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CHEMICAL COMPOSITION OF RICE MILLING BY-PRODUCTS; THE MAKURDI VARIANTS

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ABSTRACT

A detailed information on the chemical composition of alternative feed ingredients is needed for feed formulation. Therefore, chemical composition; proximate composition, amino acid profile, phytochemical analysis, mineral and vitamin analysis were carried out on the makurdi variants of rice milling by-products (RMBPs). The RMBPs identified were NPRB-non parboiled rice bran, NPGR-non parboiled grain rejects, NPRP-non parboiled rice polishing, PRB-parboiled rice bran, PGR-parboiled grain rejects and PRO-parboiled rice offal. The CP level of the NPRP was reported to be higher than the other fractions with NPGR having the lowest CP. The PGR had the highest DM and ME with PRO having the least ME value. CF was observed to be higher in PRO with the least value observed in NPGR. The phytochemical screenings of the rice milling by products indicated that these products contain some secondary metabolites found in plants, such as alkaloids, tannins, flavonoids, phenols, saponins, terpenoides, oxalates, phytates and trypsin inhibitor. These phyto chemical substances were observed to be higher in rice bran. The non-parboiled rice bran however had a higher concentration of these plant metabolites. Unexpected however, these metabolites were observed in high concentration in the par boiled grain rejects than in the non-parboiled grain rejects with the exception of alkaloids, tannins, phenols and terpenoids. The amino acid composition of rice milling by-products revealed high amounts of the limiting amino acids (methionine, lysine, trptophan, argentine and thrionine) in the bran than the other rice milling by-products. Similar to the amino acids, vitamins and phytochemical profile, the minerals elements (macro and micro minerals) were observed to be more concentrated in the bran fractions of the rice milling by-products found within Makurdi. Similar to the result of the amino acid profile, greater number of vitamins was recorded in the bran fractions of the rice milling by-products. The parboiled bran fractions however had higher amounts compared to the non-parboiled rice bran. Conversely to the result of the bran, these vitamins were higher in the non-parboiled grain rejects than observed for the parboiled grain rejects with lower values been reported for rice offal. The chemical composition of these makurdi variants of RMBPs obtained in this study compared well to literature values. Their combination with other feed materials can therefore provide a nutritionally adequate diet for farm animals.

Keywords: Feed Ingredients, Chemical Composition, Nutrient Variation.

1. INTRODUCTION

1.1 Description of Problem

Monogastric animals rely on high digestible feeds including maize for energy and soybean for protein but, in most parts of the world particularly the developing countries of sub-Saharan Africa, maize is a staple food for many people and soybean is not readily available. As such these ingredients are expensive and their inclusion in the diets increases the cost of production. High cost of feeds results from the shortage of, and consequently high cost of conventional feedstuffs like maize and soybeans which is exacerbated by competition from direct human consumption and raw materials for industries (Carew *et. al*., 2020). Inadequacy of feed ingredients and high cost of these ingredients has forced many small to medium commercial livestock farmers found in urban and peri-urban areas in Africa to stop or cut down the size of production. There is, therefore, great interest in the potential of any material to serve as feed ingredients.

The search for alternative feed ingredients is driven directly by the economics of the industry with the aim of finding nutrient sources which are at lower costs than those currently in use (Mutayoba *et al.*, 2011). The term alternative ingredient is wide and depends on location where it is used (Mutayoba *et al.*, 2011). In the US and other developed countries an alternative ingredient might mean any energy or protein source other than corn, soybean meal and fat. A broad definition of an alternative ingredient can include the following facts, an ingredient that has not previously been used on a regular basis; an ingredient whose nutrient composition has yet to be fully defined and an ingredient which the maximum level of inclusion is unclear (Mutayoba *et al.*, 2011). Therefore, it is apparent that the key aspects which need to be known about an alternative feed ingredient are nutrient composition, nutrient availability/utilization and inclusion levels. In addition, many alternative feed materials contain secondary compounds that reduce their value as feed materials. The nutrient content especially the micronutrients of most alternative ingredients used in Africa is not known due to lack of advanced analytical facilities. Most of the formulations are based on major nutrient composition such as crude protein, crude fiber, ash and fat, which in most cases do not clearly indicate the availability and utilization of nutrients by animals (Mutayoba *et al.*, 2011). Therefore, the objective of the present study was to determine the detailed chemical composition of rice milling by-products in Makurdi. The processing of paddy rice into edible product in Nigeria is increasing rapidly in both quantity and sophistication. Thus, large quantities and more types of rice milling by-products are being turned out.

