The University of Minnesota

AGRICULTURAL EXPERIMENT STATION
BULLETIN 130

FEEDING DAIRY COWS

BY

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DAIRY AND ANIMAL HUSBANDMAN

UNIVERSITY FARM, ST. PAUL
MAY 1913

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FEEDING DAIRY COWS

T. L. HAECKER

During the past two decades, Minnesota had made remarkable progress in improving the quality of her dairy products. Twenty years ago these products were not known in our great markets. Now we are receiving the highest market price for our dairy products, especially for Minnesota creamery butter. But when we examine the progress we have made in regard to milk production, we find little to be proud of. In 1890 there were in Minnesota 566,000 cows, yielding, on the average, 2,800 pounds of milk and 128 pounds of butter per cow. Now there are in the State 1,125,000 cows, yielding, on the average, 4,000 pounds of milk, containing 150 pounds of butter-fat, equivalent to 175 pounds of butter; worth, at a fair valuation, 27 cents per pound, or $47.25 per cow; which makes the total annual value of the State's dairy products alone $53,000,000.

RESULTS AT UNIVERSITY FARM

From a careful investigation we find that our common cows are capable of producing a much larger yield than is secured from the average common cow in the State. During the past decade we have always had at University Farm, in the dairy herd, a number of common cows; that is, cows with no dairy heredity. The average yield from these common cows, for 23 yearly records, is 5,000 pounds of milk and 222 pounds of butter; which last, valued at 27 cents per pound, is equal in round numbers to $60, for butter alone. The average receipt per common cow in the State is $46.40; which shows that the average cow is yielding $14 less per annum than she might easily yield if given the same care and feed as are given the cows at University Farm.

DAIRY STATISTICS

Some eight years ago the editor of *Hoard's Dairyman* sent a representative to Minnesota to take a cow census. He began on the Dakota line at the second row of counties from the south boundary. He collected data in regard to the yield of milk and butter-fat and the cost of feed, from one hundred herds, containing in the aggregate 990 cows. These cows yielded, on an average, 3,800 pounds of milk and 145 pounds of butter-fat. In dividing these herds into two groups (putting the cows that were owned by men who do not read dairy literature in one group, and the cows owned by men who read dairy literature in another group)

it was found that the first group yielded, on an average, 2,668 pounds of milk, containing, in round numbers, 98 pounds of butter-fat, valued then at $20. The cows belonging to the farmers who read dairy literature yielded, on an average, 4,442 pounds of milk containing 200 pounds of butter-fat, valued at $40. That is, the farmers who read dairy literature received $40 per cow, while those who did not, received only $20 per cow; there being a loss of $20 per cow for want of knowledge in regard to care and feeding of the animals. No claim has been made as to what could be secured if dairy-bred cows were used, but this statement is based simply on the possibilities with common cows. Since the herds of our farmers are very largely made up of that kind of cows, it becomes a matter of vital importance that these cows be so fed and cared for as to secure the possible increased yield.

FEEDING NEGLECTED

We are inclined to the opinion that farmers have not given as close study to the feeding problem as they should, for two reasons. First, many of them do not understand the terms employed by teachers. Second, the information given was not sufficiently definite and practical to command the confidence of the farmers. It will be the aim, in this bulletin, so to simplify the rules for scientific and practical feeding that those who desire may learn how to increase the returns from their cows.

CLASSES OF FEED

All animal foods are divided into two classes with reference to bulk, viz., roughage and concentrates. Roughage includes all the coarse portions of a ration, such as hay, stover, fodder corn, silage, and roots; while the term concentrates embraces all grains and mill products.

In feeds there are three groups of substances which must be considered in formulating a ration to secure the best results. These are known as protein, carbohydrates, and fat.

PROTEIN

Protein is the name of a group of materials containing nitrogen, and sometimes called the nitrogenous group, in opposition to the carbohydrates and fat, which are non-nitrogenous. The function of protein is to furnish materials for the formation of lean flesh, blood, tendons, nerves, hair, horns, wool, and the casein and albumin of milk. For the formation of these materials protein is absolutely indispensable. It is important to remember that no substance free from nitrogen can be converted into protein or be used as a substitute for protein. It is, therefore, necessary for

an animal to receive a certain amount of protein in order to maintain existence, grow, or produce milk.

CARBOHYDRATES

Carbohydrates are made up of several substances, usually divided into two groups: (1) Nitrogen-free extracts, including starch, sugar, gums, etc., and (2) crude fiber. Coarse fodders contain large amounts of crude fiber; while grain and mill-stuffs contain little fiber, but are rich in starch and sugar. Carbohydrates are either stored up in the body as fat, or are burned in the system to produce heat and energy.

FAT

Fat, or the material dissolved by ether, and for this reason often designated as ether extract, includes the fats, wax, and green coloring matter of plants. The fat of food is either stored up in the body or burned to furnish heat and energy. As a heat-producer, a pound of fat is worth as much as 2.2 pounds of carbohydrates. When fat has been multiplied by this factor, the result is called its carbohydrate equivalent.

PROPORTION OF PROTEIN AND CARBOHYDRATES

A cow, or in fact any mature animal, can economically use only from 6.5 to 7.5 pounds of digestible carbohydrates and carbohydrate equivalent to one pound of protein. If the ratio of protein to non-nitrogenous substances is materially greater, there will be a shrinkage either in milk or body weight. Ordinarily, feeds containing a high per cent of protein are expensive; and, if there is an excess of protein in the ration and a shortage of carbohydrates and fat, the more costly protein is used to make up the deficiency. It follows, therefore, that for the best and most economical results the two groups of nutrients should be fed approximately within the limits stated.

FARM FEEDS COMMONLY SHORT OF PROTEIN

All the feeds ordinarily grown on the farm have an ample supply of carbohydrates, while nearly all are short in protein. When clover or alfalfa hay is available for roughage, rations composed of either, in combination with farm grains, may be adjusted to the needs of cows, but with other roughage, such as marsh hay, prairie hay, timothy, millet, sorghum, fodder corn, stover, and straw, some concentrate with a high protein content must be added to the ration. Economical, or what might very properly be called scientific, feeding is merely providing in

the ration the constituents needed for daily maintenance and for milk production.

FOOD OF MAINTENANCE

The living body, like any intricate machinery, suffers wear and waste during every hour of its existence. It also requires nutriment for providing body-heat, and for keeping up the energy expended in carrying on all involuntary movements of the internal organs. The living body is so constituted that it constantly rebuilds the worn-out tissues; and for this purpose a daily allowance of protein must be provided, in addition to that needed for milk. For maintaining body-heat and the energy required for carrying on the muscular activities, carbohydrates and fat must be provided. The food nutrients expended daily for these purposes are termed the "food of maintenance." The amount required for this purpose depends upon the size of the animal, its disposition and environment. The larger the animal, other things being equal, the more is needed daily for maintenance, though not quite in proportion to the size. That is, a small animal requires relatively more food for this purpose than does a large one. An animal which is constitutionally timid, irritable, or discontented will use more than one having a docile, contented disposition. In practical feeding a daily allowance of 0.7 pound of digestible protein, 7 pounds of digestible carbohydrates, and 0.1 pound of fat, per 1000 pounds of live weight will suffice.

The following table gives the nutrients allowed daily for the food of maintenance for cows of given weights, ranging from 800 pounds to 1,625 pounds.

TABLE I

FOOD OF MAINTENANCE

Weight	Protein	Carbohydrates	Fat	Weight	Protein	Carbohydrates	Fat
800	.560	5.60	.08	1225	.857	8.57	.12
825	.577	5.77	.08	1250	.875	8.75	.12
850	.595	5.95	.08	1275	.892	8.92	.13
875	.612	6.12	.09	1300	.910	9.10	.13
900	.630	6.30	.09	1325	.927	9.27	.13
925	.647	6.47	.09	1350	.945	9.45	.13
950	.665	6.65	.09	1375	.962	9.62	.14
975	.682	6.82	.10	1400	.980	9.80	.14
1000	.700	7.00	.10	1425	.997	9.97	.14
1025	.717	7.17	.10	1450	1.015	10.15	.14
1050	.735	7.35	.10	1475	1.032	10.32	.15
1075	.752	7.52	.11	1500	1.050	10.50	.15
1100	.770	7.70	.11	1525	1.067	10.67	.15
1125	.787	7.87	.11	1550	1.085	10.85	.15
1150	.805	8.05	.11	1575	1.102	11.02	.16
1175	.822	8.22	.12	1600	1.120	11.20	.16
1200	.840	8.40	.12	1625	1.137	11.36	.16

FORMULATING RATIONS

In determining the nutrients needed by a cow for milk production, it is just as important to know the quantity of milk she yields, and its quality based upon the fat content, as it is to take note of the size of the cow. It is obvious that a cow yielding 30 pounds of milk requires more feed than does one giving only 20 pounds. It may not be quite as obvious, but it is equally true that a cow yielding milk testing 4 per cent fat requires more feed for the production of a given quantity of milk than is required for the production of milk testing 3 per cent.

To show why the nutrients in a ration for milk production should be adjusted to the quality of milk yielded as well as to the quantity, the following table is submitted showing the increase in protein as milk increases in per cent of butter-fat and the changes that take place in its carbohydrate or sugar content.

ORGANIC COMPOSITION OF MILK

Fat	Protein	Sugar or Carbohydrates	Fat	Protein	Sugar or Carbohydrates
3.0	2.68	4.60	5.0	3.45	4.98
3.5	2.81	4.75	5.5	3.65	4.92
4.0	3.08	4.85	6.0	3.82	4.91
4.5	3.27	4.97	6.5	4.12	4.90

From the above table it is seen that as milk increases in fat, it increases in protein, but not at the same rate, and that the sugar or carbohydrates increase up to 5 per cent milk, after which there is a slight decrease.

For many years we have kept a complete record of the feed consumed and the milk fat and other solids in milk produced by the various cows in the dairy herd at the University Farm. This has enabled us to formulate the relation between the nutrients in feed and the nutrients contained in the milk; that is, the nitrogenous and the non-nitrogenous units of nutriment required in feed to produce a unit of the corresponding components in milk.

TABLE II. FEEDING STANDARD

GIVING NET NUTRIENTS REQUIRED FOR THE PRODUCTION OF MILK CONTAINING A GIVEN PER CENT OF BUTTER-FAT

Lbs. of Milk	% FAT IN MILK 3.0			% FAT IN MILK 3.1			% FAT IN MILK 3.2		
	Pro.	C-H.	Fat	Pro.	C-H.	Fat	Pro.	C-H.	Fat
1	.047	.20	.017	.047	.20	.017	.048	.21	.018
2	.094	.40	.034	.095	.41	.035	.096	.41	.036
3	.141	.60	.051	.142	.61	.052	.143	.62	.053
4	.188	.80	.068	.190	.81	.070	.191	.83	.071
5	.234	.99	.085	.237	1.01	.087	.239	1.04	.089
6	.281	1.19	.102	.284	1.22	.104	.287	1.24	.107
7	.328	1.39	.119	.332	1.42	.122	.335	1.45	.125
8	.375	1.59	.136	.379	1.62	.139	.382	1.66	.142
9	.422	1.79	.153	.427	1.83	.157	.430	1.87	.160
10	.469	1.99	.170	.474	2.03	.174	.478	2.07	.178
	3.3			3.4			3.5		
1	.048	.21	.018	.049	.22	.018	.049	.22	.019
2	.097	.42	.036	.097	.43	.037	.098	.44	.038
3	.145	.64	.054	.146	.65	.055	.148	.66	.057
4	.193	.85	.072	.194	.87	.074	.197	.88	.076
5	.241	1.06	.090	.243	1.08	.092	.246	1.10	.094
6	.290	1.27	.109	.292	1.30	.111	.295	1.32	.113
7	.338	1.48	.127	.340	1.51	.129	.344	1.55	.132
8	.386	1.69	.145	.389	1.73	.148	.394	1.77	.151
9	.435	1.91	.163	.437	1.95	.166	.443	1.99	.170
10	.483	2.12	.181	.486	2.16	.185	.492	2.21	.189
	3.6			3.7			3.8		
1	.050	.22	.019	.051	.23	.020	.052	.23	.020
2	.100	.45	.039	.102	.46	.039	.104	.47	.040
3	.150	.68	.058	.153	.69	.059	.156	.70	.060
4	.200	.90	.077	.204	.92	.078	.208	.93	.080
5	.250	1.13	.096	.255	1.15	.098	.260	1.17	.100
6	.301	1.35	.116	.307	1.38	.118	.312	1.40	.120
7	.351	1.58	.135	.358	1.60	.137	.364	1.64	.140
8	.401	1.80	.154	.409	1.83	.157	.416	1.87	.160
9	.451	2.03	.174	.460	2.06	.176	.468	2.10	.180
10	.501	2.25	.193	.511	2.29	.196	.520	2.34	.200
	3.9			4.0			4.1		
1	.053	.24	.021	.054	.24	.021	.055	.25	.021
2	.106	.48	.041	.108	.48	.042	.109	.49	.042
3	.159	.71	.061	.162	.73	.062	.164	.74	.063
4	.212	.95	.082	.216	.97	.083	.218	.99	.084
5	.265	1.19	.102	.269	1.21	.104	.273	1.23	.105
6	.318	1.43	.122	.323	1.45	.125	.328	1.48	.127
7	.371	1.67	.143	.377	1.70	.146	.382	1.73	.148
8	.424	1.90	.163	.431	1.94	.166	.437	1.97	.169
9	.477	2.14	.184	.485	2.18	.187	.491	2.22	.190
10	.530	2.38	.204	.539	2.42	.208	.546	2.47	.211

