EXTENSION

Nutritive Values of Feeds

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Introduction

Animals require consumption of chemical elements and compounds to sustain bodily functions to support the reproductive process and for skeletal and tissue growth. The necessary chemical elements and compounds are referred to as nutrients and can be classified into six categories: water, carbohydrates, lipids or fats, proteins, minerals and vitamins. The objective of feed evaluation is to provide a rapid and economical method to determine the nutrients available (nutritional value) of a feed. For more than 100 years, the proximate analysis system has been used to describe the chemical composition of feeds. Components of proximate analysis are shown in Figure 1.

Nutritional value is determined by nutrient concentration and nutrient digestibility. Proximate analysis is one method used to determine nutrient concentration, although very little information about nutrient digestibility is gained. True nutrient digestibility information is determined using digestion trials, but it is not practical to test digestibility on all feeds. Therefore, previous digestibility information from similar feeds and previous relationships between digestibility and some nutrient concentration measures is commonly used to estimate digestibility. Table 1 contains average nutrient concentration values for numerous feeds that can be used in cattle diets. Values in the table represent averages from numerous different sources, such as the National Academy of Sciences, Engineering and Medicine's, Nutrient Requirements of Beef and Dairy Cattle publications, commercial laboratories, research trials and other publications.

Producers must recognize values published in any table are merely averages. Variation among grains, oilseeds, by-products and, in particular, forages and roughages, can be extreme. Furthermore, various processing methods also may alter digestibility. For this reason, producers are advised to have their feeds and forages tested for nutrient composition by a feed testing laboratory. To improve quality control and standardization among commercial laboratories, the National Forage Testing Association (NFTA), found at foragetesting.org, provides a unique certification service. At this website, one also can view the NFTA's recommendations for laboratory procedures and equations for use in predicting energy

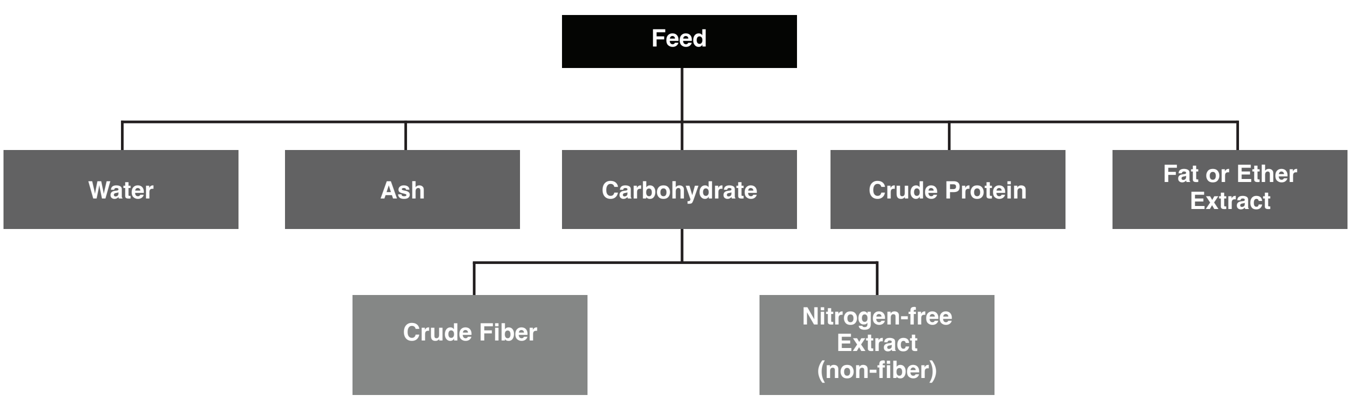

Figure 1. Nutrient components of feed determined from proximate analysis.

availability for different forage types.

Wet chemistry procedures are more expensive, although they represent the standard for nutritive values. Many laboratories will offer both. One of the primary decisions to make is whether to use wet chemistry procedures and Near Infrared Reflectance Spectrophotometer (NIRS) procedures to determine protein and energy values.

NIRS analyses are less expensive. Basically, random portions of a sample are loaded into an NIR sample holder and reflected light from the ground sample is measured in the infrared region (generally 1,100 nm to 2,500 nm). The NIRS instrument is part of a system calibrated by using representative samples from the population (forage type) to be tested. Prediction equations are selected based on calibration statistics. Consequently, it is important to know whether the laboratory is using equations developed with forage similar to that which you intend to have tested. For example, since alfalfa hay is common across the country, most laboratories use equations specifically designed to determine protein and energy content of alfalfa hay. However, grass and other legume species can vary widely in cell structure and chemical composition. Generally, NIRS is less costly because it predicts wet chemistry values by bouncing light through samples. With this type of analysis, the lab should have a list of types of feed samples they can analyze by this method. For instance, most labs can perform quality NIRS analysis on alfalfa samples. Consider having wet chemistry analysis completed on feeds that the laboratory has not calibrated for NIRS.

Dry Matter

Dry matter (DM) expresses the proportion of the feed that is not water. The moisture concentration is determined by weighing the feed sample soon after it has been collected. Next, the sample is placed in a drying oven until all of the water has evaporated. Finally, the dried sample is weighed again and the DM content is calculated by the difference. Other than physical characteristics of the feed, moisture content has little to no bearing on the availability of nutrients within that feed.

Dry matter is an extremely variable component among and within types of feeds. Fresh forages, silages and wet byproduct feeds are likely to vary the most in DM content. Some silages and byproduct feeds contain as little as 25% DM (75% moisture). A good rule of thumb is that dry feeds should contain no more than 12% moisture for safe long-term storage in bins.

Fiber

The original proximate analysis system separated carbohydrates into crude fiber and nitrogen-free extract (NFE) fractions. The crude fiber portion of the feedstuff was intended to represent the indigestible fiber fraction, while NFE was supposed to represent the more readily digestible carbohydrates, such as sugars and starches. However, it was soon discovered this system had serious limitations, particularly for fibrous feeds like forages.

Because of the wide variation in chemical analyses for crude fiber and NFE, a new system called the detergent fiber system was developed, which better reflects true carbohydrate digestibility in ruminants (Figure 2). The neutral detergent solubles (NDS) fraction is comprised of cell contents that are nearly 100% digestible. The neutral detergent insoluble fiber (NDF) fraction is primarily cell wall tissue, which consists of hemicellulose, cellulose and lignin. The NDF fraction also contains small amounts of silica and fiber-bound or heat-damaged protein. The NDF fraction of feeds and forages is quite variable in digestibility. Using an acid solution, the NDF residue can be further separated into acid detergent solubles (ADS; primarily hemicellulose) and acid detergent insoluble fiber (Figure 3). The acid detergent insoluble fiber fraction contains cellulose and lignin. The lignin portion is nearly indigestible, whereas the cellulose portion is variable in digestibility.

