NUTRIENT COMPOSITION, INSECT PESTS AND MICROBIAL POPULATION IN RICE BRAN SAMPLES FROM SOME MILLS IN KUMASI AND ITS ENVIRONS

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ABSTRACT

Two experiments were conducted to determine the nutrient composition, insect pests numbers and microbial population in rice bran (RB). Samples from ten different mills in Kumasi, Abuakwa, Mfensi, Koforidua and Akropong all in the Ashanti Region, were analysed for the presence of microorganisms and insects and for their proximate components as well as ADF, NDF and Hemicellulose contents. Questionnaires were administered at each mill to determine inter alia the source of paddy rice, the type and age of rice milling machines, the level of experience of rice mills' operators and the average quantity of paddy rice milled daily. The study indicated that five of the mills were made locally (Magazine # 7); three were imported from Japan (Satake rice mill), and two from China (Daiichi rice mill). The mean % DM, CP, EE, CF, Ash and NFE ranged between 93.97-95.57, 5.23-9.74, 4.78-10.20, 14.06-21.83, 9.16-17.77 and 44.96-53.84, respectively. The % ADF, NDF and hemicellulose were between 28.45-41.64, 37.93-55.09 and 5.98-14.57, respectively. E. coli, Staphylococcus spp. and Proteus spp. were present in all the ten samples with average bacteria count ranging from 1.06 x 10^6 to 8. 03 x 10^6 cfu per gram . However, only one of the samples showed the presence of an insect; four adults and 3 larvae of Tribolium spp were found per 10g of the sample. Aspergillus spp. and Rhizopus spp. were also present in all the samples. The RB samples from the imported rice mills had better ($p<0.05$) nutrient composition in terms of CP, EE, and NFE and were lower ($p<0.05$) in Ash and CF contents. The study revealed that the variability in nutrient composition of the various RB samples could be due to the type of rice huller/polisher, its age and the extent of adulteration of the RB with rice hulls.

Keywords: *Rice Bran, Nutrient composition, Rice huller/polisher, Microorganisms, Insects.*

INTRODUCTION

Feed inputs have been identified as the most costly item in livestock production [Devendra and Fuller, 1979; Pond et al, 1995]. It would therefore be economically expedient to explore the use of non-conventional feed resources (NCFR), which are abundant and cheap. [Okai, 1978] provided a list of some crops and agro-industrial by-products (AIBP) suitable for pigs which he grouped under broad headings of cereals and their by-products, plantation crops and their by-products, field crops and their by-products and other miscellaneous items.

Devendra [1992] noted that one of the main constraints to the use of NCFR is limited knowledge on the composition of these resources such as proximate components, intake and nutritive value, which are pertinent to the development of utilisation technology. Earlier, Nkhonjera [1987] observed that some of the constraints in the efficient utilisation of AIBP include lack of documentation of previous research works on the nutritive value of these food resources making it impossible to derive suitable feed combination for the various requirements of farm animals.

Cereals form, by far, the greater part of the diet fed to livestock, but these grains are attacked on the field by birds, insects and rodents. Rodents in particular can spread disease-causing organisms such as *Salmonella* with their faeces. Vehicles conveying grains and silos storing the grains can also become sources of infections with *Salmonella* and *Enterobacteria* [Adams, 1999]. Two very common pests when storing ingredients for long periods under suboptimal conditions of little or no ventilation combined with high humidity are insects and moulds. These insects and moulds can reduce the nutrient-rich grains to worthless dust thereby eating away profits. The economic performance of birds and livestock are adversely affected when a contaminated feed ingredient is utilised in the feed [Nilipour, 1996].