TABLE II. FEEDING STANDARD—*Continued*

Lbs. of Milk	% FAT IN MILK 4.2			% FAT IN MILK 4.3			% FAT IN MILK 4.4		
	Pro.	C-H.	Fat	Pro.	C-H.	Fat	Pro.	C-H.	Fat
1	.055	.25	.021	.056	.25	.022	.056	.26	.022
2	.111	.50	.043	.112	.51	.044	.113	.52	.044
3	.166	.75	.064	.167	.76	.065	.169	.78	.067
4	.221	1.00	.086	.223	1.02	.087	.226	1.04	.089
5	.276	1.25	.107	.279	1.27	.109	.282	1.30	.111
6	.332	1.50	.129	.335	1.53	.131	.339	1.56	.133
7	.387	1.76	.150	.391	1.78	.153	.395	1.82	.155
8	.442	2.01	.172	.446	2.04	.174	.452	2.08	.178
9	.497	2.26	.193	.502	2.29	.196	.508	2.34	.200
10	.553	2.51	.215	.558	2.55	.218	.565	2.60	.222
	4.5			4.6			4.7		
1	.057	.26	.023	.058	.27	.023	.058	.27	.023
2	.114	.53	.045	.116	.54	.046	.117	.54	.047
3	.172	.79	.068	.174	.80	.069	.175	.81	.070
4	.229	1.06	.090	.232	1.07	.092	.234	1.09	.093
5	.286	1.32	.113	.289	1.34	.115	.292	1.36	.116
6	.343	1.58	.136	.347	1.61	.138	.350	1.63	.140
7	.400	1.85	.158	.405	1.88	.161	.409	1.90	.163
8	.458	2.11	.181	.463	2.14	.184	.467	2.17	.186
9	.515	2.38	.203	.521	2.41	.207	.526	2.45	.210
10	.572	2.64	.226	.579	2.68	.230	.584	2.72	.233
	4.8			4.9			5.0		
1	.059	.28	.024	.060	.28	.024	.060	.28	.024
2	.118	.55	.047	.119	.56	.048	.121	.57	.049
3	.177	.83	.071	.179	.84	.072	.181	.85	.073
4	.236	1.11	.094	.239	1.12	.096	.242	1.14	.097
5	.295	1.38	.118	.298	1.40	.120	.302	1.42	.121
6	.355	1.66	.142	.358	1.68	.144	.362	1.70	.146
7	.414	1.93	.165	.418	1.96	.168	.423	1.99	.170
8	.473	2.21	.189	.478	2.24	.192	.483	2.27	.194
9	.532	2.49	.212	.537	2.52	.216	.544	2.56	.219
10	.591	2.76	.236	.597	2.80	.240	.604	2.84	.243
	5.1			5.2			5.3		
1	.061	.29	.025	.062	.29	.025	.062	.29	.025
2	.122	.57	.049	.124	.58	.050	.125	.59	.051
3	.183	.86	.074	.185	.87	.075	.187	.88	.076
4	.244	1.15	.099	.247	1.17	.100	.250	1.18	.101
5	.305	1.44	.123	.309	1.46	.125	.312	1.47	.126
6	.367	1.73	.148	.371	1.75	.150	.375	1.77	.152
7	.428	2.01	.173	.433	2.04	.175	.437	2.06	.177
8	.489	2.30	.198	.494	2.33	.200	.500	2.36	.202
9	.550	2.59	.222	.556	2.62	.225	.562	2.65	.228
10	.611	2.88	.247	.618	2.91	.250	.625	2.95	.253

TABLE II. FEEDING STANDARD—*Continued*

Lbs. of Milk	% FAT IN MILK 5.4			% FAT IN MILK 5.5			% FAT IN MILK 5.6		
	Pro.	C-H.	Fat	Pro.	C-H.	Fat	Pro.	C-H.	Fat
1	.063	.30	.026	.064	.30	.026	.064	.31	.026
2	.126	.60	.051	.128	.60	.052	.129	.61	.053
3	.190	.90	.077	.192	.91	.078	.193	.92	.079
4	.253	1.20	.102	.256	1.21	.104	.258	1.23	.105
5	.316	1.49	.128	.320	1.51	.129	.322	1.53	.131
6	.379	1.79	.154	.383	1.81	.155	.386	1.84	.158
7	.442	2.09	.179	.447	2.12	.181	.451	2.15	.184
8	.506	2.39	.205	.511	2.42	.207	.515	2.45	.210
9	.569	2.69	.230	.575	2.72	.233	.580	2.76	.237
10	.632	2.99	.256	.639	3.02	.259	.644	3.07	.263
	5.7			5.8			5.9		
1	.065	.31	.027	.066	.31	.027	.066	.32	.027
2	.130	.62	.053	.131	.63	.054	.133	.64	.055
3	.195	.93	.080	.197	.94	.081	.199	.95	.082
4	.260	1.24	.106	.262	1.26	.108	.265	1.27	.109
5	.325	1.55	.133	.328	1.57	.134	.331	1.59	.136
6	.391	1.86	.160	.394	1.89	.161	.398	1.91	.164
7	.456	2.17	.186	.459	2.20	.188	.464	2.23	.191
8	.521	2.48	.213	.525	2.51	.215	.530	2.54	.218
9	.586	2.79	.239	.590	2.83	.242	.597	2.86	.246
10	.651	3.10	.266	.656	3.14	.269	.663	3.18	.273
	6.0			6.1			6.2		
1	.067	.32	.028	.068	.33	.028	.069	.33	.028
2	.134	.64	.055	.136	.65	.056	.138	.66	.057
3	.200	.97	.083	.204	.98	.084	.207	.99	.085
4	.267	1.29	.110	.272	1.30	.112	.276	1.32	.113
5	.334	1.61	.138	.339	1.63	.139	.344	1.65	.141
6	.401	1.93	.166	.407	1.96	.167	.413	1.98	.170
7	.468	2.25	.193	.475	2.28	.195	.482	2.31	.198
8	.534	2.58	.221	.543	2.61	.223	.551	2.64	.226
9	.601	2.90	.248	.611	2.93	.251	.620	2.97	.255
10	.668	3.22	.276	.679	3.26	.279	.689	3.30	.283
	6.3			6.4			6.5		
1	.070	.33	.029	.071	.34	.029	.072	.34	.029
2	.140	.67	.057	.142	.67	.058	.144	.68	.059
3	.210	1.00	.086	.213	1.01	.087	.216	1.02	.088
4	.280	1.34	.114	.284	1.35	.116	.288	1.37	.117
5	.350	1.67	.143	.355	1.69	.144	.360	1.71	.146
6	.420	2.00	.172	.426	2.03	.173	.433	2.05	.176
7	.490	2.34	.200	.497	2.36	.202	.505	2.39	.205
8	.560	2.67	.229	.568	2.70	.231	.577	2.73	.234
9	.630	3.00	.257	.639	3.04	.260	.649	3.07	.264
10	.700	3.34	.286	.710	3.38	.289	.721	3.42	.293

TABLE III

GIVING POUNDS OF DRY MATTER AND NUTRIENTS CONTAINED IN A GIVEN NUMBER OF POUNDS OF FEED STUFF

CURED ROUGHAGE

Lbs.	Dry Matter	Digestible		
		Pro.	C-H.	Fat
Fodder Corn (Drilled)				
1	.76	.037	.41	.015
2	1.52	.074	.83	.029
3	2.28	.111	1.24	.044
4	3.04	.148	1.66	.058
5	3.80	.185	2.07	.073
6	4.56	.222	2.48	.088
7	5.32	.259	2.90	.102
8	6.08	.296	3.31	.117
9	6.84	.333	3.73	.131
10	7.60	.370	4.14	.146
Sorghum Fodder				
1	.50	.024	.32	.016
2	1.01	.048	.64	.032
3	1.51	.072	.96	.048
4	2.01	.096	1.28	.064
5	2.51	.120	1.60	.080
6	3.02	.144	1.93	.096
7	3.52	.168	2.25	.112
8	4.02	.192	2.57	.128
9	4.53	.216	2.89	.144
10	5.03	.240	3.21	.160
Timothy				
1	.87	.028	.43	.014
2	1.74	.056	.87	.028
3	2.60	.084	1.30	.042
4	3.47	.112	1.74	.056
5	4.34	.140	2.17	.070
6	5.21	.168	2.60	.084
7	6.08	.196	3.04	.098
8	6.94	.224	3.47	.112
9	7.81	.252	3.91	.126
10	8.68	.280	4.34	.140
Prairie (Upland)				
1	.87	.03	.42	.014
2	1.75	.06	.84	.028
3	2.62	.09	1.25	.042
4	3.50	.12	1.67	.056
5	4.37	.15	2.09	.070
6	5.25	.18	2.51	.084
7	6.12	.21	2.93	.098
8	7.00	.24	3.34	.112
9	7.87	.27	3.76	.126
10	8.75	.30	4.18	.140

Lbs.	Dry Matter	Digestible		
		Pro.	C-H.	Fat
Corn Stover				
1	.59	.014	.31	.007
2	1.19	.028	.62	.014
3	1.78	.042	.94	.021
4	2.38	.056	1.25	.028
5	2.97	.070	1.56	.035
6	3.57	.084	1.87	.042
7	4.16	.098	2.18	.049
8	4.76	.112	2.50	.056
9	5.35	.126	2.81	.063
10	5.98	.140	3.12	.070
Millet				
1	.86	.050	.47	.011
2	1.72	.100	.94	.022
3	2.58	.150	1.41	.033
4	3.44	.200	1.88	.044
5	4.30	.250	2.34	.055
6	5.16	.300	2.81	.066
7	6.02	.350	3.28	.077
8	6.88	.400	3.75	.088
9	7.74	.450	4.22	.099
10	8.60	.500	4.69	.110
Red Top				
1	.91	.048	.47	.010
2	1.82	.096	.94	.020
3	2.73	.144	1.41	.030
4	3.64	.192	1.88	.040
5	4.55	.240	2.34	.050
6	5.47	.288	2.81	.060
7	6.38	.336	3.28	.070
8	7.29	.384	3.75	.080
9	8.20	.432	4.22	.090
10	9.11	.480	4.69	.100
Prairie (Mixed)				
1	.84	.029	.41	.012
2	1.62	.058	.83	.024
3	2.52	.087	1.24	.036
4	3.36	.116	1.66	.048
5	4.20	.145	2.07	.060
6	5.05	.174	2.49	.072
7	5.89	.203	2.90	.084
8	6.73	.232	3.32	.096
9	7.57	.261	3.73	.108
10	8.41	.290	4.15	.120

