MARDI Res. J. 24(2) (1996): 135–146

Antinutritional factors, metabolizable energy and chemical composition of rice bran

(Faktor antipemakanan, tenaga metabolisme dan kandungan kimia dedak)

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Key words: rice bran, antinutritional factors, proximate values, metabolizable energy, minerals, amino acids

Abstrak

Sampel dedak dari United Kingdom (UK) dan Malaysia telah dianalisis kandungan tenaga metabolisme (ME), nilai proksimat, kandungan mineral, profil asid amino dan aktiviti faktor antipemakanan iaitu lektin (hemaglutinin) dan perencat tripsin. Aktiviti lektin pada dedak penuh lemak menunjukkan kesan penghemaglutinatan yang tinggi pada eritrosit manusia kumpulan B. Dedak nyahlemak tidak menunjukkan pengaglutinatan dengan mana-mana jenis darah yang diuji. Di UK, mengautoklaf dedak penuh lemak selama 5–20 minit pada 15 psi (121 °C) menurunkan aktiviti lektin dan perencat tripsin masing-masingya kepada 12–25% dan 7–10% daripada aktiviti asal dedak berbanding dengan yang tidak diautoklaf. Bagaimanapun di Malaysia, mengautoklaf sampel dedak penuh lemak selama 20 minit memusnahkan keseluruhan aktiviti perencat tripsin dan merendahkan aktiviti lektin sehingga separuh daripada sampel yang tidak diautoklaf. Nilai purata proksimat dedak Malaysia ialah 13.6% protein kasar, 9.3% serabut kasar, 14.3% ekstrak eter, 7.6% abu dan 10.1 MJ/kg daripada ME yang dikira. Bagaimanapun apabila diuji pada ayam jantan dewasa, nilai ME sebenar dedak Malaysia berjulat antara 12.5 dan 14.0 MJ/kg. Dedak Malaysia mengandungi 0.06% kalsium, 0.64% magnesium, 1.50% fosforus dan 1.21% kalium. Di samping itu, dedak Malaysia juga mengandungi 155 ppm mangan, 128 ppm ferum, 8 ppm kuprum dan 123 ppm zink. Kandungan lisina dedak yang diperoleh di Malaysia sangat rendah dan tidak seimbang sebagai diet poltri.

Abstract

Rice bran (RB) samples from the United Kingdom (UK) and Malaysia were analysed for their metabolizable energy (ME), proximate values, mineral contents, amino acid profiles and activities of antinutritional factors, namely lectin (haemagglutinin) and trypsin inhibitor (TI). The lectin activity in the fullfat RB had its greatest haemagglutinating effect on human type B erythrocytes. Defatted RB had no agglutination in any of the blood types tested. In the UK, autoclaving of RB for 5–20 min at 15 psi (121 °C) reduced the lectin and TI activities to 12–25% and 7–10% of its original values respectively, as compared with the activity in the raw forms. However, in Malaysia, autoclaving of RB sampels for 20 min totally destroyed the activity of TI and suppressed their lectin activity to about one half of its original activity. The mean proximate values of

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the Malaysian RB were: 13.6% crude protein, 9.3% crude fibre, 14.3% ether extract, 7.6% ash and 10.1 MJ/kg of calculated ME. However, when tested on adult cockerels, the ME values ranged from 12.5 to 14.0 MJ/kg. The Malaysian RB contained 0.06% calcium, 0.64% magnesium, 1.50% phosphorus and 1.21% potassium. It also contained 155 ppm manganese, 128 ppm iron, 8 ppm copper and 123 ppm zinc. Lysine content of the RB collected in Malaysia was low and was not well balanced for poultry diet.

Introduction

Rough rice or paddy consists of a white, starchy endosperm kernel surrounded by a tightly adhering bran coat and an adhering germ totally enclosed within a loose outer hull or husk. All rough rice is dehulled by milling to produce brown rice. Most all brown rice is polished to produce bran and white rice.

Rice bran (RB) is rich in protein, lipid, dietary fibre, vitamins and minerals. These qualities lead to a high demand for RB as animal feed (Piliang et al. 1982). The quantity of RB and rice germ available from rice mills throughout the world is about 30 million t/year (Luh et al. 1991). With a few limited exceptions, neither RB nor germ is consumed as food. This is due to its high fibre content possibly contaminated with hull and the rapid development of rancidity caused by lipase and lipoxidase activities after milling (Luh et al. 1991).