With purchased feeds that come with a feed tag, crude fiber is the only fiber analysis required. Unfortunately, this provides little assistance in determining the nutrient value or digestibility of the feed. However, it may be possible for a feed representative to provide NDF and ADF values. NDF concentration is inversely related to the amount of the feed the cattle will eat. Because digestibility of fiber is proportional to the amount of lignin in the plant material, ADF is inversely related to the digestibility of feed ingredients. This relation-

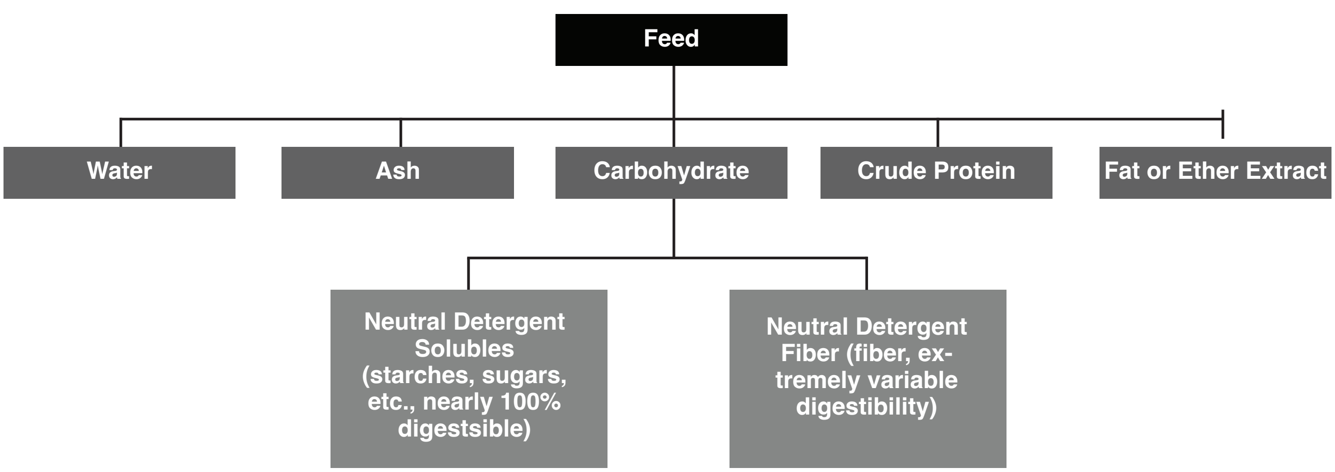

Figure 2. The detergent fiber system

ship explains why some forages and feeds contain high NDF concentrations, but remain high in digestibility, while others may contain moderate or low NDF concentrations, yet are low in digestible energy.

Effective NDF

The physical effectiveness factor (pef) value shown in Table 1 is a measure of the feed particle size and an indication of its potential to stimulate chewing. NDF is effective in stimulating rumen motility or churning (Figure 4). The physical effectiveness factor ranges from 0 to 1.0. This factor is multiplied by the NDF concentration to determine the physically effective NDF content of the feed (peNDF). Long-stem grass hay has a pef of 1.0 and other feeds are rated relative to grass hay according to particle size. Most of the pef values provided in Table 1 are estimates based on particle size and nDF content.

For example, chopped alfalfa haylage has NDF of 42% (dry matter basis) and pef of 0.6. Therefore the peNDF value is 25.2%. From there, average diet peNDF is calculated and used to predict ruminal pH. Diets containing lower peNDF and lower ruminal pH require more intensive management due to increasing risk of acidosis, bloat and founder. Between 12% and 20% peNDF is recommended for growing cattle and for limit-fed diets (NASEM 2016). The layman term for eNDF is the scratch value of the feed. If the rumen stops churning, acidic gases build up causing the pH to drop. The result is bloat, acidosis and/or founder, as well as reduced diet digestibility. Table 1 expresses eNDF as a percentage of NDF. This value is determined by several factors including particle size, density, hydration and degree of lignification. To maintain optimal forage digestion, the diet should contain a minimum of 20% eNDF on a DM basis.

Protein

Protein values in Table 1 reflect CP, which is simply nitrogen concentration multiplied by 6.25. The rumen degradable intake protein (RDIP) column is an estimate of the proportion of the crude protein that is actually degradable in

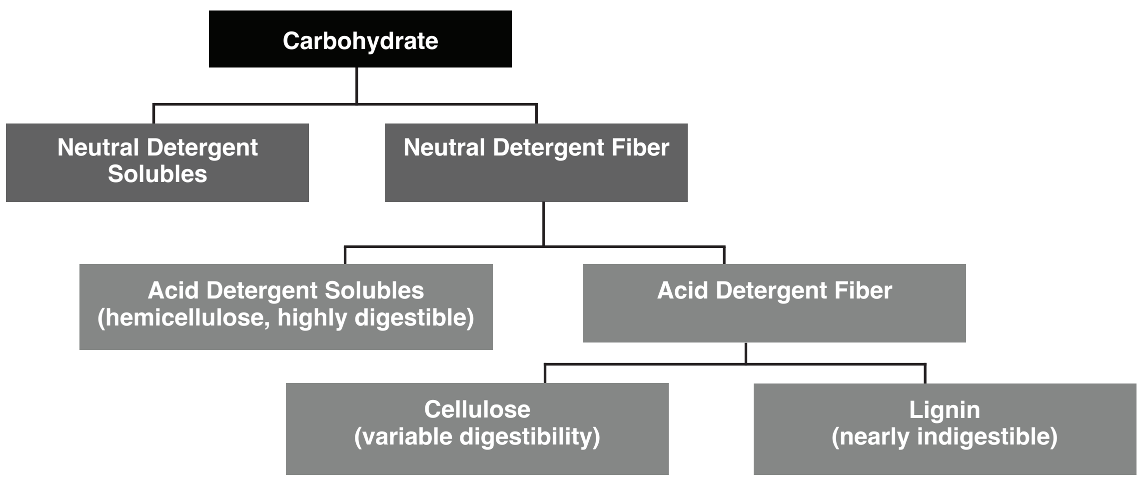

Figure 3. Fiber fractions in the detergent fiber system.

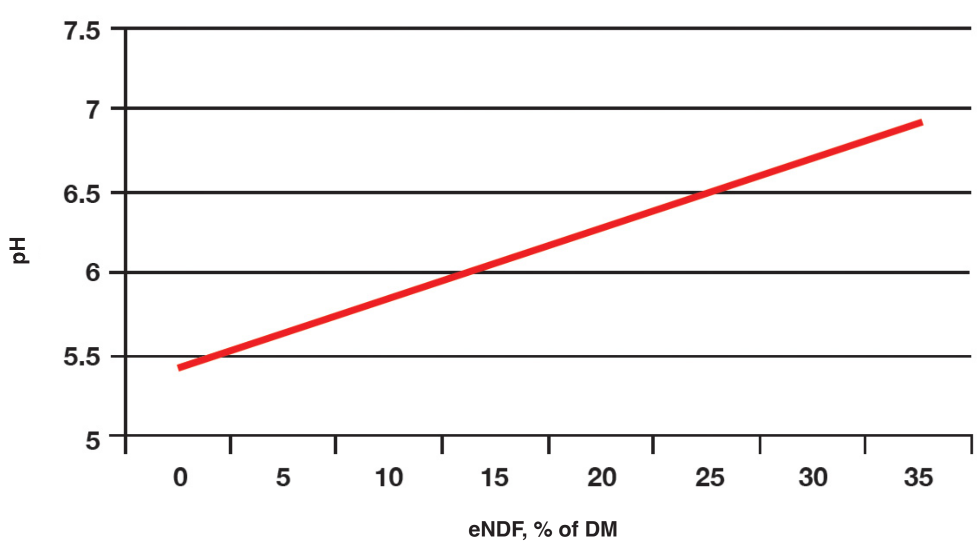

Figure 4. The relationship of effective NDF and rumen pH.

the rumen and is expressed as a percentage of CP. Rumen undegradable protein (percent of CP) can be calculated by subtracting the RDIP value from 100.

