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RESEARCH ARTICLE

Dietary arginine supplementation in multiparous sows during lactation improves the weight gain of suckling piglets

ZHU Cui[1, 2], GUO Chang-yi[1], GAO Kai-guo[1], WANG Li[1], CHEN Zhuang[2], MA Xian-yong[1], JIANG Zong-yong[1, 2]

[1] *Key Laboratory of Animal Nutrition and Feed Science (South China), Ministry of Agriculture/Institute of Animal Science, Guangdong Academy of Agricultural Sciences, Guangzhou 510640, P.R.China*

[2] *Agro-Biological Gene Research Center, Guangdong Academy of Agricultural Sciences, Guangzhou 510640, P.R.China*

Abstract

This study investigated the effects of dietary arginine (Arg) supplementation, just during lactation, on sow and litter performance, plasma concentrations of metabolites and hormones, and milk yield and composition in multiparous sows. Thirty-one sows were randomly assigned to 3 dietary treatments supplemented with 0.0 (control, *n*=10), 0.5% (*n*=10), or 1.0% (*n*=11) L-Arg-HCl, respectively. Experimental diets were provided to the sows from d 3 to 21 of lactation. Plasma and milk samples were collected at d 14 and 21 of lactation. The average daily gain (ADG) of piglets from sows fed diets supplemented with 0.5 or 1.0% L-Arg-HCl at d 3 to 14 of lactation, were higher than that of controls (P<0.05). Maternal supplementation with 1.0% L-Arg-HCl also increased ADG of piglets between d 3 and 21 of lactation than that of the controls (P<0.05). There was no significant effect of supplementation on average daily feed intake (ADFI), body weight loss, and backfat thickness loss of lactating sows. Supplementation with 0.5 or 1.0% L-Arg-HCl had a trend towards increasing milk yields and milk fat contents (0.05<P<0.10); milk protein and lactose were unchanged. Supplementation with 1.0% L-Arg-HCl increased plasma concentrations of prolactin and insulin in sows at d 14 and 21 of lactation, and plasma concentrations of non-esterified fatty acid (NEFA), insulin-like growth factor-1 (IGF-1), and nitric oxide (NO) in sows at d 21 of lactation, when compared to the controls (P<0.05). Supplementation with 1.0% L-Arg-HCl increased IGF-1 and spermine in milk at d 14 of lactation, relative to the controls (P<0.05). Plasma Arg concentrations at d 14 and 21 of lactation, as well as plasma NO level and milk IGF-1 at d 21 of lactation, were increased, while plasma urea nitrogen (PUN) concentration at d 14 and 21 of lactation was decreased, by supplementation with 0.5 or 1.0% L-Arg-HCl when compared to the controls (P<0.05). Collectively, dietary supplementation of multiparous sows with Arg, just during lactation, is beneficial for enhancing litter weight gain but the complete mechanism remains to be determined and may involve in the maternal endocrine changes and milk polyamines contents.

Keywords: arginine, lactating sows, hormone, suckling piglets, milk composition, polyamines

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ZHU Cui, E-mail: juncy2010@gmail.com; Correspondence JIANG Zong-yong, Tel: +86-20-87596262, Fax: +86-20-87503358, E-mail: jiangz28@qq.com

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1. Introduction

Arginine (Arg) plays multiple roles in animal metabolism by serving as a substrate for protein synthesis, and as a precursor for the synthesis of important biological molecules

such as nitric oxide (NO) and polyamines (Wu *et al.* 2004). Previous study has shown that neonatal pigs have a high requirement for arginine for growth and development (Wu *et al.* 2004). The low concentration of Arg in sow's milk and declining endogenous Arg synthesis from neonatal small intestine, are insufficient for supporting the potential growth of neonatal and sucking piglets (Wu and Knabe 1994; Kim and Wu 2004; Wu *et al.* 2004; Frank *et al.* 2007).

Dietary supplementation of sows with Arg provides an effective way to improve arginine provision for sow-reared piglets. Previous studies showed that increasing dietary Arg supplementation in primiparous sows, starting from pregnancy to lactation until weaning, led to an increased litter weight gain of piglets (Mateo *et al.* 2008). Other studies indicated that dietary supplementation with 1% L-Arg-HCl continuously from d 22 after breeding enhanced pregnancy outcomes in primiparous and multiparous sows under practical production conditions (Gao *et al.* 2012). This long-term supplementation of sows with Arg was marginally cost-effective. It is of great interest to determine if a similar beneficial effect could be obtained if Arg supplementation was provided for a shorter interval, just during lactation, in multiparous sows.

