Amino Acid Digestibility of Chemically Treated and Extruder Cooked Defatted Rice Polishing

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ABSTRACT

Rice polishing is a by-product of rice milling. It is a good source of energy and an assortment of amino acids. The anti-nutritive factors associated with rice polishing reduce the availability of amino acids and other nutrients to poultry. Defatted rice polishing (DRP) was chemically treated with 0.4N HCl and 6% H_2O_2 solutions by soaking in ratio of 1:1.5. After the chemical treatments, one portion of each was further cooked with an extruder cooker maintained at 130°C for 10 seconds. The amino acid digestibility trial of untreated and treated DRP was done using precision fed cockerel assay. Thirty White Leghorn cockerels of 24 weeks of age, having uniform weight, were selected for the experiment and divided into five groups of six cockerels each. Three birds in each group were force-fed treated DRPs @ 25g per bird through crop intubation with the help of a funnel and plunger passed via the oesophagus. The other three were kept without feed throughout the experimental period to measure the endogenous amino acids excreted in the faeces. The excreta voided during 24 hours following force-feeding was collected at 12-hour intervals. The excreta of different groups were weighed, oven-dried and used for amino acid analysis. The results indicated that chemical or chemical plus extrusion cooking decreased the total amino acids present in DRP. The content of several amino acids were reduced as a result of chemical treatment. Further reduction of the amino acid content was observed when the chemically treated DRP were subjected to extrusion cooking. However, the acid (0.4N HCl), acid plus extrusion cooking and 6% H_2O_2 treatments improved the amino acid digestibility. On the other hand, treating DRP with 6% H_2O_2 plus extrusion cooking reduced the amino acids digestibility.

INTRODUCTION

Rice is one of the most important cereal crops in Pakistan, ranking third in importance. In the year 1999-2000, its production was 5156 thousand tonnes (Finance Division, 2000). Rice polishing is a by-product of rice milling and is the cheapest source of energy and protein for poultry feeding. It has great potential as an ingredient in poultry feed because it is a good source of protein, energy, vitamins and minerals (Saunders, 1990). It contains 16-18% protein and a better assortment of

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amino acids, particularly lysine and methionine, compared to other cereal grains, e.g. corn, wheat and rice. It also contains good quality oil. Upon milling, the oil is exposed to lipase enzymes in the rice polishing, causing its rapid breakdown to free fatty acid contents (Desikachar, 1974). This hydrolytic and oxidative rancidity process results in severe nutritive losses and development of toxic substances like peroxides. These toxic substances cause economic losses when fed to poultry. To avoid the rancidity problem, oil is extracted with solvents for human consumption or for industrial uses.

A considerable portion of defatted rice polishing is included in poultry and livestock feed formulation. However, the presence of anti-nutritive factors like crude fibre, phytic acid, anti-trypsin and hemagglutinin in rice polishing reduce the availability of amino acids and other nutrients to poultry birds (Saunders, 1986). A few research workers have reported that chemical or physical treatments improved the availability of nutrients, particularly protein and amino acids, from rice polishing (Varela & Escriva, 1974; Ohtsubo & Yanase, 1985; Majid, 1997). The present study was, therefore initiated to determine the effect of chemical treatment alone and/or in combination with extrusion cooking on the digestibility and total availability of amino acids from the defatted rice polishing.

MATERIALS AND METHODS

Rice treatment methods

Full fat rice polishing was procured from a local rice milling factory soon after shelling of Basmati-385 variety of rice. The removal of oil from this rice polishing was done by solvent (hexane) extraction within three hours. The solutions of 0.4N hydrochloric acid (HCl) and 6% hydrogen peroxide (H_2O_2) were prepared by diluting 1N HCl and 35% (w/w) H_2O_2 solutions (Khalique *et al.*, 2003). The defatted rice polishing (DRP) was divided into five equal parts of one kg each. One part was kept untreated and used as control. Two parts of DRP were treated with a solution of HCl (0.4N) and the remaining two parts were treated with H_2O_2 (6%) by soaking in ratio of 1:1.5. All the differently treated DRP were left for four hours to equilibrate the DRP with the chemical solutions. The different chemically-treated DRP were sun-dried (for 48 hours) by spreading approximately a 1-cm thick layer on a plastic sheet to less than 12% moisture. The extrusion cooking of one part from each chemically treated defatted rice polishing was done by passing the treated rice polishing at 130ºC for 10 seconds through a locally fabricated extruder cooker maintained at 20% moisture. The extruded DRP samples were again sun-dried, weighed, and kept in specialised feed drying ovens (Koster tester®) at 70ºC to determine its moisture content. Each representative sample of differently treated DRP was then homogenised and a 25 g sample of each was kept in a polythene bag for determination of amino acids digestibility by force-feeding trial.