Feed Energy Values

Feed energy values are expressed on a DM basis as percent total digestible nutrients (TDN), net energy for maintenance (NEm) and net energy for gain (NEg) units (mega calories per 100 pounds of feed). TDN is determined by carrying out a digestion trial and summing the digestible protein and carbohydrates plus 2.25 times digestible ether extract. Ether extract (EE) is the fat or lipid portion of the feed. The net energy system is generally thought to be more precise in estimating the energy value of feeds, particularly roughages. The net energy of feed is the portion available to the animal for maintenance or various productive purposes. The portion used for maintenance (NEm) is used for muscular work, maintenance and repair of tissues, maintaining a stable body temperature and other body functions. Most of this digested energy will leave the animal's body as heat. Energy used for productive purposes (NEg) may be recovered as growth through retaining energy in tissues. Energy for productive purposes is less efficient than energy used for maintenance. Milk production is unique because its energy efficiency is similar to maintenance uses.

Minerals

Minerals needed by animals in larger quantities are referred to as macro minerals. These minerals are shown in Table 1 and feed concentration is expressed on a percent of DM basis. Minerals needed by animals in much smaller quantities are referred to as micro minerals and feed concentration is expressed in parts per million (ppm) in Table 1. To convert ppm to percent, simply move the decimal place four places to the left. For example, if a feed contained 12 ppm copper, the copper concentration expressed as a percentage would be 0.0012%.

Conclusion

Producers need to ensure their animals' diets include the proper balance of the six essential nutrients in a physical form that maintains digestive system health and function. To accomplish this, producers must have good knowledge of available feed nutrient composition, physical and digestive characteristics and the animal's nutrient requirements.

Nutrient concentration and digestibility data can be determined by using digestion trials or measuring chemical composition and applying this information to estimate digestibility. It is imperative producers recognize the values published in any table are merely averages and variation among feed commodities, oilseeds and, in particular forages and roughages, can be extreme. For this reason, producers are advised to have their feeds and forages tested for nutrient composition by commercial laboratories.

References

2014 Feed Composition Guide. (2014) Beef. Retrieved from beefmagazine.com/datasheet/2014-feed-composition-table

NRC. (2000) Nutrient Requirements of Beef Cattle (7th Edition). National Academy Press, Washington, DC.

National Academy of Sciences, Engineering and Medicine (NASEM). Nutrient Requirements of Beef Cattle (8th Revised Edition), 2016.

For more detailed information on mineral sources and their chemical composition, see Nutrient Requirements of Beef Cattle (2016) and Nutrient Requirements of Dairy Cattle (2001).

Table 17.1. Typical composition of feeds and forages.

	DM %	CP %	DIP % of CP	TDN %	NEm (Mcal/cwt.)	NEg (Mcal/cwt.)	NDF %	pef[a] %	ADF %	EE %	Ca %	P %	S %	Cu ppm	Mn ppm	Zn ppm	Se ppm
FEEDSTUFF																	
Hay																	
Alfalfa hay, early bloom	88	20	80	63	66	38	45	.7	34	3.0	1.56	0.30	0.41	9	41	24	0.28
Alfalfa hay, midbloom	88	18	80	60	60	34	46	.8	34	2.6	1.89	0.29	0.36	10	41	27	0.28
Alfalfa hay, mature	88	14	75	52	47	22	47	.9	36	1.3	1.52	0.26	0.28	10	44	21	0.28
Barley hay	91	10	59	54	28	58	98	.8	35		0.36	0.22	0.16	6.6	38	22	0.09
Bermuda hay, vegetative	90	15	80	57	55	29	69	.7	37	—2.3	0.59	0.28	0.30	12	170	36	0.12
Bermuda hay, early bloom	90	10	72	53	49	24	75	.8	37	1.9	0.51	0.20	0.25	8	140	31	0.12
Bermuda hay, full bloom	90	8	68	47	39	15	79	.9	36	1.8	0.43	0.18	0.21	8	110	26	0.05
Bermuda hay, mature	88	6	70	49	42	18	78	.9	39	3.8	0.51	0.24	0.21	6	145	17	0.05
Birdsfoot trefoil, hay	89	16	78	57	57	25	50	.8	38	2.2	1.73	0.24	0.25	—		28	—
Bromegrass hay	89	10	80	55	55	21	66	.8	41	2.3	0.40	0.23	0.19	—	—	19	—
Clover ladino hay	90	21	75	61	62	31	36	.7	32	2.0	1.35	0.32	0.20	—	—	17	—
Clover red hay	88	15	72	55	55	21	51	.7	39	2.5	1.50	0.25	0.17	—	—	17	—
Clover sweet hay	91	16	70	53	53	18	50	.8	38	2.4	1.27	0.25	0.46	—	—		—
Corn stover (stalk hay)	85	6	70	50	44	19	67	1.0	39	1.3	0.57	0.10	0.14	—	—	22	—
Corn, whole hay	88	7.5	61	70	0.74	0.46	43	1.0	25	2.8	0.20	0.19	0.10	5.7	0.15	25	0.30
Fescue hay, early bloom	87	15	72	59	59	29	68	.8	31	4.8	0.45	0.37	0.21	11	200	34	—
Fescue hay, full bloom	88	9	68	50	52	16	73	.9	42	3.5	0.40	0.26	0.17	7	100	23	—
Lespedeza hay	92	14	40	54	54	20	65	.8	—	3.0	1.10	0.22	0.19	—	—	29	—
Meadow hay	90	7	77	50	50	12	70	.8	44	2.5	0.61	0.18	0.17	—	—	24	—
Millet hay	92	11	75	53	45	20	63	.8	40	1.7	0.52	0.24	0.19	10	100	38	—
Milo stalk hay	90	4	—	49	50	16	78	1.0	—	—	0.46	0.11	—	—		—	
Milo-soybean hay	90	11	72	55	48	23	58	.9	35	1.5	0.46	0.18	0.17	9	41	27	—
Oat hay	91	9	75	59	53	28	59	.8	38	2.3	0.32	0.21	0.14	8	62	19	0.17
Oat straw	91	4	60	48	48	9	73	1.0	48	2.3	0.24	0.07	0.22	—	—	6	—
Orchardgrass hay	88	10	73	59	59	28	67	.8	40	3.3	0.32	0.30	0.20	—	—	26	—
Old world bluestem hay, early bloom	90	10	—	58	59	34	—	.8	—	2.8	0.38	0.20	0.18	9	60	24	0.12
Old world bluestem hay, mature	90	6	51	52	25	—	—	.8	—	2.4	0.38	0.20	0.18	9	60	24	0.12
Peanut hay	91	11	—	57	54	28	49	.8	39	2.8	1.39	0.16	0.14	14	66	28	—
Peavine hay	91	13	—	57	52	27	47	.9	35	2.1	1.24	0.21	0.16	10	59	29	—
Prairie hay	91	6	63	52	50	12	73	.9	47	2.0	0.40	0.15	0.06	4	59	34	0.05
Rice hay	93	7	70	55	48	23	60	1.0	41	1.8	0.21	0.22	0.15	16	558	60	—
Rice straw	91	4	100	40	42	0	72	1.0	47	1.4	0.23	0.08	0.11	—	—		—
Rye grass hay	90	10	70	58	58	26	65	.9	39	3.3	0.45	0.30	0.18	7	87	27	—
Rye straw	89	4	100	44	44	1	71	1.0	55	1.5	0.24	0.09	0.11	—	—		—
Sorghum hay	91	10	—	55	47	22	62	1.0	40	1.8	0.52	0.22	0.16	11	65	32	—
Sorghum-sudan, hay	92	11	100	54	46	21	64	1.0	40	1.8	0.50	0.24	0.17	11	62	29	—
Soybean hay	92	15	100	60	57	31	47	.9	37	2.3	1.40	0.22	0.19	10	69	32	—
Soybean straw/residue	88	5	100	42	43	0	70	1.0	54	1.4	1.59	0.06	0.26	—		56	—
Sudan hay, boot stage	91	9	70	58	54	26	67	.8	43	2.6	0.40	0.26	0.06	9	41	38	0.12
Sudan hay, mature	91	5	—	52	52	24	68	1.0	44	2.4	0.45	0.20	0.06	9	37	38	0.12
Sugarcane hay	92	6	70	50	38	16	66	1.0	43	1.9	0.48	0.19	0.17	11	77	31	—
Sunflower hay	90	7	70	64	68	41	55	1.0	43	0.0	1.81	0.12	0.00	10	36	10	—
Timothy hay, early bloom	88	11	78	59	59	28	63	.8	39	2.7	0.58	0.26	0.21	—	—	30	—
Timothy hay, full bloom	88	8	75	57	57	25	65	.9	40	2.6	0.43	0.20	0.13	—	—	25	—
Triticale hay	91	11	80	59	53	27	59	.8	38	2.1	0.35	0.23	0.15	7	40	25	—
Wheat hay, immature	87	12	75	58	70	40	66	.8	38	2.2	0.15	0.20	0.22	9	60	23	0.19
Wheat hay, mature	88	9	75	48	56	31	58	.9	42	2.1	0.15	0.20	0.22	9	60	23	0.09
Wheat straw	89	4	40	41	29	5	81	1.0	58	1.8	0.18	0.05	0.19	4	41	29	0.09
Wheat straw, ammoniated	85	9	75	50	50	12	76	.9	55	1.5	0.15	0.05	0.16	5	35	6	—

