Evaluation of Chinese Brown Rice as an Alternative Energy Source in Pig Diets**

X. S. Piao*, Defa Li, In K. Han[1], Y. Chen, J. H. Lee[1], D. Y. Wang, J. B. Li and D. F. Zhang
Ministry of Agricultural Feed Industry Center, China Agricultural University, Beijing 100094, P. R. China

ABSTRACT : A total of six crossbred barrows (Duroc×Landrace×Large White, 44.17±1.94 kg BW) were housed conducted to evaluate apparent fecal digestibilities of Brown Rice (BR) as an alternative energy source in growing pigs. Pigs were housed individually on metabolism crate on the basis of body weight. Four treatments contained: 1) 100% of corn-soybean meal (C100; Control diet), 2) 75% of corn-soybean meal diet plus 25% of corn meal (C25), 3) 100% of brown rice-soybean meal diet (BR100), 4) 75% of brown rice-soybean meal diet plus 25% of brown rice meal (BR25). Brown rice has an excellent gross energy and crude protein composition compared to corn. The BR used had 3,801 kcal of gross energy/kg, 8.0% crude protein, 2.6% of ether extract, 0.035% calcium and 0.35% total phosphorus. The best digestibilities of energy (87.75%), DM (81.71%) and CP (78.57%) were observed in BR 100 group and the worst were found in Corn 25 group. The nutrient digestibility was not significantly different in most nutrients. Through this experiment, BR appeared a good alternative energy source that can replace corn yellow to 100% in growing pigs. Therefore, the price relationship between corn and BR may provide an excellent opportunity for pork producers to use BR in order to reduce feed costs provided that diet has been balanced for digestible amino acids. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 1 : 89-93)***

Key Words : Brown Rice, Corn, Energy Source, Growing Pigs, Digestibility

INTRODUCTION

An important challenge is to reduce the production cost in animal industry. Feed is the primary factor to increase the production costs in animal production, especially for the monogastric animals. Corn grain is most commonly used carbohydrate or energy source in pig diets because of its availability and good quality. However, high price of corn sometimes limited its utilization in feed industry.

Thus there is a great need to replace corn with alternative carbohydrate sources in the animal diets. Recently, Centre-China Agricultural University found that brown rice (BR), as a nonconventional energy source, which was originated from China, has a relatively high carbohydrate and protein contents. Its protein content is comparable with those of corn grain.

China is the world's largest producer of BR with an annual production of 2.4 million tons (80% of the total rice products. BR's price is relatively low (2/3 of corn), and energy content is high (table 3). But BR also contains approximately 25% straight chain starch and these compounds have been suggested to impart a poorer use in human foods (He et al., 1994).

Precise statements on their nutritional values are limited. It is essential to determine the nutritional values of BR for the use of animal feeds.

Therefore, this experiment was designed to evaluate BR as an alternative energy source in growing pig diets. In this experiment, the availability of proximate nutrients and gross energy were measured.

MATERIALS AND METHODS

Experimental design, animals and diets

A total of six crossbred barrows (Duroc×Landrace× Large White, 44.17±1.94 kg BW) were housed individually on metabolism crate on the basis of body weight. Four treatments contained : 1) 100% of corn-soybean meal (C100; Control diet), 2) 75% of corn-soybean meal diet plus 25% of corn meal (C25), 3) 100% of brown rice-soybean meal diet (BR100), 4) 75% of brown rice-soybean meal diet plus 25% of brown rice meal (BR25). 6 pigs were used (which is completely inadequate design) and fed 4 diets over 4 weeks (table 1). Control diets contained 3,265 kcal ME/kg, 18% crude protein, 1.15% lysine, 0.45% methionine, 0.7% Ca and 0.6% P (table 2). All diets were mash and adquate amount of vitamins and minerals were supplied as suggested by the NRC (1998).

