DIET FORMULATION AND COMMON FEED INGREDIENTS

General References on Feedstuffs and Nutrition:

- *Miller, E. R., D. E. Ullrey, and A. J. Lewis. 1991. Swine nutrition. Butterworth-Heinemann, Boston.*
- *Lewis, A. J., and L. L. Southern. 2001. Swine nutrition. 2nd. ed. CRC Press, Boca Raton.*
- *Chiba, L. I. 2013. Sustainable swine nutrition. Willey-Blackwell, A JohnWiley & Sons, Inc., Hoboken, NJ.*

Books and Major References on Feedstuffs:

(Books)

- *Thacker, P. A., and R. N. Kirkwood. 1990. Nontraditional feed sopurces for use in swin production.. Butterworth, Stoneham, MA.*
- *Kellems, R. O., and D. C. Church. 1998. Livestock feeds and feeding. 4th ed. Prentice_Hall, Inc., Upper Saddle River, NJ. [Latest = ". . . 2002. 5th ed. & 2009. 6th ed. . . ."]*
- *Jurgens, M. H., and K. Bregendahl. 2007. Animal feeding and nutrition. 10th ed. Kendall/Hunt Publishing Co., Dubuque, IA.*

(Book Chapters)

- *Knabe, D. A. 1991. Bioavailability of amino acids in feedstuffs for swine. In: E. R. Miller, D. E. Ullrey, and A. J. Lewis, editors, Swine nutrition. Butterworth-Heinemann, Boston. p. 327-339.*
- *Liptrap, D. O., and M. G. Hogberg. 1991. Physical form of feed: Feed processing and feeder design and operation. In: E. R. Miller, D. E. Ullrey, and A. J. Lewis, editors, Swine nutrition. Butterworth-Heinemann, Boston. p. 373-386.*
- *Seerley, R. W. 1991. Major feedstuffs used in swine diets. In: E. R. Miller, D. E. Ullrey, and A. J. Lewis, editors, Swine nutrition. Butterworth-Heinemann, Boston. p. 451-481.*
- *Leibbrandt, V. D., ad N. J. Benevenga. 1991. Utilization of liquid whey in feeding swine. In: E. R. Miller, D. E. Ullrey, and A. J. Lewis, edityors, Swine nutrition. Butterworth-Heinemann, Boston. p. 559-571.*
- *Danielson, D. M., and J. D. Crenshaw. 1991. Raw and processed soybeans in swine diets. In: E. R. Miller, D. E. Ullrey, and A. J. Lewis, editors, Swine nutrition. Butterworth-Heinemann, Boston. p. 573-584.*
- *Holden, P. J., and Dr. R. Zimmerman. 1991.Utilization of cereal grain by-products in feeding swine. In: E. R. Miller, D. E. Ullrey, and A. J. Lewis, editors, Swine nutrition. Butterworth-Heinemann, Boston. p. 585-593.*
- *Gabert, V. M., H. Jorgensen, and C. M. Nyachoti. 2001. Bioavailability of amino acids in feedstuffs fr swine. In: A. J. Lewis and L. L. Southern, editors, Swine nutrition. 2nd ed. CRC Press, Boca Raton. p.151-186.*

- *Hancock, J. D., and K. C. Behnke. 2001. Use of ingredient and diet processing tyechnologies (grinding, mixing, pelleting and extruding) ot produce quality feed fo pigs. In: A. J. Lewis and L. L. Southern, editors, Swine nutrition. 2nd. ed. CRC Press, Boca Raton. p. 469-497.*
- *van Heugten, E. 2001. Mycotoxins and other antinutritional factors in swine feeds. In: A. J. Lewis and L. L. Southern, editors, Swine nutrition. 2nd. ed. CRC Press, Boca Raton. p. 563-583.*
- *Sauber, T. E., and F. N. Owen. 2001. Cereal grains and by-products for swine. In: A. J. Lewis and L. L. Southern, editors, Swine nutrition. 2nd. ed. CRC Press, Boca Raton. p. 785-802.*
- *Chiba, L. I. 2001. Protein supplements. In: A. J. Lewis and L. L. Southern, editors, Swine nutrition. 2nd. ed. CRC Press, Boca Raton. p. 803-837.*
- *Myer, R. O., and J. H. Brendemuhl. 2001. Miscellaneous feedstuffs. In: A. J. Lewis and L. L. Southern, editors, Swine nutrition. 2nd. ed. CRC Press, Boca Raton. p. 839-864.*
- *Chiba, L. I. 2010a. Feedstuffs: Protein sources. In: W. G. Pond, and A. W. Bell, editors, Encyclopedia of animal science. 2nd ed. Taylor & Francis, New York. p. 416-421.*
- *Chiba, L. I. 2010b. By-product feeds: Animal origin. In: W. G. Pond, and A. W. Bell, editors, Encyclopedia of animal science. 2nd ed. Taylor & Francis, New York. p. 169-174.*
- *Zijlstra, R. T., and E. Beltranena. 2013. Alternative feedstuffs in swine diets. In: L. I. Chiba, editor, Sustainable swine nutrition. Willey-Blackwell, A John Wiley & Sons, Inc., Hoboken, NJ. p. 229-253.*
- *Kil, D. Y., S. K. Servantes-Pahm, and H. H. Stein. 2013. Bioavailability of amino acids, lipids, and carbohydrates in feedstuffs. In: L. I. Chiba, editor, Sustainable swine nutrition. Willey-Blackwell, A John Wiley & Sons, Inc., Hoboken, NJ. p. 317-339.*
- *Baker, D. H. and H. H. Stein. 2013. Bioavailability of minerals and vitamins in feedstuffs. In: L. I. Chiba, editor, Sustainable swine nutrition. Willey-Blackwell, A John Wiley & Sons, Inc., Hoboken, NJ. p. 341-364.*

AS-FED, DRY MATTER, AND AIR-DRY

1. Expressing the Nutrient & Energy Content

A. Dry matter (DM) basis - The amount contained in only the DM portion of the feed ingredient/diet, i.e., without water. [Because feeds contain varying amounts of DM, perhaps, simpler and more accurate if both the composition and nutrient requirements are expressed on a DM basis!?]

B. As-fed basis - The amount contained in the feed ingredient/diet as it would be fed to the animal; including water.

C. Air-dry basis:

1) Usually, assumed to be approximately 90% DM.
2) Most feeds will equilibrate to about 90% DM after a prolonged, aerobic storage.
3) Air-dry and as-fed basis may be the same for many common feeds.

D. Percent dry matter?

1) Determined by drying a sample to remove all the moisture, and the weight of the remaining is expressed as a percent of the original weight.
2) Example - "1.0 g of corn is dried and 0.90 g of corn remained after drying," then:

$$\frac{0.90}{1.00} \times 100 = 90\% \text{ DM}$$

2. As-Fed Basis Converted to DM Basis

A. Can be converted by:

$$\frac{\text{Nutrient \% on as-fed basis}}{\text{\% DM in the feed expressed as decimal fraction}} = \text{Nutrient \% on DM basis}$$

or

$$\frac{\text{\% Nutrient (as-fed basis)}}{\text{\% Feed DM}} = \frac{\text{\% Nutrient (DM basis)}}{\text{100\% DM}}$$

B. Example? - "Alfalfa silage analyzed to contain 7% CP on an as-fed basis and contained 40% DM. What would be the CP content on DM basis?"

7 ÷ 0.40 = 17.5, thus 17.5% CP on DM basis, or

$$\frac{7}{40} = \frac{X}{100} \Rightarrow 40X = 700 \Rightarrow X = \frac{700}{40} = 17.5\% \text{ CP on DM basis}$$

3. DM Basis Converted to As-Fed Basis

A. Can be converted by:

Nutrient % on DM basis x % DM in the feed expressed as decimal fraction = Nutrient % on as-fed basis

or

$$\frac{\text{\% Nutrient (as-fed basis)}}{\text{\% Feed DM}} = \frac{\text{\% Nutrient (DM basis)}}{\text{100\% DM}}$$

B. Example? - "Alfalfa silage analyzed contain 10% crude fiber on a DM basis. If the linseed meal contains 91% DM, what would be the % crude fiber expressed on an as-fed basis?"

10.0 x 0.91 = 9.1, thus 9.1% on as-fed basis, or

$$\frac{X}{91} = \frac{10}{100} \Rightarrow 100X = 910 \Rightarrow X = \frac{910}{100} = 9.1\% \text{ Crude fiber on as-fed basis}$$

4. Converted to Air-Dry Basis

A. DM basis to air-dry basis (90% DM):

Nutrient % on DM basis x 0.90 = Nutrient % on air-dry basis

B. As-fed basis to air-dry basis (90% DM):

$$\frac{90}{\text{\% Feed DM}} \times \text{Nutrient \% on as-fed basis} = \text{Nutrient \% on air-dry basis}$$

5. Amount in DM and as-fed?

A. Amount in DM = Amount in as-fed * DM content (decimal)
B. Amount in DM = X (amount in as-fed) * DM content (decimal)

C. Amount in as-fed? $$X = \frac{\text{Amount in DM}}{\text{DM content (decimal)}}$$

6. Rule of thumb for conversions?

A. When converting from "as-fed to DM?"

1) The nutrient content will increase.
2) The weight will decrease

B. When converting from "DM to as-fed?"

1) The nutrient content will decrease.
2) The weight will increase.

SIMPLE DIET FORMULATION TECHNIQUES

1. Formulating a Diet with Two Ingredients

- Can be used for two mixtures rather than two ingredients!

A. Algebraic diet formulation (using an equation with one unknown, X)

1) Example - "Formulate a 14% crude protein (CP) diet using corn (8.8% CP) and a protein supplement (38% CP), and also check the results for accuracy."

Algebraic equation with one un known, X:

If % supplement = X
% corn = 100 - X

0.088 (100 - X) + 0.38X = 0.14 (100)
[lb CP from corn] [lb CP from supplement] [lb CP in 100 lb of diet]

8.8 - 0.088X + 0.38X = 14
0.38X - 0.088X = 14 - 8.8
0.292X = 5.2
X = 17.81 [lb supplement]
100 - X = 82.19 [lb corn]

0.088 (82.19) + 0.38 (17.81) = ?
7.233 + 6.768 = 14.00

2) Procedure & check - See boxes.

B. Algebraic diet formulation [using equations with two unknowns, X & Y; See Kellems & Church (1998) or Jurgens (2002)]

1) Use the same example - "Formulate a 14% CP diet using corn (8.8% CP) and a protein supplement (38% CP), and check the results for accuracy."
2) Procedure (Formulate 100 lb of a diet containing 14% CP) & check - See boxes.

Algebraic equation with two unknowns, X & Y:

X = lb corn in the diet
Y = lb supplement in the diet

Equation 1: X + Y = 100.0 lb diet
Equation 2: 0.088X + 0.38Y = 14.0 lb CP
(14% of 100 lb)

☞ To solve this problem, need to develop a third equation to subtract from Equation 2 to cancel either X or Y - Develop Equation 3 by multiplying Equation 1 by a factor of 0.088, thus:

Equation 2: 0.088X + 0.38Y = 14.0
Equation 3: -0.088X + -0.088Y = -8.8 (Subtract)

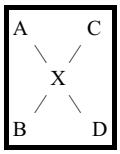
0 + 0.292Y = 5.2

$$Y = \frac{5.2}{0.292} = 17.81 \text{ (lb supplement)}$$

X = 100 - 17.81 = 82.19 (lb corn)

82.19 lb corn	x	8.8% CP	= 7.23 lb CP
17.81 lb supplement	x	38.0% CP	= 6.77 lb CP
100.00 lb diet			14.00 lb CP

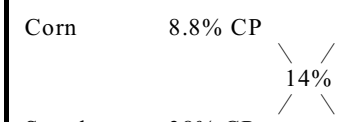
C. Pearson square - A simple procedure originally devised to blend milk products to a known fat percentage, and can be used for diet formulation too. [See Kellems & Church (1998) or Jurgens (2002)]



1) Use the same example - "Formulate a 14% CP diet using corn (8.8% CP) and a protein supplement (38% CP), and check the results."
2) How?

a) The desired solution is placed in the center ("X").
b) Feed sources "A" & "B" are then added.
c) To solve, the difference between X & A goes in the D position, and the difference between B & X goes in the C position . . . without regard to sign.
d) The answer is expressed as parts as illustrated in the example (formulate 100 lb of a diet containing 14% CP):

Pearson square:



24.0 parts corn
5.2 parts supplement
29.2 total parts

$$\frac{24.0 \text{ parts corn}}{29.2 \text{ total parts}} \times 100 = 82.19\% \text{ corn}$$

$$\frac{5.2 \text{ parts supplement}}{29.2 \text{ total parts}} \times 100 = 17.81\% \text{ supplement}$$

3) Check - See the box.

82.19 lb corn	x	8.8% CP	= 7.23 lb CP
17.81 lb supplement	x	38.0% CP	= 6.77 lb CP
100.00 lb diet			14.00 lb CP

2. Including a Fixed Ingredient(s)

A. Algebraic diet formulation (equation with one unknown, X)

1) Example - "Formulate a 12% CP diet using corn (8.8% CP) and a protein supplement (35% CP), with 3% rye (11.9% CP) and 7.5% milo (11.0% CP)."
2) Known quantities? 3% Rye + 7.5% milo = 10.5%, thus remaining 89.5% to be balanced!
3) Procedure & check? - See the box.

Algebraic equation with one un known, X:

If % supplement = X
% corn = 89.5 - X

$0.119\ (3) + 0.11\ (7.5) + 0.088\ (89.5 - X) + 0.35X = 0.12\ (100)$

☞ From left, lb CP from rye, lb CP from milo, lb CP from corn, lb CP from supplement, and lb CP in 100 lb of diet.

$0.357 + 0.825 + 7.876 - 0.088X + 0.35X = 12$

$0.35X - 0.088X = 12 - 7.876 - 0.825 - 0.357$

$0.262X = 2.942$

$X = 11.229$ [lb supplement]

$89.5 - X = 78.271$ [lb corn]

Check?

$0.119\ (3) + 0.11\ (7.5) + 0.088\ (78.271) + 0.35\ (11.229) = ?$

$0.357 + 0.825 + 6.888 + 3.930 = 12$

B. Algebraic diet formulation (using equations with two unknowns, X & Y)

1) The same example - "Formulate a 12% CP diet using corn (8.8% CP) and a protein supplement (35% CP), with 3% rye (11.9% CP) and 7.5% milo (11.0% CP)."
2) Known quantities & fixed amount of CP?
   a) 3% Rye + 7.5% milo = 10.5%, thus remaining 89.5% to be balanced.
   b) 0.119 (3) + 0.11 (7.5) = 0.357 + 0.825 = 1.182, or 1.182 lb of CP per 100 lb of diet (or 1.182%) is fixed. Thus, the remaining protein (10.818 lb/100 lb feed) must be balanced with corn and supplement.
3) Procedure & check? - See the box

Algebraic equation with two unknowns, X & Y:

X = lb corn in the diet
Y = lb supplement in the diet

Equation 1: $X + Y = 89.5$ lb diet

Equation 2: $0.088X + 0.35Y = 10.818$ lb CP
Equation 3: $-0.088X - 0.088Y = -7.876$ (Subtract)

$0 \quad 0.262Y = 2.942$

$$Y = \frac{2.942}{0.262} = 11.229 \text{ (lb supplement)}$$

$X = 89.5 - 11.229 = 78.271$ (lb corn)

Check?

$0.119\ (3) + 0.11\ (7.5) + 0.088\ (78.271) + 0.35\ (11.229) = ?$

$0.357 + 0.825 + 6.888 + 3.930 = 12$

C. Pearson square

1) The same example - "Formulate a 12% CP diet using corn (8.8% CP) and a protein supplement (35% CP), with 3% rye (11.9% CP) and 7.5% milo (11.0% CP)."
2) Known quantities & fixed amount of CP?

a) 3% Rye + 7.5% milo = 10.5%, thus remaining 89.5% to be balanced.
b) 0.119 (3) + 0.11 (7.5) = 0.357 + 0.825 = 1.182, or 1.182 lb of CP per 100 lb of diet (or 1.182%) is fixed. Thus, the remaining protein (10.818 lb/100 lb of feed or 10.818%) must be balanced with corn and supplement.
c) Need to determine the % CP necessary in corn-supplement combination to provide 10.818 lb/100 lb of feed . . . 10.818/89.5 x 100 = 12.087%.

Pearson square:

Corn 8.8% CP — 22.913 parts corn
\ /
12.087%
/ \
Supplement 35% CP — 3.287 parts supplement
26.2 total parts

22.913 parts corn / 26.2 total parts x 100 = 87.454% corn

3.287 parts supplement / 26.2 total parts x 100 = 12.546% supplement

89.5 x 87.454% = 78.271 lb corn
89.5 x 12.546% = 11.229 lb supplement

Check?

3.00 lb rye	x 11.9% CP =	0.357 lb CP
7.50 lb milo	x 11.0% CP =	0.825 lb CP
78.271 lb corn	x 8.8% CP =	6.888 lb CP
11.229 lb supplement	x 35.0% CP =	3.930 lb CP
100.00 lb diet		12.000 lb CP

3) Procedure & check? - See the box

3. Applications?

A. As you would expect, these same/similar approaches can be applied to balance diets for other nutrients, and this simple or basic concept can be used to formulate more complex diets with many ingredients . . . with some modifications, that is!
B. To formulate actual diets, need to balance for other major nutrients, such as Ca & P, and also need to provide some additional "space/room" for additional ingredients, e.g., salt, vitamin and(or) trace mineral premix(es), antibiotics, etc.
C. Also, similar approaches can be used to formulate vitamin or mineral premixes.

A COMPLETE DIET, SUPPLEMENT, AND BASE MIX

- To formulate actual/practical diets in most instances, need to balance for other major/important nutrients such as Ca & P!
- Also, may need to formulate a supplement or base mix [& also a vitamin and(or) mineral premixes?] that will be fed along with major energy and(or) protein sources
- A simple approach used to formulate a diet with only two ingredients can be used to (after some modifications, that is!) accomplish the task!

1. Formulating a Complete Diet

◦ *Will use a grower-finisher pig diet as an example, but the same/similar approach can be used for a diet for other species!*

A. ***Please formulate a grower-finisher diet:***

Containing: **14%** CP,
0.50% Ca, and
0.40% P

Using:

Item	*CP, %*	*Ca, %*	*P, %*
Corn	8.8	0.03	0.27
Soybean meal (**SBM**)	50.9	0.26	0.62
5% Alfalfa meal	17.0	1.33	0.24
Dicalcium phosphate (**Dical**)	-	23.35	18.21
Limestone (**Lime**)	-	35.8	-

With: **0.5%** salt, **0.1%** trace mineral (**TM**) premix, and **1.0%** vitamin (**Vit**) premix premix.

- Assume that salt, TM & Vit premixes do not contain protein, Ca, or P.

B. ***Step 1 - Balance for protein:***

SBM = x & Corn = 93.4 - x (100% - 5% alfalfa - 1.6% salt, TM premix & Vit premix = 93.4)

0 (1.6) + 0.17 (5) + 0.088 (93.4 - x) + 0.509x = 0.14 (100) [From left, CP from salt-TM-Vit, alfalfa, corn, and SBM!]

0 + 0.85 + 8.219 - 0.088x + 0.509x = 14
0.509x - 0.088x = 14-8.219 - 0.85
0.421x = 4.931
x = 11.712 (SBM)
93.4 - 11.712 = 81.688 (Corn)

Check: 0 (1.6) + 0.17 (5) + 0.088 (81.688) + 0.509 (11.712) = 0 + 0.85 + 7.188544 + 5.961408 = **14.0**

C. ***Step 2 - Balance for P:***

- This is done before balancing for Ca because all the supplemental P must come from one of the minerals, which may also provide part of the Ca need.
- For this example, Dical contains both P & Ca.

Dical = x & Corn = 81.688 - x (Use corn to make an adjustment.)

0.0024 (5) + 0.0027 (81.688 - x) + 0.0062 (11.712) + 0.1821x = 0.004 (100) [From left, P from alfalfa, corn, SBM, and Dical.]

0.012 + 0.2206 - 0.0027x + 0.0726 + 0.1821x = 0.004 (100)
0.1821x - 0.0027x = 0.40 - 0.012 - 0.2206 - 0.0726
0.1794x = 0.0948
x = 0.5284 (Dical)
81.688 - 0.5284 = 81.1596 or 81.160 (Corn)

Check: 0.0024 (5) + 0.0027 (81.1596) + 0.0062 (11.712) + 0.1821 (0.5284) = 0.012 + 0.2191309 + 0.0726 + 0.0962216 = **0.40**

D. ***Step 3 - Balance for Ca:***

Lime = x & Corn = 81.160 - x

0.0133 (5) + 0.0003 (81.160 - x) + 0.0026 (11.712) + 0.2335 (0.5284) + 0.358x = 0.005 (100)
[From left, Ca from alfalfa, corn, SBM, Dical, and Lime.]

0.0665 + 0.0243 + 0.0003x + 0.0304 + 0.1234 + 0.358x = 0.50
0.358x - 0.0003x = 0.50 - 0.1234 - 0.0304 - 0.0243 - 0.0665
0.3577x = 0.2553
x = 0.7139 (Lime)
1.160 - 0.7139 = 80.4461 (Corn)

Check: 0.0133 (5) + 0.0003 (80.4461) + 0.0026 (11.712) + 0.2335 (0.5284) + 0.358 (0.7139) = 0.0665 + 0.0241338 + 0.0304512 + 0.1233814 + 0.2555762 = **0.50**

E. ***Step 4 - Balance for protein again with adjustments made for fixed quantities to account for Dical & Lime:***

SBM = x & Corn = 92.16 - x [93.4 - 0.5284 (Dical) - 0.7139 (Lime) = 92.16]

0 (2.84) + 0.17 (5) + 0.088 (92.16 - x) + 0.509x = 0.14 (100) [From left, CP from salt-TM-Vit-Dical-Lime portion, alfalfa, corn, and SBM.]

0 + 0.85 + 8.1101 - 0.088x + 0.509x = 14
0.509x - 0.088x = 14 - 8.1101 - 0.85
0.421x = 5.0399
x = 11.97 (SBM)
92.16 - 11.97 = 80.19 (Corn)

Check: 0 (2.84) + 0.17 (5) + 0.088 (80.19) + 0.509 (11.97) = 0 + 0.85 + 7.05672 + 6.09273 = **14.00**

2. Formulating a Supplement or Base Mix

- Again, will use a grower-finisher pig diet as an example, but the same/similar approach can be used for a supplement/base mix for other species!

A. What do you mean by a "supplement, a base mix, or a premix?" (Provided some definitions used for pig diets, but other folks may define differently, so . . . ?)

1) "Supplement"

a) Contain protein, minerals, and vitamins.
b) Mix with grain(s) to produce complete diets.

2) "Base mix"

a) Contains minerals and vitamins.
b) Mix with grain(s) and protein supplement(s) to produce complete diets.

3) "Premix"

a) Mineral or vitamin mix.
b) Mix with grain(s), protein supplement(s), and mineral or vitamin premix to produce complete diets.

B. General procedures for formulating supplements & base mixes:

1) A supplement to be mixed or fed with the grain portion of a diet - Steps:

a) Formulate a complete diet.
b) Determine the amount of supplement needed: "Total - Grain Portion = Supplement."
c) Express ingredients as a percent of the supplement, rather than the diet.
d) Write the specification for the supplement.

2) A base mix to be fed with the grain and protein portion of the diet - Steps:

a) Formulate a complete diet.
b) Determine the amount of base mix needed: "Total - (Grain + Protein Portion) = Base Mix."
c) Express ingredients as a percent of the base mix rather than the diet.
d) Write specifications for the base mix.

3) A supplement to be fed with the known amount of grain and the supplement:

a) Determine the contribution of the known amount of grain toward the animal's requirement.
b) Write the specifications for the supplement.
c) Formulate the supplement.

C. An example - "Formulate a **supplement (500 lb)** to be fed with **1,500 lb of corn/ton** of complete diet."

	CP, %	Ca, %	P, %
Corn	8.8	0.03	0.27
SBM	50.9	0.26	0.62
Dical	-	23.35	18.21
Lime	-	35.8	-

- Use SBM, Dical, Lime, salt, Vit premix, TM premix, and corn as a carrier, and Pigs need **14% CP**, **0.5% Ca**, **0.4% P**, **0.5% salt**, **0.1% TM premix** & **1.0% Vit premix**.

1) Determine the "**specifications**" for the supplement

a) ***Complete diet is:***

1,500/2,000 = 75% Corn & 500/2,000 = 25% Supplement

b) ***% CP in supplement:***

0.088 (75) + x (25) = 0.14 (100)
6.6 + 25x = 14
25x = 7.4
x = 0.296 [Thus, 0.296 x 100 = 29.6% (% CP in supplement)]

- *Please note that, unlike before, "x" for CP & others to determine specifications represents the "content" of particular nutrient in a feed ingredient . . . Not the "amount/lb (or %)" of a feedstuff!*

c) ***% Ca in supplement:***

0.0003 (75) + x (25) = 0.005 (100)
0.0225 + 25x = 0.5
25x = 0.4775
x = 0.0191 [Thus, 0.0191 x 100 = 1.91% (% Ca in supplement)]

d) ***% P in supplement:***

0.0027 (75) + x (25) = 0.004 (100)
0.2025 + 25x = 0.4
25x = 0.1975
x = 0.0079 [Thus, 0.0079 x 100 = 0.79% (% P in supplement)]

e) ***% salt in supplement:***

0 (75) + x (25) = 0.005 (100)
25x = 0.5
x = 0.02 [Thus, 0.02 x 100 = 2% (% salt in supplement)]

f) ***% TM in supplement:***

0 (75) + x (25) = 0.001 (100)
25x = 0.1
x = 0.004 [Thus, 0.004 x 100 = 0.4% (% TM premix in supplement)]

g) ***% Vit in supplement:***

0 (75) + x (25) = 0.01 (100)
25x = 1.0
x = 0.04 [Thus, 0.04 x 100 = 4% (% Vit premix in supplement)]

Supplement Specifications, %	
CP	29.6
Ca	1.9
P	0.8
Salt	2.0
TM premix	0.4
Vit premix	4.0

2) Supplement Specifications - Please see the box.
3) Formulate a supplement:

a) ***Step 1 - Balance for CP:***

100 - [2 (salt) + 0.4 (TM) + 4.0 (Vit)] = 93.6 SBM = x & Corn = 93.6 - x

0.088 (93.6 - x) + 0.509x = 0.296 (100)
8.24 - 0.088x + 0.509x = 29.6
0.421x = 21.36
x = 50.74 (SBM)
93.6 - 50.74 = 42.86 (Corn)

b) ***Step 2 - Balance for P:*** Dical = x & Corn = 42.86 - x

0.0027 (42.86 - x) + 0.0062 (50.74) + 0.1821x = 0.008 (100)
0.1157 - 0.0027x + 0.3146 + 0.1821x = 0.8
0.1794x = 0.3697
x = 2.06 (Dical)

c) ***Step 3 - Balance for Ca:*** Lime = x & Corn = 40.80 - x (42.86 - 2.06 = 40.80)

0.0003 (40.80 - x) + 0.0026 (50.74) + 0.2335 (2.06) + 0.358x = 0.019 (100)
0.0122 - 0.0003x + 0.1319 + 0.481 + 0.358x = 1.9
0.3577x = 1.2749
x = 3.56 (Lime)

d) ***Step 4 - Re-balance for CP:***

SBM = x & Corn = 87.98 - x [93.6 - 2.06 (Dical) - 3.56 (Lime) = 87.98]

0.088 (87.98 - x) + 0.509 x = 0.296 (100)
7.74 - 0.088x + 0.509 x = 29.6
0.421x = 21.86
x = 51.92 (SBM)
87.98 - 51.92 = 36.06 (Corn)

e) ***Supplement (%)? - Please see the box:***

SBM. 51.92
Corn. 36.06
Vit premix. 4.00
Lime. 3.56
Dical. 2.06
Salt. 2.00
TM premix. 0.40

3. **Formulating a Base Mix or a Premix?**

A. Assume we have a diet with the following composition (per ton or 2,000 lb):

Corn	1,553
SBM	353
Lime	11
Dical	51
Salt	10
TM premix	2
Vit premix	20

B. Formulate base mix to be fed with the corn & SBM:

2,000 - (1553 + 353) = 94 lb (Should be the base mix)

Lime	11/94 x 100 =	11.70%
Dical	51/94 x 100 =	54.26%
Salt	10/94 x 100 =	10.64%
TM premix	2/94 x 100 =	2.12%
Vit premix	20/94 x 100 =	21.28%
		100.00%

C. Formulating a TM or Vit premix?

1) Determine each TM or vitamin requirement.
2) The requirement must be satisfied with the amount or proportion of TM premix or Vit premix included in the base mix (or supplement or diet) - i.e., Should be included at "X" percent of the base mix, supplement, or diet!
3) Each source of TM or vitamin may not be 100% pure, thus may need to provide some "space/room" to make some adjustment, thus use a carrier(s).
4) Express each source of TM or vitamin needed in % or unit/certain weight.

VARIABILITY, AVAILABILITY, AND DIET FORMULATION

- Please see: *Chiba, L.I. 2000. Feeding system for pigs. In: Theodorou, M. K. and J. France, editors, Feeding systems and feed evaluation models. CABI Publishing, Oxon, UK. p. 181-209.*

1. General

A. Many factors can influence nutrition of animals under commercial conditions:

1) For instance, biological variations (both animals & nutrient sources), bioavailability and stability of nutrients in feed ingredients, interactions among the nutrients and non-nutritive factors, stress, physical and social environment, infectious diseases, parasite infestations, and others
2) Thus, satisfying the needs of a population of animals can be a challenging task!?