	DM %	CP %	DIP % of CP	TDN %	NEm (Mcal/cwt.)	NEg (Mcal/cwt.)	NDF %	pef[a] %	ADF %	EE %	Ca %	P %	S %	Cu ppm	Mn ppm	Zn ppm	Se ppm
Standing forage/Pasture/Green chop																	
Alfalfa	24	19	82	61	62	31	46	.41	34	3.0	1.35	0.27	0.29	—	—	18	—
Barley forage	38	14		62	60	34	54	—	33	3.3	0.44	0.34	0.19	8	36	40	—
Bermuda, vegetative	30	16	85	65	67	40	68	.80	—	3.0	0.46	0.31	0.33	13	185	32	0.12
Bermuda, boot stage	35	13	75	60	59	33	72	1.0	—	2.7	0.59	0.28	0.30	12	160	36	0.12
Bermuda, fall, mature	80	8	60	48	41	16	77	1.0	—	2.1	0.26	0.18	0.21	9	140	20	0.05
Bermuda, winter, mature	90	5	55	44	34	10	80	—	—	1.5	0.30	0.15	0.15	7	45	15	0.05
Bermuda, stockpiled, Nov.-Dec.	85	11	65	54	50	25	74	1.0	—	2.1	0.52	0.22	0.27	5	117	26	0.05
Bermuda, stockpiled, Sep.-Oct.	35	13	70	57	55	29	70	1.0	—	2.5	0.66	0.24	0.26	6	151	27	0.05
Bermuda, stockpiled, Jan.-Feb.	90	7	60	47	39	15	77	1.0	—	1.5	0.48	0.18	0.25	4	116	26	0.05
Birdsfoot trefoil	22	21	80	66	68	38	47	.8	31	4.4	1.78	0.25	0.25	—	—	31	—
Bluestem, mature	61	6	100	50	50	12		1.0		5.0	0.40	0.12	0.05	—	—	28	—
Brassica, immature	24	19	—	68	71	44	26	.8	21	4.2	1.71	0.39	0.60	8	52	70	—
Brassica, mature	32	13	—	79	88	59	22	.9	20	0.9	0.97	0.33	0.43	4	27	30	—
Bromegrass	30	15	88	64	65	36	54	.8	33	4.1	0.45	0.34	0.21	—	—	20	—
Cheatgrass	21	16	100	68	70	41	68	.9		2.7	0.60	0.28	—	—	—	—	
Clover ladino	19	25	80	69	71	43	35	.6	33	4.8	1.27	0.38	0.20	—	—	20	—
Clover red	24	18	79	64	65	36	44	.6	33	4.0	1.70	0.30	0.17	—	—	23	—
Corn forage	37	8	—	72	75	48	42	.9	24	2.9	0.21	0.22	0.09	6	28	23	—
Corn stalks	39	7	—	53	43	18	67	—	44	1.6	0.33	0.16	0.08	8	57	25	—
Fescue, vegetative	29	18	80	64	65	39	60	.7	32	4.5	0.50	0.40	0.24	13	175	36	—
Fescue, boot stage	33	12	75	57	55	29	65	.8	31	3.8	0.45	0.30	0.21	10	150	32	—
Fescue, mature	70	8	70	49	42	18	74	.9	42	3.2	0.38	0.20	0.18	7	120	26	—
Fescue, stockpiled, Nov.-Dec.	40	13	75	52	47	22	72	.8	36	2.7	0.45	0.30	0.21	12	150	32	—
Fescue, stockpiled, Jan.-Feb.	60	11	68	40	27	3	75	.9	37	2.2	0.38	0.20	0.18	7	120	26	—
Fodder, oat	13	18	82	70	76	49	30	.8	7	7.0	0.28	0.53	—	—	—	—	—
Fodder, wheat	24	18	82	83	92	62	31	.8	6	7.0	0.40	0.40	0.22	—	—	—	—
Fodder, wheat, short germination	12	24	82	68	71	44	31	.7	27	7.0	0.40	0.40	0.22	—	—	—	—
Legume pasture	56	27	—	68	72	44	33	.7	24	3.7	1.24	0.36	0.28	9	53	39	—
Lespedeza	25	16	50	60	60	30	60	.7	—	2.0	1.20	0.24	0.21		—	—	—
Millet forage	38	16	—	60	55	29	60	.8	36	2.5	0.47	0.33	0.22	15	110	41	—
Native range, Jan.-March	85	4	55	49	42	18	80	1.0	—	1.7	0.23	0.07		—	—	—	
Native range, April-June	30	14	75	70	74	47	68	1.0	—	3.2	0.30	0.20	0.15	11	—	—	—
Native range, July-Aug.	35	10	70	64	65	39	71	1.0	—	3.0	0.33	0.15		—	—	—	
Native range, Sept.-Oct.	46	7	65	59	58	32	75	1.0	—	2.5	0.28	0.12	—	—	—	—	—
Native range, Nov.-Dec.	75	5	65	55	52	26	78	1.0	—	2.2	0.25	0.09		—	—	—	
Oat forage	39	17	80	63	62	36	52	.7	33	3.8	0.48	0.35	0.22	8	70	29	—
Orchardgrass	24	14	77	65	66	37	54	.8	32	4.0	0.33	0.39	0.20	—		21	—
Peanut forage	26	20	—	61	60	34	50	.7	36	0.0	1.45	0.30	0.23	8	150	36	—
Peavine forage	42	20	—	65	66	39	43	.8	32	3.4	1.03	0.36	0.21	10	55	38	—
Pineapple forage	38	8	—	59	55	29	57	.9	33	1.9	0.47	0.17	0.14	11	121	48	—
Rye forage	41	20	70	66	67	40	50	.8	30	4.2	0.56	0.40	0.26	10	67	44	—
Sorghum forage	44	9	—	62	58	32	56	.9	34	2.2	0.35	0.22	0.13	8	42	29	—
Sorghum stover	87	5	100	54	54	20	65	1.0	41	1.8	0.50	0.12	—	—	—	—	
Sorghum-sudan forage	67	13	71	63	60	33	60	1.0	35	2.6	0.45	0.29	0.18	9	74	26	—
Soybean forage	74	19	—	62	60	34	44	.8	32	3.8	1.43	0.31	0.26	10	78	28	—
Sudangrass, mature	36	12	72	58	52	27	62	1.0	38	2.7	0.48	0.30	0.18	11	44	36	—
Sudangrass, immature	18	17	100	70	73	44	55	.8	29	3.9	0.46	0.36	0.11			24	—
Sunflower	18	13	—	66	70	43	40	.9	29	6.3	1.33	0.28	0.24	14	148	37	—

