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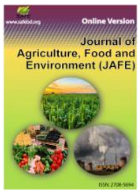

Research Article

Digestibility of de-oiled rice bran and its effect on the growth performance of native sheep in Bangladesh

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A B S T R A C T

This experiment aimed to assess the digestibility of de-oiled rice bran and its impact on the growth performance of sheep. Twelve Indigenous male lambs, approximately 10 months of age, were subjected to a feeding trial involving different levels of de-oiled rice bran (50 g, 100 g, and 150 g) for 45 days. The results revealed that the digestibility of crude protein (CP) was significantly higher ($P<0.01$) in the 100 g de-oiled rice bran group compared to the 50 g and 150 g groups. The mean values for CP digestibility in these groups were 59.711±0.833, 60.711±0.890, and 48.719±2.329, respectively. Similarly, the digestibility of crude fiber (CF) was significantly higher ($P<0.01$) in the 100 g de-oiled rice bran group compared to the 50 g and 150 g groups. The mean values for CF digestibility in these groups were 63.174±.94, 63.840±1.61, and 51.584±0.91, respectively. However, the digestibility of ether extract (EE) and nitrogen-free extract (NFE) did not exhibit significant differences ($P= 0.305$ and $P= 0.147$, respectively). The average weight gain of the control, 50 g, 100 g, and 150 g de-oiled rice bran-fed groups were 1.03±0.033, 2.63±0.185, 4.36±0.185, and 4.16±0.166, respectively. The body weight gain tended to be higher in the 100 g de-oiled rice bran-fed group compared to the control, 50 g, and 150 g de-oiled rice bran-fed groups. Therefore, it can be concluded that supplementing 100 g of de-oiled rice bran with ad libitum green grass per day was more beneficial for the sheep than any other levels of de-oiled rice bran.

INTRODUCTION

Sheep farming plays a pivotal role in the agricultural sector of Bangladesh, particularly for landless and marginal farmers. As of 2024, the national sheep population is approximately 3.903 million, distributed across various regions (DLS, 2024). In Bangladesh, escalating feed prices, limited arable land, and increasing competition between humans and livestock pose challenges to nutritional adequacy, necessitating the exploration of alternative feed sources. Consequently, de-oiled rice bran (DORB) emerges as a promising solution, characterized by its affordability and nutritional benefits (Ranjan *et al.*, 2018). DORB is notably abundant as a by-product of the rice milling industry and possesses a rich array of nutritional properties. Its potential as a cost-effective, high-efficiency feed ingredient is significant, as DORB, derived from full-fat rice bran, is abundant in protein, fiber, and essential micronutrients while being low in fat, which is advantageous for livestock diets (Ranjan *et al.*, 2022; Bishwass *et al.*, 2023; Garg *et al.*, 2004). Research indicated that DORB can enhance nutrient digestibility and improve growth performance in ruminants. Strategies to optimize weight gain, feed efficiency, and nutrient utilization have involved substituting conventional feed components such as maize or wheat bran with DORB, without adverse effects (Gadberry *et al*., 2004; Gadberry *et al*., 2007). Additionally, processing techniques mitigate antinutritional factors like phytates, thereby improving digestibility and suitability for ruminant feeding (Islam *et al*., 2022).

DORB also contains antioxidants and bioactive compounds that contribute to improved animal health outcomes (Ryan, 2011). The inclusion of DORB in the diets of growing sheep has been demonstrated to enhance nutrient uptake and microbial protein synthesis in the rumen, thereby facilitating improvements in feed utilization and growth (Bishwass *et al*., 2023). With its extended shelf life, DORB is a more practical option for smallholder farmers, as its long shelf life and ease of incorporation into feed formulations render it a viable choice (Ranjan *et al*., 2022). These benefits support the increased use of DORB in sheep nutrition; however, its utilization is constrained by a lack of farmers' awareness and the unavailability of processed feed formulations on a large scale. Further research on optimal inclusion rates and feeding strategies of DORB is warranted to maximize its advantages (Bishwass *et al*., 2023).

