Comparative Study of Blood Biochemical Parameters, Gastrointestinal Digestive Enzyme Activities, and Volatile Fatty Acid Contents in Meishan and Large White Piglets during Lactation: Postprint

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Abstract

(Purpose) To comparatively study the early physiological characteristics of Meishan and Large White piglets during the suckling period. (Methods) Six purebred Meishan sows and Large White sows with similar expected delivery dates were selected, and on day 14 postpartum, one piglet from each litter was randomly selected for slaughter; blood, pancreas, gastrointestinal tract contents, and fecal samples were collected to determine blood biochemical indices, digestive enzyme activities, and volatile fatty acids (VFA). (Results) The results showed that serum total cholesterol and high-density lipoprotein contents in suckling Large White piglets were significantly higher than those in suckling Meishan piglets ($P<0.05$); gastric lipase activity in suckling Meishan piglets was significantly higher than that in suckling Large White piglets ($P<0.05$), while jejunal lactase activity was significantly lower ($P<0.01$); the contents of acetic acid, propionic acid, and total volatile fatty acids, as well as the proportion of propionic acid in the cecum of suckling Meishan piglets, were extremely significantly higher than those in suckling Large White piglets ($P<0.01$), whereas the concentration of acetic acid in the jejunum and the acetic acid to propionic acid ratio in the colon were lower ($P<0.05$). (Conclusion) These findings indicate that during the early growth stage, differences exist between suckling Meishan and Large White piglets in blood biochemical indices and their gastrointestinal digestive enzyme activities and volatile fatty acid contents.

Full Text

Comparison of Blood Biochemical Parameters, Gastrointestinal Digestive Enzyme Activities, and Volatile Fatty Acid Content in Suckling Meishan and Yorkshire Piglets

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Abstract

Objective: To compare the early physiological characteristics of suckling Meishan and Yorkshire piglets. **Method:** Six purebred Meishan sows and six Yorkshire sows with similar expected delivery dates were selected. On day 14 postpartum, one piglet from each litter was randomly selected for slaughter. Blood, pancreas, gastrointestinal contents, and fecal samples were collected to measure blood biochemical parameters, digestive enzyme activities, and volatile fatty acids (VFA). **Result:** The results showed that serum total cholesterol and high-density lipoprotein levels were significantly higher in suckling Yorkshire piglets than in Meishan piglets ($P<0.05$). Gastric lipase activity was significantly higher in suckling Meishan piglets ($P<0.05$), while jejunal lactase activity was significantly lower ($P<0.01$). The concentrations of acetate, propionate, and total volatile fatty acids in the cecum, as well as the propionate proportion, were significantly higher in suckling Meishan piglets ($P<0.01$), whereas jejunal acetate concentration and the acetate-to-propionate ratio in the colon were lower ($P<0.05$). **Conclusion:** These findings indicate that significant differences exist in blood biochemical parameters, gastrointestinal digestive enzyme activities, and volatile fatty acid content between suckling Meishan and Yorkshire piglets during early growth.

Keywords: blood biochemical parameters; digestive enzyme activity; volatile fatty acid concentration; suckling Meishan piglets; suckling Yorkshire piglets

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Different pig breeds, particularly fat-type and lean-type breeds, exhibit distinct physiological and biochemical characteristics. He et al. [1] employed nuclear magnetic resonance (NMR) spectroscopy for blood metabolomic analysis and found significant differences in lipid synthesis, fatty acid oxidation, energy metabolism, and protein/amino acid metabolism between 4-month-old fat-type Ningxiang pigs and lean-type three-way crossbred pigs. Our laboratory previously reported that suckling Meishan piglets showed higher gastrointestinal tract development levels than Yorkshire piglets at 28 days (weaning age) and

49 days, suggesting that Meishan piglets may possess stronger nutrient absorption capacity [2]. These findings indicate that fat-type and lean-type piglets exhibit substantial metabolic differences after weaning. However, research on physiological characteristics of different pig breeds during the suckling period remains limited. Kelly et al. [3] found that piglets of the same genotype fed milk from different sow breeds showed significant differences in lactase activity, villus height, and crypt depth. Rzasa et al. [4] reported that when different genotypes of suckling piglets were fed identical sow milk composition, differences in weight gain decreased during later growth stages. These studies demonstrate that both genotype and maternal milk profoundly affect the growth and development of suckling piglets during the exclusive breastfeeding stage. Therefore, this experiment was designed to investigate differences in physiological traits between suckling fat-type Meishan piglets and lean-type Yorkshire piglets.

1. Materials and Methods

1.1 Experimental Design and Animal Management

The experiment was conducted at a commercial pig farm in Jiangsu Province. Six purebred Meishan sows and six Yorkshire sows (parity 3-4) with similar expected delivery dates were selected and paired into six replicate pairs. Sows were fed a corn-soybean meal-based diet containing 63% corn, 24% soybean meal, 3% fish meal, 6% wheat bran, and 4% premix. The dietary nutrient levels were 20.67% crude protein, 3.22% crude fat, and 3.21% crude fiber. During the trial, all sows had free access to feed and water, were housed under identical environmental conditions, and managed according to routine procedures.

