Laboratory Evaluation of By-product Liquid Feed Ingredients

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Story in Brief

Nine by-product, liquid feed ingredients were evaluated for protein content, nonprotein nitrogen content, solubility in buffer solution and *in vitro* release of ammonia-nitrogen in rumen fluid. Soybean meal and urea were used as controls. Ingredients with the highest NPN content tended to be more soluble and produce the highest levels of rumen ammonia. Condensed distillers' solubles, condensed whey, liquid yeast and, to a lesser extent, corn steep liquor were relatively high in natural protein and produced *in vitro* ammonia-nitrogen levels more similar to soybean meal than to urea. Ammonia-nitrogen levels from lignin sulfonate, dynoferm, condensed molasses solubles and fermentation end liquor were not significantly different from urea after 1-hr incubation in rumen fluid but produced lower ammonia-nitrogen levels than urea after 4-hr incubation.

Introduction

Liquid supplements today contain a variety of ingredients, many of which are by-products from the manufacture of food products, alcoholic beverages and other fermentation processes. The increased use of these types of ingredients has been due to several factors, among which are the high cost of molasses, poor results from feeding urea-molasses liquid feeds and environmental regulations prohibiting the dumping of waste products.

Little is known about the composition of many liquid ingredients. If the protein is primarily microbial in origin, some by-products could be excellent protein sources for range cows. On the other hand, by-products with mostly highly soluble nonprotein nitrogen (NPN) might be little better than urea for cows grazing low quality roughages.

The objective of this research was to evaluate nine common liquid feed ingredients for nitrogen form (protein or NPN), nitrogen solubility and nitrogen breakdown in rumen fluid. Two products from the nine would be selected for further study with range cows.

Experimental Procedures

The following paragraphs briefly describe the liquid ingredients used in this study.

Corn steep liquor (CSL) or condensed fermented corn extractives are obtained by the partial removal of water from the liquid resulting from steeping corn in water and sulfur dioxide solution, which is allowed to ferment with lactic acid-producing organisms during the wet milling of corn. The CSL is 30 to 60 percent dry matter, up to 50 percent crude protein on a dry matter basis and contains the soluble portion of the corn kernel together with microorganisms from the fermentation process.

Whey is the by-product of the manufacture of cheese, casein and other sour milk products. It has a high sugar content but is only about 7 percent dry matter. Whey may be condensed to 35 to 65 percent dry matter.

Lignin sulfonate (LS) is a phenolic product from the paper pulping industry. It will contain 50 to 55 percent dry matter, which will consist of 40 to 50 percent lignin, 10 to 25 percent sugars and 12 to 25 percent NPN.

Condensed molasses solubles (CMS) are the residue from molasses used in various fermentations to produce alcohol, bakers' yeast, citric acid, monosodium glutamate, etc. On an "as is" basis, CMS contains 65 to 75 percent dry matter of which 4 to 5 percent is nitrogen. The CMS used in this study is a commercial mixture from ethyl alcohol and glutamic acid production.

Condensed distillers' solubles (CDS) are obtained after the removal of ethyl alcohol from yeast fermentation of grains. Distillers' solubles may contain up to 30 percent protein but are relatively low in dry matter (30 to 35 percent).

Brewers' liquid yeast (LY) is a by-product of the brewing of beer and ale, containing about 35 percent crude protein on a dry basis. Brewers' yeast, however, is low in dry matter.

Condensed Steffens' filtrate (CSF) is produced by concentrating the filtrate resulting from the precipitation of calcium sucrate in treatment of beet molasses to recover additional sugar.

Glutamic acid fermentation end liquor (FEL) was produced by splitting glutamic acid from beet molasses. This is actually one form of CMS. Dynaferm (DF) is a trade name for FEL that has been ammoniated to raise the pH to reduce damage to metal equipment and storage facilities.