This study aimed to investigate the impact of varying levels of DORB inclusion in sheep diets on nutrient digestibility and growth performance. The research endeavoured to identify optimal feeding strategies and promote DORB as a concentrate feed supplement within sheep farming systems. The anticipated findings were expected to assist farmers in utilizing this locally available and relatively inexpensive feed source to enhance the productivity and sustainability of their sheep farming operations.

MATERIALS AND METHODS

Experimental site

The entire research was conducted at the Goat, Sheep, and Horse Farm, BAU as well as in the laboratory of the Department of Animal Science and the Shahjalal Animal Nutrition Field Laboratory of Bangladesh Agricultural University, Mymensingh. This experiment was conducted for 59 days, comprising a 45-day feeding trial, a 7-day adjustment period, and a 7-day sample collection period.

Animals and Management System

Twelve Indigenous growing lambs, with an initial average body weight of 10.7 kg (approximately 10 months of age), were selected for this experiment. They underwent deworming treatment according to the clinical report of the fecal examination conducted at the veterinary clinic of BAU, Mymensingh, fourteen days before the trial. To identify each animal uniquely, individual numbers were affixed to their necks. The lambs were provided with a specific grazing period (6 hours daily) during the day and were housed overnight in a platform system with adequate ventilation. This platform was divided into four sections, with three animals housed in each section, maintaining separate mangers and water troughs to prevent the mixing of feed with water, urine, and feces. A skilled shepherd was employed to supervise the animals throughout the experiment. Identical housing, healthcare, and sanitary measures were facilitated to all the lambs.

Experimental design

A completely randomized block design was exploited in this experiment during the selection of the animals for each group. 12 animals were distributed into four dietary treatments designated as T_0, T_1, T_2, and T_3. The initial live weight of the animals was measured using the weight machine. T_0, T_1, T_2, and T_3 were the group numbers of animals that were supplied 0 g of DORB (control feed), 50 g of DORB, 100 g of DORB, and 150 g of DORB per day respectively (Table 1).

Table 1: Initial live weight of the animals

Dietary Treatment			
T_0(Control)	**T_1**	**T_2**	**T_3**
Initial live weight(kg)			
9.0 (1)	10.0(4)	12.0 (7)	11.0 (10)
10.6 (2)	11.0(5)	11.0 (8)	12.5 (11)
9.5 (3)	9.5(6)	11.5 (9)	11.5 (12)

Feeding trial

All animals were supplied an equal amount of mixed concentrate feed (rice polish, soybean meal and salt) with ad libitum green grass. T_1 animals were given mixed concentrate feed including 50g DORB, T_2 animals were given 100 g DORB and T_3 animals were given 150 g DORB while the animals of the controlled group were supplied ad libitum green grass and concentrate feed without de-oiled rice bran (DORB) (Table 2).

Table 2: Feeding trial of the animals for growth performance

	T_0	T_1	T_2	T_3
De-oiled Rice Bran(g)	0	50	100	150
Rice Polish(g)	100	100	100	100
Soybean meal(g)	100	100	100	100
Salt (g)	3	3	3	3

Sample collection

Ad libitum green grass and concentrate feed with 0 g DORB, 50 g DORB, 100 g DORB, and 150 g DORB per day were supplied to 4 lambs from the four groups (control, T_1, T_2, and T_3). Residual feed, urine, and feces were collected for proximate analysis.