1.2 Sample Collection

Piglets were fed maternal milk until 14 days of age, at which point one male piglet from each litter was randomly selected for slaughter. Prior to slaughter, piglets were weighed and blood was collected from the anterior vena cava. Blood samples were allowed to clot for 4 hours, then centrifuged at 3,000 rpm for 15 minutes, and the serum was stored at -20°C. After euthanasia via jugular exsanguination, stomach, anterior jejunum, and pancreatic tissues were collected for amylase, protease, and lipase activity measurements. Jejunal, cecal, and colonic contents, as well as fecal samples, were collected and stored at -20°C for subsequent VFA analysis.

1.3 Measurements and Methods

Blood biochemical parameters: Serum concentrations of total protein, albumin, globulin, glucose, urea, total cholesterol, triglycerides, high-density lipoprotein (HDL), and low-density lipoprotein (LDL) were determined using an AU-400 automatic biochemical analyzer (Olympus, Japan) according to kit instructions.

Digestive enzyme activities: One gram of stomach and jejunal contents and pancreatic tissue were processed with simple pretreatment, and the supernatant was collected. Amylase, protease, and lipase activities were measured using colorimetric methods according to kit protocols (Nanjing Jiancheng Bioengineering Institute).

VFA concentrations: VFA concentrations were determined according to the method of Qin (1982) [5] using a GC-14B gas chromatograph (Shimadzu, Japan) equipped with a capillary column. The column temperature was 130°C, vaporization temperature 180°C, and detection temperature 180°C using a hydrogen flame ionization detector. Carrier gas was nitrogen at 60 kPa, hydrogen pressure 50 kPa, oxygen pressure 50 kPa, sensitivity 10^1, and attenuation 3.0.

1.4 Statistical Analysis

Data were organized in Excel and analyzed using one-way ANOVA with SPSS 17.0 software. Results are expressed as mean ± standard error (SE). Differences were considered significant at $P<0.05$ and highly significant at $P<0.01$.

2. Results

2.1 Comparison of Blood Biochemical Parameters Between Suckling Meishan and Yorkshire Piglets

As shown in , no significant differences were observed between the two piglet groups in serum glucose, total protein, globulin, albumin, urea, triglyceride, or LDL concentrations. However, HDL and total cholesterol concentrations were significantly higher in suckling Yorkshire piglets compared to Meishan piglets ($P<0.05$).

2.2 Comparison of Digestive Enzyme Activities Between Suckling Meishan and Yorkshire Piglets

As presented in , suckling Meishan piglets exhibited higher gastric lipase activity ($P<0.05$) and lower jejunal lactase activity ($P<0.01$) compared to Yorkshire piglets. Jejunal amylase activity in Meishan piglets showed a trend toward being lower than in Yorkshire piglets ($0.05<P<0.1$). Due to the small size of the piglets, gastric protease and jejunal protease activities were below the detection limit of our assay kits and thus could not be reliably measured.

2.3 Comparison of VFA Concentrations Between Suckling Meishan and Yorkshire Piglets

As shown in , concentrations of acetate, propionate, and total volatile fatty acids in the cecum were significantly higher in suckling Meishan piglets than in Yorkshire piglets ($P<0.01$), while jejunal acetate concentration was significantly lower ($P<0.05$). No significant differences were observed in VFA concentrations at other gut sites. Additionally, except for acetate, other volatile fatty acids in

the jejunum were below detection limits using our methodology. The proportion of propionate in the colon and cecum was significantly higher in Meishan piglets ($P<0.01$), while the acetate-to-propionate ratio in the colon was significantly lower than in Yorkshire piglets ($P<0.05$) ().

3. Discussion

3.1 Blood Biochemical Parameters Reflect Lipid Metabolism Trends in Different Breeds

Blood metabolites reflect the physiological status of an organism. In this study, suckling Yorkshire piglets had significantly higher HDL content than Meishan piglets, with no significant difference in LDL content. This suggests that the amount of cholesterol available for fatty acid synthesis was reduced in Yorkshire piglets, resulting in significantly higher serum total cholesterol levels. We observed that serum triglyceride content tended to be lower in suckling Meishan piglets compared to Yorkshire piglets, which contradicts the findings of He et al. [1] who reported higher triglycerides in fat-type Ningxiang pigs versus lean-type three-way crossbred pigs, but aligns with the results of Pond et al. [6]. This discrepancy may be related to differences in growth stage and diet. Additionally, the higher proportion of propionate in the cecum and colon of Meishan piglets would be expected to intensify gluconeogenesis [7]; however, blood glucose content was actually lower in Meishan piglets. This suggests that the increased glucose production may be utilized by other metabolic pathways. Enhanced glucose metabolism can provide sufficient acetyl-CoA and ATP, both essential for de novo fatty acid synthesis. Therefore, we speculate that the additional glucose may be stored as triglycerides in adipose tissue.

