UPDATE ON FEED COMPOSITION TABLES

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A recent survey conducted by the American Feed Industry Association showed that the National Research Council (NRC) publications were the most frequently used source of feedstuff composition information available to its members. Nutritionists, feed manufacturers and livestock producers commonly rely on the NRC values when making diet formulation decisions. However, the reliability of this data set for the future is being questioned because there has not been a systematic up-dating of table values in recent years, and there are no plans to up-date it in the future.

In addition, because crop varieties, weather, soil fertility and type, processing method, storage conditions, and sampling technique all influence nutrient concentrations, an average value without an estimate of the normal variation is of limited value. An estimate of the variation associated with the nutrient concentration of a given feed would allow the use of stochastic programming to reduce rations costs beyond that obtained with least costs linear programming (Roush et al., 1992). A mean and standard deviation would also allow producers and feed companies to know whether the data they received from their feed analyses are within the normal ranges.

Survey Data to Compare with NRC

With this in mind, a survey was conducted to compare the mineral concentrations of common feedstuffs as determined in commercial laboratories with NRC values as reported in the third revision of the United States-Canadian Tables of Feed Composition (NRC 1982). The purpose of this data set is not to replace NRC values but to identify mineral values which are markedly different from NRC and to give an indication of the variation that should be expected. Data from laboratories in New York, Indiana, Idaho and Arizona were pooled and summarized. Feedstuffs from all 50 states were analyzed by these four laboratories but no attempt was made to summarize the data by region because state of origin was often not identified. Mineral concentrations were determined primarily by atomic absorption and inductive coupled plasma emission spectrometry. In a few samples (less than 10%) of alfalfa and corn silage, calcium, phosphorus, magnesium and potassium were determined by near infrared reflectance spectroscopy. This technique was used only when there were large data sets available for instrument calibration and where values obtained using this technique were routinely compared with one of the other two techniques. Chloride, cobalt and selenium values are not reported because of the infrequency of analysis.

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In presenting results of this survey, feedstuffs are identified by name and International Feed Number (IFN) from the United States-Canadian Tables of Feed Composition. In each table the column titled "Average" represents the mean values for all analyses summarized. The column titled "Ratio" is the average concentration of a mineral for the samples in the survey divided by the value given in the United States-Canadian Tables of Feed Composition. For example, 8,197 samples of corn silage (Table 1) contained an average of .25% calcium which was 1.09 times or 109% of the NRC book value. The standard deviations was .14 meaning that 66.7% of the samples analyzed had calcium concentrations between .11 and .39% (.25±.14).

Corn silage was the most frequently analyzed feedstuff in this survey (Table 1) with over 8,000 samples analyzed. There was good agreement between the survey and NRC table values for calcium, phosphorus, potassium and magnesium in corn silage. However, the average corn silage sodium was less than one-third of the NRC value. Similarly, the average iron, zinc, copper and manganese values were only 38, 58, 30 and 57%, respectively of the NRC values. It is also important to note that standard deviations for the trace minerals were often greater than the mean. Since corn silage is often a major component of ruminant diets, the risk of relying on only NRC values in formulating trace mineral supplements for corn silage based diets becomes obvious.

Alfalfa samples were averaged across preservation methods (hays and silages) and maturities in this survey. However, only samples described as pure alfalfa were included. The NRC description for alfalfa hay, sun-cured, early bloom was used as the standard because of its similar crude protein content with the average of the survey. When approximately 4,000 samples were analyzed, calcium, potassium and magnesium were fairly close while phosphorus was 38% greater than NRC values (Table 2). The ratio for alfalfa sodium was only 10% of NRC value. Although stage of maturity and preservation method does result in some changes in sodium concentration according to NRC tables, none of these factors concentration according to NRC tables, none of these factors approach the ten-fold difference observed here. Trace minerals were also considerably below NRC with zinc, copper and manganese at 54, 40 and 73% of table values, respectively. Since alfalfa and corn silage are often fed as major components of diets for dairy and beef cattle and both are considerably below NRC values for the same trace minerals, proper trace mineral supplementation may become critical.

