Treatments Effect on Biological Values of Defatted Rice Polishings

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ABSTRACT : Defatted rice polishings (DRP) was subjected to chemical treatments i.e., 0.4 N HCl, and 6% H_2O_2, with or without physical treatment i.e. extrusion cooking. The treated DRP was evaluated chemically and biologically using male broiler chicks (108) of approximately uniform weight, selected out of 220 chicks, previously fed on commercial diets for 7 days as a settlement period. The chicks were then divided into 36 experimental units of 3 chicks each. Each experimental diet was randomly allotted to three experimental units and fed for 10 days to broiler chicks. The experimental diets were designated as A (Commercial), B (10% HCl treated DRP), C (20% HCl treated DRP), D (10% HCl plus extruded DRP), E (20% HCl plus extruded DRP), F (10% H_2O_2 DRP) and G (20% H_2O_2 DRP), H (10% H_2O_2 plus extrusion DRP) and I (20% H_2O_2 plus extrusion DRP), J (10% untreated DRP), K (20% untreated DRP) and L (Protein free). The birds fed on diet L were used to measure the endogenous nitrogen loss. The biological evaluations of diets containing differently treated DRP were compared with a commercial feed and feeds containing untreated defatted rice polishings. It was observed that these treatments liberated bound nutrients, making them more accessible to the normal digestive enzymes and increased their apparent nutrient availability. This process probably also detoxified the anti-nutritive factors i.e. phytates, lectin, trypsin inhibitor present in DRP. The results of the feeding trials revealed that diets containing 6% H_2O_2 treated DRP showed better weight gain, feed consumption and utilization, protein efficiency and digestibility, biological value and net protein utilization than all other treatments. ***(Asian-Aust. J. Anim. Sci. 2006. Vol 19, No. 2 : 209-216)***

Key Words : Defatted Rice Polishings, Chemical Treatments, Extrusion Cooking, Broiler Chicks, Biological Values

INTRODUCTION

Rice is a major cereal crop of South Asia and Southeast Asia or Far East. Rice polishing is the by-product of rice milling industry. It constitutes about 10% of brown rice and is used as an animal feed (Farrell, 1994). The quantity of rice polishing available from rice mills throughout the world is about 30 million tonnes/year (Luh et al., 1991).

Rice polishing is comparatively less expensive and rich source of protein and energy. These qualities lead to a high demand for rice polishing as poultry feed (Piliang et al., 1982). It contains high amount of oil 12-13% (NRC, 1994), however, its oil contains higher amount of unsaturated fatty acids which are rapidly broken down (1% per hour) to free fatty acids by endogenous enzymes lipases and lipo-oxygenases (Desikachar, 1974). This oxidation process results in severe nutritional and economic losses, if fed after prolonged storage to poultry (Yokochi, 1972; Subrahmanyan, 1993). In spite of all its nutritional merits its utilization has some problems due to the presence of comparatively high fiber than other cereals (Sieden and Fander, 1957) and undesirable anti-nutritive factors such as phytate, trypsin inhibitor and lectin (Kratzer and Payne, 1977; Deolankar and Singh, 1979; Tsuda, 1979). These anti-nutritive factors can be rendered non-toxic by modifying their structure or breaking their bonds through chemical or physical treatments (Ali et al., 1995; Plavnik and Sklan, 1995). The possibilities for improvement in nutritive quality of DRP can be achieved by innovative technology, which must be cost effective in terms of animal productivity (Keith, 1996). Extrusion cooking is comparatively new technology in Pakistan. It enhances the nutritive value of feed ingredients by cooking (Ali et al., 1995). However, a very scant literature is available on the chemical treatment of feedstuffs particularly of rice polishing alone or its combination with extrusion cooking to eliminate the anti-nutritive factors and to utilize its full nutritional potentials for poultry feeding. If successful, its inclusion in poultry feeds can provide efficient and economical diets and spare huge quantities of cereal grains for human consumption. To avoid the effect of lipase and lipo-oxygenase, defatted rice polishing was preferred. In Pakistan it is also commercially available at a lower rate than full fat rice polishing.