Proximate analysis

Dry matter

Five grams of the sample was placed in the crucible. Subsequently, it was heated to 105°C in an electric oven for 24 hours. This procedure was conducted as per the guidelines outlined in the (AOAC, 2005) standard. All determinations were performed in duplicate, and the mean value was subsequently recorded.

$$\text{Dry matter} = \frac{\text{Dried weight of the sample}}{\text{Weight of the sample}} \times 100$$

Crude protein

Crude protein content was determined using the Kjeldahl method (Salo-Väänänen and Koivistoinen, 1996). The procedure was outlined in the following diagram:

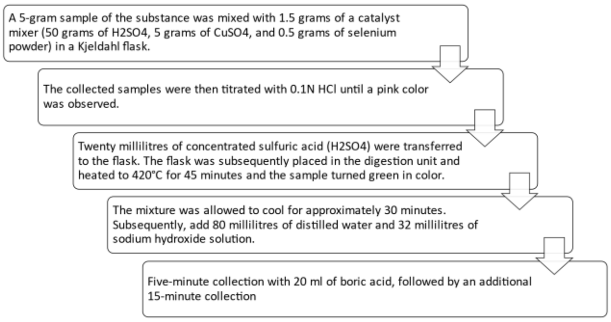

Figure 1: Flow diagram of crude protein determination

The correspondence formula to determine the % nitrogen requirement is:

$$\frac{\text{titrate required(ml)} \times 0.014(\text{mili equivalent of N2}) \times \text{strength of HCL}}{\text{Weight of the sample}} \times 100$$

Again % of CP=% of nitrogen × conversion factor (6.25)

Ether extract

The ether extract content was determined using a Soxhlet apparatus with diethyl ether as the solvent. Initially, the weight of the first flask was recorded. Subsequently, a 1-gram sample was placed in a thimble, and 200 millilitres of acetone was added to the Soxhlet apparatus. The extraction process was conducted at 40-45°C, which took approximately 7-8 hours. After extraction, the flask was removed and dried in an oven at 100°C for 30 minutes. Subsequently, the flask containing the ether extract was cooled in a desiccator and weighed. The calculated value for ether extract content was obtained as a percentage of the sample.

The formula for calculating ether extract content is provided below:

$$\text{Ether extract} = \frac{\text{Weight of the ether extrct}}{\text{Weight of the sample}} \times 100$$

Crude fiber

A 2-gram sample was boiled with 125 millilitres of 1.25% hydrochloric acid (H_2SO_4) for 30 minutes. The resulting acid solution was filtered to remove the acid, and the residue was boiled with 1.25% sodium hydroxide for another 30 minutes. The resulting residue was then dried in an oven drier at 105°C for 24 hours. Finally, the residue was ignited in a muffle furnace within a crucible at 600°C for 4-5 hours. The resulting ash was weighed.

$$\text{Crude Fiber (\%)} = \frac{\text{Waste (residue)dried weight} - (\text{crucible+ash weight})}{\text{Weight of the sample}} \times 100$$

Ash

A 5-gram sample was placed in the crucible. Subsequently, it was heated to 105°C in an electrical oven for 24 hours. Subsequently, the crucible containing its contents was transferred into a muffle furnace and ignited at 500-600°C for 5 hours. After combustion, the crucible was removed and cooled in desiccators before being weighed. The formula is provided below:

$$\text{Percentage of total Ash} = \frac{\text{Weight of the ash}}{\text{Weight of the sample}} \times 100$$

Digestibility of DORB

After sample collection and proximate analysis, the digestibility of DORB was determined. The general formula for calculating the digestibility of DORB is:

$$\frac{\text{nutrient in test food} - (\text{nutrient in faeces} - \text{nutrient in faeces from basal diet})}{\text{nutrient in test food}}$$

Statistical analysis

Data were presented as the mean ± standard error (SE). Initially, the raw data were organized using Microsoft Excel and subsequently analyzed using SPSS statistical software for one-way analysis of variance (ANOVA). The significance of differences among means was determined using Tukey's Honest Significant Difference (HSD) test (1953). Differences with a P-value less than 0.05 were considered statistically significant, while those with a P-value less than 0.01 were deemed highly statistically significant.

