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The Nutritional Composition of Local Rice Varieties in Guyana

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ABSTRACT

Rice is one of the most popular cereals worldwide, one of Guyana's major staple foods produced and consumed. With most of the population dependent on rice as a significant part of their diet, it becomes critical to analyze and monitor its composition. This project was aimed at comparatively analyzing four different local rice varieties cultivated in Guyana and one candidate line for proximate chemical components, vitamins and mineral elements. 2kg of paddy of each variety/line was harvested from pre-basic plots and were cleaned and shelled. Analyses were done by Kaizen Environmental Services Inc. All methods were carried out based on the AOAC (Association of Official Analytical Chemists) method.

In this study, the genetic diversity of the rice varieties/lines was reflected by the range of nutritional characteristics. There was no variety that was superior to another in terms of its overall nutritional content; however, there were some that recorded higher levels of one or more nutrients. The average protein was relatively high in both cargo and polished rice (8.50% and 7.78% respectively). Carbohydrates, present in the largest amount in all 5 varieties, ranged from 70.94% to 73.57% for cargo/brown rice and 73.85% to 77.11% for polished rice. It was also observed that the degree of milling also influenced the nutritional composition of the grain. The unpolished /brown/cargo rice contained higher amounts of all nutrients except carbohydrates when compared to the polished/white rice.

The effect of poor nutritional value of rice can result in short life expectation, the prevalence of diseases, poor physical development and reduced working capacity; and so it is important that rice produced meets the requirements for its population.

ABBREVIATION

AOAC – Association of Official Analytical Chemists
FAO – United Nations for Food and Agriculture
GRDB – Guyana Rice Development Board

INTRODUCTION

Rice is considered the main staple for thirty-nine countries and nearly half of the world's population (Vetha et al 2013, 503 and FAO 1993). It is the most popular cereal worldwide and accounts for twenty-two percent of the total energy supply. Rice contributes to the greatest percentage of calories and protein for persons living in many developing countries (Vetha et al 2013, 503). In addition to being an excellent source of carbohydrates, rice is also a good source of thiamine, riboflavin and niacin (FAO 2004).

Consumers are becoming more health conscious in their choice in the quality of food. Quality of rice does not only include the physical characteristics but also the chemical and cooking attributes of the grain. Therefore, when selecting a particular variety, there is the need to consider the nutritional value derivable from that variety (Mbatchou and Dawda 2013, 308). New research is now moving towards improving the nutritional intake of the population through improvements to staple crops (FAO 2004). This can be done either by: using selected rice varieties with superior nutrient content and breeding these with locally grown varieties to enhance the nutrient content of the grains; or by modifying the genetic code to enhance the nutritional value (FAO 2004).

In Guyana, rice is the major staple produced and consumed. With most of the population dependent on rice as a significant part of their diet, it becomes critical to analyze and monitor its composition. There are many rice varieties grown across the country; however, the nutrient content of these varieties have not yet been explored. This project was aimed at comparatively analyzing five different rice varieties cultivated in Guyana for proximate chemical components such as protein, crude fiber, crude fat, crude ash, total carbohydrates, energy and water. It also determined the nutrient levels for vitamins and mineral elements.

The nutritional composition of rice varies according to a number of factors such as: varieties, location, soil fertility, fertilizer application, environmental conditions and post-harvest transformations (Oko et al 2012, 16 and FAO 2006). The paddy is milled before marketing and the milling processes usually yield a number of fractions: brown/cargo rice, hull, white/polished rice and bran (Oko et al 2012, 16). These fractions differ in their chemical composition according to variety and the type of milling performed (Oko et al 2012, 16). Of the various milling fractions of rice, the bran has the highest protein content and the hull the lowest. Milling done to remove the pericarp, seedcoat, testa, aleurone layer and embryo to achieve milled rice usually results in a loss of fat, protein, fibre, ash, thiamine, riboflavin and niacin (FAO 1993). The process of milling and polishing that converts the brown rice to the white rice removes 67% of the vitamin B3, 80% of vitamin B1, 50% of phosphorus, 60% of iron and all of the dietary fibre and essential fatty acids (Oko et al 2012, 17). On the other hand, carbohydrates are higher in milled rice than in brown rice (FAO 1993). This research sought to determine the difference in nutrient content of the brown and white rice.

