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Rumen Escape Protein of some Dairy Feedstuffs

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Dairy cattle require dietary energy and protein to meet the requirements of their ruminal populations of microorganisms. If ruminal microorganisms, particularly bacteria, become energy or protein deficient, then their growth and fermentative activity can be restricted leading to reduced digestion of structural carbohydrates (i.e., fiber) and declining levels of feed intake. These microorganisms, which die and wash out of the rumen to the small intestine, generally provide 40 to 60% of the protein which is absorbed from the small intestine of lactating dairy cows to meet their requirements for intestinally absorbable protein. To allow dairy cows with high milk production capability to achieve their high genetic potential, it is necessary to provide dietary ingredients with proteins that escape the rumen undegraded, to be digested from the small intestine, in order to fill the deficit between the animal's protein requirement and the protein supplied by rumen microorganisms.

Unfortunately, the proportion of the protein in a particular feedstuff that escapes the rumen undegraded cannot be chemically analyzed, as can feedstuff components such as crude protein and ADF. This is because the net degradability of a protein source in the rumen is a function of the nature of its protein (i.e., the more resistant it is to microbial degradation in the rumen, the more of it will escape the rumen undegraded), how long it stays in the rumen (i.e., the longer it stays in the rumen, the more of it will be degraded), as well as the size of the microbial population relative to the protein available for degradation in the rumen (i.e., the higher the microbe/feed protein ratio, the more of it will be degraded). These factors vary both within and among feedstuffs and rations due to factors such as the source of the feedstuff, the balance of rumen available protein to energy, and the amount of feed consumed.

Purpose

The purpose of this article is to provide information on the estimated undegraded intake protein (UIP) proportion of several feedstuffs fed to dairy cattle as well as the digestible portion of this UIP (i.e., DigUIP). In addition, the attached table shows the impact of level of feed intake on the estimated UIP and DigUIP proportion of the feedstuffs, by presenting separate values for use in High and Mid String dairy cows.

Methods Used

Feedstuff analytical data presented come from a variety of published and unpublished sources. The calculations to estimate the UIP and DigUIP proportions of the feedstuffs integrate estimated rumen rates of digestion and passage and how they are affected by level of feed intake. Values presented should only be considered as guides to the values that occur in specific lots of feedstuffs.

Use of the Data

The data presented in the tables can be utilized in preparing, or evaluating, rations for dairy cattle under situations where the requirements of the animals for intestinally absorbable protein have been estimated. However, feedstuffs are generally variable in their composition among and within sources. For this reason, the values presented should be only be considered as a guide. There is no substitute for analysis of specific feedstuffs if high accuracy of the predicted UIP and DigUIP levels is desired.

Evaluating Specific Lots of Feedstuffs

The author strongly urges that individual lots of feedstuffs for use on specific dairy ranches be analyzed for total CP, soluble CP and bound CP in order to allow accurate estimation of their UIP and DigUIP proportions. In general, increasing levels of soluble CP will decrease the UIP and DigUIP values versus those listed, and increasing levels of bound protein will increase the UIP value but decrease its digestibility. If you desire more specific estimates of the UIP and DigUIP values of specific samples, or if the analysis of specific samples diverges greatly from the tabular values, then contact your UCCE Dairy Advisor or the author.

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Protein Fractions of some Feedstuffs for Dairy Cattle