Nutritional evaluation

One hundred, day-old male, White Leghorn chicks (Nick Chick) were procured as stock birds. They were reared under standard feeding and management conditions up to maturity (North, 1984). At the age of 24 weeks, 30 cockerels approximately of the same weight (2.0-2.25 kg) and of good physique were selected for experimentation. The amino acid digestibility trial of untreated and treated DRP was done using the precision fed cockerel procedure (Sibbald, 1986). The birds were kept in individual metabolic cages (116.13 cm × 77.42 cm × 77.42 cm) in a specially built metabolic chamber. Cages

with raised wire floors were supplied with built-in waterers and feeders. The cages were kept at environmentally regulated temperatures (22- 24ºC) and humidity levels (50-60%) with 16 hours of light daily. Feed and water was provided *ad-libitum* for a period of ten days as an adjustment period. Following 24 hours of fasting, each bird was given 25g of fine ground samples of untreated and differently treated DRP using crop intubation with a funnel and plunger passed via the oesophagus. Six sets of the funnels and plungers were specially prepared by joining a steel tube measuring 40 cm × 1.2 cm with a 10 cm long steel funnel that had a diameter of 12 cm, attached by a flexible rubber tube. A steel rod measuring 50 × 1.1 cm was used as a plunger.

Three birds in each treatment were fed differently treated defatted rice polishing. The other three birds were kept without feed throughout the experimental period to measure the endogenous amino acids excreted in the faeces. The data obtained were used to correct the excreta outputs of all birds for assay of differently treated DRP. During the experimental period, the birds were crop intubated with 50 ml of an aqueous glucose solution (500g/kg) in two doses approximately 8 and 32 hours after feed withdrawal (McNab & Blair, 1988). All the birds were also given 50-ml water through a funnel in the crop at 24-hour intervals during assay period.

A plastic tray lined with aluminum foil was placed under each cage and the excreta were collected separately for each cockerel for 24 hours. The excreta voided during the 24 hours following force-feeding were collected at 12-hour intervals. Droppings retained on the wire screen floor of the cage were also collected. Efforts were made to remove every bit of feathers from the droppings to avoid contamination. The excreta from various groups were weighed and oven-dried at 100ºC for two hours initially to prevent fermentation, and then at 60ºC to avoid nitrogen loss until it was completely dried. The dried excreta of different groups were ground to 60-mesh size and stored for analysis.

Amino acid analysis

All the samples of differently treated defatted rice polishing and the faeces voided by the experimental cockerels were subjected to determination of amino acid composition using an automatic amino acid analyser (Hitachi L-8500; Hitachi Ind., Tokyo, Japan) according to the method of Spackman, Stein and Moore (1958). The samples were hydrolysed with 6N HCl under vacuum at 110ºC for 24 hours. The hydrolysates were dried in a rotary evaporator at 40ºC under vacuum to remove the excess acid (6N HCl). The dry residues were then dissolved in a known quantity of 2.2 citrate pH buffer and filtered to obtain a clean solution of the hydrolysate. An aliquot of it was injected into the column of the analyser. The amino acids were eluted using sodium citrate buffers of different pH and detected by a ninhydrin colour reaction at 570 nm for all amino acids.

The amino acid digestibilities of differently treated DRP were calculated as the difference between the amino acids consumed and excreted by the birds. The correction of the latter for metabolic and endogenous amino acids excretion was also made.

Amino acid Digestibility

$$= \frac{IAA - (Ex\ AA - En\ AA)}{IAA}$$

Where:

AA   = Amino acids

IAA   = Ingested amino acids

Ex AA = Excreted amino acids

En AA = Endogenous amino acids

The amino acid availability was determined by:

AA availability

= Digestibility (%) X Determined AA value in the sample

Statistical analysis

The data collected were subjected to analysis of variance using Completely Randomised Design (Steel & Torrie, 1996; Muhammad, 2000) and the comparisons of means were done according to Multiple Range Test (Duncan, 1955). The analysis was performed using the SPSS software (SPSS, 1993).