RESEARCH OBJECTIVES

To determine the nutritional composition of cargo/brown rice and polished/white rice of five rice varieties grown in Guyana.

METHODOLOGY

Selection and Sampling

Four varieties (GRDB 10, GRDB 12, GRDB 13, GRDB 14) and one candidate variety (FG12-49) were selected for this study. Varieties were selected based on their acreage cultivated in Guyana. Two kilograms of paddy of each variety were harvested from the pre-basic plots at the Rice Research Station, Burma.

Sample Processing and Storage

Paddy samples were cleaned to remove any straw or other contaminants and were taken to the Rice Research Station Quality Control Laboratory for shelling and milling. 500g of cargo/brown rice and 500g of white/polished rice of each variety/line were placed in sealed labeled containers and stored at room temperature for further analyses.

Nutrient Analyses

Analyses were done by Kaizen Environmental Services Inc. All methods were determined based on the AOAC (Association of Official Analytical Chemists) method.

Moisture - Vacuum Oven (AOAC 925.09)

Sample was weighed into a dish and placed into a vacuum oven for at least five hours. The sample was then removed from the oven and cooled in a dessicator. When cool, the weight of the dried sample was determined. The difference between the weight of the undried portion prior to going in the oven and the weight of the dried sample was calculated.

Proteins – Combustion (AOAC 990.03, 992.15)

Sample was placed into the combustion chamber of a protein analyzer, in which the gas from the combustion was analyzed for nitrogen content and calculated to protein.

Fat – Acid Hydrolysis (AOAC 954.02)

Sample was hydrolyzed with HCl. The hydrolyzed sample was extracted in a liquid-liquid extraction with a combination of ethyl and petroleum ethers. The ethers containing the fat were collected and dried. The resulting extracted fat was used to calculate the crude fat in the sample.

Ash (AOAC 942.05)

2 grams of sample was weighed into a crucible, dried in an oven, ashed in a muffle furnace, and then weight of the ash was determined.

Carbohydrates – Calculated (reference Method – CFR 21 – calc.)

Carbohydrates = 100 – (proteins + Fat + Moisture + Ash)

Energy – Calculated Method

At water Calculation: 4xg (carbs) + 9 x g (fat) + 4 x g (protein)

Phosphorus (P), Sodium (Na), Magnesium (Mg), Calcium (Ca), Potassium (K), Iron (Fe), Copper (Cu), and Zinc (Zn) – (AOAC 984.27, 927.02)

In this analysis the sample was digested. The resultant digest was analyzed by Inductively Coupled Plasma Optical Emission Spectrophotometry against a set of ISO certified standards.

Thiamine – Vitamin B1 (AOAC 942.23 mod)

The sample was extracted by autoclaving in 0.1 N HCl to break down the matrix. Then the sample was incubated with alpha-amylase overnight to free bound thiamine. The extract was filtered and poured through column filled with Biorex 70 Cation Exchange resin. The purified thiamine was oxidized by potassium ferricyanide to create the chromophore, which was extracted by isobutanol. The analyte was then quantified via fluorescence spectrophotometer at excitation 365nm and emission 435 nm.

Riboflavin – Vitamin B2 (AOAC, 970.65 – Levels < 25mg/100g)

Samples were hydrolyzed by autoclaving in 0.1 N HCl for 30 min. Proteins were removed by precipitation at pH 4.5. Interfering fluorescent substances were destroyed by oxidation with potassium permanganate. Fluorescence measurements include sample solutions containing added riboflavin as an internal standard and on sample solutions containing water in place of the spike solution. Hydrosulfite was then added to sample tubes to convert riboflavin to the no fluorescent, reduced leuco form to provide a blank reading.