TABLE III—*Continued*

CURED ROUGHAGE—*Continued*

Lbs.	Dry Matter	Digestible		
		Pro.	C-H.	Fat
Prairie (Swale)				
1	.86	.026	.42	.011
2	1.73	.052	.84	.022
3	2.59	.078	1.26	.033
4	3.45	.104	1.68	.044
5	4.31	.130	2.09	.055
6	5.18	.156	2.51	.066
7	6.04	.182	2.93	.077
8	6.90	.208	3.35	.088
9	7.77	.234	3.77	.099
10	8.63	.260	4.19	.110
Oat				
1	.86	.047	.37	.017
2	1.72	.094	.73	.034
3	2.58	.141	1.10	.051
4	3.44	.188	1.47	.068
5	4.30	.235	1.83	.085
6	5.16	.282	2.20	.102
7	6.02	.329	2.57	.119
8	6.88	.376	2.94	.136
9	7.74	.423	3.30	.153
10	8.60	.470	3.67	.170
Cow Pea				
1	.89	.058	.39	.013
2	1.79	.116	.78	.026
3	2.68	.174	1.80	.039
4	3.58	.232	1.57	.052
5	4.47	.290	1.96	.065
6	5.37	.348	2.36	.078
7	6.26	.406	2.75	.091
8	7.16	.464	3.14	.104
9	8.05	.522	3.54	.117
10	8.95	.580	3.93	.130
White Clover				
1	.90	.115	.42	.015
2	1.81	.230	.84	.030
3	2.71	.345	1.27	.045
4	3.61	.460	1.69	.060
5	4.51	.575	2.11	.075
6	5.42	.690	2.53	.090
7	6.32	.805	2.95	.105
8	7.22	.920	3.38	.120
9	8.13	1.035	3.80	.135
10	9.03	1.150	4.22	.150

Lbs.	Dry Matter	Digestible		
		Pro.	C-H.	Fat
Barley				
1	.85	.057	.44	.01
2	1.70	.114	.87	.02
3	2.55	.171	1.31	.03
4	3.40	.228	1.74	.04
5	4.25	.285	2.18	.05
6	5.10	.342	2.62	.06
7	5.95	.399	3.05	.07
8	6.80	.456	3.49	.08
9	7.65	.513	3.92	.09
10	8.50	.570	4.36	.10
Pea				
1	.90	.080	.41	.017
2	1.80	.160	.82	.034
3	2.71	.240	1.23	.051
4	3.61	.320	1.64	.068
5	4.51	.400	2.05	.085
6	5.41	.480	2.47	.102
7	6.31	.560	2.88	.119
8	7.22	.640	3.29	.136
9	8.12	.720	3.70	.153
10	9.02	.800	4.11	.170
Soy Bean				
1	.88	.106	.41	.012
2	1.76	.212	.82	.024
3	2.65	.318	1.23	.036
4	3.53	.424	1.64	.048
5	4.41	.530	2.04	.060
6	5.29	.636	2.45	.072
7	6.17	.742	2.86	.084
8	7.06	.848	3.27	.096
9	7.94	.954	3.68	.108
10	8.82	1.060	4.09	.120
Red Clover				
1	.85	.071	.38	.018
2	1.69	.142	.76	.036
3	2.54	.213	1.13	.054
4	3.39	.284	1.51	.072
5	4.23	.355	1.89	.090
6	5.08	.426	2.27	.108
7	5.93	.497	2.65	.128
8	6.78	.568	3.02	.144
9	7.62	.639	3.40	.162
10	8.47	.710	3.78	.180

TABLE III—*Continued*

CURED ROUGHAGE—*Continued*

Alsike Clover					Alfalfa				
Lbs.	Dry Matter	Digestible			Lbs.	Dry Matter	Digestible		
		Pro.	C-H.	Fat			Pro.	C-H.	Fat
1	.90	.084	.42	.015	1	.94	.117	.41	.01
2	1.81	.168	.85	.030	2	1.87	.234	.82	.02
3	2.71	.252	1.27	.045	3	2.81	.351	1.23	.03
4	3.61	.336	1.70	.060	4	3.74	.467	1.64	.04
5	4.51	.420	2.12	.075	5	4.68	.585	2.04	.05
6	5.42	.504	2.55	.090	6	5.62	.702	2.45	.06
7	6.32	.588	2.97	.105	7	6.55	.819	2.86	.07
8	7.22	.672	3.40	.120	8	7.49	.936	3.27	.08
9	8.13	.756	3.82	.135	9	8.42	1.053	3.68	.09
10	9.03	.840	4.25	.150	10	9.36	1.170	4.09	.10
	Wheat Straw					Oat Straw			
1	.90	.008	.35	.004	1	.91	.013	.39	.008
2	1.81	.016	.70	.008	2	1.82	.026	.79	.016
3	2.71	.024	1.06	.012	3	2.72	.039	1.18	.024
4	3.62	.032	1.41	.016	4	3.63	.052	1.58	.032
5	4.52	.040	1.76	.020	5	4.54	.065	1.97	.040
6	5.42	.048	2.11	.024	6	5.45	.078	2.37	.048
7	6.33	.056	2.46	.028	7	6.36	.091	2.76	.056
8	7.23	.064	2.82	.032	8	7.26	.104	3.16	.064
9	8.14	.072	3.17	.036	9	8.17	.117	3.55	.072
10	9.04	.080	3.52	.040	10	9.08	.130	3.95	.080
	Barley Straw					Kaffir Forage			
1	.86	.009	.40	.006	1	.48	.009	.26	.011
2	1.72	.018	.80	.012	2	.96	.019	.52	.022
3	2.57	.027	1.20	.018	3	1.44	.028	.78	.033
4	3.43	.036	1.60	.024	4	1.92	.038	1.04	.044
5	4.29	.045	2.00	.030	5	2.39	.047	1.29	.055
6	5.15	.054	2.41	.036	6	2.87	.057	1.55	.066
7	6.01	.063	2.81	.042	7	3.35	.066	1.81	.077
8	6.86	.072	3.21	.048	8	3.83	.076	2.07	.088
9	7.72	.081	3.61	.054	9	4.31	.085	2.33	.099
10	8.58	.090	4.01	.060	10	4.79	.095	2.59	.110
	Oat and Pea					Oat and Vetch			
1	.89	.076	.41	.015	1	.85	.083	.36	.013
2	1.79	.152	.83	.030	2	1.70	.166	.72	.026
3	2.68	.228	1.24	.045	3	2.55	.249	1.07	.039
4	3.58	.304	1.66	.060	4	3.40	.332	1.43	.052
5	4.47	.380	2.07	.075	5	4.25	.415	1.79	.065
6	5.37	.456	2.49	.090	6	5.10	.498	2.15	.078
7	6.26	.532	2.90	.105	7	5.95	.581	2.51	.091
8	7.16	.608	3.32	.120	8	6.80	.664	2.86	.104
9	8.05	.684	3.73	.135	9	7.65	.747	3.22	.117
10	8.95	760	4.15	.150	10	8.50	.830	3.58	.130

TABLE III—*Continued*

SILAGE

Lbs.	Dry Matter	Digestible		
		Pro.	C-H.	Fat
Corn Silage				
1	.26	.012	.14	.007
2	.53	.025	.28	.014
3	.79	.037	.43	.021
4	1.06	.050	.57	.028
5	1.32	.062	.71	.035
6	1.58	.075	.85	.042
7	1.85	.087	.99	.049
8	2.11	.100	1.14	.056
9	2.38	.112	1.28	.063
10	2.64	.125	1.42	.070
Clover Silage				
1	.28	.020	.13	.010
2	.56	.040	.27	.020
3	.84	.060	.40	.030
4	1.12	.080	.54	.040
5	1.40	.100	.67	.050
6	1.68	.120	.81	.060
7	1.96	.140	.94	.070
8	2.24	.160	1.08	.080
9	2.52	.180	1.21	.090
10	2.80	.200	1.35	.100
Cow Pea Silage				
1	.21	.015	.09	.009
2	.41	.030	.17	.018
3	.62	.045	.26	.027
4	.83	.060	.34	.036
5	1.03	.075	.43	.045
6	1.24	.090	.52	.054
7	1.45	.105	.60	.063
8	1.66	.120	.69	.072
9	1.86	.135	.77	.081
10	2.07	.150	.86	.090
Pea Cannery Refuse				
1	.23	.021	.13	.008
2	.46	.042	.26	.016
3	.70	.063	.39	.024
4	.93	.084	.52	.032
5	1.16	.105	.65	.040
6	1.39	.126	.79	.048
7	1.62	.147	.92	.056
8	1.86	.168	1.05	.064
9	2.09	.189	1.18	.072
10	2.32	.210	1.31	.080

Lbs.	Dry Matter	Digestible		
		Pro.	C-H.	Fat
Sorghum Silage				
1	.24	.004	.13	.002
2	.48	.008	.27	.004
3	.72	.012	.40	.006
4	.96	.016	.54	.008
5	1.19	.020	.67	.010
6	1.43	.024	.81	.012
7	1.67	.028	.94	.014
8	1.91	.032	1.08	.016
9	2.15	.036	1.21	.018
10	2.39	.040	1.35	.020
Alfalfa Silage				
1	.27	.030	.08	.019
2	.55	.060	.17	.038
3	.82	.090	.25	.057
4	1.10	.120	.34	.076
5	1.37	.150	.42	.095
6	1.65	.180	.51	.114
7	1.92	.210	.59	.133
8	2.20	.240	.68	.152
9	2.47	.270	.76	.171
10	2.75	.300	.85	.190
Soy Bean Silage				
1	.26	.027	.09	.013
2	.52	.054	.17	.026
3	.77	.081	.26	.039
4	1.03	.108	.35	.052
5	1.29	.135	.43	.065
6	1.55	.162	.52	.078
7	1.81	.189	.61	.091
8	2.06	.216	.70	.104
9	2.32	.243	.78	.117
10	2.58	.270	.87	.130
Corn Cannery Refuse				
1	.21	.003	.12	.006
2	.42	.006	.24	.012
3	.63	.009	.36	.018
4	.84	.012	.48	.024
5	1.05	.015	.59	.030
6	1.26	.018	.71	.036
7	1.47	.021	.83	.042
8	1.68	.024	.95	.048
9	1.89	.027	1.07	.054
10	2.10	.030	1.19	.060

TABLE III—*Continued*

ROOTS AND TUBERS

Lbs.	Dry Matter	Digestible			Lbs.	Dry Matter	Digestible		
		Pro.	C-H.	Fat			Pro.	C-H.	Fat
	Carrot					Potato			
1	.11	.008	.08	.002	1	.21	.011	.16	.001
2	.23	.016	.16	.004	2	.42	.022	.31	.002
3	.34	.024	.23	.006	3	.63	.033	.47	.003
4	.46	.032	.31	.008	4	.84	.044	.63	.004
5	.57	.040	.39	.010	5	1.04	.055	.78	.005
6	.68	.048	.47	.012	6	1.25	.066	.94	.006
7	.80	.056	.55	.014	7	1.46	.077	1.10	.007
8	.91	.064	.62	.016	8	1.67	.088	1.26	.008
9	1.03	.072	.70	.018	9	1.88	.099	1.41	.009
10	1.14	.080	.80	.020	10	2.09	.110	1.57	.010
	Sugar Beet					Common Beet			
1	.13	.013	.10	.001	1	.11	.012	.08	.001
2	.27	.026	.20	.002	2	.23	.024	.16	.002
3	.40	.039	.29	.003	3	.34	.036	.24	.003
4	.54	.052	.39	.004	4	.46	.048	.32	.004
5	.67	.065	.49	.005	5	.57	.060	.39	.005
6	.81	.078	.59	.006	6	.69	.072	.47	.006
7	.94	.091	.69	.007	7	.80	.084	.55	.007
8	1.08	.104	.78	.008	8	.92	.096	.63	.008
9	1.21	.117	.88	.009	9	1.03	.108	.71	.009
10	1.35	.130	.98	.010	10	1.15	.120	.79	.010
	Mangel					Rutabaga			
1	.09	.010	.05	.002	1	.11	.010	.08	.002
2	.18	.020	.11	.004	2	.23	.020	.16	.004
3	.27	.030	.16	.006	3	.34	.030	.24	.006
4	.36	.040	.22	.008	4	.46	.040	.32	.008
5	.45	.050	.27	.010	5	.57	.050	.40	.010
6	.55	.060	.33	.012	6	.68	.060	.49	.012
7	.64	.070	.38	.014	7	.80	.070	.57	.014
8	.73	.080	.44	.016	8	.91	.080	.65	.016
9	.82	.090	.49	.018	9	1.03	.090	.73	.018
10	.91	.100	.55	.020	10	1.14	.100	.81	.020
	Flat Turnip					Wet Beet Pulp			
1	.10	.009	.06	.001	1	.10	.005	.08	.000
2	.20	.018	.13	.002	2	.20	.010	.15	.000
3	.30	.027	.19	.003	3	.31	.015	.23	.000
4	.40	.036	.26	.004	4	.41	.020	.31	.000
5	.49	.045	.32	.005	5	.51	.025	.38	.000
6	.59	.054	.38	.006	6	.61	.030	.46	.000
7	.69	.063	.45	.007	7	.71	.035	.54	.000
8	.79	.072	.51	.008	8	.82	.040	.62	.000
9	.89	.081	.58	.009	9	.92	.045	.69	.000
10	.99	.090	.64	.010	10	1.02	.050	.77	.000