B. Conceivable that not only energy and AA, but some vitamins and minerals may play critical roles in pigs to express fully their genetic potential for growth, production, or reproduction.

1) For instance, the NRC publications/requirements are generally designed to prevent nutrient deficiency signs and(or) satisfy the requirements of average pigs.

2) For the optimum performance of pigs, it's necessary to make appropriate adjustments to those recommendations based on various factors, including economical factors.

C. Formulation of diets to satisfy the needs economically depend on the knowledge of the nutrient requirements and he nutrient contents of feed ingredients and the availability of the nutrients in feed ingredients - Mostly associated with the evaluation of feed ingredients, but cannot be treated in isolation from that of the requirements.

2. Energy/Nutrient Variability

A. Considerable variations in nutritional value of feed ingredients exists because of various factors - e.g., the CP content of corn can range form < 8% to > 9%.
B. Cereal grains are not only main sources of energy, but are also main sources of protein/AA, and may account for 40 to 50% of the CP in a typical diet. Thus, their CP/AA contents are importance.
C. Variability? - Associated with other nutrients in cereal grains, and also the variability associated with various laboratories and analytical techniques may have to be considered.

3. Energy/Nutrient Availability

A. In addition to the variation in the content of nutrients in feed ingredients, must consider the availability because not all of the energy and nutrients can be used by animals.
B. Reasons? - For instance:

1) Amino acids may not be available because of incomplete protein hydrolysis by enzymes, suppression of enzymatic activity by inhibitors, and(or) inhibition of absorption.
2) Mineral elements may be bound to phytate and fiber, or form complexes with others, thus not availble.
3) Vitamins can exist as either precursor compounds or as coenzymes that may be bound or complexed in some manner, which render them unavailable to animals.

C. "Bioavailability or availability?"

1) Can be defined as the degree to which an ingested nutrient in a particular source is absorbed in a form that can be utilized in the metabolic process by the animal.
2) e.g, for AA, involves the digestion, absorption, and utilization by the tissue after absorption.
3) Availability influences not only the requirements but also tolerance of a nutrient.

4. Diet Formulation Based on Available Nutrients

A. Animals can use only those nutrients available to them, thus, should be expressing the requirements and formulating diets on the available nutrient basis, rather than the total? Would be more effective in precisely meeting the animal's needs!?

B. Energy - Most of the data on ME values have been derived mathematically from DE, thus, these 2 systems can be used interchangeably to a large extent? NE? - Maybe too sensitive to be of a practical use, and also no reliable database for feedstuffs?
C Amino acids - The use of standardized ileal digestible values for pigs, and, perhaps, others too?
D. Minerals - Perhaps, the utmost importance might be "P" because of the phytate and also the increased use of phytase!?
E. Alternative feed ingredients:

1) Have different feeding values because of variations in the nutrient contents and others, and also may have some "maximum" inclusion rate!?

- Please see "Relative Feeding Value of Alternative Energy Sources."
- Also, please see "Relative Feeding Values and Suggested Maximum Incorporation Rates of Some Protein Sources."

2) Thus, perhaps, necessary to obtain accurate information on the feed ingredients to make appropriate adjustments for the formulation, including the availability of energy and nutrients.

F. Based on availability? - Contributes greatly to the efficiency and economics of animal production and would have a positive impact on the environment, but:

1) Questionable whether there is sufficient information on the nutritive value of individual feed ingredients, thus, a little agreement on how to address the availability issue in a day-to-day diet formulation.
2) Also, no certain that whether this practice will improve the precision of diet formulation sufficiently to meet the needs of the industry.
3) Thus, further progress must be made in developing procedures to describe "true" nutritional value of feed ingredients so that practical, convenient, cost-effective and environmentally-friendly pig diets can be formulated.

- **Relative Feeding Value of Alternative Energy Sources**: (Feeding value of "corn" = 100%; Nebraska Swine Diet Suggestion, 1992)

		Maximum recommended percent of complete diet[b]				
Ingredient	Feeding value[a]	Starter	G-F	Gestation	Lactation	Remarks
Alfalfa, dehy	75-85	0	5	25	10	Low energy, high in B vitamins
Alfalfa hay, early bloom	75-85	10	10	66	10	Low energy, high in B vitamins
Bakery waste, dehy	95-100	20	40	40	40	High energy, about 13% fat
Barley (48 lb/bu)	90-100	25	85	90	80	Low energy
Beet pulp	70-80	0	0	10	10	Bulky, high fiber, laxative
Corn & cob meal	80-90	0	0	70	10	Bulky, low energy

Corn distiller grains, dehy	115-130	5	15	40	10	B vitamin source, low lysine
Corn gluten feed	75-85	5	10	90	10	Dry pelleted source preferred
High lysine corn	100-105	60	90	90	90	Test lysine level
Corn silage (20-30% DM)	20-30	0	0	90	0	Bulky, low energy, for sows only
Fat (stabilized)	185-210	5	5	5	5	High energy, reduces dust
Hominy feed	100-105	0	60	60	60	Subject to rancidity
Millet, proso	90-95	40	75	90	40	Low lysine
Milo	95-97	60	85	90	80	Low lysine
Molasses (77% DM)	55-65	5	5	5	5	Energy source, used in pelleting
Oats (36 lb/bu)	85-95	15	20	70	10	May ↓ gut edema & nutritional scours
High protein oats	90-100	20	50	70	10	May ↓ gut edema & nutritional scours
Oat groats	110-115	20	85	90	90	Palatable, but expensive
Potatoes (22% DM)	20-25	0	25	80	0	Should be cooked, low protein
Rye	85-90	0	25	20	20	Watch for ergot toxicity
Triticale	90-95	20	75	90	40	Watch for ergot toxicity
Wheat bran	60-65	0	0	30	10	Bulky, High fiber, Laxative
Wheat, hard	100-105	35	85	40	40	Avoid fine grinding
Wheat middlings	110-125	5	15	30	10	Partial grain substitute

[a]Value apply when ingredients fed at no more than the maximum recommended % of complete diet; ranges presented to compensate for quality variation.

[b]Higher levels may be fed, but the performance may decrease.

- **Relative Feeding Values and Suggested Maximum Incorporation Rates of Some Protein Sources** (soybean meal with hulls & 44% CP = 100%; Chiba, 2001)

Ingredient	Relative Feeding Value[a,c]	Lys (g/100 g CP)[d]	Maximum Recommended Inclusion Rate (% of Diet)[a,b]			
			Starter	Grow-finish	Gestation	Lactation
Alfalfa meal, dehy	-	4.35-4.59	0	10	25	0
Blood meal, spray-dried	220-230	8.39	3	5-6	5	5
Canola meal	70-80	5.84	0	15	15	15
Cottonseed meal	-	4.15	0	10	15	0
Fish meal, menhaden	160-170	7.72	20	6	6	6
Meat and bone meal	105-115	4.87	5	5	10	5
Meat meal	130-140	5.69	0	5	10	5
Plasma protein, spray-dried	205-215	8.77	10	¶	¶	¶
Skim milk, dried	105-115	8.27	30	¶	¶	¶
Soy protein concentrate	135-145	6.56	20	¶	¶	¶
Soy protein isolate	-	6.13	10	¶	¶	¶
Soybean meal	100	6.46	15	25	15	20
Soybean meal, dehulled	105-110	6.36	15	25	15	20
Soybeans, full-fat, heat-treated	85-95	6.31	0	20	10	10
Sunflower meal	55-65	2.84-3.77	0	20	10	0
Whey, dried	55-65	7.44	30-40	15	5	5

[a]Source: Reese et al. (1995) and Hill et al. (1998).

[b]A sign (¶) indicates no nutritional limitation in a diet balanced for indispensable amino acids, minerals and vitamins, but the economical consideration may preclude the use of an ingredient for a particular class of swine.

[c]44% crude protein soybean meal = 100%. Values apply when ingredients are fed at no more than maximum recommended percent of complete diet. A range is provided to compensate for quality variation.

[d]Based on values reported by NRC (1998).

FEED INGREDIENTS IN GENERAL

- *References - Please see:*

  Thacker and Kirkwood (1990),
  Holden and Zimmerman (1991) & Seerley (1991) in Miller et al. (1991),
  Kellems and Church (1998),
  Sauber and Owen (2001), Chiba (2001) & Myer and Brendemuhl (2001) in Lewis & Southern (2001),
  Jurgens (2002),
  Chiba (2010a,b) in Pond & Bell (2005),
  Zijlstra and Beltranena (2013),
  and others for detailed info on major feed ingredients & others.

1. Classification of Feedstuffs/Ingredients & Some Examples

A. General:

1) Feedstuffs - Can be defined as any component of a diet that serves some useful function (Kellems & Church, 1998).
2) Most feedstuffs provide one or more of nutrients such as protein, lipids, carbohydrates, minerals, or vitamins.
3) Some feedstuffs are included to modify the diet's characteristics rather than simply providing energy or nutrient - e.g., to emulsify fat, provide bulk, reduce oxidation, provide flavor, color, etc.
4) Feedstuffs are given an "International Feed Number (IFN)," which indicates how a feedstuff has been categorized.
5) The International Feed Identification System classifies feedstuffs into eight general categories with the first digit of the IFN indicates the "Major Category:"

   - 1. Roughages - Dry forages and roughages, 2. Pasture, range plants and forages fed fresh, 3. Silages & hayleges, 4. Energy feeds, 5. Protein supplements, 6. Mineral supplements, 7. Vitamin supplements, and 8. Additives.

B. Categories:

1) Roughages or Dry forages and roughages

   a) All forages and roughages cut & cured, and other products with more than 18% crude fiber or containing more than 35% cell wall (dry basis). Usually low in net energy per unit weight because of the high cell-wall content.
   b) Carbonaceous roughages (low protein) - Straws, Stalks, Weathered grass, etc.
   c) Proteinaceous roughages - Legume hays, grass/legume hays, etc.

2) Pasture, range plants and forages fed fresh

a) All forage feeds either not cut (including feeds cured on the stem) or cut and fed fresh - Grazed parts (growing & dormant), greenchop, food crop residues, etc.
b) Carbonaceous (low protein) - Fresh Grama grass, fresh Wheatgrass, etc.
c) Proteinaceous (high protein) - Fresh & early vegetative Wheatgrass, etc.

3) Silages & haylages

a) Includes only ensiled forages, but not ensiled fish, grain, roots, and tubers.
b) Carbonaceous (low protein) - Corn silages, grass silage, etc.
c) Proteinaceous - Alfalfa silage, clover silage, etc..

4) Energy feeds

a) Ones with less than 20% CP and less than 18% crude fiber or less than 35% cell wall on a dry basis - e.g., grain, mill byproducts, fruit, nuts, roots, tubers, etc.
b) Carbonaceous concentrates (low protein) - Cereal grains (corn, oats, barley, rye and wheat), sorghums (kafir, milo and hybrids), milling by-products of cereal grains, beet and citrus pulp, molasses of various types, seed and mill screenings, animal, marine, and vegetable lipids, fresh or ensiled root & tubers, etc.

5) Protein supplements

a) Products that contain 20% or more of protein (dry basis) from animal origin (including ensiled products), as well as oilseed meals.
b) Supplements of vegetable origin - Soybean meal, flaxseed meal (linseed meal), cottonseed meal, peanut meal, corn gluten meal, sorghum gluten meal, brewer's dried grains, sesame meal, etc.
c) Supplements of animal origin:

(1) Animal tissues - Tankage, tankage with bone, meat scraps, meat and bone scraps, blood meal, meat meal, etc.
(2) Fish products - Fish meal, dried fish solubles, condensed fish solubles, etc.
(3) Milk products - Dried skim milk, dried whole milk, dried butter milk, condensed butter milk, dried whey, etc.

d) Also, include single-cell sources (bacteria, yeast, and algae), non-protein N (urea, ammonia, biuret, etc.), etc.

6) Mineral supplements - Steamed bone meal, calcium carbonate, limestone, etc.
7) Vitamin supplements - Ensiled yeast, carotene, fish, salmon, oil, wheat germ oil, etc.
8) Additives - Antibiotics, antioxidants, probiotics, coloring material, flavors, hormones, enzymes, emulsifying agents, buffers, etc.

2. Roughages in General

A. Earth's surface? (Kellems and Church, 1998)

1) Approximately one-third of the earth's surface is land (34 billion acres):

a) Out of this total land, 3 to 4% is utilized for urban and industrial purposes, 10% is being farmed, and 28 to 30% is forest lands, some of which can be used by animals, approximately 15% is non-productive, i.e., deserts to land covered by ice in the Arctic and Antarctic regions.
b) The remaining 40% is comprised of rangeland (more suitable vs. cultivation) such as grassland, savannas, scrublands, tundra, alpinr communities, coastal marshes, and wet meadows.

2) Thus, it is obvious that production of materials useful for humans (food, fiber clothing, etc.) can only be achieved from a large portion of the world's land by grazing animals, both domestic and wild!?

B. Forages, roughages, and herbages?

1) "Forage" - Defined as the total plant material available to be consumed by an animal.
2) "Roughage" - A terms often used to describe those dietary components that are characterized by being high in fiber (cellulose).
3) "Herbage" - Often used by ones involved in management of wildlife, and is plant materials that does not include the seeds or roots and can be utilized by as food by herbivorous animals.
4) The terms “forages and roughages” are often used interchangeably to describe plant materials that are high in structural carbohydrates, which contain high amounts of cellulose and hemicellulose.

C. General characteristics:

1) Low in energy and containing more than 18% crude fiber, and variable in protein content.
2) Higher in Ca and trace mineral elements than most concentrates.
3) Legumes are higher in protein and B vitamins than some concentrates.
4) Better source of fat-soluble vitamins than most concentrates.
5) Usually, palatable to ruminant species.
6) Limited use in swine diets, and also beef finishing rations & some high-energy lactating rations.
7) Required by lactating dairy cows to help maintain a normal milk fat content.
8) More variable in nutritive contents and acceptability than concentrates because of variations in maturity, harvesting (i.e., stages?), and storing procedures.

3. High-Energy Feedstuffs in General

A. High-energy feedstuffs - Fed or added to a diet/ration primarily to increase energy intake or dietary energy density, but many of them also provide amino acids, minerals and vitamins!
B. Include various cereal grains and many of their milling by-products, roots and tubers, liquid feeds, such as molasses, fats and oils, and others.
C. Available energy (digestible, metabolizable, or net) per unit of dry matter is much higher than roughages.
D. Depending on the type of diet and the class of animal, may make up a substantial portion of the animal's total diet.
E. General characteristics:

    1) Low in fiber, and high in energy.
    2) Low in protein vs. oil seed meals & some mill feeds, and protein quality is variable and generally low.
    3) Low in Ca, but fair in P (good vs. forages).
    4) Low in vitamin D, vitamin A (excluding yellow corn), riboflavin, vitamin B_{12}, and pantothenic acid, and fair in vitamin E.
    5) High in thiamin and also high in niacin but mostly in a bound, unavailable form.

4. Protein Supplements in General

A. Protein is a critical nutrient, i.e., the one likely to be low or deficient, especially for young, rapidly growing animals and, e.g., high-producing dairy cattle.
B. Protein supplements? - Those having 20% or more crude protein on a dry matter basis.
C. Optimum use is a must simply because protein supplements are usually much more expensive than energy sources, and wasteful usage can increase the production cost.
D. For nonruminant species and young suckling ruminant species, a diet must supply the indispensable amino acids (thus, protein quality is important) and adequate N to synthesize dispensable amino acids.
E. For ruminant species:

    1) Dietary need is a combination of needs to nourish microorganisms and the needs for adequate supply of digestible, indispensable amino acids in the gut.
    2) Protein quality is important for high-producing ruminants because of the increased needs for rumen undegradable protein. Microbial protein may not be adequate for high-producing animals.

F. Protein supplements? Animal, plant, marine, and microbial sources are available, but today, the major protein sources used for animal production are oilseed meals. Some animals protein source are also being used though!
G. Oilseed meals in general:

    1) Soybean is clearly the prominent oilseed produced in the world, and soybean meal accounted for 64.1% of the world production of protein meals in 1997 to 1998.

2) Moderate heating is generally required to inactivate anti-nutritional factors present in oilseed meals. But, overheating can reduce amino acid availability!
3) Generally high in crude protein content, except some with hulls. The CP content is usually standardized before marketing by dilution with hulls or other materials.
4) Generally low in Ca, but high in P content. The biological availability of minerals in plant sources, such as oilseeds, are generally low, especially true for P.

H. Animal protein sources in general:

1) Good sources of lysine and other amino acids, and the amino acid pattern is often very similar to the dietary needs of animals.
2) Compared with plant proteins, very good sources of vitamins and minerals, such as the B vitamins (especially vitamin B_{12}) and Ca and P.
3) More variable in the nutrient content, and are subjected to high drying temperatures for dehydration and sterilization. Obviously, proper heating is necessary to produce a quality product.
4) Some clarifications on meat meal, meat and bone meal, meat meal tankage, and meat and bone meal tankage:

a) The only difference between meal and tankage is that the meal does not contain blood.
b) Meat meal is distinguished from meat and bone meal based on the P content - If the product contains more than 4.4% P, it is considered as meat and bone meal.
c) Meat meal tankage and meat and bone meal tankage can be differentiated similarly on the basis of P content.
d) For all these, Ca should not be more than 2.2 times the actual P content.

5. Mineral Supplements in General

A. Minerals are the inorganic components and make up only a relatively small portion of the animal diet, but vital to the animal.
B. All the required minerals are needed in an animal's diet and(or) water supply, but the need for supplementation vary widely among species. Classified as either macrominerals or microminerals (or trace minerals/elements!?).
C. Macrominerals:

1) Include salt (NaCl), Ca, P, Mg, & sometimes K & S.
2) Ca? - Little difference in availability among Ca sources. Most are utilized well by different animals.
3) P sources differ wide in availability, especially when fed to noruminant species simply because ½ to ⅔ of plant P is bound to phytic acid, which is poorly utilized by nonruminants.
4) Salt - Often iodized and(or) added small amounts of other trace elements (e.g., Co, Mn, Fe, Zn, and Cu). Either as a block (free-choice) or a loose form.

D. Micro or trace minerals/elements:

1) Include Cu, Fe, I, Mn, Se, Zn, and also Co. (Others? - Cr, F, Ni, Si, etc.)
2) Differences exist in biological availability depending on the form. Some forms may not be available to animals at all.
3) Chelation? Chelating with other molecules (e.g., some amino acids) may improve the stability and absorption/utilization of some trace elements.

6. Vitamin Supplements in General

A. Almost all feedstuffs contain some vitamins, but their concentrations vary widely.
B. In plants, vitamin concentration can be affected by harvesting, processing, and storage conditions, as well as plant species and part.
C. In animals, the liver and kidney are generally good sources of most of the vitamins.
D. Yeasts and other microorganisms are excellent source, especially, B vitamins.
E. Limiting vitamins in natural diets (mostly for nonruminants), thus the need for supplementation!?

1) Mostly for nonruminants - Vitamins A, D, E, riboflavin, pantothenic acid, niacin, choline, and vitamin B_{12}, depending on the species & class. Also, biotin (in pigs & poultry) and vitamin K (with reduced microbial synthesis) in some instances?!
2) For ruminants - Vitamin A & also β-carotene, and vitamin D & E for dairy cows? Also, thiamin & niacin in some instances!?

F. Vitamins can be purchased individually or as a mixture.
G. Fat-soluble vitamins need a antioxidant to retain their potency.
H. Some/most(?) water-soluble vitamins are subject to destruction by heat, moisture, light, trace elements, etc.

COMMON FEED INGREDIENTS

- *See: Kellems and Church (1998), Chiba (2001), and Jurgens (2002), and others.*
- Abbreviations: CP = crude protein; TDN = total digestible nutrients; SBM = soybean meal; DM = dry matter.

1. Brief Description of Some Feed Ingredients

Alfalfa - Perennial plant varying in height from 18 in. to 3 ft. Grown extensively throughout the Midwest and western US. Hay is high in the feeding value and excellent for general purposes - 15 to 15% CP, > 50% TDN, high in Ca (1.3 to 1.5%), and fair in P. "Dehydrated meals" - Dried products produced after cutting & grinding. Contains 15 to 23% CP, but ones with 17 & 20% CP are common.

Animal fat - Obtained from the tissues of mammals and(or) poultry in the commercial rendering or extraction. Usually treated with an antioxidant to prevent rancidity. Used to increase the energy, decrease dustiness, improve texture & palatability, facilitate pelleting, and reduce machinery wear.

Bakery, waste, dehydrated - Blended, dried and ground meal consists of stale bakery products and certain other bakery wastes. Similar to corn in the nutrient composition, but much higher in fat (12 to 16%) and also salt. Because of the high salt content, should be limited to about 20% of total for cattle & pig

diets.

Barley, grain - Majority is grown in North Central & Far Western states. Contains 70 to 75% TDN & 11 to 12% CP, and 88 to 90% feeding value of corn for cattle and sheep & 80% for pigs. Limit in pig and poultry diets because of the fiber content (5 to 6%), but can be used as the only grain in all concentrate diets with cattle.

Beet pulp, dehy - The residue from sugar beet processing. Contains 65 to 70% TDN & 8 to 10%CP. 18 to 19% in the fiber content, and a good laxative in sow diets. Generally, should not replace > 15 to 20% of grain.

Bermudagrass, common & coastal- "Common" - Long-lived perennial spreading by runners, rootstocks or both, and by seeds. Stems are very leafy. Requires warm weather during the growing season and will bear intense heat without injury. Not resistant to cold & not stand shading well. Most commonly used for pasture rather than for hay. Contains 6 to 15% CP (DM). "Coastal" - A hybrid superior to common Bermudagrass, but does not produce viable seed. More growth, cold resistant, and resistant to leaf diseases and root-knot nematode. Most extensively produced hay crop in the Deep South. With adequately fertilization & cutting at the proper stage, can make a high quality hay. Contains 7 to 18% CP (DM).

Blood, meal - Coagulated packing house blood that has been dried into a meal. Drying methods include drum, ring, and flash/spray. High in CP (80%+), but may be low in digestibility and quality because of the heat damage during the drying process, and also unpalatable. Contains highly undegradable protein for ruminants.

Blood, plasma - Plasma fraction of blood yields a fine, light tan powder containing 78% CP (spray-dried plasma). High in Lys, Trp, Thr, but low in Met & Ile. Highly digestible & contains an amino acid profile that closely matches the young pig's needs, and may have a positive effect on the immune system of the young pig.

Bluegrass, Kentucky - Long-lived, perennial sod grass with rhizomes & grows 6 to 30 in. tall. Often the earliest growing grass in the spring. Very sensitive to heat and summer drought. Highly palatable and nutritious to all species of livestock. Able to withstand continued heavy grazing. Undesirable as a hay grass because of its low growth, low yield, and maturity before other grasses are ready to cut. Contains 12 to 17% CP (DM).

Brewer's grain, dehydrated - The dried extracted residue of barley malt alone or in mixture with other cereal grain or grain products resulting from the manufacturing of wort. Contains 25 to 27% CP and 14 to 16% crude fiber. Commonly fed to dairy cattle up to about ⅓ of the grain mix. Often included in horse rations but seldom fed to swine or poultry because of the high fiber content.

Brewer's yeast, dehydrated - Dried yeast product (nonfermentative) with a minimum of 35% CP (DM). Contains protein of high quality and high in many B vitamins.

Bromegrass, smooth - Erect, leafy, long-lived, drought-resistant perennial. 2 to 4 ft tall with many underground rootstocks. Used for pasture, hay, silage, and erosion control. Produces abundant herbage in the spring and late summer. Best growth in the second and third year. Quite palatable for all classes of animals. Contains 4 to over 20% CP (DM) depending on maturity and fertilization.

Buckwheat, grain - Originated in Asia & minor crop in the US. A summer annual with rather coarse, branched stems and large, broadly arrow-shaped leaves. Seeds are pointed, broad at the base, and triangular to nearly round in cross section. Japanese buckwheat is most widely grown in the US. Whole buckwheat being used for poultry scratch feed mixtures. The middlings from milling make good livestock feed as they are high in protein.

Canarygrass, Reed - Coarse, vigorous, long-lived perennial 2 to 6 ft tall with leafy, short stems, tending to grow in dense bunches of 2 or 3 ft in diameter. Prefers a moist, cool site and thrives on land too wet for most other grasses. One of the most heat & drought tolerant cool-season grasses. Used mostly as pasture, but increasing hay and silage usage. Has a long growing season and recovers quickly from grazing or mowing. Contains 9 to 13% CP (DM).

Canola, meal - The remaining portion of seeds after removing most of the hull and oil. Contains 35 to 40% CP, 13 to 14% fiber. Lower in palatability, energy and Lys vs SBM. Unprocessed rapeseed contains erucic acid and the enzyme myrosinase - Thyrotoxic or goitrogenic activity. Canola - Cultivars of rapeseed with much lower erucic acid and glucosinolate content. To be called canola, oil must contain less than 5% erucic acid, while the meal must contain less than 3 mg/g of glucosinolates. For young pigs and poultry, 5% of the total diet, whereas 12% for older pigs and poultry. Not palatable to ruminants, but can use up to 10% of the ruminant diet.

Casein, dehydrated - The solid residue obtained by acid or rennin coagulation of defatted milk & dried.

Citrus pulp, dehydrated - Dried residue of citrus family, producing a coarse, flaky product. High in fiber (13%) and low in CP (6 to7%) & P (0.12%). Ca content may be> 2% because of the use of certain Ca compounds for processing. Fed mainly to dairy cattle but may be fed to beef cattle. Generally, < 20 to 25 of

the ration.

Clover, Ladino - A giant, rapid-growing, white clover. Leaves, stems and flower heads grow from two to three times large vs common white clover. Thrives in a temperate climate and favors moist fertile soils. Primarily a grazing crop, but does not withstand close or continuous grazing. Difficult to mow and cure. Hay yields usually quite low. A similar feeding value, but has a higher "carrying" capacity compared to common white clover.

Clover, Red - Perennial plant normally growing taller than alfalfa but does not have as extensive root development nor productive life. Best suited to regions with abundant rainfall. An important crop in the north central and northeastern regions of the US. Used primarily for hay, and it has a similar nutrient composition to alfalfa except for slightly lower CP (12 to 22%)

Coconut, meal - Also known as Copra meal. Widely grown/distributed in many tropical areas of the world. Residual oil content falls between 9 and 16%, but some may contain > 20%. Its oil composed predominantly of short- and medium-chained fatty acids. Contains about 21%CP and 10% fiber. Deficient in Lys & Met, and generally a poor source of amino acids for nonruminants.

Corn, cobs, ground - A potential feed source where ear corn is harvested. Low in CP (2 to 3%), but useful as an energy source.

Corn, distiller's grain, dehydrated - Obtained by the processing of the residue remaining after removal of the alcohol and some water from a yeast-fermented mash. Made from the dried coarse grain fraction. Contains 25 to 27% CP and 9 to 11% fiber.

Corn, distiller's grain with/solubles -Obtained after the removal of ethyl alcohol by distillation from the yeast fermentation of the grain by condensing & drying at least ¾ of the solids of the resultant whole stillage. Contains 25 to 27% CP.

Corn, distiller's solubles - Obtained after removing ethyl alcohol by distillation from the yeast fermentation of the grain by condensing the thin stillage fraction and drying. Contains 25 to 27% CP & 4% crude fiber.

Corn, gluten feed - Dried residue remaining after removal of the larger portion of the starch, gluten and germ. Contains corn bran, and 20 to 25% CP.

Corn, gluten meal - Dried residue remaining after removal of larger part of starch, germ and bran, and contains 40 to 60% CP.

Corn, grain - Most popular and widely used grain in Midwest. High in energy (80% TDN), thiamin, niacin (bound form for pigs & poultry though!), fair in P & low in Ca, CP (8 to 9%), vitamin D, riboflavin and pantothenic acid. Fed in various forms - air-dried (88 to 90% DM), high-moisture(20 to 34%), and whole ear, i.e., corn-and-cobmeal.

Corn, hominy feed - A mixture of corn bran, corn germ and part of the starchy portion of the grain. Must contain not less than 4% crude fat. Contains 10 to 11% CP. Generally about equal to corn in the feeding value.

Corn, silage - Most popular silage in the US in areas where corn grows well. Excellent for most classes of livestock. Moderate to high energy content, but low in CP (7 to 9%).

Cottonseed, hulls - By-product of oil extraction process. Consists primary of the outer covering of the cottonseed. Contains 4 to 5% CP (DM).

Cottonseed, ground - Feeding whole cottonseed to lactating dairy cattle has become popular in recent years. May increase milk production/milk fat.

Cottonseed, meal, mechanical & solvent extracted - Grown primary in southern US. Removing kernels from hulls & crushed, and then oil is removed via mechanical or solvent extraction. Contains 36 to 41% CP & 61 to 70% TDN. Protein quality is low. Contains gossypol (0.03 to 0.20%), which is toxic to noruminants, especially young pigs & chicks (& also calves), and symptoms are similar to pneumonia, except fluid fluids accumulates in abdominal cavity. Many factors (species, age, dietary components, etc.) affect the toxicity. Should not make up more than 25 to 30% of protein supplement.

Feather meal, hydrolyzed - Pressure-treated, clean undecomposed feather from poultry. Contains 85% CP, and 75% of the CP should be guaranteed digestible. Primarily used in swine and poultry feeds. Low in histidine, lysine, methionine & tryptophan. High bypass protein for ruminant species.

Fescue, Tall - A deeply rooted and strongly tuffed perennial bunchgrass with stems 3 to 4 ft tall. Adapted to moist, deep soils, tolerates moderately high soil salinity, able to survive prolonged winter flooding, but not tolerant of extended drought. Used for pasture and hay, but more widely for pasture, especially winter grazing. Contains 10 to 15% CP (DM). ["Summer toxicosis" due to the formation of a plant endophyte fungus and high plant content of the alkaloid perloline - Reduce palatability and digestibility and cause an increase in body temperature and roughened hair coat of the cattle. Cattle prefer to stand in the shade or in water. Lessened or eliminated by planting a variety of tall fescue, which is resistant to endophyte.]