RESULTS AND DISCUSSION

Digestibility of de-oiled rice bran

The dietary inclusion of de-oiled rice bran (DORB) in the diet of growing lambs demonstrated a substantial impact on the digestibility of crude protein (CP). The study revealed significant differences in CP digestibility among the treatment groups. The CP digestibility values for the T_1, T_2, and T_3 groups were 59.711±.883, 60.711±.890, and 48.719±2.329, respectively, as presented in Table 3. Furthermore, the digestibility of crude fiber (CF) also exhibited significant variation among the treatment groups. The CF digestibility values for the T_1, T_2, and T_3 groups were 63.174±.542, 63.840±.929, and 51.584±.525, respectively. Similar to CP, the incorporation of moderate levels of DORB (50g and 100g) exhibited a positive impact on CF digestibility, as evidenced in Table 3. Crude protein (CP) and crude fiber (CF) digestibility of a feed is influenced by several factors, including feed composition, processing methods, and animal-specific characteristics. The chemical composition of the feed ingredient, such as the presence of anti-nutritional factors and the ratio of soluble to insoluble fibers, can significantly affect nutrient digestibility (Choct, 1997). Processing methods like pelleting, grinding, and enzyme treatment can improve digestibility by breaking down complex fiber structures and enhancing nutrient availability (Amerah *et al.*, 2007). Animal-specific factors such as age and breed also play a role; younger lambs often exhibit lower digestibility due to an underdeveloped digestive system, while certain breeds have genetic differences that affect nutrient utilization (Luo *et al.*, 2004). Environmental factors, including housing and climate, can impact feed intake and digestion efficiency, further influencing the digestibility of CP and CF (Hales *et al.*, 2015).

In this experiment, the findings suggest that the moderate inclusion of DORB (50g and 100g) in the diet can enhance CP digestibility compared to the other groups. This improvement may be attributed to the better amino acid profile and higher biological value of the proteins in DORB. Rice bran, a globally produced resource, possesses exceptional nutritional value. Scientific research has demonstrated its abundance of vitamins, minerals, essential fatty acids, dietary fiber, and other sterols (Gul *et al*., 2015). The nutritional profile of rice bran ranges from 12–16% protein, 12–23% fat, and 23–30% dietary fiber (Sohail *et al*., 2016). However, the highest inclusion level (150g) led to a significant decrease in CP digestibility, indicating that excessive DORB might have adverse effects, possibly due to the presence of anti-nutritional factors like phytic acid, which can bind to proteins and reduce their availability (Selle *et al*., 2000; Ravindran and Blair, 1992). Additionally, the higher fiber content in DORB might also contribute to reduced protein digestibility by increasing the rate of passage through the digestive tract, thus limiting the time for nutrient absorption (Jha and Berrocoso, 2015).

The improvement in CF digestibility with moderate DORB inclusion could be due to the higher fiber content and better fermentability of rice bran, which promotes microbial activity in the rumen (Soest, 1994). However, the highest inclusion level (150g) resulted in a significant reduction in CF digestibility, likely due to an imbalance in the fiber content, which could disrupt the rumen environment and hinder fiber breakdown (NRC, 2001).

The results indicate that moderate levels of DORB (50 and 100g/d) can enhance the digestibility of both CP and CF in growing lambs. This aligns with previous research that has highlighted the potential benefits of including agro-industrial by-products like rice bran in ruminant diets to improve nutrient utilization and overall animal performance (Wadhwa and Bakshi, 2013). However, it is crucial to determine the optimal inclusion level to avoid potential negative effects, as observed with the highest DORB level (150g) in this study.