TABLE III—*Continued*

CONCENTRATES—*Ground Grains and By-Products*

Lbs.	Dry Matter	Digestible		
		Pro.	C-H.	Fat
Corn				
1	.89	.079	.67	.043
2	1.78	.158	1.33	.086
3	2.67	.237	2.01	.129
4	3.56	.316	2.67	.172
5	4.45	.395	3.33	.215
6	5.35	.474	4.00	.258
7	6.24	.553	4.67	.301
8	7.13	.632	5.34	.344
9	8.02	.711	6.00	.387
10	8.91	.790	6.67	.430
Oats				
1	.90	.107	.50	.038
2	1.79	.214	1.01	.076
3	2.69	.321	1.51	.114
4	3.58	.428	2.01	.152
5	4.48	.535	2.51	.190
6	5.38	.642	3.19	.228
7	6.27	.749	3.52	.266
8	7.17	.856	4.02	.304
9	8.06	.963	4.53	.342
10	8.96	1.070	5.03	.380
Wheat Bran				
1	.88	.119	.42	.025
2	1.76	.238	.84	.050
3	2.64	.357	1.26	.075
4	3.52	.476	1.68	.100
5	4.40	.595	2.10	.125
6	5.29	.714	2.52	.150
7	6.17	.833	2.94	.175
8	7.05	.952	3.36	.200
9	7.93	1.071	3.78	.225
10	8.81	1.190	4.20	.250
Wheat Shorts				
1	.89	.130	.46	.045
2	1.78	.260	.91	.090
3	2.66	.390	1.37	.135
4	3.55	.520	1.83	.180
5	4.44	.650	2.28	.225
6	5.33	.780	2.74	.270
7	6.22	.910	3.20	.315
8	7.10	1.040	3.66	.360
9	7.99	1.170	4.11	.405
10	8.88	1.300	4.57	.450

Lbs.	Dry Matter	Digestible		
		Pro.	C-H.	Fat
Barley				
1	.89	.084	.65	.016
2	1.78	.168	1.31	.032
3	2.68	.252	1.96	.048
4	3.57	.336	2.61	.064
5	4.46	.420	3.26	.080
6	5.35	.504	3.92	.096
7	6.24	.588	4.57	.112
8	7.14	.672	5.22	.128
9	8.03	.756	5.88	.144
10	8.92	.840	6.53	.160
Wheat				
1	.89	.088	.67	.015
2	1.79	.176	1.35	.030
3	2.68	.264	2.02	.045
4	3.58	.352	2.70	.060
5	4.47	.440	3.37	.075
6	5.37	.528	4.05	.090
7	6.26	.616	4.72	.105
8	7.16	.704	5.40	.120
9	8.05	.792	6.07	.135
10	8.95	.880	6.75	.150
Flour Wheat Middlings				
1	.90	.17	.54	.041
2	1.80	.34	1.07	.082
3	2.70	.51	1.61	.123
4	3.60	.68	2.14	.164
5	4.50	.84	2.68	.205
6	5.40	1.01	3.22	.246
7	6.30	1.18	3.75	.287
8	7.20	1.35	4.29	.328
9	8.40	1.52	4.82	.369
10	9.00	1.69	5.36	.410
Red Dog Flour				
1	.90	.162	.57	.034
2	1.80	.324	1.14	.068
3	2.70	.486	1.71	.102
4	3.60	.658	2.28	.136
5	4.50	.810	2.85	.170
6	5.41	.972	3.42	.204
7	6.31	1.134	3.99	.238
8	7.21	1.296	4.56	.272
9	8.11	1.458	5.13	.306
10	9.01	1.620	5.70	.340

TABLE III—*Continued*

CONCENTRATES—*Continued*

Lbs.	Dry Matter	Digestible		
		Pro.	C-H.	Fat
Emmer (Speltz)				
1	.92	.10	.70	.02
2	1.84	.20	1.41	.04
3	2.76	.30	2.11	.06
4	3.68	.40	2.81	.08
5	4.60	.50	3.51	.10
6	5.52	.60	4.22	.12
7	6.44	.70	4.92	.14
8	7.36	.80	5.62	.16
9	8.28	.90	6.33	.18
10	9.20	1.00	7.03	.20
Kaffir Corn				
1	.90	.052	.44	.014
2	1.80	.104	.89	.028
3	2.70	.156	1.33	.042
4	3.60	.208	1.77	.056
5	4.50	.260	2.21	.070
6	5.41	.312	2.66	.084
7	6.31	.364	3.10	.098
8	7.21	.416	3.54	.112
9	8.11	.468	3.99	.126
10	9.01	.520	4.43	.140
Buckwheat Bran				
1	.92	.059	.34	.02
2	1.84	.118	.68	.04
3	2.75	.177	1.02	.06
4	3.67	.236	1.36	.08
5	4.59	.295	1.70	.10
6	5.51	.354	2.04	.12
7	6.43	.413	2.34	.14
8	7.34	.472	2.72	.16
9	8.26	.531	3.06	.18
10	9.18	.590	3.40	.20
Rye Bran				
1	.88	.112	.47	.020
2	1.77	.224	.94	.036
3	2.65	.336	1.40	.054
4	3.54	.448	1.87	.072
5	4.42	.560	2.34	.090

Lbs.	Dry Matter	Digestible		
		Pro.	C-H.	Fat
Corn and Cob Meal				
1	.85	.044	.60	.029
2	1.70	.088	1.20	.058
3	2.55	.132	1.80	.087
4	3.40	.176	2.40	.116
5	4.24	.220	3.00	.145
6	5.09	.264	3.60	.174
7	5.94	.308	4.20	.203
8	6.79	.352	4.80	.232
9	7.64	.396	5.40	.261
10	8.49	.440	6.00	.290
Sorghum Seed				
1	.87	.045	.61	.028
2	1.74	.090	1.22	.056
3	2.62	.135	1.83	.084
4	3.49	.180	2.44	.112
5	4.36	.225	3.05	.140
6	5.23	.270	3.67	.168
7	6.10	.315	4.28	.196
8	6.98	.360	4.89	.224
9	7.85	.405	5.50	.252
10	8.72	.450	6.11	.280
Buckwheat Middlings				
1	.87	.227	.37	.061
2	1.74	.454	.75	.122
3	2.62	.681	1.12	.183
4	3.49	.908	1.50	.244
5	4.36	1.135	1.87	.305
6	5.23	1.362	2.25	.366
7	6.10	1.589	2.62	.427
8	6.98	1.816	3.00	.488
9	7.85	2.043	3.37	.549
10	8.72	2.270	3.75	.610
Rye Middlings				
1	.88	.110	.53	.026
2	1.76	.220	1.06	.052
3	2.65	.330	1.59	.078
4	3.53	.440	2.12	.104
5	4.41	.550	2.64	.130

TABLE III—*Continued*

CONCENTRATES—*Continued*

Millet					Hominy Feed				
Lbs.	Dry Matter	Digestible			Lbs.	Dry Matter	Digestible		
		Pro.	C-H.	Fat			Pro.	C-H.	Fat
1	.88	.071	.48	.025	1	.90	.068	.60	.074
2	1.76	.142	.97	.050	2	1.81	.136	1.21	.148
3	2.64	.213	1.45	.075	3	2.71	.204	1.81	.222
4	3.52	.284	1.94	.100	4	3.62	.272	2.42	.296
5	4.39	.355	2.42	.125	5	4.52	.340	3.02	.370
	Corn Oil Meal					Bean Meal			
1	.91	.158	.39	.108	1	.89	.202	.42	.013
2	1.83	.316	.78	.216	2	1.78	.404	.85	.026
3	2.74	.474	1.16	.324	3	2.67	.606	1.27	.039
4	3.66	.632	1.55	.432	4	3.56	.808	1.69	.052
5	4.57	.790	1.94	.540	5	4.45	1.010	2.11	.065
	Cow Pea Meal					Soy Bean Meal			
1	.85	.168	.55	.011	1	.88	.291	.23	.146
2	1.71	.336	1.10	.022	2	1.77	.582	.47	.292
3	2.56	.504	1.65	.033	3	2.65	.873	.70	.438
4	3.42	.672	2.20	.044	4	3.53	1.164	.93	.584
5	4.27	.840	2.74	.055	5	4.41	1.455	1.16	.730
	Gluten Feed					Gluten Meal			
1	.91	.213	.53	.029	1	.90	.297	.42	.061
2	1.82	.426	1.06	.058	2	1.81	.594	.85	.122
3	2.72	.639	1.58	.087	3	2.71	.891	1.27	.183
4	3.63	.852	2.11	.116	4	3.62	1.188	1.70	.244
5	4.54	1.065	2.64	.145	5	4.52	1.485	2.12	.305
	Linseed Meal					Cotton-seed Meal			
1	.90	.302	.32	.069	1	.93	.376	.21	.096
2	1.80	.604	.64	.138	2	1.86	.752	.43	.192
3	2.71	.906	.96	.207	3	2.79	1.128	.64	.288
4	3.61	1.208	1.28	.276	4	3.72	1.504	.86	.384
5	4.51	1.510	1.60	.345	5	4.65	1.880	1.07	.480
	Flax Seed					Tankage			
1	.91	.206	.17	.290	1	.930	.501	.00	.116
2	1.82	.412	.34	.580	2	1.860	1.002	.00	.232
3	2.72	.618	.51	.870	3	2.790	1.503	.00	.348
4	3.63	.824	.68	1.160	4	3.720	2.004	.00	.464
5	4.54	1.030	.85	1.450	5	4.650	2.505	.00	.580

TABLE III—*Continued*

CONCENTRATES—*Continued*

Lbs.	Brewers' Grain—Dried: Dry Matter	Digestible: Pro.	C-H.	Fat	Lbs.	Malt Sprouts: Dry Matter	Digestible: Pro.	C-H.	Fat
1	.91	.200	.32	.060	1	.90	.203	.46	.014
2	1.83	.400	.64	.120	2	1.81	.406	.92	.028
3	2.74	.600	.97	.180	3	2.71	.609	1.38	.042
4	3.65	.800	1.29	.240	4	3.62	.812	1.84	.056
5	4.56	1.000	1.61	.300	5	4.52	1.015	2.30	.070
	Distillery Grain—Dried					Dried Beet Pulp			
1	.92	.228	.40	.116	1	.92	.041	.65	.000
2	1.85	.456	.79	.232	2	1.82	.082	1.30	.000
3	2.77	.684	1.19	.348	3	2.75	.123	1.95	.000
4	3.70	.912	1.59	.464	4	3.66	.164	2.60	.000
5	4.62	1.140	1.98	.580	5	4.58	.205	3.24	.000

BALANCING A RATION

As an illustration to show how to adjust a ration, let it be assumed that common cows weighing approximately 1,000 pounds yield, on an average, 20 pounds of milk, testing 3.8 per cent fat. The first step is to determine the nutrients required for maintenance of the body, that is, the nutrients she needs daily for herself; and, second, the nutrients needed for the production of the 20 pounds of milk. All common cows do not give milk testing just 3.8 per cent butter-fat, but our creamery records show that this is approximately the yearly average.

Referring to Table I, we find that the food of maintenance based upon body weight for a thousand-pound cow is of protein 0.7 pound, carbohydrates 7.0 pounds, and 0.1 pound of fat.

