Composition and Nutrients Depletion after Cooking Three Pigmented Varieties of Whole Grain Rice from Côte d'Ivoire

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ABSTRACT

Rice (*Oryza sativa*) is the most consumed food in the world and represents an important diet element in Côte d'Ivoire. Composition data on rice varieties produced and consumed in Côte d'Ivoire are not available rendering it difficult to evaluate their nutritional importance in consumers. The purpose of the present study was to determine whole grains' biochemical composition of three local pigmented varieties and evaluate the effect of boiling on this composition. The moisture, ashes, carbohydrates, lipids, proteins and polyphenols rates were determined using standard methods on raw and cooked whole grain samples from studied varieties. Results showed that the nutrient characteristics of raw rice are superior to those of cooked rice. The boiling treatment used to cook the rice induced starch and fibre hydrolysis into simple carbohydrates, and reduced rates of all nutrients. This first study focused on Côte d'Ivoire locally produced rice varieties open the road for further investigations that will nourish the food composition tables for the main types of raw and cooked foods consumed in West Africa.

Keywords: Cooked rice, Côte d'Ivoire, Nutritional characterization, *Oryza sativa*, Whole grain rice.

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I. INTRODUCTION

In the particular context of the nutritional double burden observed in Sub-Saharan African countries, it is necessary to set up and continuously update food composition tables/data bases that could serve as tools to evaluate effective nutrients intake in the population and provide appropriate recommendations for healthy nutrition [1], [2]. One of the challenges in building such databases is to cover nutrient composition of all the available foods or at least, the most consumed foods in the region and determine nutrients retention factors at least for the most used processing or cooking methods.

In West Africa, a regional food composition table was set up but more efforts are still needed in capacity building and some foods are still needed to be analyzed in order to complete the table [3], [4]. In addition, there are some specificities due to some food varieties produced in climatic particularities in some West African countries as well as some underestimated edible species. Rice (*Oryza sativa*) occupies an important place in West African countries food systems due to its accessibility and potentials for transformation into several foods [5]. It was introduced in Côte d'Ivoire from Asia in the 15th century and evolved during centuries to present some specific features in the country [6].

In Côte d'Ivoire, rice is consumed in several forms

according to household resources and cooking methods. Among the available rice in markets, the whole grain rice is highly recommended by health care providers because of its high rates of proteins, vitamins and minerals present in germs and bran that are removed in the refined white rice [7], [8]. Moreover, the whole rice presents a relatively low glycemic index in comparison to refined white rice making it a preferred cereal for patients suffering from diabetes [9, 10]. Composition data and processing nutrients retention factors in locally produced whole grain rice are missing despite their high importance in Ivoirians' nutrition. It is therefore of great importance to determine the composition of locally produced rice and estimate the nutrients retention factors following rice cooking in order to contribute to the developing West African food composition database.

The present study was designed with the purpose of performing a comparative study between raw and cooked whole grain rice of three different varieties produced in Côte d'Ivoire and distinguishable based on grain colour. The study also intended to determine the influence of the commonly used cooking method in Côte d'Ivoire on main nutrients present in rice.

II. MATERIAL AND METHODS

A. Rice Varieties

The study was focused on three commonly consumed rice varieties distinguished by their colours (Beige, brown, and black). The sampled rice was produced locally and sampled in duplicate from two rice sellers in Abidjan and Bongouanou. For each variety, 2 kg were sampled, cleaned, and split into two parts for biochemical analyses of raw and cooked rice.

B. Biochemical Analysis

Each sample was split into two parts. The first part was kept for biochemical analysis of the raw rice whereas the second part was cooked before analyses. The cooking process was performed by boiling rice in two-fold volumes of rice for 25 minutes.

The moisture and rates of ashes and proteins were determined using the AOAC methods of analyses [11]. Total starch and fibre rates were obtained by spectrophotometric approaches [12]. The level of lipids in the rice grains and cooked rice was determined using French standards procedures [13]. Polyphenols were analysed by the folin-ciocalteu reagent method and polyphenols rates expressed in mg/100g of the Gallic acid equivalent (GAE) [14]. The whole carbohydrates level was estimated using the differential method [15]. The Atwater formula was used to calculate the whole energy value [16].

C. Data Analysis

All the obtained data were entered in an excel data sheet and analyzed using Statistica 7.1. All analyses and tests were performed with a significance level set at $p < 0.05$.