Due to the ethical concerns over lactation research with women and children, swine have been considered to be an ideal animal model to study nutrition influence on mammary gland development and health of offspring (Kim and Wu 2009). The present study, therefore, has tested the hypothesis that dietary Arg supplementation in multiparous lactating sows, exclusively during lactation, might improve the weight gain of sow-reared piglets. Sow and litter performance, plasma concentrations of hormones and metabolites, and milk composition of sows were determined herein.

2. Materials and methods

2.1. Animals, housing and diets

The experiment was carried out in a commercial farrow-to-wean operation (INVA Co. Ltd., Enping, Guangdong, China), and all procedures were approved by the Animal Care and Use Committee of Guangdong Academy of Agricultural Sciences, China.

A total of 31 Landrace×Large White multiparous sows (average parity=2.5) were moved into the farrowing room with individual slatted-floor farrowing crates on approximately d 110 of pregnancy. Each crate had a single feeder and a nipple drinker, and was equipped with a heat lamp for newborn piglets. The temperature of the farrowing room was maintained at 18 to 20°C.

After farrowing, sows with similar body weight and parity were randomly allotted into 3 dietary treatments where the basal diet (Table 1) was supplemented with 0.0 (control, *n*=10), 0.5% (*n*=10) or 1.0% (*n*=11) L-Arg-HCl. Diets were formulated to meet or exceed the nutrient requirements for lactating sows recommended by the NRC (2012). The 3 experiment diets contained total amounts of 0.82, 1.23, and 1.64% of Arg, respectively and alanine was used for the isonitrogenous control. The L-Arg-HCl and L-alanine were purchased from the Qianjiang Siwei Amino Acids Co. Ltd., Hubei, China, with purities of 99.7 and 99.2%, respectively. All sows were fed 2.5 kg d^{-1} per sow of the common basal diet (control diet) from d 110 of pregnancy until the start of the experiment on d 3 of lactation. Then the experimental diets were provided until d 21 of lactation. Feed was gradually increased from farrowing to d 5 of lactation, then provided *ad libitum*. Piglets had no access to creep feed but water was freely available.

2.2. Sow and litter performance

The daily feed intake (ADFI) of sows was recorded accord-

Table 1 Ingredient and composition of experimental diets (as fed basis)

Item	Supplemental L-Arg-HCl in diets (%)		
	0.0 (control)	0.5	1.0
Ingredients (%)			
Corn	65.12	65.46	65.82
Wheat	12.30	12.30	12.30
Soybean meal	12.00	12.00	12.00
Spray-dried blood cells	2.00	2.00	2.00
Soybean oil	1.80	1.80	1.80
Dicalcium phosphate	1.85	1.85	1.85
Limestone	1.10	1.10	1.10
Salt	0.40	0.40	0.40
Trace mineral premix[1)]	0.44	0.44	0.44
Vitamin premix[2)]	0.52	0.52	0.52
Amino acid premix[3)]	0.77	0.77	0.77
L-Arg-HCl	0.00	0.50	1.00
L-Alanine	1.70	0.85	0.00
Total	100.00	100.00	100.00
Calculated nutrition composition			
DE (kcal kg^{-1})	3418	3413	3407
CP (%)	16.30	16.30	16.30
Ca (%)	0.90	0.90	0.90
Available P	0.46	0.46	0.46
Arginine (%)	0.82	1.23	1.64
Lysine (%)	0.97	0.97	0.97
Methionine+Cystine (%)	0.47	0.47	0.47
Threonine (%)	0.63	0.63	0.63
Tryptophan (%)	0.18	0.18	0.18

[1)] Supplied per kilogram of final diet: 60 mg Zn; 60 mg Fe; 35 mg Mn; 8 mg Cu; 0.35 mg I, and 0.30 mg Se.
[2)] Supplied per kilogram of final diet: 25 000 IU vitamin A; 3 000 IU vitamin D_3; 65 mg vitamin E; 5 mg vitamin K; 12.5 mg riboflavin; 50 mg niacin; 25 mg D-pantothenic acid; 37.5 μg vitamin B_{12}; 5 mg pyridoxine; 2.15 mg folic acid; 0.1 mg biotin; 5 mg thiamin, and 0.75 g choline choline.
[3)] Supplied per kilogram of final diet: 3.82 g L-lysine-HCl; 0.20 g DL-metioninne; 1.07 g L-threonine; 0.30 g L-tryptophan; 1.60 g L-valine; and 0.67 g L-isoleucine.