RESULTS AND DISCUSSION

The results of the amino acid analysis, digestibility, and availability to poultry are given in Tables 1-4.

Amino acid content of differently treated defatted rice polishing

The amino acid composition of the untreated DRP sample, determined in the present study, compared well with findings of Warren & Farrell (1990). The small variations observed may be due to varietal differences, as well as climatic and soil effects. The results of the present study indicated that chemical treatment of DRP with or without further treatment with extrusion cooking decreased the total amino acids present in the DRP. The contents of some of the amino acids in the DRP were also significantly affected (Tables 1 & 2).

The 0.4 NHCl treatment reduced significantly the content of several amino acids present in the protein of the DRP, for example methionine, tryptophan, arginine, leucine, histidine, alanine, aspartic acid and glutamic acid (Table 1). Further treatment of the acid-treated samples with extrusion cooking further reduced the content of some of the amino acids, for example lysine, isoleucine, leucine, histidine and glutamic acid.

The content of some amino acids were also significantly reduced as a result of 6%

H_2O_2 treatment. These include arginine, isoleucine, leucine, histidine, glycine, praline, alanine, aspartic acid, and glutamic acid. On the other hand, the content of lysine and phenylalanine increased significantly after the peroxide treatment. Subsequent treatment of the DRP with extrusion cooking resulted in further losses in the content of almost all the amino acids present in DRP protein, except lysine. The content of lysine remained higher than the untreated DRP after subsequent extrusion cooking. After extrusion cooking, phenylalanine content, which increased significantly after the peroxide treatment, dropped to a level lower than that of the untreated DRP (Table 1).

The protein content of DRP treated with either 0.4N HCl or 6% H_2O_2 followed by extrusion, was not affected (Table 2). Most of the essential amino acids were increased by treatment of DRP with 6% H_2O_2 especially lysine and phenylalanine, which are the essential and important amino acid for poultry. Methionine contents of both the treatments i.e. HCl and H_2O_2 plus extrusion groups were reduced by 15 and 18 per cent, respectively. Lysine contents of 6% H_2O_2 and 6% H_2O_2 plus extruder cooked increased by 21.31 and 16.39 per cent, respectively. The tryptophan decreased by 20 per cent by treatments with dilute HCl or HCl plus extrusion cooking or 6% H_2O_2. The contents of arginine, leucine, aspartic acid and glutamic acid were lowered relative to protein after treatments.

The theronine, valine, and serine contents remained statistically unchanged after treatments, except samples that had undergone 6% H_2O_2 plus extruder cooking, which reduced the amino acid values (Table 2). The diluted HCl or HCl plus extrusion cooking did affect the amino acid contents. The amino acid degradation via the Strecker reaction takes place especially at high temperatures, but in this study less amino acid degradation

Table 1. Amino acid contents (g/100g) of untreated and treated defatted rice polishing (DRP)

