Performance of Crossbred Gilts Fed on Diets with Higher Levels of Fat and Fibre through Addition of Rice Bran

N. M. Soren*, R. Bhar, A. K. Chhabra[1] and A. B. Mandal[2]

Centre of Advanced Studies in Animal Nutrition, Indian Veterinary Research Institute, Izatnagar
Bareilly 243 122 (U.P.) India

ABSTRACT : Crossbred gilts (n=54) of about 26.38±0.85 kg body weight and 25 weeks of age were randomly divided into 18 groups of 3 animals each. Three dietary treatments viz., T_1, T_2 and T_3 were formulated. The treatment T_1 containing maize grain (35%) and wheat bran (47%) along with soybean meal and fish meals served as control diet. Rice bran (RB) was selected as a single source of fat (13.02%) and fibre (17.12%), which was gradually increased in diets T_2 (41%) and T_3 (82%) replacing maize grain and wheat bran of T_1 at 50% and 100% in the diets T_2 and T_3, respectively. The fat and fibre levels of the diets were thus 3.46 and 5.24, 9.31and 9.69 and 11.61and 13.26% in T_1, T_2 and T_3, respectively. All the diets, however, contained almost similar concentration of CP (18.35±0.29%). Each dietary treatment was offered to six replicated groups of 3 piglets in following completely randomized design and feeding was continued for 112 days during the growing phase. Growth, feed utilization, reproductive performance, nutrient utilization and different blood biochemical parameters were studied. Growth rate, feed intake and feed conversion were lower ($p<0.01$) in T_3 in comparison to T_1 or T_2. Digestibility of all the nutrients except EE was reduced significantly ($p<0.01$) in T_3. Serum glucose level decreased ($p<0.01$), whereas the urea and cholesterol concentration in the blood increased ($p<0.01$) in T_3. The duration of estrus of pigs fed diet containing 82% RB (T_3) was highly variable within the group, but all the groups showed statistically similar duration of estrous. Feed cost per unit gain was found to be comparable between control (T_1) and T_2 group. The results indicated that RB can be included up to 41% in swine diets replacing 50% of maize and wheat bran. Higher concentrations of ether extract and fibre beyond 9.31 and 9.69% in diet had detrimental effect on growth, nutrient utilization and reproductive performance. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 11 : 1650-1655)***

Key Words : Gilts, Rice Bran, Performance, Estrous, Blood Biochemical

INTRODUCTION

The nutrient requirements of exotic pure or crossbred pigs are relatively higher in comparison to indigenous and under developed breeds, available in India because of relatively poor performance (Bhar, 1998). However, in crossbred (Landrace×Local Indian) pigs the amount of nutrient required for optimum performance, may be in between the local Indian and developed pure breed Landrace. To economize swine production in sustainable mixed farming systems, incorporation of agricultural by-products in swine rations at a higher rate may be one of the most practical approaches to reduce the cost of production under competitive livestock production systems (Lal and Makkar, 1976; Bhar et al., 2001). Rice bran appears to be one of the best sources of energy, which is cheaper as well as easily and abundantly available in Asian countries.

Incorporation of rice bran at higher levels increases the ether extract (EE) and gross energy (GE) content of the diet with concomitant increase in crude fibre (CF) content. Therefore, incorporation of rice bran at higher levels or solvent extracted rice bran (SERB) even at a medium level (Bhar et al., 2001) resulted in poor performance in pigs fed on diets containing higher than recommended (BIS, 1987) levels of fibre in the diet. BIS (1987) recommendation of dietary levels of CF, EE and total ash are 6 (maximum), 2 (minimum.), 8 (maximum) %, respectively. However, inclusion of rice bran at a reasonable level increases CF, EE and total ash, far beyond the recommended level. Performances of Indian crossbred pigs was found quite satisfactory even up to a dietary level of 7.18% (Garg and Pathak, 1983) and 9.4% (Bhar et al.).Therefore, the present experiment was conducted to optimize the levels of rice bran, and fat and fibre contents in the diet of grower-finisher pigs for optimum economic performance of the crossbred gilts (Landrace×Local Indian).

