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EFFECT OF PROCESSED RICE BRAN ON GROWTH PERFORMANCE OF BROILER CHICKS FROM PAKISTAN

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Abstract

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Rice bran was added in broiler chicks feed by replacing 20% maize or 15% wheat. Significant difference in weight gain, feed consumed, feed conversion ratio (FCR), dressing percentage, pancreas weight, feed cost/chick, feed cost/kg live weight and feed cost/kg dressed meat was observed. Insects and larvae were found to be dead in PRB (processed rice bran). The highest weight gain (growth rate), feed efficiency and dressing percentage were obtained in chicks fed on T_4 which also showed the minimum feed cost/kg live weight and feed cost/kg dressed meat. Thus, acetic acid treatment combined with extrusion cooking improved the nutritive value of rice bran and also minimized the toxic factors. T_2 (RRB = raw rice bran) exhibited poor performance. The pancreas weight of chicks was normal by feeding extruded rice bran. PRB can be an excellent substitute of maize and wheat for good quality of poultry feed. It can improve nutritional quality of poultry feed which has been reflected by the performance of PRB in different parameter of chicks. It is helpful to give high yield of chicks and to utilize a by-product (rice bran) as good quality feed ingredient for value addition of poultry feed.

Key words: Rice bran; poultry feed; feed conversion ratio (FCR); Broiler chicks
Abbreviations: PRB – Processed Rice Bran; RRB – Raw Rice Bran; FCR – feed conversion ratio; DRB – defatted rice bran

Introduction

Rice is the staple food in "rice growing countries" of Asia, which is one of the most populated regions in the world. However, more than 90% of the world's rice is grown and consumed in Asia. On average basis about 30–70% of caloric intake is derived from rice in some very poor countries (Nadina, 2013). Rice bran is a by-product of rice milling industry. This plentiful material is derived from the outer layers of the rice caryopsis and consists of fine particles of pericarp, seed coat, nucleus, embryo, aleurone layer and part of sub-aleurone layer of the starchy endosperm obtained from the polishing of brown rice (Juliano, 1988).

The protein efficiency ratio of rice bran has been reported to be in the range of 1.6 to 1.9 as compared to casein value of 2.5. The digestibility of rice bran protein has been found to be 73%. It is a good source of lysine and methionine and can be an effective tool to supplement the lysine and methionine deficient foods such as wheat, maize and sorghum to overcome the malnutrition problem (Dale, 1997).

The major carbohydrates of rice bran are cellulose and hemi-celluloses. Starch is also additionally present due to breakage of endosperm during milling. The quantity of starch varies according to the amount of breakage and degree of milling and varies from 10 to 20% or even higher (Saunders, 1986).

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Undoubtedly, rice is one of the world's basic food items but rice bran (a valuable by-product of rice milling) has yet not been efficiently utilized. Despite of its excellent nutrition, the anti-nutritional or toxic factors present in rice bran limit its potential as a food or feed ingredient. Therefore, it is used in livestock or poultry feed as low quality ingredient (Warren and Farrell, 1990). The field fungi and bacteria present in rice bran produce lipases, proteases and amylases, which destroy nutrients, produce off-flavors, impart browning of color, give bitter taste and even produce aflatoxins (Schroeder, 1969).

Therefore in order to utilize rice bran's nutritional potential efficiently, the anti-nutritional or toxic factors must be eliminated or minimized. The advancement in recent technology and skills has made it possible to remove undesirable anti-nutritional factors in an efficient and economical way. The preparation of various diversified feed products after improving the nutritional quality of rice bran has been possible by combining the various appropriate techniques. In the present study anti-nutritional factors were denatured by using combined chemical and physical treatments (Shaheen et al., 2004). However, more work is needed on feeding trial of chicks for nutritional evaluation of rice bran. It is very important to study the quality and utilization of rice bran under the prevailing conditions in Pakistan. Therefore, the present research study was under taken to carry out biological assay of rice bran supplemented poultry feed and to develop an appropriate and economical technique for its commercialization as good quality feed ingredient. It will help to utilize agro-industrial by-product (rice bran) for value addition of poultry feed. It will also assist to utilize rice bran as a cheap source of energy and protein for chicks. The present study may provide practical guideline for industry for the preparation of an economical and nutritive diet formulation for chicks.

Materials and Methods

Rice bran of Basmati 385 was obtained from Reem Rice Mills (Pvt.) Ltd., Muridke, Pakistan. Rice bran revealed crude protein 13%, crude fat 12.93%, crude fiber 7.65%, ash 10.34% and nitrogen free extract 56.08%.