	DM %	CP %	DIP % of CP	TDN %	NEm (Mcal/cwt.)	NEg (Mcal/cwt.)	NDF %	pef[a] %	ADF %	EE %	Ca %	P %	S %	Cu ppm	Mn ppm	Zn ppm	Se ppm
Timothy	26	11	80	64	65	36	59	.8	36	3.8	0.40	0.28	0.15	—	—	28	—
Triticale forage	34	15	85	63	61	35	55	.8	33	2.9	0.38	0.32	0.18	8	48	30	—
Wheat forage	21	22	84	71	76	48	50	.7	30	4.0	0.35	0.36	0.22	10	85	35	
Silage/Haylage																	
Barley silage	38	12	—	61	59	33	55	.7	35	3.5	0.45	0.30	0.17	8	43	32	—
Bermudagrass silage	39	13	75	56	50	25	67	.8	40	3.3	0.53	0.29	0.24	14	98	43	—
Corn silage, well eared	34	8	72	71	73	46	44	.8	26	3.3	0.25	0.24	0.10	7	31	25	0.09
Corn stalklage	49	6	70	53	45	20	65	1.0	47	1.9	0.90	0.16	0.09	8	82	38	—
Distillers corn stillage	7	22	45	92	103	70	21	.5	10	8.1	0.14	0.72	0.60			60	—
Grass silage	30	11	76	61	62	31	60	.8	39	3.4	0.70	0.24	0.22	11	92	29	—
Legume silage	40	21	75	58	32	44	44	.7	34	3.8	1.41	0.33	0.25	10.3	48.6	27.2	0.17
Millet silage	38	13	75	55	47	22	62	.7	40	2.4	0.54	0.33	0.20	14	130	47	—
Millet/soybean silage	38	12	72	57	52	26	57	.7	40	3.0	0.84	0.32	0.19	9	76	41	—
Milo/soybean silage	31	12	—	60	58	32	44	.7	37	3.4	0.72	0.28	0.16	11	55	34	—
Grass silage, mixed forage	39	16	78	60	56	30	56	.9	35	3.8	1.43	0.33	0.25	9	66	31	—
Legume silage, mixed forage	39	19	78	60	57	31	48	.8	36	3.9	1.25	0.33	0.23	9	44	26	—
Oat silage	35	13	79	60	56	30	59	.8	39	3.7	0.52	0.33	0.19	9	66	28	—
Peanut silage	41	15	60	57	54	28	52	.7	39	4.4	1.25	0.26	0.18	15	176	41	—
Peavine silage	35	17	—	60	58	32	50	.8	36	3.8	1.03	0.33	0.21	12	65	35	—
Corn silage, processed	33	8	—	71	74	47	44	.7	26	3.4	0.23	0.24	0.10	9	28	29	—
Rice silage	62	7	—	55	49	24	53	.7	39	2.5	0.24	0.21	0.12	11	570	34	—
Rye grass silage	32	14	75	59	59	28	59	.7	37	3.3	0.43	0.38	0.23	11	90	36	—
Small grain silage	38	13	—	61	57	31	57	.7	37	3.6	0.54	0.32	0.19	9	78	33	—
Sorghum silage, early bloom	36	10	71	58	53	28	58	.8	37	3.0	0.48	0.24	0.14	10	55	40	0.22
Sorghum Silage, late bloom	26	7	71	61	62	35	59	.9	38	3.0	0.35	0.21	0.11	15	60	32	0.22
Sorghum-sudan silage	45	12	71	58	52	27	61	.8	39	3.3	0.57	0.28	0.17	12	67	34	—
Soybean silage	56	16	65	57	53	28	48	.7	38	4.3	1.36	0.30	0.20	12	81	65	—
Sudangrass silage	31	10	72	58	56	31	64	.8	—	3.0	0.58	0.27	0.14	13	69	29	—
Sugarcane bagasse, silage	68	4	100	42	25	7	75	1.0	62	1.2	0.35	0.06	0.10	8	74	18	—
Sugarcane silage	54	6	—	52	42	18	64	.9	45	1.8	0.36	0.12	0.30	8	77	102	—
Sunflower silage	27	11	—	70	78	50	48	.9	39	14.4	1.42	0.33	0.24	15	33	35	—
Sweet corn silage	23	10	—	67	66	39	64	.8	36	5.3	0.21	0.27	0.12	11	27	39	—
Triticale silage	34	14	100	60	56	30	58	.8	38	3.7	0.50	0.34	0.20	11	50	36	—
Wheat silage	34	13	79	60	56	30	57	.7	37	3.5	0.41	0.34	0.18	10	56	29	—
Pellets/Cubes																	
Alfalfa cubes	91	18	70	57	52	27	44	.4	34	2.3	1.52	0.24	0.26	9	46	24	0.2
Alfalfa pellets	91	18	70	57	53	27	46	.25	34	2.4	1.47	0.28	0.25	11	58	35	0.20
Alfalfa, dehydrated 17% CP	92	19	41	61	61	35	45	.25	34	3.0	1.42	0.25	0.24	9	34	21	0.2
Barley malt pellets with hulls	90	18	64	68	71	44	50	.25		1.9	0.21	0.59	0.32	10	44	61	0.25
Grass cubes	92	12	—	55	48	23	59	.5	40	2.1	0.76	0.22	0.20	22	94	72	—
Grass pellets	91	14	—	59	55	29	54	.3	36	2.8	0.82	0.29	0.20	10	86	48	—
Byproducts																	
Almond hulls, dry	89	6	—	60	58	32	36	.4	30	2.9	0.28	0.12	0.05	5	18	18	—
Almond hulls, wet	80	6	—	61	61	35	34	.3	28	4.0	0.29	0.13	0.04	5	19	16	—
Apple pomace, wet	21	7	—	66	67	40	48	.3	40	6.8	0.18	0.15	0.07	10	15	10	—
Bakery byproduct, dry	90	13	—	91	108	75	11	.2	6	9.8	0.28	0.34	0.16	5	30	38	—
Beet pulp, dry	92	9	56	66	66	39	42	.3	26	1.3	0.94	0.08	0.29	9	61	23	—