MATERIALS AND METHODS

Fifty four crossbred gilts (Landrace×Local Indian) of about 26.0 kg body weight and 25 weeks of age were randomly divided into 18 groups of 3 animals each. Three dietary treatments viz., T_1, T_2 and T_3 were formulated (Table 1). Treatment T_1 contained maize (35%), wheat bran (47%) along with soybean meal and fishmeal, and served as the control diet. Rice bran (RB) was selected as a single source

* Corresponding Author: N. M. Soren, Tel: +91-581-2300940, E-mail: drmanik75@rediffmail.com
[1] Swine Production Farm, LPM Section, Indian Veterinary Research Institute Izatnagar, Bareilly 243122 (U.P.) India.
[2] Avian Nutrition and F.T. Division, Central Avian Research Institute, Izatnagar, Bareilly 243122 (U. P.) India.
Received December 17, 2002; Accepted June 30, 2003

Table 1. Ingredient, chemical composition (%) and calorific values of the diets (DM basis)

Ingredients	Diets		
	T_1	T_2	T_3
Maize	35.0	17.5	-
Wheat bran	47.0	23.5	-
Rice bran	-	41.0	82.0
Soyabean meal	10.0	10.0	10.0
Fish meal	6.0	6.0	6.0
Mineral mixture*	1.5	1.5	1.5
Salt	0.5	0.5	0.5
Vitablend AD_3 (g/100kg)	15	15	15
Attributes			
Organic matter	91.51±0.26	88.94±0.41	85.99±0.59
Crude protein	19.01±0.48	18.17±0.59	17.89±0.42
Ether extract	3.46±0.32	9.31±1.12	11.61±1.17
Crude fibre	5.24±0.77	9.69±0.84	13.26±1.60
Nitrogen free extract	63.80±0.13	51.77±0.56	43.23±1.35
Total ash	8.49±0.26	11.06±0.41	14.01±0.59
Gross energy (kcal/kg)	4,516±0.17	4,738±0.05	4,382±0.10
Digestible energy (kcal/kg)	3,386±58.34	2,713±57.64	2,366±32.07

* Composition of mineral mixture, calcium-28%, phosphorus-12%, iodine (as potassium iodide)-0.13%, copper-0.13%.
Dietary treatments T_1, T_2 and T_3 contain rice brain 0, 41 and 82%, respectively.

of fat (13.02%) and fibre (17.12%), which was gradually increased in diets T_2 (41%) and T_3 (82%) replacing maize grain and wheat bran of T_1 at 50% and 100% in the diets T_2 and T_3, respectively. The fat and fibre levels of the diets were thus 3.46 and 5.24, 9.31 and 9.69, 11.61 and 13.26% in T_1, T_2 and T_3, respectively. DE concentration of the diets was 3,386, 2,713 and 2,366 kcal/kg in respective dietary treatments. All the diets, however, contained almost similar concentrations of CP (18.35±0.29%). Lysine, methionine, methionin+cystine and threonine contents were 0.86, 0.32, 0.64 and 0.61% in T_1, 0.93, 0.34, 0.63 and 0.67% in T_2 and 1.0, 0.35, 0.73 and 0.74% in T_3 respectively .Each diets was assigned to 6 groups of three gilts each, following a completely randomized design. Feed was offered once daily and the gilts were fed *ad libitum* in groups for 112 days with free access to potable water throughout the day. The experiment was conducted on the gilts under standard hygienic and uniform managemental conditions throughout the experimental period at the Swine Production Farm of the Indian Veterinary Research Institute as a part of an All India Coordinated Research Project on pigs. The animals were housed in well ventilated cement-floored pen of 2.95×4.65 m size with a run of 7.15×4.65 m. The average temperature during the experimental period was 20±2°C. All the animals were vaccinated and dewormed as per the normal schedule.