Amino acids	Treatment methods					Statistical analysis			
	Untreated	0.4N HCl	0.4N HCl plus Extrusion	6% H_2O_2	6% H_2O_2 plus Extrusion	N^1	Mean	SEM^2	$C.O.V.^3$
Methionine	0.34 ± 0.006 a	0.29 ± 0.010 b	0.30 ± 0.013 b	0.33 ± 0.006 a	0.28 ± 0.009 b	3	0.308	1.158	8.44
Cystine	0.35 ± 0.009 a	0.36 ± 0.020 a	0.37 ± 0.012 a	0.36 ± 0.000 a	0.35 ± 0.058 a	3	0.358	0.0037	2.35
Met + Cyst	0.69 ± 0.012 a	0.65 ± 0.026 a	0.67 ± 0.023 a	0.69 ± 0.006 a	0.63 ± 0.003 a	3	0.664	0.0117	3.92
Lysine	0.61 ± 0.009 c	0.62 ± 0.007 c	0.59 ± 0.010 d	0.74 ± 0.003 a	0.71 ± 0.007 b	3	0.652	0.0289	9.91
Threonine	0.66 ± 0.000 a	0.65 ± 0.010 a	0.65 ± 0.012 a	0.65 ± 0.000 a	0.59 ± 0.003 b	3	0.640	0.0127	4.42
Tryptophan	0.20 ± 0.003 a	0.16 ± 0.006 b	0.16 ± 0.007 b	0.19 ± 0.003 a	0.16 ± 0.003 b	3	0.174	0.0087	11.21
Arginine	1.14 ± 0.013 a	1.04 ± 0.015 b	1.01 ± 0.003 b	0.90 ± 0.006 c	0.78 ± 0.025 d	3	0.974	0.0618	14.18
Isoleucine	0.60 ± 0.006 a	0.60 ± 0.000 a	0.57 ± 0.003 b	0.57 ± 0.003 b	0.52 ± 0.007 c	3	0.572	0.0146	5.72
Leucine	1.15 ± 0.012 a	1.13 ± 0.009 b	1.10 ± 0.006 c	1.02 ± 0.003 d	0.88 ± 0.000 e	3	1.056 0	.0493	10.43
Valine	0.90 ± 0.032 a	0.91 ± 0.003 a	0.89 ± 0.030 a	0.85 ± 0.006 a	0.75 ± 0.003 b	3	0.860	0.0293	7.63
Histidine	0.43 ± 0.003 a	0.41 ± 0.003 b	0.40 ± 0.000 bc	0.39 ± 0.008 c	0.37 ± 0.007 d	3	0.400	0.0100	5.60
Phenylalanine	0.63 ± 0.006 b	0.64 ± 0.006 b	0.62 ± 0.020 b	0.69 ± 0.012 a	0.59 ± 0.003 c	3	0.634	0.0163	5.76
Glycine	0.93 ± 0.000 a	0.92 ± 0.003 a	0.91 ± 0.003 b	0.89 ± 0.000 c	0.85 ± 0.003 d	3	0.900	0.0141	3.51
Serine	0.76 ± 0.009 a	0.75 ± 0.006 a	0.75 ± 0.006 a	0.74 ± 0.003 a	0.66 ± 0.007 b	3	0.732	0.0183	5.59
Proline	0.65 ± 0.003 a	0.64 ± 0.007 a	0.62 ± 0.007 a	0.57 ± 0.009 b	0.55 ± 0.009 c	3	0.606	0.0197	7.24
Alanine	1.04 ± 0.010 a	1.00 ± 0.006 b	0.99 ± 0.003 b	0.99 ± 0.003 b	0.85 ± 0.003 c	3	0.974	0.0323	7.42
Aspartic acid	1.50 ± 0.012 a	1.40 ± 0.006 b	1.39 ± 0.010 b	1.39 ± 0.003 b	1.34 ± 0.024 c	3	1.400	0.0262	4.19
Glutamic acid	2.26 ± 0.019 a	2.12 ± 0.015 b	2.08 ± 0.024 bc	2.05 ± 0.003 b	1.97 ± 0.015 d	3	2.100	0.0478	5.10
Total amino acids	14.15	13.64	13.40	13.32	12.20				

1 N - No of replicates
2 SEM - Standard error of the means
3 C.O.V - Coefficient of variation

Table 2. Amino acid analysis relative to protein (%) of differently treated samples of defatted rice polishing (DRP)

