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EFFECT OF CORN PROCESSING ON GLYCEMIC RESPONSE IN HORSES

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Summary

An experiment was conducted to evaluate how cracking, grinding or steam processing affects starch digestibility of corn, using glycemic response as an indirect measure of prececal starch digestibility. In a replicated 3 x 3 Latin square design, six mature horses were fed either cracked, ground, or steam-flaked corn (2 g/kg of BW in a single meal) and 1% BW/d hay over six periods, each lasting 8 to 10 d. At the end of each period, horses were fed their respective grain meals and blood samples were taken at 30-min intervals for 8 h. Area under the curve, mean glucose and lactate, peak glucose and lactate, and time to peak glucose and lactate were determined. Steam-flaked corn produced a greater glycemic response than cracked or ground corn. Peak glucose was also greater for steam-flaked corn. Results of this study indicate that steam flaking alters glycemic response (and presumably starch digestibility) to a much greater extent than grinding or cracking.

Introduction

Previous research has demonstrated that prececal starch digestibility of corn is improved by grinding or popping (Meyer et al., 1993). In this study, digestibility increased 17 and 61% following grinding and popping of the whole kernel. Crushing or rolling the corn kernel did not improve the digestibility of starch in the small intestine. It was concluded that starch granules are not significantly altered from their original form in the whole kernel when crushed or rolled. However, when further processing occurs, such as grinding, the structure of the starch granule is altered, allowing the granule to be more available to digestive enzymes and thus improving nutrient availability (Fahrenholz, 1994). Steam rolling, extruding, or micronizing corn (all of which involve heating the kernel) may result in even greater digestibility than grinding or cracking. This experiment was conducted to determine if steam processing alters glycemic response, an indirect measure of prececal starch digestibility.

Materials and Methods

Management of Horses

Six mature geldings, four Arabians and two Thoroughbreds, with a mean age of 8.4 y (range of 6 to 10) and mean BW of 493 kg (range of 405 to 645), were used

in the experiment. Horses were maintained on pasture during the day (0800 to 1600) and housed in 3.0 m x 3.0 m box stalls overnight (1600 to 0800). Horses were not subjected to forced exercise, but were given free access to exercise while on pasture.

Treatments

Horses were used in a replicated 3 x 3 Latin square design to evaluate how processing affects starch digestibility. Glycemic response was used as an indirect measure of prececal starch digestibility. Horses were fed either cracked, ground, or steam-flaked corn (2 g/kg of BW in a single meal) and 1% BW/d alfalfa-grass hay over six periods. Each period lasted 8 to 10 d. Amounts fed were based on BW established prior to the first period. Grain rations were fed once per day (0700) and hay was divided into two equal feedings per day (1600 and 2200). Horses were offered free choice salt in 2-kg salt blocks when in box stalls and had free access to water at all times. Horses were allowed free access to grazing while maintained on pasture. Three-day transition periods occurred at the beginning of each new period to gradually introduce new diets.

Sample Collection

At the end of each period, horses were housed in box stalls and an 8-h blood collection was conducted. Horses were catheterized in the jugular vein prior to feeding and a fasting blood sample was taken to determine baseline glucose (mg/dl) and lactate (mmol/L) values. Horses were then fed their respective treatment diets and blood samples were taken at 30-min intervals for 8 h. Plasma concentrations of glucose and lactate were determined using a YSI Model 2300 STAT glucose and L-lactate analyzer (Yellow Springs Instrument Co., Inc., Yellow Springs, OH).

Statistical Analysis

Area under the curve, mean glucose (mg/dl) and lactate (mmol/L), peak glucose (mg/dl) and lactate (mmol/L), and time to peak glucose and lactate (min) were determined. Plasma glucose and lactate concentrations were statistically analyzed by the general linear model procedure for analysis of variance. Period, horse, and diet were included in the model.

Results

The glycemic response of each grain was compared using a glycemic index where each feed's glucose area under the curve was expressed relative to cracked corn (Figure 1). Steam-flaked corn produced a greater glycemic response than cracked or ground corn ($P < .05$; Table 1). Peak glucose was also greater for steam-flaked corn ($P < .01$). Horses on the cracked corn diet demonstrated greater peak glucose than those on ground corn ($P < .01$). Plasma glucose concentrations were consistently lower for cracked and ground corn treatments, when compared with steam-flaked corn, from 90 to 180 min post-feeding during

sample collection (P < .05; Figure 2). Time to peak glucose was unaffected by processing. Area under the curve for lactate was greater for steam-flaked corn when compared with ground corn (P < .05; Table 2). Plasma lactate concentrations were greater for steam-flaked corn than cracked or ground corn between 90 and 150 min post-feeding (P < .05; Figure 3). Mean lactate, peak lactate, and time to peak lactate were unaffected by processing.

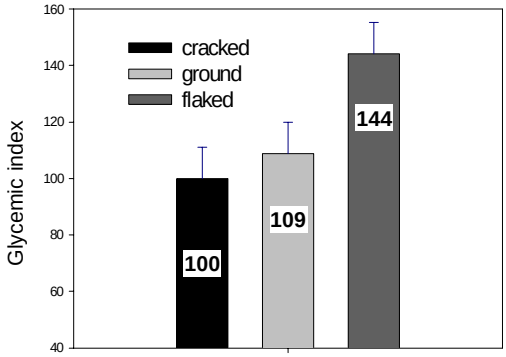

Figure 1. Glycemic index for all diets.

Table 1. Area under the curve, mean glucose, peak glucose, and time to peak glucose for all diets.