| | DM % | Fat ----- | NDF % DM | NFC | Crude Protein | | | High Strings | | Mid Strings | |
|---------------------------------|---------|--------------|-------------|-----|---------------|---------|-------|--------------|--------|-------------|--------|
| | | | | | Total | Soluble | Bound | UIP | DigUIP | UIP | DigUIP |
| | | | | | | | | % CP | | | |
| Forages | | | | | | | | | | | |
| Barley hay | 88 | 2.0 | 65 | 15 | 10.5 | 20 | 5 | 34 | 29 | 33 | 28 |
| Barley silage (HQ) | 35 | 2.0 | 55 | 19 | 16.0 | 60 | 5 | 17 | 12 | 17 | 12 |
| Barley silage (LQ) | 35 | 2.0 | 60 | 19 | 11.5 | 50 | 6 | 22 | 16 | 22 | 16 |
| Corn/sun silage | 30 | 4.0 | 65 | 8 | 9.7 | 55 | 7 | 33 | 26 | 33 | 26 |
| Corn sil (30-40% gr) | 30 | 2.0 | 55 | 22 | 9.1 | 58 | 5 | 30 | 25 | 30 | 25 |
| Corn sil (30-40% gr) | 30 | 2.0 | 45 | 32 | 8.9 | 55 | 6 | 33 | 27 | 33 | 27 |
| Grass hay (HQ) | 88 | 2.0 | 60 | 16 | 16.0 | 25 | 6 | 27 | 21 | 27 | 21 |
| Grass hay (MQ) | 88 | 2.0 | 65 | 15 | 12.0 | 20 | 7 | 33 | 26 | 33 | 26 |
| Grass hay (LQ) | 88 | 2.0 | 70 | 14 | 8.0 | 15 | 8 | 38 | 30 | 38 | 30 |
| Grass silage (HQ) | 40 | 2.0 | 55 | 21 | 16.0 | 55 | 6 | 19 | 13 | 19 | 13 |
| Grass silage (MQ) | 40 | 2.0 | 60 | 20 | 12.0 | 50 | 7 | 21 | 14 | 21 | 14 |
| Grass silage (LQ) | 40 | 2.0 | 65 | 19 | 8.0 | 45 | 8 | 23 | 15 | 23 | 15 |
| Legume hay (PQ) | 88 | 2.5 | 37 | 27 | 25.0 | 30 | 6 | 21 | 15 | 21 | 15 |
| Legume hay (HQ) | 88 | 2.5 | 40 | 29 | 20.0 | 25 | 7 | 24 | 17 | 25 | 18 |
| Legume hay (MQ) | 88 | 2.5 | 45 | 29 | 15.0 | 20 | 8 | 28 | 20 | 29 | 21 |
| Legume hay (LQ) | 88 | 2.5 | 50 | 29 | 10.0 | 15 | 9 | 34 | 25 | 34 | 25 |
| Legume sil (PQ) | 35 | 2.5 | 37 | 27 | 25.0 | 65 | 7 | 16 | 9 | 16 | 9 |
| Legume sil (HQ) | 35 | 2.5 | 40 | 29 | 20.0 | 60 | 8 | 19 | 11 | 19 | 11 |
| Legume sil (MQ) | 35 | 2.5 | 45 | 29 | 15.0 | 55 | 9 | 22 | 13 | 22 | 13 |
| Legume sil (LQ) | 35 | 2.5 | 50 | 29 | 10.0 | 50 | 10 | 25 | 15 | 25 | 15 |
| Oat hay | 88 | 3.0 | 65 | 14 | 10.5 | 20 | 5 | 34 | 29 | 33 | 28 |
| Oat silage (HQ) | 35 | 3.0 | 55 | 18 | 16.0 | 60 | 5 | 17 | 12 | 17 | 12 |
| Oat silae (LQ) | 35 | 3.0 | 60 | 18 | 11.5 | 50 | 6 | 22 | 16 | 22 | 16 |
| Sudan hay | 88 | 2.0 | 70 | 8 | 11.0 | 15 | 5 | 37 | 32 | 36 | 31 |
| Sudan silage | 35 | 2.0 | 70 | 8 | 11.0 | 50 | 7 | 21 | 14 | 20 | 13 |
| Plant Source By-Products | | | | | | | | | | | |
| Alfalfa pellets (dehy) | 88 | 3.0 | 45 | 23 | 18.9 | 26 | 15 | 46 | 31 | 43 | 28 |
| Almond hulls | 88 | 3.0 | 45 | 40 | 6.0 | 10 | 30 | 64 | 34 | 60 | 30 |
| Almond shells | 88 | 2.0 | 35 | 53 | 2.5 | 5 | 40 | 71 | 31 | 67 | 27 |
| Apple pomace | 85 | 5.0 | 45 | 41 | 5.4 | 11 | 32 | 55 | 23 | 52 | 20 |
| Bakery waste | 88 | 13.0 | 22 | 50 | 10.7 | 40 | 3 | 26 | 23 | 23 | 20 |
| Beet pulp (dehy) | 88 | 0.5 | 50 | 35 | 9.9 | 26 | 7 | 38 | 31 | 35 | 28 |
| Beet pulp (HM) | 25 | 0.5 | 50 | 34 | 11.0 | 35 | 7 | 36 | 29 | 33 | 26 |
| Brewers grns (dehy) | 88 | 6.0 | 45 | 17 | 27.4 | 8 | 10 | 46 | 36 | 42 | 32 |
| Brewers grns (HM) | 25 | 6.0 | 45 | 15 | 29.2 | 17 | 8 | 37 | 29 | 34 | 26 |
| Carrots (tubers/fresh) | 12 | 1.4 | 9 | 72 | 9.9 | 25 | 5 | 33 | 28 | 30 | 25 |
| Citrus pulp (dehy) | 88 | 4.0 | 23 | 59 | 6.7 | 25 | 8 | 38 | 30 | 33 | 25 |
| Citrus pulp (HM) | 25 | 8.0 | 23 | 57 | 6.4 | 25 | 8 | 39 | 31 | 34 | 26 |
| Citrus peel silage | 12 | 2.0 | 30 | 53 | 9.1 | 25 | 8 | 39 | 31 | 34 | 26 |
| Cottonseed hulls | 88 | 2.0 | 85 | 6 | 4.5 | 20 | 15 | 52 | 37 | 47 | 32 |
| Corn (hominy) | 88 | 7.0 | 55 | 24 | 11.5 | 18 | 3 | 53 | 50 | 49 | 46 |
| Corn gluten fd (HM) | 40 | 2.4 | 31 | 35 | 25.6 | 55 | 3 | 24 | 21 | 21 | 18 |
| Dist grn, crn/dehy/sol | 88 | 10.0 | 45 | 7 | 28.0 | 28 | 6 | 44 | 38 | 41 | 35 |
| Dist grn, wht/dehy/sol | 88 | 10.0 | 45 | 1 | 34.0 | 14 | 6 | 52 | 46 | 49 | 43 |

