Effects of High- and Low-Nutrient-Level Diets on Reproductive Performance, Body Composition, and Plasma Biochemical Parameters in Pregnant Huanjiang Xiang Pigs (Postprint)

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Abstract

This experiment aimed to investigate the effects of high- and low-nutrient-level diets on the reproductive performance and body composition of pregnant sows, and to explore their biochemical mechanisms. Forty-eight primiparous Huanjiang Xiang pigs were selected and randomly divided into 2 groups based on body weight, with 8 replicates (pens) per group and 3 pigs per replicate. After mating, they were fed either an NRC diet [digestible energy (DE) 14.73 MJ/kg, crude protein (CP) content 13.11%] or a local pig diet (DE 12.24 MJ/kg, CP content 9.77%). Sow body weight was measured on days 45, 75, and 110 post-mating. One sow per pen was selected for blood collection from the anterior vena cava for biochemical parameter analysis, then euthanized by exsanguination and dissected to record the number of fetuses, weigh individual fetal weight, and determine maternal body composition. The results showed that compared with the local pig diet group, differences in reproductive performance and body composition indices in the NRC diet group were not significant ($P>0.05$). Plasma alanine aminotransferase activity at days 45 and 75 of gestation and aspartate aminotransferase activity at day 75 of gestation were significantly decreased ($P<0.05$), while low-density lipoprotein-cholesterol concentration at day 45 of gestation, alkaline phosphatase activity, high-density lipoprotein-cholesterol and total cholesterol concentrations at day 75 of gestation, and triglyceride concentration throughout the gestation period were significantly increased ($P<0.05$). The effects of the two diets on the measured indices differed to some extent across different gestational periods. It can be concluded that neither diet had significant effects on the reproductive performance and body composition of Huanjiang Xiang pigs. The NRC diet improved metabolism and promoted growth and development to a certain extent, but simultaneously increased fat deposition.

Full Text

High- or Low-Nutrient Level Diets Affect Reproductive Performance, Body Composition, and Plasma Biochemical Parameters of Pregnant Huanjiang Mini-Pigs

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Abstract

This study investigated the effects of high- and low-nutrient level diets on reproductive performance and body composition in pregnant sows and explored the underlying biochemical mechanisms. Forty-eight primiparous Huanjiang mini-pigs were randomly assigned to two groups based on body weight, with eight replicates (pens) per group and three pigs per replicate. After mating, the pigs were fed either an NRC diet (digestible energy [DE] 14.73 MJ/kg, crude protein [CP] 13.11%) or a local-pig diet (DE 12.24 MJ/kg, CP 9.77%). Body weight was recorded at 45, 75, and 110 days post-mating. One sow per pen was selected for blood collection via cranial vena cava puncture for biochemical analysis, then euthanized by exsanguination and dissected to record litter size and individual fetal weight, and to determine maternal body composition.

Results showed that compared with the local-pig diet group, the NRC diet group exhibited no significant differences in reproductive performance or body composition indices ($P>0.05$). However, plasma glutamic-pyruvic transaminase (GPT) activity at 45 and 75 days of gestation and glutamic oxaloacetic transaminase (GOT) activity at 75 days were significantly lower ($P<0.05$). Plasma low-density lipoprotein cholesterol (LDL-C) concentration at 45 days, high-density lipoprotein cholesterol (HDL-C) and total cholesterol (TC) concentrations at 75 days, triglyceride (TG) concentrations throughout gestation, and alkaline phosphatase (ALP) activity at 75 days were significantly higher ($P<0.05$). The effects of the two diets on measured parameters varied across gestational periods.

These findings indicate that neither diet significantly affected reproductive performance or body composition in pregnant Huanjiang mini-pigs, though the NRC diet improved metabolic status and promoted growth while simultaneously increasing fat deposition.

Keywords: nutrient levels; Huanjiang mini-pigs; reproductive performance; body composition; plasma biochemical parameters

Introduction

In intensive swine production, multiple factors including genetics, nutrition, environment, and disease can cause prenatal and postnatal fetal mortality, with nutrition being one of the most critical factors. Modern commercial sows ovulate 20–30 oocytes with fertilization rates exceeding 95%; if all zygotes developed in the uterus, average litter size would reach 14 piglets or more, yet actual production yields only about 10 piglets per litter. Research indicates that primiparous sows experience 30%–50% embryonic mortality during gestation, with early pregnancy representing the peak period for embryonic loss. High embryonic and fetal mortality rates have thus become a primary constraint on improving sow reproductive efficiency in swine production. Reducing embryonic and fetal losses in early pregnancy therefore represents an important pathway for increasing litter size and enhancing both reproductive performance and economic returns.