Niacin – (AOAC 944.13)

Samples were extracted by autoclaving in 1 N H_2SO_4. The pH of sample solutions was adjusted to 6.8, followed by serial dilutions as necessary. Sample solution was then mixed with growth media and inoculated with *L. Plantarum*. After overnight incubation at 37°C, the concentration of niacin in the sample was determined on Autoturb by reading the turbidity of the sample.

RESULTS AND DISCUSSION

Results were obtained for the cargo and polished rice of four varieties and one line/candidate variety. The nutrients were divided into three categories, namely: proximate, minerals, and vitamins.

Proximate

Proximate represents the gross components that make up food and include: water / moisture, protein, fat, carbohydrate, total dietary fiber and ash.

Moisture

The percentage moisture varied among varieties for both cargo and parboiled rice; however the moisture for polished/white rice was more than that of the cargo/brown rice. The aromatic variety, GRDB 13, recorded the lowest percentage moisture for both the cargo and polished rice (14.6 and 14.9 % respectively) while the GRDB 14 recorded the highest (17.5 and 17.6 % respectively) (see table 2).

Table 2: The percentage of proximate nutrients in cargo and polished rice

Parameter	GRDB 10		GRDB 12		GRDB 13		GRDB 14		FG12-49	
Name	Cargo	Polished	Cargo	Polished	Cargo	Polished	Cargo	Polished	Cargo	Polished
Moisture (%)	15	15.8	15.4	16.2	14.6	14.9	17.5	17.6	16.3	16.9
Ash (%)	1.19	<0.40	1.05	<0.40	1.12	0.55	1.03	<0.40	1.04	<0.40
Fat (%)	3.36	1	3.04	1.08	2.72	1.16	2.04	0.92	2.72	0.85
Fiber (Crude) (%)	0.7	<0.2	0.6	<0.2	0.7	0.2	0.5	<0.2	0.7	<0.2
Protein (%)	6.88	6.09	8.71	8.1	9.95	9.32	7.77	7.01	9	8.4
Carbohydrates (%)	73.57	77.11	71.8	74.62	71.61	74.07	71.66	74.47	70.94	73.85

Ash

As expected the percentage of ash was higher for cargo rice of all varieties/line when compared to the polished rice. The percentage ash ranged from 1.03% to 1.19% for cargo rice and <0.40% to 0.55% for polished rice (See table 2).

Fat

The percentage of fat in the cargo rice was more than double that of the polished rice for all the varieties and line. GRDB 10 recorded the highest percentage of fat in cargo/brown rice (3.36%) and GRDB 13 recorded the highest in polished rice (1.16%) (See table 2).

Crude Fiber

Rice has the lowest dietary fibre content when compared to other cereals (4.0g for brown rice) (FAO 1993). The proximate nutrient present in the lowest amount for all varieties was crude fiber with a range of 0.5% to 0.7% for cargo rice and <0.2 to 0.2 for polished rice (see table 2).

Protein

Protein quality is determined by the amino acid composition and its digestibility. Rice protein quality is very high when compared to other crops (Frei and Becker 2005). Rice has favorable amino acid compositions, high amount of lysine and a high protein digestibility which makes it a fairly good source of protein in diets where animal protein is limited (Frei and Becker 2005). Brown rice/cargo rice not only has a higher amount of protein but is also known to have a higher amount of lysine when compared to polished/white rice. In this study, the amount of protein in each variety/line varied in both cargo and polished rice (figure 1). The average percentage of protein found in both cargo (8.50%) and polished rice (7.78%) for local lines/varieties was higher when compared to the findings of FAO (cargo rice: 7.1-8.3% and white rice: 6.3 to 7.1%) (FAO 1993). GRDB 13 has the highest amount of protein for both cargo and polished rice (9.95% and 9.92% respectively) while GRDB 10 recorded the lowest amount of protein (cargo: 6.88% and polished: 6.09%) (table 2).