2. MATERIALS AND METHODS

2.1 Chemical Analysis

Proximate composition of rice offal, rice bran, grain rejects, the experimental diets as well as the faecal samples collected during digestibility trial were determined using the methods described by A.O.A.C. (2002). The metabolizable energy contents of the test ingredients were calculated by the use of the following equation ME (kcal/kg) = [37 x % CP + 81 x % EE + 35.5 x % NFE + 35.5 x (0.22) % CF] (Pauzenga, 1985 as Modified by Carew, 2016; verbal communication). The basis of the modification being that rabbits use caecal micro-organisms to digest approximately 22 % CF into NFE).

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Where, ME=Metabolizable Energy, CP=Crude Protein; EE=Ether Extract and NFE= Nitrogen Free Extract. The phyto-chemical analysis was carried out using the general procedure as described by Harbone (1993) and Olaniyi *et al*. (2018). Determination of amino acids was by the high-performance liquid chromatographic (HPLC) method described by ASEAN (2011). The methods described by Thomas *et al.* (2015) was used for mineral analysis. Determination of vitamins (thiamine and riboflavin) was by the HPCL, while niacin and B complexes was by microbial assay and vitamin C by the micro-fluorometric method as described by ASEAN (2011).

3. RESULTS AND DISCUSSION

3.1 Proximate composition of rice milling by-products

The result of proximate composition is shown in Table 1. Result revealed that parboiled rice offal contained 7.69% CP. However, 6.00%, 6.00-7.00% and 4.38% was reported by Aduku (1993), Harris and Staples (1990) and Anongo (2017) respectively. The Crude fibre of 28. 33% in this study was lower than 33%, 34.73%, 36.90% and 30.07% reported by Aduku (1993), and Anongo (2017) respectively. This result was however similar to 28.00% reported by Harris and Staples (1990). Ether extract, NFE and ash were 4.40%, 37.07% and 16.77% respectively. These values with the exception of NFE were lower than those reported by Anongo (2017). Though the proximate fractions in rice offal did not agree with earlier findings, differences were not wide which would probably have resulted from the rice varieties used for this study. Expectedly, ash and fibre contents were high while reduced protein and NFE observed in this study affirmed the report of Kalpanadevi *et al.* (2018) who earlier reported that the outer layers of rice grain have the highest fibre and ash contents and this decreases towards the centre of the grain.

The proximate composition of rice bran in this study revealed the crude protein values of 11.00% and 12.06%, crude fibre of 11.92% and 10.57% for non-parboiled rice bran and the parboiled rice bran respectively; higher than values 8.19% and 7.00% reported by Anongo (2017) for parboiled rice bran. According to Medugu *et al.* (2011) rice bran normally contains 9 to 18 % crude protein and 10 to 14 % crude fibre. Similarly, Hossain, *et al.* (2012) also reported crude protein level of 13.2 to 17.1 % and fibres 9.5 to 13.2 % respectively. While the present study reported values of crude fat of 9.36 % and 5.51 % for non-parboiled and parboiled rice bran respectively, Hossain *et al.* (2012) reported that beside crude protein rice bran contains an appreciable level of crude fat ranging between 14.0 %- 22.9 %, Aduku and Olukosi (1992) reported 15 % EE implying that, values obtained in the present study were lower than reported by these authors. The high fibre, low ash contents in rice bran compared to polishing can be attributed to the relatively lesser endosperm breakages and consequently, lower contamination with starch. Thus, fibre content decreases with an increase in the degree of milling.