	DM %	CP %	DIP % of CP	TDN %	NEm (Mcal/cwt.)	NEg (Mcal/cwt.)	NDF %	pef[a] %	ADF %	EE %	Ca %	P %	S %	Cu ppm	Mn ppm	Zn ppm	Se ppm
Beet pulp, wet	23	10	—	63	61	35	48	.25	28	1.1	1.07	0.10	0.21	10	58	24	—
Bread, wet	66	15	—	90	103	72	5	.1	3	8.4	0.19	0.21	0.18	3	13	17	—
Breading	93	13	—	105	131	94	7	.1	4	17.9	0.11	0.20	0.17	2	6	10	—
Breweres condensed solubles	25	26	—	88	100	69	5	.1	2	4.2	0.54	0.71	0.46	27	19	48	—
Brewers grains, dry	93	26	46	73	79	51	51	.25	24	8.7	0.30	0.65	0.31	14	54	90	—
Brewers grains, wet	26	30	—	74	81	53	49	.25	24	9.4	0.35	0.68	0.00	11	52	92	—
Candy byproduct, dry	91	9	100	94	113	80	14	.1	7	15.2	0.25	0.23	0.09	5	18	20	—
Carrots, wet	14	10	—	73	78	50	25	.35	21	4.3	0.86	0.35	0.12	9	30	28	—
Cerial byproduct, dry	91	11	—	84	95	65	12	.1	6	5.2	0.23	0.37	0.13	6	37	84	—
Chocolate byproduct, dry	91	11	80	95	117	83	18	.15	12	20.0	0.24	0.31	0.13	9	25	31	—
Citrus pulp, dry	88	7	—	70	75	47	24	.3	20	2.6	1.88	0.12	0.10	6	13	11	—
Citrus pulp, wet	20	9	—	70	75	47	27	.25	23	3.5	1.50	0.15	0.10	6	13	12	—
Coconut meal, dry	93	22	—	70	78	49	52	.3	31	13.1	0.15	0.61	0.28	38	104	55	—
Cookie byproduct, dry	91	10	—	93	111	78	10	.1	5	11.8	0.20	0.29	0.12	4	24	30	—
Corn cobs, dry	93	5	30	61	56	30	65	.9	35	1.9	0.15	0.14	0.09	7	21	27	—
Corn cobs, wet	66	4	30	59	51	25	80	.8	44	0.7	0.11	0.08	0.05	7	9	25	—
Corn gluten feed, dry	89	24	75	73	78	50	36	.4	11	4.1	0.11	1.04	0.50	6	22	69	0.3
Corn gluten feed, wet	61	22	75	76	84	55	35	.3	12	5.3	0.36	1.26	0.47	6	24	70	—
Corn gluten meal	91	67	40	87	98	67	8	.2	5	3.0	0.07	0.54	0.86	3	7	31	—
Corn steep liquor	41	37	70	84	94	64	3	0	1	3.0	0.08	2.74	1.41	6	50	155	0.30
Cotton gin trash (burrs)	92	11	100	44	34	10	70	.9	51	2.7	0.90	0.12	0.05	10	55	10	0.25
Cottonseed hulls, dry	91	4	55	35	14	2	79	.9	65	4.3	0.35	0.21	0.12	5	28	22	0.30
Cottonseed, whole	91	24	62	77	93	63	53	.8	40	19.9	0.19	0.69	0.23	6	16	34	0.25
Cottonseed, whole, delinted	92	27	61	90	113	80	43	.8	29	22.9	0.34	0.75	0.56	8	25	37	—
Cottonseed, whole, extruded	94	31	50	67	74	46	45	.7	37	9.7	0.29	0.81	0.30	10	20	43	—
Distillers condensed solubles	32	20	100	102	126	90	4	.1	2	17.9	0.10	1.55	1.06	5	32	87	—
Distillers dried solubles	93	31	53	87	96	64	22	.2	7	13.0	0.35	1.20	1.10			91	—
Distillers grain, corn, wet	36	30	53	90	101	69	31	.3	16	12.0	0.09	0.75	0.70	5	21	65	0.42
Distillers grain, sorghum, wet	35	33	45	86	95	63	34	.3	19	12.0	0.20	0.68	0.50	5	21	50	0.42
Distillers grains with solubles, corn, dry	89	31	50	89	100	69	33	.35	18	13.0	0.07	0.87	0.65	5	21	68	0.42
Distillers grains with solubles, sorghum, dry	92	31	47	88	99	68	46	.35	18	10.0	0.25	0.65	0.40	5	21	68	0.42
Fruit byproduct, dry	86	8	—	72	76	48	40	.4	29	4.9	0.36	0.19	0.15	9	56	18	—
Fruit byproduct, wet	28	8	—	72	77	49	35	.35	25	4.9	0.42	0.21	0.12	10	34	19	—
Fuzzpellet	92	23	50	90	102	70	47	.6	39	18.4	0.17	0.52	0.27	9	15	37	0.25
Malt sprouts, dry	92	24	—	68	68	41	43	.4	19	2.1	0.21	0.60	0.31	10	46	64	—
Oat hulls	92	7	75	54	45	20	65	.7	36	3.2	0.16	0.22	0.09	8	50	29	—
Palm kernel meal	90	17	—	68	71	43	64	.6	40	9.1	0.41	0.62	0.20	24	263	43	—
Pasta, dry	90	12	—	92	106	73	3	.25	2	6.2	0.10	0.16	0.12	2	8	10	—
Peanut hulls	93	11	40	39	24	5	65	.5	54	5.3	0.33	0.13	0.11	13	45	21	—
Peanut skins	92	17	100	—	—	0	28	.2	20	22.0	0.19	0.20				—	
Pet food	91	24	—	93	112	79	17	.3	7	14.1	1.63	1.11	0.35	22	63	190	—
Pineapple forage, dry	90	6	—	60	55	29	61	.4	31	1.5	0.37	0.14	0.12	10	155	15	—
Potato byproduct, dry	85	15	—	79	87	58	19	.35	14	4.5	0.30	0.30	0.21	7	23	23	—
Potato byproduct, wet	27	11	—	80	89	60	23	.3	16	6.8	0.46	0.31	0.13	9	30	31	—
Poultry litter, dry	94	25	90	57	53	29	38	.5	26	2.5	2.56	1.44	0.52	291	421	480	—
Poultry manure, wet cage	67	27	90	57	53	29	36	.5	25	3.6	4.12	1.86	0.00	349	483	441	—
Rice bran, full fat	91	14	55	84	100	69	23	.5	17	16.0	0.66	1.70	0.19	12	396	40	—
Rice byproducts	92	8	39	68	68	41	52	.4	45	3.7	0.11	0.27	0.08	16	226	41	—
Rice hulls	92	3	45	13	35	—	81	.6	70	0.9	0.14	0.07	0.08	3	320	24	—