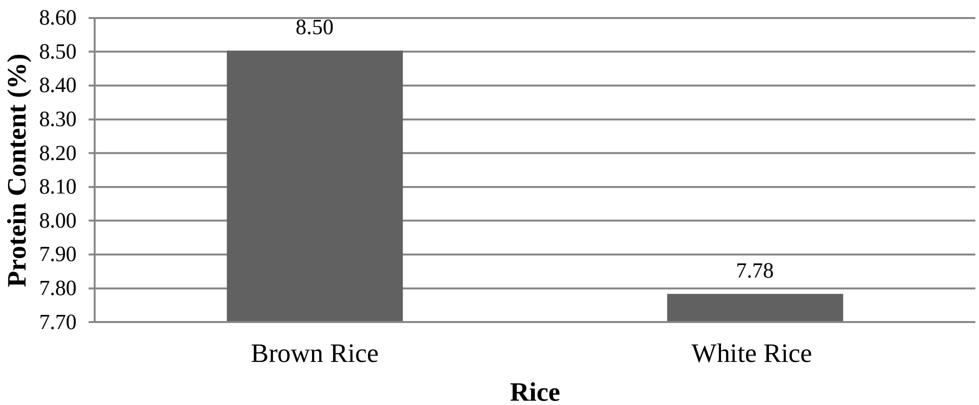

Figure 1: The average protein content found in the brown and white rice of the five varieties/lines

Carbohydrates

Rice is a starchy staple food which supplies a large amount of dietary energy (as high as 90% in Asia). Frei and Becker in 2005 stated that brown rice contains 75-85 percent of carbohydrates while milled/white/polished rice contains approximately 90% (Frei and Becker 2005). In figure 2, it can be observed that the average percentage carbohydrate in brown rice was much less than white rice; 71.92% as compared to 74.82%.

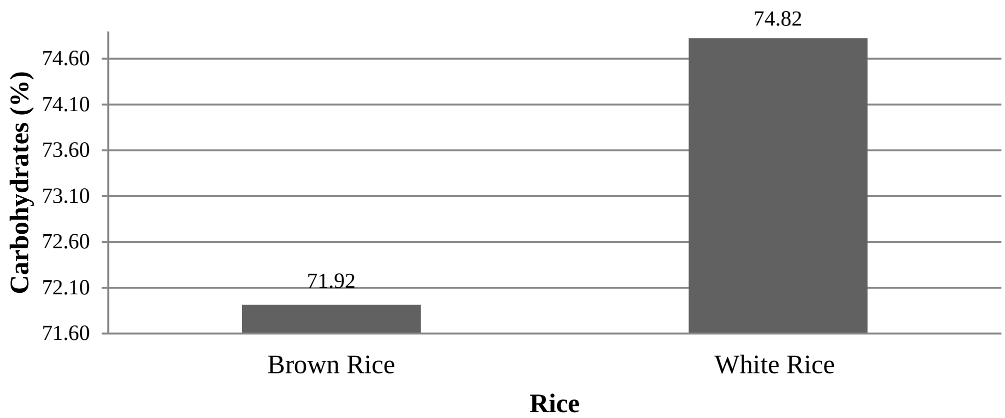

Figure 2: The carbohydrate contents of cargo and polished rice for the five varieties/lines

In this study, carbohydrate was present in the largest amount in all of the five line/varieties tested with a range of 70.94% to 73.57% for cargo/brown rice and 73.85% to 77.11% for polished rice (see table 2). The amount of starch in the grain is an important factor for determining grain quality. Starch can vary in the proportion of two starchy fractions: amylose which consists of linearly linked glucose molecules and amylopectin which has glucose molecules with branched links (Frei and Becker 2005). Rice with more amylopectin absorbs less water when cooked and tends to have a sticky texture. Rice with higher amylose content can absorb more water and have fluffy texture after cooking (Frei and Becker 2005). Rice starch is digested more rapidly when compared to other starchy foods such as: sweet potatoes or cassava, and can lead to a fast and high increase in blood glucose levels after digestion (Frei and Becker 2005).

Energy

Rice has the highest energy contribution for developing countries (29.3% of the regional total) and its energy composition falls just below maize, millet and oats (FAO 1993).