Processing of Rice Bran

The processing of rice bran was done to inactivate the anti-nutritional factors and samples (RRB: Raw Rice Bran; PRB: Processed Rice Bran) were prepared (Shaheen et al., 2004; Shaheen et al., 2012). Rice bran was packed in air impermeable plastic bags with Free Oxygen Absorber according to *Hirokazu and Takao* (2000) and stored at room temperature for further study.

Extraneous matters (pests, larvae and eggs)

Contamination in rice bran for pests and their eggs, larvae, maggots and nematodes was determined according to AOAC (2000) by using separating funnel stereoscopic microscope and silk blotting cloth (10xx). Sample (20 g) was transferred into the separating funnel using plenty of hot water and 30 ml n-heptane containing 8% toluene. Shaking was done several times. The funnel was filled with stream of water. Swirling and standing of funnel was done repeatedly. Then 250 ml of water was drained and filtered through dark colored silk bolting cloth (10xx). The pests, eggs and larvae were counted using stereoscope microscope with the help of the probe.

Broiler chicks feeding trials

Two experiments were conducted for nutritional evaluation of diets containing rice bran by using one day old Hubbard broiler chicks (150 chicks were used in each experiment). The data on weight gain, feed consumption and feed conversion ratio (FCR) were collected during the experimental period of 8 weeks. After slaughtering, the dressing percentage was calculated by removing feathers, skin, half head and versa i.e. toe with feet, lungs and gastro-intestinal tract. Organs (liver, heart and gizzard) were properly cleaned and weighed along with dressed carcass.

The data obtained were subjected to statistical analysis according to completely randomized design by following the statistical model given below (Steel et al., 1997).

$$Xij = \mu + Di + Eij,$$

where I = 1, 2, 3… (number of diets)
J = 1, 2, 3… (number of observations on each ration)
Xij = j^{th} observation on i^{th} treatment
μ = Population mean
Di = Effect of i^{th} diet
Eij = Random error associated with j^{th} observation on i^{th} treatment

Results and Discussion

Extraneous matters (pests, larvae and eggs)

The pests, larvae and eggs were found to be 6/g in raw rice bran. However, the insects and larvae were found to be dead in PRB. These results are identical to the findings of Kelley and Walker (1999) who suggested that single-screw dry-extrusion process can reduce population of potentially pathogenic bacteria in food waste-amended animal feed. This was accomplished due to the rearrangement of chemical structure between nutrients available to micro organisms (Plavnik and Sklan, 1995; Said, 1996). Bullerman and Bi-

anchini (2007) showed that extrusion processing is supportive for lowering mycotoxin concentrations in finished processed products. Feeding trial toxicity tests in rats showed some reduction in toxicity of extruded grits. Maciorowski et al. (2007) showed that type of feed, processing treatments and storage conditions can influence the level and types of microorganisms present in feed.

Broiler chicks feeding trials for nutritional evaluation of processed rice bran

Experiment 1. Replacement of maize with processed rice bran (PRB).

This study was conducted by adding 20% rice bran in broiler chicks ration (maize was replaced and lysine was not added). The statistical analysis revealed significant ($P \leq 0.01$) difference in weight gain, feed consumed, feed conversion ratio (FCR), dressing percentage and pancreas weight while liver and gizzard weight showed non-significance difference among all treatments (Table 1).

The highest weight gain (2410 g) of chicks was observed in ration containing PRB-II (T_4). The lowest weight gain was found in ration containing 20% RRB (T_2). The chicks fed on PRB (extruded, acidic and alkaline) gained 138, 260 and 223 g more weight than that of control (maize ration). These results indicated that partial replacement of maize by PRB increased the weight gain of chicks. The highest feed consumption was recorded in chicks fed on T_5 (5510 g) while the lowest feed consumption ratio was observed (4990 g) in chicks fed on T_2 (raw rice bran). The ration T_2 was less consumed (7.25%) by the chicks than control (T_1).