The present study was therefore planned to determine the effect of chemical treatments and a combination of the chemical treatment with extrusion cooking to overcome the undesirable nutritional factors present in DRP. The treated DRP was nutritionally evaluated by chemical analysis and biologically evaluated by feeding male broiler chicks. The parameters of study were weight gain, feed efficiency ratio (FCR), protein efficiency ratio (PER), protein digestibility (PD), net protein utilisation (NPU) and biological value (BV).

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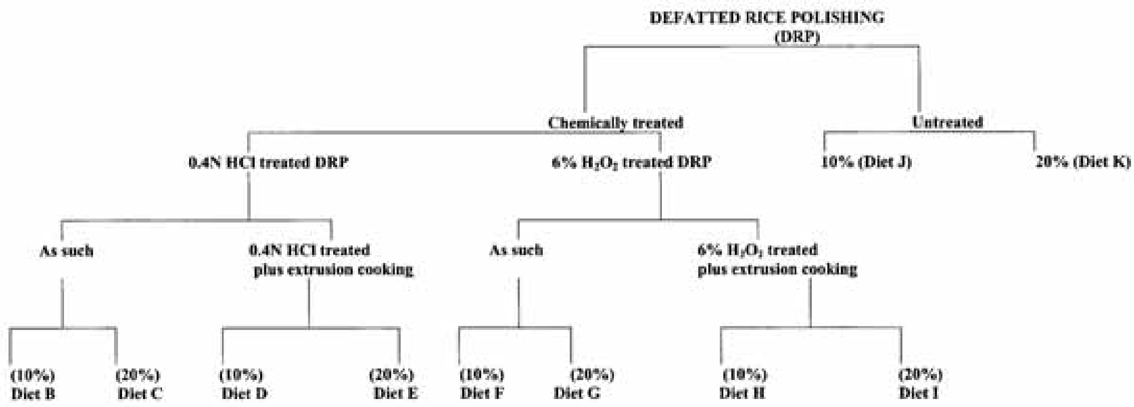

Figure 1. Treatment scheme of defatted rice polishing and related experimental diets. B to K: Experimental diets×Diets other than treatment scheme. Diet A = Commercial diet (control), Diet L = Protein free (-ve control).

MATERIALS AND METHODS

Procurement of defatted rice polishing

Defatted rice polishing (DRP) was procured from a local solvent extraction plant. Hydrochloric acid (0.4 N HCl) and Hydrogen peroxide (6% H_2O_2) treatment alone or in combination with extrusion treatment were done to defatted rice polishing according to the proceadure already described by Khalique et al. (2003). The treatments were done to hydrolyse or oxidize toxic factors or to break down the complex carbohydrate bonds with protein, minerals and carbohydrates and to make them biologically more available.

Treatments of defatted rice polishing

Fresh defatted rice polishing was divided into five equal portions of 31.5 kg each. One portion of the DRP was left untreated. The remaining of the four portions of DRP were then treated by thorough mixing with the selected solutions of 0.4 N HCl or 6% H_2O_2 by soaking at ratio of 1.5 L/kg DRP in such a way that there was no leaching of treated chemicals (Khalique et al., 2003). Thereafter, the two different chemically treated portions of DRP were passed through a locally fabricated extruder cooker maintained at 130°C for 10 seconds. After the treatments all four portions of DRP were sun dried by spreading 1-cm thick layer on a plastic sheet to less than 12 per cent moisture. Thus, the chemically treated DRP was used in broiler diets at rate of 10 and 20 per cent and compared with untreated DRP and a commercial control diet. The treatment scheme of DRP and their inclusion levels in various experimental diets is shown in Figure 1.

Chemical evaluation

The proximate analyses of differently treated rice polishing and feed ingredients used in diets were performed according to the methods of AOAC (1990). The trypsin inhibitor activity from untreated and differently treated DRP was determined by using trypsin substrate N-benzoyl-DL-arginine-p-nitro-anilide (BAPNA) as described by Liu and Markakis (1989). Trypsin inhibitor activity is expressed as unit per milligram. One trypsin inhibitor unit (TIU) is defined as an increase in absorbance of 0.01 at 410 nm. Similarly, Lectin activity was determined in samples as previously outlined by Tan et al. (1993). Lectin is measured in haemagglutinin units (HU). One HU is defined as the least amount of haemagglutinin that produces positive evidence of agglutination of 25 ml of a 3% suspension of washed, trypsinized erythrocytes of broiler chicken blood after 3-h incubation at room temperature.