Fish meal - Consists of whole fish or fish cuttings (by-products) with or without the extraction of part of the oil, dried and ground into a meal. Several types depending on the type of fish used. CP ranges from 35% to 70% depending on type of product (whole fish

or cuttings). Excellent protein quality and source of B vitamins. High in the content of Ca and P.

Fish solubles - Evaporated product of the aqueous portion the oil removal process. If dehydrated, contains about 60% CP. If condensed (50% DM), contains about 30% CP. Excellent protein quality and source of B vitamins. Fish protein sources are used primarily in diets for pigs and poultry

Meat meal & Meat and bone meal - By-products of the meat packing industry & also from rendering plants. Consists of unusable animal tissues cooked in steam jacketed kettles. Blood meal is normally not added, and usually does not contain gut, tendon and connective tissue to the extent of tankage. Contains 45 to 55% CP. If more than 4.4% P, must be labeled "meat and bone meal. Mostly used for pigs and poultry.

Milk, skim, dehy - Rsidue obtained by drying defatted milk. Contains less than 8% moisture and about 33% CP.

Millet, grain - Grown primary in Asia & Africa, and there are several different types. "Proso," resembling some sorghums, is sometimes grown in the US. Others include foxtail, pearl, finger millet, etc. Intermediate in feeding value between oats & corn.

Molasses, sugar beet or sugarcane - By-product of the sugar production. Commonly fed in the liquid form (70 to 80% DM). Readily available source of energy, and quite palatable. Often used as a pellet binder and to reduce dustiness. Form the basis for most liquid protein supplement containing urea. Should not use more than 10% of the replacement value of corn in livestock diets. Most commonly fed to ruminants or horses at 3 to 7% of the diet.

Oats, grain - Widely grown, but most common in Midwestern and North Central states. Contains 65 to 70% TDN and 12% CP. Quite palatable and 85% feeding value of corn for most species. Limit in beef finishing ration and pig & poultry diets because of high fiber (11%) & low energy. Excellent grain for horses to provide bulk.

Oats, groats - Kernels produced from cleaned and dried oats with the hull removed. Contain 16 to 17% CP and only about 3% crude fiber. Approximately equal to corn in feeding value, but too expensive for general livestock feeding. May be used in special diets such as early weaning diets for pigs.

Oats, hulls - By-product of oat groats. Consists primarily of the outer covering of the oat. Contain 5 to 6% CP and 26 to 28% crude fiber.

Oats, straw - What remains after harvesting the grain. Used commonly for bedding than for feeding because of low feeding value (2 to 5% CP).

Orchardgrass - Long-lived perennial that forms dense circular bunches. Commonly grows in clumps 2 to 4 ft tall. Shade tolerant, moderately heat and cold resistant and establishes a stand rapidly. Starts growth early in the spring, and new, immature growth is highly palatable. Grows and matures rapidly & palatability and nutritive value decline as matures. Generally recognized as superior to smooth bromegrass as a deterrent to bloat when used in mixtures with alfalfa. Contains 8 to 18% CP (DM).

Pea, seeds - A number of different species usually grown for humans, but may become available for animal feeding. Contain 20 to 28% CP. Deficient in S-amino acids & Trp?

Peanut meal, mechanical or solvent extracted - Consists of fat-extracted kernels ground, with some ground peanut hulls added. Contents vary, but 40 to 48% CP & 6 to 13% fiber. Poor amino acid balance & limiting in Lys & Met. May contain certain aflatoxins. For pigs and poultry, can replace 5 to 10% of the diet or 30 to 50% of SBM. For ruminants, equal to SBM in feeding value.

Poultry byproduct meal - Made from ground, dry-rendered or wet-rendered parts of the carcass, i.e., heads, feet, undeveloped eggs & intestines, but no feathers. Must not contain more than 16% ash. Contains 55 to 65% CP.

Rice, bran - Consists primarily of the seed coat and germ removed from polished rice production. Contains 13 to 15% CP & 12% crude fiber. Comparable to wheat bran in the feeding value, even though lower in CP. Some fed to dairy cattle or used as a carrier in feed additive premixes.

Rice, grain/groats - Not normally used as a feed grain, but occasionally, rough rice (unmilled) may become available for animals. Contains about 8% CP, 9% fiber, and 1.7% ether extract.

Rice, hulls - By-product from polished rice production, and consists primary of the outer covering of the rice. Contains 3 to 4% CP (DM).

Rye, grain - Least palatable of the grains, and may be contaminated with ergot (black fungus - reduces palatability, causes abortion & reduces blood supply to extremities, resulting in necrosis). Contains 75% TDN & 12% CP. Tend to cause digestive disturbances if ground too fine & should not make up more than ⅓ of the diet.

Ryegrass, Perennial - Short-lived, rapid-growing, leafy perennial that ordinarily attains a height of 1 to 2 ft. On poor soils, the grass lives only 2 yr, and when seeded in hay mixtures, perennial ryegrass will disappear after the first year. Serves as a temporary covering. Contains 6 to 13% CP (DM).

Safflower, meal, solvent extracted, with and without hulls - Produced by extracting oil from dehulled safflower seeds. Generally, less palatable vs

other oil meals. CP & fiber contents are 23 & 30%, respectively, for undecorticated meal, and 42 & 15%, respectively, for dcorticated meal. Lys is the first limiting amino acid, & also limiting in S-amino acids. Not more than 30% of SBM for pig diets. Similar value for ruminants?

Sesame, meal, mechanically extracted - By-product of extracting oil from the sesame seed. On the average, contains 42% CP & 6.5% fiber for dehulled meal. Low in Lys, but a good source of in Met, Cys, Trp, Ca, P, Mg & others. Can be used in limited amounts in nonruminant diets.

Sorghum, grain - Quite drought resistant and grown in those areas inadequate in rainfall for corn production. Somewhat lower in energy than corn (75 to 78% TDN) and 95 to 98% feeding value of corn for poultry and pigs and 85 to 90% for cattle and sheep. Higher but more variable in CP (8 to 12%) than corn. Must be processed for maximum digestibility.

Soybean, hulls - Consist primary the outer covering of the soybeans. Contain digestible fiber even for nonruminant species. Urea solution absorbed soy hulls seems to be a satisfactory means of feeding dairy cows.

Soybean, meal, solvent extracted & without hulls - The residue of soy oil extraction, and the most widely used oilseed meal in the US. Must be heated to destroy anti-nutritional factors, and standardized to 44 (with hulls) to 48-50% (without hulls) by dilution with hulls. Most common & most complete amino acid source used to supplement or balance the amino acid deficiencies in grains. Properly processed SBM = standard protein source!?

Soybean, protein concentrate - Produced from dehulled and oil-extracted soybeans and leached with water to remove most of the water-soluble nonprotein constituents. Contains about 70% CP.

Soybean, seeds, heat processed - Properly processed soybeans can be used in place of SBM in pig diets. Contain 37 to 38% CP, 17 to 18% fat, and 84 to 92%TDN. Improve feed efficiency because of the fat content.

Sunflower, meal without hulls - Produced from oil extracted, dehulled sunflower seeds. Wide range in CP (32 to 45%?) and fiber (11 to 24%) depending on the oil extraction method and the amount of hulls removed. Rich source of B-complex vitamins. Limiting in Lys and energy vs SBM. Replace 30 to 50 of SBM in pig and poultry diets? Similar to other protein sources for most ruminant species.

Timothy - Perennial bunchgrass, 2 to 3½ ft tall, with a swollen or bulblike base but without rhizomes. Primarily a hay plant and does not stand heavy grazing. When grown in mixtures with clover or alfalfa, the first growth frequently is harvested for hay and the later after growth pastured. Especially popular as a hay for horses and should be cut no later than the early bloom stage for maximum nutrient value. Contains 8 to 12% CP (DM).

Triticale, grain - Hybrid derived from a cross of wheat and rye. Lower test weight and yield than either wheat or rye. Contains 78% TDN and 15% CP. Unpalatable and may contain ergot similar to rye.

Urea - Not a protein supplement, but a source of N (42 to 45% N) for protein synthesis by rumen bacteria (1lb of urea = 2.62 to 2.81 lb protein, or 262 to 281% CP). Works well in mixtures with plant proteins to lower protein cost (1 lb of urea & 6 lb of corn to replace 7 lb of SBM). General rules - No more than: a) ⅓ of N in ration, b) 1% of diet or 3% of concentrate mix, c) 10 to 15% of a typical protein supplement, and d) 5% of a supplement to be used with low-quality forages.

Wheat, bran - Coarse outer coating of the kernel containing 15 to 17% CP and 9 to 11 % CF. Included in swine farrowing diets or in diets of horses or cattle used for show because of its bulky and mild laxative properties. Generally limited to 10% to 15% of the diet.

Wheat, grain - Widely grown in US, but too expensive for livestock? Contains 80% TDN and 12 to 14% CP, and 105% feeding value vs corn in limited amount to pigs and cattle (not > 50%).

Wheat, middlings - Consists of the fine particles of wheat bran, wheat shorts, wheat germ, wheat flour and some of the offal from the tail of the mill. Contain 16 to 18% CP and must contain not more than 9.5% crude fiber. Most commonly used in pig diets because the fine particle size of middlings makes them unpalatable to ruminants.

Wheat, red dog - Consists of mill tailings together with some fine particles of bran, germ and flour. More floury particles than any other millfeed, and appearance is much like greyish flour flecked with small brown bran particles.

Wheat, shorts Consists of the same components as wheat middlings, but should not contain more than 7% crude fiber.

Whey, dehydrated - Whey is a fluid obtained by separating the coagulum from milk, cream, or skim milk in the manufacturing of cheese. Contains less than 10% DM and 1% CP. Dried product contains at least 11% CP and 61% lactose.

Yeast, Torula, dehydrated - Dried yeast (*Torulopsis* spp.) containing a minimum of 40% CP. Protein is of high quality and rich in most B vitamins.

2. Cereal Grains in General [Please see Sauber and Ownes (2001) & others]

A. The primary ingredient in most diets fed to many nonruminant species in many countries is cereal grain because of their availability, energy content, palatability, and others.
B. For instance, a corn (& other cereal grains)-soybean meal mixture has become the standard diet for swine, poultry, and many other species.
C. The composition and availability of nutrient vary considerably among cereal grains, and to a certain extent, within a particular cereal grain:

1) Reasons? - The difference in the growing or environmental conditions, genetics/variety, processing methods, etc.
2) Thus, important to analyze cereal grains for the content of energy, nutrient, and others.

D. Energy:

1) Starch, lipids, and protein are the major sources of energy.
2) Dilution of those with non-energy components (moisture, ash, bound protein and carbohydrates, etc.) can affect the energy value.
3) In addition, the fiber content can affect the available energy.

E. Amino acids:

1) Lys is the first limiting AA in many cereal grains and either Trp or Thr are usually the second limiting AA.
2) Considerable variations in the availability of AA, and diets should be formulated based on the digestible or available AA basis.
3) Unfortunately, both the requirement estimates based on digestible/available AA and digestible/available AA values in cereal grains (& other sources) are lacking.
4) Nevertheless, should keep in mind that more than 50% of AA would be supplied by cereal grains in typical nonruminant diets.

F. Others:

1) Minerals - Limiting in many minerals in terms of the requirement, and Ca is clearly inadequate and also available P (& other minerals) is rather low because of phytate. The content of Se would depend on environmental/soil conditions.
2) Vitamins- Low or unreliable contents of fat-soluble vitamins (the content per se and subsequent loss o vitamins), and variable contents of water-soluble vitamins. Niacin and vitamin B_{12} are clearly deficient, and choline, pantothenic acid, and riboflavinare usually added o cereal grain-based diets.
3) Antinutritive factors - Certain strains of milo contain tannins andbarley also contains soluble polyphenols. Corn may contain amylase inhibitors, and some carbohydrates. such as bete-glucans and lectins can reduce digestibility.

3. Protein Supplements in General [Please see Chiba (2001) and others]

A. Oilseed meals

1) The major protein sources used for animal production are oilseed meals.
2) Soybean is the prominent oilseed produced in the world, and soybean meal accounted for 64.1% of the world production of protein meals in 1997 to 1998.
3) Moderate heating is generally required to inactivate anti-nutritional factors, but overheating of oilseed meals can greatly reduce the amount of digestible or available Lys and others.
4) As a group, the oilseed meals are high in CP content except safflower meal with hulls.
5) The CP content is usually standardized before marketing by dilution with hulls or other materials.
6) Relative to the AA requirement of nonruminant species, most oilseed meals are low in Lys, but soybean meal is an exception.
7) Oilseed meals are generally low in Ca, but high in P content.
8) The biological availability of minerals in plant sources such as oilseeds are generally low, and this is especially true for P.

B. Animal protein sources

1) Animal protein supplements are good sources of Lys and other AA, and the AA pattern is often very similar to the dietary needs!?
2) Compared with plant proteins, they are also very good sources of vitamins and minerals such as the B vitamins (especially vitamin B_{12}) and Ca and P.
3) Animal protein supplements are generally more variable in nutrient content compared with plant sources.
4) Proper heating is necessary to produce a quality product, ad subjecting to high drying temperatures during processing for dehydration and sterilization may affect availability.
5) Meat meal, meat and bone meal, meat meal tankage, and meat and bone meal tankage:

    a) The only difference between meal and tankage is that the meal does not contain blood.
    b) Meat meal is distinguished from meat and bone meal based on the P content. If the product contains more than 4% P, it is considered as meat and bone meal.
    c) Meat meal tankage and meat and bone meal tankage - The Ca level should not be more than 2.2 times the actual P level. Also, these products should not contain more than 14% pepsin indigestible residues and not more than 11% of the CP in the product should be pepsin indigestible.
    d) Meat by-products produced in the past tended to contain more meat and internal organs, but considerable variations in the quality of meat products can be expected mostly because of less meat and internal organs in the products.

e) in depending on many factors. Clearly distinguishing one meat-product from other meat-products may be very difficult, and also there seem to be differences in the terminology used by various countries. For this reason, the description of meat meal and meat and bone meal or the discussion on the use of those products in pig diets in this chapter should be viewed with such uncertainties in mind.

6) Bovine spongiform encephalopathy (BSE) or "mad cow disease:"

- No naturally occurring transmissible spongiform encephalopathy, including BSE, has ever been detected in pigs and poultry.

a) A fatal neurodegenerative disease (encephalopathy) in cattle that causes a spongy degeneration in the brain and spinal cord, which has a long incubation period of 30 mo to 8 yr and usually affect adult cattle at a peak age onset of 4 to5 yr.
b) Most easily transmitted to humans by eating food contaminated with the brain, spinal cord or digestive tract of infected carcasses, but the infectious agent can be found in virtually all tissues throughout the body, including blood.
c) Meat and bone meal and other processed animal proteins:

(1) The vector of the bovine epidemic in Western Europe in the 1980-1990s.
(2) For that reason, many countries have restricted the feeding of meat and bone meal, and some only allow meat and bone meal derived from nonruminant animals to be fed to ruminant animals and vice versa.
(3) The use of meat and bone meal for livestock feeding was banned in 2002 in the European Union.

FEED ADDITIVES

- For additional info, please see Kellems and Church (1998), Jurgens (2002), and Cromwell, G. L. 2013. Feed additives in swine diets. In: L. I. Chiba, editor, Sustainable swine nutrition. Willey-Blackwell, A John Wiley & Sons, Inc., Hoboken, NJ. p. 341-364.

1. Common Additives

A. Antibiotics - Compounds synthesized by living organisms that can inhibit the growth of other microorganisms. Two types (mostly derived from bacteria and molds):

1) Broad spectrum - Effective against both Gram positive and negative bacteria; e.g., Aureomycin (chlortetracycline) & Terramycin (oxytetracycline).
2) Narrow spectrum - Effective against Gram positive or negative (e.g., Tylosin & Penicillin).
3) Some examples:

Bacitracin methylene disalicylate. . . . . Chicken, swine, turkey
Bacitracin, zinc. . . . . Cattle, chicken, swine, turkey
Bambermycins. . . . . Chicken, swine, turkey, cattle

Chlortetracycline	Cattle, chicken, horse, sheep, swine, turkey
Laidlomycin	Cattle
Lasalocid	Cattle, sheep
Lincomycin	Chicken
Oxytetracycline	Cattle, chicken, sheep, swine, turkey
Penicillin	Chicken, swine, turkey
Tylosin	Chicken, swine
Virginiamycin	Chicken, swine, cattle

B. Chemotherapeutics (or chemobiotics):

1) Bacteriostatic/bactericidal compounds - Unlike antibiotics, produced chemically.
2) e.g., Sulfa compounds for swine, copper sulfate for chickens & swine, arsanilic acid for poultry & swine, carbadox for swine, and roxarsone for poultry.

C. Combinations - A combination of antibiotic(s) and chemobiotic(s) such as CSP 250, ASP 250 & Tylan Sulfa-G.

D. Probiotics - Bacteria, yeasts or a combination (e.g., live yeast cultures, lactobacillus sp., sarsaponin, etc.), which may competitively inhibit the development of undesirable microorganisms and(or) favor the development of desirable microorganisms.

E. Anthelmintics or dewormers - Examples include:

Dichlorvos (Atgard)	Swine
Fenbendazole (Safe-Guard)	Swine, cattle
Hygromycin B (Hygromix)	Chicken, swine
Ivermectin (lvomec)	Swine
Levamisole hydrochloride (Tramisol)	Cattle, swine
Morantel tartrate (Rumatel)	Cattle
Pyrantel tartrate (Banminth)	Swine

F. Coccidiostats - Prevent and treat coccidiosis (infectious diseases caused by protozoan parasites that attack the epithelial tissues of animals . . . rarely, man), and examples include:

Amprolium	Cattle, chicken, turkey
Clopidol	Chicken, turkey
Decoquinate	Cattle, chicken
Halofuginone hydrombromide	Chicken, turkey
Lasalocid	Chicken, sheep, turkey
Monensin	Chicken, cattle, turkey
Nicarbazin	Chicken
Narasin	Chicken
Robenidine hydrochloride	Chicken
Salinomycin	Chicken
Sulfadimethoxine and ormetoprim 5:3	Chicken, turkey
Zoalene	Chicken, turkey

G. Others?

1) Buffers and neutralizers - e.g., Sodium or potassium bicarbonate, Ca or Mg carbonate, Mg oxide, and sodium bentonite.
2) Antioxidants - e.g., Butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), ethoxyquin, and vitamin E.
3) Chemical preservatives - e.g., Ascorbic acid, Ca sorbate, citric acid, phosphoric acid, propionic acid, Na propionate, propylene glycol, etc.
4) Pellet-binding agents - e.g., Bentonite, ball clay, lignin sulfonate, molasses, etc.

2. Antibiotics & Growth Promoting Activity

A. Responses (e.g., in pigs):

1) Age: (Summary of 937 studies with 20,472 pigs; Peo, 1986. Proc. NE Whole Hog Days)

Item	Control	Antibiotics	% ↑
Starter (15-57 lb):			
ADG, lb	0.86	1.01	16
Feed:gain	2.32	2.16	7
Grower (37-108 lb):			
ADG, lb	1.30	1.45	11
Feed:gain	2.91	2.78	5
Grower-finisher (44-189):			
ADG, lb	1.50	1.56	4
Feed:gain	3.37	3.30	2

2) Experiment station vs. commercial production unit: (Data based on 12,000 pigs; Peo, 1986. Proc. NE Whole Hog Days)

Item	Exp.	ADG (% ↑)	F:G (% ↑)
Exp. Station	128	16.9	7.0
Commercial Prod. Unit	32	28.4	14.5
Average		*19.2*	*8.5*

3) Antibiotics & reproductive performance: (Cromwell, 1986. Univ. of Kentucky)

Item	Antibiotics (1963-1972)	No antibiotics (1972-1984)
Conception rate, %	91.4	82.6
No. pig born	10.8	10.2
No. pigs weaned	8.8	7.5
Survival rate, %	89.7	80.9
Incidence of MMA, %	< 10	66

B. Mode of action?

1) Metabolic effect:

a) Directly affect the rate or pattern of metabolic processes.
b) Bacteriostatic or bactericidal effects. (Metabolism is likely to be affected by systemic infections.)

2) Nutrient-sparing effect - May stimulate the growth of desirable microorganisms that synthesize vitamins and(or) amino acids.
3) Disease-control effect - Can suppress organisms that cause clinical or subclinical manifestation of diseases.

C. Drug resistance:

1) Resistance?

a) For every 10-mil bacteria, usually one is resistant to a particular antibiotic.
b) With continuous use of the same antibiotic, the majority of bacteria will be inhibited or killed, but the "resistant" bacteria will multiply rapidly.
- Equally applicable to domestic species, humans, etc.!

2) Two types of resistance:

a) "Mutational" - Being passed on to daughter cells only.
b) "Transferable" - Has a R factor or resistance factor, which can be transferred to other bacteria of the same or different types.

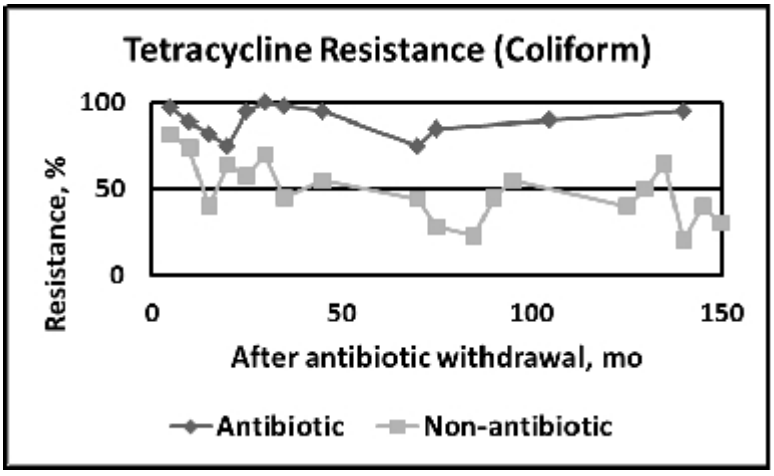
3) Questions/problems?

a) Are antibiotics still effective in animals? - Similar responses to antibiotics, ∴ still effective (Table)!
b) Can R factors from normal bacteria be transferred to pathogenic bacteria such as salmonella? Can be, but very rarely, and disease-causing capability is ↓ considerably when they are transferred!
c) Can the resistant pathogen be passed on to humans? (If so, antibiotics are no longer effective in treating humans, and drugs of the greatest concern are penicillin and tetracycline!) - Resistant bacteria are unable to establish themselves in the GI tract of human volunteers, so . . .

Percentage improvement by using antibiotics: (Cromwell, 1986. Univ. of Kentucky)

	1950-77	1978-85
ADG	16.1	15.0
Feed:gain	6.9	6.5

4) Resistant fecal coliforms in pigs - See a figure [Cromwell, 1991. In: Miller et al. (Ed.). Swine Nutrition. Butterworth-Heinemann, Boston]



- **The Bottom Line?**

  a) Antibiotics are still effective!
  b) Not likely to transfer the resistance from animals to humans! (But, theoretically possible! Thus, continues to be a subject of concern!)
  c) Discontinuing their use may have little impact on antibacterial resistance!

3. Additives and Residues

- Many feed additives must be withdrawn from feeds to ensure residue-free carcasses, and withdrawal periods before slaughter vary among additives.
- The main concern is "sulfa residues!"

A. Reasons for concern (sulfa):

1) Some people are hypersensitive to sulfa. Can develop allergic reactions, and some people show reactions to undetectable levels (. . . fortunately, very small percentage of population)!
2) Sulfamethazine may cause cancer in the thyroid of rodents, which was reported by a group of researchers in 1988 . . . but:

   a) Their findings have been refuted by many toxicologists during the FDA hearing.
   b) The amount of sulfonamide consumed through meat/pork is unlikely to cause problem. Example - The total from consumption of one pork chop containing 0.1 ppm/day for 80 years equals one daily dose of human sulfonamide medication that has no adverse effect on human thyroid!

Incidence of violations in pork liver: (Cromwell, 1986. Univ. of Kentucky)

Year	% viol.	Year	% viol.
1970's	>15	1981	6.0
1977	13.2	1982	4.3
1978	9.7	1983	8.0
1979	6.3	1984	5.9
1980	4.5	1985	5.4

& More recent data on "Sulfa-on-Site (SOS)" surveillance of market pigs: [Large Anim. Vet. 50(4):10 (1995)]

1988 - 0.28%	1991 - 0.20%
1989 - 0.44%	1992 - 0.21%
1990 - 0.26%	1993 - 0.10%

B. Tolerance level: (FDA)

1) "0.1 ppm" in muscle, liver or kidney - Established based on a long-term toxicology study, and it provides at least a 2,000-fold safety margin for humans!
2) Incidence of violations in pork liver (Please see the tables).

C. Prevention check list:

1) Always read and follow directions, i.e., use proper dosage and follow withdrawal times & keep records! Don't rely on the memory!
2) Use part of other ingredients as a carrier for uniform mixing, and mix diets in proper sequence & flush the mixer - e.g., medicated feed → non-medicated feed for non-marketable animals → withdrawal feed.
3) Use only a granulated, not a powdered form!
4) Restrict its use to starter diets.
5) Clean everything regularly - Mixing equipment and rooms, transporting equipment (feed and pigs), holding bins, etc.
6) Avoid the use of feeders for both medicated and non-medicated feed. Just one mouthful can result in a tissue concentration that can violate!
7) Do not mix pigs receiving diets with sulfa with market hogs.
8) After sulfa withdrawal, move pigs to clean pens, and clean pens thoroughly 3 to 4 consecutive days.

ANALYSIS OF FEED INGREDIENTS AND DIETS

- *Reference: Kellems and Church (1998) & Jurgens (2002).*
- Also, see appropriate sections for additional information on the analysis of feedstuffs and(or) diets.

1. Analysis for the Composition of Nutrients

A. Feed ingredients/diets can be analyzed for nutrients using some direct analytical methods.
B. Three general analytical methods:

1) Chemical procedures - Gravimetric procedures, titration, calorimetry, chromatography, etc.
2) Biological procedures - Use animals (e.g., chick or rat) to assess the value . . . more tedious & expensive.
3) Microbiological procedures - Similar to biological procedures but use isolated bacteria or other microorganisms.

2. Samples for Analysis?

A. The most important factor in evaluating feeds? Obtaining a "representative sample" is as important as the accuracy of the analysis in obtaining reliable results!
B. Sampling - Recommendations for obtaining representative samples?

1) Grains or mixed feeds

    a) Sacked feeds - Take two samples (a handful) each from 5 to 7 different sacks.
    b) Bulk feeds or grain in bins - Take 12 to 15 samples from a given lot (. . . samples should be as widely separated as possible).
    c) Samples should be mixed in a clean container, and take a 1- to 2-lb random subsample.

2) Hay

    a) Should us a drill-type core sampler for maximum reliability.
    b) Take 12 to 15 separated samples from each lot. One/per bale if baled.
    c) If a core sampler is not available, take at least ten "grab" samples.
    d) Mix core or grab samples (. . . cut to 1- to 2-in lengths) in a clean container (stems & leaves should not be separated) and take a random subsample.

3) Haylage or silage

    a) Upright silos - Can be collected during the feeding period while the unloader is in operation, and collect the sample in the cart/similar feeding unit if hand feeding.
    b) Pit or bunker silos - Take 4 to 5 grab samples from the freshly opened ones.
    c) Do not collect spoiled sample unless mixing thoroughly so that animals would not separate it.
    d) Approximately 1 to 2 lb should be collected each day for 2 to 4 days.
    e) Samples should be frozen immediately after collection to prevent bacterial fermentation and moisture loss.
    f) Mixed thoroughly in a clean container and take a random subsample.

4) Harvest sampling

    a) Many times, more convenient and reliable to obtain samples during harvest.
    b) Sampling procedures would be the same.

2. Proximate Analysis

A. Different fractions that result from the proximate analysis include: water, ash, crude protein, ether extract, crude fiber, and nitrogen-free extract (NFE).
B. Most widely used chemical scheme for describing feedstuffs, even though the information may not be useful in terms of nutrition for animals, or, even, misleading sometimes.
C. Proximate analysis

    1) Dry matter:

        a) Heat samples to a constant weight at a temperature above the boiling point of water (100-105°C) - Loss in weight = loss in water (100 - H_2O = % DM).

b) Source of error? - Loss of materials via volatilization & some liquids may be oxidized?

2) Ash (minerals):

a) Burn samples by placing a weighed amount in a muffle furnace for 2 hr at 600°C. Ash is considered as the remaining dry inorganic residues.
b) High temperature may alter forms of some minerals, and may even volatilize some, such as chlorine, zinc, selenium, and iodine.

3) Crude protein (Kjeldahl process):

a) Digest samples in concentrated sulfuric acid until all organic matter is destroyed. The N exits in the form of ammonium sulfate.
b) Neutralize digesta with sodium hydroxide and distilled, driving the ammonia over into standard acid, and titrated.
c) The procedure determines the amount of N in the sample, and total N x 6.25 = crude protein (. . . proteins contain an average of 16% N).
d) Does not distinguish one form of N from another, thus cannot tell true protein/ amino acids vs. other non-protein N.

4) Ether extract (fat):

a) Extract samples with ether for a period of 4 hr or more. Removes the fat, thus the loss of weight after drying/evaporation of ether = fat.
b) Includes any ether-soluble compounds, including some non-nutritive compounds such as chlorophyll, volatile oils, resins, pigments, and plant waxes (which are of little value to animals) as "fat."