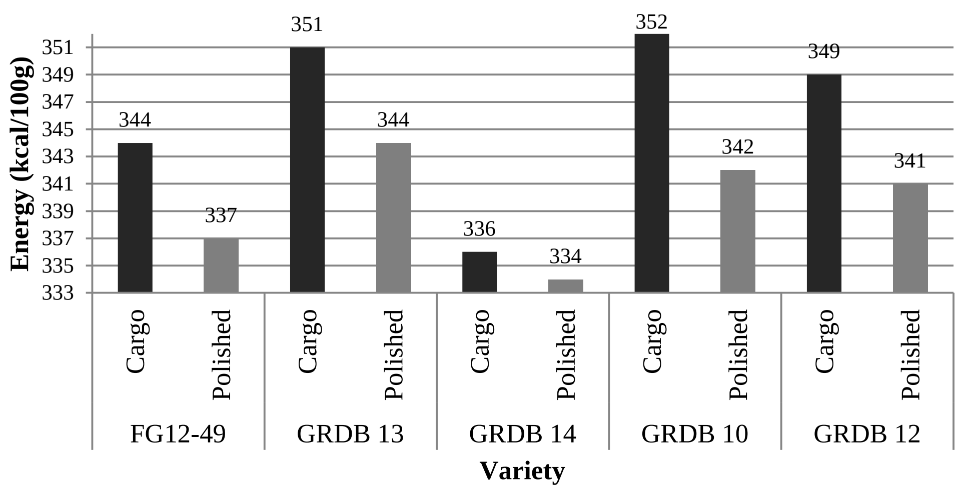

Figure 3: The energy composition of the four varieties and new line for brown and white rice

According to FAO, the amount of energy in brown rice is 363-385 kcal and in white rice is 349-373 kcal (FAO 1993). Figure 2 shows that the amount of energy in the local lines/varieties was slightly lower when compared to FAO findings and ranged from 336-351 kcal/100g for cargo rice and 334-344 kcal/100g for polished rice. GRDB 10 recorded the highest energy level for cargo while GRDB 13 recorded the highest for polished rice.

Minerals

Eight minerals were tested, these were: Phosphorus, Sodium, Magnesium, Calcium, Potassium, Iron, Copper and Zinc. There minerals were present in very small amounts.

Table 3: The percentage of minerals in cargo and polished rice for the five varieties/line

Mineral	FG12-49		GRDB 13		GRDB 14		GRDB 10		GRDB 12	
	Cargo	Polished	Cargo	Polished	Cargo	Polished	Cargo	Polished	Cargo	Polished
Phosphorus (P) (%)	0.245	0.096	0.297	0.147	0.246	0.122	0.241	0.1	0.25	0.092
Sodium (Na) (%)	0.003	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	<0.002
Magnesium (Mg) (%)	0.093	0.024	0.109	0.043	0.095	0.035	0.092	0.028	0.092	0.021
Calcium (Ca) (%)	0.01	0.004	0.006	0.005	0.008	0.004	0.008	0.005	0.007	0.004
Potassium (K) (%)	0.221	0.094	0.25	0.122	0.232	0.134	0.213	0.088	0.236	0.097
Iron (Fe) (%)	0.0014	0.0003	0.0013	0.0005	0.0011	0.0004	0.001	0.0003	0.0011	0.0003
Copper (Cu) (ppm)	4.3	2.3	3.9	2.5	3.8	2.3	2.7	1.6	3.1	2
Zinc (Zn) (ppm)	31	23	27	21	27	18	22	16	32	23

Minerals are concentrated in the outer layers of brown/cargo rice or in the bran fraction (FAO 1993). Potassium and magnesium are the main salts of phytim and approximately 90% of phytin is found in the bran. In this study, phosphorus was the most dominant mineral of the eight that were tested and was the highest in GRDB 13 cargo/brown rice (0.297%) and lowest in GRDB 12 polished/white rice (0.092%). The range of this mineral falls within that specified by FAO (table 4).