There are fairly good agreement between the survey and NRC for the macrominerals in corn (Table 3) with one exception, sodium. The average survey value for sodium was only 23% of the NRC. In contrast to corn silage and alfalfa, all the trace minerals except copper were considerably above the NRC. Corn copper was 75% of table values.

Ear corn or earlage is a popular feedstuff among dairymen as evidenced by the fact that results of 905 samples (Table 4) were available for this survey. Ear corn calcium was 71% and sodium only 50% of NRC phosphorus, potassium and magnesium values. However, iron, copper and manganese were only 81, 38 and 71% of NRC, respectively. In contrast, zinc was 179% of the NRC value. Question marks in the table, as with molybdenum (Table 4), means that no NRC values were given so a ratio could not be calculated.

Soybean meal (50% protein, Table 5) mineral values reflected current feed industry concerns in that calcium averaged .41%, 142% of NRC, with a standard deviation of .29%. Soybean meal phosphorus, potassium, magnesium, and sulfur were fairly close to NRC values. Soybean meal was the only feedstuff in this survey where sodium was above the NRC value, at 206%. Whether a sodium source is being added in combination with limestone to improve handling cannot be determined from this data.

Brewers grains (Table 6) were higher in potassium (210%) and magnesium (139), but much lower in sodium (16%) than NRC values. Similarly, zinc (323%) and manganese (14%) were high but copper lower (49%) relative to NRC values. Although there are fewer observations per mineral with brewers grains than some feedstuffs discussed previously, 138 per mineral is still enough to make meaningful comparisons.

Distillers dried grains (Table 7) were higher than NRC in all macrominerals except sodium (57%). Calcium, potassium, magnesium and sulfur concentrations were 192, 235, 183, and 131% of NRC values, respectively. Iron (185%) and zinc (147%) followed the same pattern as the macrominerals while copper was only 17% of the table value.

The next three feedstuffs are common grains but were not frequently analyzed by the survey participants. Consequently, these data are included to suggest trends rather than to give definitive values. For example, 115 analyses for barley (Table 8) calcium suggest that the NRC value is too low (1.43 ratio) while phosphorus is almost identical to the survey average (1.02 ratio). Although less reliable (57 observations), the survey potassium was 134% and sodium only 47% of NRC values, respectively. Zinc was twice as concentrated in the survey samples as compared to NRC values while iron and copper were much closer to table values.

Oat macrominerals concentrations (Table 9) were all higher than NRC, except sodium which was 12% of the table value. A similar trend was noted for trace minerals. With 35 to 38 samples per mineral analyzed, these numbers indicate trends and could be altered if large numbers of samples were analyzed.

Similarly, wheat mineral concentrations (Table 10), with only 21 samples per mineral analyzed, tended to be fairly close to NRC values. Again, the notable exception was sodium which was only 18% of the table value.

Whole cottonseed has become a popular feedstuff among dairymen in the past several years. With 110 samples for most minerals (Table 11) phosphorus appears low at 72% and sodium very low at only 3% of the NRC value. In the trace minerals, iron and copper were below the NRC at 62 and 15%, respectively. Manganese was approximately twice (206%) the concentration given in the NRC.

Summary

In summary, the markedly low sodium values for all feedstuffs, except soybean meal, are very difficult to explain. Since a majority of the forages analyzed in this survey were produced east of the Mississippi, one might speculate that regional differences were a big factor. However, this logic does not hold for many other feedstuffs like whole cottonseed or wheat which were from the South and High Plains regions, respectively. Another proposed explanation which has not been verified is that some of the early sodium analyses were actually estimates made by measuring chloride and assuming a one-to-one ratio. Whatever the explanation, these data show that basal dietary sodium concentrations can be far below what would be predicted from NRC tables.

Similar results were obtained by Belyea et al. (1989). In that study the nutrient profiles of 10 different samples of distillers dried grains, whole cotton seed, corn gluten feed, and soybean hulls were compared. Soybean hulls were close to NRC values, but the other three feeds were all less than 20% of the NRC sodium values.