Turning to Table II, third column and third block under 3.8, we find that the nutrients required for the production of 1 pound of milk testing 3.8 per cent fat are 0.052 pound of protein, 0.23 pound of carbohydrates, and 0.020 pound of fat. Multiplying this by 20, we have the nutrients required for the production of 20 pounds of milk, or by taking the figures in the second line, which give the nutrients required for the production of 2 pounds of milk, and removing the decimal point one figure to the right, which is multiplying it by 10, we have the nutrients required for the production of 20 pounds of milk: protein 1.04 pounds, carbohydrates 4.7 pounds, and fat 0.40 pound. By adding the nutrients required for maintenance and those required for milk, we have the following:

NUTRIENTS REQUIRED FOR A THOUSAND-POUND COW GIVING 20 POUNDS OF MILK TESTING 3.8 PER CENT FAT

	Protein	Carbo-hydrates	Fat
For maintenance	.70	7.0	.10
For 20 lbs. of milk	1.04	4.7	.40
Nutrients required	1.74	11.7	.50

This means that the daily ration of a cow weighing 1,000 pounds and giving 20 pounds of milk, testing 3.8 per cent butter-fat, should contain approximately 1.74 pounds of digestible crude protein, 11.7 pounds of digestible carbohydrates, and 0.50 of a pound of fat.

The next step is so to adjust the ration that it will provide the nutrients needed and at the same time give her enough food in bulk to satisfy the appetite. If she were fed only timothy hay, she could eat only about 25 pounds a day. By referring to Table III, giving the dry matter and nutrients contained in a given number of pounds of feed, we find in the first column, third block, under "Timothy" second line, that in 2 pounds of timothy hay there are 0.056 pound of digestible protein, 0.87 pound of carbohydrates, and 0.028 pound of fat, and by removing the decimal point one figure to the right, which is multiplying by 10, we have the nutrients contained in 20 pounds of timothy hay, which is 0.56 pound of protein, 8.70 pounds of carbohydrates, and 0.28 pound of fat. Then by adding the nutrients contained in 5 pounds of timothy, we find that the 25 pounds of timothy hay would provide daily 0.7 pound of protein, 10.87 pounds of carbohydrates, and 0.35 pound of fat.

	Protein	Carbo-hydrates	Fat
Timothy hay 20 lbs	.56	8.70	.28
Timothy hay 5 lbs	.14	2.17	.07
Total nutrients in 25 lbs	.70	10.87	.35

This would provide only protein enough for her daily maintenance and none for milk production, and more carbohydrates than she needs for maintenance. She would rapidly lose in milk flow and gain in weight. As a general proposition, a cow in milk needs about 2 pounds of hay per day per hundredweight or its equivalent, and the balance of her ration should be some grain mixture adjusted to the quantity and quality of her daily milk yield. For the production of milk of average quality, 1 pound of the grain mixture to 3 pounds of milk, will generally suffice.

Farmers prefer to use only farm grains, so a trial ration will be made with corn and barley meal. Again referring to Table III, we find that 20 pounds of timothy hay, 3 pounds of corn, and 4 pounds of ground barley will provide nutrients as follows:

	Lbs.	Protein	Carbo-hydrates	Fat
Timothy hay	20	.56	8.70	.28
Corn, ground	3	.24	2.01	.13
Barley, ground	4	.42	3.26	.08
		1.22	13.97	.49

Comparing this with the nutrients required for the production of 20 pounds of milk, we find the ration is short of protein, and contains too much of carbohydrates, and that the grain mixture must contain more protein and less carbohydrates. It should also be noticed that in formulating a ration, the nutrients are carried out only two figures after the decimal point. If the third figure is 5 or under, it is dropped, if over 5, the second figure is increased by 1. For example, in 3 pounds of corn, there is 0.237 pound of protein, but it appears as 0.24 in the ration. This is done to simplify matters.

Oats have more protein and less carbohydrates than either corn or barley, so oats will be substituted for barley, which gives the following ration:

	Lbs.	Protein	Carbo-hydrates	Fat
Timothy hay	20	.56	8.70	.28
Corn, ground	3	.24	2.01	.13
Oats, ground	4	.43	2.01	.15
Nutrients provided		1.23	12.72	.56
Nutrients required		1.74	11.70	.50

This ration is 0.51 pound of protein short and has an excess of 1.02 pounds of carbohydrates. Since bran contains more protein and less carbohydrates than corn, bran will be substituted for the corn, so as to provide the following nutrients:

	Lbs.	Protein	Carbo-hydrates	Fat
Timothy hay	20	.56	8.70	.28
Oats, ground	4	.43	2.01	.15
Bran	3	.36	1.26	.07
		1.35	11.97	.50

This improves the ration, and cows might for some considerable time do fairly good work with such a grain mixture. The ration is short by 0.39 pound of protein. It is good practice to balance the ration as nearly as possible with the most common feed stuffs, and complete the balancing with such feed as oil meal, cottonseed meal, gluten feed, or white wheat middlings. On account of the excess of carbohydrates, cottonseed meal will be substituted for 1 pound of oats.

	Lbs.	Protein	Carbo-hydrates	Fat
Timothy hay	20	.56	8.70	.28
Oats, ground	3	.32	1.51	.11
Bran	3	.36	1.26	.07
Cottonseed meal	1.5	.56	.32	.14
Nutrients provided		1.80	11.79	.59
Nutrients required		1.74	11.70	.50

This is a good ration, being palatable and available nearly everywhere. If oil meal is substituted, it will require 1.8 pounds. The grain mixture may be 300 pounds each of oats and bran, and 150 pounds of cottonseed meal, or 180 pounds of oil meal.

In case the roughage available is a mixture of clover and timothy, the grain mixture may be adjusted as follows:

	Lbs.	Protein	Carbo-hydrates	Fat
Timothy	10	.28	4.34	.14
Clover	10	.71	3.78	.18
Corn, ground	2	.16	1.33	.09
Barley, ground	2	.17	1.31	.03
Wheat middlings	2	.34	1.07	.08
Nutrients provided		1.66	11.83	.52
Nutrients required		1.74	11.70	.50

This is an excellent ration as two-thirds of the concentrates are farm grains, and the other third is composed of by-products of farm grains. It will be noticed that the total nutrients are slightly in excess of the required amount, even though there is 1 pound of grain less in the ration containing timothy and clover. This illustrates the importance of providing clover for milk production.

When clover is available for roughage, a little straw can be fed to good advantage. The ration may be adjusted as follows:

	Lbs.	Protein	Carbo-hydrates	Fat
Clover, medium red	16	1.14	6.05	.29
Straw, oat	4	.05	1.58	.03
Barley, ground	4	.34	2.61	.06
Corn, ground	3	.24	2.01	.13
Nutrients provided		1.77	12.25	.51
Nutrients required		1.74	11.70	.50

It is not expected that in general practice rations will be adjusted to individual cows but that a ration will be adjusted to the herd and to the roughage that is to be fed. In the illustration given, the basis was the common cow, and a light yield of milk of medium quality. In the next illustration it will be assumed that Guernseys are employed. The standard weight of a Guernsey is 1,050 pounds, but their average

weight does not exceed 1,000 pounds, and this will be the basis for computing the food of maintenance. It will also be assumed that the daily yield is 25 pounds of milk, testing 5 per cent butter-fat. Referring to Table II, second page, third column, third block, it is found that for the production of 2 pounds of milk testing 5 per cent, there is prescribed 0.121 pound of protein, 0.57 pound of carbohydrates, and 0.049 pound of fat. Multiplying this by ten or removing the decimal point one figure to the right, we find that for the production of 20 pounds of milk, there will be needed 1.21 pounds of protein, 5.70 pounds of carbohydrates, and 0.49 pound of fat. Adding to this 0.302 pound of protein, 1.42 pounds of carbohydrates, and 0.121 pound of fat, the nutrients required for the production of 5 pounds of milk testing 5 per cent butter-fat, we have the following:

NUTRIENTS REQUIRED BY A THOUSAND-POUND COW PRODUCING 25 POUNDS OF 5 PER CENT MILK

	Protein	Carbohydrates	Fat
For 20 lbs. of 5 per cent milk	1.21	5.70	.49
For 5 lbs. of 5 per cent milk	.30	1.42	.12
For Maintenance	.70	7.00	.10
Nutrients required	2.21	14.12	.71

From this it is seen that the daily ration for a thousand-pound cow producing 25 pounds of milk testing 5 per cent butter-fat is practically 2.25 pounds of protein, 14.1 pounds of carbohydrates, and 0.7 pound of fat.

If timothy or wild hay is fed, the ration may be combined as follows:

	Lbs.	Protein	Carbohydrates	Fat
Prairie hay	20	.30	8.40	.28
Corn, ground	3	.24	2.01	.13
Oats, ground	3	.32	1.51	.11
Wheat middlings	3	.51	1.61	.12
Linseed meal	3	.91	.96	.21
Nutrients provided		2.28	14.49	.85
Nutrients required		2.21	14.12	.71

When prairie or timothy is used for roughage, 6 pounds of farm grains and 6 pounds of purchased concentrates are required to balance the ration of which 3 pounds were oil meal, which is an expensive feed. This grain mixture is made by mixing 300 pounds each of ground corn, ground oats, middlings, and linseed meal.

When the roughage is timothy and clover, the ration may be adjusted as follows:

	Lbs.	Protein	Carbo-hydrates	Fat
Timothy and clover	20.0	.99	8.12	.32
Corn, ground	3.5	.28	2.34	.15
Barley, ground	3.0	.25	1.96	.05
Oats, ground	2.5	.26	1.26	.09
Linseed meal	1.5	.45	.48	.10
Nutrients provided		2.23	14.16	.71

It is always considered well to have the fat in the ration a little in excess of the amount required to keep the digestive system in good physical tone. When half the roughage was clover, the concentrates in the ration were composed of 9 pounds of farm grains and 1.5 pounds of oil meal, requiring only 10.5 pounds of concentrates, while the ration required 12 pounds of concentrates when prairie hay was fed.

When the roughage is clover, the ration may be adjusted as follows:

	Lbs.	Protein	Carbo-hydrates	Fat
Clover hay	20.0	1.42	7.61	.36
Barley, ground	4.0	.34	2.61	.06
Corn, ground	4.7	.37	3.14	.20
Oats, ground	1.3	.14	.65	.05
Nutrients provided		2.27	14.01	.67
Nutrients required		2.21	14.12	.71

When the roughage is clover hay, 10 pounds of farm grains will meet the requirements, the excess of the protein making good the slight deficiency in carbohydrates. It will be seen that 10 pounds of grain provides for 25 pounds of milk testing 5 per cent fat, being 1 pound of grain to 2.5 pounds of milk. The mixture for this ration is 400 pounds of ground barley, 470 pounds of ground corn, and 130 pounds of ground oats. The rations are formulated from the feed stuffs in general use by farmers, and are chiefly given to show how the concentrates may be combined to adapt them for economical milk production. The amount of each kind of grain to use is determined by trial. After a little practice and experience, one soon learns how to adjust this. In the above ration the clover hay, corn, and barley provided 2.13 pounds of protein, and 2.21 pounds were needed; in addition, there was a shortage in carbohydrates. It was not thought best to use more of corn or barley, because these are so-called heavy feeds, and are quite heating. Something was needed to lighten the grain mixture, and for this purpose the oats were used. The requirements are 0.08 pound of protein in excess of what is provided by the clover, barley, and corn, and there is a shortage of 0.76 pound of carbohydrates. Adding the shortage of protein to the shortage of carbohydrates, gives a total shortage of 0.84 of a pound of carbohydrates since within certain limits

protein can be used for carbohydrates. To determine how much oats should be used, the 0.84 pound of shortage was divided by the sum of the protein 0.107 and carbohydrates 0.50 in 1 pound of oats, .840+.607=1.3+. That is, by adding the 1.3 pounds of oats to the ration, it provided 2.27 pounds of protein and 14.01 pounds of carbohydrates; the excess of protein making up in part for the shortage in carbohydrates.

It is not expected that in general feeding practice, rations will exactly meet the requirements of each individual cow, because cows vary in the amount of roughage they will take, but the allowance of 2 pounds per hundredweight is found to be a fair average, and the grain should be adjusted to each cow by actually weighing it, allowing 1 pound of the mixture to 2.5 pounds of 5 per cent milk.

SUCCULENT FOOD FOR DAIRY COWS

We know that cows usually give the largest amount of milk when they are on good pasture. Their chief feed is, then, new-grown grass. This would indicate that such feed is better for milk-production than are the dry feeds fed in winter. Green feed is more easily digested than is dry, coarse fodder, such as hay, fodder corn, and corn stover. Moreover, less energy is required to digest it, it tends to keep the body and digestive system in better condition, and it stimulates the appetite. We know this from human experience. In the winter, when vegetables are scarce and we eat potatoes, bread, and meat for a long time, we become tired of them, and crave something succulent, like fruit or green vegetables. In well-regulated homes, such food is supplied by canned or fresh vegetables and fruits.