As reported by Hossain *et al.* (2012) rice polishing are a good source of protein (13.2 to 17.1 %), fat (14.0 to 22.9 %) and fiber (9.5 to 13.2 %). This report compared well with the result of this study with the exception of crude fat which was found to be lower than 14.0-22.9 % reported by Hossain *et al.* (2012). Expectedly, compared to rice bran, the reduced fat, fibre, ash and an increase in the NFE contents observed in rice polishing could be related to the excess breakages during milling, removal of the inner endosperm during further cleaning and shaping leading to progressive dilution of the polishing fraction with starch.

Grain rejects (GR) consist of a mixture of discoloured grains, immature grains (slender and chalky), the wild variety of rice as well as other foreign materials (Trigo-stockli and Pederson, 1990). These rice grains are therefore separated from the head rice to prevent contamination hence termed ''Rice grain Rejects.'' Anongo (2017) reported values of 5.25 %, 4.00 %, 6.80 %, 3.30 %, and 71.35 % of CP, CF, EE, Ash, and NFE respectively for rice grain rejects. These values were higher than those obtained in the present study for both parboiled and non-parboiled grain rejects with the exception of CP in the parboiled sample. Variations in chemical composition are typical of agricultural by-products (Mutayoba *et al.*, 2011). This could partly account for the differences observed in the present study and previous authors. The degree of milling, rice varieties which could probably affect the distribution of the various nutrients within the rice grain and milling process/principles performed could be responsible for the differences observed. It can also be observed that there was little effect of parboiling on the proximate fractions of the rice milling by-products.

Table 1: Proximate Composition of Rice Milling By-products

Constituents(%)	NPRB	NPGR	NPRP	PRB	PGR	PRO
DM	92.56	93.82	93.00	98.81	98.52	98.25
Moisture	7.44	6.18	7.00	6.19	1.48	5.75
CP	11.00	6.56	13.19	12.06	10.57	5.51
CF	11.92	0.45	9.85	10.57	3.34	28.33
EE	9.36	2.10	2.38	5.51	1.93	4.40
Ash	4.74	0.96	1.83	9.55	0.90	16.77
NFE	55.54	83.75	65.75	56.12	83.60	37.06
*ME(Kcal/Kg)	3280.88	3389.65	3092.10	2967.89	3455.10	2178.06

NPRB-non parboiled rice bran, NPGR-non parboiled grain rejects, NPRP-non parboiled rice polishing, PRB-parboiled rice bran, PGR-parboiled grain rejects, PRO-parboiled rice offal, DM-Dry matter, NFE-nitrogen free extract, ME- *metabolizable energy (pauzena, 1986; modified by Carew 2016; Anongo, 2017) = 37X%CP + 81.1X%EE + 35.5X%NFE + 35.5(0.22) %CF

3.2 Phytochemical Constituents of Rice Milling By-Products

The phytochemical screenings (Table 2) of the rice milling by products indicated that these products contained some secondary metabolites found in plants, including alkaloids, tannins, flavonoids, phenols, saponins, terpenoides, oxalates, phytates and trypsin inhibitor. This result showed that the phytochemical constituents of rice reside more in the bran fractions of rice, thus, affirming an earlier observation by Moko *et al*. (2014) who reported that phytochemical compounds would accumulate in the pericarp and testa of the rice kernel. Expectedly, the phytochemical screening revealed that these plant metabolites were higher in the non-parboiled fractions including grain rejects and the polishing compared to their par boiled counterparts. The processing (parboiling) of rice before milling could partly explain the decrease in the level of phytochemicals in the parboiled fractions of the milling by products. This was in-line with the findings of Pal (2011) who observed that, anti-nutritional factors are mostly associated with bran fraction, protein in nature and thus heat labile except phytin. This suggests that, par boiling could be one processing method that can be used to reduce the levels of these plant metabolites and thus, minimising their anti-nutritional effect on animals