Secondly, diets containing large amounts of corn silage or alfalfa may require additional trace mineral supplementation than would be predicted from NRC tables. This is especially important with high producing dairy cows where proper trace mineral supplementation is essential for optimal reproduction.

Third, standard deviations for many minerals were 30 to 100% of the average value. One of the weaknesses of the current NRC tables is that they give no indication as to the amount of variation to expect. Few users of the NRC tables appreciate how far an individual sample can vary from the average or whether their feed analysis data is within a normal range. The development of stochastic programming for least cost formulation will require an estimate of the variation in nutrient concentrations for each feedstuff. Also, and indication of the number of samples being analyzed for each nutrient mean would give the user more insight into the reliability of the mean and standard deviation.

Finally, for the NRC to continue as the leading source of feedstuff composition information, a systematic updating of the data must be accomplished. As genetically engineered plants are developed it will be increasingly important that an independent source of feed composition data be available for producers to use in determining what best meets the needs of their operation. Also, as we improve our techniques to convert grains into alcohol, high fructose syrups or other chemical feed stocks, accurate characterization of the byproduct feeds will be critical to their efficient use by the livestock and poultry industries.

References

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Alfalfa & CS were generally < NRC values for Fe, Zn, Cu, & Mn

TABLE 1. Corn Silage Mineral Values
(IFN 3-28-250)

Mineral	Number of Samples	Average[a]	Ratio[b]	Standard Deviation
Calcium, %	8197	.25	1.09	.14
Phosphorus, %	8197	.23	1.05	.06
Potassium, %	8139	1.08	1.13	.33
Magnesium, %	8137	.18	.95	.04
Sodium, %	8136	.003	.31	.03
Sulfur, %	837	.12	.81	.04
Iron, ppm	8146	98.2	.38	302
Zinc, ppm	8146	12.2	.58	18.8
Copper, ppm	8138	3.02	.30	2.7
Manganese, ppm	8138	17.1	.57	20.3
Aluminum, ppm	41	125	?	164

[a]Mean value of all analyses summarized from the survey.

[b]Average concentration divided by the value given in the United States-Canadian Tables of Feed Composition.

TABLE 2. Alfalfa Mineral Values 17% CP x̄
(IFN 1-00-059)

Mineral	Number of Samples	Average[a]	Ratio[b]	Standard Deviation
Calcium, %	4096	1.31	.93	.33
Phosphorus, %	4096	.30	1.38	.06
Potassium, %	3864	2.63	1.04	.44
Magnesium, %	3864	.27	.82	.08
Sodium, %	3861	.014	.10	.05
Sulfur, %	420	.26	.92	.07
Iron, ppm	3867	159	.83	147
Zinc, ppm	3872	13.4	.54	17.5
Copper, ppm	3866	4.39	.40	6.3
Manganese, ppm	3862	22.7	.73	13.9
Chloride, %	5	.48	1.27	.23
Aluminum, ppm	12	208	?	119

[a]Mean value of all analyses summarized from the survey.

[b]Average concentration divided by the value given in the United States-Canadian Tables of Feed Composition.

TABLE 3. Corn Mineral Values (IFN 4-02-935)

Mineral	Number of Samples	Average[a]	Ratio[b]	Standard Deviation
Calcium, %	912	.029	.97	.02
Phosphorus, %	912	.32	.086	.07
Potassium, %	846	.44	1.18	.07
Magnesium, %	840	.13	.93	.02
Sodium, %	846	.007	.23	.005
Sulfur, %	157	.12	1.00	.02
Iron, ppm	832	56.9	1.90	16.4
Zinc, ppm	833	25.0	1.79	5.6
Copper, ppm	833	2.99	.75	1.3
Manganese, ppm	833	8.91	1.78	2.04
Molybdenum, ppm	814	.60	?	.40
Aluminum, ppm	18	20.8	?	14.4

[a]Mean value of all analyses summarized from the survey.

[b]Average concentration divided by the value given in the United States-Canadian Tables of Feed Composition.