All digestibility trial, chemical analysis and statistical analysis were conducted in the Ministry of Agricultural Feed Industry Center, College of Agricultural Animal Science and Technology, China Agricultural University in Beijing, China.

Methods of experiments

Digestibility trial : Digestibility trial was conducted in

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* Address reprint request to X. S. Piao. Tel: 8610-62893581, Fax: 8610-62893688, E-mail: piaoxsh@eyou.com

[1] 806 Kwachon Officetel, 1-14 Pyullyan-dong, Kwachon-shi Kyunggi-do, 427-040, Korea.

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Table 1. Experimental design

Period	Individual metabolic crate					
1st week	C100	C100	C100	R100	R100	R100
2nd week	R100	R100	R100	C100	C100	C100
3rd week	C25	C25	C25	R25	R25	R25
4th week	R25	R25	R25	C25	C25	C25

Table 2. Formula and chemical composition of the experimental diets for growing pigs

Treatment	Corn100	BR100	Corn25	BR25
Ingredients (%)				
Corn	60	-	70	-
Brown rice (BR) [1]	-	60	-	70
Wheat bran	3.9	3.9	2.92	2.92
Soybean meal	29.55	29.55	22.16	22.16
Dicalcium phosphate	0.89	0.89	0.66	0.66
Limestone	1.2	1.2	0.9	0.9
Vit.-Min. mix[2]	1	1	0.75	0.75
Salt	0.3	0.3	0.22	0.22
Soy oil	2.63	2.63	1.97	1.97
L-Lysine. HCl	0.28	0.28	0.21	0.210
Cr_2O_3	0.25	0.25	0.25	0.25
Total	100	100	100	100
Chemical compositions (%)[3]:				
GE (kcal/kg)	3,879	3,913	3,902	3,945
Crude protein	18.25	18.18	17.15	17.44
Lysine	1.15	1.16	0.92	0.92
Methionine	0.45	0.47	0.44	0.45
Calcium	0.71	0.72	0.53	0.54
Phosphorus	0.60	0.61	0.44	0.44

[1] Brown rice : QuanYouZhe 3 breed (Called Early Long-grain Nonglutinous brown rice, Produced in Hunan province, China).
[2] Vit.-Min. mixture contains per kg : vitamin A, 2,000,000 IU; vitamin D_3, 400,000 IU; vitamin E, 250 IU; vitamin K_3, 200 mg; vitamin B_1, 20 mg; vitamin B_2, 700 mg; riboflavin 10,000 mg; pantothenic calcium, 3,000 mg; choline chloride, 30,000 mg; niacin, 8,000 mg; folacin, 200 mg; vitamin B_{12} 13 mg; Mn 12,000 mg; Zn, 15,000 mg; Co, 100 mg, Cu, 500 mg; Fe, 4,000 mg; folic acid, 40 mg; BHT, 5,000 mg; sucrose to make 1 kg vit.-min. mixture.
[3] Analyzed value.

individual metabolic crates. The barrows were fed at 08:00 h and 20:00 h each day. Fecal samples were collected on day 4, 5, 6 and 7 after 3 days of adaptation period. To measure the nutrient digestibility of the experimental diets, the digestibility coefficient was calculated by total fecal collection method. Experimental diets and water were fed to satiation. Collected excreta were pooled and dried in an air-forced drying oven at 60°C for 72 h to gain constant dry weight and were ground with 1 mm mesh Wiley mill for chemical analysis.