	DM %	CP %	DIP % of CP	TDN %	NEm (Mcal/cwt.)	NEg (Mcal/cwt.)	NDF %	pef[a] %	ADF %	EE %	Ca %	P %	S %	Cu ppm	Mn ppm	Zn ppm	Se ppm
Rice mill byproduct	91	7	60	42	43	—	60	.3	50	5.7	0.40	0.31	0.30	—	—	31	—
Rice polishings	90	13	—	83	99	68	24	.2	16	14.1	0.93	1.28	0.15	10	146	80	—
Snack food	48	10	—	86	100	68	20	.2	14	11.1	0.58	0.30	0.15	8	17	25	—
Snack Food, dry	93	9	—	100	125	89	12	.25	7	22.6	0.65	0.21	0.09	3	13	16	—
Soy byproduct, dry	89	34	—	85	99	68	29	.25	20	12.1	0.41	0.44	0.30	12	27	51	—
Soy byproduct, wet	39	31	—	82	97	66	31	.3	22	12.9	0.42	0.32	0.00	20	24	43	—
Soybean hulls	91	14	47	63	60	33	63	.4	44	3.3	0.64	0.18	0.13	9	24	46	0.14
Sugarcane bagasse	39	4	100	43	25	11	75	.9	61	0.9	0.09	0.02	0.04	7	56	9	—
Sugarcane bagasse, dry	93	3	100	48	34	12	80	1.0	62	0.9	0.35	0.04	0.09	7	59	12	—
Sunflower seed hulls	90	4	35	40	42		73	.9	63	2.2	0.00	0.11	0.19	—	—	200	—
Sunflower seeds	92	22	7	113	150	109	38	.8	29	35.2	0.33	0.68	0.00	19	30	57	—
Tapioca (cassava), dry	88	4	62	75	80	52	20	.2	16	0.8	0.30	0.08	0.04	7	58	29	—
Tapioca meal, cassava byproduct	89	1	63	82	89	59	34	.2	8	0.8	0.03	0.05	0.04	7	58	29	—
Vegetable byproduct, wet	27	20	85	62	61	35	43	.3	35	8.8	0.81	0.43	0.34	10	46	35	—
Wheat germ meal	88	29	75	85	99	68	22	.2	6	6.3	0.11	1.23	0.26	7	193	138	—
Wheat midds	90	18	78	73	79	51	38	.3	13	5.9	0.15	1.07	0.19	12	126	84	0.21
Wheat mill run	90	17	72	75	81	53	37	.35	12	4.4	0.12	1.00	0.22	21		90	—
Wheat shorts	89	19	75	78	83	54	30	.3	10	5.3	0.10	0.93	0.20	—	—	118	—
Whey, dry	94	14	85	82	89	59	0	0	—	0.9	0.98	0.88	0.92	4	2	10	—
Whey, wet	23	14	85	82	93	63	1	0	1	3.9	1.10	1.37	0.23	4	2	24	—
Yeast, dry	29	44	—	82	91	62	7	.1	4	3.5	0.42	1.37	0.00	17	20	85	—
Grains/Concentrate																	
Barley, dry	90	12	—	81	89	60	19	.3	8	2.4	0.10	0.40	0.14	6	20	32	0.22
Buckwheat, dry	90	17	—	76	82	54	27	.3	19	3.7	0.13	0.58	0.20	8	38	30	—
Canola seed	94	25	70	—	—	—	28	.3	20	39.7	0.55	0.72	0.43	3	50	60	—
Corn bran	92	13	100	83	95	65	33	.35	10	8.4	0.06	0.51	0.25	5	17	70	—
Corn grain, high moisture	74	9	58	93	104	71	10	.3	4	4.1	0.03	0.31	0.10	2	6	19	—
Corn grain rolled	88	9	46	88	98	65	10	.2	4	4.2	0.02	0.30	0.14	3	9	24	0.15
Corn grain, steam flaked	87	9	41	93	104	71	9	.25	4	3.6	0.03	0.24	0.09	2	5	17	—
Corn grain, whole	88	9	42	88	99	65	9	.35	3	4.3	0.02	0.30	0.12	3	8	18	—
Corn screenings	87	9	48	87	96	64	10	.2	4	3.8	0.04	0.25	0.11	—	—	16	—
Corn snaplage, wet	59	8	70	81	90	61	24	.8	12	3.6	0.06	0.27	0.10	4	11	22	—
Corn, ear	89	9	—	84	94	64	19	.8	8	3.9	0.42	0.31	0.10	4	12	26	—
Corn, high moisture ears	64	8	—	83	93	63	21	.6	10	3.6	0.05	0.29	0.10	3	10	20	—
Fat, animal or vegetable	99	—	100	195	285	230		0	—	99.0	0.00	0.00	—	—		—	
Flax seed	91	29	—	110	144	104	32	.2	19	23.2	0.31	0.71	0.30	15	38	57	—
Glycerol (glycerin)	88	—	100	90	100	68	0	.15	—		—	—	—				
Hominy feed	89	10	52	86	99	68	17	.2	6	6.9	0.04	0.55	0.12	4	13	40	0.11
Lupine beans, dry	91	33	—	81	93	63	28	.25	21	6.5	0.29	0.40	0.22	7	279	36	—
Milk replacer, dry	92	27	—	108	138	100	2	0	—	20.9	0.93	0.77	0.36	10	40	74	—
Milk, dry, skim	94	36	100	87	96	64		0	—	0.9	1.36	1.09	0.34	—	—	41	—
Millet, dry	84	12	43	77	85	56	21	.3	12	3.1	0.83	0.30	0.39	6	22	26	—
Milo/sorghum, dry	90	11	45	84	93	63	16	.35	9	3.4	0.15	0.36	0.11	4	20	22	0.22
Milo/sorghum, steam flaked	82	11	38	90	102	70	20	.1	—	3.1	0.04	0.28	0.14	5	15	18	—
Molasses cane, dried	94	9	100	74	78	49	7	0	3	0.3	1.10	0.15	23	61	30	—	
Molasses cane, wet	73	9	100	72	77	49	1	.1	—	2.3	1.00	0.25	1.00	23	61	71	—
Mung beans	90	23	25	79	87	58	28	.3	8	3.0	1.19	0.68	0.25	—	—		—
Mung bean cracks	90	25	25	88	96	64	20	.2	8	1.3	0.15	0.39	0.25	—	—		—
Oats, rolled	89	12	82	75	77	52	30	.4	15	5.4	0.09	0.33	0.23	7	42	41	0.26
Pearl millet grain	87	13	100	82	89	59	18	.25	6	4.5	0.03	0.36				—	
Peas, dry	89	24	17	79	86	57	14	.2	9	2.0	0.14	0.42	0.18	8	19	38	—