Feed intake of the gilts was recorded daily. Body weight was recorded at fortnightly intervals and feed conversion (FC) was also calculated. At the end of the experimental feeding, a metabolism trial of six days collection period, preceded by six days adaptation period was carried out on eight representative gilts per treatments (n=24) to study nutrient utilization. There was daily recording and collection of feed offered, residues left and faeces and urine excreted on 24 h basis. Besides feeds and residues, an aliquot of faeces were dried at 100±1°C for 24 h for the estimation of DM. The dry samples were pooled for proximate analysis. Day to day fresh samples of faeces was preserved with 1:4 sulphuric acid for nitrogen determination. Similarly, suitable aliquot of urine was preserved for estimation of nitrogen. On attainment of 31 weeks of age, heat detection was started in all the gilts twice daily at 9.00 AM and 5.00 PM using a teaser boar and was carried out for a period of 90 days. Duration of oestrous cycle (days) was measured by recording the intervals (days) between two successive estrous. On the other hand estrous duration (h) was measured by recording the time interval (h) when the gilts exhibited heat symptoms. The effects of the respective diet on duration of estrous cycle (days), duration of estrous (h), heat symptoms and regularity of estrous was studied for three consecutive cycles. Symptoms like swelling and reddening of the vulva, discharges of mucous, standing heat reflex, cock ear etc. were considered for studying heat symptoms.

For studies on change of blood biochemicals, blood samples was collected in the morning 2 h before feeding from four representative gilts in each treatments groups. It was collected twice, i.e. initially, before the start of experimental feeding and then after 60 days of feeding. It was collected from the anterior venecava and blood serum was separated by centrifugation. Serum glucose was determined by O-toluidine method (Hultmann, 1959). Total serum protein and albumin was determined as per Doumas (1975) and Doumas et al. (1971). Serum globulin was

Table 2. Chemical composition (%) of dietary ingredients (DM basis)

Attributes	Maize	Wheat bran	Dietary ingredients rice bran	Fish meal	Soyabean meal
Organic matter	98.19±0.02	94.23±0.52	89.39±0.16	55.84±0.94	92.22±0.15
Crude protein	11.76±0.32	14.44±0.37	12.91±1.39	38.99±1.64	50.35±0.60
Ether extract	4.97±0.06	3.65±0.09	13.02±1.55	5.74±1.18	2.16±0.33
Crude fibre	1.63±0.08	9.63±0.76	17.12±1.54	7.05±0.80	7.01±0.47
Nitrogen free extract	79.83±0.27	66.51±0.99	46.33±0.94	4.06±5.14	32.70±1.06
Total ash	1.81±0.02	5.77±0.52	10.62±0.16	44.16±0.94	7.78±0.15
Gross energy (kcal/kg)	4,622±0.05	4,835±0.07	49,752±0.09	33,560±0.04	4,790±0.10

Table 3. Digestibility and performance of the gilts during the experiment period

Attributes	Rations			SEM
	T_1	T_2	T_3	
Body weight kg.^{NS}	52.79	50.44	50.95	0.07
Dry matter Digestibility**	70.63^a	55.45^b	44.12^c	2.36
Organic matter Digestibility**	73.97^a	60.10^b	47.62^c	2.34
Crude protein Digestibility**	70.04^a	63.30^b	61.88^b	1.12
Ether extract Digestibility^{NS}	71.77	74.57	79.02	0.69
Crude fibre Digestibility**	31.08^a	21.53^b	18.99^b	3.40
Nitrogen free extract Digestibility**	80.01^a	67.95^b	52.36^c	1.20
Total carbohydrate Digestibility**	75.08^a	57.57^b	39.81^c	
Number of animals	18	18	18	
Average daily gain (kg/day)**	0.348^a	0.322^a	0.218^b	0.001
Average daily feed intake (kg/day)**	1.84^a	1.85^a	1.43^b	0.06
Feed: gain**	5.32^b	5.74^b	6.69^a	0.17
Feed cost (Rs/kg BW gain)**	34.93^a	30.34^b	26.82^c	0.94