Table 2: Phytochemical Profile of Rice Milling By-products in Makurdi

Constituents(mg/100g)	NPRB	PRB	PGR	PRO	NPGR	NPRP
Alkaloids	1180.13	1050.82	993.15	676.19	880.34	706.79
Condensed tannins	51.14	60.49	71.22	80.93	74.12	83.12
Hydrolysable tannins	739.10	606.34	415.78	294.15	383.65	203.14
Flavonoids	1479.34	1225.68	918.50	611.60	720.13	503.12
Phenols	903.10	702.16	304.18	206.71	418.76	177.53
Saponins	411.67	304.39	200.14	177.64	194.14	208.21
Terpenoids	93.12	70.85	31.88	21.59	45.67	39.49
Oxalates	11.40	17.12	12.33	9.10	7.11	8.08
Phytates	186.76	150.50	112.80	95.68	102.80	89.71
Trypsin	56.88	45.06	78.31	81.40	88.19	101.50

NPRB-non parboiled rice bran, NPGR-non parboiled grain rejects, NPRP-non parboiled rice polishing, PRB-parboiled rice bran, PGR-parboiled grain rejects, PRO-parboiled rice offal.

3.3 Amino acid profile of rice milling by-products

The amino acid profile (Table 3) revealed that rice milling by products contain the essential amino acids (methionine, lysine, tryptophan and argenine) that are limiting in rabbit nutrition. These values were comparable with the previous works of Aduku and Olukosi (1993) and Leeson and Summers (2008). The methionine content reported in this study was 0.21 % and 0.25 % for the PRB and NPRB respectively; similar to the amount reported by Aduku and Olukosi (1993) and Leeson and Summers (2008). While the lysine contents of both PRB and NPRB reported in this study were lower than 0.51 % reported by Leeson and Summers (2008), tryptophan and Argenine were however higher than reported by Aduku and Olukosi (1993), Leeson and Summers (2008) and Batal and Dale (2010). While methionine, argenine and lysine for NPRP in this study were lower than 0.21 %, 0.6 % and 0.5 %, tryptophan was however higher than 0.12 % reported by Leeson and Summers (2008). The high levels of nutrients reported in the bran also affirm the report of previous researchers, notably; the work of Satter *et al.* (2014) who reported that, rice bran contains about 65 % of the nutrients. During milling process, rice containing nutrients is completely removed with bran. The values (0.08 %, 0.11 %, 0.30 % and 0.26 %) for methionine, lysine, tryptophan and argentine respectively reported in this study compared favourably with the values reported by Aduku and Olukosi (1993) for the PRO. The variations among the amino acid composition of the different portions of the rice milling fractions can also be attributed to be reflections of differing protein composition. It is known for instance, that the bran protein contains higher amounts of the water-soluble albumins and salt soluble globulins than those found in the rice kernel (Houston *et al.*, 1969). Results of NPGR and PGR also show the presence of an appreciable level of methionine, lysine, tryptophan, argentine and other amino acids. Data on grain rejects and polishings are scarce and result obtained could not be compared as results for nutrients composition of grain rejects and polishings could not be found in literature. This could partly be explained by the fact that these

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products are relatively new entrants in and for use in animal nutrition particularly in the developing countries like Nigeria.