Chemical analysis : Analysis of proximate nutrients composition of experimental diets and excreta was conducted according to the methods of AOAC (1990), and amino acids composition was measured using an automatic amino acid analyzer (Pharmacia Biotech, Biochrom 20, England) after 24 h of acid hydrolysis in 6 N HCl. Phosphorus content were measured using the UV-visible spectrophotometer (Hitachi, U-1000, Japan) and gross energy content of feeds and excreta were measured using the Bomb Calorimeter (Parr Instrument Co., Model 1241, USA). Chromium was measured using atomic absorption spectrophotometer (Shimadzu, AA6145F, Japan). The fatty acid compositions of the experimental diets were measured using gas chromatography (HP 5890, Hewlett-Packard Co., USA) according to the method of Lepage and Roy (1986). Blood samples were collected from three pigs of each treatment. The blood samples were centrifuged (3,000/rpm) at 5°C for 15 minuets. The serum was stored at -20°C until the analyses for blood urea nitrogen and total glucose analyzed using commercially available kits.

Statistical analysis

Statistical analysis for the present data was carried out by comparing means according to Duncan's multiple range

Table 3. Nutrient composition of corn and brown rice*

	Corn	Brown rice
Proximate composition :		
Moisture (%)	11.8	11.7
Crude Protein (%)	7.93	8.00
Crude Ash (%)	1.32	1.60
Calcium (%)	0.029	0.035
Phosphorus (%)	0.28	0.35
Gross energy (kcal/kg)	3,857	3,801
Amino acids (%)		
Aspartic acid	0.6389	0.5273
Threonine	0.2631	0.3025
Serine	0.2784	0.3737
Glutamic acid	1.2839	1.5575
Glycine	0.3797	0.3038
Alanine	0.4902	0.6224
Valine	0.4571	0.3438
Methionine	0.2436	0.1714
Isoleucine	0.3106	0.2845
Leucine	0.6024	1.0370
Tryptophan	0.3550	0.3762
Phenylalanine	0.3975	0.4726
Histidine	0.2704	0.2825
Lysine	0.3124	0.2487
Arginine	0.6041	0.3512
Cystine	0.5730	0.4872
Total	7.4603	7.7461
Fatty acids, % of total fatty acids:		
Saturated		
C14:0	-	-
C16:0	1.3016	1.8931
C18:0	0.0824	0.1139
Sub total	1.3840	2.0070
Monounsaturated		
C16:1	-	-
C18:1	0.5226	0.1169
Polyunsaturated		
C18:2	0.4087	0.7643
C18:3	0.0286	0.0243
Sub total	0.4373	0.7886
Saturated	1.3840	2.0070
Unsaturated	0.9599	0.9055
Unsaturated/Saturated	0.6936	0.4512

* Analyzed value.
C14:0: Myristic acid; C18:1: Oleic acid; C18:3: Linolenic acid; C16:0: Palmitic acid; C18:2: Linoleic acid; C20:4: Arachidonic acid; C16:1: Palmitoleic acid; C18:0: Stearic acid; C22:6: Cervonic acid.

test (Duncan, 1955), using General Linear Model (GLM) procedure of SAS (1985) package program.

RESULTS AND DISCUSSION

Chemical composition

Chemical compositions of corn and brown rice used in this experiment were given in table 3.

Brown rice has an excellent gross energy and crude protein composition compared to corn. The BR used had 3,801 kcal of gross energy/kg, 8.0% crude protein, 2.6% of ether extract, 0.035% calcium and 0.35% total phosphorus. But the corn (2.2%) was almost three times higher in crude fiber than brown rice (0.7%). These data are similar to the results by He et al. (1993). In terms of chemical composition at seems that BR has high potential to be a good feed ingredient for animals. BR also has an excellent fatty acids composition. Out of the energy sources predominantly composed of long-chain fatty acids with chain lengths of 14 or more carbons, corn was relatively high in proportion of unsaturated fatty acids (USFA>40.95%), while the BR was relatively high in proportion of saturated fatty acids (SFA>68.91%). Also, corn was almost one and half times higher in USFA/SFA ratio (0.6936) than BR (0.4512). Usually, feeds containing high levels of USFA produce pork with low oxidative stability (He et al., 1995). The USFA and SFA concentrations of the brown rice meal is better than that of corn meal (He et al., 1995).