3.2 Digestive Enzyme Activities and Their Role in Gut Microbial Metabolism

During the exclusive breastfeeding stage, we found that gastric lipase activity was significantly higher than jejunal lipase activity, indicating that the stomach plays a more important role in fat digestion during early animal development [8]. Since Meishan piglets exhibited significantly higher gastric lipase activity than Yorkshire piglets, more milk fat would be hydrolyzed, and the resulting fatty acids could be transported to adipose tissue or liver for triglyceride synthesis. This may partly explain why Meishan piglets have higher backfat proportion and thickness (data not shown). Lactase is primarily produced by small intestinal mucosal epithelial cells and secreted into the intestinal lumen, where it hydrolyzes milk lactose into galactose and glucose. These monosaccharides are not only the most important energy sources but also play crucial roles in promoting brain and neural development and improving growth performance [9]. Kim et al. [10] reported that adding different levels of lactose to weaned piglet diets significantly improved growth performance within a certain range. In this study, both piglet groups consumed maternal milk with similar lactose content (57.02 mg/mL in Meishan sow milk vs. 57.99 mg/mL in Yorkshire sow milk

at day 14). However, jejunal lactase activity was significantly lower in Meishan piglets, which would result in higher concentrations of undigested lactose. Additionally, jejunal amylase activity tended to be lower in Meishan piglets, leading to more undigested starch reaching the large intestine. The increased availability of these fermentable substrates likely contributed to the significantly higher VFA concentrations observed in the cecum and colon of Meishan piglets. Many studies have similarly reported higher VFA concentrations in the cecum and colon of fat-type animals compared to lean-type animals. This phenomenon has been attributed to higher abundance of VFA-producing Firmicutes, particularly Ruminococcaceae and Clostridia clusters IX and XIVa involved in cellulose degradation and acid production [11-12]. Such differences in microbial composition have also been observed between fat-type Erhualian pigs and lean-type Landrace pigs [13]. The differences in VFA concentrations are thus closely associated with structural differences in the gut microbiota between the two piglet breeds.

Conclusions

1. Significant differences exist in digestive enzyme activities, blood biochemical parameters, and volatile fatty acid concentrations between suckling Meishan and Yorkshire piglets.
2. Suckling Meishan piglets have higher serum total cholesterol and HDL concentrations, significantly higher gastric lipase activity, and lower jejunal lactase activity compared to Yorkshire piglets.
3. Suckling Meishan piglets have higher concentrations of acetate, propionate, and total volatile fatty acids in the cecum.

References

[1] HE Q, REN P, KONG X, Wu Y, Wu G, et al. Comparison of serum metabolite compositions between obese and lean growing pigs using an NMR-based metabonomic approach[J]. The Journal of Nutritional Biochemistry, 2012, 23(2): 133-139.

[2] 杨利娜, 朱志刚, 边高瑞, 石晓峰, 苏勇, 朱伟云. 哺乳梅山仔猪和哺乳大白仔猪生长性能和消化道发育的比较研究 [J]. 动物营养学报, 2014, 26(6): 1644-1651.

[3] KELLY D, KING T, MCFADYEN M, et al. Effect of lactation on the decline of brush border lactase activity in neonatal pigs[J]. Gut, 1991, 32(4): 386-392.

[4] RZASA A, POZNANSKI W, AKINCZA J, et al. The influence of primiparous sow litter standardization on their performance[J]. Roczniki Naukowe Zootechniki, 2002(suppl. 2):

[5] 秦为琳. 应用气相色谱测定瘤胃挥发性脂肪酸方法的研究改进. 南京农业大学学报, 1982, 4: 110-116.

[6] POND W, YEN J, LINDVALL R, HILL D. Dietary alfalfa meal for genet-

ically obese and lean growing pigs: effect on body weight gain and on carcass and gastrointestinal tract measurements and blood metabolites[J]. Journal of Animal Science, 1980, 51(2): 367-373.

[7] NICHOLSON JK, HOLMES E, KINROSS J, et al. Host-gut microbiota metabolic interactions[J]. Science, 2012, 336(6086): 1262-1267.

[8] HENNING SJ. Postnatal development: coordination of feeding, digestion, and metabolism[J]. American Journal of Physiology-Gastrointestinal and Liver Physiology, 1981, 241(3): G199-G214.

[9] BANO G. Glucose homeostasis, obesity and diabetes[J]. Best Practice & Research Clinical Obstetrics & Gynaecology, 2013, 27(5): 715-726.

[10] KIM JS, SHINDEPL, YANGYX, et al. Effects of dietary lactose levels during different starter phases on the performance of weaning pigs[J]. Livestock Science, 2010, 131(2):

[11] SCHWIERTZ A, TARAS D, SCHÄFER K, et al. Microbiota and SCFA in lean and overweight healthy subjects[J]. Obesity, 2010, 18(1): 190-195.

[12] TREMAROLI V, BÄCKHED F. Functional interactions between the gut microbiota and host metabolism[J]. Nature, 2012, 489(7415): 242-249.

[13] LUO YH, SU Y, WRIGHT ADG, ZHANG LL, et al. Lean breed Landrace pigs harbor fecal methanogens at higher diversity and density than obese breed Erhualian pigs[J]. Archaea, 2012, 2012.

Note: Figure translations are in progress. See original paper for figures.