Feeding

The experimental room, brooding batteries, drinkers and feeders were disinfected at the start of experiment. The temperature of the experimental room was maintained at 32°C during first week and then it was decreased by 3°C per week later on. Two hundred twenty (220), day-old Hubbard male broiler chicks were purchased from a local hatchery. These birds were reared in brooding batteries for 7 days and fed on a commercial diet for their adjustment. Out of 220 chicks, 108 of approximately similar weight were selected for biological trial. These chicks were randomly divided into 36 experimental units of 3 chicks each. Eleven iso-caloric and iso-nitrogenous experimental diets were formulated. These were designated as A (Commercial), B (10% HCl treated DRP), C (20% HCl treated DRP), D (10% HCl plus extruded DRP), E (20% HCl plus extruded DRP), F (10% H_2O_2 DRP), G (20% H_2O_2 DRP), H (10% H_2O_2 plus extrusion DRP), I (20% H_2O_2 plus extrusion DRP), J (10% untreated DRP) and K (20% untreated DRP). The twelfth diet was basal diet L (Protein free). This diet was to measure the endogenous nitrogen losses. Each experimental diet was randomly allotted to three experimental units. The ingredients compositions of experimental diets are given in Table 2.

Table 1. Chemical composition and anti-nutritive factors of differently treated defatted rice polishing on dry matter basis

Samples	Per cent						Anti-nutritional factors		
	DM	CP	CF	EE	Ash	NFE	Phytate (%)	Trypsin Inhibitor TIU[1]/mg	Hemagglutinin HU[2]/mg
Untreated DRP[3]	93.82±0.017[a,4]	14.48±0.027[a]	10.60±0.032[a]	0.9	12.46±0.032[b]	55.38±0.026[a]	3.503±0.015[a]	0.87±0.012[a]	18.21±0.133[a]
0.4 N HCl trt.[5] DRP	89.83±0.021[b]	14.51±0.026[a]	10.50±0.025[b]	-	12.50±0.015[b]	52.32±0.049[e]	0.113±0.016[d]	0.32±0.021[b]	3.160±0.057[b]
0.4 N HCl trt. and extruded DRP	89.91±0. 040[b]	14.44±0.023[a]	9.58±0.015[e]	-	12.59±0.026[a]	53.30±0.015[b]	0.000±0.000[e]	0.00±0.000[d]	1.107±0.056[c]
6% H_2O_2 trt. DRP	89.87±0.015[b]	14.47±0.012[a]	10.30±0.015[c]	-	12.42±0.029[b]	52.68±0.038[d]	1.437±0.032[b]	0.18±0.012[c]	1.110±0.070[c]
6% H_2O_2 trt. and extruded DRP	89.91± 0.007[b]	14.48±0.042[a]	9.98±0.020[d]	-	12.45±0.025[b]	53.00±0.103[c]	0.507±0.015[c]	0.00±0.000[d]	0.000±0.000[d]
Mean	90.67	14.48	10.19		12.48	53.33	1.11	0.27	4.72
SD[6]	1.63	0.046	0.39		0.071	1.11	1.34	0.33	7.06
SE[7]	0.42	0.012	0.10		0.018	0.29	0.35	0.086	1.82

[1] TIU = Trypsin inhibitor unit. [2] HU = Hemagglutinin unit. [3] DRP = Defatted rice polishing
[4] In this and succeeding tables, results with in a column with the same superscript are not significantly different (p>0.05).
[5] trt. = Treated. [6] SD = Standard deviation. [7] SE = Standard error.

Chick bio-assay

The experimental chicks were kept in metabolic cages equipped with automatic drinkers and feeders. The experimental diets were provided for 10 days (age 8-17 days). The feeds and water were provided *ad-libitum*. The excreta was collected from each metabolic cage after every 8 h through out the experimental period. It was mixed, homogenized, weighed and dried for nitrogen estimation. At the end of the experiment, all birds were killed replicate wise with chloroform in desiccators. To avoid protein losses, the killed birds were kept for few hours on laboratory shelf for their blood coagulation. To avoid fermentation, vertical surgical incisions from anus to beak were given to expose the internal organs of the birds and which were then immersed in a vat of liquid nitrogen (Daniel et al., 1999) for immediate freezing. This process facilitated easy grinding, mixing and drying. The finally ground chicks were dried in a forced air oven at 75-80°C. The dried and ground materials of carcasses were used for nitrogen estimation. The weight gain, feed consumed, feed efficiency ratio (FCR), protein efficiency ratio (PER), protein digestibility (PD), net protein utilization (NPU) and biological value (BV) of untreated or treated DRP were determined as prescribed by Pellet and Young (1980).