The feed conversion ratio (FCR) of rations containing processed rice bran ranged from 2.22 to 2.40. The chicks fed on ration T_2 showed FCR (2.92). It might be due to decline in body weight and poor feed consumption of chicks fed on RRB ration. The highest dressing percentage was obtained in T_4 ration and minimum in T_2 (20% RRB) ration. The chicks fed on ration T_2 showed significantly the highest pancreas weight. This indicated that anti-nutritive factors present in raw rice bran affected this organ and its secretions. However, no gizzard erosion was observed. A significant decrease in growth rate (live weight) and feed-consumption was noted in chicks fed on ration T_2 as compared to control (T_1). The decrease in above parameters might be due to the presence of toxic or anti nutritive factors present in RRB. The results of the present study are in concordance with the findings of Saunders (1990) and Majid (1997). The improvement in growth of chicks fed on rations containing processed rice bran (PRB I, PRB II, PRB III) exhibited that toxic or anti nutritional factors were inactivated or eradicated by moist heat treatment (extrusion) and treatment with acetic acid and calcium hydroxide. Tsai (1976) also reported that mixing of moist rice before autoclaving at 120°C improved the feed efficiency of chicks.

The reason for improvement in growth response and feed efficiency of chicks fed on PRB might be due to removal or reduction in anti-tryptic activity, breakdown of calcium-magnesium-phytate complex, inactivation of lipase and haemagglutinin activity etc. Other toxic factors i.e. haemagglutinin (Ory et al., 1981) and phytates (Thompson and Weber, 1981) were reduced or removed. Kratzer et al. (1974) also found that the processing of rice bran with acetic acid (1%) and extruded (steam) denatured the toxic factors which improved the growth and feed efficiency of chicks. They further observed that pancreas weight of chicks was normal. Gallinger et al. (2004) observed that rice bran should be included in broiler diets at a level between 10 and 20% if strategies are not used to decrease the anti-nutritive activity.

It may be concluded from the results that acetic acid treatment combined with extrusion cooking of rice bran improved the nutritive value of rice bran and also minimized the toxic factors. Poultry feed comprised of up to 65% cereal

Table 1

Performance of broiler chicks fed on maize diet supplemented with PRB

Treatments	Wt. gain/chick, g	Feed consumed/chick, g	Feed Conversion Ratio	Dressing, %	Liver wt., g	Gizzard wt., g	Pancreas wt., g
T 1	2150d	5380b	2.50b	61.98a	49.49a	33.49a	5.12b
T 2	1710e	4990c	2.92a	57.01b	48.54a	35.80a	6.46a
T 3	2288c	5490a	2.40c	63.30a	48.94a	34.05a	5.18b
T 4	2410a	5350b	2.22d	64.85a	51.37a	35.01a	5.21b
T 5	2373b	5510a	2.32c	62.45a	48.92a	35.76a	5.32b
Mean Square	492077.217**	963659.972**	0.410**	87.036**	116.565 NS	2.719 NS	1.142**

Mean values sharing similar letters in a column are not significantly different. PRB = Processed Rice Bran. ** = $P \leq 0.01$,
NS = Non significant. T1 = Control (maize basis), T2 = RRB (Raw), T3 = PRB-I (extruded), T4 = PRB-II (1% acetic acid), T5 = PRB-III (1% Calcium hydroxide).

grains. Thus PRB can be used as cereal substitute for poultry feed. It will also improve the nutritional quality of poultry feed.

Feed cost of broiler chicks (maize replacement)

The data on feed cost/chicks, feed cost/kg live weight and feed cost/kg dressed meat were calculated (Table 2). The results showed significant ($P \leq 0.05$) differences among all the parameters. Significantly high feed cost/chick was observed in ration T_1 (control). The feed cost of T_3, T_4 and T_5 indicated statistically non-significant differences with one another and it was significantly lower than the price of control ration. Low cost of raw rice bran ration (T_2) is due to no physical and chemical treatment to this bran and its price is much lower than maize.

The substitution of PRB (20%) decreased feed cost/kg live weight by 13.21, 15.49 and 15.15% among T_3, T_4 and T_5, respectively as compare to control (T_1). However, the differences among these treatments were non-significant. The feed cost/kg dressed meat was found to be higher for T_2 and the lowest in chicks fed on T_4. In T_4 feed cost/kg live weight reduced by Rs.4.07 (15.49%) as compared to control. However, for RRB ration, the cost increased by Rs.0.72 (2.74%) than control ration. The feed cost/kg dressed meat increased by 11.49% when RRB was substituted with 20% maize.