The barrel of apples in the cellar is not especially valuable from the standpoint of the amount of nourishment contained. The great value of the apples is due to the fact that they aid in toning up the whole system and satisfy the craving for something succulent. In like manner it pays to supply the live stock on the farm with something to take the place of the green grass they get in summer. The whole ration need not be of a succulent material but that a portion of it should be such is quite essential to best results. Just as an apple or two each day is good for a boy or girl, so are a few pounds each day of succulent feed, such as roots or silage, good for farm animals.

ENSILAGE

Silage is one of the best and most economical feeds for all kinds of stock. In the fall of 1911, 700 tons of silage stored at the University Farm represented a yield equivalent to 5 tons of hay per acre

and that without the risk of losing a large percentage by rain, coarseness because of a poor stand, or waste because of letting the grass get too old, depressing palatability and digestibility, and requiring more energy for mastication and digestion. It is handy to deal out, and very much relished by all classes of stock.

In feeding silage it should be borne in mind that one pound of hay is, under average conditions, equal to three pounds of silage; so if a cow is fed 30 pounds of silage daily, it will replace 10 pounds of hay. Continuing the proposition that a cow weighing 1,000 pounds gives 25 pounds of milk daily, testing 5 per cent fat, the ration with ensilage may be adjusted as follows:

	Lbs.	Protein	Carbohydrates	Fat
Timothy hay	10.0	.28	4.34	.14
Corn silage	32.0	.40	4.54	.22
Corn, ground	3.0	.24	2.01	.13
Wheat middlings	3.0	.51	1.61	.12
Wheat bran	2.0	.24	.84	.05
Linseed meal	1.8	.54	.58	.13
Nutrients provided		2.21	13.92	.79

It will be noticed that in this ration less grain is used than in any of the other rations adjusted to cows weighing 1,000 pounds and yielding 25 pounds of milk testing 5 per cent fat. This is chiefly due to the feeding of silage. On account of its succulence and palatability, a little more can be fed than will replace the decrease in the hay. In this ration corn could be replaced by barley, oats might be used instead of bran and either gluten feed or buckwheat middlings in place of oil meal. It will be noticed that the amount of roughage to be fed is always placed first. Then follow the farm grains and the most common farm grain by-products arranged either in the order of protein content or cost. This is done to encourage the average farmer to make an effort to adjust feed to the needs of the individual animal, because it is more profitable and in every way more satisfactory. The last concentrate added to the ration is generally one containing a high per cent protein and therefore expensive, so before this is added to the ration, it is well to add the nutrients and see what is lacking, and how the balance can be most economically and conveniently made. In applying this rule to the last ration, it was found that there was a shortage of 0.54 pound of protein, 0.78 pound of carbohydrates, and 0.05 pound of fat. One familiar with the composition of feeds can readily decide what concentrate to use in the ration, and the quantity needed, but one who has not made a study of this subject, will seek for the feed that will meet the requirements best. In this case, 1.8 pounds of linseed meal filled the requirements, even though it left the ration short

in carbohydrates because there was an excess of fat in the ration which could be used.

As a further illustration in formulating rations for milk production when clover hay and silage are available, the following is submitted:

	Lbs.	Protein	Carbohydrates	Fat
Clover hay	10	.71	3.78	.18
Corn silage	32	.40	4.54	.22
Corn, ground	3	.24	2.01	.13
Barley, ground	2	.17	1.31	.03
Oats, ground	5	.53	2.51	.19
Nutrients provided		2.05	14.15	.75

From this it is seen that when clover hay and silage are fed, the ration is fairly well balanced with the ten pounds of farm grains. The roughage may be fed in such quantity as will be eaten up clean and the grain adjusted to the flow of milk, allowing approximately 1 pound of the grain mixture to 2.5 pounds of milk yielded.

This is an excellent ration. All of the feeds are available on nearly every farm; all are greatly relished by cattle; and, with the variety of concentrates and the succulence of the silage, cows will not tire of this ration if fed with it all winter.

ROOTS

Roots are excellent feed for dairy cows and are especially desirable for the fall and early winter, as they are palatable, easy to digest, and stimulate the flow of milk. They are especially effective with cows that freshened in the spring, and whose flow of milk has been depressed during the summer because of annoyance by flies and mosquitoes and unfavorable pasture conditions. If such are given a liberal supply of roots when brought to stall feeding, the flow of milk is often materially increased. Less grain is required while roots are being fed. The change from roots to more grain should be made gradually, adding grain at the rate of 1 pound for 10 pounds of roots withdrawn. The ration may be made up as follows:

	Lbs.	Protein	Carbohydrates	Fat
Clover hay	10	.71	3.78	.18
Silage	30	.37	4.30	.21
Rutabagas	30	.30	2.40	.06
Corn, ground	2	.16	1.33	.09
Oats, ground	2	.21	1.01	.08
Wheat bran	3	.36	1.26	.07
Nutrients provided		2.11	14.08	.69

By feeding rutabagas at noon, the cows will take the same amount of roughage, and the grain ration can be reduced at the rate of 1

pound of grain to 8 or 10 pounds of roots, depending upon the kind of roots fed. The 10 pounds of grain in the clover and silage ration contain 7.12 pounds of digestible matter, while the 30 pounds of rutabagas and the 7 pounds of grain in this ration contain 7.33 pounds of digestible matter. That is, the 30 pounds of roots replace 3 of grain.

RATIONS FOR TWELVE-HUNDRED POUND COWS, YIELDING 40 POUNDS OF 3.5 PER CENT MILK

As a further illustration of the proper method of adjusting rations to dairy herds giving a large flow of milk containing relatively a low per cent of butter-fat, it will be assumed that the cows weigh 1,200 pounds each, and yield approximately 40 pounds of milk testing, say, 3.5 per cent of butter-fat. Referring to Tables I and II, it is found that the daily ration should provide the following nutrients:

	Protein	Carbohydrates	Fat
For maintenance	.84	8.40	.12
For 40 lbs. milk	1.97	8.80	.76
Nutrients required	2.81	17.20	.88

With prairie hay and farm grains available, and allowing the amount of hay usually taken in addition to the grain which is approximately 2 pounds per hundredweight, and in this case 24 pounds, and concentrates at the rate of 1 pound of grain to 3 pounds of milk yielded, there will be about 14 pounds of grain in the ration. Taking for a trial ration 3 pounds each of ground corn, ground oats, bran, and flour middlings, and by adding what oil meal is needed, we have the following:

	Lbs.	Protein	Carbohydrates	Fat
Prairie hay	24.0	.72	10.07	.34
Corn, ground	3.0	.24	2.01	.13
Oats, ground	3.0	.32	1.51	.11
Wheat bran	3.0	.36	1.26	.07
Wheat middlings	3.0	.51	1.61	.12
Linseed meal	2.3	.69	.74	.16
Nutrients provided		2.84	17.20	.93

When large production is to be provided for, there should be a greater variety of concentrates, which will increase the palatability so that the cows will be less likely to go off feed. Flour middlings have a high feeding value and will materially improve a ration with oats and bran. This ration can be adjusted to individual cows by feeding what roughage they will take, and then give 1 pound of the grain mixture for each 3 pounds of milk yielded.

If roots are available, the ration may be adjusted as follows:

	Lbs.	Protein	Carbohydrates	Fat
Prairie hay	22	.66	9.24	.31
Rutabagas	36	.36	2.89	.07
Oats, ground	3	.32	1.51	.11
Wheat middlings	3	.51	1.61	.12
Wheat bran	3	.36	1.26	.07
Total		2.21	16.51	.68
Linseed meal	2	.60	.64	.14
Nutrients provided		2.81	17.15	.82
Nutrients required		2.81	17.20	.88

By adding the nutrients provided by 22 pounds of hay, 36 pounds of rutabagas, and 3 pounds each of oats, flour middlings, and wheat bran, it is found that the ration is short 0.60 pound of protein, and 0.69 of carbohydrates. By looking over Table III, it is found that 2 pounds of linseed meal or gluten meal will complete the ration. In this case linseed meal is selected because it is in more common use than gluten meal.

By comparing this ration with the one preceding, it will be seen that roots take the place of part of the grain ration.

When silage is available, they will take on an average 12 pounds of timothy or prairie hay and 36 pounds of silage. The same grain mixture may be made.

	Lbs.	Protein	Carbohydrates	Fat
Upland prairie hay	12	.36	5.03	.17
Corn silage	36	.45	5.12	.26
Corn, ground	3	.24	2.01	.13
Oats, ground	3	.32	1.51	.11
Wheat middlings	3	.51	1.61	.12
Wheat bran	3	.36	1.26	.07
Linseed meal	2	.60	.64	.14
Nutrients provided		2.84	17.18	1.00

To show the influence that clover hay has upon the grain mixture, it will be substituted for prairie hay in the following formula:

	Lbs.	Protein	Carbohydrates	Fat
Clover hay	12.00	.85	4.53	.21
Corn silage	36.00	.62	5.11	.25
Corn, ground	3.00	.24	2.01	.13
Barley, ground	4.00	.37	2.61	.06
Oats, ground	5.00	.53	2.51	.19
Linseed meal	.75	.23	.24	.06
Nutrients provided		2.84	17.01	.90

By feeding clover and silage for roughage, it is made possible to

feed largely of farm grains and avoid the purchase of any great amount of the more expensive by-products.

It sometimes happens that farmers are in possession of extra good cows, but not realizing the amount of feed required by cows giving a large yield, they are soon allowed to shrink in milk because the feed given does not provide sufficient nutriment. While cows in good condition when they freshen can, for a time, give more milk than the feed provides, by drawing upon the fat stored in the body, yet if the grain is not gradually increased as the cows lose in body weight, there will soon follow an abnormal shrinkage in milk flow, and also a decrease in the quality of milk yielded. To give some idea as to the quantity of feed needed for a large flow of milk, it will be assumed that a cow weighing 1,400 pounds yields 60 pounds of milk containing 3 per cent butter-fat for which the following nutrients are required:

	Protein	Carbo-hydrates	Fat
For maintenance	.98	9.80	.14
For 60 lbs. milk	2.81	11.90	1.02
Nutrients required	3.79	21.70	1.16

To provide the nutrients needed, the following ration or its equivalent, will have to be given:

	Lbs.	Protein	Carbo-hydrates	Fat
Hay, prairie or timothy	13	.36	5.64	.18
Corn silage	38	.47	5.44	.28
Corn, ground	3	.24	2.01	.13
Barley, ground	3	.25	1.96	.05
Oats, ground	4	.43	2.01	.15
Wheat bran	4	.48	1.68	.10
Wheat middlings	4	.68	2.14	.16
Total		2.91	20.88	1.05
Linseed meal	3	.91	.96	.21
Nutrients provided		3.82	21.84	1.26
Nutrients required		3.79	21.70	1.16

It should be borne in mind that the protein allowed for milk production is in all cases more than the amount actually needed because allowance had to be made for variation in composition of feeds, so if the amount provided in the ration is only approximately equal to that said to be required, it will suffice. Attention is directed to the relative light roughage and heavy grain supplied in the ration. This is found to be necessary with large yielders to lessen bulk and increase the nutrient content of the ration. If more roughage were fed, she might not have sufficient feeding capacity to take the amount of grain required to provide the nutrients needed for the milk she is giving. A cow is

not injured by heavy feeding so long as the feed does not provide nutrients materially in excess of the amount needed for the work she is doing. This is especially true with carbohydrates and fat, but an excess of protein is harmful as it has a tendency to cause shy breeding or barrenness, while on the other hand, a shortage in protein will cause an abnormal loss in body weight or shrinkage in milk. Rations for cows giving a very large yield of milk should contain a large variety of grains to make them appetizing, so the cows will not go off feed. The grain mixture for the above ration should be made of 300 pounds each of ground corn and barley, 400 pounds each of ground oats, wheat bran and white or flour middlings, and 300 pounds of linseed meal or gluten meal.