	Area under curve	Mean (mg/dl)	Peak (mg/dl)	Time to glucose peak (min)
Dietary Treatment				
Cracked Corn	1,734[a]	95.6[a]	114.8[b]	62.5
Steam-Flaked Corn	2,500[b]	98.4[b]	125.1[c]	72.5
Ground Corn	1,887[a]	95.4[a]	109.1[a]	62.5
SEM	191	42	1.77	5.2
Statistical significance	.05	.01	.01	NS[d]

[abc] Treatments lacking a common superscript differ (P < .05)
[d] Not significant

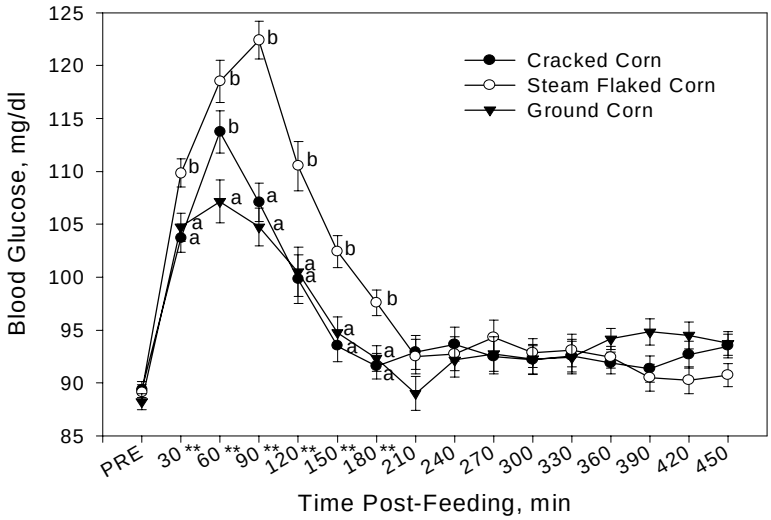

Figure 2. Plasma glucose concentrations post-feeding.

[ab] Treatments lacking a common superscript differ (P < .05)

[**] Treatments different at given sample time (P < .01)

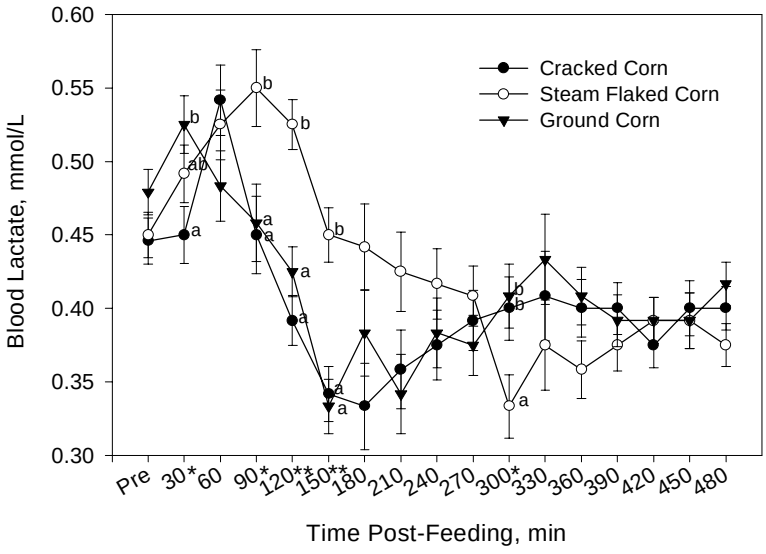

Figure 3. Plasma lactate concentrations post-feeding.

[ab] Treatments lacking a common superscript differ (P < .05)

[*] Treatments different at given sample time (P < .05)

[**] Treatments different at given sample time (P < .01)

Table 2. Area under the curve, mean lactate, peak lactate, and time to peak lactate for all diets.

	Area under curve	Mean lactate (mmol/L)	Peak lactate (mmol/L)	Time to peak (min)
Dietary Treatment				
Cracked Corn	5.25[ab]	.40	0.57	97.5
Steam Flaked Corn	8.81[b]	.43	0.64	140.0
Ground Corn	3.56[a]	.41	0.59	102.5
SEM	1.41	.08	0.03	37.3
Statistical significance	.05	NS[c]	NS	NS

[ab]Treatments lacking a common superscript differ (P < .05)
[c]Not significant

Discussion

Results of this study indicate that steam-flaked corn alters glycemic response (and presumably prececal starch digestibility) to a much greater extent than grinding or cracking. Similar improvements in starch digestibility have been found in cattle fed steam-flaked corn, when compared to cattle fed whole, ground, or dry-rolled corn (Theurer, 1986).

Higher peak concentrations of glucose in the plasma of horses fed steam-flaked corn indicates that steam flaking results primarily in small intestinal digestion, avoiding excessive microbial fermentation in the large intestine and greater lactate production by the hindgut. Processing of starch, starch intake levels, and source and timing of forage feeding have a large effect on prececal starch digestibility, and the misapplication of these factors has the potential to result in digestive disorder such as colic or laminitis (Meyer et al., 1993). High lactate and glucose concentrations demonstrated in the present experiment occurred at similar collection times (between 90 and 150 min post-feeding), suggesting that lactate produced and absorbed into the bloodstream may have resulted from bacterial fermentation of soluble carbohydrate in the nonglandular region of the stomach (Meyer, 1983).

Conclusions

Steam flaking alters glycemic response to a much greater extent than grinding or cracking. Further research is necessary to determine if other processing techniques that involve heating the corn kernel, such as extruding or micronizing, will result in similar improvements in glycemic response. Additional research is also required to determine if glycemic improvements have a beneficial effect on performance of the horse.

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