Statistical analysis

The data collected were tabulated and subjected to statistical analysis using Completely Randomized Design Orthogonal Contrast technique (Steel and Torrie, 1996; Muhammad, 2000). The significant means were compared by Duncan multiple range test (Duncan, 1955). The analysis was performed using Minitab 11-12 software (1996).

Results

The chemical composition and anti-nutritional factors are presented in Table 1. The moisture contents of DRPs were less than 11%. The CP, CF, EE, Ash, Phytate, Trypsin inhibitors and hemagglutinin were analysed on dry matter basis. The crude protein content of untreated and treated DRPs remained unchanged after their treatments and was non-significant to each other (Table 1). The chemical treatments decreased the fiber content of DRP. However, when these chemical treated DRPs were subjected to extrusion cooking, there was further decrease in crude fiber (Table 1). The chemical treatment of DRP with 0.4 N HCl and 6% H_2O_2 decreased CF by 0.94% and 2.83%, respectively. Whereas, CF values of DRPs treated with 0.4 N HCl plus extruded and 6% H_2O_2 plus extruded were decreased by 9.62% and 5.85%, respectively. The statistical analysis revealed significant difference among differently treated samples of DRP. The ash contents of all the treated DRPs remained unchanged except of treatment C. In which the ash contents increased by 0.09% and was statistically different from other treatments. The NFE values declined with the treatments. The analysis revealed that untreated DRP contained higher concentration of phytate, 3.50%, 0.87 TIU/mg trypsin inhibitor and 18.21 HU/mg of hemagglutinin. The different treatments did either decline or completely eradicated these anti-nutritive factors from DRP. The phytate, trypsin inhibitor and hemagglutinin present in DRP was reduced to 0.113%, 0.32 TIU/mg and 3.16 HU/mg, respectively after its treatment with 0.4 N HCl. The phytate and trypsin inhibitor present in DRP was reduced to zero (could not be detected), when it was treated with 0.4 N HCl plus extrusion cooking, however, hemagglutinin was reduced to 1.1 HU/mg. Similarly, 6% H_2O_2 treatment reduced the phytate, trypsin inhibitors and hemagglutinin to 1.437%, 0.18 TIU/mg and 1.11 HU/mg, respectively. However, when 6% H_2O_2 treated DRP was subjected to extrusion cooking, the phytate value was reduced to 0.507% whereas, trypsin inhibitors and hemagglutinin activity were completely eradicated.

The results of weight gains, feed consumption, feed conversion ratio, protein consumption, protein efficiency ratio, protein digestibility, net protein utilisation and biological value are given in Table 3. Maximum average weight gain (282±0.330) was observed in birds fed on diet G containing 20% DRP treated with 6% H_2O_2. The next in

Table 2. Composition of experimental diets with 10% and 20% levels of raw and differently treated rice polishings[1]