5) Carbohydrates (CHO):

a) Not determined by the analysis as such. CH_2O = CF + NFE.
b) Crude fiber (CF):

(1) After removal of water & ether extract, the sample is boiled in weak acid (0.255 N H_2SO_4) and then in weak alkali (0.312 N NaOH). Removes the proteins, sugars, and starches, which are discarded.
(2) Cellulose, lignin, and mineral matters are left in the residue. Dried and weighed, then burped in a muffle furnace at 600°C, and the loss in the weight is reported as crude fiber.
(3) Consists mainly of hemicellulose, cellulose, and some insoluble lignin.

c) Nitrogen-free extract (NFE):

(1) Estimated by the difference, not by the actual analysis.

(2) Add % water, ash, protein, fiber, and fat, and subtracted from 100.
(3) Made up primarily of readily available CH_2O, such as sugars and starches, but may contain some hemicellulose and lignin, particularly in forages.

3. Method of Forage Evaluation

A. Proximate analysis:

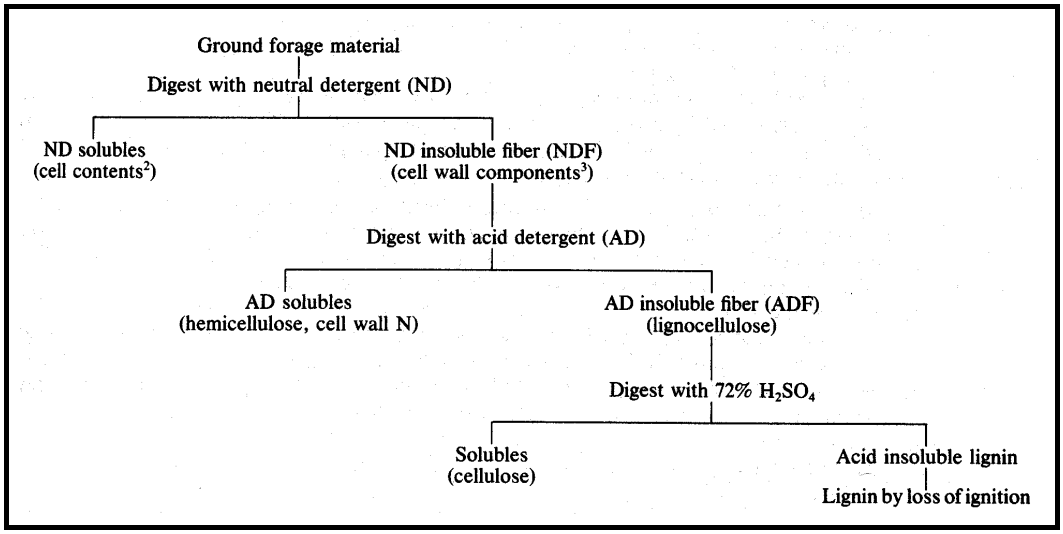
1) Served for many years and continues to serve a useful purpose in predicting the nutritive value of feeds.
2) But, there are some definite limitations of the system, especially with the crude fiber and NFE fractions:

   a) The material that was dissolved by the solvents (NFE) was assumed to be digestible, and the residue (crude fiber) was assumed to be indigestible.
   b) But, some studies showed that, in some cases, crude fiber was more digestible than the NFE fraction.

3) Thus, predicting the nutritive value from the proximate analysis may not be reliable, especially for those with more fibrous components.
4) Over the years, various procedures that may provide a more definitive separation of the carbohydrate portion than does the proximate analysis have been evaluated.

B To develop a chemical procedure that fractionates forages into relatively digestible and indigestible portions, Van Soest (1967. JAS 26:119) proposed the extraction scheme - See the figure (Jurgens, 2002):

1) Cell contents - Sugar, starch, soluble carbohydrates, pectin, NPN, lipids, miscellaneous vitamins, etc.
2) Cell wall components - Cellulose, hemicellulose, lignin, silica, heat-damaged protein.



3) Nutritional value for animals?

a) Soluble in neutral detergent - Completely digested by the ruminant.
b) Fraction insoluble in neutral detergent - Low but variable availability depending upon the species of plant and its stage of maturity.
c) A similar statement can be made for the acid detergent fiber and cellulose.
d) Lignin is indigestible.

4. Near Infrared Reflectance Spectroscopy

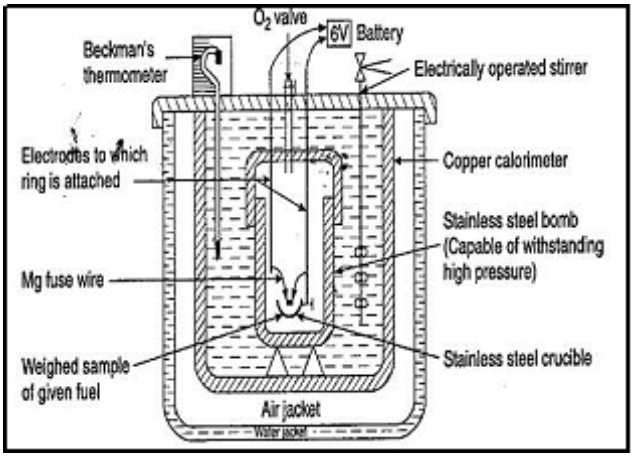
A. Development of near infrared reflectance spectroscopy (NIRS) technology? - Very useful in assessing the forage quality.
B. A rapid and reproducible determination of the chemical composition of samples with little or no sample preparation.
C. Distinguish one another based on the fact that each of the major chemical components of a sample has near infrared absorption properties.
D. In the near infrared range, absorption occurs primarily as a result of vibrations of light-weight atoms that have strong molecular bonds.
E. The vibration frequency is low and will not be detected in the near infrared range when there are weak chemical bonds, or heavy atoms:

1) Thus, NIR is primarily limited to chemical bonds containing hydrogen attached to atoms such as nitrogen, carbon, or oxygen.
2) Consequently, the detection of minerals is poor unless the mineral exists in association with some organic constituent.

G. Advantages over the more traditional wet-lab procedures? - Speed (typical time ranging from 30 sec. to 3 min.), simplicity of sample preparation (only grinding?), no portion of the sample is consumed by the procedure, and ability to analyze multiple components in one operation.
H. Disadvantages? - Require a high-precision instrument, dependence on calibration procedures, and inability to measure minor constituents.

5. Determination of Vitamins

A. Because of the diversity of compounds, no routine analysis for vitamins, even though methods are available for assaying individual vitamins.
B. Biological assays are used for some, whereas the chemical analysis is used for others.



6. Determination of Gross Energy

A. Use a bomb calorimeter [please see the figure (unknown source)] to determine the gross energy of a sample (solid, liquid, or gas):

1) Determine the energy value by burning it in an atmosphere of oxygen.
2) Liberated heat increases the temperature of water surrounding the container (which contains the sample) when the sample is burned.
3) The increased temperature provides the basis for calculating the energy value.

B The energy value is expressed in units called calories where 1 calorie = the amount of heat required to raise the temperature of 1 g of water from 14.5 to 15.5°C.

PROCESSING OF FEED INGREDIENTS AND(OR) DIETS

- *Please see Kellems and Church (1998), which include a section on "Feed Preparation and Processing," and also Hancock and Behnke (2001).*

1. Processing in General

A. Purposes? To alter the physical form or particle size, prevent spoilage, improve palatability, increase surface area, obtain a uniform mixture of various ingredients, avoid sorting by animals, increase digestibility by subjecting to pre-digestion (e.g., heat processing), etc.
B. Feed processing may involve mechanical, chemical, and(or) thermal methods, and also microbial fermentation may be involved.
C. As the level of production and feeding increases: (Kellems & Church, 1998)

1) Feed preparation/processing method may become more important.
2) Heavily fed animals become more selective and tend to sort out less palatable ingredients, or refuse and(or) waste feed.

2. Common Processing Methods for Grains

A. Cold processing:

1) Grinding - Hammer mills

a) The most common method, and perhaps the cheapest and most simple?
b) The size can be controlled by changing a screen size.
c) For nonruminants? - Fine (1/8- to 3/16-in screen or smaller), medium (¼- to ⅜-in screen) or coarse, with medium being the best? Depending the grain though!
d) For ruminants? - Perhaps, prefer coarsely ground grains because they don't like finely ground meals, especially, dusty meals.

2) Rolling/cracking - Produce smaller particles by compressing it between two corrugated rolls (less dusty feed vs. a hammer mill), and the physical texture is acceptable to many species.
3) Soaking, reconstitution, and high-moisture grain

    a) Soaking for 12 to 24 hr can soften the grain (swells during the process) and make a palatable product. But, no advantage in performance? Also, some problems (storage space, souring/fermentation, etc.) have discouraged a large-scale use.
    b) Reconstitution - Similar to soaking, and add water to dry grain to increase the moisture content to 25 to 30% and store the wet grain in an oxygen-limiting silo for 14 to 21 d prior to feeding. Improve performance in beef cattle, but the storage might be the major problem?
    c) Harvest grain at high-moisture content (20 to 35%) and store in silo (or under plastic) to preserve the grain. A proper storage or chemical treatment (e.g., 1 to 1.5% of organic acid/mixture) is must to avoid heat & mold if weather is not cold.

B. Hot processing methods

1) Steam-rolling and steam-flaking

    a) Steam-rolling - Grains are subjected to steam for a short period (3 to 5 min - just enough to soften the seed, but no modification of the starch granule) before rolling. Improve animal performance.
    b) Steam-flaking - Similar to steam-rolling, but the grain is subjected to high-moisture steam for a longer time 15 to 30 min (. . . rupture of starch granules). Similar animal performance vs. steam-rolled grains?

2) Pelleting

    a) By grinding feed and then forcing it through a thick, spinning die with the use of rollers, which compress the feed into holes in the pellet die.
    b) Can be made in different diameters, length, and hardness, and all domestic animals generally like the physical nature of pellets.

3) Extruding

    a) By passing the feed through a machine with a spiral screw that forces the feed through a tapered head.
    b) Feed is ground, heated, and extended, producing a ribbonlike product.
    c) Being used to process whole soybean seeds or other oil seeds. Heating is enough to destroy anti-nutritional factors in soybean & others.

4) Popping, micronizing, and roasting

a) Popping - Dry heat causing a sudden expansion that ruptures the endosperm of the grain. Usually rolled before feeding to reduce its bulkiness.
b) Micronizing - Essentially the same as popping, except heat is provided in the form of infrared energy.
c) Roasting - By passing the grain through a flame, resulting in heating and some expansion of the grain.

- Cost of equipment & also maintenance difficulties . . . !?

C. Effect of Processing on Performance (e.g., in pigs)

1) Ground cereal grains & pig performance: [Modified the data compiled by Lawrence, 1985. In: Cole & Haresign (Ed.) Recent Developments in Pig Nutrition]

Grain	Whole grain	Coarse ground	Medium ground	Fine ground	Rolled
Barley:					
Weight gain, kg/d	0.52	0.64	0.65	0.66	0.66
Feed:gain	3.98	3.19	3.17	3.14	3.10
Oats:					
Weight gain, kg/d		0.48	0.57	0.73	
Feed:gain		4.60	4.10	3.60	
Maize:					
Weight gain, kg/d	0.56		0.63		
Feed (DM):gain	2.94		2.63		
Sorghum:					
Weight gain, kg/d	0.81		0.85		
Feed:gain	4.01		3.72		

2) Effects of steam-flaking on starch digestion (%): (Osman et al., 1970. J. Nutr. 100:1133)

Processing	Barley	Milo
Untreated	22.7	16.0
Steamed, not flaked	18.4	11.7
Poorly flaked	26.5	14.4
Intermediately flaked	36.8	31.3
Flat flaked	51.2	41.0

3) Effects of popping & micronizing: (Adapted from Aumaitre, 1976. Journées Rech. Porcine Fr. 211 & Lawrence, 1973a,b. Anim. Prod. 16:99 & 16:109)

Item	Corn	Barley	Wheat
Dry matter, %			
Control	86	78	
Popped	88	79	
Dry matter, %			

Ground	86.9	79.7	
Micronized	86.5	80.9	
Gain to 90 kg, kg/d			
Ground	0.76	0.73	0.75
Micronized	0.83	0.77	0.78
Efficiency, kg DM/kg gain			
Ground	2.17	2.36	2.17
Micronized	2.04	2.25	2.23

4) Effects of pelleting: (% improvement or the No. of papers reported a positive response)

Reference/ criterion	% improvement or No. of papers
Vanschoubroek et al., 1971. (Nutr. Abstr. Rev. 41:1):	
Growth rate	+ 6.6%
Efficiency	+ 7.9%
Feed intake	- 2.1%
Braude, 1972. [57 published papers; In: Cole (Ed.) Pig Production]:	
Improved growth rate	38 papers
Improved efficiency	48 papers

3. Common Processing Methods for Roughage

A. Bailing - Still one of the most common methods of handling roughage, and large bales are becoming more common.
B. Chopping or grinding - Provide more uniform product & can reduce feed refusal and wastage. But, additional expense of grinding and loss of dust may be substantial?!
C. Pelleting - Usually consumed readily by ruminants, horses, and rabbits, and improve animal performance more with "low-quality" roughage. Some must be ground first, and the cost of processing is a bigger item vs. other methods.
D. Cubing - Hay is forced through dies that produce a square product (about 3 cm in size) of varying lengths & hardness. Often used for dairy cattle.
E. Dried/dehydrated, e.g., alfalfa - A substantial amount of alfalfa meal is produced. The cost is relatively high, thus used in limited amounts in pig or poultry diets as a source of carotene, vitamins, etc.

F. Effect of processing on performance?

1) Effect of processing of alfalfa hay on performance of growing-finishing cattle:

Item	Gain, kg/d	DM, kg/d	Feed:gain
Alfalfa hay (Webb & Cmarik, 1957. Univ. of IL Rep. 15-40-329)			
Baled		0.29	4.31	15.1
Chopped		0.28	4.22	15.1
Pelleted		0.78	6.49	8.3

Alfalfa hay (25 Kercher et al., 1971. Proc. W. Sec. ASAS 22:33)			
Baled	0.67	6.14	9.1
Cubed	0.86	6.65	7.8
Haylage	0.77	6.79	8.9

2) Effect of processing on feedlot performance of lambs

Item	Gain, g/d	Feed, kg/d	Feed:gain
Alfalfa (Weir et al., 1959. JAS 18:805)			
Chopped	136	1.41	10.31
Pelleted	177	1.68	9.43
Chopped + 30% barley	141	1.27	9.16
Pelleted + 30% barley	163	1.45	8.97
Alfalfa hay:Corn (50:50) (Fontenot & Hopkins, 1965. JAS 24:62)			
Long hay			
Ground corn	141	1.30	9.18
Pelleted corn	145	1.25	8.54
Ground hay			
Ground corn	145	1.34	9.38
Pelleted corn	154	1.20	7.79
Pelleted hay			
Ground corn	177	1.42	8.02
Pelleted corn	177	1.37	7.83
Pelleted complete ration	186	1.43	7.88
Pelleted complete, then ground	168	1.39	8.36

COMPOSITION OF COMMON FEED INGREDIENTS

- *References: Mostly based on Jurgens (2002), but others are based on NRC publications (1994, 1998, and 2000). For details/additional info, please see Jurgens (2002) or NRC (1994, 1998, 2000) using International Feed Name or Number (IFN) as a guide.*

- Abbreviations for feed ingredient name/description:

  dehy = dehydrated;
  DG = distiller's grains;
  sol ext = solvent extracted;
  rend = rendered;
  prot conc = protein concentrate;
  w/ = with;
  mech ext = mechanically extracted;
  by-pro = by-product;
  wo/ = without;
  heat proc = heat processed.

- Dash ("-") indicates no available data.

- Each ingredient has 2 sets of values:

  Top = On an "as-fed" basis!
  Second = On a "DM" or "100% DM basis!"

1. Table 1. Nutrients in Generl {DM = dry matter; CP = crude protein; RUP = ruminal undegradable protein [NRC, 2000 or 2001 (with forage = 25% DM intake); Ones in parentheses - Based on Kellems & Church (1998) & values for unknown IFN]; ADF = acid detergent fiber; NDF = neutral detergent fiber}

Ingredient name/ description & IFN	DM, %	CP %	RUP %	Cellulose, %	Crude fiber, %	Ether extract, %	Ash, %	ADF, %	NDF, %
1. Alfalfa, fresh	26.0	5.3		-	6.0	1.0	2.5	-	-
2-00-196	100.0	20.5	-	-	23.0	3.8	9.5	-	-
2. Alfalfa, hay	91.0	17.0		23.1	25.5	3.3	7.8	33.6	42.0
1-00-063	100.0	18.7	(28)	25.4	28.0	3.6	8.5	36.9	46.0
3. Alfalfa, dehy 17% CP	91.8	17.4		-	24.0	2.8	9.8	31.5	41.0
1-00-023	100.0	18.9	59	-	26.2	3.0	10.6	34.3	45.0
4. Alfalfa, dehy 20% CP	91.6	20.3		-	20.8	3.3	10.2	27.0	38.0
1-00-024	100.0	22.1	-	-	22.7	3.6	11.2	29.4	42.0
5. Bakery, waste, dehy	91.2	10.1		-	1.3	10.9	3.7	1.6	16.0
4-00-466	100.0	11.1	18	-	1.4	11.9	4.0	1.8	18.0
6. Barley, grain	88.6	11.5		5.2	4.9	1.8	2.4	7.7	17.0
4-00-549	100.0	13.0	27	5.9	5.6	2.0	2.7	8.7	19.0
7. Barley, straw	91.4	4.0		34.1	37.9	1.7	6.7	42.2	73.0
1-00-498	100.0	4.4	25	37.3	41.5	1.9	7.3	46.2	80.0
8. Beet pulp, dehy	91.0	8.9		18.3	18.2	0.5	4.9	25.0	49.0
4-00-669	100.0	9.8	45	20.1	20.0	0.6	5.3	27.5	54.0
9. Bermudagrass, fresh	28.9	4.2		8.1	7.7	0.6	3.3	9.1	-
2-00-712	100.0	14.6	-	28.0	26.6	2.0	11.4	31.4	-
10. Bermudagrass, hay	91.2	9.4		29.4	28.5	2.0	7.9	35.7	69.0
1-00-703	100.0	10.3	-	32.3	31.3	2.1	8.7	39.1	76.0
11. Blood, meal, spray dried	92.6	87.7		-	1.0	0.7	2.3	-	-
5-00-381	100.0	94.7	(82)	-	1.1	0.8	2.5	-	-
12. Blood, plasma (NRC, 1998)	91.0	78.0		-	-	2.0	-	-	-
13. Bluegrass, fresh	30.8	5.4		-	7.8	1.1	2.9	9.0	17.0
2-00-777	100.0	17.4	-	-	25.2	3.5	9.4	29.0	55.0
14. Bluegrass, hay	88.9	9.3		26.1	26.7	2.6	6.0	-	-
1-00-776	100.0	10.5	-	29.4	30.0	2.9	6.7	-	-
15. Brewer's grain, dehy	92.2	27.1		12.0	13.2	6.5	3.7	21.1	42.0
5-02-141	100.0	29.5	50	13.0	14.3	7.1	4.0	22.9	46.0
16. Brewer's yeast, dehy	93.1	43.4		-	3.2	1.0	6.7	3.7	-
7-05-527	100.0	46.6	-	-	3.5	1.1	7.2	4.0	-
17. Brome, fresh	27.0	4.1		-	7.5	0.8	-	9.5	16
2-00-963	100.0	15.2	-	-	28.0	3.0	-	35.2	58.0
18. Brome, hay	89.6	12.4		-	29.0	2.6	7.1	33.4	58.0
1-00-947	100.0	13.9	(44)	-	32.4	2.9	8.0	37.3	65.0
19. Buckwheat, grain	88.4	11.3		-	10.8	2.3	2.1	11.6	-
4-00-994	100.0	12.8	-	-	12.2	2.6	2.4	13.1	-
20. Canary grass, fresh	22.8	3.9		4.9	5.6	0.9	2.3	6.5	-
2-01-113	100.0	17.0	19	21.6	24.4	4.1	10.2	28.3	-
21. Canary grass, hay	89.3	9.1		-	30.2	2.7	7.3	32.7	-
1-01-104	100.0	10.2	22	-	33.9	3.0	8.1	36.6	-
22. Canola, meal	91.2	36.9		-	11.9	1.7	6.8	-	-
5-03-871	100.0	40.5	28	-	13.1	1.9	7.5	-	-
23. Casein, dehy	91.6	85.6		-	0.2	0.5	2.2	0.0	0.0
5-01-162	100.0	93.5	(19)	-	0.2	0.5	2.4	0.0	0.0
24. Citrus pulp, dehy	91.1	6.1		-	11.6	3.4	6.0	21.0	21.0
4-01-237	100.0	6.7	30	-	12.8	3.7	6.6	23.0	23.0
25. Clover, Landino, fresh	17.7	4.4		-	2.5	0.9	1.9	-	-
2-01-383	100.0	24.7	-	-	14.2	4.8	10.5	-	-
26. Clover, Landino, hay	89.1	20.0		-	18.5	2.4	8.4	28.5	32.0
1-01-378	100.0	22.4	22	-	20.8	2.7	9.4	32.0	36.0
27. Clover, Red, fresh	26.2	3.8		-	6.8	0.8	2.0	9.0	11.0
2-01-429	100.0	14.6	22	-	26.1	2.9	7.8	35.0	43.0
28. Clover, Red, hay	88.4	13.0		-	27.1	2.5	6.7	36.2	41.0
1-01-415	100.0	14.7	24	-	30.7	2.8	7.5	41.0	46.0
29. Coconut, meal	91.1	21.3		-	14.4	2.1	6.1	21.9	-
5-01-573	100.0	23.4	(63)	-	15.8	2.3	6.7	24.0	-
30. Corn, cobs, ground	89.8	2.8		-	32.2	0.6	1.6	39.5	80.0
1-02-782	100.0	3.1	-	-	35.8	0.7	1.8	44.0	89.0
31. Corn, DG, dehy	93.5	27.8		-	11.5	8.9	2.2	15.9	40.0
5-02-842	100.0	29.7	(54)	-	12.3	9.5	2.4	17.0	43.0
32. Corn, DG w/solubles	91.8	27.1		-	9.1	9.2	4.5	16.5	40.0
5-02-843	100.0	29.5	(47)	-	9.9	10.1	4.9	18.0	44.0

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Table 1. Nutrients in General (Continued)

Ingredient name/ description & IFN	DM, %	CP %	RUP %	Cellulose, %	Crude fiber, %	Ether extract, %	Ash, %	ADF, %	NDF, %
33. Corn, distiller's solubles	92.9	27.4		-	4.6	8.6	7.2	6.5	21.0
5-02-844	100.0	29.5	-	-	4.9	9.3	7.7	7.0	23.0
34. Corn, gluten feed	89.9	22.9		-	8.7	2.2	6.7	10.8	40.0
5-02-903	100.0	25.5	(22)	-	9.7	2.5	7.4	12.0	45.0
35. Corn, gluten meal	91.3	43.2		-	4.5	2.2	3.1	8.2	34.0
5-02-900	100.0	47.3	(55)	-	4.9	2.4	3.4	9.0	37.0
36. Corn, grain	88.0	9.1		2.1	2.2	3.6	1.3	3.8	8.0
4-02-935	100.0	10.4	(52)	2.4	2.5	4.1	1.5	4.3	9.0
37. Corn, hominy feed	90.2	10.3		-	4.8	6.5	2.8	11.7	50.0
4-02-887	100.0	11.4	24	-	5.3	7.2	3.1	13.0	55.0
38. Corn, silage	34.1	2.8		-	8.1	1.0	1.5	9.7	17.0
3-02-823	100.0	8.1	(31)	-	23.7	3.1	4.5	28.3	51.0
39. Cottonseed, hulls	90.4	3.8		-	43.2	1.5	2.6	59.0	81.0
1-01-599	100.0	4.2	50	-	47.8	1.7	2.9	65.3	90.0
40. Cottonseed, ground	92.2	21.7		-	18.2	22.4	3.5	24.0	34.0
5-01-608	100.0	23.6	-	-	19.8	24.3	3.8	26.0	37.0
41. Cottonseed, meal, mech ext	92.6	41.0		9.1	11.9	4.7	6.2	16.7	26.0
5-01-617	100.0	44.3	(36)	9.8	12.9	5.0	6.6	18.0	28.0
42. Cottonseed, meal, sol ext	91.0	41.3		12.0	12.2	1.5	6.5	18.2	24.0
5-01-621	100.0	45.4	(50)	13.2	13.4	1.7	7.1	20.0	26.0
43. Feather meal, hydrolyzed	92.9	83.4		-	1.3	5.5	2.9	5.7	-
5-03-795	100.0	89.8	76	-	1.4	5.9	3.1	6.2	-
44. Fescue, fresh	28.4	3.5		-	8.6	1.0	2.4	-	-
2-01-920	100.0	12.5	-	-	30.1	3.7	8.4	-	-
45. Fescue, hay	87.5	8.2		-	28.0	2.4	7.9	43.8	63.0
1-01-912	100.0	9.4	-	-	32.0	2.7	9.0	50.0	72.0
46. Fish, anchovy, mech ext	92.0	65.5		-	1.0	4.1	14.7	-	-
5-01-985	100.0	71.2	60	-	1.1	4.5	16.0	-	-
47. Fish, herring, mech ext	91.8	71.1		-	1.8	8.4	10.7	-	-
5-02-000	100.0	77.4	-	-	1.9	9.1	11.7	-	-
48. Fish, menhaden, mech ext	91.7	62.2		-	0.7	9.8	18.9	-	-
5-02-009	100.0	67.9	60	-	0.8	10.7	20.6	-	-
49. Fish, white, mech ext	91.2	62.9		-	0.5	4.6	22.9	-	-
5-02-025	100.0	68.9	-	-	0.6	5.1	25.1	-	-
50. Fish, solubles, condensed	50.4	31.5		-	0.5	6.0	10.1	-	-
5-01-969	100.0	62.5	-	-	1.0	11.9	20.1	-	-
51. Fish, solubles, dehy	92.8	60.3		-	2.0	9.2	13.1	-	-
5-01-971	100.0	65.0	-	-	2.1	9.9	14.1	-	-
52. Meat meal, rend	93.8	50.6		-	2.7	8.9	28.1	-	-
5-00-385	100.0	54.0	56	-	2.9	9.5	29.9	-	-
53. Meat meal w/bones	93.3	50.2		-	2.3	10.4	27.8	-	-
5-00-388	100.0	53.8	(49)	-	2.4	11.2	29.7	-	-
54. Milk, skim, dehy	94.1	33.4		0.0	0.2	1.0	7.9	0.0	0.0
5-01-175	100.0	35.5	-	0.0	0.2	1.0	8.4	0.0	0.0
55. Millet, grain	89.9	11.9		-	6.2	3.9	2.8	15.3	-
4-03-098	100.0	13.2	-	-	6.9	4.3	3.1	17.0	-
56. Molasses, sugar beet	77.9	6.6		-	-	0.2	8.9	-	-
4-00-668	100.0	8.5	20	-	-	0.2	11.4	-	-
57. Molasses, sugarcane	74.3	4.3		-	0.4	0.2	9.9	0.3	-
4-04-696	100.0	5.8	20	-	0.5	0.2	13.3	0.4	-
58. Oats, grain	89.2	11.8		-	10.7	4.6	3.1	14.2	28.0
4-03-309	100.0	13.3	17	-	12.0	5.2	3.4	15.9	32.0
59. Oats, groats	89.6	15.5		-	2.5	6.1	2.0	-	-
4-03-331	100.0	17.3	-	-	2.8	6.8	2.3	-	-
60. Oats, hay	90.7	8.6		-	29.1	2.2	7.2	34.8	56.0
1-03-280	100.0	9.5	20	-	32.0	2.4	7.9	38.4	62.0
61. Oats, hulls	92.4	3.8		27.3	30.6	1.4	6.1	36.5	72.0
1-03-281	100.0	4.1	25	29.5	33.2	1.5	6.6	39.6	78.0
62. Oats, silage	30.5	2.9		-	9.6	1.0	2.6	11.6	-
3-03-298	100.0	9.5	-	-	31.4	3.3	8.5	38.1	-
63. Oats, straw	92.2	4.1		39.5	37.2	2.0	7.2	44.2	64.0
1-03-283	100.0	4.4	30	42.8	40.4	2.2	7.8	47.9	70.0
64. Orchardgrass, fresh	23.5	3.0		6.0	7.5	0.9	1.9	7.2	-
2-03-442	100.0	12.8	20	25.6	32.0	3.7	8.1	30.7	-
65. Orchardgrass, hay	89.6	10.5		26.4	31.1	2.8	6.5	34.0	56.0
1-03-438	100.0	11.8	-	29.4	34.7	3.1	7.3	37.9	63.0
66. Pea, seeds	89.1	23.4		-	5.6	0.9	2.8	-	-
5-03-600	100.0	26.3	(22)	-	6.3	1.0	3.2	-	-
67. Peanut, meal, mech ext	92.6	49.2		4.2	6.2	5.6	5.0	5.6	13.0
5-03-649	100.0	53.1	-	4.5	6.7	6.0	5.4	6.1	14.0

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Table 1. Nutrient in General (Continued)