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Potatoes, wet	24	11	—	81	89	60	11	.2	8	3.7	0.14	0.29	0.14	6	15	19	—
Rice	89	8	70	79	85	55	16	.15	12	1.9	0.07	0.32	0.05	5	47	17	—
Rye	89	14	80	80	86	56	19	.2	8	2.5	0.07	0.55	0.17	5	49	36	—
Triticale	89	12		82	91	61	15		.15	1.7	0.08	0.36	0.15	5	42	90	—
Wheat bran	90	18	72	72	76	48	40	.2	14	4.5	0.16	1.08	0.18	12	135	87	—
Wheat grain	89	14	77	84	93	63	13	.15	5	2.0	0.12	0.39	0.15	4	41	31	0.29
Wheat grain sprouted	86	12	82	88	98	65	13	.2	4	2.0	0.04	0.36	0.17	—	—	45	—
Protein Meals																	
Biuret	99	248	100	—	—	—	—	0	—	—	—	—	—	—	—	—	—
Blood meal, dry, non-ruminant	90	100	40	72	77	50	2	.1	1	1.1	0.18	0.2	0.56	5	6	29	
Canola meal, dry	91	40	71	69	73	45	30	.25	21	7.4	0.74	1.1	0.71	6	65	60	—
Corn germ meal	90	23	50	81	92	61	39	.2	14	10.1	0.06	0.8	0.28	3	15	77	—
Cotton seed meal	91	43	73	70	74	47	32	.25	23	5.7	0.31	1.2	0.43	13	27	64	0.32
Feather meal	93	88	27	78	91	61	17	.15	3	10.0	0.56	0.4	1.77	12	10	89	0.9
Fish meal	92	61	40	77	91	62	23	.15	4	12.1	5.04	2.9	0.84	7	37	113	—
Linseed meal, mech. extracted	91	37	60	82	89	59	24	.15	18	6.0	0.42	0.9	0.46	19	50	70	—
Linseed meal, solv. extracted	91	39	64	72	78	53	26	.15	18	1.9	0.43	0.9	0.52	19	50	70	—
Meat meal, dry	96	59	—	67	79	51		.15	29	14.2	7.89	4.40	0.45	19	17	130	—
Peanut meal	94	44	73	79	89	59	24	.15	16	8.8	0.21	0.6	0.27	15	33	51	0.12
Poultry meal, blood & feather	95	67	46	75	91	61	0	.1	0	13.9	4.04	2.4	0.73	16	11	104	—
Safflower meal	95	24	—	58	56	30	53	.3	38	9.1	1.06	0.6	0.26	29	111	140	—
Soybean meal, 44%	89	49	65	84	92	61	15	.15	10	1.5	0.36	0.7	0.41	23	41	62	0.11
Soybean meal, 48%	91	54	64	87	98	67	9	.15	6	1.2	0.28	0.7	0.47	23	41	61	0.11
Soybeans whole	88	41	72	92	103	70	15	.3	11	18.8	0.27	0.6	0.34	15	32	43	—
Soybeans whole, extruded	88	40	65	93	104	71	15	.25	11	18.8	0.27	0.6	0.34	14	34	50	—
Soybeans whole, roasted	88	40	52	93	104	71	15	.3	11	18.8	0.27	0.6	0.34	13	30	44	—
Sunflower meal	92	33	68	66	69	42	41	.1	29	11.5	0.45	1.1	0.00	29	43	87	0.18
Sunflower meal, solvent extracted	91	39	73	64	65	36	36	.1	22	2.0	0.42	1.00	0.37	20	35	70	
Urea 46% N	99	288	100	—	—	—	—	0	—	0.0	0.00	0.00	0.00	—	—	—	—

a Physical effectiveness factor.

		DM	Macromineral						Trace Mineral					
Number	**FEED NAME**	**DM %**	**CA %**	**Phos %**	**Na %**	**K %**	**MG %**	**S %**	**CO ppm**	**CU ppm**	**FE ppm**	**MN ppm**	**SE ppm**	**ZN ppm**
Calcium	Calcium Carbonate	99	38	0.04		0.06	0.05	0.01		33	300	300		39
	Calcium phosphate (monobasic)	99	16.4	21.6				1.2			15800			
	Limestone, dolomitic		22.3				9.9							
	Limestone, ground		34				2.1							
Cobalt	Cobalt Carbonate	99							430000					
	Cobalt Sulfate	99							210000					
Copper	Copper chloride dihydrate									372000				
	Copper Sulfate	99						38		254500				
	Copper Oxide	99								798800				
Phosphorous	Dicalcium phosphate	99	22	19.3		0	0.59	1.14	0	10	14400	330	0	100
	Phosphoric acid	99		31.6				1.55			17500			
Magnesium														
	Magnesium chloride	99	3.1				12							
	Magnesium hydroxide	99					41.7							
	Magnesium Oxide	99					56.2					600000		
	Magnesium sulfate heptahydrate						9.8							
Manganese	Manganese chloride	99										430000		
	Manganese sulfate monohydrate											325069		
	Manganese sulfate pentahydrate											227891		
Potassium	Potassium bicarbonate	99				39								
	Potassium carbonate	99				57								
	Potassium chloride	99	0.05			50	0.11	0.19			600			
	Potassium iodide[a]	99				21								
Sodium	Sodium chloride[b]	99			39.3									
	Sodium bicarbonate	99			27									
	Sodium phosphate (monobasic)	99		22.5	16.7									
Selenium	Selenium 600	99											600	
	Sodium selenate decahydrate												213920	
	Sodium selenite				26.6								456000	
Sodium	Sodium Chloride	99			39									
Zince	Zinc carbonate													521400
	Zinc chloride													479700
	Zinc Oxide	99												780000
	Zinc sulfate monohydrate	99												363600

[a] Potassium iodide = 681,700 ppm iodine

[b] Sodium chloride = 60.6% chloride

Source: Nutrient Requivrements of Beef Cattle, 2016 and Nutrient Requirements of Dairy Cattle, 2001

The Oklahoma Cooperative Extension Service
Extension Everywhere for Everyone

The Cooperative Extension Service is the largest, most successful informal educational organization in the world. It is a nationwide system funded and guided by a partnership of federal, state, and local governments that delivers information to help people help themselves through the land-grant university system.

Extension carries out programs in the broad categories of agriculture, natural resources and environment; family and consumer sciences; 4-H and other youth; and community resource development. Extension staff members live and work among the people they serve to help stimulate and educate Americans to plan ahead and cope with their problems.

Some characteristics of the Cooperative Extension system are:

- The federal, state, and local governments cooperatively share in its financial support and program direction.
- It is administered by the land-grant university as designated by the state legislature through an Extension director.
- Extension programs are nonpolitical, objective, and research-based information.
- It provides practical, problem-oriented education for people of all ages. It is designated to take the knowledge of the university to those persons who do not or cannot participate in the formal classroom instruction of the university.
- It utilizes research from university, government, and other sources to help people make their own decisions.
- More than a million volunteers help multiply the impact of the Extension professional staff.
- It dispenses no funds to the public.
- It is not a regulatory agency, but it does inform people of regulations and of their options in meeting them.
- Local programs are developed and carried out in full recognition of national problems and goals.
- The Extension staff educates people through personal contacts, meetings, demonstrations, and the mass media.
- Extension has the built-in flexibility to adjust its programs and subject matter to meet new needs. Activities shift from year to year as citizen groups and Extension workers close to the problems advise changes.

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