Amino acids	Treatment methods					Statistical analysis			
	Untreated	0.4N HCl	0.4N HCl plus Extrusion	6% H_2O_2	6% H_2O_2 plus Extrusion	N[1]	Mean	SEM[2]	C.O.V.[3]
Crude protein	14.48 ± 0.027 a	14.51 ± 0.026 a	14.44 ± 0.023 a	14.47 ± 0.012 a	14.48 ± 0.042 a	3	14.48	0.012	0.311
Methionine	2.35 ± 0.044 a	2.00 ± 0.070 b	2.06 ± 0.093 b	2.28 ± 0.040 a	1.96 ± 0.061 b	3	2.13	0.049	8.92
Cystine	2.39 ± 0.055 a	2.48 ± 0.143 a	2.54 ± 0.087 a	2.49 ± 0.003 a	2.42 ± 0.041 a	3	2.46	0.034	5.32
Met + Cyst	4.74 ± 0.081 a	4.48 ± 0.188 a	4.60 ± 0.166 a	4.77 ± 0.041 a	4.38 ± 0.020 a	3	4.59	0.060	5.10
Lysine	4.24 ± 0.058 c	4.25 ± 0.055 c	4.09 ± 0.074 c	5.14 ± 0.027 a	4.88 ± 0.060 b	3	4.52	0.112	9.62
Threonine	4.55 ± 0.009 a	4.48 ± 0.060 a	4.50 ± 0.087 a	4.49 ± 0.003 a	4.10 ± 0.017 b	3	4.43	0.048	4.15
Tryptophan	1.36 ± 0.020 a	1.10 ± 0.038 b	1.09 ± 0.047 b	1.33 ± 0.023 a	1.13 ± 0.027 b	3	1.20	0.034	11.00
Arginine	7.89 ± 0.089 a	7.17 ± 0.093 b	7.01 ± 0.017 b	6.22 ± 0.038 c	5.39 ± 0.182 d	3	6.73	0.233	13.39
Isoleucine	4.14 ± 0.044 a	4.14 ± 0.009 a	3.96 ± 0.020 b	3.96 ± 0.025 b	3.62 ± 0.054 c	3	3.96	0.053	5.12
Leucine	7.96 ± 0.092 a	7.77 ± 0.047 b	7.62 ± 0.052 b	7.07 ± 0.030 c	6.08 ± 0.018 d	3	7.30	0.183	9.70
Valine	6.22 ± 0.227 a	6.25 ± 0.015 a	6.14 ± 0.216 a	5.87 ± 0.038 a	5.20 ± 0.023 b	3	5.94	0.117	7.64
Histidine	2.99 ± 0.024 a	2.85 ± 0.021 b	2.77 ± 0.005 bc	2.72 ± 0.059 c	2.53 ± 0.044 d	3	2.77	0.043	5.99
Phenylalanine	4.35 ± 0.044 bc	4.41 ± 0.044 b	4.29 ± 0.145 bc	4.79 ± 0.078 a	4.10 ± 0.023 c	3	4.39	0.068	5.94
Glycine	6.42 ± 0.012 a	6.36 ± 0.026 a	6.28 ± 0.031 b	6.15 ± 0.005 c	5.89 ± 0.023 d	3	6.22	0.051	3.22
Serine	5.23 ± 0.064 a	5.17 ± 0.036 a	5.19 ± 0.049 a	5.14 ± 0.022 a	4.58 ± 0.035 b	3	5.06	0.067	5.12
Proline	4.46 ± 0.027 a	4.39 ± 0.046 a	4.32 ± 0.054 a	3.96 ± 0.057 b	3.77 ± 0.052 c	3	4.18	0.074	6.82
Alanine	7.18 ± 0.082 a	6.89 ± 0.048 b	6.83 ± 0.033 b	6.86 ± 0.024 b	5.89 ± 0.023 c	3	6.73	0.119	6.82
Aspartic acid	10.38 ± 0.095 a	9.65 ± 0.035 b	9.62 ± 0.084 b	9.63 ± 0.023 b	9.28 ± 0.169 c	3	9.71	0.103	4.11
Glutamic acid	15.58 ± 0.152 a	14.61 ± 0.113 b	14.43 ± 0.188 b	14.19 ± 0.023 b	13.58 ± 0.121 c	3	14.48	0.182	4.85
Total amino acids	97.69	93.97	92.74	92.29	84.40				

1 N - No of replicates
2 SEM - Standard error of the means
3 C.O.V - Coefficient of variation

Table 3. Amino acids digestibility (%) of untreated and treated defatted rice polishing (DRP)