If it is desired to feed some roots, a grain mixture may be made of 500 pounds each of wheat bran and white middlings, 400 pounds each of ground oats and brewers' grains, and 35 pounds of rutabagas, and give only 18 pounds of the grain mixture in addition to the hay, silage, and roots, as follows:

	Lbs.	Protein	Carbohydrates	Fat
Hay, prairie or timothy	13	.36	5.64	.18
Corn silage	38	.47	5.44	.28
Oats, ground	4	.43	2.01	.13
Wheat bran	5	.59	2.10	.12
Wheat middlings	5	.84	2.68	.20
Brewers' grains	4	.80	1.28	.24
Rutabagas	35	.35	2.80	.07
Nutrients provided		3.84	21.95	1.22
Nutrients required		3.79	21.70	1.16

If it is desired to feed mangels instead of rutabagas, the grain mixture may be composed of 300 pounds of ground corn, 200 pounds of ground oats, 500 pounds each of wheat bran and flour middlings, and 300 pounds of dried brewers' grains and by feeding 16.5 pounds of the grain mixture, 36 pounds of mangels with the hay and silage, the nutrient requirements will be provided.

SOME GENERAL SUGGESTIONS

The object in formulating a ration is to provide sufficient bulk to satisfy the appetite and feeding capacity, and to furnish the amount of each nutrient needed for the work a cow is doing. If the ration lacks in bulk, the cow will be discontented. If it contains nutriment in excess of the amount needed for the maintenance of the body and the milk yield, a gradual gain in weight will follow, and if it is short of the required amount of nutriment there will be a decrease in the flow of milk or a shrinkage in body-weight.

Proportion of Roughage to Concentrates.—Since it is important that a cow should have enough feed to satisfy the appetite, the proportion of coarse feed to grain must be adjusted to her actual needs. The tables give the nutrients needed for milk production. Roughage in a general way should be fed according to her size, allowing 2 pounds of hay per hundredweight when it is the only roughage used. When silage is fed, the general rule may be to feed 1 pound of hay and 3 pounds of silage per hundredweight and the balance of the nutrients needed should be provided in concentrates, except that when roots are fed they will take the place of a part of the grain at the rate of 10 pounds of roots for 1 pound of grain. These directions are only general, as in feeding practice it will be found that spare, big-bodied cows will take relatively more roughage.

Palatability.—In formulating a ration, due regard should be given to its palatability. A cow will give better returns if she relishes her food. It stimulates the appetite and aids digestion. To this end, forage should be cut early and not exposed to sunshine any longer than is absolutely necessary. Dews and sunlight in alteration will bleach forage and reduce its palatability and digestibility. The ration should be composed of a reasonable number of feeds, since a mixture is relished better than only one kind of grain or roughage; but frequent changes in a ration should be avoided, as they cause imperfect digestion and assimilation. The dairyman should so adjust the supply of feed that the ration can be made from two kinds of roughage and several varieties of grain, and then make no more changes during the winter than is necessary. If an appetizing, well-balanced ration can be fed all winter, better results will be obtained than when changes in the ration are made. Succulent feed such as roots and silage is greatly relished, and it stimulates the appetite and the flow of milk. It also aids digestion by keeping the cow in better physical tone.

Order of Feeding.—It is of great importance that strict regularity should be observed, both in feeding and in milking, in order to secure the greatest degree of contentment in the herd. If cows are fed at stated intervals, they will not worry for food until the time for feeding arrives. If it is then given to them in proper quantity, they will eat and lie down, chew the cud and sleep or rest contentedly until the time for another feed. First give the grain mixture, and milk the cows while they are eating it. This routine is recommended because, with some cows, the milk comes more freely while they are eating that portion of their ration which has the most relish. Cured roughage should be fed after milking, because it fills the air in the barn or stable with dust. Succulent feed, like silage and roots, should also be fed after milking, because of the odor that it gives. Feeding twice a day will

bring better returns than more frequent and wasteful feeding. Give half the concentrates and half the roughage in the morning, and half in the evening. Cows will soon become accustomed to this routine. In the winter they should be allowed to spend the day in the stall, and for two or three hours about midday they should not be disturbed. Turning them out into the yard, or giving them access to a straw-stack or field of corn stalks, will cause them to shrink in milk, no matter how much or how well they may be fed in the morning and evening. No more feed should be given them than they will eat up. The mangers should be absolutely clean and free from any feed, during the day and night.

Handling the Herd.—In order to secure a large yield of milk, it is quite as important that the cow or herd is handled properly as that proper feeding is practiced. We know of many instances where the best of dairy cows were kept, and where good methods of feeding were practiced; and still results fell far short of what might reasonably be expected, simply because the animals did not receive that kindly treatment which is so essential to a cow giving much milk for a long period. The herd as a whole should always be moved slowly. Never hurry a cow, or strike her or speak loudly and harshly. A gentle voice and a caressing touch are quite as potent as is digestible protein. If you so handle the cows that they are fond of you, you have learned one of the most important lessons that lead to profitable dairying. The most successful milk-producers are always in close touch with every cow in the herd. The milk-producer has to do with motherhood, in which affection always plays an important part. A cow's affection for the calf prompts the desire to give it milk; if you gain her affection, she will desire to give you milk. If you have not been in the habit of caressing the cows, the time to inaugurate the practice is when they approach the time of calving, as it is at that particular time when they take kindly to grooming and to gentle rubbing of the udder.

Name the Cows.—Each cow should have a name, which should always be spoken when approaching her. This one point counts for much in the successful handling of a herd. Suppose the cows are slowly filing into the barn, and you see that Rose is about to go into the wrong stall, a quick call of "Rose!" will attract her attention, and she will forget that she was about to go into her neighbor's stall to steal a mouthful of her feed. If Rose, when in the yard, is about to hook another member of the herd, and just at that moment hears her name called, she will forget what she was about to do. Again, suppose the herd is slowly wending its way down the lane to the pasture, and someone has thoughtlessly left a side gate open, leading into a grain field. Rose is in the lead; and, as you see her turning toward the

open gate, a quick, sharp call of "Rose!" will exert a wonderful influence in bringing her back into line. It is by such methods that a herd can be gradually taught to do the right things, to save you many steps, and at the same time bring a larger return.

Feeding When Dry.—During the eight or ten weeks that cows go dry their food should be chiefly roughage. A daily allowance of two pounds of bran or oats, or a mixture of two parts each of bran and oats and one part of linseed meal or corn oil-meal, makes a proper feed for a cow near calving. Some roots, cabbage, pumpkins, or squashes are also very good. Highly carbonaceous roughage, such as straw and corn stalks, is not good at this particular time. Such feeds, with cold water, cold drafts, or lying out at night on damp or frozen ground, are the chief causes of caked udder or garget.

Care Previous to Calving.—For ten days preceding the time for calving, the cow should be kept in a comfortable, well-littered box-stall or pen, in which there is no manger. The feed should be given in a box or basket, which should be removed after the feed is taken. The coarse feed may be put in the corner, and no more should be given than she will eat. This rule should be observed, not only before calving, but at all times. Throwing large quantities of roughage before a cow leads her into the bad habit of eating only the most appetizing parts, and so wasting much feed. It is a good practice to take a lantern and go the rounds of the barn, before retiring for the night, to see that everything is as it should be.

Care of the Young Calf.—When the calf is dropped, leave it with the dam a few hours, to afford her an opportunity to lick it. If the cow gives milk containing only a medium amount of solids, the calf may be permitted to take what nourishment it wants the first time; but if the cow gives very rich milk, only a little should be allowed; otherwise there is danger of having a bad case of indigestion on your hands the second day. Just at this time much attention should be given the cow by way of grooming; not with a curry-comb, but with a brush and frequent rubbing of the udder. This will prove beneficial to the cow and profitable to you. After the calf has taken nourishment once, it should be removed, preferably when the dam is not in the stall or pen; for it is better that she should not associate you with the loss of her calf, that she may more readily transfer her affection to you. By removing the calf at once, it is soon forgotten, and thus disturbance is minimized.

Care of Fresh Cow.—The first mess for the cow should be about half a pail of whole or, preferably, ground oats, which has been allowed to stand covered for half an hour after pouring hot water over its contents. There are stimulating properties in the oats, which will aid

her in passing the after-birth. If oats are not to be had, give her a warm bran mash, containing a pint of oil-meal or corn oil-meal, or a handful of ground flax. The degree of her usefulness during this period of her lactation depends largely on your skill in bringing her to a full feed and full flow of milk. It takes a cow several weeks to reach her full flow, and the same time should be taken in getting her to full feed. If nature takes its proper course, the after-birth will pass the first day, though this may not take place until the second day. In the meantime the oats or bran mash should be fed twice a day for two days, when a gradual change may be made to the regular ration. The amount that should be given at first depends, of course, upon the cow. But, in a general way, a half ration of the concentrates will answer, permitting her to satisfy her appetite preferably on clover or pea hay. She has, if properly fed, stored up in her body a surplus of nutriment upon which nature intended that she should draw, and thus make it unnecessary for her to eat heating carbohydrates, to add more heat to an already feverish condition of the system. So, if the nourishment for a few days is scant, the system will the more quickly be reduced to a normal temperature, and the liability to caked bag or milk fever will be lessened.

The linseed meal or flax was recommended with a view to keeping the bowels in a laxative condition. Special care should be exercised not to expose the cow to cold drafts at this critical period. If it seems necessary to leave the barn or stable door open for a while, the cow should be blanketed, but the blanket should be removed soon after the door is closed; for, if she becames accustomed to a blanket, she will be more liable to take cold. During the period when the cow is being brought to full feed, she should be encouraged to consume a large quantity of roughage; and to this end a variety of tempting morsels may be given her.

Regularity.—While the routine of the barn work may be adjusted to your convenience, strict regularity should be observed in all things, to maintain as much as possible the pace of the cow's system, secured when she was in full flow. If feeding or milking is delayed, the elaboration of milk is interrupted and the flow lessened. So, in order to get a full yield for a long time, everything should be done with the strictest regularity. The milking should be done in such a way that a cow will receive the largest possible satisfaction from the semi-daily event.

TABLE IV

GIVING COST OF ONE POUND AT A GIVEN PRICE PER TON

Price per Ton	Cost of 1 Lb.	Price per Ton	Cost of 1 Lb.	Price per Ton	Cost of 1 Lb.	Price per Ton	Cost of 1 Lb.
Dollars	Cents	Dollars	Cents	Dollars	Cents	Dollars	Cents
.25	.0125	.78	.0390	8.75	.437	22.00	1.100
.26	.0130	.79	.0395	9.00	.450	22.25	1.112
.27	.0135	.80	.0400	9.25	.462	22.50	1.125
.28	.0140	.81	.0405	9.50	.475	22.75	1.137
.29	.0145	.82	.0410	9.75	.487	23.00	1.150
.30	.0150	.83	.0415	10.00	.500	23.25	1.162
.31	.0155	.84	.0420	10.25	.512	23.50	1.175
.32	.0160	.85	.0425	10.50	.525	23.75	1.187
.33	.0165	.86	.0430	10.75	.537	24.00	1.200
.34	.0170	.87	.0435	11.00	.550	24.25	1.212
.35	.0175	.88	.0440	11.25	.562	24.50	1.225
.36	.0180	.89	.0445	11.50	.575	24.75	1.237
.37	.0185	.90	.0450	11.75	.587	25.00	1.250
.38	.0190	.91	.0455	12.00	.600	25.25	1.262
.39	.0195	.92	.0460	12.25	.612	25.50	1.275
.40	.0200	.93	.0465	12.50	.625	25.75	1.287
.41	.0205	.94	.0470	12.75	.637	26.00	1.300
.42	.0210	.95	.0475	13.00	.650	26.25	1.312
.43	.0215	.96	.0480	13.25	.662	26.50	1.325
.44	.0220	.97	.0485	13.50	.675	26.75	1.337
.45	.0225	.98	.0490	13.75	.687	27.00	1.350
.46	.0230	.99	.0495	14.00	.700	27.25	1.362
.47	.0235	1.00	.0500	14.25	.712	27.50	1.375
.48	.0240	1.25	.0625	14.50	.725	27.75	1.387
.49	.0245	1.50	.0750	14.75	.737	28.00	1.400
.50	.0250	1.75	.0875	15.00	.750	28.25	1.412
.51	.0255	2.00	.1000	15.25	.762	28.50	1.425
.52	.0260	2.25	.1125	15.50	.775	28.75	1.437
.53	.0265	2.50	.1250	15.75	.787	29.00	1.450
.54	.0270	2.75	.1375	16.00	.800	29.25	1.462
.55	.0275	3.00	.1500	16.25	.812	29.50	1.475
.56	.0280	3.25	.1625	16.50	.825	29.75	1.487
.57	.0285	3.50	.1750	16.75	.837	30.00	1.500
.58	.0290	3.75	.1875	17.00	.850	30.25	1.512
.59	.0295	4.00	.2000	17.25	.862	30.50	1.525
.60	.0300	4.25	.2125	17.50	.875	30.75	1.537
.61	.0305	4.50	.2250	17.75	.887	31.00	1.550
.62	.0310	4.75	.2375	18.00	.900	31.25	1.562
.63	.0315	5.00	.2500	18.25	.912	31.50	1.575
.64	.0320	5.25	.2625	18.50	.925	31.75	1.587
.65	.0325	5.50	.2750	18.75	.937	32.00	1.600
.66	.0330	5.75	.2875	19.00	.950	32.25	1.612
.67	.0335	6.00	.3000	19.25	.962	32.50	1.625
.68	.0340	6.25	.3125	19.50	.975	32.75	1.637
.69	.0345	6.50	.3250	19.75	.987	33.00	1.650
.70	.0350	6.75	.3375	20.00	1.000	33.25	1.662
.71	.0355	7.00	.3500	20.25	1.012	33.50	1.675
.72	.0360	7.25	.3625	20.50	1.025	33.75	1.687
.73	.0365	7.50	.3750	20.75	1.037	34.00	1.700
.74	.0370	7.75	.3875	21.00	1.050	34.25	1.712
.75	.0375	8.00	.4000	21.25	1.062	34.50	1.725
.76	.0380	8.25	.4125	21.50	1.075	34.75	1.737
.77	.0385	8.50	.4250	21.75	1.087	35.00	1.750

