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International Journal of Research Publications

Phytochemicals and Nutrients Constituents of Varieties of Hungry Rice and their Significance in Nutrition

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Abstract

Analyses on phytochemicals and nutrients composition of two varieties of hungry rice were conducted to supply data and information on the cereal's significance in nutrition. Results on phytochemical screening and quantification indicated that the two varieties of cereal contained appreciable amounts (mg/100g sample) of saponins, tannins, phenolics, steroids, flavonoids, coumarins, glycosides, and alkaloids. Some of the secondary metabolites were higher in one variety than the other ($p<0.05$). Nutritional composition showed that both varieties have appreciable levels of dry matter (DM), carbohydrate (CHO), Energy, crude protein (CP), lipids, dietary fibre, and mineral matter. The amino acids, vitamins and mineral composition data presented the two varieties of hungry rice as containing appreciable quantities of nutrients differing in level from one variety to the other. The study established that hungry rice contained adequate nutrients to provide nutritious food/feed and beneficial phytochemicals as valuable nutraceutical.

Keywords: *Digitaria exilis*, *Digitaria iburua*, Food and Feed, Neutralceuticals, Nutrition, Phytochemical composition.

1. Introduction

Many species and varieties of cereals are cultivated for their grains or seeds which serve as food and feeds for man and animals. The cultivation of cereals as starch plants takes first place in world agricultural production in terms of value followed by fruits and oil plants [1]. In economically developing parts of the world like the tropics and subtropics, the nutritional requirements of animals by feeding with conventional feedstuffs (maize, milo, millet) are not met due to scarcity and high cost of the feeding materials. Besides, the two limitations, there is problem of competition among humans, animals and industries for the limited traditional feeding stuffs [2, 3]. Current trends in developing countries therefore are to search for alternatives to the conventional feedstuffs to maintain the animal production sector of agriculture hence research activities into some novel, less-known or endangered crops that are underutilised are on the increase. Hungry rice (white and black varieties) considered in this experiment are one of the novel food/feedstuff in nutrition. Scientifically known as *Digitaria exilis* (white variety) and *Digitaria iburua* (black variety), hungry rice has many common names like Digitaria, acha, fonio, fundi, fundi millet, hungry millet, hungry koos, etc. [4-6]. Some of the attributes of this relatively lesser-known grain-bearing plant include the capacity to grow in poor soils, high nutritional and therapeutic values such as carbohydrates, storage-proteins, minerals, vitamins, and phytochemicals beneficial to health. However, some of Digitaria phytochemicals serving as protective mechanisms for the crop may be harmful or present as antinutritional factors. In spite of the use of this cereal in some parts of Africa like West, East and Central Africa [7], there is a paucity of data and information on its phyto-constituents and nutritional composition based on geographical locations. This experiment reported the phytochemical profile and nutritional composition of two varieties of hungry rice grown on soils of some States in Northern Nigeria, the significance of their primary and secondary metabolites constituents in nutrition.

2. Materials and Methods

Black and white varieties of hungry rice grains were obtained from National Cereal Research Institute (NCRI), Baddegi, Niger State of Nigeria. The grains were first identified and authenticated by the Taxonomy section of the Institute before supply. Five hundred grams of each variety was weighed and separately ground into uniform flour using a Thomas Wiley machine (Model Ed-s-USA). The flours were dried and stored in airtight polyethylene bags prior to chemical analyses.

2.1. Phytochemical analyses

Quantitative and qualitative analyses were carried out on the hungry rice flours for phytochemical constituents. Qualitative determination of phytochemicals was conducted using the methods of [8] while quantitative analysis was carried out by methods outlined by past works [9-16]. Profiling of the amino acids in the two varieties was carried out by the procedures of [5] while the proximate analyses was conducted by the methods of [17].

2.2. Statistical analysis

All determinations were replicated thrice and data were subjected to the student's t-test at 5% protection level in R Data Analysis Software, version (3.5.1). Significant differences between mean values of chemical compositions were reported when $p < 0.05$.