Table 4: Amino Acid Profile of Rice Milling By-Products available as Feedstuff for Livestock Production in Makurdi

Constituents(%)	PRB	NPRB	NPGR	PGR	NPRP	PRO
Aspartic acid	7.11	8.39	5.67	4.50	3.21	2.88
Serine	10.25	11.44	9.11	7.94	8.03	8.56
Glutamine	3.56	2.33	1.89	1.02	0.29	0.72
Glycine	4.08	4.97	3.54	3.01	1.77	2.55
Proline	9.33	7.45	6.03	5.12	4.33	3.07
Methionine	0.21	0.25	0.13	0.10	0.05	0.08
Lysine	0.30	0.38	0.25	0.18	0.10	0.11
Alanine	2.16	2.21	1.92	1.34	1.02	1.11
Leusine	0.38	0.35	0.20	0.17	0.18	0.12
Cysteine	4.81	7.22	4.04	3.71	2.80	2.55
Tyrosine	11.21	10.47	9.61	7.31	5.10	6.06
Histidine	1.17	1.24	1.10	0.56	0.17	0.10
Threonine	0.98	1.02	0.57	0.42	0.06	0.08
Tryptophan	0.37	0.42	0.31	0.28	0.20	0.30
Phenylalanine	1.22	1.91	1.74	1.33	1.27	1.37
Isoleusine	0.65	0.81	0.40	0.28	0.14	0.10
Argenine	0.54	0.75	0.44	0.27	0.20	0.26
Valine	1.18	1.12	1.05	0.95	0.68	0.77

NPRB-non parboiled rice bran, NPGR-non parboiled grain rejects, NPRP-non parboiled rice polishing, PRB-parboiled rice bran, PGR-parboiled grain rejects, PRO-parboiled rice offal

3.4 Minerals Composition of Rice Milling By-Products

Result of the inorganic constituents of the rice milling by products revealed an appreciable level of both macro and trace minerals valuable in animal nutrition. Result is shown in Table 4. These minerals were however higher in the bran fractions of the milling by-products thus agreeing to an earlier inference made by Satter *et al.* (2014). They inferred that, rice bran constitutes 8 % of the weight of the whole grain that contains about 65 % of the nutrients therefore, during milling process; rice containing nutrients is completely removed with bran. Bran is the coarse outer covering of grains separated during processing. Rice bran is an incredible source of vitamins, amino acids, essential fatty acids, dietary fibre and more than 100 antioxidant nutrients that helps to fight against disease and promote good health (Satter *et al.*, 2014) and it contains high amount of beneficial antioxidants including tocopherols and oryzanols. It is a rich source of B-vitamins and minerals such as phosphorus, potassium, iron, copper and zinc.

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Table 4: Mineral Profile of Rice Milling By-Products in Makurdi

Constituents (g/100g)	PRB	NPRB	NPGR	PGR	NPRP	PRO
Calcium	809.21	681.34	503.81	409.21	388.89	433.09
Phosphorus	474.70	366.10	251.60	201.02	193.76	188.63
Potassium	285.62	202.60	144.80	161.90	100.40	141.60
Sodium	161.40	181.20	100.30	120.10	11.10	98.85
Zinc	129.50	100.30	81.71	90.82	76.21	70.62
Manganese	92.10	71.44	50.90	46.61	41.72	48.63
Magnesium	56.89	30.90	31.21	29.76	27.71	26.83
Iron	9.33	7.21	5.20	5.06	2.77	2.68
Copper	6.79	9.68	8.61	4.11	2.87	2.02
Selenium	10.40	12.35	10.03	9.80	8.11	8.31

NPRB-non parboiled rice bran, NPGR-non parboiled grain rejects, NPRP-non parboiled rice polishing, PRB-parboiled rice bran, PGR-parboiled grain rejects, PRO-parboiled rice offal.

3.5 Vitamin Composition of Rice Milling By-Products

Vitamins are essential organic compounds implicated in health, normal growth, and maintenance of life and metabolic processes of all living organisms (Table 5). Result of this study revealed a high concentration of the vitamins in the bran (PRB and NPRB) fractions than the polishing, the grain rejects (NPGR and PGR) and rice offal (PRO) in that order of the rice milling by products. Results published by Free nutrition facts (2021) on the vitamin components of rice bran were: vitamins B-1 2.27mg, B-2 0.28mg 5mg, B-3 33.99mg, B-5 7.39mg, B-6 4.10mg, B-9 63mg, E 4.92mg, K 1.9ug. These values were similar to values obtained in this study with the exception of vitamins B-1 in concentrations of 16.08mg and 10.06mg for PRB and NPRB respectively. Vitamins content were expectedly higher in the bran fractions. Both the PRB and NPRB fractions did not show remarkable differences in their vitamin profile, suggesting little effect of the pre-treatment (steeping or parboiling) on their composition.