| | DM % | Fat ----- | NDF % DM | NFC ----- | Crude Protein | | | High Strings | | Mid Strings | |
|---------------------|---------|--------------|-------------|--------------|---------------|---------|-------|--------------|--------|-------------|--------|
| | | | | | Total | Soluble | Bound | UIP | DigUIP | UIP | DigUIP |
| | | | | | | | | % CP | | | |
| Grape pomace | 85 | 8.0 | 55 | 13 | 14.0 | 15 | 30 | 52 | 22 | 50 | 20 |
| Soybean hulls | 88 | 2.0 | 65 | 16 | 12.1 | 18 | 12 | 34 | 22 | 31 | 19 |
| Tomato pomace | 85 | 10.0 | 45 | 19 | 19.0 | 15 | 15 | 43 | 28 | 40 | 25 |
| Wheat (bran) | 88 | 4.5 | 50 | 23 | 15.1 | 35 | 4 | 13 | 9 | 12 | 8 |
| Wheat (middlings) | 88 | 5.0 | 32 | 39 | 19.4 | 40 | 2 | 18 | 16 | 15 | 13 |
| Wheat (millrun) | 88 | 4.5 | 34 | 39 | 17.0 | 50 | 3 | 16 | 13 | 13 | 10 |
| Wheat (millrun/fat) | 88 | 20.0 | 29 | 31 | 14.5 | 50 | 3 | 16 | 13 | 13 | 10 |
| Wheat (shorts) | 88 | 5.0 | 35 | 37 | 18.0 | 40 | 5 | 14 | 9 | 11 | 6 |

Grains

| | | | | | | | | | | | |
|--------------------|----|-----|----|----|------|----|---|----|----|----|----|
| Barley (HM/rolled) | 50 | 2.0 | 16 | 66 | 13.5 | 28 | 6 | 29 | 23 | 26 | 20 |
| Barley (ground) | 88 | 2.0 | 15 | 67 | 13.0 | 24 | 3 | 24 | 21 | 20 | 17 |
| Barley (rolled) | 88 | 2.0 | 15 | 67 | 13.0 | 22 | 3 | 24 | 21 | 20 | 17 |
| Barley (SR) | 84 | 2.0 | 15 | 67 | 13.0 | 30 | 7 | 38 | 31 | 34 | 27 |
| Corn (HM ear) | 50 | 4.0 | 28 | 57 | 9.5 | 60 | 8 | 33 | 25 | 32 | 24 |
| Corn (HM rolled) | 50 | 4.5 | 12 | 71 | 10.1 | 22 | 2 | 40 | 38 | 37 | 35 |
| Corn (HM whole) | 50 | 4.5 | 12 | 71 | 10.1 | 18 | 2 | 40 | 38 | 36 | 34 |
| Corn (cracked) | 88 | 4.5 | 12 | 71 | 10.1 | 16 | 1 | 64 | 63 | 59 | 58 |
| Corn (ground) | 88 | 4.5 | 12 | 71 | 10.1 | 18 | 1 | 62 | 61 | 56 | 55 |
| Corn (SR) | 84 | 4.5 | 12 | 71 | 10.1 | 24 | 4 | 53 | 49 | 49 | 45 |
| Milo (HM) | 50 | 6.0 | 23 | 56 | 12.5 | 30 | 5 | 45 | 40 | 41 | 36 |
| Milo (ground) | 88 | 6.0 | 23 | 56 | 12.5 | 15 | 4 | 58 | 54 | 53 | 49 |
| Oats (ground) | 88 | 5.5 | 24 | 56 | 11.3 | 35 | 4 | 20 | 16 | 17 | 13 |
| Oats (rolled) | 88 | 5.5 | 24 | 56 | 11.3 | 25 | 5 | 22 | 17 | 18 | 13 |
| Rye (ground) | 88 | 1.5 | 14 | 71 | 12.0 | 36 | 2 | 13 | 11 | 11 | 9 |
| Rye (rolled) | 88 | 1.5 | 14 | 71 | 12.0 | 31 | 3 | 14 | 11 | 12 | 9 |
| Triticale (ground) | 88 | 1.5 | 14 | 69 | 13.5 | 50 | 3 | 10 | 7 | 9 | 6 |
| Triticale (rolled) | 88 | 1.5 | 14 | 69 | 13.5 | 45 | 4 | 11 | 7 | 10 | 6 |
| Wheat (ground) | 88 | 2.0 | 12 | 70 | 14.0 | 35 | 2 | 14 | 12 | 12 | 10 |
| Wheat (rolled) | 88 | 2.0 | 12 | 70 | 14.0 | 30 | 3 | 15 | 12 | 13 | 10 |