Ingredients	Experimental diets											
	A	B	C	D	E	F	G	H	I	J	K	L
Starch	-	-	-	-	-	-	-	-	-	-	-	80.5
Grounded wheat straw	-	-	-	-	-	-	-	-	-	-	-	11
Corn	48	44	47.4	48	45.99	48	47.62	48	47.11	44	47.79	-
Rice tips	9.64	14	3.44	8.45	10	8.91	10	9.94	10	14	3.49	-
Defatted rice polishing	9	10	20	10	20	10	20	10	20	10	20	-
Canola meal	10	10	8.85	10	4.52	10	3.45	10	2.91	10	8.44	-
Soybean meal	8.02	6	6	6	6	6	6	6	6	6	6	-
Fish meal	4	4.66	4	3.71	4	2.72	4	3.5	4	4.66	4	-
Corn gluten 60%	4	3.67	4	4	4	4	4	4	4	4	4	-
Cotton seed meal	4	4	3	4	2.36	4	1.93	4	2.81	4	3	-
Soybean oil	-	-	-	-	-	-	-	-	-	-	-	3
$CaCO_3$ (Chips)	1.65	1.65	1058	1.56	1.67	1.66	1.76	1.6	1.74	1.65	1.62	1.5
DCP	0.39	0.29	0.46	0.57	0.21	0.52	-	-	0.09	0.32	0.38	3
Lysine	0.25	0.33	0.21	0.31	0.21	0.33	0.21	0.3	0.24	0.32	0.23	-
Methionine	0.05	0.06	0.05	0.06	0.03	0.06	0.03	0.07	0.04	0.05	0.04	-
Premix[1]	1	1	1	1	1	1	1	1	1	1	1	1
Total	100	100	100	100	100	100	100	100	100	100	100	100
Calculated chemical composition of experimental diets												
ME (kcal/kg)	2,800	2,800	2,800	2,800	2,800	2,800	2,800	2,800	2,800	2,800	2,800	2,800
CP (%)	20	20	20	20	20	20	20	20	20	20	20	3.93
Crude fiber (%)	4.12	4.14	4.61	4.41	4.8	4.62	4.88	4.35	4.9	4.1	4.62	4.44
Ca (%)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.26
Available P	0.45	0.45	0.45	0.45	0.45	0.45	0.49	0.45	0.45	0.45	0.45	0.5
Lysine	1.1	1.16	1.16	1.1	1.1	1.1	1.1	1.1	1.1	1.136	1.136	-
Methionine	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	-
Na	0.047	0.058	0.059	0.43	0.05	0.039	0.055	0.045	0.057	0.54	0.055	-
K	0.041	0.40	0.39	0.386	0.33	0.492	0.54	0.397	0.36	0.385	0.357	-
Linoleic acid	1.29	1.2	2.99	1.2	2.47	1.35	2.6	1.63	3.6	1.22	3.057	-

A = Commercial diet
B = 10% DRP treated with 0.4 N HCl
C = 20% DRP treated with 0.4 N HCl
D = 10% DRP treated with 0.4 N HCl plus extruded
E = 20% DRP treated with 0.4 N HCl plus extruded
F = 10% DRP treated with 6% H_2O_2
G = 20% DRP treated with 6% H_2O_2
H = 10% DRP treated with 6% H_2O_2 plus extruded
I = 20% DRP treated with 6% H_2O_2 plus extruded
J = 10% Untreated DRP
K = 20% Untreated DRP
L = Protein free diet

[1] Supplied per kilogram of diet: Vitamin A, 1,500 IU; Vit. D_3 200 ICU; Vit. E 10 IU; Vit. K 0.5 mg; Vit. B_1 1.8 mg; Vit B_2 3.6 mg. Vit. B_6 5.5 mg; Vit. B_{12} 0.01 mg; Biotin 0.15 mg; Choline 1,300 mg; Folic acid 0.55 mg; Pentothenic acid 10 mg; Niacin 35 mg. Iron 0.002%; iodine 6.6×10^{-5} %; zinc 9×10^{-4} %.

order was the average weight gain (237±1.155) of birds fed on diet I containing 20% DRP treated with 6% H_2O_2 plus extrusion cooking. The birds fed on these diets showed significantly better ($p<0.05$) weight gain than the weight gains of birds fed on commercial diet A (control). The birds fed on diets having HCl treated or HCl treated plus extruded DRP (10% or 20%) except group D showed statistically lower weight gains with the weight gain of birds fed on control diet A ($p>0.05$). However, all the diets containing treated DRP were better ($p<0.05$) than diet containing 20 per cent untreated DRP in term of weight gains.

The maximum feed consumption was observed in birds fed on diet G containing 20% DRP treated with 6% H_2O_2. The next better feed consumption was observed in diet F containing 10% DRP treated with 6% H_2O_2. These two diets were statistically non-significant to each other. The diets B, D and J containing 10 percent untreated and HCl treated DRP showed similar feed consumption (362-365 g) and were statistically non-significant ($p>0.05$). However, these feed consumptions were statistically higher than the commercial diet A (control). The birds fed on diets E and I containing 20% 0.4 N HCl and 6% H_2O_2 treated plus extruder cooking DRPs showed statistically lower feed consumption as compared to control diet. It is evident that chemical treatment combined by extruder cooking reduced the feed consumption of broiler chicks (Table 3).