Apart from fibre and oil, RB contains antinutrients such as trypsin inhibitors (Kratzer and Payne 1977; Deolanker and Singh 1979) and lectins or haemagglutinin (Tsuda 1979). Antinutrient properties can be overcome by autoclaving at 15 pound per square inch (psi), 121 °C (Kratzer et al. 1974; Kratzer and Payne 1977; Majun and Payne 1977).

This article reports the nutrient composition and activities of trypsin inhibitor and lectin/haemagglutinin in raw and autoclaved RB samples.

Materials and methods

Collection of samples

The samples used in this study came from various sources. In the UK, the defatted rice bran (DFRB) originated from India was used for analyses. The fullfat RB came from Malaysia (MRB) and USA (USRB). Long grain brown rice imported from USA was processed to produce white rice and RB which was used for analyses. MRB was obtained commercially in Malaysia.

In Malaysia, samples of RB were collected from rice mills in Selangor, Kedah, Kelantan and Terengganu during the milling of paddy. The samples were kept in an ice-cooled container and transported to the laboratory. Six varieties of paddy were collected from MARDI Station in Bertam and milled using a Satake rice machine (Type THU Class 35 A, Satake Engineering Co Ltd, Tokyo) to obtain their bran. All samples were kept frozen at –20 °C to avoid changes in chemical composition prior to analysis.

About 100 g of each of the samples collected in the UK were autoclaved at 15 psi (121 °C) for 5, 10, 15, 20, 30 and 40 min to identify the most suitable time to suppress the activities of trypsin inhibitor and lectin. A sample of black kidney beans was analysed (raw and autoclaved) together with other samples as a reference. In Malaysia, about 100 g of each sample was autoclaved at 15 psi (121 °C) for 20 min only and analysed for nutrient contents, trypsin inhibitor and lectin activities.

Determination of antinutritional factors

Lectin activity of raw and autoclaved samples was assayed as previously outlined by Tan et al. (1983). Lectin is measured in haemagglutinin units (HU). One HU is defined as the least amount of haemagglutinin that will produce positive

evidence of agglutination of 25 mL of a 3% suspension of washed, trypsinized erythrocytes after a 3-h incubation at room temperature.

Trypsin inhibitor activity from the raw and autoclaved samples was determined 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 sample, where one trypsin inhibitor unit (TIU) is defined as an increase in absorbance of 0.01 at 410 nm under the condition of assay.

Proximate analyses

The dry matter, crude protein, acid detergent fibre, ether extract and ash contents of the samples were determined as described by Faichney and White (1983). Crude fibre was determined by the Fibertec System. The sample was boiled with 0.128 *M* sulphuric acid, and then was boiled again with 0.223 *M* potassium hydroxide solution. The remaining residue after the digestion was collected on a filter, dried and ashed. Gross energy was determined by a Gallenkamp adiabatic bomb calorimeter. Metabolizable energy was calculated based on the formula suggested by Carpenter and Clegg (1956).

Determination of minerals, amino acids and metabolizable energy

Macrominerals (calcium, phosphorus, magnesium and potassium) and microminerals (manganese, iron, copper and zinc) were determined by inductively coupled plasma (ICP) atomic absorption spectrophotometry following wet digestion with nitric acid (Anon. 1991). Amino acid profile was determined by preparing protein hydrolysates using acid hydrolysis (6 *M* HCl containing 0.5% phenol). To determine the individual amino acid, the hydrolysates were subjected to ortho-pthalaldehyde-9-fluoroenylmethylchloroformate (OPA-FMOC) derivatisation (Schuster 1988). Metabolizable energy of RB samples collected in Malaysia was tested using six adult cockerels at the Institute of Animal Physiology and Genetic Research, Roslin, Midlothian using glucose as the control standard. The determination was carried out by means of the tube feeding technique (Sibbald 1986).

Results and discussion

Lectin or haemagglutinin activity in the RB was determined using different types of erythrocytes, human type A, B and O, and from broiler chicken. Results of the tests *(Table 1)* showed that the lectin in all fullfat RB tested, in common with that of black kidney beans, had their greatest haemagglutinating effect on human type B erythrocytes. Defatted RB elicited no agglutination in any of the blood types tested, presumably the extraction processed used to remove the oil had inactivated all lectin activity. Takahashi et al. (1973) reported that RB lectin was an ABO blood group non-specific which meant that it would bind to any type of human erythrocytes. The Malaysian fullfat RB tends

Table 1. Lectin activities in rice bran and black kidney beans on four types of blood