The inclusion of de-oiled rice bran (DORB) in the diet of growing lambs did not significantly alter the digestibility of ether extract (EE). The average EE digestibility values for the T_1, T_2, and T_3 groups were 43.583±.793, 43.583±1.055, and 41.941±.330, respectively (Table 3). Similarly, there were no significant differences in nitrogen-free extract (NFE) digestibility among the treatment groups. The average NFE digestibility values for the T_1, T_2, and T_3 groups were 85.492±1.405, 85.159±0.497, and 82.696±.620, respectively (Table 3). These results suggested that the inclusion of DORB at various levels (50, 100, and 150g/d) does not significantly alter the lambs' ability to digest ether extract. This finding was consistent with previous studies indicating that the inclusion of moderate amounts of rice bran or its derivatives does not significantly impact fat digestibility in ruminants (Sauvant *et al*., 2004). The fat content in DORB may be relatively low compared to other feed components, and the fat digestibility mechanisms in the rumen are not significantly influenced by the inclusion levels used in this study.

NFE represents the carbohydrate fraction of the diet, excluding fiber. The absence of significant differences in NFE digestibility suggests that carbohydrate digestibility remained stable across varying levels of DORB inclusion. This stability could be attributed to the fact that the primary components of NFE, such as starches and sugars, are efficiently utilized by rumen microbes irrespective of the DORB level. Previous research has shown that ruminants have a robust capacity to digest and utilize dietary carbohydrates, which might explain the consistent NFE digestibility observed in this study (Soest, 1994).

Processing methods such as grinding, pelleting, and heat treatment can improve EE and NFE digestibility by enhancing nutrient availability and reducing anti-nutritional factors (Svihus *et al*., 2004). The fat content and fatty acid profile of the feed ingredient affect EE digestibility, as highly unsaturated fats are more digestible compared to saturated fats (Palmquist and Jenkins, 1980; Doreau and Ferlay, 1994). The carbohydrate composition of the feed ingredient, particularly the ratio of soluble to insoluble carbohydrates, influences NFE digestibility; easily fermentable carbohydrates improve NFE digestibility (Soest, 1994).

Table 3: Digestibility of de-oiled rice bran

Group	DCP%	DCF%	DEE%	DNFE%
T_1	59.711^b± .883	63.174^b± .542	43.583± .793	85.492± 1.405
T_2	60.711^b± .890	63.840^b± .929	43.583± 1.055	85.159± 0.497
T_3	48.719^a± 2.329	51.584^a± .525	41.941± .330	82.696± .620
P value	0.000	0.000	0.305	0.147
Sig.	***	***	NS	NS

***= significant (p=0.000-0.001), NS= Non significant (p>0.05)

Growth performance of lamb supplemented with de-oiled rice bran

The results indicated significant differences among the groups regarding body weight gain (Table 4). The average weight gain values were 1.03±0.033 kg for T_0, 2.63±0.185 kg for T_1, 4.36±0.185 kg for T_2, and 4.16±0.166 kg for T_3. These findings highlighted the beneficial effects of including DORB in the diet of growing lambs up to a certain level. Previous studies have shown that DORB is a good source of energy and protein, with less fiber content compared to other common eating ingredients (Bishwass *et al*., 2023). Replacing wheat bran with DORB resulted in greater weight gain and better blood sheep parameters, indicating a positive nutritional impact (Bishwass *et al*., 2023). This discovery suggests that DORB is a dense calorie food and contributes to a healthier metabolic profile in lambs. The improvement in growth performance is closely linked to the nutritional composition of the feed, and DORB is a viable alternative due to its nearby composition. The body weight gain tended to be higher in the 100 g de-oiled rice bran-fed group compared to the control, 50 g and 150 g de-oiled rice bran-fed groups. The potential reason for this observation is that as the amount of de-oiled rice bran increases, the quantity of rejected particles also increases. This rejected de-oiled rice bran may negatively impact the growth rate. This observation aligns with the findings of Madhukar *et al.* (2024) indicating that the moderate inclusion of alternatives such as Rice Bran offers ideal sheep growth performance. Weight gain and the use of improved feeding observed in the 100gm DORB group can be attributed to the DORB nutrient profile and its palatability, which may encourage greater feed intake. This is consistent with Shashikumar *et al.* (2017) who found that feed alternatives with balanced nutrient profiles have positive effects on meat performance in sheep.