The increase in feed cost might be due to depressed growth and low feed efficiency of RRB. These results are fully in agreement with the findings of Chauhan and Sharma (1996), who concluded that rations having treated defatted rice bran in their formulation were economical (reduced feed cost/kg weight) than those containing maize. Donkoh and Zanu (2010) also observed that the inclusion of agro industrial wastes gives considerable economic advantage by reducing feed cost and increasing net profits without sacrificing performance for egg production. Cost per kg diet reduced by using agro-industrial byproducts. Seasonal increase in cost of conventional feedstuffs like maize etc would make the use of agro-industrial byproducts even more attractive. In the present study it was concluded that replacement of maize (20%) with PRB was economical but moist acetic acid plus extrusion was found to be the most effective which significantly reduced the feed cost by 15.49 and 19.26% for weight gain and dressed meat/kg.

Experiment II. Replacement of wheat with processed rice bran (PRB)

This study was conducted by adding 15% rice bran in broiler chicks feed (wheat was replaced and lysine was not added). The analysis of variance indicated statistically significant ($P \leq 0.01$) differences in weight gain and pancreas weight. The feed consumed, feed conversion ratio (FCR) and dressing percentage also showed statistically significant ($P \leq 0.05$) differences. The Liver and Gizzard weights showed non-significant differences among various treatments (Table 3).

The weight gain/ chick decreased 14.14% for T_2. Significantly higher weight gain was observed in chicks fed on T_4 ration, which was 27.92% more than control (T_1) ration. The chicks fed on ration T_2 consumed 63 g less feed as compared to control (T_1). However the chicks on feeds T_3, T_4 and T_5 consumed 177, 427 and 569 g more feed than control. The chicks fed on ration T_4 showed the lower FCR (1.86) while chicks fed on T_2 indicated the highest FCR (2.49). The dressing percentage of chicks fed on T_2 was the lowest (Table 3). The pancreas weight of chicks fed on T_2 was the highest (6.15 g) which was 21.54% high as compared to control.

The ration (T_2) significantly depressed growth rate (live weight) and feed consumption. It might be due to low weight gain and poor feed consumption. The decrease in above parameters might be due to the presence of growth depressant in RRB. These anti-nutritive factors might be lipases; trypsin inhibitors, haemagglutinin-lactin and phytates etc. present in raw rice bran as reported by Thompson and Weber (1981), Ory et al. (1981), Saunders (1990) and Takemasa and Hijikuro (1991). The body weight gain, feed intake and utiliza-

Table 2

Feed cost of broiler chicks fed on maize diet supplemented with PRB

Treatments	Feed cost/ chick, Rs.	Feed cost/ kg live wt., Rs.	Feed cost/ kg dressed meat, Rs.
T 1	56.49a	26.27a	42.47b
T 2	46.16b	26.99a	47.35a
T 3	52.16c	22.80b	35.97c
T 4	53.50c	22.20b	34.29d
T 5	52.90c	22.29b	35.74c
Mean Square	83.769**	29.588**	92.525**

Mean values sharing similar letters in a column are not significantly different.
** = $P \leq 0.01$. The treatments (T1 to T5) are same as described in Table 1

Table 3
Performance of broiler chicks fed on wheat diet supplemented with PRB

Treatments	Weight gain/ chick, g	Feed consumed/ chick, g	Feed Conversion Ratio	Dressing, %	Liver wt., g	Gizzard wt., g	Pancreas wt., g
T 1	2009b	4360c	2.17b	61.15a	48.42a	33.86a	5.06b
T 2	1725c	4297c	2.49a	55.75b	47.92a	33.18a	6.15a
T 3	2188b	4537bc	2.07b	63.12a	48.97a	34.02a	5.20b
T 4	2570a	4787ab	1.86c	64.99a	50.32a	34.25a	5.16b
T 5	2487a	4929a	1.98c	62.39a	49.58a	34.52a	5.23b
Mean Square	151375.26**	133946.841*	0.044*	7.559*	1.045NS	2.826 NS	0.285**

Mean values sharing similar letters in a column are not significantly different. * = $P \leq 0.05$, ** = $P \leq 0.01$,
NS = Non significant. The treatments (T1 to T5) are same as described in Table 1

Table 4
Feed cost of broiler chicks fed on wheat diet supplemented with PRB

Treatments	Feed cost/ chick, Rs.	Feed cost/ kg live wt., Rs.	Feed cost/ kg dressed meat, Rs.
T 1	53.41a	26.59a	43.42b
T 2	44.26b	25.66a	46.10a
T 3	48.77c	22.29b	35.34c
T 4	52.66a	20.49c	31.53d
T 5	52.25a	21.01bc	33.71c
Mean Square	15.415**	15.168**	30.268**

Mean values sharing similar letters in a column are not significantly different
** = $P \leq 0.01$. The treatments (T1 to T5) are same as described in Table 1

tion (FCR) of chicks fed on treated defatted rice bran (DRB) were significantly higher than the chicks fed on untreated DRB which showed that treatments improved the nutritive value of DRB (Majid, 1997).