Blood type	Lectin activity (HU/mg sample)			
	US fullfat rice bran	Malaysian fullfat rice bran	Indian defatted rice bran	Black kidney beans
Human				
Type O	32	16	0	1 024
Type A	32	32	0	1 024
Type B	48	32	0	2 048
Chicken	32	nd	0	nd

nd = not determined

Table 2. Lectin activities (using human type B erythrocyte) in raw and autoclaved rice bran and black kidney beans

Treatment	Lectin activity (HU/mg sample)		
	US fullfat rice bran	Malaysian fullfat rice bran	Black kidney beans
Raw	32	32	1 024
Autoclaved (15 psi, 121 °C)			
5 min	8	8	1 024
10 min	8	8	16
15 min	8	4	0
20 min	8	4	nd
30 min	8	nd	nd
40 min	8	nd	nd

to have a lower lectin content compared with the US fullfat RB. The variation in results among the fullfat RB was probably due to the different varieties of rice. Variation in lectin content within a single species of plant had been reported by many researchers (e.g. Pull et al. 1978; Tan et al. 1983).

Autoclaving affected the lectin activity in RB (*Table 2).* Autoclaving for 5–40 min reduced the lectin activity of US fullfat long grain rice bran (USRB) down to 25% of its original value as compared with the activity in the raw sample. Lectin activities in the two RB samples were quite low, when compared with kidney beans, a material well known to have dangerous levels of lectin activity. Although the lectin activity of the RB was quickly reduced to 25% of its original value, the residual lectin activity proved to be surprisingly refractory.

Results were generally similar to those of earlier work which reported that RB lectin was non-specific to any particular human blood type (Indravathamma and Seshadri 1980; Ory et al. 1981; Goldstein and Poretz 1986). Nevertheless, on the basis of the slightly higher sensitivity of human erythrocyte type B, it was used in all subsequent tests on lectin activity.

The activities of trypsin inhibitor in the RB were also affected by autoclaving *(Table 3).* Autoclaving for 5–20 min suppressed the trypsin inhibitor activities to levels below 10% of the raw samples. Raw or autoclaved Indian defatted RB had a very low level of trypsin inhibitors. The heat generated during the oil extraction process probably destroyed most of its trypsin inhibitors.

In 12 RB samples collected in Malaysia, autoclaving the samples at 15 psi (121 °C) for 20 min completely destroyed the activities of trypsin inhibitor and suppressed their lectin activities to about one half of its original activity in the raw samples *(Table 4).*

Results obtained from this study were in agreement with some earlier findings (Kratzer et al. 1974; Kratzer and Payne 1977; Majun and Payne 1977). Deolanker and Singh (1979) had shown that the activity of trypsin inhibitor in RB was inactivated if the RB had undergone moist heat treatment. Apart from temperature, the stability of RB trypsin inhibitors was also reported to be pH dependent (Tashiro and Maki 1986).

In the proximate analysis of the RB in the UK, the MRB and USRB showed quite a marked difference in ADF, fat and crude protein content *(Table 5).* More consistent results were obtained from bran of different varieties collected from various locations in Malaysia *(Table 6).* The relatively lower ether extract value obtained for MR 77 sample and the higher ash value for MR 123 sample were probably due to sampling errors. The Malaysian and US fullfat RB

Table 3. Trypsin inhibitor activities in raw and autoclaved* rice bran and black kidney beans

Sample	Trypsin inhibitor unit (TIU/mg)	% of raw sample
US fullfat rice bran		
Raw	12.13	
Autoclaved for 5 min	0.98	8.1
10 min	0.89	7.3
15 min	1.17	9.6
20 min	1.12	9.2
Malaysian fullfat rice bran		
Raw	8.43	
Autoclaved for 20 min	0.65	7.7
Indian defatted rice bran		
Raw	0.66	
Autoclaved for 20 min	0.65	98.5
Black kidney beans		
Raw	29.06	
Autoclaved for 5 min	12.06	41.5
10 min	7.92	27.3

*autoclaved at 15 psi, 121 °C

Table 4. Trypsin inhibitor and lectin activities in raw and autoclaved Malaysian rice bran from different rice varieties and rice mills* in Malaysia

