Kasetsart J. (Nat. Sci.) 38 : 113 - 119 (2004)

The Comparative Effects of Corn and Cassava Diets on Physiological Properties of Gastrointestinal Tract of Broilers

Suwanna Promthong[1], Uthai Kanto[2,3], Chanin Tirawattanawanich[4], Soontaranee Tongyai[4], Supaporn Isariyodom[2], Kanchana Markvichitr[2] and Arunee Engkagul[5]

ABSTRACT

This experiment was conducted to investigate the comparative effects of corn, cassava chip and cassava pellet diets on physiological properties of the digestive tract of the broilers. Forty-eight day-old Cobb broilers were randomly divided into 3 groups receiving 3 dietary treatments. The diets containing corn, cassava chips, or cassava pellets as the basal feed ingredient are isonitrogenous, isocaloric, and semipurified. The experimental diets were pelleted and fed *ad libitum* to the animals. At 28 days of age, 8 out of 16 birds per group were euthanized and organ samples were collected. The broilers fed the cassava pellet diet showed lower gizzard weight than those fed corn or cassava chip diets (P<.05). Liver weights of broilers fed cassava diets were higher (P<0.05) than those fed corn diets. Sucrase and maltase activities in duodenum and sucrase activity in jejunum of the broilers fed corn diet were significantly lower (P<0.05) than those fed cassava chip and cassava pellet diets. There were no significant differences in mucosal protein as well as sucrase and maltase activities in ileum of broilers in all 3 groups. Broilers fed cassava chip diets showed higher percentage of caecal butyrate than those fed corn or cassava pellet diets.
Key words: cassava, corn, gastrointestinal tract, broiler, disaccharidase activity, SCFA

INTRODUCTION

Cereal carbohydrate in the form of starch is an important energy source for man and animals. Ingested carbohydrate is not only digested and absorbed into the animal body but also is utilized by the intestinal microorganisms via bacterial fermentation to produce short-chain fatty acids, including acetate, propionate and butyrate, which have been found benefit to their host (Bird *et al*., 2000). Corn is the major basal feed ingredient used in poultry feed in Thailand. However, there are problems of insufficient domestic corn production and the obligation of importing of high prices and high risk of mycotoxin contamination that have adverse effects to the broilers. Feed ingredients with lower cost, highly digestible and no mycotoxin contamination are required in the broiler production industry. Cassava, which is extensively grown in Thailand, has a potential to substitute corn in the broiler diets. In poultry, there are microorganisms which colonize in the caeca and can utilize resistant

1 Department of Agricultural Technology, Faculty of Science, Ramkhumhaeng University, Bangkok 10210, Thailand.
2 Department of Animal Science, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.
3 Animal Nutrition Research and Development Center, Kasetsart University, Kamphaengsaen, Nakhon Pathom 73140, Thailand.
4 Department of Physiology, Faculty of Veterinary Medicine, Kasetsart University, Bangkok 10900, Thailand.
5 Department of Biochemistry, Faculty of Science, Kasetsart University, Bangkok 10900, Thailand.

starch or non-starch polysaccharides that are not digested and absorbed in the small intestine to produce short-chain fatty acids. The acids can influence the health and the function of the small intestine (Scheppach, 1994; D'Mello, 2000). The objective of this experiment to compare the effects of cassava and corn diets on the physiological properties of gastrointestinal tract of the broilers.

MATERIALS AND METHODS

Animals, housing and diets

Forty-eight day-old Cobb broiler chicks with an average initial body weight of 41.16 g were divided into 3 groups. A total of 16 chicks in each group were kept in a brooder equipped with light and heat sources for 14 days, after which they were housed individually in metal cages. Feed and water were provided *ad libitum*. The chicks in group I, II, and III were randomly fed isonitrogenous, isocaloric, pelleted semi-purified diets containing corn, cassava chips and cassava pellets as the basal feed ingredient, respectively, until 28 days of age. The feed ingredients and chemical composition of the experimental diets were shown in Table 1.

Sample collection

At the end of the experiment, the chickens

Table 1 Feed ingredients and chemical composition of the experimental diets.