^{a,b,c} Means with different superscripts in a row differ significantly.
* $p<0.05$. ** $p<0.01$. ^{NS} non significant.

obtained by subtraction of albumin from total serum protein. Serum urea in the sample was determined as per the method of Wybenga et al. (1971). Cholesterol content in serum samples were estimated as per the method of Wybenga et al. (1970). All these parameters were estimated as per standard colorimetric methods using reagent kits supplied by M/s Qualigens Fine Chemicals (A division of Glaxo India Ltd.) using a spectrophotometer.

Proximate principles of the feeds and faeces were determined by the methods of AOAC (1995). Gross energy (GE) content of the feed ingredients and rations were determined by Gallenkamp Ballistic Bomb Calorimeter (CBB 330) supplied by M/S Expotech USA., Inc. Houston, Texas. The data obtained from the experiment was subjected to one way analysis of variance following completely randomized design for all the parameters to ascertain the effect of various treatments on the performance of the gilts as per the standard methods of statistical analysis (Snedecor and Cochran, 1967). Difference among the means were tested applying Duncan's multiple range test (Duncan, 1965).

RESULTS AND DISCUSSION

Chemical composition of the diets

The chemical composition of the dietary ingredients used in the experiment is given in Table 2. Ingredients and chemical composition of the experimental diets along with GE are presented in Table 1. The three experimental diets i.e. T_1, T_2 and T_3 were almost similar (18.35±0.29% CP). The GE value of the T_3 diet was higher when compared to the other diets. The differences in chemical composition and GE values between the diets were obviously due to higher level of EE, CF and ash in rice bran which was incorporated in place of cereal grain, maize and wheat bran.

Dry matter intake

Average daily dry matter intake (DMI; kg/animal) was significantly ($p<0.01$) lower (Table 3) in the T_3 group, while it was comparable in the T_1 and T_2. The decrease in DMI in T_3 might be due to higher level of CF and ash, (13.26 and 14.01%), which reduced the palatability of the diet in spite of a higher EE content. The present findings are in agreement with the findings of Lindemann et al., (1986) and Bauza et al., (1990). The comparable intake between T_1 and T_2 diets was similar with the finding of Nicolaiewsky et al. (1989), where RB was incorporated in the diets up to 42%. Which in turn indicated that 9.69% of fibre along with 9.31% fat and 11.06% total ash could be tolerable for crossbred (Landrace×Local Indian) pigs.

Average daily gain

The initial body weight of the animals were almost similar (26.38±0.85 kg) among the groups but at the end of the experiment the body weight of the gilts in T_3 (82% RB) were 50.15±1.95 kg, which was significantly ($p<0.01$) lower than that of group T_1 and T_2 i.e. (65.27±2.73 and

Table 4. Effect of different treatments on certain blood biochemical in gilts

Attributes	Initial			SEM	Final			SEM
	T_1	T_2	T_3		T_1	T_2	T_3	
Serum glucose (mg/dl)**	101.1	109.2	101.7	1.80	109.9^a	100.9^b	72.7^a	5.03
Serum cholesterol (mg/dl)**	103.3	104.6	105.2	0.51	120.6^a	114.1^b	123.7^a	5.61
Total protein^{NS} (g/dl)	8.1	8.2	7.4	0.31	8.4	7.9	8.3	0.26
Serum albumin^{NS} (g/dl)**	3.9	3.8	4.1	0.05	4.1^b	4.3^a	4.4^a	0.04
Serum globulin (g/dl)	4.1	4.3	3.4	0.22	4.3	3.6	4.1	0.26
Serum urea (mg/dl)**	21.5	21.0	21.9	0.43	21.5^c	29.7^b	33.5^a	1.55

^{a,b,c} Means bearing different superscripts in a row differ significantly. * $p<0.05$, ** $p<0.01$, ^{NS} non-significant.