Apparent retention factors (ARF) were calculated using the following formula: $ARF = 100 \times N_c / N_r$.

N_c = nutrient content per g of cooked whole rice

N_r = nutrient content per g of raw whole rice.

III. RESULTS

Three locally produced rice varieties were sampled in duplicate and subjected to biochemical analyses before and after cooking.

A. Moisture and ashes level

Three locally Raw rice varieties presented moisture rates ranging from 9.47 to 11.27 % whereas boiled rice showed significantly higher moisture rates of 70.12 to 71.10 % (Fig. 1). Mineral nutrients in rice samples were evaluated as a whole in the rate of ashes. In raw rice samples this rate ranged from 1.24 to 1.40%. After cooking rice samples by boiling in water, the ashes content dropped significantly to a range from 0.55 to 0.72% (Table 1).

Fig. 1. Moisture rates in raw and cooked rice.

TABLE1: BIOCHEMICAL COMPOSITION OF RAW AND COOKED RICE SAMPLES

Compound	Beige rice		Brown rice		Black rice	
	Raw	Cooked	Raw	Cooked	Raw	Cooked
Ashes (%)	1.24±0.11	0.55±0.11	1.42 ±0.13	0.69±0.13	1.31 ±0.20	0.72±0.33
Fibres (%)	6.11±0.33	2.30±0.23	5.21±0.33	2.03±0.11 ^d	5.50±0.77	2.04±0.80
Carbohydrates (%)	73.9±0.9	26.20±0.53	73.85±0.98	27.52±0.9	74.87±0.95	30.17±0.94
Starch (%)	70.81±0.98	23.03±0.91	71.51±0.91	24.06±0.9	70.21±0.93	27.11±0.88
Protéins (%)	5.92±0.93	3.8±0.90	6.02±0.53	2.60±0.83	8.5±0.90	3.50±0.11
Fat (%)	1.35±0.33	0.56±0.11	1.35±0.15	0.75±0.13	1.65±0.93	0.80±0.03
Polyphenols (mg GAE /100g)	50.01±0.91	30.22±0.6	56.12±0.95	32.31±0.80	81.04±0.96	41.25±0.60
Energetic value (Kcal/100g)	331.5±0.13	116.36±0.36	331.48±0.21	121.13±0.03	348.33±0.18	129.28±0.05

B. Composition in macronutrients

The evaluation of the macronutrients content revealed carbohydrates as the main components in both raw and boiled rice samples. Total carbohydrates represented a fraction of 73.21 to 74.51 % in raw rice samples. Boiling this rice induces a decrease in total carbohydrates of almost a tierce in the three varieties. The black rice variety presented the highest rate of total carbohydrates (30.17%) after cooking. The major carbohydrate was starch which was found to be present in proportions comprised between 70.21 and 71.21 % in raw rice, and 23.03 to 27.11 in cooked rice. The fibre fraction accounted from 5.21 to 6.11 % in raw rice and 2.03 to 2.30 in boiled rice. The highest rate of fibre was recorded in rice coloured in beige (Table 1).

Like carbohydrates, cooking rice also induced a decrease in protein content in rice samples. In fact, the protein level dropped from a range from 5.92 to 8.5 % in raw rice to a range from 2.60 to 3.80 after cooking. The black rice presented the highest content in proteins (Table 1).

As presented in Table 1, lipids were found to be present in raw rice with rates of 1.35 to 1.65 %. These rates drop to 0.56 to 0.80 % after cooking rice samples (Table 2).

Based in the content in macronutrients, the energetic value of sampled rice varieties was estimated using the Atwater method. The energetic value was found to range from 331.48 to 348.33 kcal/100g in raw rice. After cooking, the energetic value ranged from 116.36 to 129.28 kcal/100g (Tables 1 and 2).

TABLE 2: APPARENT RETENTION FACTORS OF STUDIED NUTRIENTS

Compound	Beige rice	Brown rice	Black rice
Ashes	44.35	48.59	54.96
Fibres	35.45	37.26	40.30
Carbohydrates	32.52	33.65	38.61
Starch	37.64	38.96	36.91
Protéins	64.19	43.19	41.18
Fat	41.48	55.56	48.48
Polyphenols	60.43	57.57	50.90
Energetic value	35.10	36.54	37.11

All apparent retention factors are expressed in percentage.