Rice bran (RB), which is a by-product in the processing of paddy rice, has been used in several feeding trials with varying results, but generally the RB diets had been found to be cheaper. It has been suggested [Okai, 1998] that RB can be used as a replacement for wheat bran and as a partial replacement for maize or the cereal component of the diet. In one such feeding trial, diets containing up to 50% RB were reported to be satisfactory for growing-finishing pigs [Tuah and Boateng, 1982]. However, in an earlier experiment [Tuah et al., 1974] when RB levels of 40, 50 and 60% were fed to finishing pigs, reduced growth rate ($p<0.05$) was reported. The variability in the results obtained in the two studies mentioned above could, perhaps be due to differences in the nutrient composition of the RB and re-emphasises the need for a study of this nature.

The objectives of the study were to assess the nutrient composition of RB samples from ten mills located in the Kumasi district and its environs, assign reasons for the causes of variability in nutrient composition and determine the status of the RB samples with respect to insects, fungi and bacterial contamination.

MATERIALS AND METHODS

Location of Mills and Sources of Rice Bran

The samples of RB were taken from ten rice mills in Kumasi and some surrounding towns and villages. Samples A, B, D and H were collected from Akwatia Line whilst sample F was collected from Aboabo Zongo, both suburbs of Kumasi. On the Kumasi-Sunyani Road, samples G, J, C, E and I were collected at Abuakwa, Mfensi, Akropong and Koforidua, respectively.

The sources of paddy rice were varied; with the exception of sample I that was produced locally, the paddy from which the RB was obtained for the other samples were from the Brong-Ahafo, Ashanti, Western, Volta, Eastern and the Northern regions of Ghana.

Experimental Outline

Questionnaire and Sample Collection

A questionnaire was prepared with the intention of obtaining information on, *inter alia,* the level of experience of the rice huller's operator(s), the level of maintenance and the educational background of the operator(s) at each mill.

During the administration of the questionnaire, 5 sub-samples of RB were collected from the RB available at each rice mill and later bulked to obtain representative samples of about 1.5kg each. These were put into polythene bags and kept at room temperature at the Microbiological and the Nutritional Laboratories of the Department of Animal Science, KNUST until analyses.

Chemical Analyses:

Triplicates of each sample were analysed for DM, CP, EE, CF and Ash. The NFE was determined by difference [AOAC, 1990]. The NDF and ADF were estimated by the method of Goering and Van Soest [1970] while the hemicellulose contents were obtained by difference.

Microbiological Analyses:

Nutrient, MacConkey and Blood agar were the culturing media used in this study and the streak plate technique was employed throughout. The viable plate count method was used to estimate the bacterial numbers [Atlas, 1995] and the gram staining procedure was adopted in identifying the bacterial species. Sabouraud agar was used in isolating fungi which were then identified using the light microscope [Atlas, 1995].

Statistical Analyses:

The data were analysed by analysis of variance and comparisons among the means were done using th simple t-test [Mstat, 1986].

RESULTS AND DISCUSSION

Questionnaire Details

The study indicated that there were 3 different milling machines in use in the study areas and these are the Satake and Daiichi (imported machine) rice hullers/ polishers and the Magazine # 7 (local machine) rice hullers/polishers. The number of years the operators of the mills have been working ranged from one-and – half to eighteen years. The age of the workers ranged from 15 to more than 46 years with most of them being in the 26-35 years range. Most of the workers at the mills have had no formal education; two have had primary and nine had completed middle or junior secondary school level education. The operator of mill A, however, had been educated to the GCE Ordinary Level. The experience of the millers could influence their output as well as the effective adjustment of the milling mechanisms of the machines to enable efficient separation of the rice hulls from the bran. Operators using the imported rice machines tended to mill more tonnage of paddy rice daily than those using the locally-made machines. For instance mill A, which had an imported machine could mill about 50 bags of 90kg paddy rice daily while mill I (local machine) was barely milling 1 bag of 90kg paddy daily. The locally-made mills produced relatively coarser RB than the imported Daiichi and Satake rice mills.

Chemical Composition

Table 1 shows the analysed proximate composition of the RB samples from the 10 rice mills.