Table 5. Effect of different treatments on the duration of estrus in gilts

Estrus cycles No.	Duration of cycle (days)			SEM
	T_1	T_2	T_3	
1	20.1	20.1	20.6	0.69
2	19.3	18.5	19.7	0.29
3	19.0	18.7	17.8	0.42
Overall	19.4	19.1	19.4	0.35
Estrus cycles No.	Duration of estrus (h)			
1	60.0	56.6	52.6	2.74
2	63.3	59.3	49.3	2.56
3	63.3	63.5	49.5	3.01
Overall	62.0	58.8	50.3	0.23

SEM standard error of the mean.
Differences between the means were non-significant.

62.38±2.29 kg), respectively. Lower gain in T_3 may be associated with lower NFE and reduced digestibility of nutrients. However, the values were comparable between the control and T_2 group (41% RB) in the present study corroborates well with the findings of Bauza et al., (1990) and Conci et al., (1995). The pattern of the body weight gain also corroborated well with the feed intake. Significant reductions in body weight gain were associated with reductions ($p<0.01$) in feed intake because of the bulkiness and low palatability of the diet, when RB was included up to 82% in T_3. Moreover, the concentration of limiting amino acids like lysine, methionine+cystine and threonine in the experimental diets were higher than that of required levels as specified NRC (1988).

Feed conversion efficiency

The feed conversion efficiency of the gilts of different treatment groups (Table 3) showed that gilts of the T_3 group utilized feed less efficiently ($p<0.01$) in comparison with the other two groups. Present findings were similar to the findings of Bhar et al. (2001). The efficiencies were comparable among the gilts of T_1 and T_2, which were supported further, by the findings of Bauza et al. (1990). The inclusion of RB beyond 41% replacing maize and wheat bran reduced feed conversion, which may be attributed to lower digestibility of all nutrients except ether extract, higher ash and fibre content in T_3, leading to poorer nutritive value.

Digestibility of nutrients

The DM and OM digestibility (Table 3) of all the three diets differed significantly ($p<0.01$) from each other which might be due to higher levels of acid insoluble ash (AIA) and CF, which in turn also increased the rate of passage through the gastro-intestinal tract (Stanogias and Pearce, 1985). Overall digestibility of all the constituents except that of EE decreased ($p<0.01$) as the level of RB increased with the proportional decrease of maize in the diets. The digestibility values of CP and CF were significantly ($p<0.01$) lower in T_2 and T_3, respectively, due to variation in the proportion of highly digestible maize and non-starch polysaccharide. These findings are in agreement with the reports of Brooks and Lumanta (1975), Lal and Makkar (1976) and Bhar et al. (2001).

Blood biochemical profile

There was no significant difference in serum glucose, cholesterol, total protein, albumin, globulin and serum urea during the initial period of the experiment (Table 4). However, toward the end of experiment serum glucose levels differed significantly ($p<0.01$) between the groups. These lower values in the RB fed group indicated energy deficiency, which might be caused by higher level of dietary fibre affecting glucose absorption. The present findings are in accordance with the finding of Mazur et al. (1990). Moreover, the diets in groups T_1 contained higher amount of NFE, which was followed by group T_2 and T_3. Moreover, NFE contents (i.e. available carbohydrate) reduced linearly due to inclusion of RB which might be the cause of significant reduction of blood glucose in T_2 and T_3 in comparison to T_1. Serum cholesterol values in T_2 group were significantly ($p<0.01$) lower than groups, T_1 and T_3, while the difference between these was non-significant. In spite of higher EE intake in gilts fed RB based diets, the serum cholesterol level was maintained at par with the control. This might have been possible due to quality of fat (unsaturated) in RB. Higher fibre intake also might have reduced cholesterol levels (Edington et al., 1987). Moreover, the RB may have some anti-cholesterolemic effect (Sharma and Rukmini, 1986). Total serum protein, and globulin level were comparable between the groups. Serum urea levels were higher in groups fed higher levels of fibre. Higher

values in T_2 and T_3 might be due to breakdown of amino acids, for gluconeogenesis as evidenced from lower blood glucose levels in these groups (T_2 and T_3), to supply available energy (McDonald et al., 1995).