Sample	Trypsin inhibitor unit (TIU/mg)		Lectin (HU/mg)	
	Raw	Autoclaved**	Raw	Autoclaved**
Rice variety				
MR 77	0.31	0.0	8	4
MR 84	1.76	0.0	32	16
MR 123	0.75	0.0	16	4
MR 127	0.81	0.0	8	8
Basmati	0.34	0.0	4	4
Pulut Siding	0.76	0.0	4	2
Big rice mill				
Rice mill A	1.78	0.0	4	2
Rice mill B	2.33	0.0	64	16
Rice mill C	1.35	0.0	16	16
Small rice mill				
Rice mill D	1.46	0.0	8	4
Rice mill E	1.41	0.0	8	8
Rice mill F	0.42	0.0	4	2
Average	1.12	0.0	14.7	7.2
Std error	0.18	0.0	5.1	1.6

*big rice mills have capacity up to 8 t/h while small rice mills 1–2 t/h
**autoclaved at 15 psi, 121 °C for 20 min

Table 5. Proximate analysis of rice bran

Sample	Dry matter (%)	Crude protein (%)*	Oil (%)*	ADF (%)*
US fullfat rice bran	90.7	14.7	20.3	11.0
Malaysian fullfat rice bran	90.2	11.9	16.9	20.5
Indian defatted rice bran	88.2	16.0	1.0	21.2

* % dry matter

Table 6. Proximate analysis of rice bran from different rice varieties and rice mills* in Malaysia

Sample	% as is basis							Energy (MJ/kg)	
	DM	CP	CF	ADF	Oil	Ash	NFE	GE	ME**
Rice variety									
MR 77	87.96	13.37	9.56	9.87	8.90	6.28	61.90	18.60	9.66
MR 84	83.89	14.90	8.64	10.56	14.77	7.42	54.28	19.25	10.80
MR 123	89.99	13.80	8.76	12.05	19.75	14.20	43.50	18.56	10.31
MR 127	89.69	14.08	8.27	16.30	14.57	7.25	55.84	18.74	10.82
Basmati	83.53	13.94	7.59	10.96	15.38	6.82	56.29	19.05	11.60
Pulut Siding	90.19	12.44	8.39	14.70	12.34	4.37	62.47	17.69	10.13
Big rice mills									
Rice mill A	80.14	13.19	7.81	8.30	16.37	7.78	54.87	19.38	11.60
Rice mill B	81.73	12.52	9.81	nd	18.32	8.84	50.52	19.41	9.86
Rice mill C	83.60	13.71	8.93	8.46	10.72	6.20	52.41	19.47	10.67
Small rice mill									
Rice mill D	82.89	14.13	9.11	11.44	12.49	8.07	53.66	19.91	10.75
Rice mill E	82.66	13.69	12.58	14.19	14.49	6.84	56.22	18.98	7.25
Rice mill F	85.60	13.75	12.43	12.85	13.11	7.06	52.41	19.33	7.52
Average	85.15	13.62	9.32	12.46	14.27	7.59	55.20	19.03	10.08
Std error	0.96	0.19	0.45	0.93	0.84	0.32	1.02	0.16	0.38

*big rice mills have capacity up to 8 t/h while small rice mills 1–2 t/h
**ME = GE x 0.953 (1 – % CF/21) (Source: Carpenter and Clegg 1956)

showed quite a marked difference in acid detergent fibre, fat and crude protein contents.

Variations in proximate values of RB have been reported widely (Warren et al. 1985; Grist 1986; Creswell 1988; Sotelo et al. 1990; Warren and Farrell 1990a). Adulterated RB from the Asian region may contain as low as 2.3% crude protein, 45% high crude fibre and 27.7% ash, mainly sand. The normal RB usually contains 15% crude protein, 12% crude fibre and 9% ash (Creswell 1988). The variations can also be due to rice variety or contamination (Creswell 1988) and type of milling process involved (Barber and Benedito de Barber 1980).

RB samples collected from small rice mills had a relatively high crude fibre content *(Table 6)*. This was probably due to the inefficient separation of hulls from the bran during the milling process. In small rice mills, the operations of dehulling and polishing were done in a single pass. Palipane and Swanasiri (1985) reported that small traditional rice mills in Sri Lanka produced bran with a high crude fibre content, probably due to contamination with paddy hulls.