Plant Protein Meals

| | | | | | | | | | | | |
|------------------------|----|------|----|----|------|----|---|----|----|----|----|
| Canola meal (sol) | 88 | 2.0 | 22 | 31 | 38.4 | 25 | 4 | 35 | 31 | 30 | 26 |
| Corn gluten feed | 88 | 2.5 | 45 | 20 | 25.6 | 45 | 3 | 36 | 33 | 32 | 29 |
| Corn gluten meal | 88 | 2.5 | 5 | 24 | 65.9 | 4 | 2 | 80 | 78 | 75 | 73 |
| Cottonsd meal (sol) | 88 | 1.5 | 30 | 18 | 44.8 | 20 | 2 | 36 | 34 | 32 | 30 |
| Linseed meal (exp) | 88 | 6.5 | 26 | 32 | 30.0 | 14 | 7 | 51 | 44 | 44 | 37 |
| Linseed meal (sol) | 88 | 1.5 | 25 | 36 | 32.0 | 22 | 4 | 38 | 34 | 33 | 29 |
| Palm kernal meal | 92 | 11.0 | 64 | 3 | 17.2 | 20 | 3 | 25 | 22 | 23 | 20 |
| Potato meal (dehy) | 88 | 0.5 | 18 | 68 | 10.5 | 37 | 7 | 32 | 25 | 28 | 21 |
| Saff'r meal (20CP/sol) | 88 | 1.5 | 6 | 63 | 23.5 | 20 | 8 | 38 | 30 | 34 | 26 |
| Saff'r meal (42CP/sol) | 88 | 1.5 | 6 | 38 | 46.5 | 30 | 4 | 31 | 27 | 27 | 23 |
| Soymeal (44CP/sol) | 88 | 1.5 | 6 | 37 | 48.9 | 16 | 2 | 36 | 34 | 31 | 29 |
| Soymeal (49CP/exp) | 88 | 5.0 | 6 | 28 | 54.0 | 14 | 3 | 45 | 42 | 40 | 37 |
| Soymeal (49CP/sol) | 88 | 1.5 | 6 | 32 | 54.0 | 18 | 1 | 34 | 33 | 30 | 29 |
| Soymeal (chem trt) | 88 | 1.5 | 8 | 34 | 50.0 | 8 | 1 | 59 | 58 | 53 | 52 |
| Sunflower meal (sol) | 88 | 1.5 | 40 | 20 | 32.9 | 20 | 3 | 25 | 22 | 22 | 19 |

| | DM % | Fat ----- | NDF % DM | NFC ----- | Crude Protein | | | High Strings | | Mid Strings | |
|--|---------|--------------|-------------|--------------|---------------|---------|-------|--------------|--------|-------------|--------|
| | | | | | Total | Soluble | Bound | UIP | DigUIP | UIP | DigUIP |
| | | | | | | | | % CP | | | |

Animal and Marine Protein Meals

| | | | | | | | | | | | |
|-----------------------|----|-----|---|---|------|----|----|----|----|----|----|
| Blood meal (ring dry) | 88 | 1.5 | 0 | 3 | 89.2 | 2 | 3 | 84 | 81 | 80 | 77 |
| Feather meal (hyd) | 88 | 3.0 | 0 | 5 | 88.0 | 12 | 17 | 81 | 64 | 77 | 60 |
| Fish meal (hi sol CP) | 88 | 6.0 | 0 | 2 | 74.0 | 40 | 8 | 45 | 37 | 42 | 34 |
| Fish meal (lo sol CP) | 88 | 6.0 | 0 | 2 | 74.0 | 10 | 8 | 59 | 51 | 56 | 48 |