While substantial research has established nutrient requirements for piglets, growing pigs, and finishing pigs, few studies have focused on pregnant sows. Nutritional levels before and after mating are believed to affect embryonic survival in early pregnancy, with higher pre-mating nutrition improving ovulation rate and oocyte quality, but continued high nutrition post-mating reducing embryonic survival. Providing pregnant sows with appropriately formulated diets is therefore crucial for optimizing reproductive performance. Developing dietary formulations that maximize sow reproductive performance can improve productivity while reducing feeding costs and increasing farm profitability.

Huanjiang mini-pigs, produced in the specific geographic region of Huanjiang County, represent an excellent local breed in Guangxi and one of China' s key protected indigenous miniature pig breeds. However, current feeding and management practices remain relatively extensive, with weak foundational research and no scientifically established nutrient requirements or feeding standards, resulting in slow growth and low reproductive performance. This limitation constitutes a major barrier to large-scale, intensive Huanjiang mini-pig production. Additionally, the widespread decline in reproductive performance among Chinese indigenous pigs may be related to long-term feeding of high-nutrient diets under intensive production systems. This study therefore examined the effects of two different nutrient-level diets on body composition and plasma biochemical parameters in Huanjiang mini-pigs at different gestational stages, investigating whether high-nutrient diets adversely affect reproductive performance to provide evidence for improving reproductive efficiency in this breed.

1.1 Experimental Animals, Grouping, and Management

The animal feeding trial was conducted from June to December 2014 at the Huanjiang Mini-Pig Experimental Base of the Huanjiang Karst Ecosystem Ob-

servation and Research Station, Chinese Academy of Sciences. Forty-eight primiparous Huanjiang mini-pigs were randomly allocated into two groups based on body weight, with 24 pigs per group housed in eight pens (replicates) of three pigs each. Prior to the trial, each sow' s fasting body weight was recorded and all pigs were fed a local Huanjiang mini-pig diet. After mating, the groups were fed either an NRC diet (formulated according to NRC nutrient requirements) or a local-pig diet (formulated according to Chinese indigenous pig feeding standards) . Throughout the trial, total daily feed intake per pen was maintained at 2.5% of the total body weight of the three sows in that pen. Pigs were fed twice daily at 08:30 and 17:00 with free access to water, and all experimental animals were managed according to the farm' s standard protocols.

1.2 Sample Collection

At 45, 75, and 110 days of gestation, body weight was recorded for all sows. One sow per pen (eight per group) was randomly selected for blood collection via cranial vena cava puncture using heparin as an anticoagulant. Plasma was separated by centrifugation at 3,000 r/min for 10 minutes and stored at -20°C. Selected sows were then euthanized by carotid artery exsanguination and dissected. The entire uterus was removed to observe and record fetal number, uterine weight, and individual fetal weight. The carcass was split to measure backfat thickness and liver weight, and to calculate liver and uterine coefficients (organ weight/live body weight). Carcass weight was recorded, and skin, bone, muscle, and fat were separated and weighed individually to calculate muscle and fat percentages (100 × tissue weight/live body weight).

1.3 Plasma Biochemical Parameter Determination

Plasma samples were thawed at 4°C and analyzed using a CX4 automatic biochemical analyzer (Beckman, USA) to determine alkaline phosphatase (ALP), glutamic-pyruvic transaminase (GPT), glutamic oxaloacetic transaminase (GOT), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), total cholesterol (TC), triglyceride (TG), and glucose (GLU) activities or concentrations. Biochemical assay kits were purchased from Beijing Leadman Biochemical Technology Co., Ltd.

1.4 Data Processing and Analysis

Data are expressed as means ± standard error. Independent samples t-tests were used to compare data between different groups at the same gestational stage, and one-way ANOVA was used to compare data across different gestational stages within the same group. Differences were considered significant at $P<0.05$ and trends at $0.05 \leq P<0.10$.

2.1 Effects of Different Nutrient Level Diets on Reproductive Performance of Pregnant Huanjiang Mini-Pigs

As shown in Table 2 , no significant differences were observed in reproductive performance indices between the NRC diet group and the local-pig diet group ($P>0.05$). Litter weight and individual fetal weight increased significantly with advancing gestation in both diet groups ($P<0.05$).

2.2 Effects of Different Nutrient Level Diets on Body Composition of Pregnant Huanjiang Mini-Pigs

Table 3 shows that no significant differences were found in maternal body composition indices between the NRC diet group and the local-pig diet group ($P>0.05$). Within the local-pig diet group, backfat thickness at 110 days of gestation was significantly higher than at 45 days ($P<0.05$), uterine coefficient at 75 and 110 days was significantly higher than at 45 days ($P<0.05$), liver coefficient at 110 days was significantly lower than at 45 and 75 days ($P<0.05$), and muscle percentage at 75 days was significantly lower than at 45 days ($P<0.05$).

