Animal Feed Science and Technology 159 (2010) 122–130

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Sources of variation in composition of DDGS

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ARTICLE INFO

Article history:
Received 23 July 2009
Received in revised form 10 June 2010
Accepted 21 June 2010

Keywords:
Composition
DDGS
Dry grind processing
RUP
Variation

ABSTRACT

High protein and high energy content make distillers dried grains with solubles (DDGS) a unique ingredient for ruminant diets, but variation in composition reduces nutritional quality and market value. There is little published information that addresses the specific causes of variation. Samples of DDGS from dry grind processing (ethanol) plants in the upper Midwest were analyzed for nutrient concentrations and sources of variation were evaluated.

Significant plant × period (time) interactions indicated that variation was associated with specific fermentation batches, rather than plants or time (periods) *per se*. Differences in maize characteristics and in processing conditions probably were responsible for batch to batch effects. Fat content of DDGS samples was relatively uniform, but there was considerable variation in protein concentration (260–380 g/kg DM). Low lysine (8.9 g/kg DM) and elevated pepsin insoluble (bound) protein concentrations were additional concerns. Published values for ruminally undegradable protein content were as accurate as estimates using specific plant data.

1. Introduction

Maize is converted to ethanol by two main technologies—dry grind processing and wet milling (Rausch and Belyea, 2006). In wet milling, the maize kernel is fractionated into starch and other components, and starch is converted into ethanol; wet milling requires significant amounts of equipment and capital. In dry grind processing, the whole (unfractionated) maize kernel is used as a substrate for fermentation, requiring less equipment and capital. In both processes, unfermented residual material is converted into distillers dried grains with solubles (DDGS). DDGS are used mainly in ruminant diets and are valuable because of high concentrations of energy (due to high fat content), protein and ruminally undegradable protein (RUP).

The composition of DDGS can be quite variable (Belyea et al., 1989, 2004; Shurson et al., 2001), which makes precise diet formulation difficult. When diets are formulated to contain DDGS, average protein concentration often is assumed. Actual protein content could be greater than average, resulting in excess protein intake or less than average, resulting in protein deficiency. Protein deficiency can reduce animal productivity, while excess protein can result in protein wastage (from increased nitrogen excretion in feces and urine) and in adverse physiological responses. There is little published information

Abbreviations: ADF, acid detergent fiber; DDGS, distillers dried grains with solubles; EAA, essential amino acids; NDF, neutral detergent fiber; RUP, ruminally undegradable protein.

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doi:10.1016/j.anifeedsci.2010.06.005

that addresses causes of variation. This information could help to provide the basis for strategies to reduce variation and improve quality of DDGS. The objective was to identify and evaluate sources of variation in the composition of DDGS and determine effects on nutritional quality.

2. Materials and methods

2.1. Sample collection

Samples of DDGS and corresponding maize samples were obtained from nine dry grind ethanol plants located in the upper Midwest. Maize was grown by local producers and presumably reflected a variety of soils, climatic conditions and hybrids. Dry grind processing is a batch type fermentation method (Rausch and Belyea, 2006). The length of time from the initial step (grinding of maize) to the last step (drying of DDGS) can vary from 60 to 90 h, depending on processing conditions. Each fermentation batch remains separated from other batches and retains its unique characteristics until DDGS are placed in storage facilities. The characteristics of each sample of DDGS reflect a specific batch of maize and processing conditions. Fermentation equipment and processing conditions generally were similar among the ethanol plants. When processing conditions at a particular plant were aberrant (*i.e.*, increased pH in the fermentation tank), sampling was delayed until conditions returned to normal. In actuality, this occurred only a few times.

Samples of maize and DDGS (about 0.5 kg each) were taken at each processing plant during four different periods (fall, winter, spring and summer); within each period, samples were taken during each of three successive weeks, frozen and shipped to the University of Missouri for analytical measurements. A total of 108 samples (9 plants × 4 periods × 3 weeks per period) were obtained.

2.2. Analytical methods

Maize and DDGS samples were ground to pass a screen with 2.0 mm diameter openings. Analytical dry matter was determined by method 934.01 (AOAC, 1997).

NDF concentrations were determined according to Van Soest et al. (1991); sodium sulfate and heat stable amylase were not used, and there was no correction for residual ash. ADF was determined by method 978.13 (AOAC, 1997) and was exclusive of residual ash. N was measured by thermoelectric conductivity (method 968.06, AOAC, 1997) using a FP-428 N Determinator (Leco Corp., St. Joseph, MI); total protein was estimated as N × 6.25. Buffer soluble N was determined using the method of Krisnamoorthy et al., 1982; buffer soluble protein (rapidly degraded or immediately soluble protein fraction) was estimated as soluble N × 6.25. Pepsin insoluble N was determined according to Goering et al. (1972); pepsin insoluble protein (estimate of bound protein) was calculated as pepsin insoluble N × 6.25. Ash was measured using method 942.05 (AOAC, 1997). Fat was determined by method 920.39 (AOAC, 1997). A subset of 16 samples of DDGS was selected from the four periods; essential amino acid (EAA) concentrations were determined in these samples and in corresponding maize samples using method 982.3 (AOAC, 1997).

2.3. N disappearance measurements

N disappearance data were determined following the *in situ* method of Stern and Satter (1984). Subsamples (2.0 g) of each DDGS sample were placed in triplicate *in situ* digestion bags (Ankom, 2 cm × 6 cm, 50 μm pore size); sets of samples were digested for 6, 12 or 24 h in the rumens of two lactating, fistulated dairy cows consuming a conventional diet. Sets of bags were removed at the appropriate time, rinsed thoroughly and dried at 105 °C for 24 h. Dried bags were weighed so that dry matter remaining could be calculated. A sample of residue was removed from each bag, and N content was determined as described previously. N remaining was calculated as:

$$\text{N remaining (g/kg N)} = \frac{\text{g N in residue}}{\text{g N in original sample}} \times 1000$$

N disappearance rates were determined by regression of N remaining upon digestion time using a simple linear regression procedure. Ruminally undegradable protein (RUP) is the fraction of protein in a feed ingredient that is not degraded in the rumen. The amount of N remaining at 24 h was used to estimate RUP (RUP = N remaining at 24 h × 6.25). For comparison purposes, N disappearance equations were calculated for each processing plant from their specific data; in addition, an overall (across plants) equation also was calculated. RUP concentrations then were estimated using the plant-specific equations and the overall equation.

2.4. Statistical analyses

Compositional data were analyzed for effects of plant, period and period × plant using a general linear model (SAS, 2003). Means were compared for effects that were significant ($P<0.01$). N disappearance data were analyzed using a mixed model (SAS, 2003); the model included effects for period, week, digestion time; period × week, week × digestion time and week × period × digestion time. Means were compared when effects were significant ($P<0.01$).