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Partial replacement of barley grain for corn grain: Associative effects on lambs' growth performance

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Abstract

Our objective was to study the positive effects of partial replacement of barley grain for corn in high concentrate diets on growth performance of growing lambs, and to determine the minimum amount of corn needed to produce such effects. Thirty-three male Awassi lambs weaned at 60 days of age were divided into three groups of 11 according to their live weight and offered three isonitrogenous diets. The control diet (B) contained 81 and 14% barley grain and wheat straw, respectively (DM basis). Corn grain replaced barley grain at 10 and 20% of dietary DM for low (LC) and high (HC) corn diets, respectively. Barley had a higher ($P < 0.05$) rate of digestion (11.5%/h) compared with corn (8.3%/h). The in vitro 30-h digestion extent was also higher ($P < 0.05$) for barley. The digestion rate for the B diet was higher ($P < 0.05$) compared with the HC diet, whereas the value for the LC diet was intermediate. Lambs fed LC and HC diets consumed more ($P > 0.05$) DM (average = 855 g/day) compared with lambs fed B diet (757 g/day). DM and CP digestibilities were similar among diets and averaged 67.0 and 64.2%, respectively. Final BW, BW change and average daily gain (ADG) for lambs fed HC were higher ($P < 0.05$) compared with B and LC. Moreover, lambs that consumed LC tended ($P = 0.12$) to grow faster than lambs fed B. Feed to gain ratio was lower ($P < 0.05$) for lambs fed HC (4.6) compared with B and LC (5.2). In summary, positive associative effects of partial replacement of barley with corn in high concentrate diets for fattening sheep were detected. However, a minimum of 20% replacement of dietary DM from barley with corn was needed to positively improve both performance and feed efficiency.

Keywords: Corn; Barley; Associative effects; Awassi

1. Introduction

Management practices to improve growth performance of weaned ruminants include manipulating feed so that digestion is neither too rapid, which can result in digestive disorders, nor too slow, which can result in poor feed efficiency (Cheng et al., 1991). Small cereal grains such as barley are more rapidly and thoroughly fermented in the rumen than corn; which can result in greater microbial protein synthesis (Feng et al., 1995). However, excessive fermentable carbohydrates from barley can also lead to negative associative effects (Mould et al., 1983). Therefore, feeding a mixture of rapidly (e.g., barley) and slowly digested cereal grains (e.g., corn) may reduce the incidence of acidosis and yield a favourable balance of starch digestion in the rumen and postruminal tract to improve feed efficiency as compared with diets based primarily on one type of grain or the other (Mendoza et al., 1990).

In the Middle Eastern areas, because of low pasture availability, diets for growing ruminants are based on concentrates. Barley and corn are the main cereal grains

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in the diets of growing ruminants. The price of corn is typically 50–80% greater than that of barley because all corn is imported and barley is produced locally. Therefore, using diets with high proportions of corn will not be economically competitive with diets high in barley (Harb and Habbab, 1989).

Much research conducted dealing with mixtures of different cereal grains to enhance feed efficiency has dealt with relatively high proportions of the grain added or substituting rather the minimal amount needed to produce the desired associative effect. Therefore, our objective was to study the positive effects of partial replacement of barley grain with corn in a high concentrate diet on growth performance of growing lambs, and to determine the minimum amount of corn needed to produce such effects.

2. Materials and methods

2.1. Animals and diets

Thirty-three male Awassi lambs weaned at 60 days of age were divided into three groups of 11, according to their live weight, housed in individual pens (1.5 m × 0.75 m) and offered three isonitrogenous experimental diets. Lambs were allowed 1 week for adjustment before receiving the experimental diets. The control diet (B) contained 81 and 14% whole barley grain and chopped wheat straw, respectively (DM basis). Coarsely ground corn grain replaced barley grain at 10 and 20% of dietary DM for low corn (LC) and high corn (HC) diets, respectively, as shown in Table 1.

Experimental diets were mixed manually on a weekly basis and sampled upon mixing. The experiment lasted for 12 weeks. Lambs were offered the experimental diets twice daily at 09:00 and 15:00 h in amounts to ensure 10% orts. Amounts of feed offered and refused were recorded daily. Animals were maintained at ambient temperature and natural daylength. Clean drinking water was available in plastic buckets.

At day 70 of the experiment, 15 lambs (five lambs/treatment) were selected randomly for the digestibility determination. Total fecal collection was carried out for 6 days using fecal bags. Total fecal output for each animal was weighed and a 20% sample was removed for further analysis. Samples of individual ingredients, diets and feces were oven dried at 60 °C, ground through a 1 mm screen and analyzed for nitrogen by procedures of AOAC (1990) and neutral detergent fiber (NDF) according to Van Soest et al. (1991). Metabolizable energy (ME) contents of the experimental diets were calculated using tabular values (NRC, 1985).

2.2. In vitro digestive kinetics

In vitro digestion kinetics of barley and corn grains as well as the experimental diets were measured using the procedure that was modified from Tilley and Terry (1963) as described by Harris (1970). Grains and diets were ground through a 2-mm screen. Samples (0.5 g) were incubated at 38 °C in tubes containing 30 ml of McDougal's buffer and 7 ml of ruminal fluid. Tubes were placed in a chamber incubator and swirled every 4 h. Ruminal fluid was collected from a ruminally fistulated dairy cow fed a 50% forage and 50% concentrate diet. Triplicate tubes for each grain and diet and one blank tube at each time were incubated for 0, 2, 4, 6, 9, 12, 18, 24 and 30 h.

Microbial fermentation was stopped by cold-shocking the tubes in ice water for 30 min. Tubes were centrifuged at 500 × *g* for 15 min, and the supernatant was decanted and dried in a forced-air oven at 60 °C. Digestion kinetics estimates were calculated according to Bowman and Firkins (1993). The procedure was replicated three times.

2.3. Statistical analysis

Means for diet effects were analyzed as a completely randomized design using the general linear model procedure of SAS (1991). Differences among treatment means were detected by least significant difference (LSD) of SAS (1991).

3. Results and discussion

The experimental diets were isonitrogenous (Table 1). Although ME concentration is higher for corn, replacing

Table 1
Ingredient and chemical compositions of the experimental diets

Item	Diet		
	B	LC	HC
Ingredient (% of DM)			
Wheat straw, chopped	14.0	14.0	14.0
Corn grain[a], coarsely ground	0.0	10.0	20
Barley grain[b]	81.4	71.2	61
Sodium bicarbonate	1.0	1.0	1.0
Salt	0.9	1.0	1.0
Limestone	0.5	0.5	0.5
Urea	1.7	1.8	2.0
Mineral and vitamin mix[c]	0.5	0.5	0.5
Chemical composition			
Dry matter (%)	93.0	92.7	92.4
Nitrogen (% of DM)	2.6	2.6	2.6
Neutral detergent fiber (% of DM)	25.8	25.1	24.4
Metabolizable energy (Mcal/kg)[d]	2.74	2.74	2.75
Cost ($/t)	118	126	134

[a] Cost = 165$/t; based on the average market price for 6 months prior to this experiment.
[b] Cost = 105$/t; based on the average market price for 6 months prior to this experiment.
[c] Supplies per kilogram of feed: 4.9 mg of Zn, 4.05 mg of Mn, 0.45 mg of Cu, 0.075 mg of I, 0.1 mg of Se, 2500 IU Vitamin A, 400 mg of Vitamin D, 2.5 IU Vitamin E.
[d] Calculated using tabular values (NRC, 1985).