In the present study the supplementation of 15% PRB (PRB-I, PRB-II and PRB-II) to wheat enhanced the growth of chicks. Maximum improvement in the growth of chicks and feed efficiency was observed in PRB II (T_4) which indicated that acetic acid treatment with extrusion process was a potent tool to get rid of the growth depressing factors. Eggum et al. (1984) found that wet heat treatment destroyed the anti-tryptic activity. Saunders (1990) reported that lipase activity was checked by heating the rice bran hence to improve its nutritive value. Kratzer et al. (1974) indicated that processed rice bran (acetic acid plus extension cooking), denatured the toxic proteins which improved the growth and feed efficiency of chicks. The pancreas weight of chicks was normal by feeding extruder cooked rice bran. The present study suggests that processed rice bran can be substituted with wheat to improve the nutritional status of the diet which has been reflected by the performance of PRB in different parameters of chicks.

Feed cost of broiler chicks (wheat replacement)

The feed cost (economic) of broiler chicks by substituting wheat with 15% rice bran was evaluated. The analysis of variance indicated statistically significant ($P \leq 0.05$) difference among feed cost/chicks, feed cost/kg live weight and feed cost/kg dressed meat (Table 4).

The results indicated that feed cost reduced to 17.13, 8.69, 1.40 and 2.17% by incorporation of raw rice bran and PRB to various rations (T_2, T_3, T_4 and T_5) as compared to control ration (T_1). The highest feed cost was given by T_1 (Rs. 53.41) and the lowest Rs. 44.26 by T_2 (raw rice bran). PRB rations are relatively more costly than T_2 due to processing of rice bran. Feed cost depends upon price of raw material, processing and its consumption etc. The cost of feed varies but usually it is low when production of raw material is on its peak. Feed cost/chick may vary due to its formulation too. However, the highest feed cost/kg live weight was recorded in chicks fed on control (T_1) ration (Rs. 26.59) and the lowest in chicks fed on T_4 (Rs. 20.49). Similar pattern was observed for feed cost/kg dressed meat (Table 4). The feed cost/kg live weight is reduced by Rs. 4.30, 6.10 and 5.58 when chicks fed on T_3, T_4 and T_5 rations, respectively. Previously it was reported that rations having treated defatted rice bran in formulations were economical (Chauhan and Sharma, 1996).

The results of the present study clearly indicated that minimum feed cost/kg live weight and feed cost/kg dressed meat was observed in chicks fed on ration (T_4) containing 15% PRB for getting more yield and good quality of chicken meal. However, this study suggested that moist acetic acid

plus extrusion was found to be the most effective treatment for rice bran. Thus agro-industrial by-product (rice bran) can be utilized as a cheap source of energy and protein for chicks.

Conclusions

The partial replacement of maize and wheat with PRB increased the body weight gain of chicks. The feed cost/ kg live weight was decreased in chicks fed on ration (T_4) as compared to control (T_1). The processed rice bran can be excellent substitute of maize or wheat to improve the nutritional status of the boiler chick's diet. It is concluded that acetic acid treatment combined with extrusion cooking of rice bran (T4) improved the nutritive value of rice bran and also minimized the toxic factors. Thus agro-industrial by-product (rice bran) can be utilized as a cheap source of energy and protein for chicks. This study is a practical guideline for feed industry for the preparation of an economical and nutritive diet formulation for chicks.

References

AACC, 2000. Approved Methods of American Association of Cereal Chemists. *Am. Assoc. Cereal Chem. Inc.*, St. Paul., Minnesota (USA).

Bullerman, L. B. and A. Bianchini, 2007. Mycotoxins from the field to the table: Stability of mycotoxins during food processing. *International Journal of Food Microbiology*, **119** (1–2): 140–146.

Chauhan, R. K. and R. K. Sharma, 1996. Rice bran as a replacer for maize in the diet for broiler chicks. *Industrial Journal of Poultry Science,* **3**: 163–167.

Dale, N., 1997. Feedstuffs ingredient analysis table. *Feed Stuff. Watt Pub. Co.*, IL. USA, pp. 48–52.