Table 4: Effect of DORB on body weight gain

Parameter	Treatment			
	T_0	T_1	T_2	T_3
Average Initial wt (Kg)	9.7	10.17	11.5	11.5
Average Final wt (Kg)	10.73	12.8	15.87	15.67
Gain (Kg)	$1.03^a \pm 0.033$	$2.63^b \pm 0.185$	$4.36^c \pm 0.185$	$4.16^c \pm 0.166$
P-Value	0.000			
Sig. Level	***			

***= significant (p=0.000-0.001)

CONCLUSIONS

This study illustrated that the inclusion of DORB in lamb diets can significantly influence weight gain and feeding efficiency, with moderate inclusion levels producing the best results. DORB's potential as a sustainable and economically viable feeding option for indigenous lambs justifies further investigation, particularly in field tests to validate controlled results and increase comprehension of long-term benefits and sustainability. Continuous research can help explore various alternative food sources by improving agricultural practices and addressing global food safety challenges.

REFERENCES

Amerah AM, Ravindran V, Lentle RG, Thomas DG 2007: Influence of feed particle size and feed form on the performance, energy utilization, digestive tract development, and digesta parameters of broiler starters. Poultry Science **86**(12): 2615-2623.

Bishwass KC, Surovy NF, Shuvo AAS, Murshed HM, Parvin S, Pasha MMH, Rahman SME 2023: Effect of replacing wheat bran with de-oiled rice bran on growth and blood parameters of native sheep. *Journal of Agriculture Food and Environment* **4**(4): 14-19.

Choct M 1997: Feed non-starch polysaccharides: chemical structures and nutritional significance. Feed Milling International **191**(4): 13-26.

Department of Livestock Services (DLS) 2024: Annual Livestock Statistics. People's Republic of Bangladesh.

Doreau M, Ferlay A 1994: Digestion and utilization of fatty acids by ruminants. Animal Feed Science and Technology **45**(3-4): 379-396.

Gadberry MS, Beck PA, Gunter SA 2004: Forage intake and performance by beef heifers grazing cool-season pasture supplemented with de-oiled rice bran or corn. The Professional Animal Scientist **20**(5): 394-400.

Gadberry MS, Beck PA, Gunter SA 2007: Rice milling coproducts as feedstuffs for beef cattle. The Professional Animal Scientist **23**(4): 309-315.

Garg AK, Singh P, Malik R, Agrawal DK 2004: Effect of replacing maize grain with de-oiled rice bran on intake and utilisation of nutrients in adult ewes. Small Ruminant Research **52**(1-2): 75-79.

Gul K, Yousuf B, Singh AK, Singh P, Wani AA 2015: Rice bran: Nutritional values and its emerging potential for development of functional food – A review. Bioactive Carbohydrates and Dietary Fiber **6**(1): 24–30.

Hales KE, Brown-Brandl TM, Freetly HC 2015: Effects of decreased dietary roughage concentration on energy metabolism and nutrient balance in finishing beef cattle. Journal of Animal Science **92**(1): 264-71.

Islam KM, Shuvo AA, Achergee S, Kabir A 2019: Comparison of Rice Bran and Deoiled Rice Bran as Feed Ingredient for Broiler. *Journal of Agricultural Engineering and Food Technology* **5**(2):58-61.

Islam KMS, Elsabagh M, Lv R, Dang HL, Sugino T, Obitsu T 2022: Anaerobic fermentation of rice bran using rumen liquor for desirable chemical changes as animal feed. *Journal of Advanced Veterinary and Animal Research* **9**(4): 728-735.

Jha B, Chandra R, Vijay VK, Subbarao PMV, Isha A 2020: Utilization of de-oiled rice bran as a feedstock for renewable biomethane production. Biomass and Bioenergy 140.

