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Director's Digest

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ACHIEVEMENT OF OPTIMUM AMINO ACID BALANCE POSSIBLE

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In protein feeding of dairy cattle, the industry and scientific communities are striving for a more complete application of basic nutritional concepts. Protein is an expensive component of the dairy cow's diet and limitations or excesses can seriously affect production and/or herd health. The goal is to provide the proper complement of essential amino acids at tissue levels for support of all physiological functions.

Much progress has been made in our understanding of the need to consider protein as rumen degradable and undegradable. The 1988 National Research Council (NRC) (4) presents extensive information on the needs of these two pools of protein and limited data on the characteristics of individual feed ingredients.

It is only logical that amino acid quality of the undegradable protein fraction must be of importance since the primary reason for emphasis on undegradable protein is the provision of certain essential amino acids at tissue levels. In a recent issue of FEEDSTUFFS, Cornell works (3) presented an excellent study relating to predictions of amino acid needs and the amounts supplied. The primary purpose of this article is to expand on that concept from the point of view of field application and to discuss the features

of certain ingredients that might have application in achieving better amino acid nutrition.

Rumen undegraded protein

The first step in addressing amino acid nutrition is to project the protein that escapes rumen fermentation. This requires a valid data base for feed ingredients and a reliable chemical assay to update variable feed ingredients that are encountered. Chemical techniques for protein solubility in borate-phosphate buffer and protein degradability *in vitro* using protease from *Streptomyces griseus* type V have been applied very effectively by Mantysaari and Sniffen (2). However, the feed/forage testing industry has not developed to the extent that we could expect reliable results from all assays reported in this area.

The 1988 NRC Table 7-3 (4) provides limited information on escape feed protein. Table 1 presents a summary of some of the more common ingredients. One very significant point to recognize is the amount of variation associated with individual feed ingredients. For example, even though fish meal is a rather undegradable feed protein with 60% escaping rumen fermentation, the variation is such that values could easily run from 44 to 76% escape. Mantysaari and Sniffen (2) presented extensive amounts of variation resulting from fish meal assays and pointed out that the main variables were amounts of solubles returned to fish meal prior to drying as well as the freshness of the fish meal prior to pressing. Specific examples in the NRC table show well-preserved fish meal to be 78% escape, while stale fish meal is only 48%. Obviously the quality of the meal will have a strong influence on the amount that escapes rumen fermentation.

Another interesting example is with soybean meal. The average of 39 samples provides a rumen escape of 35% with a standard deviation of 12%. The amount of soybean protein to escape is directly correlated with heating during processing. Unheated soybean meal protein showed an escape value of 14% whereas when heated to 120°C, 130°C and 140°C, the escape values were 59, 71 and 82%, respectively. It is apparent that a large amount of the variation noted in the 39 samples of soybean meal is due to variations in heating during

processing. It should also be noted that proper heating of bean meal can result in a very effective rumen escape protein.

Amino acid quality

The choice of the proper feed protein for the supply of rumen escape protein is not only dependent on its extent of rumen degradability, but also its amino acid content. In the model of the Cornell workers (3) it was shown that in order to satisfy the projected needs for 85 lb. production, a crude protein content of 17.4%, with 34% undegradable and 50.78 lb. dry matter intake, was necessary. With the supplemental undegradable protein provided from corn gluten meal or fish meal, there were several essential amino acids found to be limiting. The most limiting amino acids of both diets were isoleucine (54%), valine (38%) and leucine (29%). Arginine and methionine showed a 28% and 16% deficiency, respectively.

The classical approach to evaluating amino acid quality of individual feed ingredients is the chemical score and resulting essential amino acid index as developed by Oser (5). Rather than using whole egg protein as the reference, the values of milk protein, corrected for the metabolic utilization efficiency coefficients of absorbed amino acids as quoted by Cornell (3) were used.

Table 2, derived from the amino acid composition of feed ingredients as tabulated by Allen (1) and data used in the Cornell model (3), presents the resulting chemical scores for several escape feed proteins as well as rumen microbes. All scores greater than 100 were assigned values of 100, as that protein source was given credit for only 100% supply of a particular essential amino acid.

The resulting Essential Amino Acid Index, along with the first three limiting amino acids according to chemical score, is given in Table 3.

Based on the chemical scores and the resulting Essential Amino Acid Index, rumen microbial protein exhibits superior biological value over all of the potential escape protein sources. Chemical scores would suggest that rumen microbial protein is deficient in leucine, isoleucine and valine. It is interesting to note that based on the model of the Cornell workers (3), these same amino acids were found to be limited. More than adequate ratios were present for threonine and lysine. Of the feed protein sources considered, soybean protein had the highest biological value. This points to the possible success of using soybean protein that has had proper heat treatment.

The rumen escape protein source should be strong in those amino acids that are limiting in rumen microbial protein. Therefore, according to this approach, it would be desirable to supply escape protein sources that are highest in leucine, isoleucine and valine. Among the protein sources studied, corn gluten meal excels in leucine, brewers grain in isoleucine and blood meal in valine. No single protein source studied provides an optimum complement for all the limitations of rumen microbial protein.

This approach has one obvious limitation in that it is assumed that the escape protein has the identical amino acid content to that of the original feed protein. That assumption is not valid as pointed out by Mantysaari, et. al. (3). Based upon the amino acid profile of the original feed protein to that of the residual feed protein following in vitro treatment, the amino acid profile changes according to protein source and amino acid. Over all protein sources there was approximately a 12% increase in the concentration of leucine, isoleucine and valine in the escape protein, compared with that of the original feed protein. Among all protein sources the escape protein was approximately equal to the feed protein for the amino acids of methionine, trytophan and histidine. Of those amino acid sources that showed reduction in the escape protein, lysine was by far the greatest, with an approximate reduction of 7% over all protein sources. Thus the degree of amino acid limitation as pointed out for leucine, isoleucine and valine may be overcome somewhat through a higher concentration of these amino acids in the rumen escape protein. Likewise, the degree of adequacy that is noted for an amino acid such as lysine could be moderated by a reduction of this amino acid in the escape protein.