3. Results and Discussion

Qualitative phytochemical composition of white and black varieties of hungry rice (tables 1 & 2) showed that both varieties contained tannins, phenolics, flavonoids, steroids, terpenoids, coumarins, glycosides and alkaloids. Saponins were not detected in the white variety. This finding is congruent with [15] works who also reported no trace of saponins in raw and treated white hungry rice. However [18] observed the presence of that secondary metabolite in Digitaria exilis though the values quantified were so low it could not elicit any health hazard. Quantitative analysis of the grain flours indicated that the cereal contained some plant chemicals or secondary metabolites which have been reported to be evidently advantageous or deleterious to man and animal health depending on the level of intake [19, 20]. For instance, with regards to beneficial secondary metabolites, hungry rice varieties contained flavonoids, steroids, tannins. These metabolites are widely distributed in grain and seed plants [21]. Flavonoids family encompasses flavonoids, flavones, anthocyanidins, flavons and flavonols [22]. The family has been reported to act as antioxidants in biological systems where they provide free radical scavenging activities and other biological activities including vasodilation, anti-carcinogenic, anti-allergic, antiviral agents, estrogenic effects as well as being inhibitors of the enzymes, phospholipase A2, cyclooxygenase, lipooxygenase, glutathione reductase, xanthine oxidase [22-26]. Main flavonoids include hyperin, rutin, quercetin while rutin and quercetin are reported to prevent platelet agglutination [27]. In addition to the mentioned activities of flavonoids, they are also known to reinforce the stability of the capillary vessels and improve venous blood flow. In nutrition, beneficial effects of flavonoids include helping in digestion and assimilation of food/feed and nutrients in the body [27]. Isoflavones as effective phytoestrogens are reported to modulate oestrogen levels in the body and have significant clinical value in low oestrogen states like imbalances, toxic oestrogen-sensitive conditions [26, 28]. Isoflavones also have been reported to prevent diseases like cancers, cystic ovaries, endometriosis among females [29] and individuals that consume food/feedstuffs such as grains, seeds loaded with these secondary metabolites are observed to experience less breast/udder, uterine, prostate cancers and increment in semen quality.

The hungry rice varieties in this study both contain high level phytosterols. Phytosterols are responsible for lowering cholesterol levels and are chemical compounds that have structures very similar to cholesterols in human and animal bodies and their presence in diet in sufficient quantities is expected to lower blood levels of cholesterol, to enhance immunity and decrease the risk of some cancers [30-32]. The two varieties of the cereal contain appreciable levels of tannins. Phenolic tannins of certain levels are needed as anticancer agents and offer cardioprotective benefits, intake of high concentrated food/feedstuffs with tannins especially condensed tannins are limited due to their antinutritional effects as they combine with proteins and make them indigestible and unavailable to the body [21]. On the other hand, phenols and tannins phytochemicals have been linked to cancers prevention and improvement in cardiovascular health [33-34]. Saponins, coumarins, glycosides, alkaloids are the other secondary metabolites in hungry rice used in this experiment. High quantities of alkaloids for example, are found in the white and black varieties of hungry rice. The high alkaloid contents may predispose the consumer to toxic effects of these phytochemicals [21]. Alkaloids like cyanides, dhurrin are highly toxic due to their ability to produce hydrogen cyanide (HCN) on hydrolysis in vivo and as little as 0,5g HCN is sufficient to kill animals like cattle [21]. Despite the toxic effects of some alkaloids, pure isolated plant alkaloids and their synthetic derivatives are often utilised as basic medicinal agents for their bacterial, analgesic and antispasmodic effects [12, 28, 35].

Proximate composition of white and black hungry rice (table3) indicated that the two varieties contain high level of dry matter, carbohydrates with corresponding high calorific values. The white hungry rice gross energy level is significantly higher ($p < 0.05$) than that of the black one. However its value is below the one reported by [4]. The difference observed with that previous work could be due to edaphoclimatic conditions. The black variety of hungry rice bear higher level ($p < 0.05$) of crude protein compared to white hungry rice.

The same trend is observed with past work [36] though the protein content was higher for the two varieties. There is no significant differences between the two varieties of cereals for crude fibre, crude fat and mineral matter. Those values felt within the range established by [37]. Besides, proximate composition of the two varieties of hungry rice are comparable to or even superior to those of the conventional cereals like maize, rice, wheat, millet, sorghum [38-41].