Table 4: Comparison of mineral content in local lines/varieties to that of FAO Findings

Nutrients	Local Lines/Varieties		FAO Findings	
	Brown/Cargo	White/Polished	Brown/Cargo	White/Polished
Phosphorus (P) (%)	0.24-0.29	0.092-0.147	0.17-0.43	0.08-0.15
Calcium (Ca) (%)	0.006-0.01	0.004-0.005	0.1-0.5	0.1-0.3
Iron (Fe) (%)	0.001-0.0014	0.0003-0.0005	0.002-0.052	0.002-0.028

Sources for FAO Data: Juliano 1985; Juliano and Maniñgat 1982; Pedersen and Eggum 1983.

Calcium was highest in the cargo/brown rice of line FG12-49 (0.01%); all other varieties recorded much lower levels of calcium in both the cargo and polished rice. When compared to the FAO findings for both brown and white rice, the calcium content of the local lines/varieties was much lower (table 4).

Iron was present in very small amounts in both cargo (0.001-0.0014%) and polished rice (0.0003-0.0005%) and was lower than the FAO findings. Sodium recorded the lowest percentage of the eight minerals and ranged from 0.003% to <0.002% for cargo rice. Polished rice from all line/varieties recorded sodium levels <0.002%.

Magnesium levels ranged from 0.109% to 0.092% for cargo and 0.021% to 0.043% for polished rice. GRDB 13 had the highest level of magnesium for both polished and cargo rice for all varieties. Potassium levels for cargo rice ranged from 0.213% in GRDB 10 to 0.25% in GRDB 13 and for polished rice, ranged from 0.088% in GRDB 10 and 0.134% in GRDB 14.

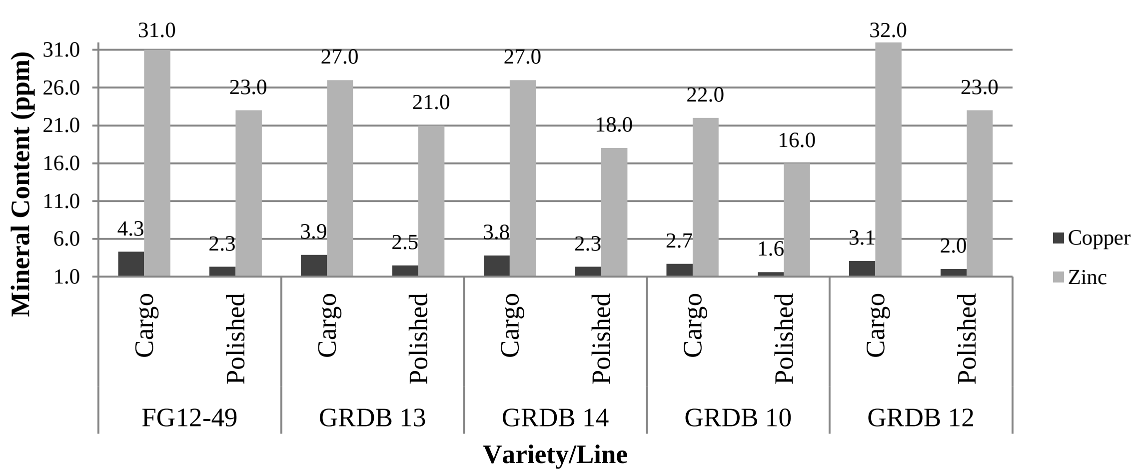

Figure 4: The copper and zinc content of cargo and polished rice

Copper and Zinc were measured in parts per million. Zinc was present in much higher amounts in both cargo and polished rice when compared to Copper (figure 4).

Vitamins

The rice grain has no vitamin A, D, or C; however, it is known to be a good source of thiamine (vitamin B1), riboflavin (vitamin B2) and niacin (vitamin B3) (Rohman et al 2014, 14). These vitamins are concentrated mostly in the bran layers of the rice grain. Approximately 50% of the total thiamine can be found in the scutellum and 80-85% of the niacin can be found in the pericarp and aleurone layer (FAO 1993).