He et al. (1994) reported that gross energy (GE) and crude protein concentrations of brown rice were 4,003 kcal/kg and 8.8% and corn were 4,006 kcal/kg and 8.6%, respectively. The apparent digestibilities of BR for pigs and poultry have been determined by the fecal methods (He et al., 1994).

Nutrient digestibility

Nutrient digestibility from the present experiment was summarized in table 4 and figure 1. During the overall period, all BR groups showed better digestibility than corn diet group in energy, DM and CP. BR 100 diet showed the best gross energy digestibilities, which was significant higher ($p<0.05$) than those of pigs fed corn diets. The best digestibilities of energy (87.75%), DM (81.71%) and CP (78.57%) were observed in BR 100 group and the worst were found in Corn 25 group. The nutrient digestibility was not significantly different in most nutrients. Nutrient digestibility had a tendency (not significant) to decrease as the level of corn in the diet was increased. As noted by He et al. (1994), apparent nitrogen digestibility in pigs fed BR (78.71%) in the diet was significantly higher than corn groups (69.17%, $p<0.05$). The present study suggested similar trends with that result of He et al. (1994).

He et al. (1994) reported that apparent crude protein

Table 4. Effects of brown rice on apparent fecal nutrient digestibility of growing pigs (%)

Treatment	DE	DM	CP	C. Ash	Ca	P
Corn100	80.51[b]	80.24	75.21	38.29	46.52	59.15
BR100	87.75[a]	81.71	78.57	35.64	45.91	53.57
Corn25	79.63[ab]	78.98	73.58	34.98	48.51	48.03
BR25	81.04[ab]	80.09	74.62	31.54	43.01	47.83
PSE[1]	0.7512	0.7197	1.0051	2.0644	2.3170	2.4434
P value	0.0680	0.6383	0.3437	0.7420	0.8840	0.3191
			Contrast			
Corn vs. BR	0.0500	0.3932	0.2813	0.4869	0.5394	0.5548
C100 vs. BR100	0.0385	0.4918	0.2459	0.6677	0.9306	0.4220
C25 vs. BR25	0.7421	0.8711	0.8411	0.7587	0.5095	0.7373

[1] Pooled standard error.

[a,b] Values with different superscripts within the same column significantly differ (p<0.05).

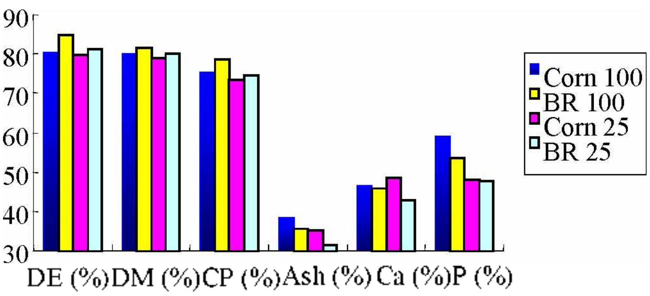

Figure 1. The apparent fecal nutrient digestibility of growing pigs (%)

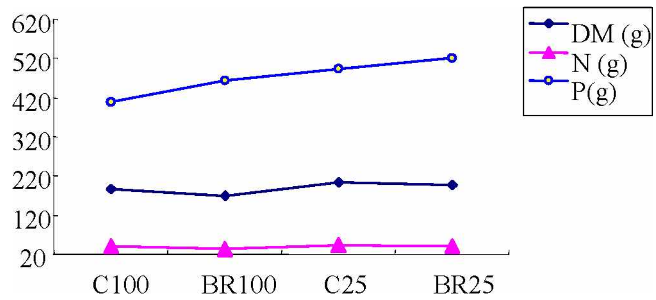

Figure 2. Nutrients excretion of growing pigs

digestiility and metabolizable rate were 73.71% and 65.03% in brown rice and 69.17%, 59.89% in corn, respectively.