TABLE 4. Ear Corn Mineral Values (IFN 4-28-238)

Mineral	Number of Samples	Average[a]	Ratio[b]	Standard Deviation
Calcium, %	905	.05	.71	.07
Phosphorus, %	905	.29	1.07	.08
Potassium, %	905	.50	.94	.08
Magnesium, %	905	.13	.93	.02
Sodium, %	905	.01	.50	.07
Sulfur, %	110	.10	.63	.02
Iron, ppm	905	74	.81	68
Zinc, ppm	905	25	1.79	14
Copper, ppm	905	3	.38	2
Manganese, ppm	905	10	.71	8
Molybdenum, ppm	905	.6	?	.3

[a]Mean value of all analyses summarized from the survey.

[b]Average concentration divided by the value given in the United States-Canadian Tables of Feed Composition.

To ↑ flowability

added limestone?

added sodium bentonite?

TABLE 5. Soybean Meal (50%) Mineral Values (IFN 5-04-612)

Mineral	Number of Samples	Average[a]	Ratio[b]	Standard Deviation
Calcium, %	147	.41	1.42	.29
Phosphorus, %	148	.72	1.03	.28
Potassium, %	95	2.46	1.07	.30
Magnesium, %	95	.32	1.00	.02
Sodium, %	96	.062	2.06	.30
Sulfur, %	43	.43	.89	.05
Iron, ppm	95	247	1.67	210
Zinc, ppm	95	69.5	1.14	141
Copper, ppm	95	17.7	.80	7.0
Manganese, ppm	95	50.7	1.24	33.2

[a]Mean value of all analyses summarized from the survey.

[b]Average concentration divided by the value given in the United States-Canadian Tables of Feed Composition.

TABLE 6. Brewers Grain Mineral Values (IFN 5-02-141)

Mineral	Number of Samples	Average[a]	Ratio[b]	Standard Deviation
Calcium, %	139	.33	.99	.12
Phosphorus, %	139	.59	1.08	.08
Potassium, %	138	.19	2.10	.19
Magnesium, %	138	.22	1.39	.05
Sodium, %	138	.04	.16	.05
Sulfur, %	54	.37	1.16	.05
Iron, ppm	138	238	.89	100
Zinc, ppm	138	97.	3.23	16
Copper, ppm	138	11.2	.49	5.0
Manganese, ppm	138	56.6	1.41	13
Molybdenum, ppm	138	4.2	?	.9

[a]Mean value of all analyses summarized from the survey.

[b]Average concentration divided by the value given in the United States-Canadian Tables of Feed Composition.

TABLE 7. Distillers Dried Grains Mineral Values (IFN 5-28-236)

Mineral	Number of Samples	Average[a]	Ratio[b]	Standard Deviation
Calcium, %	114	.29	1.92	.15
Phosphorus, %	114	.83	1.17	.17
Potassium, %	113	1.03	2.35	.34
Magnesium, %	113	.33	1.83	.11
Sodium, %	112	.32	.57	.28
Sulfur, %	49	.43	1.31	.07
Iron, ppm	113	467	1.85	134
Zinc, ppm	113	73.5	1.47	47
Copper, ppm	113	9.74	.17	9
Manganese, ppm	113	28.6	1.15	7.9
Molybdenum, ppm	110	2.07	?	.5
Aluminum, ppm	3	46.7	?	17

[a]Mean value of all analyses summarized from the survey.

[b]Average concentration divided by the value given in the United States-Canadian Tables of Feed Composition.

TABLE 8. Barley Mineral Values (IFN 4-00-549)

Mineral	Number of Samples	Average[a]	Ratio[b]	Standard Deviation
Calcium, %	115	.07	1.43	.02
Phosphorus, %	115	.38	1.02	.07
Potassium, %	57	.63	1.34	.11
Magnesium, %	57	.14	.93	.02
Sodium, %	56	.014	.47	.012
Sulfur, %	1	.24	1.41	--
Iron, ppm	56	86	1.01	37
Zinc, ppm	56	38	2.00	7.0
Copper, ppm	56	7	1.22	2.0
Manganese, ppm	56	22	1.22	6
Molybdenum, ppm	56	1.1	?	.5

[a]Mean value of all analyses summarized from the survey.