The average calculated ME values for RB in Malaysia, as recorded in this study, was 10.08 MJ/kg. The value is similar to the figure reported recently (Anon. 1993), but 25% lower than the Asian RB (Creswell

Table 7. True metabolizable energy (TME) of fullfat Malaysian rice bran on adult cockerels

Sample	DM (g/kg)	Nitrogen (g/kg)	GE (MJ/kg)	TME (MJ/kg)	TME_n (MJ/kg)
Long grain rice bran (raw)	888.1	215.0	19.36	14.16	13.66
Long grain rice bran (autoclaved*)	878.0	212.0	19.82	14.40	14.01
Medium grain rice bran (raw)	904.6	215.0	19.33	12.95	12.54
MR 84 (raw)	885.5	215.0	19.79	13.19	13.10

*autoclaved at 15 psi, 121 °C for 20 min

Table 8. Some mineral contents of rice bran obtained from different rice varieties and rice mills* in Malaysia

Sample	% as is basis				ppm as is basis				Ca:P
	Ca	Mg	P	K	Mn	Fe	Cu	Zn	
Rice variety									
MR 77	0.058	0.668	1.844	1.214	189	120	6	132	0.035
MR 84	0.054	0.704	1.620	1.296	156	232	7	105	0.033
MR 123	0.049	0.594	1.435	1.204	98	97	8	176	0.034
MR 127	0.053	0.623	1.496	1.194	93	101	5	194	0.035
Basmati	0.061	0.630	1.683	1.096	130	150	9	188	0.036
Pulut Siding	0.043	0.389	0.892	0.822	95	107	6	142	0.048
Big rice mill									
Rice mill A	0.057	0.801	1.689	1.420	119	119	8	84	0.034
Rice mill B	0.062	0.805	1.756	1.439	120	146	9	89	0.035
Rice mill C	0.064	0.621	1.529	1.322	201	119	6	98	0.042
Small rice mill									
Rice mill D	0.069	0.769	1.705	1.424	211	127	8	93	0.040
Rice mill E	0.064	0.551	1.164	1.002	205	97	9	85	0.055
Rice mill F	0.069	0.557	1.135	1.033	234	125	11	93	0.067
Average	0.058	0.643	1.496	1.206	155	128	8	123	0.041
Std error	0.002	0.034	0.084	0.553	15	11	0.5	12	0.003

*big rice mills have capacity up to 8 t/h while small rice mills 1–2 t/h

1988) and 27% higher than the value reported by Allen (1992).

In contrast to the calculated values, the true metabolizable energy (TME) of a few RB samples collected in Malaysia indicated that fullfat RB seemed to be a good energy source *(Table 7)*. Autoclaving at 15 psi, 121 °C for 20 min marginally improved (2.5%) the TME values of long grain RB as compared with their raw forms. However, the ME values of fullfat RB of 12.5–14.0 MJ/kg were lower than that for fullfat Australian RB (14.7–15.0 MJ/kg) as reported by Warren and Farrell (1990b), but higher then those reported by National Research Council (1984).

The mineral content in RB is presented in *Table 8.* High phosphorus (P) and low calcium (Ca) levels produced a low Ca:P ratio. The Ca:P ratio of one is nutritionally desirable for Ca absorption, but the ratio in RB may be as low as 0.03 (Resurreccion et al. 1979). Excess Ca, however, reduces the bioavailability of trace elements such as zinc (Morris and Ellis 1980). The average Ca:P ratio of 0.04 in the RB recorded in this study is similar to the value of the bran from IR 32 rice variety (Eggum et al. 1982). The Ca:P ratios calculated for brans from other cereals are also low: 0.07 for rye, 0.05 for wheat and 0.4 for barley (Pederson and Eggum 1983a, b, c).

Table 9. Amino acid profile of rice bran from different rice varieties and rice mills* in Malaysia

