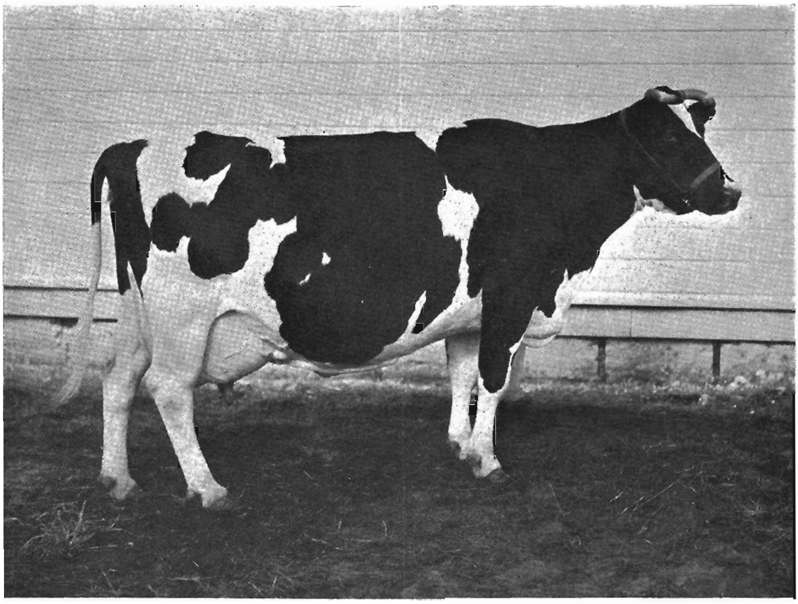
Table 9. WEIGHTS OF COMMON FEEDS

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



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