Amino acids profiles of the varieties (table 4) revealed that apart from the primary limiting amino acid lysine which was absent in both varieties, and glutamate, threonine, leucine which were absent in the black variety, the overall amino acid profile of this cereal was found to be as good as or even better compared to those of the traditionally used cereals like maize, millet, milo, wheat, barley, rye [38, 42-43]. This is because the amino acid composition of hungry rice is not limited in the indispensable amino acids of methionine, tryptophan, phenylalanine [44]. White hungry rice had higher carbohydrate (74%) followed by the black variety (69.85%). The carbohydrate content of cereals usually comprises starch, dietary fibre, sucrose, glucose, fructose, raffinose [45-46]. While dietary fibre and starch components of carbohydrates are water-insoluble (made of amylose and amylopectins), carbohydrates like glucose, fructose, sucrose, raffinose are water-soluble and sweet in taste. The values of crude fibre in the two varieties were 2.30 and 2.88% in the white and black rice respectively. Hungry rice, like the other cereals, possesses the attribute of supplying dietary fibres which among other benefits soften stool enhancing waste products removal including bile acids, sterols and bad cholesterols (LDL and VLDL-cholesterols) [45]. Thus, fibres act to clean the intestines like a broom by sweeping via absorption, toxins and carrying out poisonous substances like biliary acids -the precursor of cholesterols- [47]. The other attributes of cereal fibres are that when ingested in diet, they swell up with water increasing in volume and consequently give consistency to the faeces and facilitate its transit through the gastrointestinal tract till the faeces are removed via the rectum. However, when a diet contains little or no fibre, the faeces are hard, dry and concentrated which eventually cause the intestines to eliminate the faeces by force resulting in or exacerbating many problems such as intestinal diverticulum, haemorrhoids and even cancer of the large intestines [47-49]. Fibres constitute an indispensable component of a healthy diet because they prevent intestinal constipation, promote reduction of tracolonic pressure which is beneficial in diverticular diseases like cancer of the colon and haemorrhoids [47, 49-50].

The two varieties on analysis gave moderate lipid content (4.70 and 4.34%). The fatty acids profile of cereals such as hungry rice include myristic, palmitic, stearic, hexadecanoic, oleic, linoleic acids with phospholipids [21].

Vitamins contents data (table 5) showed that hungry rice is rich in both fat and water-soluble vitamins except biotin (B7). List of B-complex vitamins in the cereal included thiamin (B1), riboflavin (B2), niacin (B3), pyridoxine (B6), folacin (B9). The black variety contained higher quantity of the water soluble ascorbic acid (3.50mg/100g) than the white (0.67mg/100g). Among the B-complex vitamins present, only niacin is stable during processing of the cereal [44]. Fat soluble vitamins detected were vitamin A (retinol, retinal and beta carotene) and vitamin E (tocopherols, tocotrienols). Pantothenic acid (B5), cyanocobalamin/ methylcobalamin as members of B-complex and vitamins D and K (cholecalciferol and phylloquinonr/menaquinones) as members of fat soluble vitamins were not detected in the varieties.

White and black varieties had 2.5 and 3.67% mineral matter (ash) respectively (table 3). Total ash of a feeding material gives an indication of the level of macro- and micro-minerals in the stuff. The mineral contents of the varieties (table 6) comprise calcium, phosphorus, potassium, magnesium, iron, zinc, selenium. Most of the minerals (except selenium, 0.03ppm), were present in appreciable amounts. Adequate amount of macro-minerals like calcium, phosphorus are vital to the health of man and animals because their deficiency in the diet is reported to cause ricket [49] and osteoporosis. Osteoporosis is the disease of decrease in bone density such that even adequate mechanical support may not provide or sustain the bone integrity leading to spontaneous fractures [51]. This deficiency disease occurs more in the adults than the young.

Table 1. Phytochemical screening of white and black hungry rice varieties

Chemicals	White	Black
Saponins	-	+
Tannins	+	+
Phenols	+	+
Flavonoids	+	+
Steroids	+	+
Terpenoids	+	+
Coumarins	+	+
Anthocyanins	-	-
Glycosides	+	+
Phlobatannins	-	-
Allkaloids	+	+
Triterpenes	-	-

(-)Not detected; (+) present.

