

Nutritional Composition and Phenolic Compound Profile of Three Different Sudanese Rice Types Denoted Locally as Crown, Narica and Pabenjeda

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Abstract – Nutritional composition and phenolic compound profile of three different rice types denoted locally as Crown (CR), Narica (NR) and Pabenjeda (PR) grown in Sudan were assessed. Different analysis was carried out including: proximate composition, minerals elements, sugars, essential amino acids and phenolic compound. The results obtained revealed significant ($p < 0.05$) difference in components between the three different rice varieties. Crown rice (CR) contained the highest levels of protein, ash, glucose, sucrose, fructose, Lysine, Methionine, Phenyl alanine, Tyrosine, Leucine, Isoleucine, Therionine, Na, K and Fe. While the highest carbohydrate, cystine, isoleucine, valine and Zn were recorded for Pabenjeda rice (PR). Regarding fat, Ca and Mg data showed that Narica rice contained the highest level of them. Crown rice had the highest total phenol value of 100 (μ /g GAE) as compared with the other local rice varieties. Pabenjeda rice recorded 40(μ /g GAE total phenol. While Narica rice was recorded the lowest total phenol level. Therefore, nutritional components of tested local rice were type or variety dependent. Thus the findings support selection of the suitable local rice types for food formulation based on their nutritional components and amount existing.

Keywords – Sudanese, Rice, Types, Composition, Phenol.

I. INTRODUCTION

The increased rate of morbidity and mortality due to nutritional deficiencies in economically compromised countries encouraged the production of cost effective high nutritional functional food from local ingredient as functional food. Despite the fact that Sudan is rich with its resources, yet many people are below poverty line. Therefore, optimal use of local ingredients to produce functional food for special groups is a target for researchers.

Cereals are the most important food crops worldwide and considered as staple food crops both directly for human consumption and indirectly via livestock feed [1]. As stated [2] cereal consumption directly provides about 50 % of the protein and energy necessary for human diet. Moreover, cereal based food is a rich source of vitamins, minerals, carbohydrates, fats, oils and protein [3].

Among cereal, rice (*Oryzasativa L.*) has been cultivated in warm climates for tens of thousands of years. It is one of the most important crops and the staple food for two-third of the world's population. Over 95 % of world production of rice is used for human consumption, representing principal food in Asia and in some countries in Africa and Latin America [4]. It was estimated that when world population reaches 8.3 billion in 2030, most people will eat rice to meet the challenges of feeding on growing world population [4]. Currently, rice also represented one of the largest consumed agricultural crop in the world, only next to maize. Rice had been consumed as milled rice after dehulling process and whitening (removal of pericarp, bran layer and embryo from brown rice [5]. On the other hand, rice is a good source of B complex vitamins which plays an important role in the overall development of the baby including physical and brain development. The proteins found in rice are very useful for muscle development. The amino acids found in rice protein help in rejuvenating muscles after stretching and contracting. The amino acids in rice also help in building ligaments and tendons [6].

Studies that had conducted in cooperation with Japan International Cooperation Agency (JICA) during 1973-78 periods to prove the feasibility of growing rice in White Nile State as the average productivity for the experiments reached 9.9 tons per hectare under irrigated low land cultivation. Flooded rice is being cultivated traditionally (local varieties) at Kosti area on White Nile state banks about 5000-8000 hectares with average productivity of 3.5 tons per hectare. In spite of the fluctuation of the productivity of rice in 1990's, its cultivated area has been increased three times and its productivity reached about 3.5 tons per hectare [7]. Rice development policies at national level are designed to provide necessary technical assistance to enhance rice productivity and promote its cost effectiveness in Sudan in support of the national efforts in food security and poverty alleviation. Therefore, this study was conducted to explore the chemical composition and functional ingredient (phenolic compound) of three different Sudanese rice types denoted locally as Crown, Narica and Pabenjeda.

II. MATERIALS AND METHODS

2.1 Rice varieties

Long grain rice locally denoted (Crown) planted in Sudan was collected from supermarket in Khartoum State, Pabenjeda rice is a wild rice grown in white Nile State was collected from the local market in (Kosti Town), and Narica rice planted in Algezira scheme was obtained from the Rice Department, Ministry of Agriculture, (Khartoum – Sudan). Care was taken to ensure that good quality of rice grains was selected.

2.2 Proximate composition

All analysis of moisture, protein, fat, crude fibers and ash contents were determined according to the methods of [8]. The total carbohydrate was calculated by difference.

2.3 Minerals contents

Analysis of the Iron (Fe), Calcium (Ca), Potassium (K), Zinc (Zn), Manganizum (Mg) and Sodium (Na) was carried out according to the standard atomic absorption spectrophotometric (Model 210 VGP) method of [9].