2.3 Effects of Different Nutrient Level Diets on Plasma Enzyme Activities of Pregnant Huanjiang Mini-Pigs

Table 4 reveals that compared with the local-pig diet group, plasma ALP activity was significantly higher in the NRC diet group at 75 days of gestation ($P<0.05$) and showed an increasing trend at 110 days ($P=0.056$). Plasma GPT activity at 45 and 75 days and GOT activity at 75 days were significantly lower in the NRC diet group ($P<0.05$). Within the local-pig diet group, ALP activity at 75 and 110 days was significantly lower than at 45 days ($P<0.05$), while GOT activity at 110 days was significantly higher than at 45 and 75 days ($P<0.05$).

2.4 Effects of Different Nutrient Level Diets on Plasma Metabolite Concentrations of Pregnant Huanjiang Mini-Pigs

Table 5 demonstrates that compared with the local-pig diet group, the NRC diet group showed significantly higher plasma LDL-C concentration at 45 days, HDL-C and TC concentrations at 75 days, and TG concentrations throughout gestation ($P<0.05$). Within the local-pig diet group, GLU concentration at 110 days was significantly higher than at 45 and 75 days ($P<0.05$). Within the NRC diet group, LDL-C concentration at 110 days was significantly higher than at 75 days ($P<0.05$).

Discussion

Nutrient level substantially influences reproductive performance in pregnant sows, particularly primiparous animals with greater nutritional demands for both maternal and fetal growth. Providing appropriate nutrition to primiparous

pregnant sows can improve reproductive performance and longevity. In this study, the absence of significant effects on reproductive performance may be attributed to the strong coarse-feed tolerance of pregnant Huanjiang mini-pigs. Huang et al. also reported no significant effects of high-energy, high-protein versus low-energy, low-protein diets on sow reproductive performance. However, Zhou et al. found that high-energy, high-protein diets improved primiparous sow reproductive performance while low-energy, low-protein diets significantly reduced it, possibly due to differences in breed, feeding stage, diet composition, and management among studies. The significantly greater uterine coefficient in the local-pig diet group at 75 and 110 days compared with 45 days suggests that moderately reducing dietary nutrient levels in mid-to-late gestation may meet uterine developmental requirements. While increasing dietary fiber can improve sow reproductive performance when digestive systems are fully developed, this study did not reach that conclusion, likely because sows at different gestational stages have distinct developmental characteristics and nutritional requirements.

Since primiparous sows reach sexual maturity before physical maturity, their body composition is highly susceptible to nutritional levels. Energy and protein are key nutrients for pigs, and providing adequate amounts can meet requirements for maternal growth as well as uterine, placental, fetal, and mammary development, thereby improving reproductive performance. The lack of significant differences in maternal body composition indices between diet groups indicates that the NRC diet did not adversely affect primiparous sow growth. Zhou et al. reported that increasing energy levels increased body fat and lean mass deposition, a conclusion not supported by this study, possibly due to differences in diet composition, sow breed, and parity.

Plasma biochemical parameters reflect nutritional metabolic status and organ function, indirectly indicating animal growth and development. GPT and GOT are important transaminases that play crucial roles in non-essential amino acid synthesis, protein catabolism, and interconversion of fat and carbohydrate metabolism, with their activities reflecting protein synthesis and breakdown status. The significantly lower plasma GPT (at 45 and 75 days) and GOT (at 75 days) activities in the NRC diet group suggest that high-nutrient diets in early and mid-gestation benefit maternal health and may reduce pregnancy syndromes such as obesity and hyperlipidemia. ALP is a key enzyme in digestive metabolism, and its activity reflects animal production performance. The NRC diet' s significant increase in plasma ALP activity in mid-gestation further suggests it promotes growth and development, which is particularly important for primiparous pregnant sows.

Blood concentrations of TC, TG, HDL-C, and LDL-C are important indicators of lipid metabolism. Adipose tissue development and fat deposition depend on blood TG levels, with decreased TG concentrations indicating reduced fat deposition. HDL-C and LDL-C are closely related to lipid transport. Adding alfalfa meal to finishing pig diets can reduce serum TC, TG, and LDL-C concentrations while increasing HDL-C, and increasing dietary fiber can lower serum TC and

TG concentrations. The changes in TC and TG concentrations in this study relate to the higher fiber level in the local-pig diet, though TC was not significantly reduced throughout gestation, again suggesting different nutritional physiological characteristics across gestational stages require tailored nutrition. The HDL-C concentration changes differ from Wang et al.'s report, possibly due to diet composition and metabolic syndrome in mid-to-late gestation, as lipid metabolism abnormalities occur during pregnancy metabolic syndrome. The NRC diet increased fat deposition, which may lead to dystocia, postpartum paralysis, and foot-and-leg diseases.

Conclusions

1. High- and low-nutrient level diets had no significant effects on the reproductive performance or body composition of pregnant Huanjiang mini-pigs.

2. The NRC diet improved metabolic status and promoted growth and development to some extent, but simultaneously increased fat deposition, which is detrimental to perinatal sow health.

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