The dry matter (DM) content of the RB samples ranged from 93.97-95.57%. The RB samples from mill B andD were drier ($p<0.05$) than the RB samples from the other mills, probably due to the fact that the samples were collected immediately post-milling. The differential drying times and the qualitative determination, by hand inspection, of the moisture contents of paddy rice at the various rice mills before milling may account for the significant ($p<0.05$) differences in the DM contents of the RB samples.

De Padua [1970] advocated the use of a Universal Moisture Metre and a hygrometer for the accurate determination of moisture content of paddy rice before milling. This would help to reduce losses in head yield by milling at incorrect moisture contents. However, these devices were not available at the mills studied.

Table 1: Analysed Proximate Composition of Rice Bran from the 10 Mills [%, as-Fed basis]

Mill	Rice Mill Type	DM	CP	EE	ASH	CF	NFE
A	Imported	94.96^{b}	7.98^{b}	7.93^{bc}	11.25^{f}	15.18^{f}	52.62^{bc}
B	Imported	95.57^{a}	7.82^{b}	8.27^{b}	9.80^{g}	18.73^{d}	50.95^{d}
C	Locally-made	94.91^{b}	5.50^{f}	5.81^{e}	17.77^{a}	20.87^{b}	44.96^{g}
D	Imported	95.54^{a}	7.91^{b}	10.20^{a}	12.64^{d}	14.38^{g}	50.40^{d}
E	Locally-made	94.85^{b}	5.97^{c}	5.94^{e}	12.97^{d}	20.81^{bc}	49.17^{ec}
F	Imported	93.97^{b}	7.33^{c}	7.44^{d}	9.66^{c}	16.41^{e}	53.10^{b}
G	Locally-made	94.81^{b}	5.23^{g}	5.84^{e}	13.39^{c}	21.83^{a}	48.52^{ef}
H	Imported	94.49^{c}	9.74^{a}	7.69^{cd}	9.16^{h}	14.06^{h}	53.84^{a}
I	Locally-made	94.10^{d}	6.39^{d}	4.78^{f}	11.84^{c}	18.82^{d}	52.27^{c}
J	Locally-made	94.80^{b}	6.10^{c}	5.92^{e}	14.12^{b}	20.50^{c}	48.16^{f}
Std. Error		0.1263	0.1105	0.1979	0.1660	0.1547	0.3417

a, b, c, d, e, f, g, h: Values in the same column with different superscript are significantly different ($p<0.05$).

Generally, the RB studied here were drier than the RB from Iraq (91.1%), Philippines (88.7%) and Guyana (88.7%) as reported by Gohl [1981]. They were, however, comparable to the DM contents for Ghanaian RB (91.10-95.30) reported by Atakora [1982].

The crude protein (CP) values ranged from as low as 5.23 to as high as 9.74%. The mean CP of the RB from mill A, B and D were similar ($p>0.05$). Mill F produced RB of significantly ($p<0.05$) lower CP than the rest of the imported rice machines. This could be due to the fact that the machine was over 18 years old and had some portions of the sieve that separates the hulls from the bran torn at some places. Mill H, however, produced RB of higher ($p<0.05$) CP content than the other imported machines. This could be due to the rich experience of the operator (more than 18 years) as well as the excellent condition of the mill (less than 2 years old). Although mill D was also barely 2 years old, it produced RB of lower ($p<0.05$) CP than mill H. This could be due to the shorter experience of the operators (between 6 months and 2 years). It is also possible that varietal differences in the paddy might have contributed to the differences in the CP contents between the two mills as the paddy rice found at mill H was the red type while the paddy found at mill D was the white type.

Generally, the locally-made rice machines produced RB of lower ($p<0.05$) CP. This could be attributed to the inefficient separation of the hulls from the RB in the locally-made machines since the bran and the husks were voided through a common spout.