C. Polyphenols content

Due to their importance as antioxidants, polyphenols were also analysed in this rice composition study. Results show that these components are present in sampled rice varieties at ranges comprised between 50.01 and 81.04 mgGAE/100g in raw rice. After boiling the rice, polyphenols were recorded at rates ranging from 30.22 to 41.25 mgGAE/100g (Tables 1 and 2).

IV. DISCUSSION

With the aim of providing more data on the composition of locally produced foods for a better nutritional valorisation, the present study was conducted on three coloured rice varieties produced in Côte d'Ivoire. Rice samples were collected from markets in order to evaluate the composition of effectively consumed rice in households. Results show that these locally produced rice varieties present high nutritional values in comparison to other widely consumed rice.

Among physicochemical parameters, the moisture content is a key element that determines rice susceptibility to pests, fungi and microbes [17], [18]. These contaminants require high water activity to proliferate. It is therefore necessary to dry grains till low moisture content for better storage, however, too low moisture content can lead to fissures [19]. The three studied rice samples presented moisture rates lower than 10%. These values highlight a potential for long period storage. In addition whole grains absorb less amount of water during storage in comparison to polished rice. It is important to notice that during rice boiling, grains absorb water and swell at rates variable according to cooking time and variety [20].

At biochemical composition level, the three studied rice varieties are quite similar with high levels of proteins, ashes, and fibres. The black rice revealed to be a relatively higher quality variety with highest values of energy, total carbohydrates, proteins, ashes, and polyphenols content. This variety should be highly promoted as it could be with great added value in the eradication of malnutrition. The three studied rice varieties interestingly showed high levels of fibre (5.21 to 6.11 %) in comparison to other varieties produced elsewhere [21]. This finding should encourage the promotion of these three locally produced varieties in people suffering from special conditions that require high levels of fibre in their food for a better digestion and metabolism [22].

Another added value observed in the studied rice is their content in polyphenols. Deeper investigations are required to identify the specific polyphenolic compounds but there

are several studies reporting the good effect of rice polyphenols [23], [24]. A part from the potential of rice polyphenols as natural antioxidants with beneficial effects on consumers, these compounds present a particular importance in different rice processing technologies. In fact, polyphenols were proven to affect water-starch interactions and then participate in the pasting processes [25]. The use of external polyphenols in rice starch processing was also encourage as it accelerate gelatinization and changes the structural and physicochemical properties of rice starch at room temperature under high pressure [26].

As for any other foods, cooking rice by boiling it induced the reduction in the rates of all nutrients. These reductions in nutrients rates lead to a decrease in the total equivalent energy. Apparent retention factors were determined and reported in Table 2. In the studied rice samples, around 63 % of the total energy value was lost showing that the cooking process alters a huge amount of macronutrients. Alternative processes are needed allow people in Côte d'Ivoire to profit from all nutrients present in the rice they eat. Given that most the foods in West African countries are cooked by long boiling processes, there should be a regional programme to propose solutions to malnutrition that take into account the cooking methods.

The highest rates reductions are recorded for total carbohydrates, starch, fibres and mineral fraction (ashes). Polymeric carbohydrates such as starch and cellulose in fibres undergo hydrolytic reactions that generate simple and easily digestible molecules. This hydrolytic phenomenon induces an increase in carbohydrates digestibility and the glycemic index of cooked rice [27]. This result was also recorded in other studies and shows that rice cooking processes should be seriously monitored especially in individuals suffering from diabetes [10]. In addition, the starch is mobilized with water for gelatinization during the cooking process allowing all the rice varieties to swell.

The loss in rice mineral compounds can be attributed to both rice washing before preparation and the boiling process. However, despite this loss in the mineral fraction, the cooking process may have increased the bio accessibility of some minerals such as Mg, Fe, and Ca [28]. Anyway, the loss in ashes is significantly high. It is therefore necessary to pay a particular attention to people whose alimentation is mainly based on rice. Supplementations in minerals and vitamins could be necessary for some vulnerable individuals such as children.

V. CONCLUSION

The present study provides important composition data on three locally produced rice varieties in Côte d'Ivoire. These three coloured rice varieties present high nutritional qualities even if the cooking process used in the country lead to significant nutrients losses. Further investigations are needed to identify and quantify the level of vitamins and minerals in these rice varieties. Finally, nutritional recommendations should provide more advices on cooking processes that preserve rice from nutrients loss.

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