In general, result of the nutrients' profile were comparable with those reported by earlier researchers. Being by products, sample characteristics are expected to vary widely due to differences in method, machinery and thoroughness of processing. All the proximate fractions with the exception of nitrogen free extract were concentrated in the bran and decreases as the degree of milling increases thus; milling beyond the polishing would result in the loss of the nutrients. The above observation validates an earlier finding of Bhat *et al.* (2019) who reported that, milling of rice to higher degrees has been found to result in the loss of essential amino acids, minerals, fibre and vitamins. The depletion of soil nutrients is a consequence of continuous cultivation. This has led to the development of certain agricultural practices including fertilizer application, herbicides and other chemicals as well as improved seed varieties aimed at improving yield. These practices are adopted today by farmers. These reasons have resulted in the change of the soil characteristics which may partly be responsible for the differences in the nutrients profile of the rice milling by products observed in the present study with previous research findings. This is validated by the report of Ogunyemi *et al*. (2018) in a study to investigate the effect of inorganic and biochar fertilized soils on the proximate composition and mineral contents of maize. Their result revealed a significant variation in the chemical composition of the maize grown on inorganic and biochar fertilized soils. Similarly, Liu *et al.*

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(2021) reported that, there exist variations in the nutritional quality of pepper fruits grown on soils with different physical and chemical properties. This implies that there is a certain relationship between the nutritional qualities of the plant and the soil chemical and physical properties.

The technology and techniques of processing of paddy rice into edible product in Nigeria has also increased in sophistication over time. This suggests that the degree of milling would leave products with wide variations in their chemical compositions. Though previous findings fail to provide a clear distinction as to whether the products analysed were parboiled before milling or not, the researcher is of the opinion that time of pre-treatment (soaking and steaming called parboiling) could also result in the differences in the nutrients' composition of the rice milling by-products as observed in the present study compared to other findings.

Table 5: Vitamin Profile of Rice Milling Fractions in Makurdi

Constituents(Mg/100g)	PRB	NPRB	NPGR	PGR	NPRP	PRO
Vitamin A(µg)	54.78	31.91	25.37	20.11	17.05	10.33
Vitamin B1	16.08	10.06	9.18	8.07	6.88	5.81
Vitamin B2	5.73	4.77	1.89	0.72	0.56	0.34
Vitamin B3	20.81	15.50	12.46	10.41	9.84	8.05
Vitamin B6	2.33	2.02	1.98	0.84	0.33	0.57
Vitamin B7	1.77	0.68	0.41	0.27	0.16	0.10
Vitamin B9	13.84	10.57	8.62	6.11	5.11	5.08
Vitamin B12	8.43	5.02	3.01	2.20	1.05	0.86
Vitamin D	12.21	10.85	9.82	8.11	4.77	3.92
Vitamin E	2.40	4.83	1.96	0.83	0.62	8.31
Vitamin K	1.85	1.02	0.74	0.66	0.84	0.95

NPRB-non parboiled rice bran, NPGR-non parboiled grain rejects, NPRP-non parboiled rice polishing, PRB-parboiled rice bran, PGR-parboiled grain rejects, PRO-parboiled rice offal

4. CONCLUSIONS AND APPLICATION

1. Given the chemical composition of both the parboiled and non-parboiled by products (rice offal, rice bran, rice polishing and grain rejects) revealed by the results of the proximate analysis, amino acid profile, phytochemical screening, vitamin profile and mineral contents, it can be inferred that these materials are valuable feedstuff in rabbit nutrition. Their combination with other feed materials can therefore provide a nutritionally adequate diet for the rabbits.

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