Donkoh, A. and H. K. Zanu, 2010. Development of feed package for layers using low energy agro-industrial by products. *African Journal of Agricultural Research*, **5** (20): 2782–2786.

Eggum, B. O., B. O. Juliano and C. M. Villareal, 1984. Effect of treatment on composition, protein and energy utilization of rice and mung bean by rats and quail. *Plants Food for Human Nutrition*, **34**: 261–272.

Gallinger, C. I., D. M. Sua´rez and A. Irazusta, 2004. Effects of rice bran inclusion on performance and bone mineralization in broiler chicks. *Journal of Applied Poultry Research*, **13**:183–190.

Hirokazu, T. and I. Takao, 2000. Packaging method for longer food preservation. *Jpn Kakai Tokyo Koho*, Japan, pp. 255–647.

Juliano, B. O., 1988. Rice Chemistry and Technology. D. F. Houston (Ed) *Am. Assoc. Cereal Chem. Inc.*, St. Paul, Minnesota, USA.

Kelley, T. R. and P. M. Walker, 1999. Bacterial concentration reduction of food waste amended animal feed using a single-screw dry-extrusion process. *Bioresource Technology,* **67** (3) 247–253.

Kratzer, F. H., L. Earl and C. Chiaravanont, 1974. Factors influencing the feeding value of rice bran for chickens. *Poultry Science*, **53**: 1795–1800.

Maciorowski, K. G., P. Herrera, F. T. Jones, S. D. Pillai and S. C. Ricke, 2007. Effects on poultry and livestock of feed contamination with bacteria and fungi. *Animal Feed Science and Technology*, **133** (1–2): 109–136.

Majid, A., 1997. Effect of various treatments of rice bran on the performance of broiler chicks. M. Sc. Thesis. C.V.S, *Univ. Agri.*, Faisalabad, Pakistan.

Nadina, M-F., 2013. Nutrient-focused Processing of Rice. In: Agricultural Sustainability: Progress and Prospects in Crop Research. *Academic Press*, pp. 197–220.

Ory, R. L., H. T. C. Bog and R. R. Mod, 1981. Properties of haemagglutinin in rice and other cereal grains. In: Antineutrinos and Natural Toxicants in Foods. *Food Nutrition Press Inc.*, Westport, pp. 159–168.

Plavnik, I. and D. Sklan, 1995. Nutrition effects of expansion and short time extrusion of feeds for broilers. **Animal Feed Science and Technology**, **55**: 247–251.

Said, N. W., 1996. Extrusion of alternative ingredient an environmental and nutritional solution. *Journal of Applied Poultry Research*, **5**: 395–406.

Saunders, R. M., 1986. Rice bran composition and potential food uses. *Food Reviews International*, **1**: 465–495.

Saunders, R. M., 1990. The properties of rice bran as a foodstuff. *Cereal Foods World*, **35**: 632–636.

Schroeder, K. W., 1969. Factors influencing the development of aflatoxin in some crops. *Journal of Stored Products Research*, **5**: 187–192.

Shaheen, M., F. M. Anjum, A. D. Khan., T. Zahor and A. Ahmed, 2004. Effect of processing on anti-nutritional factors of rice bran. *Pakistan Journal of Food Sciences*, **14** (3–4): 11–14.

Shaheen, M., I. Ahmad and F. M. Anjum, 2012. Effect of processed rice bran supplementation on the quality of chapaties. *Thai Journal of Agricultural Science*, **45** (4): 241-247.

Steel, R. G. D., D. Dickey and J. H. Torrie, 1997. Principles and Procedures of Statistics. A Biometrical Approach, 3rd ed. *McGraw Hill Book Co. Inc.*, New York.

Takemasa, M. and S. Hijikuro, 1991. Effect of autoclaving of defatted rice bran on the phosphorus utilization for chicks. *Japanese Poultry Science*, **28** (6): 284–293.

Thompson, S. A. and C. W. Weber, 1981. Effect of dietary fiber sources on tissue mineral levels in chicks. *Poultry Science*, **60**: 840–845.

Tsai, Y. C., 1976. Contribution of protease inhibitors to the deleterious effects of fractions and heat treated rice bran fed to chicken. *Journal of the Chinese Chemical Society*, **14**: 187–194.

Warren, B. E. and D. J. Farrell, 1990. The nutritive value of full fat and defatted Australian rice bran and chemical composition. *Animal Feed Science and Technology*, **27**: 219–228.

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