ELSEVIER

Livestock Science 99 (2006) 237–247

LIVESTOCK SCIENCE

www.elsevier.com/locate/livsci

Consumption of resistant starch decreases lipogenesis in adipose tissues but not in muscular tissues of growing pigs

D. Martinez-Puig [a], J. Mourot [b], V. Ferchaud-Roucher [c], M. Anguita [a], F. Garcia [a], M. Krempf [c], J.F. Pérez [a,*]

[a] *Departament de Ciència Animal i dels Aliments. Universitat Autònoma de Barcelona, 08193 Bellaterra, Spain*
[b] *Institut National de la Recherche Agronomique, Unité Mixte de Recherche sur le Veau et le Porc-Saint-Gilles 35590, France*
[c] *Centre de Recherche en Nutrition Humaine, Inserm U539, Hotel Dieu U539, Nantes, France*

Received 10 May 2004; received in revised form 27 July 2005; accepted 27 July 2005

Abstract

The aim of the present study was to evaluate the effect of two different sources of starch on plasma glucose, acetate and insulin responses and peripheral lipogenesis in adipose and skeletal muscle tissues. Eighteen male growing pigs were fed a diet containing 250 g native corn starch/kg (CS; 26% amylose, 74% amylopectin) or 250 g raw potato starch/kg (RPS; 20% amylose, 80% amylopectin) as examples of digestible and resistant starch (type II), respectively. After 38 days on the experimental diets, twelve pigs (6 per treatment, Experiment 1) were killed and samples of adipose and muscular tissues were analysed for intramuscular lipid content and lipogenic enzyme activity. Lipogenic enzyme activities were significantly higher for CS than RPS in adipose tissues but not in muscular tissues. No differences were detected on the lipid content of the muscles tested. The six remaining pigs (3 per treatment, Experiment 2) were fitted with catheters in the saphenous vein and femoral artery after 28 days on the experimental diets. After feeding restoration to a level of 1.1 kg/day, they received a primed constant infusion of 1-^{13}C acetate for a period of 90 min, starting 5 h after feeding the meal ingestion, and a primed constant infusion of 6,6-D_2 glucose for 7 h, starting 1 h before the following meal ingestion. No differences were observed between diets on peripheral acetate entry rate. Glucose concentration, the rate of peripheral glucose appearance and insulin concentration were quantitatively higher after the meal for CS than for RPS diet. This shows the importance of type of dietary starch on lipogenesis as a result of changes in glycemia and insulinemia in adipose but not in muscular tissues of growing pigs.

Keywords: Resistant starch; Growing pigs; Glycemia; Lipogenesis

1. Introduction

Skeletal muscle triglyceride levels are considered to be very important in pig production as they con-

* Corresponding author. Tel.: +34 93 5811556; fax: +34 93 5811494.
E-mail address: josefrancisco.perez@uab.es (J.F. Pérez).

0301-6226/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.livsci.2005.07.003

tribute to the organoleptic properties of meat, such as tenderness and flavor (Cannon et al., 1995). In pigs, the synthesis of adipose tissue triglycerides, the major constituents of depot fat, either proceeds from fatty acids synthesized de novo (especially from diet starch) in that tissue or from fatty acids obtained from circulating triglycerides as a result of adipose tissue lipoprotein lipase activity (Steffen et al., 1978). Intramuscular lipids in pigs mainly originate from in situ lipogenesis, with little contribution from the liver, in contrast with other species and humans (O'Hea and Leveille, 1969). Numerous studies demonstrate the broad influence of pig genotype on lipogenesis, as indicated by the comparison between Iberian and Landrace breeds (Morales et al., 2002) or Meishan and Large White breeds (Mourot and Kouba, 1998). It is known that modern genotypes selected for growth rate and feed efficiency show a lower voluntary intake correlated with lower whole body fat and muscle triglycerides content (Karlsson et al., 1993).

However, other factors, such as nutrition, endocrine status, or the physical activity of the animals are thought to contribute to the development of skeletal muscle and lipogenesis. Energy intake is considered to be the main factor conditioning whole body lipogenesis. Thus, feed restriction can modify morphological and biochemical characteristics of muscle and adipose tissue in pigs, leading to a reduction of muscle lipid concentration, as seen in the longissimus dorsi of pigs slaughtered at the same weight as their well nourished counterparts (Candek-Potokar et al., 1999; Wood, 1990). The macronutrient composition of the diet may also affect the development of adipose tissue and lipogenesis. In particular, many studies in rodents have shown greater stimulation of fatty acid synthesis by high-sugar than by high starch diets (Glinsmann et al., 1986; Shillabeer et al., 1990). This difference is more pronounced with fat-free diets and less pronounced when the percentage of energy from fat rises. It is known that increases in the dietary fat content reduce fatty acid synthesis and activities of related enzymes in the growing pig (Allee et al., 1972). Changes on lipogenesis could be related to differences in glucose flux or insulin metabolism associated with the starch or sucrose kinetics of digestion in the gastrointestinal tract. Starch is digested more slowly than glucose, with lower post-prandial rises in insulin and glucose. Moreover, the bacterial fermentation of resistant starches or non-starch polysaccharides in the large intestine produces short-chain fatty acids (SCFA), which may also affect lipid and insulin metabolism (Nishina and Freedland, 1990; Wolever et al., 1995). However, there is not much research on the digestion of starch and the extent of hindgut fermentation as factors conditioning the peripheral lipogenesis in skeletal muscle and adipose tissues in pigs.

During the course of this experiment the influence of two different sources of starch (corn starch, CS, and raw potato starch, RPS) was compared with regards to the plasma glucose levels and insulin responses, and the peripheral acetate entry rate in growing pigs. A long term dietary effect of the type of starch on the lipogenic enzyme activities, malic enzyme (ME), glucose-6-phosphate-dehydrogenase (G6PDH) and acetyl-CoA carboxylase (ACX), and percentage of lipid content in skeletal muscle was also evaluated.

2. Materials and methods

The experiment received prior approval from the Animal Protocol Review Committee of the host institution and conformed with current European Union Regulations on Animal Care and Recommendations of the Federation of European Laboratory Animal Science Association for the care and welfare of animals.

Purified starches (native corn starch, CS, 26% amylose, 74% amylopectin; raw potato starch, RPS, 20% amylose, 80% amylopectin) were purchased from Cerestar Iberica (Barcelona, Spain). As determined by enzymatic analysis (Champ, 1992), CS contained 187 g of resistant starch/kg and RPS has 637 g of resistant starch/kg.

2.1. Experiment 1

2.1.1. Animals and diets

Twelve Landrace × Large White male growing pigs averaging 18.4 ± 1.0 kg (mean ± SD) body weight (BW) were purchased from La Balcona (Vic, Spain). On arrival, they were housed individually, and administered a pre-experimental diet mainly composed of