Laboratory evaluation of liquid supplement ingredients was conducted by the following procedures, beginning with nitrogen solubility in pH 6.5 buffer solution (Johnson, 1969). Nonprotein nitrogen was determined by precipitating protein from the soluble nitrogen fraction with tungstic acid. Soluble protein represented the difference in nitrogen between soluble nitrogen and soluble NPN.

Since solubility in buffer solutions is not always a good indicator of protein degradability in the rumen, samples of each ingredient were incubated in rumen fluid to measure ammonia release. Rumen fluid was collected from a fistulated steer fed a 50:50 mixture of alfalfa hay and concentrates. Equal quantities of rumen fluid and McDougalls' buffer were mixed, and 30 ml of inoculum were pipetted into 50 ml centrifuge tubes containing the sample. Samples of each nitrogen source were added at the rate of 20 mg per tube. The *in vitro* procedure was repeated with sucrose and cane molasses added to supply 25 percent more soluble carbohydrate than the feedstuff that contained the highest amount. Urea and soybean meal (SBM) were used as controls in all experiments.

Results and Discussion

Nitrogen solubility of the ingredients examined (Table 1) ranged from 100 percent for LS, DF and FEL to 35.7 percent for liquid yeast. Ingredients with the largest amounts of soluble nitrogen also contained the largest amounts of soluble NPN. The relatively low concentration of NPN in CDS, CW, LY and, to a lesser extent, in CSL shows that a considerable portion of the soluble nitrogen in these products is true protein. If high solubility does not result in a rapid breakdown to ammonia in the rumen, protein from CDS, CW, LY and CSL could be used efficiently by ruminants even on low quality rations. The high NPN content of CSF, LS, DF, CSM and FEL would suggest that their use as protein sources might be limited to conditions under which urea is well utilized. Further information on the makeup of the NPN fraction of each ingredient is needed. Since some bacteria apparently require preformed amino acids, ingredients with amino acids and peptides present in their NPN fraction might

Table 1. Dry matter, percentage of soluble nitrogen, percentage of NPN of nitrogen sources[a].

N Source[b]	SBM	CSF	LS	DF	CMS	FEL	CSL	CDS	CW	LY
Dry matter, %	90.58	56.01	49.08	39.05	59.87	41.43	46.53	48.95	33.60	24.84
N, %	7.36	5.00	7.17	8.35	7.20	6.76	7.22	1.96	2.38	5.84
Soluble N, %	1.23	4.66	7.17	8.75	7.14	7.04	6.40	1.12	1.73	2.05
Soluble N of total N, %	16.61	93.20	100.00	100.00+	99.35	100.00+	88.81	60.56	72.83	35.71
Soluble NPN, %	0.16	4.46	7.86	8.04	6.35	7.58	4.71	0.67	0.77	0.76
Soluble NPN of total N, %	0.02	89.31	100.00+	96.37	88.12	100.00+	65.70	33.85	32.65	13.08

[a]All values except % dry matter are on a dry matter basis.
[b]Soybean meal - SBM, concentrated Steffen's filtrate - CSF, lignin sulfonate - LS, dyno-ferm - DF, condensed molasses solubles - CMS, fermentation end liquor - FEL, condensed fermented corn extractives or corn steep liquor - CSL, condensed distillers' solubles - CDS, condensed whey - CW and liquid yeast - LY.

Table 2. *In vitro* ammonia-nitrogen concentrations (mg/100 ml) after 1- and 4-hr incubation with and without the addition of sucrose and cane molasses[a].