Jha R, Berrocoso JFD 2015: Review: Dietary fiber utilization and its effects on physiological functions and gut health of swine. Animal **9**(9):1441-1452.

Luo J, Goetsch AL, Sahlu T, Nsahlai IV, Johnson ZB, Moore JE, Galyean ML, Owens FN, Ferrell CL 2004: Prediction of metabolizable energy requirements for maintenance and gain of preweaning, growing, and mature goats. Small Ruminant Research **53**(3): 231-252.

Madhukar, Vikas 2024: Growth performance and carcass characteristics of ram lambs fed with concentrate mixture containing varying levels of rice dried distillers grains with soluble. *Journal of Krishi Vigyan* **12**(1): 84-91.

Maryam S, Faqir A, Anas K, Tahir Z, Anwaar A 2004: Effect of processing on anti-nutritional factors of rice bran. *Pakistan Journal of Food Sciences* **14**: 11-14.

Ranjan A, Kumar S, Sahu NP, Jain KK, Deo AD 2022: Strategies for maximizing utilization of de-oiled rice bran (DORB) in the fish feed. Aquaculture International **30**(1): 99–114.

Ravindran V, Blair R 1992: Feed resources for poultry production in Asia and the Pacific. II. Plant protein sources. *World's Poultry Science Journal* **48**(3): 205-231.

Ryan EP 2011: Bioactive food components and health properties of rice bran. Journal of the American Veterinary Medical Association **238**(5): 593-600.

Sauvant D, Perez JM, Tran G 2004: Tables of Composition and Nutritional Value of Feed Materials: Pigs, Poultry, Cattle, Sheep, Goats, Rabbits, Horses, Fish. INRA Editions.

Selle PH, Ravindran V, Caldwell RA, Bryden WL 2000: Phytate and phytase: consequences for protein utilization. Nutrition Research Reviews **13**(2): 255-278.

Shashikumar MG, Prabhu TM, Gloridoss RG, Singh KC, Suresh BN, Siddalingamurthy HK, Manjunatha SS 2017: Effect of feeding maize (Zea mays) husk and cob-based complete feed block on feed intake, nutrient utilization and growth in Mandya sheep. *Indian Journal of Animal Nutrition* **34**(2): 135-139.

Sohail M, Rakha A, Butt MS, Iqbal MJ, Rashid S 2016: Rice bran nutraceuticals: A comprehensive review. Critical Reviews in Food Science and Nutrition **57**(17): 3771–3780.

Salo-Väänänen P, Koivistoinen PE 1996: Determination of protein in foods: comparison of net protein and crude protein (N * 6.25) values. Food Chemistry 57: 27-31.

National Research Council 2001: Nutrient Requirements of Dairy Cattle (7th rev. ed.). National Academy Press.

Svihus B, Kløvstad KH, Perez V, Zimonja O, Sahlström S, Schüller RB, Jeksrud WK, Prestløkken E 2004: Physical and nutritional effects of pelleting of broiler chicken diets made from wheat ground to different coarsenesses by the use of roller mill and hammer mill. Animal Feed Science and Technology **117**(3-4): 281-293.

Van Soest PJ 1994: Nutritional Ecology of the Ruminant. 2nd Edition. Ithaca, NY: Cornell University Press.

Wadhwa M, Bakshi MPS 2013: Utilization of fruit and vegetable wastes as livestock feed and as substrates for generation of other value-added products. Ruminant Nutrition **41**(1): 25-34.

Palmquist DL and Jenkins TC 1980: Fat in lactation rations: Review. Journal of Dairy Science **63**(1): 1-14.

Ranjan A, Sahu NP, Deo AD, Kumar HS, Kumar S, Jain KK 2018. Comparative evaluation of fermented and non-fermented de-oiled rice bran with or without exogenous enzymes supplementation in the diet of Labeo rohita (Hamilton, 1822). Fish Physiology and Biochemistry **44**(4):1037-1049.