The birds fed on diet G showed the best feed conversion ratio (1.37), which is significantly higher ($p<0.05$) than all other diets offered to broiler chicks. The birds fed on diets C, E and I, all contained 20% chemically treated or chemical plus extruded DRP showed statistically better FCR (1.43 - 1.46) than birds fed on control diet A. The feed conversion ratio of rest of the groups ranged from 1.54 to

Table 3. Comparison of means with standard errors of weight gain, feed consumed, feed conversion ratio, protein consumption, protein efficiency ratio, protein digestibility (%), net protein utilization (%) and biological value (%) of birds fed on different experimental diets

Diets	Wt. gain g/chick	Feed consumed g/chick	FCR (g/g)	Protein consumption (g/chick)	PER	PD (%)	NPU (%)	BV (%)
A	230.67±0.882[c, 1]	351.67±0.333[d]	1.52±0.006[d]	70.89±0.042[e]	3.25± 0.012[d]	89.19±0.131[e]	52.01±0.131[d]	58.31±0.108[cd]
B	219.33±0.330[g]	364.00±0.577[c]	1.66±0.003[i]	73.43±0.123[c]	2.99±0.007[i]	89.64±0.640[de]	51.85±0.251[de]	57.85±0.465[cde]
C	228.00±1.00[de]	326.67±0.667[h]	1.43±0.007[b]	66.45±0.115[h]	3.43±0.015[b]	95.06±0.137[a]	55.11±0.185[b]	57.97±0.176[cde]
D	229.67±0.667[cd]	364.67±1.453[c]	1.58±0.009[f]	73.10±0.292[cd]	3.14±0.013[f]	87.74±0.508[f]	51.01±0.497[e]	58.13±0.307[cde]
E	227.00±0.000[e]	331.67±0.882[g]	1.46±0.006[c]	66.98±0.187[h]	3.39±0.012[c]	91.78±0.287[c]	52.97±0.171[c]	57.71±0.150[de]
F	226.67±1.202[e]	370.00±1.732[b]	1.63±0.006[h]	75.12±0.396[b]	3.01±0.015[hi]	90.40±0.295[d]	53.52±0.333[c]	59.33±0.425[b]
G	282.33±0.330[a]	387.00±0.577[a]	1.37±0.003[a]	77.58±0.090[a]	3.64±0.006[a]	93.50±0.075[b]	59.48±0.087[a]	63.62±0.272[a]
H	223.33±0.882[f]	344.33±1.856[e]	1.54±0.006[e]	69.77±0.369[f]	3.20±0.009[e]	87.37±0.147[f]	49.95±0.195[f]	57.17±0.127[e]
I	237.00±1.155[b]	339.67±0.333[f]	1.44±0.006[b]	68.43±0.000[g]	3.46±0.017[b]	92.66±0.170[bc]	53.48±0.111[c]	57.72±0.072[de]
J	221.67±0.882[fg]	362.00±1.000[c]	1.63±0.009[h]	72.58±0.233[d]	3.05±0.015[gh]	88.08±0.283[f]	51.81±0.433[de]	58.82±0.665[bc]
K	201.67±0.882[h]	324.67±0.882[h]	1.61±0.006[g]	65.75±0.164[i]	3.06±0.012[g]	85.67±0.292[g]	45.91±0.377[g]	53.58±0.303[f]
L	130.77±0.480	256.67±5.39	-	6.42±0.020	-	-	-	-

[1] In this table results within a column with the same superscript are not significantly different (p>0.05).

1.65, which was higher than the value of control diet.

The protein consumption by chicks fed on experimental diets ranged from 65 to 78 g per bird during ten days of experiment. Maximum (77.58 g) and significantly higher ($p<0.05$) protein consumption was noted in birds fed on diet G containing 20% DRP treated with 6% H_2O_2. The second best group was of chicks fed on diets B, D, F and J. These diets contained 10% untreated or treated DRP and their protein consumption per chick were in the range of 70 to 75 g. Similarly, the third group was of chicks fed on diets C, E, H, I and K. Their protein consumption was less than 70 g/chick during ten days of experimental period. The diet H contained 10% DRP treated with 6% H_2O_2 plus extrusion whereas, other diets containing untreated or treated 20% DRP. The chemical treatment showed significantly better ($p<0.05$) protein consumption than untreated DRP. Similarly, better protein consumption was observed in the birds fed on diets having only chemically treated DRP than diets containing DRP treated chemically followed by extrusion cooking.