Trial I ("as-is") N Source	SBM	Urea	CSF	LS	DF	CMS	FEL	CSL	CDS	CW	LY
1 hr	7.3^{b}	29.8^{efgh}	8.5^{bc}	42.3^{hij}	47.3^{ij}	36.8^{ghi}	40.5^{hij}	21.0^{cdef}	11.8^{bc}	17.8^{bcde}	13.5^{bcd}
4 hr	15.8^{bcd}	63.3^{k}	13.3^{bcd}	35.3^{ghi}	50.6^{jk}	39.3^{hij}	43.5^{ij}	25.8^{defg}	9.3^{bc}	20.6^{cdef}	8.1^{bc}
Trial II (+sucrose)											
1 hr	7.9^{b}	48.8^{f}	7.9^{b}	38.9^{de}	48.9^{ef}	39.9^{de}	42.4^{ef}	15.4^{bc}	7.9^{b}	13.9^{bc}	12.7^{bc}
4 hr	10.8^{b}	63.8^{g}	9.8^{b}	40.5^{ef}	45.5^{f}	31.3^{d}	42.3^{ef}	22.3^{c}	12.3^{b}	21.2^{c}	10.8^{b}
Trial III (+molasses)											
1 hr	9.3^{bc}	44.5^{fg}	4.8^{b}	41.5^{efg}	44.5^{fg}	33.3^{def}	47.0^{fg}	10.0^{bc}	4.8^{b}	10.8^{bc}	4.8^{b}
4 hr	5.5^{b}	57.8^{g}	8.8^{bc}	32.0^{def}	36.8^{ef}	24.8^{cde}	37.8^{ef}	16.8^{bcd}	6.8^{b}	17.3^{bcd}	9.3^{bc}

[a]Values expressed as mg NH_3–N per 100 ml increase above the blank value.
[bcdefghijk]Values with different superscripts differ significantly ($P<.05$) within trials.

be efficiently utilized by rumen microbes for protein synthesis as well as possibly bypassing amino acids and peptides to the lower gut for absorption.

Ammonia-nitrogen concentrations after 1- and 4-hr incubations in rumen fluid are shown in Table 2. Ammonia release at 1 hr, with each ingredient incubated without additional carbohydrate, tended to follow the same trends as NPN content and nitrogen solubility (Table 1). An exception was CSF, which had 93.2 percent soluble N but only 8.5 mg/100 ml of ammonia nitrogen at 1 hr. The poor relationship between nitrogen solubility and degradation in the rumen has been well documented. It is apparent from these data that solubility alone will lead to errors in estimating ruminal degradation of nitrogen fractions in such divergent feedstuffs as these.

Additions of sucrose or cane molasses to provide 25 percent excess soluble carbohydrate over the ingredient with the highest soluble carbohydrate content (whey) did not greatly change the ranking of the ingredients for ammonia nitrogen release. Ammonia nitrogen levels from CSL, CDS, CW, CSF and LY were not significantly different from SBM at 1 hr of incubation alone or with sucrose and cane molasses.

The largest increases in ammonia nitrogen between 1 and 4 hr of incubation occurred with urea, with or without added carbohydrate. Ammonia levels at 1 hr from LS, DF, CS and FEL were not significantly different from urea in all fermentations. Corn steep liquor incubated for 1 hr without added carbohydrate produced an ammonia nitrogen level that tended to be lower than produced by urea. Ammonia nitrogen levels were lower ($P<.05$) than urea when fermented with added sucrose or molasses.

Increases in ammonia-nitrogen levels between 1- and 4-hr incubation time were greater for urea than for any of the other ingredients. This suggests that nitrogen from the liquid ingredients was either incorporated into microbial protein more rapidly than was nitrogen from urea and/or that some nitrogen components in the ingredients were less readily degraded than urea.

These results, while by no means complete, do show that by-product liquid feed ingredients used today differ greatly in crude protein content and composition. Condensed distillers' solubles, CW, LY and, to a lesser extent, CSL contain relatively high percentages of natural protein and could be well utilized by ruminants. The high water content of LY will limit its use in liquid feeds. The extent of utilization of CSM, CSF, FEL and other ingredients with varying amounts of non-urea NPN is unclear. Condensed molasses solubles and corn steep liquor, both widely used in liquid feeds and differing in natural protein content, are currently being studied in range cow and laboratory trials at Oklahoma State University.

Literature Cited

Johnson, R. R., 1969. Techniques and Procedures in Animal Science Research, American Society of Animal Science.