TABLE V

GIVING COST OF ONE POUND AT A GIVEN PRICE AND WEIGHT PER BUSHEL

When a Bushel Costs	WHEN A BUSHEL WEIGHS						
	32 Lbs.	40 Lbs.	48 Lbs.	50 Lbs.	56 Lbs.	60 Lbs.	70 Lbs.
	1 Lb. Costs	1 Lb. Costs	1 Lb. Costs	1 Lb. Costs	1 Lb. Costs	1 Lb. Costs	1 Lb. Costs
Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents
10	.312	.250	.208	.20	.178	.167	.143
11	.344	.275	.229	.22	.196	.183	.157
12	.375	.300	.250	.24	.214	.200	.171
13	.406	.325	.271	.26	.232	.217	.186
14	.437	.350	.292	.28	.250	.233	.200
15	.469	.375	.312	.30	.268	.250	.214
16	.500	.400	.333	.32	.286	.267	.228
17	.531	.425	.354	.34	.304	.283	.243
18	.562	.450	.375	.36	.321	.300	.257
19	.594	.475	.396	.38	.339	.317	.271
20	.625	.500	.417	.40	.357	.333	.286
21	.656	.525	.437	.42	.375	.350	.300
22	.687	.550	.458	.44	.393	.367	.314
23	.719	.575	.479	.46	.411	.383	.328
24	.750	.600	.500	.48	.428	.400	.343
25	.781	.625	.521	.50	.446	.417	.357
26	.812	.650	.542	.52	.464	.433	.371
27	.844	.675	.563	.54	.482	.450	.386
28	.875	.700	.583	.56	.500	.467	.400
29	.906	.725	.604	.58	.518	.483	.414
30	.937	.750	.625	.60	.536	.500	.428
31	.969	.775	.646	.62	.554	.517	.443
32	1.000	.800	.667	.64	.571	.533	.457
33	1.031	.825	.687	.66	.589	.550	.471
34	1.062	.850	.708	.68	.607	.567	.486
35	1.094	.875	.729	.70	.625	.583	.500
36	1.125	.900	.750	.72	.643	.600	.514
37	1.156	.925	.771	.74	.661	.617	.528
38	1.187	.950	.792	.76	.678	.633	.543
39	1.219	.975	.812	.78	.696	.650	.557
40	1.250	1.000	.833	.80	.714	.667	.571
41	1.281	1.025	.854	.82	.732	.683	.586
42	1.312	1.050	.875	.84	.750	.700	.600
43	1.344	1.075	.896	.86	.768	.717	.614
44	1.375	1.100	.917	.88	.786	.733	.628
45	1.406	1.125	.937	.90	.804	.750	.643
46	1.437	1.150	.958	.92	.821	.767	.657
47	1.469	1.175	.979	.94	.839	.783	.671
48	1.500	1.200	1.000	.96	.857	.800	.686
49	1.531	1.225	1.021	.98	.875	.817	.700
50	1.562	1.250	1.042	1.00	.893	.833	.714
51	1.594	1.275	1.062	1.02	.911	.850	.728

NOTE.—The above table and the one preceding are made to aid in determining the cost of a ration. If it is desired to ascertain the cost of a pound of oats when it sells for 23 cents per bushel, follow down the column under the heading "When a Bushel Costs" until the number 23 is reached; then to the right to the column headed "32," because there are 32 pounds in a bushel, where 0.719 is given as the price of 1 pound of oats. Multiplying this factor by the number of pounds of oats to be used in the ration gives 2.157 cents, the cost of three pounds of oats. If barley is fed, follow the line to the right until the column headed "48" is reached, which gives 0.479 as the cost of 1 pound of barley when a bushel costs 23 cents. If 4 pounds of barley are fed the cost is 1.916 cents.

TABLE V—*Continued*

When a Bushel Costs	When a Bushel Weighs						
	32 Lbs.	40 Lbs.	48 Lbs.	50 Lbs.	56 Lbs.	60 Lbs.	70 Lbs.
	1 Lb. Costs	1 Lb. Costs	1 Lb. Costs	1 Lb. Costs	1 Lb. Costs	1 Lb. Costs	1 Lb. Costs
Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents
52	1.625	1.300	1.083	1.04	.928	.867	.743
53	1.656	1.325	1.104	1.06	.946	.883	.757
54	1.687	1.350	1.125	1.08	.964	.900	.771
55	1.719	1.375	1.146	1.10	.982	.917	.786
56	1.750	1.400	1.167	1.12	1.000	.933	.800
57	1.781	1.425	1.187	1.14	1.018	.950	.814
58	1.812	1.450	1.208	1.16	1.036	.967	.828
59	1.844	1.475	1.229	1.18	1.054	.983	.843
60	1.875	1.500	1.250	1.20	1.071	1.000	.857
61	1.906	1.525	1.271	1.22	1.089	1.016	.871
62	1.937	1.550	1.292	1.24	1.107	1.033	.886
63	1.969	1.575	1.312	1.26	1.125	1.050	.900
64	2.000	1.600	1.333	1.28	1.143	1.067	.914
65	2.031	1.625	1.354	1.30	1.161	1.083	.928
66	2.062	1.650	1.375	1.32	1.178	1.100	.943
67	2.094	1.675	1.396	1.34	1.196	1.117	.957
68	2.125	1.700	1.417	1.36	1.214	1.133	.971
69	2.156	1.725	1.437	1.38	1.232	1.150	.986
70	2.187	1.750	1.458	1.40	1.250	1.167	1.000
71	2.219	1.775	1.479	1.42	1.268	1.183	1.014
72	2.250	1.800	1.500	1.44	1.286	1.200	1.028
73	2.281	1.825	1.521	1.46	1.303	1.217	1.043
74	2.312	1.850	1.542	1.48	1.321	1.233	1.057
75	2.344	1.875	1.562	1.50	1.339	1.250	1.071
76	2.375	1.900	1.583	1.52	1.357	1.267	1.086
77	2.406	1.925	1.604	1.54	1.375	1.283	1.100
78	2.437	1.950	1.625	1.56	1.393	1.300	1.114
79	2.469	1.975	1.646	1.58	1.411	1.317	1.128
80	2.500	2.000	1.667	1.60	1.428	1.333	1.143
81	2.531	2.025	1.687	1.62	1.446	1.350	1.157
82	2.562	2.050	1.708	1.64	1.464	1.367	1.171
83	2.594	2.075	1.729	1.66	1.482	1.383	1.186
84	2.625	2.100	1.750	1.68	1.500	1.400	1.200
85	2.656	2.125	1.771	1.70	1.518	1.417	1.214
86	2.687	2.150	1.792	1.72	1.536	1.433	1.228
87	2.719	2.175	1.812	1.74	1.553	1.450	1.243
88	2.750	2.200	1.833	1.76	1.571	1.467	1.257
89	2.781	2.225	1.854	1.78	1.589	1.483	1.271
90	2.812	2.250	1.875	1.80	1.607	1.500	1.286
91	2.844	2.275	1.896	1.82	1.625	1.517	1.300
92	2.875	2.300	1.917	1.84	1.643	1.533	1.314
93	2.906	2.325	1.937	1.86	1.661	1.550	1.328
94	2.937	2.350	1.958	1.88	1.678	1.567	1.343
95	2.969	2.375	1.979	1.90	1.696	1.583	1.357
96	3.000	2.400	2.000	1.92	1.714	1.600	1.371
97	3.031	2.425	2.021	1.94	1.732	1.617	1.386
98	3.062	2.450	2.041	1.96	1.750	1.633	1.400
99	3.094	2.475	2.062	1.98	1.768	1.650	1.414
100	3.125	2.500	2.083	2.00	1.786	1.667	1.571

TABLE VI

AVERAGE WEIGHT OF ONE QUART OF FEEDING STUFFS*

FEEDING STUFF	Weight Pounds	FEEDING STUFF	Weight Pounds
Corn (unground)	1.75	Buckwheat (unground)	1.43
Corn meal	1.31	Buckwheat middlings	0.92
Hominy feed	1.50	Flaxseed (unground)	1.65
Gluten feed	1.50	Flaxseed meal	1.10
Gluten meal	1.65	Linseed meal, old process	1.33
Germ oil meal	1.35	Cotton seed meal (medium)	1.50
Distillers' dried grains	0.63	Beef scraps	1.49
Kaffir corn	2.00	Blood meal	1.87
Corn and cob meal	1.50	Feeding tankage	1.24
Oats (unground)	1.03	Meat meal	1.44
Oat meal	1.67	Blood and bone	1.88
Wheat, whole	1.90	Alfalfa meal	0.59
Wheat bran	0.55	Dried beet pulp	0.65
Wheat middlings	1.00	Canadian field peas	2.09
Flour middlings	1.12	Cow peas	1.70
Rye (unground)	1.85	English peas	1.65
Rye bran	0.76	Field beans	1.71
Rye middlings	1.55	German millet seed	1.59
Barley (unground)	1.01	Milo maize	1.28
Malt sprouts	0.53	Soja beans	1.81
Brewers' dried grains	0.67	Sunflower seed	1.51

*From bulletin 141, Agricultural Experiment Station, Purdue University.

TABLE VII. GESTATION TABLE

THE AVERAGE PERIOD OF GESTATION WITH CATTLE IS 282 DAYS

Date of service	Date of birth	Date of service	Date of birth	Date of service	Date of birth
Jan. 1	Oct. 8	May 6	Feb. 11	Sept. 8	June 16
" 6	" 13	" 11	" 16	" 13	" 21
" 11	" 18	" 16	" 21	" 18	" 26
" 16	" 23	" 21	" 26	" 23	July 1
" 21	" 28	" 26	Mar. 3	" 28	" 6
" 26	Nov. 2	" 31	" 8	Oct. 3	" 11
" 31	" 7	June 5	" 13	" 8	" 16
Feb. 5	" 12	" 10	" 18	" 13	" 21
" 10	" 17	" 15	" 23	" 18	" 26
" 15	" 22	" 20	" 28	" 23	" 31
" 20	" 27	" 25	April 2	" 28	Aug. 5
" 25	Dec. 2	" 30	" 7	Nov. 2	" 10
Mar. 2	" 7	July 5	" 12	" 7	" 15
" 7	" 13	" 10	" 17	" 12	" 20
" 12	" 18	" 15	" 22	" 17	" 25
" 17	" 23	" 20	" 27	" 22	" 30
" 22	" 28	" 25	May 2	" 27	Sept. 4
" 27	Jan. 2	" 30	" 7	Dec. 2	" 9
April 1	" 7	Aug. 4	" 13	" 7	" 14
" 6	" 12	" 9	" 17	" 12	" 19
" 11	" 17	" 14	" 22	" 17	" 24
" 16	" 22	" 19	" 27	" 22	" 29
" 21	" 27	" 24	June 1	" 27	Oct. 4
" 26	Feb. 1	" 29	" 6		
May 1	" 6	Sept. 3	" 11		