Protein efficiency ratio (PER) is the weight gain per unit of protein consumed. The maximum PER (3.64) was observed in diet G containing 20% DRP treated with 6% H_2O_2 (Table 3). The experimental diets C, E and I, containing 20% DRP treated with 0.4 N HCl, 0.4 N HCl plus extrusion and 6% H_2O_2 plus extrusion cooking showed significantly better ($p<0.05$) PER, respectively than the control diet A. The PER of the diets B, D, F, H, J (10% untreated or treated DRP) and K (20% untreated DRP) were significantly less than control diet A.

Protein digestibility (PD) of diet C (20% 0.4 N HCl treated) was maximum (95.06%±0.137) and statistically significant ($p<0.05$) than all other diets (Table 3). The diets E, G and I containing 20% DRP treated with 0.4 N HCl plus extruded, 6% H_2O_2 and 6% H_2O_2 plus extruded, respectively showed significantly better ($p<0.05$) PD than diet A. Similarly, diets B and F containing 10% treated with 0.4 N HCl and 6% H_2O_2 respectively, also showed better significance than control diet A. The PD of these diets was in the range of 89-95%. The PD of diets D, H, J and K were below 89% and were significantly less than control diet A (Table 3).

The maximum net protein utilization (NPU) value (59.48%±0.087) was again observed in birds fed on diet G. The other diets C, E and I (20% treated DRP) and diet F (10% H_2O_2 treated DRP) showed NPU in the range of 52-55% and significantly better ($p<0.05$) than control diet A (Table 3). The NPU values of diets B, D and J were statistically comparable to diet A. However, NPU values of diets H and K were significantly less than control diet A and were 49.95% and 45.91%, respectively (Table 3). Maximum biological value (BV) was observed in birds fed on diet G containing 20% DRP treated with 6% H_2O_2 (63.62±0.27). The next in order was the BV of birds fed on diet F and J containing 10% DRP, treated with 6% H_2O_2 and untreated DRP, respectively. These diets showed significantly better BV values ($p<0.05$) than the control diet A. The diets B, C and D showed comparable BV in a narrow range of 57.5-58.30% and were statistically non-significant with the control diet A. The BV values of diets E, H and K were statistically less than control diet A (Table 3).

Summarizing up the results, the chicks fed on treated diets, containing 20% DRP, showed better performances in term of weight gain, feed consumption, FCR, PER, PD, NPU and BV than diets containing 10% DRP. However, diet containing 20% DRP treated with 6% H_2O_2 gave maximum performance. Similarly the results of chemically treated diets were better than chemical treatment plus extrusion; particularly in case of diet having 6% H_2O_2 treated DRP.

DISCUSSION

The results indicated that analysed nutrient composition of untreated DRP are in line with Saunders (1990), who reported that nutrient composition range of defatted rice polishing was; moisture 6-9%, CP 15-20%, fat 0.5-1.5%, CF 10-15% and ash 9-12%. The treatments altered the nutrient composition of DRP. The crude fiber declined after treatments. The moisture contents of DRPs were increased after different treatments under wet conditions. It was due to high water absorption capacity of DRP.

The diet K containing higher (the highest used in the study) level of untreated DRP (20%) significantly depressed the growth and caused poor feed utilization. Ahmad (1991), Takemasa and Hijikuro (1991) and Majid (1997) also reported that the body weight gain, feed intake and feed conversion efficiency of chicks fed differently treated DRP was significantly higher than those chicks that were fed untreated DRP. The treatments of DRP improved their nutritive value. When these treated DRPs were incorporated at rate of 20% in the poultry diets, the chicks growth were better than even the commercial diet A (control). However, maximum weight gain and FCR were observed in diet G containing 20% DRP treated with 6% H_2O_2. The present study also revealed that chemical treatment or chemical treatment followed by extrusion either declined or completely eradicated the anti-nutritional factors from DRP. However, treatment followed by extrusion cooking did not increase the nutritive value further. In fact, the nutritive value was decreased when compared with non-extrusion cooking but treated with either HCl or H_2O_2. The results are in agreement with the work of Kratzer et al. (1974), who found that DRP treatment with 1% acetic acid or steam denatured the toxic proteins and improved the growth and FCR of chicks.