Sample	Amino acids** (% of the bran on an as is basis)												
	His	Gly	Thr	Arg	Val	Met	Ile	Phe	Leu	Lys	Ess	Ness	Total
Rice variety													
MR 77	0.30	0.66	0.60	1.11	0.61	0.21	0.43	0.56	0.94	0.50	5.91	6.13	12.04
MR 84	0.30	0.68	0.58	1.03	0.67	0.23	0.46	0.64	1.05	0.47	6.10	6.73	12.82
MR 123	0.29	0.64	0.62	1.15	0.66	0.22	0.47	0.61	1.01	0.47	6.14	6.60	12.74
MR 127	0.32	0.67	0.64	1.17	0.67	0.23	0.47	0.61	1.02	0.47	6.27	6.59	12.87
Basmati	0.33	0.66	0.60	1.16	0.63	0.19	0.47	0.57	0.96	0.48	6.05	6.29	12.34
Pulut Siding	0.27	0.57	0.54	0.97	0.57	0.20	0.42	0.52	0.87	0.42	5.35	5.73	11.08
Big rice mill													
Rice mill A	0.31	0.64	0.60	1.10	0.61	0.18	0.43	0.53	0.88	0.48	5.75	5.88	11.63
Rice mill B	0.29	0.65	0.61	1.07	0.62	0.19	0.44	0.55	0.90	0.51	5.82	6.18	12.00
Rice mill C	0.30	0.66	0.54	0.99	0.60	0.17	0.40	0.55	0.92	0.47	5.59	6.08	11.67
Small rice mill													
Rice mill D	0.29	0.68	0.64	0.96	0.64	0.18	0.48	0.55	0.93	0.52	5.85	6.44	12.02
Rice mill E	0.29	0.63	0.52	1.10	0.62	0.17	0.42	0.56	0.95	0.39	5.65	6.19	11.83
Rice mill F	0.30	0.66	0.53	1.08	0.59	0.17	0.40	0.53	0.90	0.42	5.56	6.05	11.62
Average	0.30	0.65	0.58	1.07	0.62	0.19	0.44	0.57	0.94	0.47	5.84	6.23	12.07
Std error	0.01	0.09	0.12	0.21	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.18

*big rice mills have capacity up to 8 t/h while small rice mills 1–2 t/h

**His = histidine
Gly = glycine
Thr = threonine
Arg = arginine
Val = valine
Met = methionine
Ile = isoleucine
Phe = phenylalanine
Leu = leucine
Lys = lysine
Ess = total of essential amino acids
Ness = non-essential amino acids

About 90% of the P in RB is in the form of phytate (Luh et al. 1991). The largest part of P in RB is linked to inositol in the Ca-magnesium salt of myoinositol hexaphosphate or phytin (Luh et al. 1991). Phosphate groups of RB can readily complex with cations such as calcium, zinc and iron, and also with protein (Juliano 1985b). Phytate-P is relatively unavailable to non-ruminants and phytate also may render other minerals poorly available (Warren and Farrell 1990a).

Results of the mineral profile of RB recorded in this study are broadly within the values reported by Barber and Benedito de Barber (1980) and Juliano (1985a). However, other workers have reported lower values for zinc and iron contents (Sotelo et al. 1990; Warren and Farrell 1990a).

The amino acid profile of Malaysian RB showed low lysine contents in all samples, i.e. at the average of 0.47%, as is basis *(Table 9)*. The values are consistently low, ranging from 0.39% to 0.52% regardless of rice variety, mill type or location of paddy planted. Low lysine content, as shown in the study, will result in wide ratios of individual amino acid to lysine *(Table 10)*. These phenomena mean that the distribution of amino acids in RB is not well balanced for poultry diet. Appropriate ratios of amino acids to lysine produce maximum growth of growing broilers (Boorman and Burgess 1986).

Methionine contents in RB collected in this study are slightly lower than the values previously recorded (Juliano 1985a; Warren and Farrel 1990a; Farrell 1992; Anon. 1993), However, they are higher than the methionine content of poor RB from South-East Asia (Creswell 1988).

Conclusion

Lectin and trypsin inhibitor in RB were low and easily destroyed or suppressed by autoclaving. These antinutritional factors are not the main cause of low performance of poultry having RB in their diets.

RB was low in protein and high in fibre and oil which will not meet the requirement of non-ruminants diet if used at a high level. Due to its low lysine content, it is necessary to balance the ration before feeding rice bran to non-ruminants.

Acknowledgements

The authors wish to express their appreciations to Ms Azizah Amri, Ms Roshidah Abdul Mutalib, Ms Zaireen Hassan and Mr Azman Ibrahim who assisted in the field and laboratory. Thanks are also due to the staff in Animal Nutrition Laboratory at MARDI, Serdang and Department of Biological and Nutritional Sciences, Newcastle University, England,

Table 10. Amino acid balance of Malaysian rice bran

Amino acid	Amount* (%)	Amino acid-to-lysine ratio	Recommended ratio**
Lysine	0.47		
Methionine + cystine	0.47	1.00	0.76
Arginine	1.08	2.30	1.08
Glycine + serine	1.32	2.81	1.31
Histidine	0.30	0.64	0.40
Isoleucine	0.44	0.94	0.72
Leucine	0.94	2.00	1.26
Phenylalanine + tyrosine	0.98	2.09	1.21
Threonine	0.58	1.23	0.63
Valine	0.62	1.32	0.79

*average of 12 samples
**source: Boorman and Burgess (1986)

and Ms Norzaina Abbas for typing this manuscript.