Amino acids	Treatment methods					Statistical analysis			
	Untreated	0.4N HCl	0.4N HCl plus Extrusion	6% H_2O_2	6% H_2O_2 plus Extrusion	N^1	Mean	SEM^2	$C.O.V.^3$
Methionine	80.98 ± 1.09 [bc]	85.05 ± 1.811 [b]	95.43 ± 1.552 [a]	96.62 ± 1.013 [a]	77.21 ± 1.988 [c]	3	87.06	3.87	9.94
Cystine	64.98 ± 1.827 [d]	82.75 ± 2.391 [b]	89.14 ± 1.379 [a]	84.95 ± 0.174 [ab]	73.64 ± 1.416 [c]	3	79.09	4.35	12.29
Lysine	78.84 ± 0.939 [d]	84.56 ± 0.834 [c]	92.28 ± 0.984 [a]	88.67 ± 0.467 [b]	75.80 ± 0.656 [c]	3	84.03	3.04	8.08
Threonine	72.72 ± 1.150 [c]	90.41 ± 1.115 [b]	94.30 ± 1.165 [a]	93.26 ± 1.107 [ab]	74.94 ± 0.915 [c]	3	85.13	4.67	12.26
Tryptophan	86.68 ± 0.428 [a]	77.84 ± 2.831 [b]	89.72 ± 2.117 [a]	92.29 ± 0.771 [a]	72.30 ± 1.166 [c]	3	83.77	3.76	10.04
Arginine	89.88 ± 1.123 [c]	94.75 ± 0.202 [b]	99.15 ± 0.238 [a]	98.00 ± 0.214 [a]	83.91 ± 1.568 [d]	3	93.14	2.81	6.75
Isoleucine	82.09 ± 0.623 [c]	88.04 ± 0.924 [b]	97.11 ± 0.463 [a]	97.57 ± 0.643 [a]	76.49 ± 0.363 [d]	3	88.26	4.13	10.47
Leucine	79.17 ± 0.518 [c]	85.32 ± 0.766 [b]	94.71 ± 0.886 [a]	93.60 ± 0.424 [a]	71.21 ± 0.631 [d]	3	84.80	4.43	11.67
Valine	75.82 ± 0.406 [c]	85.21 ± 0.667 [b]	94.75 ± 1.424 [a]	92.41 ± 0.733 [a]	72.33 ± 0.687 [c]	3	84.10	4.42	11.75
Histidine	73.06 ± 2.550 [b]	91.00 ± 0.880 [a]	91.80 ± 2.965 [a]	85.74 ± 1.506 [a]	75.89 ± 1.146 [b]	3	83.50	3.86	10.32
Phenylalanine	73.97 ± 2.649 [c]	84.47 ± 0.757 [b]	92.89 ± 1.664 [a]	91.77 ± 0.442 [a]	71.70 ± 1.781 [c]	3	82.96	4.39	11.84
Glycine	21.58 ± 1.611 [c]	89.12 ± 1.931 [a]	89.46 ± 2.016 [a]	57.83 ± 0.872 [b]	51.89 ± 0.241 [b]	3	61.98	12.73	45.93
Serine	72.17 ± 2.911 [c]	86.04 ± 0.280 [b]	92.96 ± 2.887 [a]	90.96 ± 0.634 [a]	73.99 ± 2.965 [c]	3	83.22	4.30	11.56
Proline	71.97 ± 2.450 [b]	86.94 ± 0.543 [a]	91.26 ± 1.370 [a]	91.46 ± 1.333 [a]	74.30 ± 0.977 [b]	3	83.19	4.20	11.29
Alanine	74.17 ± 1.259 [b]	84.67 ± 0.357 [b]	91.21 ± 0.859 [a]	92.16 ± 0.179 [a]	69.20 ± 0.941 [d]	3	82.28	4.58	12.46
Aspartic acid	78.61 ± 0.936 [c]	85.99 ± 0.551 [b]	92.64 ± 1.476 [a]	92.68 ± 0.625 [a]	74.76 ± 0.525 [d]	3	84.94	3.63	9.56
Glutamic acid	80.21 ± 0.97 [c]	88.63 ± 0.78 [b]	93.72 ± 0.97 [a]	92.58 ± 0.15 [a]	77.61 ± 0.46 [d]	3	86.55	3.26	8.41

1 N - No of replicates
2 SEM - Standard error of the means
3 C.O.V - Coefficient of variation

Table 4. Amino acids availability (g/100g) of untreated and treated defatted rice polishing (DRP)