Ingredients (kg)	Corn diet	Cassava chip diet	Cassava pellet diet
Ground corn	68.29	-	-
Cassava chip meal	-	63.90	-
Cassava pellet meal	-	-	63.90
Sodium casinate	19.55	24.13	24.13
Molasses	3.00	3.00	3.00
Dicalcium phosphate	2.13	2.33	2.33
Oyster shell	1.30	0.98	0.98
L-lysine	0.22	-	-
DL-methionine	0.15	0.26	0.26
L-arginine	0.51	0.55	0.55
Soybean Oil	4.00	4.00	4.00
Salt	0.35	0.35	0.35
Premix[1]	0.50	0.50	0.50
Total	100	100	100
Chemical analysis			
Crude protein (%)	21.32	21.06	21.06
Gross energy (kcal/kg)	4,358	4,357	4,329
Crude fiber (%)	1.66	2.24	2.48
Calcium (%)	1.12	1.12	1.19
Phosphorus (%)	0.47	0.46	0.46

[1] Supplied per 100 kilogram of diet : vitamin A 15,000,000 IU, vitamin D 3,000,000 IU, vitamin E 25,000 IU, vitamin K 35 g, vitamin B_1 2.5 g, vitamin B_2 7 g, vitamin B_6 254.5 g, vitamin B_{12} 25 mg, panthotinic acid 11.04 g, nicotinic acid 35 g, folic acid 1 g, biotin 15 mg, choline chloride 250 g, cupper 1.6 g, manganese 60 g, iron 1.6 g, zinc 45 g, iodine 400 mg and selenium 150 mg.

were euthanized and the abdomen was opened to excise and weigh the proventriculus, gizzard, small intestine (duodenum, jejunum and ileum), caeca, pancreas, liver and spleen. The intestinal length was also measured. Caecal content was collected and stored at -20°C until analyzed. Fresh caecal content was used for the short chain fatty acids (SCFA) analysis and pH measurement. SCFA concentration was extracted as described previously by Jacobasch *et al*. (1999). Samples of 1 µl were injected into a gas chromatograph Chrompack (CP 9001) equipped with a flame ionization detector and capillary column WCOT fused silica CP-wax 52 CB (50 m × 0.32 mm) at temperature 125°C. Helium was used as the mobile phase at flow rate 10 ml/min. Isobutyric acid was used as an internal recovery standard. Concentrations of the principle SCFA, acetate, propionate, and butyrate were reported as mmoles of SCFA per gram of dry weight of caecal content. The small intestines were opened longitudinally. Digesta were carefully rinsed out of each segment (without squeezing) with cold normal saline 0.9% (4°C) and were blot-dried. The intestinal mucosa was removed by scraping the luminal surface with metal spatula and individually stored at -20°C until analyzed (King *et al.*, 2000). Intestinal mucosa were used for protein and enzymatic activity assay. Protein was determined colorimetrically with spectrophotometer at 595 nm according to the method of Bradford (1976). Maltase (EC 3.2.1.20) and sucrase (EC 3.2.1.48) activities were assayed according to the procedure of Dahlquist (1964).

Statistical analysis

Data were subjected for analysis of variance with Completely Randomized Design. The differences among treatment means were determined by using Duncan's New Multiple Range Test. Data are presented as mean ± SEM.

RESULTS AND DISCUSSION

Performance

All chickens were generally in good health throughout the experiment. There were no significant differences in feed intake, daily gain and feed conversion among the treatment groups (Table 2). The results indicated that there was no effect of crude fiber and bulkiness of cassava on animal performance if the cassava diets had been adjusted for a proper nutrient balance and made into an appropriate pellets size.

Physiology of digestive organs and spleen

There were no significant differences in proventriculus, pancreas and spleen weights of broiler chickens fed cassava or corn diets (Table 3) while those fed cassava pellet diet showed a lighter gizzard weight ($P<0.05$). This could be due to higher solubility of cassava pellets in aqueous milieu of the digestive tract and could easily flow through the gizzard and requiring less mechanical action of the muscle wall, thus less muscle enlargement than the other two diets. On the contrary, liver weights of broilers fed cassava diets were greater than those fed corn diet. This may result from higher digestibility of soft-starch from

Table 2 Feed intake, daily gain and feed conversion of broilers fed corn diet and cassava diets.

