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Short communication

Effects of different amylose to amylopectin ratios on serum indices related to glucose metabolism and glucose transporter expression in fattening lambs

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ABSTRACT

The objective of this study was to determine the effects of different amylose to amylopectin ratios on serum indices related to glucose metabolism and the mRNA expression of glucose transporters in the small intestinal mucosa of fattening lambs. A total of 36 male 7-day-old lambs of similar weight were randomly assigned to four treatments of iso-starch diets containing tapioca starch, maize starch, wheat starch, and pea starch, with the determined ratio for amylose to amylopectin of 0.12, 0.23, 0.24, and 0.48, respectively. Serum glucose, creatinine, insulin, and glucagon were reduced with the advancing age of lambs. The results indicated that feeding lambs with a pea starch diet (high amylose to amylopectin ratio) had increased serum cholesterol (P=0.047), lactate dehydrogenase (LDH) (P=0.010), and growth hormone (GH) (P=0.037). Pea starch did not influence the serum glucose (P=0.160), but significantly decreased the serum insulin (P=0.021). The pea starch diet significantly up-regulated the mRNA expression of glucose transporters, which may increase intestinal glucose uptake. By contrast, the consumption of tapioca starch resulted in the opposite effects, and significantly down-regulated the mRNA expression of glucose transporters. Collectively, these data suggest that starches with higher amylose to amylopectin ratios promote higher concentrations of plasma cholesterol, LDH and GH, and up regulate the gene expression profile of glucose transporters in fattening lambs.

1. Introduction

In pre-weaned ruminants, solid feed intake, particularly high carbohydrate diets, initiates gastrointestinal tract (GIT) development (Suárez et al., 2006). Adaptations of the GIT and its digestive functions are critical as these young animals transition from milk to solid feed (Khan et al., 2007). In most diets, starch is the primary energy source. Starch is composed of linear glucose polymers (amylose) and highly branched polymers (amylopectin), and it is possible that the two forms have differing effects on GIT development. Early and optimal development of the GIT by a suitable starter diet is required

Abbreviations: GLU, glucose; LDH, lactate dehydrogenase; GH, growth hormone; GIT, gastrointestinal tract; SGLT1, apical sodium-dependent glucose co-transporter-1; GLUT2, facilitated glucose transporter; TS, tapioca starch; MS, maize starch; WS, wheat starch; PS, pea starch; ADG, average daily gain; ELISA, enzyme-linked immunosorbent assay; RT-PCR, real-time PCR; DM, dry matter; CP, crude protein.

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Table 1
Ingredient and chemical composition of the concentrate diets (dry matter basis).

Ingredient	g/kg	Component	g/kg
Starch source[1]	507.0	Total starch[3]	441
Soybean meal	280.6	Dry matter[3]	948
Corn gluten meal	154.0	Digestible energy[4] (MJ/kg)	13.4
Soybean oil	15.0	Crude protein[3]	195
Limestone meal	8.8	Ca[3]	7.70
$CaHPO_4$	21.0	P[3]	5.80
Salt	3.6		
Premix[2]	10.0		

[1] Starch source: tapioca starch, maize starch, wheat starch, and pea starch.
[2] Provide mineral elements (mg) and vitamins (IU) concentrate supplement per kg: S 200; Fe 25; Zn 40; Cu 8; Mn 40; I 0.3; Se 0.2; Co 0.1; Vitamin A 940; Vitamin E 20.
[3] Values based on analysis.
[4] Calculated value based on database of the NRC (2007) proposal nutrient requirement for lamb.

to ensure animal health and productivity (Zitnan et al., 2003; Odongo et al., 2006; Naeem et al., 2012). Based on these observations, the objective of this study was to determine whether diets containing different amylose to amylopectin ratios (amylose/amylopectin) influence indices of glucose metabolism in fattening lambs.

2. Materials and methods

2.1. Animals and diets

All experimental animals received care according to the Guide for the Care and Use of Laboratory Animals by the Chinese Academy of Science. A total of 36 male lambs (Northeast fine wool sheep × Merino) born in February 2013 were separated from their mothers after 7 days of age, weighed, grouped by body weight, and randomly assigned to four dietary treatments with nine lambs per group. The dietary treatment groups were as follows: tapioca starch group (TS, amylose/amylopectin = 0.12), wheat starch group (WS, amylose/amylopectin = 0.23), maize starch group (MS, amylose/amylopectin = 0.24), and pea starch group (PS, amylose/amylopectin = 0.48). The experimental diets were formulated to meet the nutrient requirements for lambs according to the NRC (2007). The chemical and ingredient composition in the basic diet are listed in Table 1. Feed and water were provided *ad libitum* throughout the experiment, and the lambs were allowed to nurse.

2.2. Chemical analysis

Samples of each lamb diet and their refusal were analyzed for dry matter (ISO 6496), crude protein (ISO 15670), according to the Association of Analytical Chemists (AOAC, 1995). Starch content was determined according to the procedure of Hall (2001). The diets were analyzed to determine the contents of amylose and amylopectin using the procedure described by Englyst et al. (1992). Calcium and P were measured by inductively coupled plasma emission spectroscopy using an Atom Scan 25 Plasma Spectroscopy (Thermo Jarrell Ash Corp., Grand Junction, CO) after acid digestion.

2.3. Growth performance and blood parameters measured

The experiment was performed for 56 days. The initial body weight, final body weight, and feed intake were measured. The average daily gain (ADG) and intake of feed, dry matter, crude protein, and starch were calculated accordingly.

Blood samples from the jugular vein of lambs at d 21, 35, and 56 were collected in evacuated tubes (10 mL) without anticoagulant. These samples were centrifuged at 1000 × *g* for 20 min, and the serum was aliquoted and stored at −20 °C. The serum concentrations of glucose (GLU), cholesterol, triglycerides, lactate dehydrogenase (LDH), and creatinine were determined using the Automatic Biochemical Analyzer (Beckman, Miami, FL, USA) with commercial diagnostic kits (Nanjing Jiancheng Bioengineering Institute, Nanjing, China) based on an enzymatic method. Serum insulin, growth hormone (GH), and glucagon were measured using an enzyme-linked immunosorbent assay (ELISA) kit (R&D Systems, Inc.), according to the manufacturer's instructions (ELISA kit for GH determination in sheep use sheep-anti-rabbit gamma globulin as antiserum, it is for research work only).

2.4. Collection of intestine tissue samples

When the feeding experiment was completed, three fattening lambs per treatment were randomly selected and sacrificed, and the mucosa samples of intestine (duodenum, jejunum, and ileum) were collected into Eppendorf tubes and immediately snap-frozen in liquid nitrogen. The samples were stored at −80 °C until analysis.