Amino acids	Treatment methods						Statistical analysis		
	Untreated	0.4N HCl	0.4N HCl plus Extrusion	6% H_2O_2	6% H_2O_2 plus Extrusion	N^1	Mean	SEM^2	$C.O.V.^3$
Methionine	0.28 ± 0.007 b	0.25 ± 0.009 c	0.28 ± 0.017 b	0.32 ± 0.007 a	0.22 ± 0.002 d	3	0.27	0.0153	12.67
Cystine	0.23 ± 0.011 c	0.30 ± 0.025 ab	0.33 ± 0.015 a	0.31 ± 0.001 a	0.26 ± 0.009 bc	3	0.28	0.0217	17.32
Lysine	0.48 ± 0.013 c	0.52 ± 0.010 b	0.54 ± 0.015 b	0.66 ± 0.004 a	0.54 ± 0.004 b	3	0.55	0.0283	11.51
Threonine	0.48 ± 0.008 b	0.59 ± 0.012 a	0.61 ± 0.018 a	0.61 ± 0.007 a	0.45 ± 0.008 b	3	0.56	0.0398	15.89
Tryptophan	0.17 ± 0.002 a	0.12 ± 0.007 c	0.14 ± 0.009 b	0.18 ± 0.004 a	0.12 ± 0.003 bc	3	0.15	0.0118	17.60
Arginine	1.03 ± 0.022 a	0.99 ± 0.014 a	1.00 ± 0.003 a	0.88 ± 0.007 b	0.66 ± 0.032 c	3	0.91	0.0828	20.34
Isoleucine	0.49 ± 0.002 c	0.53 ± 0.006 b	0.56 ± 0.005 a	0.56 ± 0.003 a	0.40 ± 0.004 d	3	0.51	0.0293	12.84
Leucine	0.91 ± 0.006 c	0.96 ± 0.008 b	1.04 ± 0.015 a	0.96 ± 0.002 b	0.63 ± 0.006 d	3	0.91	0.0742	18.23
Valine	0.68 ± 0.028 b	0.77 ± 0.004 a	0.84 ± 0.040 a	0.79 ± 0.010 a	0.55 ± 0.003 c	3	0.73	0.0630	19.32
Histidine	0.32 ± 0.012 b	0.38 ± 0.001 a	0.37 ± 0.012 a	0.34 ± 0.010 b	0.28 ± 0.005 c	3	0.34	0.0173	11.41
Phenylalanine	0.47 ± 0.016 c	0.54 ± 0.002 b	0.58 ± 0.026 b	0.64 ± 0.013 a	0.43 ± 0.011 c	3	0.55	0.0410	166.69
Glycine	0.20 ± 0.015 d	0.82 ± 0.015 a	0.81 ± 0.021 a	0.52 ± 0.008 b	0.44 ± 0.004 c	3	0.57	0.1163	45.63
Serine	0.55 ± 0.016 c	0.65 ± 0.005 b	0.70 ± 0.016 a	0.68 ± 0.002 ab	0.49 ± 0.011 d	3	0.61	0.0444	16.28
Proline	0.47 ± 0.014 c	0.55 ± 0.002 ab	0.57 ± 0.015 a	0.52 ± 0.011 b	0.41 ± 0.011 d	3	0.51	0.0291	12.76
Alanine	0.77 ± 0.012 c	0.85 ± 0.003 b	0.90 ± 0.011 a	0.92 ± 0.003 a	0.59 ± 0.007 d	3	0.81	0.0617	17.04
Aspartic acid	1.18 ± 0.017 b	1.20 ± 0.007 b	1.29 ± 0.027 a	1.29 ± 0.008 a	1.00 ± 0.013 c	3	1.21	0.0529	9.77
Glutamic acid	1.81 ± 0.015 c	1.88 ± 0.015 b	1.95 ± 0.037 a	1.90 ± 0.002 ab	1.53 ± 0.004 d	3	1.82	0.0804	9.87
Total amino acids	10.52	11.90	12.51	12.08	9.00				

1   N - No of replicates
2   SEM - Standard error of the means
3   C.O.V - Coefficient of variation

occurred due to Strecker reaction because of the short cooking time in the extruder cooker. These results confirm the findings of Schönberg & Moubacher (1952) and Hofmann *et al.* (2000) that a number of carbohydrate-derived dicarbonyls as well as glucose are able to degrade amino acids at high temperatures, thus generating an aldehyde with one carbon atom less than amino acids. It is evident from the co-efficient of variance (COV) data that treatments did not affect the amino acid profile of rice polishing (Table 1& 2).

Similar findings were noted with samples treated with 6% H_2O_2. The contents of arginine, leucine, aspartic acid, and glutamic acid were lowered relative to protein after the treatments. The thero-nine, valine, and serine contents remained statistically unchanged after treatments, except samples that had undergone 6% H_2O_2 plus extruder cooking, which reduced the amino acid values. The diluted HCl or HCl plus extrusion cooking also affected the amino acid contents. The amino acid degradation via the Strecker reaction takes place especially at high temperatures, but in this study less amino acid degradation occurred due to Strecker reaction because of the short cooking time in the extruder cooker. These results confirm the findings of Schönberg & Moubacher (1952) and Hofmann *et al.,* (2000) that a number of carbohydrate-derived dicarbonyls as well as glucose are able to degrade amino acids at high temperatures, thus generating an alde-hyde with one carbon atom less than amino acids. It is evident from the co-efficient of variance (COV) data that treat-ments did not affect the amino acid profile of rice polishing (Table 1).