The ether extract (EE) contents ranged between 4.78 and 10.20%. Again, the locally manufactured machines yielded RB of significantly ($p<0.05$) lower EE content than the imported Satake and Daiichi mills. The lower EE content could be linked to the adulteration of the RB with rice hulls as a result of the inefficient separation of the rice hulls from the bran. The crude fibre (CF) contents were between 14.06 and 21.83%. The CF value for mill G was significantly ($p<0.05$) higher than the CF values for the remaining mills. There was no significant ($p>0.05$) difference in the CF values for mills C and E. The overall CF levels of the RB samples studied here were generally higher than the acceptable limits for a good quality RB (< 14%) as mentioned by Ensminger and Olentine [1978]. The high CF content could therefore limit the extent to which such RB can be incorporated into non-ruminant diets since they have only a limited ability to digest fibre.

The Ash contents obtained were between 9.16 and 17.77%. Mill C produced RB of higher ($p<0.05$) Ash content than the remaining mills. This could be due to the storage of the bran on a dusty mud floor. Moreover, it was observed that the RB from this mill was contaminated with waste oil from the machine. The NFE values ranged from 44.96-53.84%. The differences obtained in the NFE values were most likely due to the differences obtained in the other proximate components since the value of the NFE is dependent on the EE, CF, CP, CF and Ash contents.

Table 2 shows the analysed ADF, NDF and hemicellulose contents of the RB samples. The mean ADF ranged between 28.45 and 41.64% while the NDF contents were between 37.93 and 55.09%. The significant differences in the ADF values nearly parallel the differences observed in the NDF. The locally-made mills produced RB of significantly ($p<0.05$) higher ADF and NDF contents than the imported rice machines.

As stated earlier, this could be attributed to the rather inefficient separation of the rice hulls from the bran in the locally-made machines. The hemicellulose contents were between 5.98 and 14.57%. The imported machines had a lower ($p<0.05$) hemicellulose content than the locally-made machines. It is likely that the differences obtained in the hemicellulose content were due to the significant ($p<0.05$) differences obtained in the ADF and NDF contents since the hemicellulose content was obtained as the difference of the NDF and the ADF contents. Van Soest and Robertson [1979] reported that, the recovery of cell wall protein in the determination of NDF, which is largely dissolved in the ADF determination results in an apparent increase in the hemicellulose content of feed samples. This observation may account for the high hemicellulose content of the RB from mill H, an imported machine, which had a similar ($p>0.05$) hemicellulose content as mill I, a locally-made machine.

Table 2: Van Soest's Fibre Analyses of Rice Bran from the 10 mills [%, as-Fed basis]

Mill	Rice Machine Type	ADF	NDF	Hemicellulose
A	Imported	28.52^{i}		9.41^{f}
B	Imported	33.90^{g}	37.93^{i}	14.57^{a}
C	Locally-made	40.92^{b}	48.48^{e}	14.17^{b}
D	Imported	31.51^{h}	55.09^{a}	8.11^{g}
E	Locally-made	39.96^{c}	54.20^{c}	14.24^{b}
F	Imported	36.13^{f}	42.12^{f}	5.98^{h}
G	Locally-made	41.64^{a}	54.50^{b}	12.86^{d}
H	Imported	28.45^{i}	40.62^{g}	12.17^{e}
I	Locally-made	39.07^{d}	51.50^{c}	12.43^{e}
J	Locally-made	38.18^{e}	51.32^{d}	13.13^{c}
	Std. Error	0.0808	0.1043	0.1347

a, b, c, d, e, f, g, h, i,: Values in the same column with different superscript are significantly different ($p<0.05$).

Microbial and Insect Infestations

Table 3 shows the mean bacteria colony counts. Sample H and J had the least ($p<0.05$) mean bacteria count of 10.67×10^4 and 13.33×10^4 cfu/g respectively. The RB from mill C, however, registered the highest ($p<0.05$) mean bacteria count of 80.33×10^4 cfu/g. This could be due to the appalling conditions at the mill as RB was stored on a dusty floor littered with chicken faeces. Mills C, E and I registered high ($p<0.05$) bacteria counts of 80.33, 71.00, 66.00 x 10^4cfu/g respectively, perhaps due to the fact that the mills were also used to polish maize. Usually, after the maize milling process proper cleaning and drying may not be feasible before the mill is used for paddy rice milling. This therefore creates a good environment for microbial growth.