References

Allen, R. M. D. (1992). Ingredient analysis table: 1992 edition. In *Feedstuff: Reference Issue* ***64(29):*** 24–31

Anon. (1991). Plasma application: plant tissue. In *Plasma application Vol. 1* (Foetisch, M., ed.) p. 167–80. Ecublens, Switzerland: Fison plc/ ARL Publication

—— (1993). *Rhodimet feed formulation guide* 6th ed., 40 p. Cedex, France: Rhone Poulenc Animal Nutrition

Barber, S. and Benedito de Barber, C. (1980). Rice bran: Chemistry and technology. In *Rice: Production and utilization* (Luh, B. S., ed.) p. 790–862. Westport, Connecticut: Avi Publishing Co., Inc.

Boorman, K. N. and Burgess, A. D. (1986). Responses to amino acids. In *Nutrient requirements of poultry and nutritional research* (Fisher, G. and Boorman, K. N., ed.) Poultry Sci. Symp. No. 19, Butterworth, Kent. p. 99–123

Carpenter, K. J. and Clegg, K. M. (1956). *J. Agric. Feed Chem.* ***7:*** 45. Cited by Ahmed, A. E. (1991) in Anti-nutritional role of dietary tannins in the domestic fowl (*Gallus domesticus*), Ph. D thesis, Univ. Newcastle-upon-tyne United Kingdom

Creswell, D. (1988). Amino acid composition of feedgrade rice by-products from several countries. *Proc. wld. cong. vegetable prot. utilisation in human food and animal feedstuffs* (Applewhite, T. H., ed.) p. 474–9. Illinois: Amer. Oil Chem. Soc.

Deolanker, R. P. and Singh, K. S. (1979). Trypsin inhibitor, mineral availability, and performance of broiler chickens fed on diets based on rice bran. *Anim. Feed Sci. Technol*. ***4:*** 135–41

Eggum, B. O., Juliano, B. O. and Miningat, C. C. (1982). Protein and energy utilization of rice milling fractions by rats. *Qual. Plant. Plant Foods Hum. Nutr*. ***34:*** 261–72

Faichney, G. S. and White, B. A. (1993). *Methods for the analysis of feeds eaten by ruminants* 33 p. Australia: CSIRO

Farrell, D. J. (1992). Rice bran in poultry diets. Paper presented at the Rhone-Poulenc Poultry Nutrition Symp., Kuala Lumpur, 16 Nov. 1992, 17 p. Organizer: Rhone-Poulenc Animal Nutrition Asia Pacific Pte. Ltd.

Goldstein, R. J. and Poretz, R. D. (1986). Isolation, physicochemical characterization, and carbohydrate binding specificity of lectins. In *The lectins: Properties, functions, and applications in biology and medicine* (Liener, I. E., Sharon, N. and Goldstein, I. J., ed.) p. 35–247. Orlando, Fla: Academic Press, Inc.

Grist, D. H. (1986). The origin and history of rice. In *Rice* p. 3–11. New York: Longman, Inc.

Indravathamma, P. and Seshadri, S. H. (1980). Lectin from rice. *J. Biosci.* ***2:*** 29–36

Juliano, B. O. (1985a). Polysaccharides, proteins and lipids of rice. In *Rice: Chemistry and technology* Chap. 3 (Juliano, B. O., ed.) p. 59–174. St. Paul, USA: Amer. Assoc. Cereal Chemists, Inc.

—— (1985b). Rice bran, Chap. 18, p. 647–87. ***See*** Juliano (1985a)

Kratzer, F. H., Earl, L. and Chiaravanont, C. (1974). Factors influencing the feeding value of rice bran for chickens. *Poultry Sci.* ***53:*** 1795–800

Kratzer, F. H. and Payne, C. G. (1977). Effect of autoclaving, hot-water treating, parboiling and addition of ethoxyquin on the value of rice bran as a dietary ingredient for chickens. *Br. Poultry Sci*. ***18:*** 475–82

Liu, K. and Markakis, P. (1989). An improved method for determining antitryptic activity in soybean products. *Cereal Chem.* ***66:*** 415–22

Luh, B. S., Barber, S. and Benedito de Barber, C. (1991). Rice bran: Chemistry and technology. In *Rice Vol. II: Utilization* 2nd ed. (Luh, B. S., ed.) p. 313–62. Westport, Connecticut: Avi Publishing Co., Inc.