Another point for consideration is that this approach considers only the biological quality of escape protein relative to milk protein. The needs for support of maintenance, growth and reproduction are ignored. But when evaluations are made for lactating dairy animals, this should not be a serious problem since the needs for lactation far exceed the sum of all other physiological functions.

Conclusion

Before extensive field applications of biological value of escape protein can be made, much additional research information is required. The use of factors of essential amino acids must be fully determined for cows at high levels of

milk yield. One of the reasons that this approach places so much emphasis on limitations of leucine, isoleucine and value is that their use is considered 60-70%, while amino acids such as methionine, lysine and phenylalanine are considered at 90-100%.

Because of the large amount of variation present in the escape factors within specific classes of ingredients, rapid and reliable assay procedures must be adopted by the feed testing industry to support any feed programming from this point of view. Industry suppliers of potential escape protein sources must tune their processing and production procedures to produce a uniform product that provides the "correct" amino acid profile. It seems at this point that a blend of several protein sources will be superior to any one protein source.

Because of the apparent overall superior quality of rumen microbial protein relative to the amino acid needs for milk protein, the importance of maximization of rumen microbial production is stressed. Any feed or management factor that reduces overall rumen fermentation can seriously alter the essential amino balance present at tissue levels. Based on our current understanding of amino acid quality of escape protein sources, it seeems that an amino acid loss from rumen microbial protein will be difficult to correct with escape protein. It seems likely that the many field observations of reduced milk protein content from herds fed high fat ingredients or direct additions of fat may be due to reduced rumen microbial growth and the alteration in amino acids at tissue levels.

REFERENCES

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(4) National Research Council, 1988. Nutritional Requirements of Dairy Cattle, Sixth Edition. National Academy Press, Washington, D. C.

(5) Osar, B. L. 1951. Methods of Integrating Essential Amino Acid Content in the Nutritional Evaluation of Protein. J. Amer. Dietetic Assn., 27:396.

TABLE 1. Classification of feeds by ruminal undegradability

Feed	Number of samples	Protein undegradability			
		Mean	S.D.	- S.D.	+ S.D.
High (>0.50)					
Blood Meal	2	0.82	0.01	0.81	0.83
Meat Meal	1	0.76	-	-	-
Feather Meal	1	0.71	-	-	-
Coconut Meal	5	0.63	0.07	0.56	0.70
Fish Meal	26	0.60	0.16	0.44	0.76
Alfalfa, dehydrated	8	0.59	0.17	0.42	0.76
Corn gluten meal	3	0.55	0.08	0.47	0.63
Medium (>.30<.60)					
Meat and bone meal	5	0.49	0.18	0.31	0.67
Brewers grains	9	0.49	0.13	0.36	0.62
Distillers, with sol.	4	0.47	0.18	0.29	0.65
Cottonseed meal	21	0.43	0.11	0.32	0.54
Soybean meal	39	0.35	0.12	0.23	0.47
Low (>.30)					
Wheat bran	4	0.29	0.10	0.19	0.39
Rapeseed meal	10	0.28	0.09	0.19	0.37
Peanut meal	8	0.25	0.11	0.14	0.36
Alfalfa silage	6	0.23	0.08	0.13	0.31
Corn gluten feed	2	0.22	0.11	0.11	0.33
Wheat middlings	3	0.21	0.02	0.19	0.23

TABLE 2. Chemical scores of protein sources - related to milk protein

Protein Source	HIS	PHE	LEU	THR	MET	ARG	VAL	ILE	TRP	LYS
Blood Meal	100	100	93	86	45	33	70	10	76	91
Fish Meal	77	69	58	68	100	59	59	47	71	80
Feather Meal	11	59	66	59	23	32	38	32	29	13
Meat Meal	67	65	46	59	49	76	51	36	39	58
Meat & Bone Meal	64	64	46	59	49	76	48	35	32	55
Corn Gluten Meal	67	100	100	60	100	36	48	40	30	18
Alfalfa Meal, dehy	69	100	55	80	60	50	66	51	100	46
Brewers grain	56	100	83	65	78	53	65	74	87	34
Distillers w/sol	74	84	72	63	81	42	53	38	45	24
Soybean Meal	89	100	56	74	56	89	60	55	75	70
Microbes	90	97	54	100	97	79	66	61	99	100

TABLE 3. Essential amino acid index and limiting amino acid by chemical store

Protein Source	EAA (index)	--------(Limiting amino acid)--------		
Blood Meal	60	ILE (10)	ARG (33)	MET (44)
Fish Meal	68	ILE (47)	LEV (58)	VAL (59)
Feather Meal	34	HIS (11)	LYS (13)	MET (23)
Meat Meal	53	ILE (36)	TRP (39)	LEU (46)
Meat & Bone Meal	51	TRP (82)	ILS (35)	LEU (46)
Corn Gluten Meal	52	LYS (18)	TRP (30)	ARG (36)
Alfalfa Meal, dehy	65	LYS (46)	ILE (51)	ARG (30)
Brewers grain	67	LYS (34)	ARG (53)	HIS (56)
Distillers with sol.	54	LYS (24)	ILE (38)	ARG (42)
Soybean Meal	71	ILE (55)	LEU (56)	MET (56)
Microbes	82	LEU (54)	ILE (61)	VAL (66)