Table 3: Mean Bacteria Colony Count in the RB from the 10 mills

Mill	Rice Machine Type	Mean Bacteria Count (cfu/g)x10⁴*
A	Imported	56.33^{c}
B	Imported	31.33^{d}
C	Locally-made	80.33^{a}
D	Imported	18.67^{e}
E	Locally-made	71.00^{b}
F	Imported	17.00^{e}
G	Locally-made	34.00^{d}
H	Imported	10.67^{f}
I	Locally-made	66.00^{b}
J	Locally-made	13.33^{ef}
Lsd = 0.05		2.6710

a, b, c, d, e, f: Values in the same column with different superscripts are significantly different (p<0.05).
**cfu/g is the colony forming units/g. of sample.*

The clean environment and the newness of mill H may account for the low ($p<0.05$) bacteria count of the RB from the mill. Over-aged rice machines might have influenced the proliferation of microorganisms probably because cleaning older, worn-out machines may be more difficult. The RB in the mills were stored on either bare concrete or mud floors and in nylon sacks. Storage of RB on dirty mud floors could increase the risk of contamination with microorganisms.

According to Beck [1976], the actual invasion by moulds and microorganisms occur under storage at high humidity and high temperature. These are the conditions, which prevail in a tropical environment like Ghana, and may account for the presence of microorganisms in all the ten samples. The bacteria identified were *Escherichia coli, Proteus spp.* and *Staphylococcus spp.* These are ordinarily non-pathogenic, but are potentially pathogenic organisms and assumed marked pathogenicity when they gain entrance or are introduced into the parts of the body where they multiply rapidly producing toxins [Lawrie,1991].

The fungi, *Rhizopus spp.* and *Aspergillus spp.* were identified. Some species of *Rhizopus* are pathogenic to plants causing soft rot while some species of *Aspergillus* cause spoilage of foods and fabrics. Fungi can produce mycotoxins either in the field or in storage or both depending on factors such as type of crop, climatic conditions, insect or mechanical damage, storage conditions and subsequent handling [Pans Manual No.3, 1976]. The presence of these fungi in the RB samples should be a matter of concern to animal nutritionists and producers since some of these mycotoxins are carcinogenic.

Only one (1) RB sample (i.e. sample E) contained an insect. Four adults and 3 larvae of *Tribolium sp.* were found in this sample. The presence of the insect in this sample could be attributed to the fact that maize, the primary host of *Tribolium spp.* [Haines, 1991], was stored together with the RB sample at this mill.

Conclusion and Recommendations

The experiment has provided evidence that differences exist in the nutrient composition of RB from different mills. It also revealed that the locally-made machines produced RB of lower nutrient contents in terms of CP, EE but were higher in Ash and CF. It is suggested that the variability in the nutrient composition of RB is due largely to the extent of adulteration of the RB with the rice hulls. It is recommended that to obtain RB of relatively good nutritional value, it must be from rice mills with efficient mechanisms for separating the bran from the hulls. This is especially important for the locally-made machines which should be improved upon to enable efficient separation of the bran and the hulls, since the machine was apparently initially designed for polishing maize, where there is no need for such a separation.

Escherichia coli, Staphylococcus spp. and *Proteus spp.* were present in all the ten RB samples. The moulds *Rhizopus spp.* and *Aspergillus spp.* were also present in all the samples, however, the insect *Tribolium spp.* was found in only one sample suggesting that insect infestation may not be much of a problem in the RB from the study areas. To reduce the level of contamination by moulds and bacteria, it is recommended that there should be efficient drying of the paddy; keeping a clean environment in and around the mills as well as frequent cleaning of the husking and polishing units of the rice hullers would also be very helpful.

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