Majun, G. K. and Payne, C. G. (1977). Autoclaved rice bran in layers diet. *Br. Poultry Sci*. ***18:*** 201–3

Morris, E. R. and Ellis, R. (1980). Effect of dietary phytate/zinc molar ratio on growth and bone zinc response of rats fed semipurified diets. *J. Nutr*. ***110:*** 1037–45

National Research Council (1984). *Nutrient requirements of poultry* 8th revised ed., 70 p. Washington D. C.: National Academy Press

Ory, R. L., Bog-Hansen, T. C. and Mod, R. B. (1981). Properties of haemagglutinin in rice and other cereal grains. In *Antinutrients and natural toxicants in foods* (Ory, R. L., ed.) p. 159–68. Westport, Connecticut: Food Nutr. Press, Inc.

Palipane, K. B. and Swanasiri, C. D. P. (1985). Composition of raw and parboiled rice bran from common Sri Lankan varieties and from different types of rice mills. *J. Agric. Food Chem*. ***33:*** 732–4

Pederson, B. and Eggum, B. O. (1983a). The influence of milling on the nutritive value of

flour from cereal grains. I. Rye. *Qual. Plant. Plant Foods Hum. Nutr.* ***32:*** 182–96

—— (1983b). The influence of milling on the nutritive value of flour from cereal grains. II. Wheat. *Qual. Plant. Plant Foods Hum. Nutr.* ***33:*** 51–61

—— (1983c). The influence of milling on the nutritive value of flour from cereal grains. III. Barley. *Qual. Plant. Plant Foods Hum. Nutr.* ***33:*** 99–112

Piliang, N. G., Bird, H. R., Sunde, M. L. and Pringle, D. J. (1982). Rice bran as a major energy source for laying hens. *Poultry Sci*. ***61:*** 357–63

Pull, S. P., Puepke, S. G., Hymowitz, T. and Orf, J. H. (1978). Soyabean lines lacking the 120,000–Dalton seed lectin. *Sci*. ***200:*** 1277–9

Resurreccion, A. P., Juliano, B. O. and Tanaka, Y. (1979). Nutrient content and distribution in milling fractions of rice grain. *J. Sci. Food Agric.* ***30:*** 475–81

Schuster, R. (1988). Determination of amino acids in biological, pharmacentical, plant and food samples by automated precolumn derivatization and high-performance liquid chromatography. *J. Chromato.* (Biomedical Application) ***431:*** 271–84

Sibbald, S. I. (1986). *The T.M.E. system of feed evaluation: methodology, feed composition data and bibliography. Technical Bull. 1986–4E.* 114 p. Ottawa: Anim. Res. Centre

Sotelo, A., Sousa, V., Montalvo, I., Hernandez, M. and Hernandez-Aragon, L. (1990). Chemical composition of different fractions of 12 Mexican varieties of rice obtained during milling. *Cereal Chem.* ***67:*** 209–12

Takahashi, T., Yamada, N., Iwamoto, K., Shimabayashi, Y. and Izutsu, K. (1973). Some properties and characterization of rice seed haemagglutinin. *Agric. Biol. Chem.* ***37:*** 29–36

Tan, N. H., Rahim, Z. H. A., Khor, H. T. and Wong, K. C. (1983). Winged bean (*Psophocarpus tetragonobolus*) tannin level, phytate content and haemagglutinin activity. *J. Agric. Food Chem.* ***31:*** 916–7

Tashiro, M. and Maki, Z. (1986). Stability and specificity of rice bran trypsin inhibitor. *J. Nutr. Sci. Vitaminol*. ***32:*** 591–9

Tsuda, M. (1979). Purification and characterization of a lectin from rice bran. *J. Biochem. Tokyo* ***86:*** 1451–61

Warren, B. E. and Farrell, D. J. (1990a). The nutritive value of fullfat and defatted Australian rice bran. I. Chemical composition. *Anim. Feed Sci. Technol*. ***27:*** 219–28

—— (1990b). The nutritive value of fullfat and defatted Australian rice bran. II. Growth studies with chickens, rats and pigs. *Anim. Feed Sci. Technol*. ***27:*** 229–46

Warren, B. E., Hume, I. D. and Farrell, D. J. (1985). Some nutritional problems with rice bran for poultry. *Proc. 3rd AAAP Anim. Sci. Cong* (Theme: Efficient animal production for Asian welfare) p. 637–9. Seoul, Korea: Korean Soc. Anim. Sc.

Accepted for publication on 11 September 1996