Effect on estrous

Duration of cycles recorded in different treatment did not differ statistically, but the duration was slightly shorter in group, T_3, when compared with the other two groups (Table 5). Similarly, the duration (h) of estrous was variable among the treatment groups. However, in subsequent cycles, the duration of estrous was lowest in gilts fed the T_3 diet. All the gilts in groups T_1 and T_2, exhibited normal symptoms, while only 38.39% of the gilts in T_3 exhibited normal estrous and the remaining 61.11% of gilts showed mild symptoms. Regularity of estrous showed similar trends to that of duration of estrous. About 88.89% of the gilts in groups T_1 and T_2 exhibited regular estrous, whereas only 61.11% of the gilts under group T_3 (receiving 82% RB in diet) exhibited regular estrous. Higher level of RB might have exerted an adverse effect on the estrous cycle due to a comparatively lower plane of nutrition, which in turn might have affected the growth, sexual maturity and hormonal profile leading to irregular estrous (Aherne and Kirkwood, 1985; Britt et al., 1988; and Dyck, 1988).

Feed cost of live weight gain

There was significant difference ($p<0.01$) in feed cost of live weight between the treatment groups (T_1, T_2 and T_3) (Table 3). The lower cost of feeding in the third group had no significance, since the overall performances of the gilts were very poor. Moreover, cost of feeding in second group (T_2) can be adopted practically as the performance of the gilts in T_2 was comparable with the control group.

Conclusion:

Indian crossbred pigs (Landrace×Local Indian) could be reared satisfactorily on the rice bran based diets containing higher levels of CF and ash to the extent of 9.69 and 11.06%, respectively. Therefore the requirement of such pigs could be estimated on lower plane of nutrition. Moreover, rice bran can be included up to 40% in the diet without affecting the performance.

REFERENCES

Aherne, F. X. and R. N. Kirkwood. 1985. Nutrition and sow prolificacy. J. Reprod. Fert. 33:169-183.

AOAC. 1995. Official methods of analysis (16th edn. Vol. 1) Association of official analytical chemists. Washington, DC.

Bauza, R., N. Barlocco and D. Cozzolino. 1990. Use of rice bran in diets for fattening pigs. I. Effect of different levels of inclusion and zinc supplementation. Bloetin de Investigaeion Facultad de Agronomia, Universidad de la Republica 25. p. 290.

Bureau of Indian Standards. 1987. Specification for pig feeds. First revision. Bureau of Indian Standards, New Delhi, India.

Bhar, R. 1998. Performance of crossbred (Landrace×Desi) grower and finisher barrows fed on wheat bran and deoiled ricebran based grain replaced diets. Ph.D. Thesis. Deemed University, Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh.

Bhar, R., N. N. Pathak and S. Paul. 2000. Performance of crossbred (Landrace×local Indian) finisher barrows fed maize or wheat bran based diets : short note. Asian-Aust. J. Anim. Sci. 13:1428-1432.

Bhar, R., N. N. Pathak and S. Paul. 2001. Performance of crossbred (Landrace×Local Indian) grower pig on maize replaced wheat bran and deoiled rice bran based diets. Ind. J. Anim. Sci. 71:165-168.

Borin, J. H., J. N. Gai and J. C. G. L-da Silveira. 1988. Effect of adding different amounts of defatted rice bran to diets for pigs during the growing and finishing periods. Revista-da-Sociedada-Brasileira-de-Zootecnia, 17:552-562.

Britt, J. H., J. D. Armstrong and N. M. Cox. 1988. Metabolic interfaces between nutrition and reproduction in pigs. Proceedings of the 11th International Congress on Animal Reproduction and Artificial Insemination, Vol. 5:117-125.

Brooks, C. C. and I. G. Lumanta. 1975. Effect of rice bran on pig performance and carcasses. J. Anim. Sci. 41:308 (Abstr.).