Variables	Corn	Cassava chips	Cassava pellets
No. of broilers	16	16	16
Feed intake (g/d)	49.53 ± 1.29	47.85 ± 0.74	48.10 ± 0.92
Average daily gain (g/d)	31.18 ± 0.77	30.35 ± 0.58	30.17 ± 0.76
Feed conversion	1.58 ± 0.11	1.58 ± 0.02	1.60 ± 0.02

Table 3 Relative weights of proventriculus, gizzard, pancreas, liver and spleen of broilers fed corn diet and cassava diets.

Treatments	Proventriculus	Gizzard	Pancreas	Liver	Spleen
	------------------------------------grams per100 g BW----------------------------------				
Corn	0.58 ± 0.03	1.73 ± 0.13 [a]	0.21 ± 0.02	2.32 ± 0.15 [b]	0.11 ± 0.02
Cassava chips	0.68 ± 0.05	1.84 ± 0.08 [a]	0.23 ± 0.02	2.84 ± 0.20 [a]	0.12 ± 0.01
Cassava pellets	0.55 ± 0.08	1.51 ± 0.09 [b]	0.23 ± 0.02	3.05 ± 0.09 [a]	0.09 ± 0.01

Means within the same column with different superscripts differ significantly (P<0.05).

cassava than the starch from corn, providing large supply of glucose for hepatic regulation of blood glucose and accumulation as glycogen, thereby, increasing liver weight. Whether the increase of liver weight is caused by such proposed mechanism remains to be elucidated.

Mucosal protein and weight per length of duodenum, jejunum and ileum were not significantly different among the treatment diets (Table 4). This could indicate that neither cassava nor corn has any effects on the thickness of the small intestine.

Disaccharidase activities

Sucrase and maltase activities in the duodenum and sucrase activity in the jejunum of broilers fed diets containing cassava chips and cassava pellets were significantly greater than those fed corn diet (P<0.05) while there were no significant differences in the enzyme activities observed in the ileum (Table 5). The results implied that the duodenum and jejunum of broilers fed cassava diets were adapted to spontaneous release of high disaccharide content as a result of higher enzymatic contact surface of small-particle starch of cassava compared to larger-particle corn starch (Weurding *et al.*, 2001). Thus, higher maltase activity was stimulated in the proximal intestine of cassava fed broilers. Furthermore, the extrusion process in pelleting may cause gelatinization of cassava starch granules rendering it easier to digest (David and Peter, 2001), while

Table 4 Relative weight, length and weight per length ratio of small intestine of broilers fed corn diet and cassava diets.

Organs	Treatments	Mucosal protein (mg/g mucosa)	Weight per length (g/cm)
Duodenum	Corn	92.14 ± 3.83	0.119 ± 0.012
	Cassava chips	78.78 ± 3.49	0.104 ± 0.010
	Cassava pellets	80.62 ± 5.05	0.121 ± 0.006
Jejunum	Corn	126.60 ± 10.75	0.089 ± 0.006
	Cassava chips	104.36 ± 5.47	0.072 ± 0.005
	Cassava pellets	109.59 ± 3.29	0.086 ± 0.006
Ileum	Corn	134.62 ± 26.58	0.063 ± 0.010
	Cassava chips	130.09 ± 17.30	0.060 ± 0.006
	Cassava pellets	128.62 ± 14.65	0.062 ± 0.006

Table 5 Disaccharidase activity of small intestine of broilers fed corn diet and cassava diets.

Organs	Variables	Corn	Cassava chips	Cassava pellets
		-------------------------nmol/mg protein.min-------------------------		
Duodenum	Sucrase activity	33.18 ± 3.21 [b]	59.59 ± 4.77 [a]	60.38 ± 5.82 [a]
	Maltase activity	226.55 ± 13.35 [b]	354.25 ± 19.58 [a]	364.91 ± 30.25 [a]
Jejunum	Sucrase activity	104.68 ± 2.42 [b]	168.83 ± 20.99 [a]	206.42 ± 15.63 [a]
	Maltase activity	557.88 ± 24.82	569.59 ± 11.57	590.66 ± 19.19
Ileum	Sucrase activity	52.33 ± 13.37	38.69 ± 7.38	34.00 ± 6.77
	Maltase activity	285.60 ± 55.13	267.63 ± 56.93	224.56 ± 32.50