2.4 Determination of total sugars

The sugars profiles of different rice samples were determined using HPLC as described in [10]. HPLC used for analysis consisted of an auto-sampler (SIL –Method of sugar analysis by Hplc 10 ADvp, Shimatzu, Kyoto, Japan) and binary pump system (LC10ADvp solvent delivery module, Shimatzu, Kyoto, Japan), column oven (CTO-10 ADvp, Shimatzu, Kyoto, Japan)., 20 micro liter of sample were injected onto normal –phase column (shim-pack clcNH₂ (4.6mm i.d *15 cm, 5μ practical size Shimatzu, Kyoto, Japan) equipped with a guard column of the same material. The prepared sample solution was filtered by filter paper (Whatman International Limited, Kent, England) and followed by syringe filter 0.2 μm (Germany) into a sample vial and 20μ was injected into the column. Sugar was eluted and elution was carried out with isocratic mobile phase consisting of 80:20 acetonitrile /water at 30 °C and a flow rate of 1ml/min, the retention times of fructose, glucose and sucrose sugar monitored using the refractive index detector (RID10A. Shimatzu, Kyoto, Japan; the retention time obtained was compared to that determined using standards of these sugars.

2.5 Determination of amino acid profile

The essential amino acids was determined by [11] official method 999.13 using amino acid analyzer where extracted amino acid were dissolved in 0.1 M HCl and diluted with sodium citrate buffer. Norleucine internal standard solution was added and the amino acids were separated by an amino acid analyzer using a cation exchange resin and sodium citrate buffer eluent solutions. The amino acids are measured following post – column reaction with ninhydrin.

2.6 Determination of phenolic compound

0.200 g of sample was weighed in an extraction tube, and 5 ml of 70% methanol. The extract was mixed and heated at 70°C on a vortex for 10 min. After cooling at room temperature, the extract was centrifuged at 200g for 10 min. The supernatant was decanted and extraction step was repeated twice. Both extracts were pooled and the volume adjusted to 10 ml with 70% methanol. Phenols react with phosphomolybdic acid in Folin-ciocalteu reagent in alkaline medium and produce a blue colored complex (molybdenum blue) that can be estimated colorimetrically at 765 nm.

The total polyphenol content (TPC) was determined by spectrophotometry, using gallic acid as standard, The concentration of polyphenols in samples was derived from a standard curve of gallic acid ranging from 10 to 50 µg/mL (Pearson's correlation coefficient: $r^2 = 0.9996$).

2.7 Statistical analysis

One - way ANOVA was performed to examine significant differences between normally distributed data of replicated independent runs. A possibility level of less than 0.05 was believed significant ($p < 0.05$). All data were analyzed using vision 17 MINITAB statistical software for windows [12].

III. RESULTS

3.1 Proximate composition of different rice varieties

Crude fat, crude protein, ash, crude fiber, and carbohydrates results for the Crown rice (CR), Narica rice (NR), Pabenjeda rice (PR) are presented in Table (1). There were significantly ($P < 0.05$) differences in components between different rice types. No significant ($P < 0.05$) differences in fat and ash levels of CR and NR. It is clear that Narica rice has the highest content of crude fat (1.46%), while Pabenjeda rice recorded the lowest level (1.03%). When comparing the result of the three types of rice, the percentage of fat content was in the range from 1.03 to 1.46 %.

Referring to the results in Table (1) Crown rice contained the highest content of protein (11.40 %). Narica rice verified the lowest protein percentage of 7.53%. , the higher amount of protein content in Crown rice might be due to the parboiling process of the Crown rice, parboiling process involves soaking rough rice overnight or longer in water at ambient temperature, followed by boiling or steaming the steeped rice at 100°C to gelatinize the starch, while the grain expands until the hull's lemma and palea start to separate (Gariboldi, 1984). While the other two varieties are manually dehulled. Generally crude protein content of the three rice varieties involved in this study was in the range of 11.40 to 7.53%.

The ash content of a food sample gives an idea of the mineral elements present in the food sample [13]. Regarding the ash content in this study as shown in Table (1), Crown rice has the highest ash content (1.03 %) and Pabenjeda rice was the lowest in ash level (Table 1). There were significantly ($P < 0.05$) differences in fiber between different rice varieties (Table 1). The percentage of fiber content among the three rice varieties were in the range of 0.24 -1.20%. Results presented in Table (1) showed significant ($P < 0.05$) difference in carbohydrate between different rice varieties (CR, PR and NR). The highest carbohydrate content of 90% was recorded for PR followed by NR and then CR.