Conci, V. A., R. M. Magalhaes, P. E. Bender, N. A. Weiderkehr, M. F. G-de. Oliveira, M. S. S. da Costa, M. F. G. De-Oliveira and M. S. S. Da Costa. 1995. Evaluation of rice by products in swine nutrition. III. Integral rice bran for growing finishing. Pesquisa Agropecuaria Gaucha, 1:69-77.

Doumas, B. T., W. A. Watson and H. G. Biggs. 1971. Albumin standards and the measurement of serum albumin with bromocresol green. Clin. Chim. Acta, 31:87-97.

Doumas, B. T. 1975. Standards for total serum protein assays-A collaborative study. Clin. Chem. 21:1159-1166.

Duncan, D. B. 1965. Technometrics. In: Statistical methods, 6th Ed. (Ed. G. W. Snedecor and W. G. Cochran). Oxford and Indian Book House Publishing Co. New Delhi. p. 274.

Dyck, G. W. 1988. Factors influencing sexual maturation, puberty and reproductive efficiency in the gilts. Can. J. Anim. Sci. 68:1-13.

Edington, J., M. Geekie, R. Carter, L. Benfield, K. Fisher, M. Ball and J. Mann. 1987. Effect of dietary cholesterol on plasma cholesterol concentration in subjects following reduced fat, high fibre diet. Br. Med. J. 294:233-236.

Garg, A. K. and N. N. Pathak. 1983. Studies on feeding grainless ration to landrace sows. The Ind. J. Nutr. Dietet. 20:202-206.

Hultmann, E. 1959. Rapid specific method for determination of aldohexoses (aldosaccharides) in body fluids. Nature, 103:108-109.

Lal, M. and G. S. Makkar. 1976. Utilization of nutrient in agro-industrial by products by swine. Ind. J. Anim. Sci. 46:313-318.

Lindemann, M. D., C. C. Brooks and E. T. Kornegay (undated) Evaluation of rice bran for growing finishing pig. Animal Science Report, Virginia Agricultural Experiment Station, 5:10-13.

McDonald, P., R. A. Edwards, J. F. D. Greenhalgh and C. A. Morgan. 1995. Metabolism. In: Animal Nutrition. Addison Wesley Longman, Harlow, United Kingdom. pp. 176-220.

Mazur, A., C. Remesy and C. Demigne. 1990. The effect of high fibre diet on plasma lipoproteins and hormones in genetically obese Zucker rats. Eur. J. Clin. Inv. 20:600-606.

National Research Council. 1988. Nutrient requirements of swine. 9th Ed National Academy Press. Washington, DC.

Nicolaiewsky, S., J. D'Agostin, A. M. Penz-Juior and T. M. Bertol. 1989. Evaluation of rice bran as an alternative source of phosphorus in diets for growing and finishing pigs. Revista-da-Sociedade-Brasileira-de-Zootecnia, 18:260-266.

Sharma, R. D. and C. Rukmini. 1986. Rice bran oil and hypo cholesterolemia in rats. Lipids. 21:715-717.

Snedecor, G. W. and W. G. Cochran. 1967. Statistical methods, Oxford and Indian Book House Publishing Co. New Delhi.

Soren, N. M. 2002. Performance of crossbred gilts fed on rice bran based diets. M.V.Sc. Thesis. Deemed University, Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh.

Stanogias, G. and G. R. Pearce. 1985. The digestion of fibre by pigs: 2. Volatile fatty acid concentrations in large intestine digesta. Br. J. Nutr. 53:531-536.

Wybenga, D. R., V. J. Pileggi, P. H. Dirstine and J. D. Giorgio. 1970. Direct manual determination of serum total cholesterol with a single stable reagent, Clin. Chem. 16:980-984.

Wybenga, D. R., J. D. Giorgio and V. J. Pileggi. 1971. Direct manual and automated methods for urea nitrogen measurement in whole serum. Clin. Chem. 17:981-895.