Means within the same row with different superscripts differed significantly (P<0.05).

slightly more viscous and slower moving than raw starch of cassava chips and corn (Thomas, 1998). Although the results did not show any significant differences in ileal disaccharidase activities of all 3 groups, the group fed corn starch demonstrated a tendency of stimulating higher disaccharidase activities as the digesta continuously flowed further down the intestinal tract. The slower-digestibility of corn starch when compared to cassava starch was due to the different physical structure and enzyme accessibility (Eastwood, 1992; McAllister *et al*., 1993). This experiment additionally showed that chicken sucrase activity is highest in the jejunum.

Short chain fatty acid in caeca

The level of undigested carbohydrate differed according to the characteristics of feedstuffs. This included resistant starch (RS), non-starch polysaccharide (NSP) and the small amount of incompletely digested starch in the small intestine. All of which would be the nutrient source for microorganism in the hind gut, mostly found in the caeca of chicken (Weurding *et al.*, 2001). Fermented products were SCFAs mainly acetate, propionate and butyrate (Jacobasch *et al.*, 1999). The result of the experiment neither show any significant difference of caecal SCFAs nor caecal pH (Table 6). This may be due to rapid

Table 6 Caecal SCFA and pH of broilers fed corn diet and cassava diets.

Variables	Corn	Cassava chips	Cassava pellets
Acetate (mmol/g dry wt.)	98.58 ± 14.14	86.29 ± 5.91	89.02 ± 8.03
Propionate (mmol/g dry wt.)	39.16 ± 7.16	38.95 ± 7.55	47.72 ± 5.95
Butyrate (mmol/g dry wt.)	92.96 ± 34.32	123.87 ± 16.30	87.91 ± 11.13
Total SCFA (mmol/g dry wt.)	230.70 ± 27.26	249.10 ± 25.58	224.65 ± 15.96
% Acetate (% of total)	42.64 ± 3.19	35.48 ± 1.48	40.70 ± 4.60
% Propionate (% of total)	16.76 ± 1.56	15.32 ± 2.24	21.04 ± 2.33
% Butyrate (% of total)	40.60 ± 2.11 [b]	49.20 ± 2.12 [a]	38.26 ± 3.63 [b]
pH	6.85 ± 0.11	6.61 ± 0.09	6.62 ± 0.11

Means within the same row with different superscripts differed significantly (P<0.05).

absorption of SCFAs for utilization (Eliot and Shronts, 1992). Broilers receiving cassava chip diet produced significantly higher butyrate than those fed corn or cassava pellet diet (P<0.05) when the relative level of SCFA was calculated as percentage of total SCFAs. Percentages of acetate and propionate, however, have a tendency to be higher in broilers fed corn diet and cassava pellet diet, respectively. Although the difference were not statistically different, the results showed numerical differences for raw materials on SCFAs production which indicated that there would have differences in bacterial population and fermentation in the caeca. As each SCFA plays different roles either systematically or locally on the development and repair of the digestive tract (Jacobasch *et al*., 1999; Bird *et al*., 2000), further studies on the impact of feed material on the physiology of enterocytes remain to be elucidated.

CONCLUSION

Cassava is a potential source of carbohydrate substitution for corn in broiler diets. High digestibility of cassava carbohydrate commenced in the duodenum, increased in the jejunum and decreased in the ileum. Intestinal mucosal disaccharidase activities were stimulated by cassava based diet at higher level than by corn based diet. Broilers fed cassava based diets demonstrated no detrimental effects on the proventriculus, pancreas, spleen or small intestinal mucosal thickness. Lighter gizzard weight and higher liver weight were observed in broilers fed cassava than in those fed corn. Broilers fed cassava chips produced higher butyrate in the caeca while those fed corn and cassava pellets have a tendency to produce higher acetate and propionate, respectively.

ACKNOWLEDGEMENTS

The authors would like to thank the Thai Tapioca Development Institute (TTDI) for the supporting of the research fund.

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