Ingredient name/ description & IFN	DM, %	CP %	RUP %	Cellulose, %	Crude fiber, %	Ether extract, %	Ash, %	ADF, %	NDF, %
68. Peanut, meal, sol ext	92.4	48.9		-	7.7	2.1	5.8	-	-
5-03-650	100.0	52.9	30	-	8.4	2.3	6.3	-	-
69. Poultry by-pro, meal, rend	93.8	61.1		-	2.1	13.1	14.6	-	-
5-03-798	100.0	65.1	-	-	2.3	13.9	15.6	-	-
70. Rice, bran	90.5	13.1		-	11.7	13.6	10.4	25.7	30.0
4-03-928	100.0	14.4	25	-	12.9	15.0	11.5	28.4	33.0
71. Rice, grain/groats	88.5	8.0		0.4	0.8	0.8	0.9	1.2	14.0
4-03-932	100.0	9.0	-	0.5	0.9	0.9	1.0	1.4	16.0
72. Rice, hulls	91.9	2.8		34.2	39.2	1.0	19.0	63.1	75.0
1-08-075	100.0	3.1	35	37.2	42.7	1.1	20.6	68.7	82.0
73. Rye, grain	87.5	12.0		2.1	2.2	1.5	1.8	3.7	-
4-04-047	100.0	13.7	(19)	2.4	2.5	1.7	1.9	4.2	-
74. Ryegrass, fresh	22.6	4.0		-	4.7	0.9	3.9	7.5	9.0
2-04-073	100.0	17.9	20	-	20.9	4.1	17.4	33.0	38.0
75. Safflower, meal, sol ext	91.7	22.9		-	29.9	1.2	5.3	37.6	53.0
5-04-110	100.0	25.0	27	-	32.6	1.3	5.8	41.0	58.0
76. Safflower, meal wo/hulls	91.0	42.7		-	13.4	1.2	7.8	-	-
5-07-959	100.0	46.9	-	-	14.7	1.3	8.5	-	-
77. Sesame, meal, mech ext	92.7	45.6		-	5.7	6.4	11.4	15.7	16.0
5-04-220	100.0	49.2	-	-	6.2	6.9	12.3	17.0	17.0
78. Sorghum, grain	90.1	11.5		5.0	2.6	2.7	1.7	8.3	-
4-04-383	100.0	12.7	57	5.6	2.8	3.0	1.9	9.3	-
79. Sorghum, sorgo, silage	28.8	1.9		-	7.0	0.7	2.4	11.0	-
3-04-468	100.0	6.7	-	-	24.4	2.5	8.3	38.0	-
80. Soybean, hulls	90.3	11.2		41.8	35.5	1.9	4.4	44.2	60.0
1-04-560	100.0	12.4	25	46.1	39.3	2.1	4.9	49.0	67.0
81. Soybean, meal, sol ext	89.6	45.7		-	5.8	1.2	6.2	-	-
5-04-604	100.0	51.0	-	-	6.5	1.3	6.9	-	-
82. Soybean, meal wo/hulls	89.9	49.3		4.1	3.5	1.0	6.0	5.5	7.0
5-04-612	100.0	54.8	34	4.5	3.8	1.1	6.7	6.1	8.0
83. Soybean, prot conc - (NRC, 1998)	90.0	64.0		-	-	3.0	-	-	-
84. Soybean, seeds, heat proc	92.6	36.6		-	5.1	18.7	4.7	-	-
5-04-597	100.0	39.5	29	-	5.6	20.2	5.1	-	-
85. Sunflower, meal wo/hulls	92.5	45.2		-	11.7	2.7	7.5	-	-
5-04-739	100.0	48.9	26	-	12.7	2.9	8.1	-	-
86. Timothy, fresh	26.7	3.3		-	8.6	1.0	2.0	-	-
2-04-903	100.0	12.2	20	-	32.1	3.8	7.5	-	-
87. Timothy, hay	89.1	9.6		31.2	30.0	2.5	5.1	31.4	54.0
1-04-882	100.0	10.8	22	35.0	33.6	2.8	5.7	35.2	61.0
88. Triticale, grain	89.2	14.7		-	2.9	1.5	1.8	-	-
4-20-362	100.0	16.5	-	-	3.3	1.6	2.0	-	-
89. Urea	97.0	276.9		-	-	-	1.5	-	-
5-05-070	100.0	285.4	-	-	-	-	1.5	-	-
90. Wheat, bran	89.0	15.4		9.5	10.0	3.8	5.9	12.5	45.0
4-05-190	100.0	17.4	20	10.7	11.3	4.3	6.6	14.0	51.0
91. Wheat, grain, hard red spring	87.6	14.9		7.2	2.5	1.8	1.6	11.0	-
4-05-258	100.0	17.1	(22?)	8.2	2.8	2.0	1.8	12.6	-
92. Wheat, grain, hard red winter	88.8	12.8		-	2.6	1.6	1.8	3.9	-
4-05-268	100.0	14.4	(22?)	-	2.9	1.8	2.0	4.4	-
93. Wheat, grain, soft red winter	88.4	11.4		-	2.3	1.6	1.9	-	-
4-05-294	100.0	12.9	(22?)	-	2.6	1.8	2.1	-	-
94. Wheat, grain, soft white winter	90.2	10.4		-	2.3	1.5	1.5	3.6	13.0
4-05-337	100.0	11.5	(22?)	-	2.6	1.7	1.7	4.0	14.0
95. Wheat, hay	88.7	7.7		-	25.7	2.0	7.0	36.4	60.0
1-05-172	100.0	8.7	23	-	29.0	2.2	7.9	41.0	68.0
96. Wheat, middlings	88.9	16.4		7.5	7.8	4.2	4.6	10.5	33.0
4-05-205	100.0	18.4	21	8.4	8.8	4.7	5.2	11.8	37.0
97. Wheat, red dog	88.3	15.7		4.9	2.9	3.4	2.5	8.1	-
4-05-203	100.0	17.7	-	5.6	3.3	3.9	2.8	9.2	-
98. Wheat, shorts	88.4	16.7		-	6.3	4.3	4.4	-	-
4-05-201	100.0	18.9	-	-	7.2	4.8	5.0	-	-
99. Whey, dehy	93.3	13.1		-	0.2	0.7	8.7	0.2	-
4-01-182	100.0	14.0	-	-	0.2	0.8	9.4	0.2	-
100. Yeast, Torula, dehy	93.0	49.5		-	2.5	1.6	8.6	4.0	-
7-05-534	100.0	53.2	(42)	-	2.7	1.7	8.6	4.0	-

2. Table 2. Energy Content for Various Species [DM = dry matter; TDN = total digestible nutrients; DE = digestible energy; ME = metabolizable energy; NEm = net energy for maintenance; NEg = NE for gain; NEl = NE for lactation; MEn = nitrogen-corrected ME]

Ingredient name/ description & IFN	DM, %	TDN (Cattle), %	TDN (Sheep), %	DE (Sheep), Mcal/kg	ME (Cattle), Mcal/kg	ME (Sheep), Mcal/kg	NEm (Cattle), Mcal/kg	NEg (Cattle), Mcal/kg	NEl (Cattle), Mcal/kg	MEn (Poultry), Mcal/kg	DE (Horse), Mcal/kg	DE (Pig), Mcal/kg	ME (Pig), Mcal/kg
1. Alfalfa, fresh	26.0	15.9	15.8	0.70	0.59	0.59	0.35	0.20	0.36	-	0.58	-	-
2-00-196	100.0	61.0	60.7	2.67	2.27	2.25	1.34	0.77	1.37	-	2.23	-	-
2. Alfalfa, hay	91.0	52.1	52.2	2.14	1.99	1.75	1.17	0.65	1.15	-	2.07	-	-
1-00-063	100.0	57.2	57.4	2.35	2.19	1.92	1.28	0.71	1.27	-	2.28	-	-
3. Alfalfa, dehy 17% CP	91.8	55.6	55.0	2.28	2.06	1.88	1.27	0.73	1.25	1.51	2.16	1.42	1.32
1-00-023	100.0	60.6	60.0	2.48	2.25	2.05	1.38	0.80	1.37	1.64	2.36	1.54	1.44
4. Alfalfa, dehy 20% CP	91.6	57.4	55.7	2.38	2.15	1.99	1.28	0.75	1.30	1.63	2.07	2.08	1.92
1-00-024	100.0	62.7	60.8	2.59	2.34	2.17	1.40	0.82	1.42	1.77	2.27	2.27	2.10
5. Bakery, waste, dehy	91.2	81.3	81.8	3.60	3.16	3.23	2.19	1.54	1.88	3.84	-	3.96	3.71
4-00-466	100.0	89.1	89.6	3.95	3.46	3.54	2.41	1.69	2.06	4.20	-	4.34	4.07
6. Barley, grain-	88.6	73.7	76.0	3.35	2.57	2.99	1.73	1.16	1.81	2.62	3.26	3.08	2.94
4-00-549	100.0	83.2	85.9	3.79	2.91	3.37	1.95	1.31	2.05	2.96	3.68	3.48	3.32
7. Barley, straw	91.4	41.8	43.6	1.92	1.40	1.53	0.64	0.15	0.91	-	1.47	-	-
1-00-498	100.0	45.7	47.7	2.10	1.54	1.67	0.70	0.16	1.00	-	1.62	-	-
8. Beet pulp, dehy	91.0	67.7	67.2	2.96	2.44	2.58	1.60	1.04	1.55	0.65	2.33	2.88	2.70
4-00-669	100.0	74.4	73.8	3.26	2.68	2.84	1.76	1.14	1.70	0.71	2.56	3.16	2.97
9. Bermudagrass, fresh	28.9	17.8	17.4	0.77	0.66	0.64	0.39	0.23	0.40	-	0.60	-	-
2-00-712	100.0	61.5	60.0	2.65	2.29	2.22	1.36	0.78	1.39	-	2.06	-	-
10. Bermudagrass, hay	91.2	41.1	44.5	1.96	1.41	1.57	0.65	0.16	0.88	-	1.69	-	-
1-00-703	100.0	45.1	48.8	2.15	1.55	1.72	0.71	0.18	0.96	-	1.85	-	-
11. Blood, meal, spray dried	92.6	85.4	84.3	3.71	3.38	3.34	2.13	1.48	1.98	2.77	-	2.70	1.94
5-00-381	100.0	92.2	91.0	4.01	3.66	3.60	2.30	1.60	2.14	2.99	-	2.92	2.10
13. Bluegrass, fresh	30.8	22.2	20.2	0.89	0.85	0.76	0.52	0.33	0.51	-	0.64	-	-
2-00-777	100.0	72.0	65.5	2.89	2.76	2.47	1.70	1.08	1.64	-	2.08	-	-
14. Bluegrass, hay	88.9	51.4	53.9	2.38	1.89	2.00	1.10	0.59	1.15	-	1.52	-	-
1-00-776	100.0	57.8	60.6	2.67	2.12	2.25	1.23	0.67	1.30	-	1.71	-	-
15. Brewer's grain, dehy	92.2	65.1	65.9	2.91	2.22	2.52	1.41	0.86	1.48	2.31	2.53	2.18	2.12
5-02-141	100.0	70.6	71.5	3.15	2.41	2.73	1.53	0.93	1.61	2.51	2.75	2.37	2.30
16. Brewer's yeast, dehy	93.1	73.7	72.1	3.18	2.86	2.79	1.79	1.19	1.69	2.07	3.07	-	2.87
7-05-527	100.0	79.2	77.4	3.41	3.08	3.00	1.92	1.28	1.82	2.23	3.30	-	3.08
17. Brome, fresh	27.0	16.9	13.9	0.61	0.63	0.50	0.38	0.22	0.38	-	0.54	-	-
2-00-963	100.0	62.8	51.4	2.27	2.35	1.84	1.40	0.82	1.42	-	1.98	-	-
18. Brome, hay	89.6	53.5	53.4	2.55	2.01	2.17	1.19	0.67	1.17	-	1.71	-	-
1-00-947	100.0	59.7	59.6	2.84	2.24	2.42	1.33	0.75	1.30	-	1.91	-	-
19. Buckwheat, grain	88.4	61.9	64.6	2.85	2.36	2.48	1.44	0.91	1.41	2.67	-	3.06	2.88
4-00-994	100.0	70.0	73.1	3.22	2.67	2.80	1.63	1.03	1.60	3.02	-	3.46	3.26
20. Canary grass, fresh	22.8	14.8	14.0	0.62	0.56	0.52	0.34	0.20	0.34	-	0.58	-	-
2-01-113	100.0	65.0	61.2	2.70	2.44	2.28	1.47	0.88	1.47	-	2.54	-	-
21. Canary grass, hay	89.3	49.2	44.1	1.95	1.79	1.56	1.02	0.52	1.10	-	1.78	-	-
1-01-104	100.0	55.1	49.5	2.18	2.00	1.75	1.14	0.58	1.23	-	2.00	-	-
22. Canola, meal	91.2	62.9	68.2	3.01	2.39	2.63	1.46	0.91	1.43	1.75	-	3.01	2.75
5-03-871	100.0	69.0	74.8	3.30	2.62	2.88	1.60	1.00	1.57	1.92	-	3.30	3.01
23. Casein, dehy	91.6	75.3	87.6	3.86	2.71	3.49	1.83	1.23	1.73	4.16	-	3.54	3.10
5-01-162	100.0	82.2	95.7	4.22	2.96	3.81	2.00	1.35	1.89	4.54	-	3.87	3.39
24. Citrus pulp, dehy	91.1	74.1	76.4	3.37	2.47	2.99	1.63	1.06	1.71	1.34	2.56	3.06	2.42
4-01-237	100.0	81.4	83.8	3.70	2.71	3.28	1.79	1.16	1.87	1.47	2.81	3.36	2.66
25. Clover, Landino, fresh	17.7	13.8	13.2	0.58	0.54	0.51	0.33	0.22	0.32	-	0.44	-	-
2-01-383	100.0	78.2	74.7	3.29	3.03	2.88	1.89	1.25	1.80	-	2.48	-	-
26. Clover, Landino, hay	89.1	56.6	59.2	2.61	2.12	2.24	1.27	0.75	1.28	-	1.96	-	-
1-01-378	100.0	63.5	66.5	2.93	2.38	2.51	1.42	0.84	1.44	-	2.20	-	-
27. Clover, Red, fresh	26.2	16.8	17.2	0.76	0.63	0.65	0.38	0.22	0.38	-	0.66	-	-
2-01-429	100.0	64.0	65.7	2.90	2.40	2.48	1.44	0.86	1.45	-	2.25	-	-
28. Clover, Red, hay	88.4	51.6	52.0	2.67	1.90	2.30	1.11	0.61	1.16	-	1.96	-	-
1-01-415	100.0	58.4	58.9	3.02	2.15	2.60	1.26	0.69	1.31	-	2.22	-	-
29. Coconut, meal	91.1	68.3	68.6	3.02	2.63	2.64	1.63	1.06	1.55	1.53	-	3.22	3.06
5-01-573	100.0	75.0	75.3	3.32	2.89	2.90	1.79	1.16	1.70	1.67	-	3.53	3.35
30. Corn, cobs, ground	89.8	43.6	45.4	2.00	1.62	1.62	0.86	0.37	0.96	-	1.25	-	-
1-02-782	100.0	48.5	50.5	2.23	1.80	1.80	0.96	0.42	1.07	-	1.39	-	-
31. Corn, DG, dehy	93.5	80.4	81.6	3.60	2.82	3.21	1.91	1.30	1.86	2.07	3.26	2.75	2.64
5-02-842	100.0	86.0	87.3	3.85	3.02	3.44	2.05	1.39	1.99	2.22	3.49	2.94	2.82
32. Corn, DG w/solubles	91.8	81.7	79.9	3.52	2.95	3.14	2.03	1.40	1.89	2.53	-	3.24	2.82
5-02-843	100.0	89.1	87.1	3.84	3.22	3.43	2.21	1.52	2.06	2.76	-	3.53	3.07
33. Corn, distiller's solubles	92.9	81.6	79.3	3.50	2.96	3.11	2.03	1.40	1.89	2.92	-	3.25	3.13
5-02-844	100.0	87.9	85.4	3.76	3.19	3.35	2.19	1.50	2.03	3.14	-	3.50	3.37
34. Corn, gluten feed	89.9	74.4	74.8	3.30	2.67	2.93	1.80	1.21	1.72	1.73	-	3.03	2.48
5-02-903	100.0	82.8	83.2	3.67	2.96	3.25	2.00	1.35	1.91	1.92	-	3.37	2.76

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Table 2. Energy Content for Various Species (Continued)

Ingredient name/ description & IFN	DM, %	TDN (Cattle), %	TDN (Sheep), %	DE (Sheep), Mcal/kg	ME (Cattle), Mcal/kg	ME (Sheep), Mcal/kg	NEm (Cattle), Mcal/kg	NEg (Cattle), Mcal/kg	NEl (Cattle), Mcal/kg	MEn (Poultry), Mcal/kg	DE (Horse), Mcal/kg	DE (Pig), Mcal/kg	ME (Pig), Mcal/kg
35. Corn, gluten meal	91.3	76.0	79.4	3.50	2.73	3.13	1.85	1.25	1.75	3.01	-	3.61	3.17
5-02-900	100.0	83.2	87.0	3.84	2.99	3.42	2.03	1.37	1.92	3.30	-	3.96	3.47
36. Corn, grain	88.0	78.0	82.9	3.59	2.78	3.23	1.90	1.31	1.81	3.31	3.38	3.44	3.24
4-02-935	100.0	88.7	94.2	4.08	3.16	3.68	2.16	1.48	2.05	3.77	3.84	3.92	3.68
37. Corn, hominy feed	90.2	84.8	83.5	3.68	2.85	3.31	1.95	1.34	2.00	2.89	-	3.57	3.38
4-02-887	100.0	93.9	92.5	4.08	3.15	3.67	2.16	1.48	2.22	3.21	-	3.96	3.75
38. Corn, silage	34.1	23.9	24.0	1.06	0.91	0.92	0.56	0.35	0.54	-	-	-	-
3-02-823	100.0	70.0	70.5	3.11	2.67	2.69	1.63	1.03	1.60	-	-	-	-
39. Cottonseed, hulls	90.4	40.6	43.8	1.93	1.31	1.55	0.55	0.08	0.86	-	1.71	-	-
1-01-599	100.0	44.9	48.5	2.14	1.45	1.71	0.61	0.08	0.95	-	1.89	-	-
40. Cottonseed, ground	92.2	90.3	90.3	3.98	3.61	3.61	2.28	1.60	2.10	-	-	3.57	3.12
5-01-608	100.0	98.0	98.0	4.32	3.91	3.91	2.47	1.74	2.28	-	-	3.87	3.29
41. Cottonseed, meal, mech ext	92.6	73.6	69.7	3.37	2.44	2.51	1.60	1.02	1.67	2.24	-	2.88	2.64
5-01-617	100.0	79.4	75.2	3.64	2.63	2.71	1.72	1.11	1.81	2.41	-	3.11	2.85
42. Cottonseed, meal, sol ext	91.0	71.0	64.9	3.45	2.48	2.67	1.64	1.07	1.61	1.95	2.74	2.67	2.34
5-01-621	100.0	78.0	71.3	3.79	2.73	2.93	1.80	1.17	1.77	2.14	3.01	2.93	2.59
43. Feather meal, hydrolyzed	92.9	63.0	70.1	4.14	1.84	3.76	1.05	0.53	1.43	2.43	-	2.73	2.21
5-03-795	100.0	67.8	75.5	4.45	1.98	4.05	1.13	0.57	1.54	2.62	-	2.94	2.38
44. Fescue, fresh	28.4	17.6	17.2	0.76	0.65	0.64	0.39	0.22	0.40	-	0.63	-	-
2-01-920	100.0	61.8	60.7	2.67	2.30	2.25	1.37	0.79	1.39	-	2.22	-	-
45. Fescue, hay	87.5	54.3	52.1	2.30	2.02	1.93	1.20	0.70	1.22	-	1.75	-	-
1-01-912	100.0	62.0	59.6	2.63	2.31	2.20	1.38	0.80	1.40	-	2.00	-	-
46. Fish, anchovy, mech ext	92.0	71.7	73.0	3.22	2.78	2.84	1.73	1.14	1.65	2.75	2.76	3.02	2.48
5-01-985	100.0	78.0	79.3	3.50	3.02	3.08	1.88	1.24	1.79	2.99	3.00	3.28	2.70
47. Fish, herring, mech ext	91.8	72.6	75.2	3.32	2.82	2.94	1.76	1.17	1.67	3.26	-	3.93	2.78
5-02-000	100.0	79.0	81.9	3.61	3.07	3.20	1.91	1.27	1.82	3.55	-	4.28	3.03
48. Fish, menhaden, mech ext	91.7	69.2	64.0	2.82	2.67	2.44	1.65	1.08	1.59	2.85	2.93	3.48	2.60
5-02-009	100.0	75.5	69.9	3.08	2.91	2.66	1.80	1.18	1.73	3.11	3.20	3.80	2.84
49. Fish, white, mech ext	91.2	71.2	69.2	3.05	2.76	2.67	1.72	1.14	1.63	2.59	-	3.06	2.66
5-02-025	100.0	78.0	75.8	3.34	3.02	2.93	1.88	1.24	1.79	2.84	-	3.36	2.91
50. Fish, solubles, condensed	50.4	42.0	40.9	1.80	1.73	1.60	1.20	0.84	0.97	1.66	-	1.91	1.62
5-01-969	100.0	83.3	81.1	3.58	3.42	3.16	2.37	1.66	1.92	3.30	-	3.78	3.22
51. Fish, solubles, dehy	92.8	73.8	80.6	3.55	2.66	3.17	1.78	1.19	1.70	2.92	-	3.24	2.82
5-01-971	100.0	79.6	86.8	3.83	2.87	3.42	1.92	1.28	1.83	3.14	-	3.49	3.04
52. Meat meal, rend	93.8	66.9	66.3	2.92	1.95	2.53	1.15	0.62	1.53	2.09	-	2.60	2.22
5-00-385	100.0	71.3	70.7	3.12	2.08	2.70	1.23	0.66	1.63	2.23	-	2.77	2.37
53. Meat meal w/bones	93.3	66.8	65.0	2.87	2.55	2.48	1.57	1.00	1.52	2.02	-	2.37	2.27
5-00-388	100.0	71.5	69.7	3.07	2.74	2.65	1.68	1.07	1.63	2.16	-	2.54	2.43
54. Milk, skim, dehy	94.1	79.0	80.3	3.54	2.37	3.15	1.52	0.95	1.82	2.54	3.81	3.87	3.59
5-01-175	100.0	84.0	85.3	3.76	2.51	3.35	1.62	1.01	1.94	2.70	4.05	4.12	3.82
55. Millet, grain	89.9	64.5	57.2	2.52	3.02	2.14	1.90	1.29	1.79	3.18	-	2.90	2.70
4-03-098	100.0	71.7	63.6	2.80	3.36	2.38	2.11	1.44	1.99	3.54	-	3.23	3.00
56. Molasses, sugar beet	77.9	62.0	60.3	2.66	2.29	2.33	1.54	1.04	1.42	1.93	-	2.49	2.34
4-00-668	100.0	79.6	77.4	3.41	2.94	2.99	1.98	1.33	1.83	2.48	-	3.20	3.00
57. Molasses, sugarcane	74.3	61.1	58.7	2.59	2.46	2.28	1.70	1.18	1.41	1.90	2.60	2.50	2.19
4-04-696	100.0	82.2	79.0	3.48	3.31	3.07	2.28	1.58	1.89	2.56	3.50	3.36	2.95
58. Oats, grain	89.2	68.9	68.5	3.02	2.62	2.65	1.77	1.19	1.55	2.54	2.95	2.82	2.63
4-03-309	100.0	77.3	76.7	3.38	2.94	2.97	1.98	1.33	1.74	2.85	3.30	3.16	2.94
59. Oats, groats	89.6	83.6	91.0	4.01	3.21	3.65	2.24	1.58	1.94	3.25	3.09	3.11	2.93
4-03-331	100.0	93.4	101.7	4.48	3.59	4.08	2.50	1.77	2.17	3.63	3.45	3.47	3.30
60. Oats, hay	90.7	54.3	48.9	2.16	2.04	1.77	1.26	0.73	1.22	-	1.75	-	-
1-03-280	100.0	59.9	53.9	2.38	2.25	1.95	1.39	0.81	1.35	-	1.92	-	-
61. Oats, hulls	92.4	31.8	32.0	1.41	1.00	1.01	0.36	-0.12	0.67	0.36	1.59	-	0.87
1-03-281	100.0	34.4	34.6	1.53	1.08	1.09	0.39	-0.13	0.72	0.39	1.72	-	0.94
62. Oats, silage	30.5	17.6	18.4	0.81	0.65	0.68	0.38	0.20	0.39	-	-	-	-
3-03-298	100.0	57.6	60.5	2.67	2.12	2.25	1.23	0.66	1.29	-	-	-	-
63. Oats, straw	92.2	47.9	43.7	2.52	1.72	2.14	0.94	0.43	1.06	-	1.49	-	-
1-03-283	100.0	52.0	47.5	2.74	1.86	2.32	1.02	0.47	1.15	-	1.62	-	-
64. Orchardgrass, fresh	23.5	15.5	14.3	0.63	0.59	0.53	0.35	0.22	0.35	-	0.54	-	-
2-03-442	100.0	66.0	60.7	2.68	2.49	2.25	1.51	0.91	1.50	-	2.29	-	-
65. Orchardgrass, hay	89.6	51.5	51.6	2.72	1.89	2.34	1.10	0.59	1.15	-	1.69	-	-
1-03-438	100.0	57.4	57.6	3.03	2.11	2.61	1.22	0.66	1.29	-	1.89	-	-
66. Pea, seeds	89.1	77.2	78.1	3.44	3.04	3.07	1.91	1.31	1.79	2.11	3.07	3.26	2.84
5-03-600	100.0	86.7	87.6	3.86	3.41	3.45	2.14	1.47	2.00	2.37	3.45	3.66	3.19
67. Peanut, meal, mech ext	92.6	74.1	87.1	3.84	3.01	3.46	1.89	1.28	1.78	2.66	-	4.32	4.02
5-03-649	100.0	80.0	94.1	4.15	3.25	3.74	2.04	1.38	1.92	2.87	-	4.66	4.34
68. Peanut, meal, sol ext	92.4	71.3	74.7	3.29	2.76	2.91	1.71	1.13	1.63	2.71	3.00	2.85	2.79
5-03-650	100.0	77.1	80.8	3.56	2.98	3.15	1.85	1.22	1.76	2.93	3.25	3.09	3.01
69. Poultry by-pro, meal, rend	93.8	73.3	74.4	3.28	2.66	2.89	1.78	1.18	1.68	2.87	-	3.10	2.87
5-03-798	100.0	78.1	79.3	3.50	2.83	3.08	1.89	1.25	1.79	3.05	-	3.31	3.06

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Table 2. Energy Content for Various Species (Continued)