Table 2. Quantitative phytochemicals analysis of white and black hungry rice

Chemicals (mg/100g)	White	Black	Significance
Saponins	ND	1.77	-
Tannins	10.85a	9.67b	*
Phenols	20.10a	19.56b	*
Steroids	125.50b	166.59a	*
Flavonoids	138.00	136.00	NS
Coumarins	23.61b	27.65a	*
Glycosides	4.25b	5.72a	*
Alkaloids	41.79	41.79	NS

(a,b) means in row with different superscripts are significantly different; (*)significantly different ($p<0.05$); (NS) No significant difference ($p>0.05$); (ND) Not Detected.

Table 3. Proximate composition of white and black hungry rice varieties

Nutrient	White hungry rice	Black hungry rice	Significance
Dry matter (DM) (%)	90.70	90.81	NS
CHO (%)	74	69.83	NS
Calorific value (Kcal/kg)	3674a	3578b	*
Crude protein (%)	7.7b	10.10a	*
Crude fat (%)	4.7	4.34	NS
Crude fibre (%)	2.3	2.88	NS
Mineral matter (total ash, %)	2.5	3.67	NS

(a,b) means in row with different superscripts are significantly different; (*)significantly different ($p<0.05$); (NS) No significant difference ($p>0.05$).

Table 4. Amino acids profile of white and black hungry rice varieties

Amino acids (mg/g)	White	Black	Significance
Aspartate	28.40a	12.60b	*
Glutamate	31.50	-	-
Serine	8.50b	27.10a	*
Glycine	7.00a	1.80b	*
Histidine	3.80a	2.40b	*
Arginine	19.70a	0.70b	*
Threonine	1.40	ND	-
Alanine	ND	0.20	*
Proline	7.50a	3.70b	*
Tyrosine	4.70b	8.30a	*
Valine	9.10a	5.80b	*
Methionine	1.60b	1.90a	*
Cystine	3.60a	0.30b	*
Isoleucine	6.50a	3.00b	*
Leucine	2.70	ND	-
Phenylalanine	0.70	0.90	NS
Lysine	ND	ND	-
Tryptophan	1.50b	3.10a	*

4. (a,b) means in row with different superscripts are significantly different; (*)significantly different ($p<0.05$); (NS) no significant difference ($p>0.05$); (ND) Not Detected.

Table 5. Fat and water soluble vitamins composition of the two varieties of hungry rice

Vitamin (mg/100g)	White	Black	Significance
Vit A	0.90b	5.30a	*
Beta carotene	1.82b	10.50a	*
Vit B1	6.20b	24.70a	*
Vit B2	36.10a	32.30b	*
Vit B3	154.00b	159.00a	*
Vit 6	153.00	153.00	*
Vit B7	ND	ND	-
Vit B9	5.00b	7.20a	*
Vit C	0.67b	3.50a	*
Vit E	0.96b	13.77a	*

(a,b) means in row with different superscripts are significantly different; (*)significantly different (p<0.05); (ND) not detected.

Table 6. Some macro- and micro-minerals in white and black hungry rice varieties.

Mineral (ppm)	White	Black	Significance
Phosphorus	4.20^{b}	4.60^{a}	*
Potassium	8.60^{a}	8.50^{b}	*
Calcium	27.00	27.00	NS
Magnesium	43.10^{b}	43.20^{a}	*
Iron	2.35^{b}	2.50^{a}	*
Zinc	3.20^{a}	3.20^{b}	*
Selenium	0.03	0.03	NS

$^{(a,b)}$ means in row with different superscripts are significantly different; (*)significantly different (p<0.05); (NS) no significant difference (p>0.05).

5. Conclusion

This experiment therefore established that hungry rice as a cereal contained adequate nutrients to provide nutritious food/feed and the beneficial phytochemicals like the natural flavonoids, steroids, which could enable the cereal function as a valuable nutraceuticals.

Acknowledgements

Special gratitude goes to the Institute of National Cereal Research, Baddegi, Niger State of Nigeria for providing the hungry rice varieties used in this research.

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