Table 1: Proximate composition (%) of different rice types

Raw materials	Fat	Protein	Fiber	Ash	Carbohydrate
Crown Rice	1.45±0.07 ^a	11.40±0.05 ^a	1.20±0.00 ^a	1.03±0.11 ^a	84.25±1.01 ^c
Narica Rice	1.46±0.09 ^a	7.53±0.04 ^c	1.08±0.06 ^b	1.00±0.03 ^a	88.93±1.13 ^b
Pabenjeda Rice	1.03±0.07 ^b	8.03±0.05 ^b	0.24±0.01 ^c	0.70±0.25 ^b	90.00±0.16 ^a

Values are mean ± SD for triplicates independent analysis on dry basis.

Values carrying the different superscript letter in the same column are significantly difference at $P < 0.05$.

3.2 Sugars profiles of the different local types of rice

Data in Table (2) ascertained significant differences ($P < 0.05$) in glucose, sucrose and fructose between different local rice varieties. Crown rice recording the highest values of 0.161, 1.524, 0.117 mg /L of glucose, sucrose and fructose, respectively. Pabenjeda rice contained 0.119 mg/L glucose, 1.39 mg /L sucrose and 0.052 mg /L fructose. Narica rice contained the least level of glucose (0.053 mg/L) and sucrose (0.434 mg/L).

Table 2. Sugar profile (mg/L) of different rice varieties

Rice Type	Glucose	Sucrose	Fructose
Crown Rice	0.161±0.01 ^a	1.52±0.01 ^a	0.117±0.01 ^a
Narica Rice	0.053±0.00 ^b	0.43±0.02 ^c	N.D
Pabenjeda Rice	0.119±0.03 ^c	1.39±0.00 ^a	0.05 ±0.03 ^b

Values are mean ± SD for replicate independent analysis.

N.D: Not Detected

Values that bear different superscript letter in the same column are significantly different at $p < 0.05$.

3.3 Amino acid composition of the different rice varieties

In nutritional terms, there are two main factors of prime importance in relation to protein, namely the total protein content and the concentration of essential amino acids in the food. Rice protein, when compared to that of other grains is considered as one of the highest quality proteins. It has the essential amino acids, necessary building blocks for strong muscles. However, lysine is the main limiting amino acid in cereal grains including rice. The amino acids result of different rice varieties illustrated in Table (3) revealed that Crown rice had the highest content of Lysine, Methionine, Phenyl alanine, Tyrosine, Leucine, isoleucine and Therionine. However, rice pabenjeda contained the highest level of amino acid cyctine. While Narica rice and crown rice contained equal value of isoleucine. Valine highest level was identified in Pabenjeda rice. Regarding the limiting amino acid lysine.

Table 3. Amino Acid profile (mg/100 mg) of the three varieties of rice

Amino acid Content	Rice group		
	Crown Rice	Narica Rice	Pabenjeda Rice
Lysine	3.2	3.1	2.6
Methionine	1.5	1.4	1.3
Cyctine	1.4	1.6	1.8
Phenyl alanine	4.8	4.5	3.9
Tyrosine	4.8	4.6	3.9
Isoleucine	3.3	3.3	2.6
Valine	4.6	4.6	3.9
Leucine	6.6	6.3	5.5
Threonine	3.0	2.6	2.4

Values are for single trial analysis.

3.4 Minerals content of different rice varieties

Table (4) showed that the Na, K, Ca, Mg, Fe and Zn of the different rice varieties. Crown rice (CR) contained the highest value of Na, K and Fe recording 44.2, 11.04 and 0.724 mg/L, respectively. While rice pabenjeda (PR) contained the highest value of Zn recording 0.591mg/L. Regarding Ca and Mg data showed that Narica rice contained the highest level of them amounting 0.505 and 18.8 mg/L, respectively. The Na content of the three rice varieties ranged from 44.2to 0.839 mg/L.

Table 1. Minerals composition (mg/l) of the rice varieties

Raw materials	Na	K	Ca	Mg	Fe	Zn
Crown Rice	44.2	11.04	0.379	1.779	0.724	0.51
Narica Rice	1.591	6.20	0.505	18.80	0.416	0.468
Pabenjeda Rice	0.839	10.47	0.232	3.37	0.248	0.591

Values are for single trial analysis.

3.5 Total phenols compound of the different rice varieties

The general definition of phenolic compound is any compound containing benzene ring with one or more hydroxyl groups. The phenolic acids, flavonoids, condensed tannins, coumarins and alkyl – resorcinols are examples of phenolic compounds as stated by [14]. All plant based foods have phenols affect their appearance, taste, odor and oxidative stability, and increase dietary fiber levels and nutraceutical properties. Phenolic compounds have antioxidant properties and can protect against degenerative diseases, such as heart diseases and cancer, in which reactive oxygen species are involved [14]. The phenolic compound levels in different rice varieties was revealed in Table (5). It showed that crown rice had the highest total phenol value of 100 (μ /g GAE) as compared with the other local rice varieties. Pabenjeda rice recorded 40(μ /g GAE total phenol. While Narica rice was recorded the lowest total phenol level from among the different local rice types (Table 5).