The pre-treatments might have changed the chemical nature of the anti-nutritional factors, phytin and trypsin inhibitors. The rice polishing is rich in phytin which is located in globoids in the aleurone protein bodies. Its phosphate group can readily complex with protein (Thompson & Weber, 1981). Similarly, trypsin inhibitor from rice bran has also been isolated and characterised (Tashiro & Maki, 1978; Maki *et al.,* 1980). It is rich in basic amino acid lysine (Tashiro & Maki, 1979). The increase in lysine content of DRP after the 6% H_2O_2 treatment may be due to breaking of phytin bonds and removal of trypsin inhibitor followed by partial or complete hydrolysis of protein. The results are strengthened by the study of Tsai (1976), who reported the de-naturing of trypsin inhibitor in rice polish-ing after autoclaving, boiling and treating with 1% acetic acid (4:1 v/w).

Amino acid digestibility and availability in treated defatted rice polishing

The effects of chemical treatments alone, and in combination with extrusion cooking, of rice polishing on the digestibil-ity and availability of its amino acids are shown in Tables 3 & 4. The digestibility and availability of most of the amino acids were increased by chemical treatments alone and in combination with extrusion cooking. The highest values of amino acid digestibility and availability were observed in the case of 0.4N HCl treatment plus extrusion cooking of DRP. These val-ues were comparable to those of 6% H_2O_2 treated DRP. However, amino acid digestibility and availability decreased when the later was extruded. These values were lower than the values for the untreat-ed DRP samples. The results indicated that hydrogen peroxide reacted vigorously under steam cooking of DRP and damaged the amino acids by oxidation of liberated amino acids. When subjected to statistical analysis, the amino acid digestibility and availability data in Tables 3 & 4 showed significant differences (P < 0.05) among different groups. The compar-ison of means by Duncan Multiple Range (DMR) test revealed that amino acid digestibility and availability values of 0.4N HCl plus extruder cooked and 6%

H_2O_2 treated DRP were not significantly different (P > 0.05) for all the amino acids except that of lysine and glycine. Lysine content was significantly (P < 0.05) greater with 6% H_2O_2 treatment and the value of glycine was 54% less than acid treatments (Tables 3 & 4). The data of COV showed 8-12% difference in values of all the amino acids for digestibility and 9-17% difference in availability. However, a drastic increase of up to 45% was observed in glycine digestibility and availability (Table 4). The present amino acid digestibility of DRP, at protein level of 14.48%, for lysine, methionine, cystine, threonine, and arginine were 79%, 81%, 65%, 73%, and 90%, respectively. However, Creswell (1992) determined the same amino acids at 14.5% protein level and reported the digestibilities as 73%, 76%, 64%, 68%, and 86%, respectively. Similarly, Yamazaki & Kamata (1986) reported that the overall true amino acid availability of defatted rice bran was 70%. In the present study, the digestibility percentages of these amino acids were higher, which might be due to the difference in the variety of rice polishing.

A survey of the literature has shown that not much work has been done on the amino acid digestibility and availability of defatted rice polishing treated with chemicals or chemicals plus extrusion cooking. The results of the present study showed that chemical treatments modified the chemical constituents of DRP and thus improved its nutritive value. These results are in agreement with the findings of Ledesma *et al.* (1990) that protein extracted from rice polishing had a digestibility of 90% and net protein value of 93%. The better digestibility or availability of amino acids depends to a large extent on the efficiency of protein utilisation. The findings indicate that digestibility or availability of amino acids present in DRP protein were hindered by undesirable factors present in it. The treated DRP showed better amino acid digestibility and availability than full-fat rice polishing. The results of this study are also similar to findings by Ohtsubo & Yanase (1985). They reported that, as a result of extrusion cooking, the fine structure and gelatinisation characteristics of DRP were altered. Trypsin inhibitors were also de-natured; therefore, the extrudates of DRP contained 10.5 to 12.3% crude protein and the amino acid score of lysine ranged from 71 to 75.

CONCLUSIONS

Rice polishing treated with 6% H_2O_2 improves the availability of critical amino acids required for poultry viz. lysine, methionine, threonine and tryptophan.

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