[b]Average concentration divided by the value given in the United States-Canadian Tables of Feed Composition.

TABLE 9. Oats Mineral Values
(IFN 4-03-309)

Mineral	Number of Samples	Average[a]	Ratio[b]	Standard Deviation
Calcium, %	36	.12	1.67	.04
Phosphorus, %	38	.43	1.13	.09
Potassium, %	37	.60	1.42	.08
Magnesium, %	35	.16	1.14	.02
Sodium, %	35	.01	.125	.009
Sulfur, %	3	.22	.94	.04
Iron, ppm	35	107	1.25	24
Zinc, ppm	35	45	1.10	5.9
Copper, ppm	35	10.7	1.52	3.5
Manganese, ppm	35	51	1.23	10.0

[a]Mean value of all analyses summarized from the survey.

[b]Average concentration divided by the value given in the United States-Canadian Tables of Feed Composition.

TABLE 10. Wheat Mineral Values
(IFN 4-05-211)

Mineral	Number of Samples	Average[a]	Ratio[b]	Standard Deviation
Calcium, %	21	.05	1.32	.03
Phosphorus, %	21	.43	1.02	.05
Potassium, %	21	.42	.99	.05
Magnesium, %	21	.16	1.03	.01
Sodium, %	21	.01	.18	.001
Sulfur, %	19	.18	.99	.03
Iron, ppm	21	71.6	1.17	22.6
Zinc, ppm	21	39.3	.79	8.90
Copper, ppm	21	5.76	.82	2.08
Aluminum, ppm	18	15	?	10.1

[a]Mean value of all analyses summarized from the survey.

[b]Average concentration divided by the value given in the United States-Canadian Tables of Feed Composition.

TABLE 11. Whole Cottonseed Mineral Values (IFN 5-01-614)

Mineral	Number of Samples	Average[a]	Ratio[b]	Standard Deviation
Calcium, %	110	.17	1.05	.08
Phosphorus, %	110	.54	.72	.09
Potassium, %	110	1.22	1.01	.08
Magnesium, %	110	.35	.99	.04
→ Sodium, %	110	.01	.03	.006
Sulfur, %	37	.23	.87	.05
Iron, ppm	110	93.6	.62	28.5
Zinc, ppm	110	35.6	?	5.4
→ Copper, ppm	110	7.9	.15	1.7
Manganese, ppm	110	20.6	2.06	3.0
Aluminum, ppm	9	18.9	?	12.9

[a]Mean value of all analyses summarized from the survey.

[b]Average concentration divided by the value given in the United States-Canadian Tables of Feed Composition.

Cotton Seed Hull Mineral Values (IFN 1-01-599)

Mineral	Number of Samples	Average	Ratio	Standard Deviation
Calcium, %	15	.24	1.61	.10
Phosphorus, %	15	.14	1.53	.05
Potassium, %	15	1.38	1.59	.08
Magnesium, %	14	.21	1.47	.03
Sodium, %	15	.02	1.00	.007
Iron, ppm	13	216	1.64	353
Zinc, ppm	13	21	?	8.0
Copper, ppm	13	5.0	.38	2.0
Manganese, ppm	13	29	2.90	6.0
Molybdenum, ppm	13	.8	?	.2
Sulfur, %	4	.10	-	-

Cottonseed Meal Mineral Values
(IFN 5-07-872)

Mineral	Number of Samples	Average	Ratio	Standard Deviation
Calcium, %	108	.18	.82	.03
Phosphorus, %	108	1.27	1.05	.12
Potassium, %	10	1.74	1.25	.25
Magnesium, %	10	.68	1.24	.14
Sodium, %	10	.10	2.5	.11
Sulfur, %	7	.47	1.38	.03
Iron, ppm	10	193	.87	85
Zinc, ppm	10	77	1.12	8
Copper, ppm	10	17	.85	4
Manganese, ppm	10	33	1.43	21
Molybdenum, ppm	10	3	-	1.1