Whole Seeds

| | | | | | | | | | | | |
|-----------------------------|----|------|----|----|------|----|----|----|----|----|----|
| Cottonseed (<u>w</u> lint) | 88 | 20.0 | 45 | 7 | 23.0 | 14 | 6 | 34 | 28 | 30 | 24 |
| Canola seed | 88 | 16.0 | 28 | 33 | 20.0 | 20 | 4 | 35 | 31 | 30 | 26 |
| Flax seed | 88 | 10.0 | 25 | 39 | 23.0 | 25 | 10 | 32 | 22 | 29 | 19 |
| Lupins (ground) | 88 | 8.0 | 20 | 37 | 30.0 | 60 | 1 | 14 | 13 | 13 | 12 |
| Lupins (rst/ground) | 94 | 8.0 | 22 | 35 | 30.0 | 40 | 2 | 27 | 25 | 24 | 22 |
| Peas (ground) | 88 | 1.5 | 18 | 56 | 21.3 | 56 | 1 | 9 | 8 | 8 | 7 |
| Soybeans (extruded) | 88 | 18.0 | 10 | 29 | 38.1 | 15 | 2 | 49 | 47 | 43 | 41 |
| Soybeans (mic'nized) | 92 | 18.0 | 12 | 27 | 38.1 | 40 | 2 | 18 | 16 | 16 | 14 |
| Soybeans (raw/grnd) | 88 | 18.0 | 8 | 33 | 36.0 | 40 | 1 | 16 | 15 | 13 | 12 |
| Soybeans (rst/ground) | 94 | 18.0 | 8 | 26 | 42.8 | 7 | 4 | 45 | 41 | 41 | 37 |
| Soybeans (rst/whole) | 94 | 18.0 | 8 | 26 | 42.8 | 2 | 5 | 52 | 47 | 47 | 42 |

Miscellaneous Ingredients

| | | | | | | | | | | | |
|------------------------|----|------|----|----|-------|-----|---|----|---|---|---|
| Casein (dehy) | 96 | 1.0 | 0 | 4 | 92.7 | 100 | 0 | 0 | 0 | 0 | 0 |
| Fat (animal) | 98 | 99.0 | 0 | 0 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fat (vegetable) | 98 | 99.0 | 0 | 0 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fat (rumen prot) | 98 | 80.0 | 0 | 20 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Molasses (liquid) | 98 | 0.5 | 0 | 82 | 9.8 | 100 | 0 | 0 | 0 | 0 | 0 |
| Potatoes (tubers/frsh) | 25 | 0.5 | 10 | 75 | 9.5 | 70 | 1 | 10 | 9 | 9 | 8 |
| Urea | 99 | 0.0 | 0 | 0 | 281.0 | 100 | 0 | 0 | 0 | 0 | 0 |
| Whey (dehy) | 96 | 0.5 | 0 | 72 | 18.0 | 90 | 1 | 4 | 3 | 1 | 0 |
| Whey perm'te (liquid) | 12 | 3.0 | 6 | 63 | 13.1 | 95 | 1 | 3 | 3 | 1 | 0 |

Ingredients Not Commonly Fed in the US or Illegal for Dairy Cows in the US

| | | | | | | | | | | | |
|-----------------------|----|-----|---|---|------|----|----|----|----|----|----|
| Blood meal (drum dry) | 88 | 1.5 | 0 | 3 | 89.2 | 1 | 45 | 88 | 43 | 84 | 39 |
| Meatmeal (hi solCP) | 88 | 9.0 | 0 | 8 | 56.0 | 35 | 21 | 47 | 26 | 45 | 24 |
| Meatmeal (lo solCP) | 88 | 9.0 | 0 | 8 | 56.0 | 15 | 21 | 57 | 36 | 55 | 34 |

| | | | |
|--------|--------------|---|---|
| Notes: | DM | = | dry matter |
| | NDF | = | neutral detergent fiber |
| | NFC | = | non fiber carbohydrate |
| | Soluble | = | crude protein immediately solubilized in the rumen |
| | Bound | = | crude protein that is indigestible in the entire digestive tract |
| | UIP | = | undegraded intake protein -- > protein not degraded in the rumen |
| | DigUIP | = | digestible undegraded intake protein -- > protein not degraded in the rumen that is digested in the intestine |
| | High Strings | = | cows eating 58 lbs of DM/d (26 kg) |
| | Low Strings | = | cows eating about 49 lbs of DM/d (22 kg) |