Table 5. Total Phenolic compound content of rice varieties (μ /g GAE)

Rice Type	Total phenolic (μ /g GAE)
CR	100
NR	20
PR	40

Values are total phenolic compound for single trial analysis.

GAE stands for gallic acid equivalents

IV. DISCUSSION

When comparing the result of the three types of rice, the percentage of fat content was in the range from 1.03 to 1.46 %. This finding was within the range of 0.5 – 3.5 % fat previously [13] for five major rice varieties planted in Nigeria. However, fat content of Crown rice (1.45 %) and Narica rice (1.46%) were higher than the level of 1.26 % reported in [15] for rice planted in Malaysia. At the same time fat content of the three rice varieties in this study was lower than the value 1.60% testified for rice planted in Egypt [16]. Whereas Pabenjeda rice contained 1.03% fat which, was lower than the value recorded in [15] and [16]. These variations in fat content of rice between countries might be attributed to variety types and compositions of rice grain particularly, the bran outer layer where most of the fats are concentrated [17]. Generally crude protein content of the three rice varieties involved in this study was in the range of 11.40 to 7.53%. This range is much higher than 1.58 - 6.22 % protein obtained in [13] for Nigeria rice varieties. However, the protein percentage of Crown rice (11.40%) is much higher than the levels of 8.38% and 7.10% reported in [16] and [15], respectively. Even Narica rice contains 7.53 % protein which was higher than the value 7.10% reported in [15] but it is lower than the value 8.38% recorded in [16]. This differences in protein content of rice may be attributed to variety type and treatment of prolonged parboiling which lowers the protein content of rice and some other environmental and adapted factors. Ash content of the three local varieties was within the range of 0.5 -2.0% for rice varieties planted in Nigeria but higher than 0.70 % of Malaysian rice variety [15]. The percentage of fiber content among the three rice varieties were in the range of 0.24 -1.20%. This range of fiber was a bit lower than the values 1.5 - 2.0%, 1.93 - 4.3% and 1.17% achieved in [13], [18] and [15], respectively. Whereas fiber value of 1.14% recorded in [16] was with the range of the result in Table 1. The main source of fiber in cereal grain is the bran; therefore, de-hulling of rice generally decreases the fibre contents of rice [19]. The carbohydrate values of NR and PR were higher than values 76.92 – 86.03 %, 89.42 % and 87.17 % obtained in [13], [15] and [16], respectively.

Regarding the limiting amino acid lysine, Crown rice contained approximately similar level reported in [15] for different rice; while Methionine and cystine levels were lower. Crown rice value of phenylalanine and was similar to value 9.6 mg/100mg

described in [15]. Concerning isoleucine, valine, leucine and threonine of the three local rice varieties their highest values were lower than the rates of 4.69 mg/100mg, 4.8 -6.3mg/100mg, 8.6 and 3.92mg/100mg reported in [15] for Malaysian rice, respectively.

The Na content of the three rice varieties ranged from 44.2 to 0.839 mg/L. These values were higher than the Na level in rice planted in Nigeria (0.13 -0.17 mg/L) obtained in [13]. Ca content of the three local rice types (0.232 - 0.379 mg/L) was much higher than the level of 0.07-0.11 mg/L reported in [13]. The Sudanese planted rice in this study indicates that the Mg content (1.8-18.0 mg/L) was much higher than the level of 0.19-0.23 mg/L for Nigeria rice varieties [13]. Iron (Fe) level of crown rice (0.724 mg/L) was higher than its level in Nigerian variety (0.52 mg/L). As displayed in Table (4) shows that the three local rice types contained higher level of Zn (0.461 - 0.51) in comparison to its value in Nigeria rice varieties ([13]. These variations in different mineral elements between rice types or varieties might be due to fertilizer application, variety variances the amounts of soil nutrients and rate of parboiling of rice.

Crown rice had the highest total phenol value of 100 (μ /g GAE) as compared with the other local rice varieties. This value is higher than the phenolic reference level of rice which was 40 (μ /gGAE) as stated in [20]. Pabenjeda rice recorded 40(μ /g GAE total phenol which, was approximately similar to the reference level in [20]. While Narica rice was recorded the lowest total phenol level from among the different local rice types.

V. CONCLUSION

The results of the current investigation indicated that the local rice varieties planted in Sudan are nutritionally higher. They are valuable source of protein, energy, minerals elements, phenolic compounds, sugars and essential amino acids. Crown rice is superior to other two local varieties. It contained the highest level of the most components including protein, essential amino acids and minerals. Therefore, levels of different nutritional components are type of rice or variety dependent.

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