The overall results suggest that BR meal can be replacing 100% corn in diet fed to growing pigs. However, poultry fed BR meal responses to achromia in skin or in eggs and therefore it was suggested to add vitamin A, yellow pigments, alfalfa or pine needle meal when BR was included in the diet (He et al., 1999).

Nutrients excretion

Table 5, figure 3 and figure 4 summarized the effect of different energy sources on the nutrient excretion. It showed that nutrient excretion was obviously affected by energy sources. Dry matter and nitrogen excretion had a tendency to decrease when the level of BR was increased, but no significant difference was found (p>0.05).

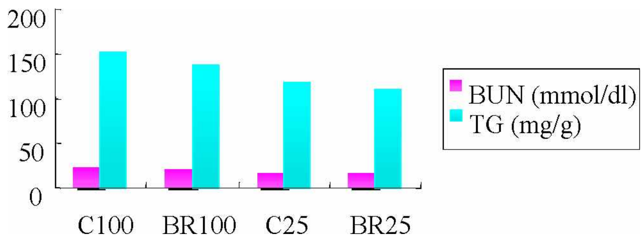

Figure 3. Blood urea nitrogen and total glucose of pigs

Plasma concentrations

The plasma concentration of urea nitrogen and total glucose of pigs were presented in table 6 and figure 3. Blood urea nitrogen (BUN) concentration ranged from 16.5 to 23 mmol/dL in this experiment. There was statistical significance found in BUN concentration among individual treatments and tended to decrease in pigs fed corn 25% and BR 25% diets. Eggum (1970) found an inverse relationship between plasma urea nitrogen and dietary amino acid balance. This relationship has been used to determine amino acid requirements in pigs (Brown and Cline, 1974). In this experiment, BUN concentration was highest in Corn 100 diet but lowest in Corn 25 diet (p<0.001). Total glucose (TG) level was examined and significant difference was detected among treatments (p<0.05). All BR groups showed better BUN and TG than the corn groups.

IMPLICATIONS

BR is a relatively unknown carbohydrate source, which has good amino acids and nutrient composition. Through

Table 5. Nutrients excretion of growing pigs (g nutrient excretion/1.000 g feed intake)

Treatment	Dry matter	Nitrogen	Phosphorus
Corn100	187.83	39.67	408.50
BR100	171.33	34.30	464.33
Corn25	202.67	42.28	492.50
BR25	197.33	40.60	521.83
PSE [1]	7.2598	1.6080	22.2496
P value	0.4666	0.3435	0.3319
	Contrast		
Corn vs. BR	0.2807	0.3437	0.4643
C100 vs. BR100	0.2465	0.3792	0.4346
C25 vs. BR25	0.8443	0.9839	0.9009

[1] Pooled standard error.

Table 6. Plasma concentrations of urea nitrogen and total glucose of pigs fed experimental diets

Treatment	BUN	TG
Corn100	23.00^{a}	151.67^{a}
BR100	21.00^{b}	137.50^{ab}
Corn25	16.50^{c}	118.00^{bc}
BR25	17.00^{c}	110.33^{c}
PSE [1]	0.6250	4.8082
P value	0.0001	0.0029
	Contrast	
Corn vs. BR	0.1947	0.1515
C100 vs. BR100	0.0199	0.1864
C25 vs. BR25	0.1052	0.9600

[1] Pooled standard error.

[a,b,c] Values with different superscripts within the same column significantly differ ($p<0.05$).

BUN: Blood urea nitrogen, mmol/dl; TG: Total glucose, mg/g.

this experiment, BR appeared a good alternative energy source that can replace corn yellow to 100% in growing pigs. Therefore, the price relationship between corn and BR may provide an excellent opportunity for pork producers to use BR in order to reduce feed costs.

However, the reason of the improvement in growth performance and amino acids digestibility was not conducted to determined in this study. Thus more study is required to show the mechanism in which how BR improve the performance of monogastric animals including broilers and hens.

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