Ingredient name/ description & IFN	DM, %	TDN (Cattle), %	TDN (Sheep), %	DE (Sheep), Mcal/kg	ME (Cattle), Mcal/kg	ME (Sheep), Mcal/kg	NEm (Cattle), Mcal/kg	NEg (Cattle), Mcal/kg	NEl (Cattle), Mcal/kg	MEn (Poultry), Mcal/kg	DE (Horse), Mcal/kg	DE (Pig), Mcal/kg	ME (Pig), Mcal/kg
70. Rice, bran	90.5	60.6	67.4	2.97	2.17	2.59	1.37	0.84	1.18	2.01	2.62	3.10	2.97
4-03-928	100.0	66.9	74.5	3.28	2.40	2.87	1.52	0.92	1.30	2.22	2.90	3.43	3.28
71. Rice, grain/groats	88.5	-	78.7	3.47	-	3.11	-	-	-	3.09	-	3.72	3.31
4-03-932	100.0	-	88.9	3.92	-	3.51	-	-	-	3.49	-	4.20	3.74
72. Rice, hulls	91.9	11.5	9.9	0.44	0.35	0.03	-0.57	-1.04	0.17	0.08	1.15	-	-
1-08-075	100.0	12.5	10.8	0.47	0.38	0.03	-0.62	-1.13	0.19	0.09	1.25	-	-
73. Rye, grain	87.5	72.3	74.8	3.30	2.60	2.94	1.75	1.18	1.63	2.65	3.36	3.25	2.91
4-04-047	100.0	82.6	85.4	3.77	2.97	3.35	2.01	1.35	1.86	3.03	3.84	3.72	3.33
74. Ryegrass, fresh	22.6	14.0	13.7	0.60	0.52	0.51	0.31	0.18	0.32	-	0.51	-	-
2-04-073	100.0	62.0	60.5	2.67	2.31	2.24	1.38	0.80	1.40	-	2.20	-	-
75. Safflower, meal, sol ext	91.7	52.2	51.4	2.27	1.82	1.88	1.04	0.53	1.17	1.19	-	-	-
5-04-110	100.0	56.9	56.1	2.47	1.99	2.05	1.14	0.58	1.27	1.29	-	-	-
76. Safflower, meal wo/hulls	91.0	69.2	64.6	2.85	2.67	2.47	1.66	1.08	1.59	1.84	-	2.35	2.00
5-07-959	100.0	76.0	71.0	3.13	2.93	2.71	1.82	1.19	1.94	2.03	-	2.58	2.19
77. Sesame, meal, mech ext	92.7	69.5	71.7	3.16	2.68	2.77	1.66	1.08	1.59	2.17	-	3.43	3.03
5-04-220	100.0	75.0	77.3	3.41	2.89	2.99	1.79	1.16	1.72	2.35	-	3.70	3.27
78. Sorghum, grain	90.1	54.0	80.3	3.54	2.00	3.17	1.18	0.66	1.21	3.41	3.21	3.52	3.25
4-04-383	100.0	59.9	89.1	3.93	2.22	3.52	1.31	0.73	1.35	3.79	3.56	3.91	3.61
79. Sorghum, sorgo, silage	28.8	16.5	17.2	0.76	0.61	0.64	0.35	0.19	0.37	-	-	-	-
3-04-468	100.0	57.4	59.6	2.63	2.10	2.20	1.22	0.66	1.29	-	-	-	-
80. Soybean, hulls	90.3	69.1	51.1	2.25	2.67	1.87	1.66	1.09	1.58	0.66	1.70	1.95	0.67
1-04-560	100.0	76.5	56.6	2.50	2.96	2.07	1.84	1.20	1.75	0.73	1.88	2.16	0.74
81. Soybean, meal, sol ext	89.6	75.0	78.8	3.47	2.94	3.11	1.84	1.25	1.73	2.33	3.15	3.49	3.01
5-04-604	100.0	83.7	87.9	3.88	3.28	3.47	2.05	1.39	1.93	2.60	3.52	3.90	3.36
82. Soybean, meal wo/hulls	89.9	75.3	77.9	3.43	2.95	3.06	1.85	1.25	1.74	2.47	3.36	3.77	3.36
5-04-612	100.0	83.7	86.6	3.82	3.28	3.41	2.05	1.39	1.93	2.75	3.73	4.19	3.74
83. Soybean, prot conc - (NRC, 1998)	90.0	-	-	-	-	-	-	-	-	-	-	4.10	3.50
84. Soybean, seeds, heat proc	92.6	92.3	92.4	4.07	3.70	3.70	2.33	1.65	2.15	-	3.52	4.13	3.64
5-04-597	100.0	99.7	99.8	4.40	3.99	3.99	2.52	1.78	2.32	-	3.80	4.46	3.93
85. Sunflower, meal wo/hulls	92.5	60.1	69.0	3.04	2.26	2.66	1.36	0.82	1.36	2.07	2.59	3.04	2.64
5-04-739	100.0	65.0	74.6	3.29	2.44	2.87	1.47	0.88	1.47	2.24	2.80	3.29	2.85
86. Timothy, fresh	26.7	17.9	16.4	0.72	0.68	0.61	0.41	0.25	0.41	-	0.70	-	-
2-04-903	100.0	67.0	61.2	2.70	2.53	2.27	1.54	0.94	1.52	-	2.37	-	-
87. Timothy, hay	89.1	52.7	50.4	2.22	1.94	1.84	1.14	0.63	1.18	-	1.83	-	-
1-04-882	100.0	59.1	56.5	2.49	2.18	2.07	1.28	0.71	1.33	-	2.06	-	-
88. Triticale, grain	89.2	69.0	75.3	3.32	2.67	2.95	1.66	1.10	1.58	3.14	-	3.21	3.14
4-20-362	100.0	77.4	84.4	3.72	3.00	3.31	1.86	1.23	1.78	3.52	-	3.60	3.52
89. Urea	97.0	-	-	-	-	-	-	-	-	-	2.45	-	-
5-05-070	100.0	-	-	-	-	-	-	-	-	-	2.52	-	-
90. Wheat, bran	89.0	62.4	62.8	2.77	2.24	2.40	1.44	0.90	1.41	1.23	2.94	2.65	2.37
4-05-190	100.0	70.1	70.5	3.11	2.51	2.69	1.62	1.01	1.58	1.38	3.30	2.97	2.66
91. Wheat, grain, hard red spring	87.6	77.1	78.5	3.46	3.04	3.10	1.91	1.31	1.78	2.70	-	3.10	2.95
4-05-258	100.0	88.0	89.6	3.95	3.47	3.54	2.18	1.50	2.04	3.08	-	3.54	3.37
92. Wheat, grain, hard red winter	88.8	78.5	78.4	3.46	3.10	3.09	1.95	1.34	1.82	3.21	3.43	3.38	3.22
4-05-268	100.0	88.4	88.3	3.89	3.49	3.48	2.19	1.51	2.05	3.62	3.86	3.81	3.63
93. Wheat, grain, soft red winter	88.4	78.7	78.0	3.44	3.11	3.07	1.95	1.35	1.82	3.09	3.41	3.23	3.05
4-05-294	100.0	89.0	88.2	3.89	3.51	3.48	2.21	1.52	2.06	3.50	3.86	3.65	3.45
94. Wheat, grain, soft white winter	90.2	80.2	79.7	3.51	3.17	3.14	1.99	1.37	1.86	2.86	3.54	3.35	3.16
4-05-337	100.0	88.9	88.3	3.90	3.51	3.48	2.21	1.52	2.06	3.17	3.92	3.71	3.51
95. Wheat, hay	88.7	53.0	45.8	2.02	1.74	1.64	0.99	0.49	1.19	-	1.68	-	-
1-05-172	100.0	59.7	51.7	2.28	1.96	1.85	1.11	0.56	1.34	-	1.90	-	-
96. Wheat, middlings	88.9	75.1	72.6	3.20	2.57	2.83	1.73	1.15	1.73	2.08	3.04	2.93	2.71
4-05-205	100.0	84.4	81.7	3.60	2.89	3.19	1.94	1.29	1.95	2.33	3.42	3.30	3.05
97. Wheat, red dog	88.3	71.6	82.0	3.62	2.87	3.25	1.80	1.22	1.70	2.59	-	3.15	2.88
4-05-203	100.0	81.1	92.8	4.09	3.25	3.68	2.04	1.38	1.92	2.94	-	3.57	3.26
98. Wheat, shorts	88.4	75.8	76.3	3.36	2.75	3.00	1.88	1.28	1.75	2.21	-	3.12	2.93
4-05-201	100.0	85.7	86.2	3.80	3.11	3.39	2.12	1.45	1.98	2.50	-	3.52	3.31
99. Whey, dehy	93.3	74.4	78.0	3.44	2.83	3.05	1.92	1.30	1.71	1.94	3.79	3.19	3.10
4-01-182	100.0	79.7	83.6	3.69	3.03	3.27	2.06	1.40	1.83	2.08	4.06	3.42	3.33
100. Yeast, Torula, dehy	93.0	74.4	70.3	3.10	2.90	2.71	1.81	1.21	1.71	2.14	-	2.84	2.42
7-05-534	100.0	80.0	75.6	3.33	3.12	2.92	1.95	1.30	1.84	2.30	-	3.05	2.60

3. Table 3. Amino Acid Content [*NRC = NRC (1994) for Gly & Ser & NRC (1998) for the rest; IFN for some ingredients may differ vs. other tables. Values for few ingredients from Jurgens (2002)] [DM = dry matter; Arg = arginine; Cys = cystine; Gly = glucine; His = histidine; Ile = isoleucine; Leu = leucine; Lys - lysine; Met = methionine; Phe = phenylalanine; Ser = serine; Thr = threonine; Trp = tryptophan; Tyr = tyrosine; Val = valine]

Ingredient name/ description & IFN	DM %	Arg %	His %	Ile %	Leu %	Lys %	Met %	Cys %	Phe %	Tyr %	Thr %	Trp %	Val %	Gly %	Ser %
1. Alfalfa, fresh 2-00-196	26.0	0.2	0.1	0.2	0.4	0.2	0.1	0.1	0.3	0.2	0.2	-	0.3	0.2	0.2
3. Alfalfa, dehy 17% CP 1-00-023 (NRC)	92.0	0.71	0.37	0.68	1.21	0.74	0.25	0.18	0.84	0.55	0.70	0.24	0.86	0.82	0.72
4. Alfalfa, dehy 20% CP 1-00-024 (NRC)	92.0	0.91	0.38	0.89	1.40	0.90	0.34	0.26	0.93	0.60	0.82	0.35	1.05	0.97	0.89
5. Bakery, waste, dehy 4-00-466 (NRC)	91.0	0.46	0.24	0.38	0.80	0.27	0.18	0.23	0.50	0.36	0.33	0.10	0.46	0.82	0.65
6. Barley, grain 4-00-572 (NRC)	89.0	0.54	0.25	0.39	0.77	0.41	0.20	0.28	0.55	0.29	0.35	0.11	0.52	-	-
8. Beet pulp, dehy 4-00-669 (NRC)	91.0	0.32	0.23	0.31	0.53	0.52	0.07	0.06	0.30	0.40	0.38	0.10	0.45	-	-
11. Blood, meal, spray dried 5-00-381 (NRC)	93.0	3.69	5.30	1.03	10.81	7.45	0.99	1.04	5.81	2.71	3.78	1.48	7.03	3.95	4.25
12. Blood, plasma, spray dried - (NRC)	92.0	4.55	2.55	2.71	7.61	6.84	0.75	2.63	4.42	3.53	4.72	1.36	4.94	-	-
15. Brewer's grain, dehy 5-02-141 (NRC)	92.0	1.53	0.53	1.02	2.08	1.08	0.45	0.49	1.22	0.88	0.95	0.26	1.26	1.09	0.80
16. Brewer's yeast, dehy 7-05-527 (NRC)	93.0	2.20	1.09	2.15	3.13	3.22	0.74	0.50	1.83	1.55	2.20	0.56	2.39	2.09	-
19. Buckwheat, grain 4-00-994 (NRC)	88.0	0.92	0.25	0.40	0.64	0.57	0.19	0.23	0.45	0.31	0.41	0.17	0.56	0.71	0.41
22. Canola, meal 5-06-145 (NRC)	90.0	2.21	0.96	1.43	2.58	2.08	0.74	0.91	1.43	1.13	1.59	0.45	1.82	1.82	1.53
23. Casein, dehy 5-01-162 (NRC)	91.0	3.26	2.82	4.66	8.79	7.35	2.70	0.41	4.79	4.77	3.98	1.14	6.10	1.79	5.81
24. Citrus pulp, dehy 4-01-237	91.1	0.2	0.1	0.1	0.3	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.3	0.2	0.2
29. Coconut, meal 5-01-573 (NRC)	92.0	2.38	0.39	0.75	1.36	0.58	0.35	0.29	0.84	0.58	0.67	0.19	1.07	0.82	0.79
31. Corn, DG, dehy 5-02-842 (NRC)	94.0	0.90	0.63	0.95	2.63	0.74	0.43	0.28	0.99	0.82	0.62	0.20	1.24	-	-
32. Corn, DG w/solubles 5-02-843 (NRC)	93.0	1.13	0.69	1.03	2.57	0.62	0.50	0.52	1.34	0.83	0.94	0.25	1.30	-	-
33. Corn, distiller's solubles 5-02-844 (NRC)	92.0	0.90	0.66	1.21	2.25	0.82	0.51	0.46	1.38	0.80	1.03	0.23	1.50	-	-
34. Corn, gluten feed 5-02-903 (NRC)	90.0	1.04	0.67	0.66	1.96	0.63	0.35	0.46	0.76	0.58	0.74	0.07	1.01	-	-
35. Corn, gluten meal, 60% CP 5-28-242 (NRC)	90.0	1.93	1.28	2.48	10.19	1.02	1.43	1.09	3.84	3.25	2.08	0.31	2.79	1.67	2.96
36. Corn, grain 4-02-935 (NRC)	89.0	0.37	0.23	0.28	0.99	0.26	0.17	0.19	0.39	0.25	0.29	0.06	0.39	0.33	0.37
37. Corn, hominy feed 4-03-011 (NRC)	90.0	0.56	0.28	0.36	0.98	0.38	0.18	0.18	0.43	0.40	0.40	0.10	0.52	0.40	0.50
41. Cottonseed, meal, mech ext 5-01-617 (NRC)	92.0	4.26	1.11	1.29	2.45	1.65	0.67	0.69	1.97	1.23	1.34	0.54	1.76	1.69	1.68
42. Cottonseed, meal, sol ext 5-07-872 (NRC)	90.0	4.55	1.17	1.30	2.47	1.72	0.67	0.70	2.20	1.22	1.36	0.48	1.78	1.69	1.78
43. Feather meal, hydrolyzed 5-03-795 (NRC)	93.0	5.62	0.93	3.86	6.79	2.08	0.61	4.13	4.01	2.41	3.82	0.54	5.88	6.13	8.52
46. Fish, anchovy, mech ext 5-01-985 (NRC)	92.0	3.68	1.56	3.06	5.00	5.11	1.95	0.61	2.66	2.15	2.82	0.76	3.51	3.68	2.51
47. Fish, herring, mech ext 5-02-000 (NRC)	93.0	4.01	1.52	2.91	5.20	5.46	2.04	0.66	2.75	2.18	3.02	0.74	3.46	4.30	2.75
48. Fish, menhaden, mech ext 5-02-009 (NRC)	92.0	3.66	1.78	2.57	4.54	4.81	1.77	0.57	2.51	2.04	2.64	0.66	3.03	4.46	2.37
49. Fish, white, mech ext 5-02-025 (NRC)	91.0	4.04	1.34	2.61	4.39	4.51	1.76	0.68	2.32	2.03	2.60	0.66	3.06	4.42	3.06
50. Fish, solubles, condensed 5-01-969 (NRC)	51.0	1.61	1.56	1.06	1.86	1.73	0.50	0.30	0.93	0.40	0.86	0.31	1.16	3.41	0.83
51. Fish, solubles, dehy 5-01-971 (NRC)	92.0	2.67	1.23	1.56	2.68	2.84	0.98	0.49	1.22	0.62	1.40	0.34	1.94	5.89	2.02

- Continues -

Table 3. Amino Acid Content (Continued)

Ingredient name/ description & IFN	DM %	Arg %	His %	Ile %	Leu %	Lys %	Met %	Cys %	Phe %	Tyr %	Thr %	Trp %	Val %	Gly %	Ser %
52. Meat meal, rend 5-00-385 (NRC)	94.0	3.60	1.14	1.60	3.84	3.07	0.80	0.60	2.17	1.40	1.97	0.35	2.66	6.30	1.60
53. Meat meal w/bones 5-00-388 (NRC)	93.0	3.45	0.91	1.34	2.98	2.51	0.68	0.50	1.62	1.07	1.59	0.28	2.04	6.65	2.20
54. Milk, skim, dehy 5-01-175 (NRC)	96.0	1.24	1.05	1.87	3.67	2.86	0.92	0.30	1.78	1.87	1.62	0.51	2.33	-	-
55. Millet, grain 4-03-120 (NRC)	90.0	0.41	0.20	0.46	1.24	0.23	0.31	0.18	0.56	0.31	0.40	0.16	0.57	0.31	0.40
58. Oats, grain 4-03-309 (NRC)	89.0	0.87	0.31	0.48	0.92	0.40	0.22	0.36	0.65	0.41	0.44	0.14	0.66	0.50	0.40
59. Oats, groats 4-03-331 (NRC)	90.0	0.85	0.24	0.55	0.98	0.48	0.20	0.22	0.66	0.51	0.44	0.18	0.72	-	-
61. Oats, hulls 1-03-281	92.4	0.2	0.1	0.2	0.3	0.2	0.1	0.1	0.2	0.1	0.2	0.1	0.2	0.2	0.3
66. Pea, seeds 5-03-600 (NRC)	89.0	1.87	0.54	0.86	1.51	1.50	0.21	0.31	0.98	0.71	0.78	0.19	0.98	1.00	1.08
67. Peanut, meal, mech ext 5-03-649 (NRC)	92.0	4.79	1.01	1.41	2.77	1.48	0.50	0.60	2.02	1.74	1.16	0.41	1.70	2.18	1.83
68. Peanut, meal, sol ext 5-03-650 (NRC)	92.0	5.09	1.06	1.78	2.83	1.66	0.52	0.69	2.35	1.80	1.27	0.48	1.98	2.67	2.25
69. Poultry by-pro, meal, rend 5-03-798 (NRC)	93.0	3.94	1.25	2.01	3.89	3.32	1.11	0.65	2.26	1.56	2.18	0.48	2.51	6.17	2.71
70. Rice, bran 4-03-928 (NRC)	90.0	1.00	0.34	0.44	0.92	0.57	0.26	0.27	0.56	0.40	0.48	0.14	0.68	0.70	0.59
71. Rice, grain/groats 4-03-932 (NRC)	89.0	0.52	0.18	0.34	0.67	0.30	0.18	0.11	0.39	0.38	0.26	0.10	0.49	0.50	0.44
72. Rice, hulls 1-08-075	91.9	0.10	0.0	0.1	0.2	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.1	0.1
73. Rye, grain 4-04-047 (NRC)	88.0	0.50	0.24	0.37	0.64	0.38	0.17	0.19	0.50	0.26	0.32	0.12	0.51	0.49	0.52
75. Safflower, meal, sol ext 5-04-110 (NRC)	92.0	2.04	0.59	0.67	1.52	0.74	0.34	0.38	1.07	0.77	0.65	0.33	1.18	1.53	0.99
76. Safflower, meal wo/hulls 5-07-959 (NRC)	92.0	3.59	1.07	1.69	2.57	1.17	0.66	0.69	2.00	1.08	1.28	0.54	2.33	2.32	-
77. Sesame, meal, mech ext 5-04-220 (NRC)	93.0	4.86	0.98	1.47	2.74	1.01	1.15	0.82	1.77	1.52	1.44	0.54	1.85	2.04	1.72
78. Sorghum, grain 4-20-893 (NRC)	88.0	0.38	0.23	0.37	1.21	0.22	0.17	0.17	0.49	0.35	0.31	0.10	0.46	0.31	0.40
80. Soybean, hulls 1-04-560	90.3	0.5	0.2	0.3	0.5	0.5	0.1	0.1	0.3	0.3	0.3	0.1	0.3	0.5	0.6
81. Soybean, meal, sol ext 5-04-604 (NRC)	89.0	3.23	1.17	1.99	3.42	2.83	0.61	0.70	2.18	1.69	1.73	0.61	2.06	1.90	2.29
82. Soybean, meal wo/hulls 5-04-612 (NRC)	90.0	3.48	1.28	2.16	3.66	3.02	0.67	0.74	2.39	1.82	1.85	0.65	2.27	2.05	2.48
83. Soybean, prot conc - (NRC)	90.0	5.79	1.80	3.30	5.30	4.20	0.90	1.00	3.40	2.50	2.80	0.90	3.40	-	-
84. Soybean, seeds, heat proc 5-04-597 (NRC)	90.0	2.60	0.96	1.61	2.75	2.22	0.53	0.55	1.83	1.32	1.41	0.48	1.68	1.55	1.87
85. Sunflower, meal wo/hulls 5-04-739 (NRC)	93.0	2.93	0.92	1.44	2.31	1.20	0.82	0.66	1.66	1.03	1.33	0.44	1.74	2.03	1.49
88. Triticale, grain 4-20-362 (NRC)	90.0	0.57	0.26	0.39	0.76	0.39	0.20	0.26	0.49	0.32	0.36	0.14	0.51	0.48	0.52
90. Wheat, bran 4-05-190 (NRC)	89.0	1.07	0.44	0.49	0.98	0.64	0.25	0.33	0.62	0.43	0.52	0.22	0.72	0.81	0.67
91. Wheat, grain, hard red spring 4-05-258 (NRC)	88.0	0.67	0.34	0.47	0.93	0.38	0.23	0.30	0.67	0.40	0.41	0.16	0.61	-	-
92. Wheat, grain, hard red winter 4-05-268 (NRC)	88.0	0.60	0.32	0.41	0.86	0.34	0.20	0.29	0.60	0.38	0.37	0.15	0.54	0.59	0.59
93. Wheat, grain, soft red winter 4-05-294 (NRC)	88.0	0.50	0.20	0.45	0.90	0.38	0.22	0.27	0.63	0.37	0.39	0.26	0.57	-	-
96. Wheat, middlings 4-05-205 (NRC)	89.0	0.97	0.44	0.53	1.06	0.57	0.26	0.32	0.70	0.29	0.51	0.20	0.75	0.63	0.75
97. Wheat, red dog 4-05-203 (NRC)	88.0	0.96	0.41	0.55	1.06	0.59	0.23	0.37	0.66	0.46	0.50	0.10	0.72	0.74	0.75
98. Wheat, shorts 4-05-201 (NRC)	88.0	1.07	0.43	0.58	1.02	0.70	0.25	0.28	0.70	0.51	0.57	0.22	0.87	0.96	0.77
99. Whey, dehy 4-01-182 (NRC)	96.0	0.26	0.23	0.62	1.08	0.90	0.17	0.25	0.36	0.25	0.72	0.18	0.60	0.30	0.32
100. Yeast, Torula, dehy 7-05-534 (NRC)	93.0	2.48	1.09	2.50	3.32	3.47	0.69	0.50	2.33	1.65	2.30	0.51	2.60	2.60	2.76

4. Table 4. Mineral Content [DM = dry matter; mg/kg = ppm]

Ingredient name/ description & IFN	DM %	Ca %	Cl %	Mg %	P %	K %	Na %	S %	Co mg/kg	Cu mg/kg	I mg/kg	Fe mg/kg	Mn mg/kg	Se mg/kg	Zn mg/kg
1. Alfalfa, fresh	26.0	0.40	0.12	0.09	0.07	0.83	0.04	0.10	0.09	3.24	-	82.07	24.11	-	9.39
2-00-196	100.0	1.52	0.46	0.34	0.28	3.18	0.17	0.38	0.35	12.44	-	315.43	92.68	-	36.08
2. Alfalfa, hay	91.0	1.24	0.34	0.32	0.22	1.42	0.11	0.26	0.36	16.09	-	204.44	25.47	-	28.09
1-00-063	100.0	1.37	0.38	0.35	0.24	1.56	0.12	0.28	0.39	17.67	-	224.60	28.00	-	30.86
3. Alfalfa, dehy 17% CP	91.8	1.38	0.47	0.29	0.23	2.40	0.10	1.22	0.30	8.56	0.15	404.93	31.05	0.34	19.32
1-00-023	100.0	1.51	0.52	0.32	0.25	2.61	0.11	0.24	0.33	9.33	0.16	441.11	33.83	0.37	21.05
4. Alfalfa, dehy 20% CP	91.6	1.59	0.47	0.33	0.28	2.42	0.11	0.40	0.26	12.17	0.14	352.41	45.23	0.29	21.84
1-00-024	100.0	1.73	0.51	0.37	0.31	2.64	0.12	0.44	0.28	13.29	0.15	384.77	49.48	0.31	23.84
5. Bakery, waste, dehy	91.2	0.14	1.47	0.16	0.22	0.39	1.02	0.02	1.22	5.95	-	160.48	65.00	0.16	17.77
4-00-466	100.0	0.15	1.61	0.18	0.24	0.43	1.12	0.02	1.34	6.52	-	175.90	71.24	0.18	19.48
6. Barley, grain	88.6	0.05	0.11	0.13	0.34	0.44	0.03	0.14	0.17	8.16	0.04	73.52	15.81	0.17	41.75
4-00-549	100.0	0.05	0.12	0.15	0.38	0.49	0.03	0.16	0.19	9.22	0.05	83.02	17.85	0.19	47.14
7. Barley, straw	91.4	0.27	0.61	0.21	0.06	2.16	0.13	0.15	0.06	4.93	-	183.46	15.13	-	6.80
1-00-498	100.0	0.30	0.67	0.23	0.07	2.36	0.14	0.17	0.06	5.39	-	200.76	16.56	-	7.44
8. Beet pulp, dehy	91.0	0.62	0.04	0.26	0.09	0.20	0.18	0.20	0.07	12.51	-	266.69	34.27	0.10	0.70
4-00-669	100.0	0.68	0.04	0.28	0.10	0.22	0.20	0.22	0.06	13.74	-	293.00	37.65	0.12	0.76
9. Bermudagrass, fresh	28.9	0.14	-	0.07	0.08	0.54	0.13	-	0.02	1.98	-	323.95	30.54	-	10.12
2-00-712	100.0	0.49	-	0.23	0.29	1.87	0.44	-	0.07	6.85	-	1119.96	105.60	-	35.00
10. Bermudagrass, hay	91.2	0.43	-	0.16	0.16	1.40	0.07	0.19	0.11	24.29	0.10	264.31	99.37	-	53.00
1-00-703	100.0	0.47	-	0.17	0.17	1.53	0.08	0.20	0.12	26.64	0.11	289.96	109.02	-	58.14
11. Blood, meal, spray dried	92.6	0.22	0.25	0.15	0.20	0.15	0.38	0.60	-	8.19	-	2772.21	6.42	-	-
5-00-381	100.0	0.24	0.27	0.17	0.21	0.16	0.42	0.65	-	8.85	-	2993.49	6.93	-	-
12. Blood, plasma - (NRC, 1998)	91.0	0.15	1.50	0.34	1.71	0.20	3.02	-	-	-	-	55.00	-	-	-
13. Bluegrass, fresh	30.8	0.15	-	0.05	0.14	0.70	0.04	0.05	-	-	-	92.46	-	-	-
2-00-777	100.0	0.50	-	0.18	0.44	2.27	0.14	0.17	-	-	-	299.96	-	-	-
14. Bluegrass, hay	88.9	0.28	0.55	0.35	0.16	1.85	0.10	0.11	-	9.76	-	248.68	216.82	0.03	68.75
1-00-776	100.0	0.31	0.62	0.39	0.18	2.08	0.11	0.13	-	10.98	-	279.60	243.78	0.03	77.30
15. Brewer's grain, dehy	92.2	0.29	0.13	0.15	0.51	0.09	0.20	0.29	0.07	21.71	0.06	233.09	37.22	0.14	27.31
5-02-141	100.0	0.32	0.14	0.16	0.55	0.09	0.22	0.32	0.08	23.56	0.07	252.94	40.39	0.16	29.63
16. Brewer's yeast, dehy	93.1	0.14	0.07	0.24	1.36	1.68	0.07	0.43	0.50	38.44	0.35	83.20	6.74	0.91	38.97
7-05-527	100.0	0.15	0.07	0.26	1.47	1.81	0.08	0.47	0.54	41.31	0.38	89.40	7.24	0.97	41.88
17. Brome, fresh	27.0	-	-	-	-	-	-	-	0.02	-	-	-	-	-	-
2-00-963	100.0	-	-	-	-	-	-	-	0.07	-	-	-	-	-	-
18. Brome, hay	89.6	0.34	0.48	0.21	0.24	1.88	0.56	0.22	-	10.14	-	142.66	41.76	-	-
1-00-947	100.0	0.38	0.54	0.23	0.26	2.10	0.63	0.26	-	11.32	-	159.27	46.63	-	-
19. Buckwheat, grain	88.4	0.08	0.04	0.16	0.31	0.45	0.01	0.14	0.04	8.83	-	227.00	31.43	0.22	15.72
4-00-994	100.0	0.10	0.05	0.18	0.36	0.50	0.02	0.15	0.05	9.98	-	256.67	35.54	0.24	17.77
20. Canary grass, fresh	22.8	0.08	-	-	0.06	0.83	-	-	-	-	-	-	-	-	-
2-01-113	100.0	0.36	-	-	0.33	3.64	-	-	-	-	-	-	-	-	-
21. Canary grass, hay	89.3	0.32	-	0.19	0.21	2.60	0.01	-	-	10.62	-	133.88	82.48	-	-
1-01-104	100.0	0.36	-	0.22	0.24	2.91	0.02	-	-	11.89	-	150.00	92.40	-	-
22. Canola, meal	91.2	0.60	0.10	0.43	0.96	1.07	0.09	1.13	-	7.94	-	222.41	45.67	0.97	35.75
5-03-871	100.0	0.66	0.11	0.48	1.06	1.18	0.10	1.25	-	8.71	-	244..01	50.11	1.06	39.22
23. Casein, dehy	91.6	0.61	-	0.00	0.85	0.00	0.01	-	-	4.12	-	17.37	3.76	-	32.18
5-01-162	100.0	0.67	-	0.01	0.93	0.01	0.01	-	-	4.50	-	18.97	4.11	-	35.14
24. Citrus pulp, dehy	91.1	1.71	-	0.16	0.12	0.70	0.08	0.07	0.16	5.59	-	328.14	6.62	-	13.76
4-01-237	100.0	1.88	-	0.17	0.13	0.77	0.08	0.08	0.18	6.14	-	360.12	7.26	-	15.10
25. Clover, Landino, fresh	17.7	0.22	-	0.09	0.07	0.33	0.02	0.02	-	-	-	63.80	12.66	-	-
2-01-383	100.0	1.27	-	0.48	0.42	1.87	0.12	0.12	-	-	-	361.45	71.70	-	-
26. Clover, Landino, hay	89.1	1.30	0.27	0.42	0.30	2.17	0.12	0.18	0.14	8.38	0.26	418.66	109.73	-	15.15
1-01-378	100.0	1.45	0.30	0.47	0.33	2.44	0.13	0.21	0.16	9.41	0.30	469.68	123.10	-	17.00
27. Clover, Red, fresh	26.2	0.26	-	0.13	0.07	0.51	0.05	0.04	-	-	-	78.59	-	-	-
2-01-429	100.0	1.01	-	0.51	0.27	1.96	0.20	0.17	-	-	-	299.96	-	-	-
28. Clover, Red, hay	88.4	1.22	0.28	0.34	0.22	1.60	0.16	0.14	0.13	18.76	0.21	210.82	95.15	-	32.47
1-01-415	100.0	1.38	0.32	0.38	0.24	1.81	0.18	0.16	0.15	21.23	0.24	238.51	107.65	-	36.73
29. Coconut, meal	91.1	0.17	0.03	0.31	0.65	1.41	0.04	-	-	-	-	-	54.47	-	-
5-01-573	100.0	0.19	0.03	0.34	0.71	1.55	0.04	-	-	-	-	-	59.78	-	-
30. Corn, cobs, ground	89.8	0.11	-	0.06	0.04	0.78	-	o.42	0.11	6.55	-	206.61	5.57	-	-
1-02-782	100.0	0.12	-	0.07	0.04	0.87	-	0.48	0.13	7.30	-	229.98	6.20	-	-
31. Corn, DG, dehy	93.5	0.09	0.07	0.07	0.39	0.16	0.09	0.43	0.07	38.94	0.04	191.73	19.32	0.35	41.74
5-02-842	100.0	0.10	0.08	0.07	0.42	0.17	0.09	0.46	0.08	41.66	0.05	205.13	20.67	0.37	44.65
32. Corn, DG w/solubles	91.8	0.16	0.17	0.18	0.69	0.47	0.47	0.30	0.15	52.60	0.05	231.33	23.98	0.33	80.68
5-02-843	100.0	0.17	0.18	0.20	0.75	0.51	0.52	0.33	0.16	57.31	0.05	252.07	26.11	0.36	87.91
33. Corn, distiller's solubles	92.9	0.30	0.26	0.60	1.30	1.70	0.23	0.37	0.16	77.92	0.07	519.99	72.04	0.37	88.03
5-02-844	100.0	0.32	0.28	0.65	1.40	1.83	0.24	0.39	0.17	83.91	0.08	559.97	77.58	0.39	94.80
34. Corn, gluten feed	89.9	0.32	0.22	0.33	0.75	0.62	0.12	0.23	0.08	43.86	0.06	413.78	22.75	0.25	68.65
5-02-903	100.0	0.35	0.25	0.37	0.83	0.69	0.13	0.26	0.09	48.77	0.07	460.15	25.30	0.28	76.34
35. Corn, gluten meal	91.3	0.15	0.06	0.06	0.48	0.03	0.09	0.27	0.07	27.65	-	383.55	7.73	1.01	173.65
5-02-900	100.0	0.16	0.07	0.06	0.51	0.03	0.10	0.30	0.08	30.29	-	420.06	8.46	1.11	190.18