Table 4: The percentage of vitamins in cargo and polished rice for the five varieties/lines

Vitamin	FG12-49		GRDB 13		GRDB 14		GRDB 10		GRDB 12	
	Cargo	Polished	Cargo	Polished	Cargo	Polished	Cargo	Polished	Cargo	Polished
Thiamine (mg/100g)	0.311	0.0595	0.538	0.148	0.306	0.0789	0.317	0.0678	0.388	0.0732
Riboflavin (mg/100g)	0.108	<0.100	<0.100	<0.100	0.142	<0.100	<0.100	<0.100	<0.100	<0.100
Niacin (mg/100g)	4.17	1.29	5.27	2.24	3.62	1.87	4.4	1.67	4.01	1.2

Of the three vitamins tested, Niacin was present in the largest amount, ranging from 3.62 mg/100g to 5.27 mg/100g for cargo rice and from 1.2 mg/100g to 2.24 mg/100g for polished rice. GRDB 13 recorded the highest levels of Thiamine and Niacin in both cargo and polished rice when compared to the other varieties/lines. Riboflavin levels were fairly low in both cargo and brown rice for the varieties/lines tested; all polished rice had less than 0.1 mg/100g of the nutrient while cargo rice levels ranged from 0.14 mg/100g to less than 0.1 mg/100g.

CONCLUSION

The effect of poor nutritional value of rice can result in short life expectation, the prevalence of diseases and poor physical development and working capacity; and so it is important that rice produced by each country meets the requirements for its population.

In this study, the genetic diversity of the rice varieties/lines is reflected by the range of nutritional characteristics. There was no variety/line that was superior to another in terms of its overall nutritional content; however, there were some that recorded higher levels of one or more nutrients.

In addition, the degree of milling also influenced the nutritional composition of the grain. The unpolished /brown/cargo rice contained higher amounts of all nutrients except carbohydrates when compared to the polished/white rice.

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REFERENCES

Ensminger, A. H and M. K. Ensminger. (1986). Food for Health: A Nutrition Encyclopedia. Pegus Press, Clovis, California, 106-108

Food and Agriculture Organization of the United Nations. (2006) Rice International Commodity Profile.http://www.fao.org/fileadmin/templates/est/COMM_MARKETS_MONITORING/Rice/Documents/Rice_Profile_Dec-06.pdf

Food and Agriculture Organization of the United Nations. (2004) Rice and Human Nutrition. http://www.fao.org/rice2004/en/f-sheet/factsheet3.pdf

Food and Agriculture Organization of the United Nations. (1993) Rice in Human Nutrition. http://books.irri.org/9251031495_content.pdf

Frei, M. and K. Becker. (2005) On Rice, Biodiversity and Nutrients. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.548.7529&rep=rep1& type=pdf

Juliano, B. O. and D. B. Bechtel. (1985) The Rice Grain And Its Gross Composition. Rice Chemistry and Technology,2nd ed., p. 17-57. St Paul, MN, USA, Am. Assoc. Cereal Chem.

Mbatchou, V. C. and S. Dawda. (2012) The Nutritional Composition of Four Rice Varieties Grown and Used in Different Food Preparations in Kassena-Nankana District, Ghana. International Journal of Research in Chemistry and Environment. 3(1): 308-315. http://www.ijrce.org/uploads/20/1034_pdf.pdf

Pedersen, B. and B. O. Eggum. (1983) The Influence Of Milling On The Nutritive Value Of Flour from Cereal Grains IV. Rice. Qual. Plant. Plant Foods Human Nutrition. 33:267-278.

Rohman, A., S. Helmiyati, M. Hapsari and D. L. Setyaningrum. (2014) Rice In Health And Nutrition. International Food Research Journal 21(1): 13-24. http://www.ifrj.upm.edu.my/21%20 (01)%202014/2%20IFRJ%2021%20(01)%202014%20Rohman% 20430.pdf

Vetha varshini P. A, Azhagu sundharam K., and Vijay Praveen P. (2013) Brown Rice - Hidden Nutrients. Journal of Bioscience and Technology. Vol 4(1), 2013, 503-507. http://jbstonline.com/documents/vol4issue1/jbst2013040101.pdf

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