The results indicated that the birds fed on diets, which showed better growth and feed efficiency also showed better protein efficiency ratio (PER), protein digestibility (PD), net protein utilization (NPU) and biological values (BV). Khalique et al. (2004) reported better availability of amino acids of rice polishing after treating it with 0.4 N HCl or 6% H_2O_2 alone or in combination with extrusion cooking. Zombade et al. (1980) correlated weight gain with the nitrogen retention efficiency. Ledesma et al. (1990) also found that protein concentrate from rice bran had better protein digestibility and net protein utilization as compared to other cereal proteins. The results indicated lowest PER, PD, NPU and BV in birds fed on diet having 20% untreated DRP. It might be due to the presence of anti-nutritive factors and high fiber content consisting of complex carbohydrates present in untreated DRP that probably caused an increase in the gut evacuation rate. Juliano (1972) reported the presences of anti-nutritive factors in the rice polishing are mostly proteins in nature and thus heat labile, except for phytin. Similarly, Annison et al. (1995) found that rice polishing is usually low in nutritive quality because it is a rich source of NSP i.e. arabinoxylans and xylose. All the treatments did improve quality of DRP but maximum effects of these treatments were shown at 20% inclusion level in broiler diet. The results of this study indicated that treatments not only reduced the crude fiber content but also either reduced or eliminated the anti-nutritive factors from DRP. The treatment might have reshaped the structure of the anti-nutritive compounds such as phytates, lectins, trypsin inhibitors etc. rendering them non-toxic. Tsai (1976); Hashmi et al. (1989); Dar (1990); Ali et al. (1995) and Plavnik and Sklan (1995) obtained similar results, when they subjected the DRP to various chemical or physical treatments.

The processing of DRP resulted into hydrolysis of protein; the amino acids which were bound to toxins form became available to birds and ultimately PER and BV were improved. This effect could be more pronounced and working in groups treated with HCl. As we are familiar with the fact that HCl is used for breaking the peptide bonds in protein hydrolysis for amino acid measurements also HCl is produced endogenously for digestion in all the animals. This means that pH of the diet will have a far reaching effect on the diets digestion. A fact that is already known to the nutritionists. Santos et al. (1983) and Wiryawan and Dingle (1999) also observed that processing was necessary for improving the PER. They assigned this improvement to the denaturing of growth inhibitor factors in such protein sources. However, Varela and Escriva (1977) and Saunders et al. (1982) reported that steam treatment alone could not improve digestibility, NPU, and BV of DRP.

The results indicated that DRP treatment with 0.4 N HCl or 6% H_2O_2 alone or in combination with extrusion cooking reduced the crude fiber contents of DRP. The decrease in NDF and hemicellulose contents of H_2O_2 treated straw was reported by Mishra et al. (2004). This might be due to the action of HCl or H_2O_2 on the non-starchy carbohydrates i.e. arabinoxylan and xylose present in the DRP. These sugars rapidly developed a gel like network as a result of the re-establishment of cross-links (Geissmann and Neukom, 1973a, b). The formation of gel coincides with the disappearance of feruloyl groups and fully cross-linked arabinoxylans hold up to 100 g of water per g polymer (Izydorczyk et al., 1990). The non-covalent interaction changes the properties of arabinoxylans and hence increases its solubility properties and eliminates anti-nutritive activities of NSP. The breakdown of bonds between nutrients such as proteins, carbohydrates and minerals made them more available biologically. These results are also in agreement with work of Jeswani (1996) and Purushothaman et al. (1989), who reported that acid treatment (HCl) of DRP reduced CF contents more than

24.49% and increased available carbohydrates about 30%.

CONCLUSIONS

It can be concluded from the results of the present experiment that up to 20% DRP can be incorporated into broiler feed provided it is treated with 6% H_2O_2 or 0.4 N HCl. The protein consumption, PER, NPU and BV of these feeds was better than the control. This can be attributed to the oxidation or hydrolysis of different compounds in DRP. These compounds might have changed or re-arranged their chemical geometry, which made it more digestible and assimilative for broiler chicks.

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