- Continues -

Table 4. Mineral Content (Continued)

Ingredient name/ description & IFN	DM %	Ca %	Cl %	Mg %	P %	K %	Na %	S %	Co mg/kg	Cu mg/kg	I mg/kg	Fe mg/kg	Mn mg/kg	Se mg/kg	Zn mg/kg
36. Corn, grain	88.0	0.05	0.05	0.11	0.27	0.32	0.01	0.11	0.12	3.67	-	30.96	5.47	0.12	19.02
4-02-935	100.0	0.05	0.06	0.12	0.31	0.37	0.01	0.12	0.14	4.17	-	35.20	6.22	0.13	21.63
37. Corn, hominy feed	90.2	0.05	0.05	0.24	0.51	0.59	0.08	0.03	0.05	13.60	-	67.28	14.51	-	-
4-02-887	100.0	0.05	0.06	0.26	0.57	0.65	0.09	0.03	0.06	15.08	-	74.58	16.09	-	-
38. Corn, silage	34.1	0.09	-	0.10	0.07	0.36	0.00	0.02	0.02	4.51	-	218.29	11.73	-	7.14
3-02-823	100.0	0.27	-	0.28	0.20	1.05	0.01	0.08	0.06	13.22	-	639.96	34.39	-	20.94
39. Cottonseed, hulls	90.4	0.13	0.02	0.13	0.08	0.79	0.02	0.07	0.01	11.98	-	118.65	107.76	0.08	19.84
1-01-599	100.0	0.15	0.02	0.14	0.09	0.88	0.02	0.08	0.01	13.26	-	131.27	119.22	0.09	21.95
40. Cottonseed, ground	92.2	0.14	-	0.32	0.67	1.10	0.03	0.23	-	50.27	-	138.72	8.79	-	-
5-01-608	100.0	0.15	-	0.35	0.73	1.20	0.03	0.25	-	54.54	-	150.51	9.54	-	-
41. Cottonseed, meal, mech ext	92.6	0.19	0.05	0.53	1.08	1.34	0.04	0.39	0.62	18.54	-	170.63	22.30	0.13	61.88
5-01-617	100.0	0.20	0.06	0.57	1.17	1.44	0.05	0.42	0.67	20.01	-	184.18	24.07	0.14	66.80
42. Cottonseed, meal, sol ext	91.0	0.17	0.05	0.54	1.11	1.38	0.04	0.26	0.48	19.49	-	187.71	20.66	0.37	60.74
5-01-621	100.0	0.18	0.05	0.59	1.22	1.52	0.05	0.28	0.53	21.42	-	206.27	22.70	0.41	66.75
43. Feather meal, hydrolyzed	92.9	0.35	0.28	0.17	0.51	0.27	0.52	1.49	0.11	7.31	0.04	523.14	11.94	0.91	71.83
5-03-795	100.0	0.38	0.30	0.19	0.55	0.29	0.56	1.61	0.12	7.86	0.04	563.10	12.86	0.98	77.32
44. Fescue, fresh	28.4	0.15	-	0.11	0.11	0.67	-	-	0.03	1.13	-	-	-	-	-
2-01-920	100.0	0.53	-	0.37	0.39	2.34	-	-	0.13	4.00	-	-	-	-	-
45. Fescue, hay	87.5	0.33	-	0.44	0.25	1.61	-	-	0.11	-	-	-	21.44	-	-
1-01-912	100.0	0.37	-	0.50	0.29	1.84	-	-	0.13	-	-	-	24.50	-	-
46. Fish, anchovy, mech ext	92.0	3.74	1.00	0.25	2.48	0.72	0.88	0.71	0.17	9.08	3.13	214.74	10.99	1.35	105.03
5-01-985	100.0	40.07	1.08	0.27	2.70	0.78	0.95	0.77	0.18	9.87	3.41	233.48	11.95	1.47	114.20
47. Fish, herring, mech ext	91.8	2.19	0.99	0.14	1.67	1.08	0.59	0.49	0.05	5.60	0.52	114.34	4.80	1.95	124.72
5-02-000	100.0	2.39	1.08	0.16	1.82	1.18	0.65	0.54	0.05	6.10	0.57	124.50	5.22	2.12	135.80
48. Fish, menhaden, mech ext	91.7	5.01	0.55	0.15	2.87	0.71	0.41	0.52	0.15	10.34	1.09	544.58	37.02	2.14	144.32
5-02-009	100.0	5.46	0.60	0.16	3.14	0.77	0.44	0.57	0.16	11.28	1.19	594.15	40.38	2.34	157.45
49. Fish, white, mech ext	91.2	6.64	-	0.18	3.97	0.53	0.62	-	3.38	4.09	-	250.93	10.04	1.61	68.43
5-02-025	100.0	7.27	-	0.20	4.35	0.58	0.68	-	3.68	4.48	-	275.03	11.00	1.77	75.00
50. Fish, solubles, condensed	50.4	0.17	3.00	0.03	0.58	1.66	2.50	0.12	0.06	47.38	1.11	325.29	12.58	-	43.14
5-01-969	100.0	0.33	5.95	0.06	1.11	3.29	4.97	0.24	0.13	93.96	2.20	645.08	24.95	-	85.56
51. Fish, solubles, dehy	92.8	1..09	-	0.30	1.27	-	0.37	-	-	-	-	-	50.44	-	76.65
5-01-971	100.0	1.17	-	0.32	1.37	-	0.40	-	-	-	-	-	54.35	-	82.59
52. Meat meal, rend	93.8	8.61	1.11	0.25	4.58	0.55	1.04	0.46	2.25	9.60	-	490.38	11.80	0.50	74.30
5-00-385	100.0	9.17	1.18	0.27	4.88	0.58	1.11	0.49	2.40	10.24	-	522.77	12.58	0.54	79.21
53. Meat meal w/bones	93.3	10.00	0.75	1.02	4.96	1.33	0.72	0.25	0.18	1.54	1.32	653.23	13.33	0.34	94.37
5-00-388	100.0	10.71	0.80	1.09	5.32	1.43	0.77	0.27	0.19	1.65	1.41	699.93	14.29	0.39	101.11
54. Milk, skim, dehy	94.1	1.28	0.90	0.12	1.02	1.60	0.51	0.32	0.11	11.68	-	7.67	2.14	0.12	38.51
5-01-175	100.0	1.36	0.96	0.13	1.09	1.70	0.54	0.34	0.12	12.41	-	8.14	2.27	0.13	40.91
55. Millet, grain	89.9	0.05	0.14	0.16	0.29	0.43	0.04	0.12	0.04	21.75	-	57.44	29.67	-	13.88
4-03-098	100.0	0.05	0.16	0.18	0.32	0.48	0.04	0.14	0.04	24.19	-	63.89	33.00	-	15.43
56. Molasses, sugar beet	77.9	0.12	1.28	0.23	0.02	4.72	1.16	0.46	0.36	16.79	-	66.06	4.50	-	14.02
4-00-668	100.0	0.15	1.64	0.29	0.03	6.06	1.48	0.59	0.46	21.55	-	87.39	5.78	-	18.00
57. Molasses, sugarcane	74.3	0.74	2.26	0.31	0.08	2.98	0.16	0.34	1.17	48.82	1.56	195.83	43.68	-	15.56
4-04-696	100.0	1.00	3.04	0.42	0.10	4.01	0.22	0.47	1.58	65.69	2.10	163.48	58.76	-	20.93
58. Oats, grain	89.2	0.08	0.09	0.14	0.34	0.40	0.05	0.21	0.05	5.95	0.11	65.45	36.14	0.21	35.03
4-03-309	100.0	0.09	0.10	0.16	0.38	0.45	0.06	0.23	0.06	6.67	0.12	73.35	40.51	0.24	39.25
59. Oats, groats	89.6	0.08	0.09	0.11	0.42	0.36	0.03	0.19	-	6.02	0.10	71.00	30.77	0.45	33.58
4-03-331	100.0	0.09	0.10	0.13	0.47	0.40	0.04	0.22	-	6.72	0.12	79.29	34.37	0.50	37.50
60. Oats, hay	90.7	0.29	0.47	0.26	0.23	1.35	0.17	0.21	0.06	4.37	-	368.66	89.56	-	40.82
1-03-280	100.0	0.32	0.52	0.29	0.25	1.49	0.18	0.23	0.07	4.82	-	406.43	98.74	-	45.00
61. Oats, hulls	92.4	0.15	0.08	0.12	0.14	0.55	0.06	0.09	-	6.59	-	128.00	25.35	0.39	26.89
1-03-281	100.0	0.16	0.06	0.13	0l5	0.59	0.07	0.10	-	7.13	-	138.51	27.43	0.43	29.10
62. Oats, silage	30.5	0.10	-	0.05	0.07	0.81	0.06	0.05	0.02	1.39	-	85.82	27.71	0.02	7.30
3-03-298	100.0	0.34	-	0.15	0.24	2.66	0.18	0.18	0.08	4.56	-	281.60	90.94	0.08	23.94
63. Oats, straw	92.2	0.22	0.71	0.16	0.06	2.33	0.39	0.20	-	9.46	-	151.21	28.99	-	5.47
1-03-283	100.0	0.23	0.78	0.17	0.06	2.53	0.42	0.22	-	10.27	-	164.04	31.45	-	5.94
64. Orchardgrass, fresh	23.5	0.06	-	0.07	0.09	0.80	0.01	0.06	-	7.76	-	184.76	24.49	-	-
2-03-442	100.0	0.25	-	0.31	0.39	3.38	0.04	0.26	-	33.06	-	784.96	104.06	-	-
65. Orchardgrass, hay	89.6	0.37	0.37	0.17	0.23	2.69	0.01	0.21	0.34	12.98	-	134.01	163.40	0.04	29.86
1-03-438	100.0	0.41	0.41	0.19	0.26	3.00	0.02	0.23	0.37	14.48	-	149.48	182.27	0.04	33.31
66. Pea, seeds	89.1	0.12	0.05	0.12	0.41	0.95	0.04	-	-	-	-	64.57	2.89	-	22.90
5-03-600	100.0	0.14	0.06	0.14	0.46	1.06	0.04	-	-	-	-	72.45	3.24	-	25.70
67. Peanut, meal, mech ext	92.6	0.20	0.03	0.27	0.56	1.15	0.08	0.23	0.11	15.40	0.06	296.41	25.52	-	33.00
5-03-649	100.0	0.22	0.03	0.29	0.60	1.24	0.09	0.25	0.12	16.62	0.07	320.07	27.56	-	35.64
68. Peanut, meal, sol ext	92.4	0.36	0.03	0.27	0.61	1.18	0.03	0.30	-	-	-	-	-	-	-
5-03-650	100.0	0.39	0.03	0.30	0.66	1.28	0.03	0.32	-	-	-	-	-	-	-
69. Poultry by-pro, meal, rend	93.8	3.95	0.54	0.17	2.06	0.52	0.78	0.51	4.92	19.87	3.10	639.00	16.51	0.91	117.41
5-03-798	100.0	4.21	0.58	0.19	2.19	0.55	0.83	0.55	5.26	21.18	3.30	681.08	17.60	0.98	125.15
70. Rice, bran	90.5	0.09	0.07	0.88	1.57	1.71	0.03	0.18	1.38	10.99	-	207.39	358.47	-	43.81
4-03-928	100.0	0.10	0.08	0.97	1.73	1.89	0.03	0.20	1.52	12.14	-	229.09	395.98	-	48.39

- Continues -

Table 4. Mineral Content (Continued)

Ingredient name/ description & IFN	DM %	Ca %	Cl %	Mg %	P %	K %	Na %	S %	Co mg/kg	Cu mg/kg	I mg/kg	Fe mg/kg	Mn mg/kg	Se mg/kg	Zn mg/kg
71. Rice, grain/groats	88.5	0.02	-	0.04	0.11	0.10	0.00	0.04	-	2.85	-	10.71	8.66	0.27	8.59
4-03-932	100.0	0.02	-	0.04	0.13	0.11	0.00	0.04	-	3.22	-	12.09	9.79	0.30	9.70
72. Rice, hulls	91.9	0.11	0.07	0.34	0.07	0.60	0.02	0.07	-	3.10	-	91.28	294.08	0.13	21.95
1-08-075	100.0	0.12	0.08	0.37	0.07	0.65	0.02	0.08	-	3.38	-	99.37	320.11	0.15	23.89
73. Rye, grain	87.5	0.06	0.03	0.11	0.32	0.45	0.02	0.14	-	7.55	-	62.83	72.01	-	28.47
4-04-047	100.0	0.07	0.03	0.12	0.36	0.51	0.03	0.16	-	8.63	-	71.80	82.30	-	32.54
74. Ryegrass, fresh	22.6	0.15	-	0.08	0.09	0.45	0.00	0.02	-	-	-	225.79	-	-	-
2-04-073	100.0	0.65	-	0.35	0.41	2.00	0.01	0.10	-	-	-	1000.0	-	-	-
75. Safflower, meal, sol ext	91.7	0.34	-	0.34	0.76	0.75	0.05	0.12	-	9.87	-	496.54	18.15	-	40.53
5-04-110	100.0	0.37	-	0.37	0.83	0.81	0.05	0.14	-	10.77	-	541.65	19.80	-	44.21
76. Safflower, meal wo/hulls	91.0	0.38	0.16	0.99	1.40	1.08	0.04	0.17	2.02	88.47	-	860.22	40.21	-	185.98
5-07-959	100.0	0.39	0.18	1.08	1.53	1.19	0.05	0.19	2.22	97.20	-	945.13	44.18	-	204.34
77. Sesame, meal, mech ext	92.7	2.01	0.06	0.46	1.36	1.27	0.05	0.35	-	-	-	92.70	47.76	-	99.67
5-04-220	100.0	2.17	0.07	0.50	1.46	1.37	0.05	0.38	-	-	-	100.0	51.51	-	107.51
78. Sorghum, grain	90.1	0.04	0.07	0.15	0.32	0.37	0.01	0.13	0.27	5.41	-	57.17	12.33	0.41	26.77
4-04-383	100.0	0.04	0.06	0.17	0.36	0.41	0.01	0.15	0.30	6.00	-	63.48	13.70	0.45	29.73
79. Sorghum, sorgo, silage	28.8	0.10	0.02	0.08	0.06	0.32	0.04	0.02	-	8.97	-	57.22	17.60	-	-
3-04-468	100.0	0.35	0.06	0.27	0.21	1.12	0.15	0.10	-	31.13	-	198.42	61.03	-	-
80. Soybean, hulls	90.3	0.48	0.02	0.20	0.17	1.17	0.02	0.09	0.10	16.07	-	369.35	9.92	0.12	43.27
1-04-560	100.0	0.53	0.02	0.22	0.18	1.29	0.03	0.11	0.12	17.80	-	409.10	10.99	0.14	47.93
81. Soybean, meal, sol ext	89.6	0.30	0.04	0.29	0.69	2.10	0.04	0.42	1.39	17.92	0.13	140.55	30.61	0.43	51.84
5-04-604	100.0	0.34	0.04	0.32	0.77	2.34	0.04	0.47	1.56	20.00	0.14	156.85	34.18	0.48	57.85
82. Soybean, meal wo/hulls	89.9	0.26	0.04	0.29	0.64	2.12	0.01	0.43	0.06	20.24	0.10	130.39	37.13	0.19	57.11
5-04-612	100.0	0.29	0.05	0.33	0.71	2.36	0.01	0.48	0.07	22.50	0.12	144.28	41.28	0.21	63.50
83. Soybean, prot conc - (NRC, 1998)	90.0	0.35	-	0.32	0.81	2.20	0.05	-	-	13.00	-	110.00	-	-	30
84. Soybean, seeds, heat proc	92.6	0.26	-	0.22	0.61	1.75	0.03	-	-	-	-	-	-	-	-
5-04-597	100.0	0.28	-	0.23	0.66	1.89	0.03	-	-	-	-	-	-	-	-
85. Sunflower, meal wo/hulls	92.5	0.42	0.15	0.65	0.94	1.17	0.03	0.30	-	37.76	-	262.99	18.91	2.12	97.57
5-04-739	100.0	0.45	0.17	0.70	1.02	1.27	0.03	0.33	-	40.84	-	284.41	20.45	2.29	105.52
86. Timothy, fresh	26.7	0.11	-	0.04	0.07	0.73	0.03	0.03	0.04	2.38	-	35.37	33.92	-	9.55
2-04-903	100.0	0.40	-	0.16	0.26	2.73	0.11	0.13	0.14	8.92	-	132.27	126.85	-	35.70
87. Timothy, hay	89.1	0.45	-	0.11	0.25	2.14	0.01	0.11	-	57.05	-	180.95	91.81	-	55.27
1-04-882	100.0	0.51	-	0.13	0.29	2.41	0.01	0.13	-	64.00	-	203.00	103.00	-	62.00
88. Triticale, grain	89.2	0.05	-	0.23	0.33	0.51	0.01	-	0.07	8.30	-	43.99	42.66	-	31.30
4-20-362	100.0	0.05	-	0.26	0.37	0.57	0.01	-	0.08	9.31	-	49.34	47.84	-	35.11
89. Urea	97.0	0.09	-	-	-	-	0.02	-	-	6.79	-	175.58	-	-	6.79
5-05-070	100.0	0.09	-	-	-	-	0.02	-	-	7.00	-	180.98	-	-	7.00
90. Wheat, bran	89.0	0.13	0.05	0.56	1.13	1.22	0.05	0.21	0.07	12.61	0.06	144.80	119.34	0.50	97.71
4-05-190	100.0	0.14	0.06	0.63	1.27	1.37	0.06	0.23	0.08	14.16	0.07	162.65	134.05	0.56	109.76
91. Wheat, grain, hard red spring	87.6	0.03	0.08	0.15	0.37	0.36	0.02	0.14	0.12	6.16	-	56.40	36.72	0.22	43.95
4-05-258	100.0	0.04	0.09	0.17	0.43	0.41	0.02	0.17	0.14	7.03	-	64.38	41.92	0.26	50.17
92. Wheat, grain, hard red winter	88.8	0.04	0.05	0.13	0.38	0.43	0.02	0.13	0.14	4.91	-	36.34	34.65	0.25	32.98
4-05-268	100.0	0.05	0.06	0.14	0.42	0.48	0.02	0.14	0.16	5.53	-	40.93	39.02	0.28	37.14
93. Wheat, grain, soft red winter	88.4	0.05	0.07	0.10	0.36	0.41	0.01	0.10	0.10	7.03	-	28.98	33.39	0.04	42.14
4-05-294	100.0	0.06	0.08	0.11	0.40	0.46	0.01	0.12	0.11	7.95	-	32.79	37.77	0.04	47.67
94. Wheat, grain, soft white winter	90.2	-	-	0.10	0.30	0.39	0.02	0.11	0.13	7.03	-	36.09	36.09	0.04	27.07
4-05-337	100.0	-	-	0.11	0.33	0.43	0.02	0.13	0.15	7.80	-	40.00	40.00	0.05	30.00
95. Wheat, hay	88.7	0.13	-	0.11	0.18	0.88	0.19	0.19	-	-	-	177.49	-	-	-
1-05-172	100.0	0.15	-	0.12	0.20	0.99	0.21	0.21	-	-	-	200.00	-	-	-
96. Wheat, middlings	88.9	0.13	0.04	0.34	0.89	0.98	0.02	0.16	0.10	15.89	0.10	89.78	114.16	0.73	97.08
4-05-205	100.0	0.14	0.05	0.38	1.00	1.10	0.02	0.18	0.11	17.87	0.12	100.94	128.35	0.82	109.14
97. Wheat, red dog	88.3	0.06	0.11	0.19	0.53	0.52	0.01	0.22	0.11	6.27	-	49.65	52.17	0.36	65.07
4-05-203	100.0	0.07	0.13	0.21	0.60	0.58	0.01	0.25	0.13	7.10	-	56.20	59.06	0.41	73.66
98. Wheat, shorts	88.4	0.08	0.05	0.27	0.90	0.93	0.02	0.19	0.10	11.51	-	73.48	114.18	0.47	102.49
4-05-201	100.0	0.10	0.06	0.31	1.01	1.05	0.03	0.21	0.11	13.01	-	83.07	129.10	0.53	115.87
99. Whey, dehy	93.3	0.85	0.07	0.13	0.76	1.16	0.62	1.04	0.11	46.51	-	194.15	5.86	-	4.79
4-01-182	100.0	0.92	0.08	0.14	0.81	1.25	0.66	1.11	0.11	49.87	-	208.15	6.29	-	5.14
100. Yeast, Torula, dehy	93.0	0.55	0.02	0.14	1.61	1.91	0.01	0.48	0.03	12.08	2.50	105.96	9.68	0.05	99.48
7-05-534	100.0	0.59	0.02	0.15	1.73	2.06	0.01	0.51	0.03	12.99	2.68	113.88	10.38	0.05	106.92

5. Table 5. Vitamin Content [DM = dry matter; Vitam = vitamin; IU = international unit; ICU = international chock unit; mg/kg = ppm]

Ingredient name/ description & IFN	DM %	Caro-tene mg/kg	Vitam D_2/D_3 IU/kg	Vitam D_s ICU/kg	Vitam E mg/kg	Vitam K mg/kg	Bio-tin mg/kg	Cho-line mg/kg	Folate mg/kg	Nia-cin mg/kg	Pantothe-nic acid mg/kg	Ribo-flavin mg/kg	Thia-min mg/kg	Vitam B_6 mg/kg	Vitam B_{12} µg/kg
1. Alfalfa, fresh	26.0	-	0.0	-	-	-	0.12	374	0.64	15.4	8.9	4.6	1.65	1.66	-
2-00-196	100.0	-	0.2	-	-	-	0.48	1439	2.47	59.1	34.3	17.5	6.35	6.38	-
2. Alfalfa, hay	91.0	-	1.4	-	-	-	-	-	-	-	-	9.6	-	-	-
1-00-063	100.0	-	1.5	-	-	-	-	-	-	-	-	10.6	-	-	-
3. Alfalfa, dehy 17% CP	91.8	-	-	-	105.9	8.2	0.32	1349	4.37	37.0	29.8	12.9	3.39	7.19	-
1-00-023	100.0	-	-	-	115.3	9.0	0.35	1470	4.76	40.3	32.4	14.1	3.69	7.83	-
4. Alfalfa, dehy 20% CP	91.6	-	-	-	143.3	14.2	0.35	1417	2.96	48.0	35.5	15.2	5.36	8.72	-
1-00-024	100.0	-	-	-	256.4	15.5	0.38	1547	3.24	52.4	38.8	16.6	5.85	9.52	-
5. Bakery, waste, dehy	91.2	-	-	-	41.0	-	0.06	916	0.18	25.6	8.2	1.4	2.92	4.29	-
4-00-466	100.0	-	-	-	44.9	-	0.07	1004	0.20	28.0	9.0	1.5	3.20	4.70	-
6. Barley, grain	88.6	-	-	-	23.2	0.2	0.15	1037	0.57	78.5	8.1	1.6	4.52	6.48	-
4-00-549	100.0	-	-	-	26.2	0.2	0.17	1170	0.64	88.6	9.1	1.8	5.11	7.32	-
7. Barley, straw	91.4	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-
1-00-498	100.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-
8. Beet pulp, dehy	91.0	-	0.6	-	-	-	-	820	-	16.8	1.4	0.7	0.39	-	-
4-00-669	100.0	-	0.6	-	-	-	-	901	-	18.4	1.5	0.8	0.42	-	-
11. Blood, meal, spray dried	92.6	-	-	-	-	-	0.27	597	0.37	22.2	3.2	2.9	0.32	4.44	12.20
5-00-381	100.0	-	-	-	-	-	0.30	645	0.40	23.9	3.5	3.1	0.35	4.79	13.18
13. Bluegrass, fresh	30.8	-	-	-	47.8	-	-	-	-	-	-	-	-	-	-
2-00-777	100.0	-	-	-	155.0	-	-	-	-	-	-	-	-	-	-
14. Bluegrass, hay	88.9	-	-	-	-	-	-	-	-	-	-	9.9	-	-	-
1-00-776	100.0	-	-	-	-	-	-	-	-	-	-	11.1	-	-	-
15. Brewer's grain, dehy	92.2	-	-	-	26.7	-	0.44	1651	0.22	43.7	8.2	1.5	0.63	1.03	3.63
5-02-141	100.0	-	-	-	29.0	-	0.48	1792	0.24	47.4	8.9	1.6	0.68	1.11	3.94
16. Brewer's yeast, dehy	93.1	-	-	-	2.1	-	1.04	3847	9.69	443.3	81.5	33.6	85.21	36.66	1.06
7-05-527	100.0	-	-	-	2.3	-	1.11	4133	10.41	476.4	87.6	36.1	91.56	39.40	1.14
17. Brome, fresh	27.0	-	0.0	-	-	-	-	-	-	-	-	2.1	0.83	-	-
2-00-963	100.0	-	0.1	-	-	-	-	-	-	-	-	7.7	3.09	-	-
19. Buckwheat, grain	88.4	-	-	-	-	-	-	442	-	18.4	11.6	4.8	3.75	-	-
4-00-994	100.0	-	-	-	-	-	-	500	-	20.9	13.1	5.4	4.24	-	-
21. Canary grass, hay	89.3	-	-	-	-	-	-	-	-	-	-	8.5	3.57	-	-
1-01-104	100.0	-	-	-	-	-	-	-	-	-	-	9.5	4.00	-	-
22. Canola, meal	91.2	-	-	-	-	-	-	6633	-	146.8	8.0	5.8	1.59	7.25	-
5-03-871	100.0	-	-	-	-	-	-	7277	-	161.1	8.8	6.4	1.74	7.95	-
23. Casein, dehy	91.6	-	-	-	-	-	0.04	210	0.46	1.3	2.7	1.5	0.42	0.43	-
5-01-162	100.0	-	-	-	-	-	0.04	230	0.50	1.4	2.9	1.7	0.46	0.47	-
24. Citrus pulp, dehy	91.1	-	-	-	-	-	-	790	-	22.2	14.0	2.1	1.47	-	-
4-01-237	100.0	-	-	-	-	-	-	867	-	24.4	15.4	2.3	1.61	-	-
25. Clover, Landino, fresh	17.7	-	-	-	-	-	-	-	-	-	-	4.2	-	-	-
2-01-383	100.0	-	-	-	-	-	-	-	-	-	-	24.1	-	-	-
26. Clover, Landino, hay	89.1	-	-	-	-	-	-	-	-	9.8	1.0	15.2	3.74	-	-
1-01-378	100.0	-	-	-	-	-	-	-	-	11.0	1.1	17.0	4.20	-	-
28. Clover, Red, hay	88.4	-	-	-	-	-	0.09	-	-	37.7	9.9	15.7	1.97	-	-
1-01-415	100.0	-	-	-	-	-	0.10	-	-	42.6	11.2	17.8	2.22	-	-
29. Coconut, meal	91.1	-	-	-	-	-	-	1089	0.30	23.8	6.5	3.5	-	4.36	-
5-01-573	100.0	-	-	-	-	-	-	1195	0.33	26.1	7.2	3.8	-	4.78	-
30. Corn, cobs, ground	89.8	-	-	-	-	-	-	-	-	7.0	3.8	1.0	0.90	-	-
1-02-782	100.0	-	-	-	-	-	-	-	-	7.8	4.2	1.1	1.00	-	-
31. Corn, DG, dehy	93.5	-	-	-	-	-	0.41	1113	1.00	38.3	11.3	5.0	1.77	4.22	0.25
5-02-842	100.0	-	-	-	-	-	0.44	1190	1.06	41.0	12.1	5.3	1.90	4.51	0.27
32. Corn, DG w/solubles	91.8	-	0.6	-	39.8	-	0.68	2581	0.91	73.4	13.8	8.5	3.01	4.74	1.51
5-02-843	100.0	-	0.6	-	43.4	-	0.74	2813	0.99	80.0	15.1	9.2	3.28	5.17	1.64
33. Corn, distiller's solubles	92.9	-	-	-	45.9	-	1.49	4750	1.34	123.6	23.3	15.1	6.76	9.41	4.18
5-02-844	100.0	-	-	-	49.4	-	1.60	5116	1.45	133.2	25.0	16.3	7.27	10.14	4.50
34. Corn, gluten feed	89.9	-	-	-	12.1	-	0.30	1587	0.27	70.5	13.6	2.2	1.99	13.93	-
5-02-903	100.0	-	-	-	13.5	-	0.34	1765	0.30	78.4	15.1	2.5	2.21	15.49	-
35. Corn, gluten meal	91.3	-	-	-	29.2	-	0.19	360	0.30	49.8	10.0	1.5	0.22	7.97	-
5-02-900	100.0	-	-	-	32.0	-	0.20	394	0.33	54.6	10.9	1.6	0.24	8.73	-
36. Corn, grain	88.0	-	-	-	20.9	0.2	0.06	495	0.31	22.5	5.1	1.1	3.73	6.16	-
4-02-935	100.0	-	-	-	23.8	0.2	0.07	563	0.35	25.6	5.8	1.2	4.24	7.01	-
37. Corn, hominy feed	90.2	-	-	-	-	-	0.13	1154	0.31	46.9	8.2	2.1	8.05	10.95	-
4-02-8878,	100.0	-	-	-	-	-	0.14	1279	0.34	52.0	9.1	2.4	8.92	12.14	-
38. Corn, silage	34.1	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-
3-02-823	100.0	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
39. Cottonseed, hulls	90.4	-	-	-	-	-	-	-	-	-	-	3.7	-	-	-
1-01-599	100.0	-	-	-	-	-	-	-	-	-	-	4.1	-	-	-

- Continues -

Table 5. Vitamin Content (Continued)

Ingredient name/ description & IFN	DM %	Caro-tene mg/kg	Vitam D_2/D_3 IU/kg	Vitam D_s ICU/kg	Vitam E mg/kg	Vitam K mg/kg	Bio-tin mg/kg	Cho-line mg/kg	Folate mg/kg	Nia-cin mg/kg	Pantothe-nic acid mg/kg	Ribo-flavin mg/kg	Thia-min mg/kg	Vitam B_6 mg/kg	Vitam B_{12} µg/kg
41. Cottonseed, meal, mech ext	92.6	-	-	-	32.4	-	0.91	2755	2.45	35.2	10.2	5.2	7.07	5.01	-
5-01-617	100.0	-	-	-	34.9	-	0.98	2974	2.65	38.0	11.0	5.6	7.63	5.41	-
42. Cottonseed, meal, sol ext	91.0	-	-	-	14.6	-	0.55	2782	2.55	40.9	13.7	4.7	7.32	5.41	-
5-01-621	100.0	-	-	-	16.1	-	0.61	3058	2.81	44.9	15.1	5.2	8.04	5.95	-
43. Feather meal, hydrolyzed	92.9	-	-	-	-	-	0.04	894	0.22	21.1	8.9	2.0	0.11	4.39	80.35
5-03-795	100.0	-	-	-	-	-	0.04	962	0.23	22.7	9.6	2.2	0.12	4.72	86.49
44. Fescue, fresh	28.4	-	-	-	46.9	-	-	-	-	-	-	2.4	3.38	-	-
2-01-920	100.0	-	-	-	165.1	-	-	-	-	-	-	8.6	11.90	-	-
45. Fescue, hay	87.5	-	-	-	118.6	-	-	-	-	-	-	-	-	-	-
1-01-912	100.0	-	-	-	135.6	-	-	-	-	-	-	-	-	-	-
46. Fish, anchovy, mech ext	92.0	-	-	-	3.7	-	0.19	3700	0.16	80.5	10.0	7.3	0.52	4.71	14.47
5-01-985	100.0	-	-	-	4.0	-	0.21	4023	0.17	87.6	10.9	8.0	0.57	5.12	33.19
47. Fish, herring, mech ext	91.8	-	-	-	22.0	2.2	0.48	5262	0.34	85.2	17.3	9.7	0.38	4.65	28.79
5-02-000	100.0	-	-	-	24.0	2.3	0.53	5730	0.37	92.8	18.8	10.6	0.41	5.06	66.91
48. Fish, menhaden, mech ext	91.7	-	-	-	6.8	-	0.17	3114	0.15	54.6	8.6	4.8	0.57	3.81	22.12
5-02-009	100.0	-	-	-	7.4	-	0.19	3398	0.17	59.6	9.4	5.3	0.62	4.15	33.24
49. Fish, white, mech ext	91.2	-	-	-	8.9	-	0.08	4305	0.35	59.4	9.9	9.1	1.68	5.32	84.51
5-02-025	100.0	-	-	-	9.8	-	0.08	4718	0.38	65.1	10.9	10.0	1.84	5.83	92.63
50. Fish, solubles, condensed	50.4	-	-	-	-	-	0.14	3314	0.22	175.9	35.6	12.7	5.53	12.20	6.38
5-01-969	100.0	-	-	-	-	-	0.27	6573	0.44	348.9	70.7	25.2	10.96	24.19	4.20
51. Fish, solubles, dehy	92.8	-	-	-	6.1	-	0.39	5525	0.57	255.8	50.4	13.5	7.39	19.71	85.93
5-01-971	100.0	-	-	-	6.5	-	0.42	5953	0.61	275.6	54.3	14.6	7.96	21.23	23.57
52. Meat meal, rend	93.8	-	-	-	0.9	-	0.12	1979	0.39	56.0	6.0	5.2	0.22	4.23	75.12
5-00-385	100.0	-	-	-	1.0	-	0.13	2110	0.42	59.7	6.4	5.5	0.23	4.51	80.08
53. Meat meal w/bones	93.3	-	-	-	0.9	-	0.10	2049	0.37	51.3	5.5	4.7	0.16	5.86	18.41
5-00-388	100.0	-	-	-	0.9	-	0.10	2195	0.40	55.0	5.9	5.0	0.17	6.28	26.88
54. Milk, skim, dehy	94.1	-	0.4	-	9.1	-	0.32	1393	0.62	11.5	36.4	19.1	3.72	4.09	50.88
5-01-175	100.0	-	0.4	-	9.6	-	0.35	1479	0.66	12.2	38.6	20.3	3.95	4.35	54.05
55. Millet, grain	89.9	-	-	-	-	-	-	746	0.22	49.0	8.8	1.8	6.58	-	-
4-03-098	100.0	-	-	-	-	-	-	830	0.25	54.5	9.8	2.0	7.32	-	-
56. Molasses, sugar beet	77.9	-	-	-	4.0	-	-	827	-	41.0	4.5	2.3	-	-	-
4-00-668	100.0	-	-	-	5.1	-	-	1062	-	52.7	5.8	2.9	-	-	-
57. Molasses, sugarcane	74.3	-	-	-	5.4	-	0.68	763	0.11	36.4	37.4	2.8	0.86	4.21	-
4-04-696	100.0	-	-	-	7.3	-	0.92	1027	0.15	49.0	50.3	3.8	1.16	5.67	-
58. Oats, grain	89.2	-	-	-	15.0	-	0.26	967	0.39	14.0	9.7	1.4	6.13	2.61	-
4-03-309	100.0	-	-	-	16.8	-	0.29	1084	0.44	15.7	10.9	1.6	6.87	2.93	-
59. Oats, groats	89.6	-	-	-	14.8	-	-	1131	0.51	9.6	13.8	1.2	6.49	1.00	-
4-03-331	100.0	-	-	-	16.5	-	-	1263	0.56	10.7	15.4	1.3	7.25	1.12	-
60. Oats, hay	90.7	-	1.4	-	-	-	-	-	-	-	-	-	-	-	-
1-03-280	100.0	-	1.5	-	-	-	-	-	-	-	-	-	-	-	-
61. Oats, hulls	92.4	-	-	-	-	-	-	260	0.96	9.2	3.1	1.5	0.61	2.19	-
1-03-281	100.0	-	-	-	-	-	-	281	1.04	10.0	3.4	1.7	0.66	2.37	-
62. Oats, silage	30.5	-	-	-	-	-	-	302	-	-	-	-	-	-	-
3-03-298	100.0	-	-	-	-	-	-	991	-	-	-	-	-	-	-
63. Oats, straw	92.2	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-
1-03-283	100.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-
65. Orchardgrass, hay	89.6	-	-	-	171.3	-	-	-	-	-	-	6.1	2.57	-	-
1-03-438	100.0	-	-	-	191.1	-	-	-	-	-	-	6.8	2.87	-	-
66. Pea, seeds	89.1	-	-	-	3.0	-	0.17	545	0.22	30.5	27.7	1.8	4.61	1.96	-
5-03-600	100.0	-	-	-	3.3	-	0.20	612	0.25	34.3	31.1	2.0	5.17	2.20	-
67. Peanut, meal, mech ext	92.6	-	-	-	2.4	-	0.33	1974	0.66	172.7	47.8	9.1	5.72	6.12	-
5-03-649	100.0	-	-	-	2.6	-	0.35	2132	0.71	186.4	51.4	9.8	6.18	6.61	-
68. Peanut, meal, sol ext	92.4	-	-	-	2.9	-	-	1893	-	177.5	36.8	5.2	-	5.95	-
5-03-650	10.0	-	-	-	3.2	-	-	2048	-	192.0	39.8	5.7	-	6.43	-
69. Poultry by-pro, meal, rend	93.8	-	-	-	2.2	-	0.08	6052	0.51	53.5	12.4	10.6	0.23	4.43	22.61
5-03-798	100.0	-	-	-	2.4	-	0.09	6450	0.54	57.1	13.2	11.3	0.24	4.72	24.10
70. Rice, bran	90.5	-	-	-	85.3	-	0.42	1243	1.60	305.9	25.0	2.6	21.94	16.21	5.14
4-03-928	100.0	-	-	-	94.2	-	0.46	1373	1.77	337.9	27.6	2.8	24.23	17.90	5.68
71. Rice, grain/groats	88.5	-	-	-	-	-	-	877	-	22.6	3.3	0.4	1.39	-	-
4-03-932	100.0	-	-	-	-	-	-	990	-	25.5	3.7	0.5	1.57	-	-
72. Rice, hulls	91.9	-	-	-	7.5	-	-	-	-	28.1	7.9	0.5	2.21	0.07	-
1-08-075	100.0	-	-	-	8.1	-	-	-	-	30.6	8.6	0.6	2.41	0.08	-
73. Rye, grain	87.5	-	-	-	14.5	-	0.05	419	0.58	14.1	7.2	1.8	4.51	2.97	-
4-04-047	100.0	-	-	-	16.6	-	0.06	479	0.66	16.1	8.3	2.0	5.16	3.40	-
75. Safflower, meal, sol ext	91.7	-	-	-	0.8	-	1.42	814	0.45	61.9	26.2	2.0	-	-	-
5-04-110	100.0	-	-	-	0.9	-	1.55	888	0.49	67.5	28.5	2.2	-	-	-
76. Safflower, meal wo/hulls	91.0	-	-	-	0.7	-	1.70	3246	1.61	22.2	39.4	2.5	4.62	11.83	-
5-07-959	100.0	-	-	-	0.8	-	1.87	3567	1.77	24.4	43.3	2.7	5.08	13.00	-

- Continues -_

Table 5. Vitamin Content (Continued)

Ingredient name/ description & IFN	DM %	Caro-tene mg/kg	Vitam D_2/D_3 IU/kg	Vitam D_s ICU/kg	Vitam E mg/kg	Vitam K mg/kg	Bio-tin mg/kg	Cho-line mg/kg	Folate mg/kg	Nia-cin mg/kg	Pantothe-nic acid mg/kg	Ribo-flavin mg/kg	Thia-min mg/kg	Vitam B_6 mg/kg	Vitam B_{12} µg/kg
77. Sesame, meal, mech ext	92.7	-	-	-	-	-	-	1534	-	18.8	5.9	3.4	2.80	12.46	-
5-04-220	100.0	-	-	-	-	-	-	1654	-	20.3	6.4	3.6	3.02	13.44	-
78. Sorghum, grain	90.1	-	-	-	-	-	0.26	692	0.22	46.6	10.2	1.2	4.52	5.40	-
4-04-383	100.0	-	-	-	-	-	0.29	768	0.24	51.8	11.3	1.4	5.02	6.00	-
80. Soybean, hulls	90.3	-	-	-	6.6	-	-	586	-	24.8	13.4	3.8	1.59	1.70	-
1-04-560	100.0	-	-	-	7.3	-	-	649	-	27.4	14.8	4.0	1.76	1.88	-
81. Soybean, meal, sol ext	89.6	-	-	-	2.4	-	0.32	2619	0.55	27.7	16.3	2.9	5.98	6.00	-
5-04-604	100.0	-	-	-	2.7	-	0.36	2923	0.61	30.9	18.2	3.2	6.68	6.70	-
82. Soybean, meal wo/hulls	89.9	-	-	-	3.3	-	0.32	2746	0.74	21.5	14.8	2.9	3.10	4.92	-
5-04-612	100.0	-	-	-	3.7	-	0.35	3053	0.82	23.9	16.4	3.3	3.45	5.47	-
84. Soybean, seeds, heat proc	92.6	-	-	-	-	-	0.29	2489	3.62	22.6	16.1	2.7	6.11	-	-
5-04-597	100.0	-	-	-	-	-	0.31	2688	3.91	24.4	17.4	2.9	6.60	-	-
85. Sunflower, meal wo/hulls	92.5	-	-	-	11.1	-	-	3627	-	242.1	40.6	3.5	-	13.67	-
5-04-739	100.0	-	-	-	12.0	-	-	3923	-	261.9	43.9	3.8	-	14.78	-
87. Timothy, hay	89.1	-	-	-	11.6	-	-	-	-	-	-	-	-	-	-
1-04-882	100.0	-	-	-	13.0	-	-	-	-	-	-	-	-	-	-
88. Triticale, grain	89.2	-	-	-	-	-	0.05	458	0.60	14.7	6.8	2.3	8.25	4.21	-
4-20-362	100.0	-	-	-	-	-	0.06	514	0.67	16.5	7.6	2.6	9.25	4.73	-
90. Wheat, bran	89.0	-	-	-	14.3	-	0.37	1201	1.77	196.7	27.9	3.6	8.36	10.33	-
4-05-190	100.0	-	-	-	16.0	-	0.42	1349	1.98	221.0	31.4	4.0	9.39	11.61	-
91. Wheat, grain, hard red spring	87.6	-	-	-	12.6	-	0.08	1009	0.43	57.2	9.5	1.4	4.22	5.16	-
4-05-258	100.0	-	-	-	14.4	-	0.09	1152	0.49	65.2	10.8	1.6	4.82	5.89	-
92. Wheat, grain, hard red winter	88.8	-	-	-	11.1	-	0.11	1006	0.38	53.0	10.1	1.3	4.52	3.02	-
4-05-268	100.0	-	-	-	12.5	-	0.12	1133	0.43	59.7	11.4	1.5	5.09	3.40	-
93. Wheat, grain, soft red winter	88.4	-	-	-	15.6	-	-	891	0.41	53.4	10.1	1.5	4.71	3.21	-
4-05-294	100.0	-	-	-	17.7	-	-	1008	0.46	60.4	11.4	1.7	5.33	3.63	-
94. Wheat, grain, soft white winter	90.2	-	-	-	30.9	-	-	-	-	62.1	11.1	-	-	4.77	-
4-05-337	100.0	-	-	-	34.2	-	-	-	-	68.8	12.3	-	-	5.29	-
95. Wheat, hay	88.7	-	1.4	-	-	-	-	-	-	-	-	15.1	-	-	-
1-05-172	100.0	-	1.5	-	-	-	-	-	-	-	-	17.0	-	-	-
96. Wheat, middlings	88.9	-	-	-	23.9	-	0.24	1228	1.24	95.0	17.8	2.0	14.18	9.15	-
4-05-205	100.0	-	-	-	26.9	-	0.27	1381	1.39	106.8	20.0	2.3	15.94	10.29	-
97. Wheat, red dog	88.3	-	-	-	37.4	-	0.10	1455	0.82	46.0	13.3	2.2	21.85	5.40	-
4-05-203	100.0	-	-	-	42.4	-	0.12	1647	0.93	52.1	15.0	2.5	24.73	6.12	-
98. Wheat, shorts	88.4	-	-	-	36.0	-	-	1698	1.51	105.2	21.9	4.1	19.52	-	-
4-05-201	100.0	-	-	-	40.7	-	-	1919	1.71	119.0	24.8	4.6	22.07	-	-
99. Whey, dehy	93.3	-	-	-	0.2	-	0.35	1791	0.85	10.6	46.2	27.4	4.00	3.22	18.89
4-01-182	100.0	-	-	-	0.2	-	0.37	1920	0.91	11.4	49.6	29.4	4.29	3.45	20.26
100. Yeast, Torula, dehy	93.0	-	-	-	-	-	1.17	2962	25.66	509.1	104.4	50.0	6.66	34.48	4.00
7-05-534	100.0	-	-	-	-	-	1.25	3184	27.58	547.2	112.2	53.8	7.16	37.06	4.30

6. Table 6. Mineral Supplements [DM = dry matter]

Ingredient name/ description & IFN	DM %	Ca %	Cl %	Mg %	P %	K %	Na %	S %	Co %	Cu %	I %	Fe %	Mn %	Se %	Zn %
1. Ammonium, dibasic phosphate	97.8	0.504	-	0.454	20.082	-	0.040	2.468	-	0.008	-	0.154	1.512	0.050	0.030
6-00-370	100.0	0.516	-	0.464	20.544	-	0.041	2.525	-	0.008	-	0.158	1.547	0.051	0.030
2. Ammonium, monobasic phosphate	97.7	0.380	-	0.460	24.411	0.138	0.078	0.821	-	0.008	-	0.183	0.990	0.046	0.063
6-09-338	100.0	0.389	-	0.471	24.994	0.141	0.080	0.841	-	0.008	-	0.187	1.013	0.047	0.065
3. Bone, meal, steamed	96.1	27.723	0.010	0.552	12.858	0.182	0.403	0.344	-	0.001	0.003	0.064	0.103	0.003	0.036
6-00-400	100.0	28.849	0.010	0.574	13.380	0.190	0.419	0.358	-	0.001	0.003	0.066	0.107	0.003	0.038
4. Calcium, carbonate	99.6	37.881	0.034	0.350	0.020	0.063	0.082	0.080	0.000	0.001	-	0.000	0.051	0.013	0.001
6-01-069	100.0	38.052	0.034	0.352	0.020	0.064	0.082	0.080	0.000	0.001	-	0.000	0.051	0.013	0.001
5. Calcium, dibasic phosphate	97.6	21.811	0.003	0.461	18.538	0.086	1.377	0.692	0.000	0.000	-	0.104	0.848	0.025	0.012
6-01-080	100.0	22.353	0.003	0.473	18.999	0.088	1.412	0.709	0.000	0.000	-	0.106	0.869	0.026	0.012
6. Calcium, mono basic phosphate	98.0	16.393	-	0.800	21.907	0.400	0.060	0.800	0.000	0.000	-	0.140	1.000	0.020	0.041
6-01-082	100.0	16.728	-	0.816	22.354	0.408	0.061	0.816	0.000	0.000	-	0.142	1.020	0.020	0.042
7. Calcium, anhydrous sulfate	79.1	23.274	0.002	-	-	-	-	18.616	-	-	-	-	0.002	-	-
6-01-087	100.0	29.429	0.003	-	-	-	-	23.539	-	-	-	-	0.002	-	-
8. Cobalt, carbonate	99.0	-	0.010	-	-	-	0.250	0.030	46.500	0.001	-	-	0.020	0.010	0.001
6-01-566	100.0	-	0.010	-	-	-	0.253	0.030	46.969	0.001	-	-	0.020	0.010	0.001
9. Collodial clay (soft rock phos[hate)	99.5	16.005	-	-	9.000	-	-	-	-	-	-	1.206	-	-	-
6-03-947	100.0	16.086	-	-	9.045	-	-	-	-	-	-	1.212	-	-	-
10. Cupric, pentahydrate sulfat	100.0	-	0.001	-	-	-	-	12.840	-	39.740	-	-	0.003	-	-
6-01-720	100.0	-	0.001	-	-	-	-	12.840	-	39.740	-	-	0.003	-	-
11. Curacao phosphate, ground	99.0	35.099	-	-	14.237	-	-	-	-	-	-	-	-	-	-
6-05-586	100.0	35.454	-	-	14.381	-	-	-	-	-	-	-	-	-	-
12. Ferrous, heptahydrate sulfate	99.5	-	-	0.205	-	-	-	10.999	-	0.010	-	-	20.898	0.000	0.010
6-20-734	100.0	-	-	0.206	-	-	-	11.055	-	0.010	-	-	21.005	0.000	0.010
13. Limestone, ground	99.7	37.113	0.025	1.056	0.214	0.112	0.055	0.040	-	0.001	-	-	0.186	0.012	0.002
6-02-632	100.0	37.220	0.025	1.059	0.215	0.113	0.055	0.040	-	0.001	-	-	0.187	0.012	0.002
14. Magnesium, anhydrous carbonate	98.0	0.020	-	30.810	-	-	-	-	-	-	0.020	-	-	-	-
6-02-754	100.0	0.020	-	31.444	-	-	-	-	-	-	0.020	-	-	-	-
15. Magnesium, oxide	98.3	1.660	-	55.188	-	-	-	0.099	-	0.000	-	0.025	1.047	0.008	0.000
6-02-756	11.0	1.689	-	56.147	-	-	-	0.101	-	0.000	-	0.025	1.066	0.008	0.000
16. Mangonous, oxide	99.0	-	-	-	-	-	-	-	-	-	-	-	-	76.670	-
6-03-056	100.0	-	-	-	-	-	-	-	-	-	-	-	-	77.450	-
17. Phosphate	99.6	31.955	-	0.293	16.907	0.100	2.067	0.130	-	0.004	-	0.179	0.839	0.049	0.009
6-01-780	100.0	32.086	-	0.294	16.977	0.100	2.075	0.130	-	0.004	-	0.180	0.842	0.049	0.009
18. Phosphate, rock	100.0	35.000	-	-	13.000	-	-	-	-	-	-	3.700	-	-	-
6-03-945	100.0	35.000	-	-	13.000	-	-	-	-	-	-	3.700	-	-	-
19. Potassium, bicarbonate	99.0	-	-	-	-	38.65	-	-	-	-	-	-	-	-	-
6-29-493	100.0	-	-	-	-	39.05	-	-	-	-	-	-	-	-	-
20. Potassium, iodide	99.0	-	-	-	-	21.00	0.100	-	-	68.170	-	-	-	-	-
6-03-759	100.0	-	-	-	-	21.02	0.100	-	-	68.238	-	-	-	-	-
21. Salt, iodine added	99.8	0.154	-	0.140	0.050	0.007	40.525	-	-	0.000	0.007	-	0.000	0.000	0.000
6-04-151	100.0	0.154	-	0.140	0.050	0.007	40.592	-	-	0.000	0.007	-	0.000	0.000	0.000
22. Salt, NaCl	99.5	-	59.950	-	-	-	38.811	-	-	-	-	-	-	-	-
6-04-152	100.0	-	60.257	-	-	-	39.011	-	-	-	-	-	-	-	-
23. Sodium, bicarbonate	99.7	0.010	-	-	-	-	28.094	-	-	-	-	-	-	-	-
6-04-272	100.0	0.010	-	-	-	-	28.188	-	-	-	-	-	-	-	-
24. Sodium, phosphate, monobasic	94.0	0.085	0.019	0.009	24.186	0.094	21.461	-	-	0.000	-	-	-	-	0.000
6-04-288	100.0	0.090	0.020	0.010	25.717	0.100	22.820	-	-	0.000	-	-	-	-	0.000
25. Sodium, selenite	99.2	-	-	0.010	-	-	26.799	-	-	0.001	-	-	0.030	-	-
6-26-013	100.0	-	-	0.010	-	-	27.003	-	-	0.001	-	-	0.030	-	-
26. Sodium, sulphate	97.0	-	-	-	-	-	13.840	9.659	-	-	-	-	0.001	-	-
6-04-292	100.0	-	-	-	-	-	14.268	9.958	-	-	-	-	0.001	-	-
27. Sodium, tripolyphosphate	96.7	-	-	-	24.529	-	30.184	-	-	-	-	0.024	0.003	-	-
6-08-076	100.0	-	-	-	25.375	-	31.225	-	-	-	-	0.025	0.004	-	-
28. Zinc, oxide	100.0	4.290	-	0.295	-	-	-	1.000	0.150	0.050	-	-	0.550	0.080	72.496
6-05-553	100.0	4.290	-	0.295	-	-	-	1.000	0.150	0.050	-	-	0.550	0.080	72.496
29. Zinc, monohydrate sulfate	99.2	0.050	0.199	-	-	-	-	17.621	-	0.005	-	-	0.052	0.016	35.907
6-05-555	100.0	0.050	0.200	-	-	-	-	17.755	-	0.005	-	-	0.052	0.017	36.181

7. Table 7. Energy Values of Various Sources of Fats and Oils[a,b] [Based on NRC (1998); as-fed basis]

[Tot SFA = total saturated fatty acids; Tot UFA = total unsaturated fatty acids; U:S ratio = unsaturated to saturated fatty acid ratio; Tot n-6 = total n-6 or omega-6 fatty acids; Tot n-3 = total total n-3 or omega-3 fatty acids; DE = digestible energy; ME = metabolizable energy; NE = net energy]

	Selected fatty acids (% of total fatty acids)																Energy (kcal/kg)		
Type of lipid/ IFN	≤ 10	12:O	14:O	16:0	16:1	18:O	18:1	18:2	18:3	≥ 20	Tot SFA	Tot UFA	U:S ratio	Iodine value	Tot n–6	Tot n–3	DE[c]	ME[d]	NE[e]
Animal fats:																			
Beef tallow/ 4-08-127	0.0	0.9	2.7	24.9	4.2	18.9	36.0	3.1	0.6	0.3	52.1	47.9	0.92	44	3.1	0.6	8,000	7,680	4,925
Choice white grease/ -	0.2	0.2	1.9	21.5	5.7	14.9	41.1	11.6	0.4	1.8	40.8	59.2	1.45	60	11.6	0.4	8,290	7,955	5,095
Lard/ 4-04-790	0.1	0.2	1.3	23.8	2.7	13.5	41.2	10.2	1.0	1.0	41.1	58.9	1.44	64	10.2	1.0	8,285	7,950	5,100
Poultry fat 4-09-319	0.0	0.1	0.9	21.6	5.7	6.0	37.3	19.5	1.0	1.2	31.2	68.8	2.20	78	19.5	1.0	8,520	8,180	5,230
Restaurant grease/ -	-	-	1.9	16.2	2.5	10.5	47.5	17.5	1.9	1.0	29.9	70.1	2.34	75	17.5	1.9	8,550	8,205	5,245
Fish oils:																			
Anchovy/ -	-	-	7.4	17.4	10.5	4.0	11.6	1.2	0.8	30.3	34.6	65.4	1.89	-	1.3	31.2	8,445	8,105	5,185
Herring/ 7-08-048	-	0.2	7.1	11.7	9.6	0.8	11.9	1.1	0.8	45.6	22.8	77.2	3.39	-	1.4	17.8	8,680	8,330	5,320
Menhaden/ 7-08-049	-	-	8.0	15.1	10.5	3.8	14.5	2.1	1.5	29.5	33.3	68.7	2.00	-	1.5	25.1	8,475	8,135	5,200
Vegetable oils:																			
Canola (Rapeseed)/ 4-06-144	0.0	0.0	0.0	4.0	0.2	1.8	56.1	20.3	9.3	3.6	7.4	92.6	12.46	118	20.3	9.3	8,760	8,410	5,365
Coonnut[f]/ 4-00-320	14.1	44.6	16.8	8.2	0.0	2.8	5.8	1.8	0.0	-	91.9	8.1	0.09	10	1.8	0.0	8,405	8,070	5,160
Corn/ 4-07-882	0.0	0.0	0.0	10.9	0.0	1.8	24.2	59.0	0.7	-	13.3	86.7	6.53	125	58.0	0.7	8,755	8,405	5,360
Cottonseed 4-20-636	0.0	0.0	0.8	22.7	0.8	2.3	17.0	51.5	0.2	0.1	27.1	72.9	2.69	105	51.5	0.2	8,605	8,260	5,275
Olive/ -	0.0	0.0	0.0	11.0	0.8	2.2	72.5	7.9	0.6	0.3	14.1	85.9	6.08	86	7.9	0.6	8,750	8,400	5,360
Palm/ -	0.0	0.1	1.0	43.5	0.3	4.3	36.6	9.1	0.2	0.1	51.6	48.4	0.94	50	9.1	0.2	8,010	7,690	4,935
Peanut/ 4-03-658	0.0	0.0	0.1	9.5	0.1	2.2	44.8	32.0	-	6.4	17.8	82.2	4.63	92	32.0	0.0	8,735	8,385	5,350
Saffower 4-20-526	0.0	0.0	0.1	6.2	0.4	2.3	11.7	74.1	0.4	-	9.5	90.5	9.52	140	74.1	0.4	8,760	8,410	5,365
Sesame/ -	0.0	0.0	0.0	8.9	0.2	4.8	39.3	41.3	0.3	0.2	14.8	85.2	5.73	110	41.3	0.3	8,750	8,400	5,360
Soybean/ 4-07-983	0.0	0.0	0.1	10.3	0.2	3.8	22.8	51.0	6.8	0.2	15.1	84.9	5.84	130	51.0	6.8	8,750	8,400	5,360
Sunflower/ 4-20-833	0.0	0.0	0.0	5.4	0.2	3.5	45.3	39.8	0.2	-	10.6	89.4	8.47	133	39.8	0.2	8,760	8,410	5,365

[a]Dash indicates that no data were available.

[b]The fatty acid data were obtained from Pearl (1995) of the Fats and Protein Research Foundation and USDA Food Composition Standard Release 11 (1997). Values for fatty acid content do not always total 100% but represent means as obtained from various fat analysis conducted by gas-liquid chromatography.

[c]Calculated by the following relationship (Powles et al., 1995): DE (kcal/kg) = (36.898 -(0.005 X FFA) - (7.330 X $e^{-0.906xU:S}$))/4.184 where FFA is the free fatty acid content in g/kg and U:S is the ratio of unsaturated to saturated fatty acids. In calculating the DE, the free fatty acid concentrations of all fats were assumed to be 50 g/kg (or 5%).

[d]Calculated as 96% of DE.

[e]Calculated by Equation 1-12 in Chapter 1 of NRC (1998).

[f]Coconut oil was considered outside the range of the data used to develnp the relationship in footnote c. The DE concentration of coconut oil was calculated from the digestibility (89.42% of GE) reported by Cera et al. (1989) for pigs from 2 to 4 weeks after weaning at 3 weeks of age.