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Effect of various cooking methods on the proximate composition and nutrient contents of different rice varieties grown in Nigeria

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Abstract

The study investigated the effect of various cooking methods on the proximate composition and nutrient contents of some varieties of rice grown in Nigeria, using the methods of Association of Analytical Chemists (AOAC methods). Atomic Absorption Spectrophotometer and High Performance Liquid Chromatography were used to analyzed minerals and vitamins. The samples were cooked using microwave, pressure pot and parboiled methods and compared with the conventional method. The results showed that moisture, ash, fat, protein and carbohydrate ranged from 8.8 to 14.1, 0.88 to 1.67, 2.9 to 5.9, 6.1 to 6.6 and 72.6 to 78.2 %, respectively, and energy content from 1489 to 1636 kJ/100 g. Zinc, iron, copper and calcium ranged from 2.8 to 4.5, 4.2 to 10.6, 0.2 to 1.9 and 28.6 to 47.6 mg/100 g, correspondingly. Ascorbic acid contents (mg/kg) of raw samples ranged from 2.6 to 10.6, pyridoxine 306 to 534, thiamine 113 to 215, and folate from 62 to 88µg/kg. The mean percentage retention of ascorbic acid ranged from 17.5 to 49.8%, pyridoxine (44.7 to 93.2%), thiamine (54.5 to 89.5%) and folate (55.16 to 91.1%), conventional cooking recorded significantly higher ($P< 0.05$) retention values for pyridoxine, thiamine and folate whereas microwave and pressure cooking lead to substantial loss of all the vitamins. The study revealed that although cooking methods negatively impaired vitamin content of rice, however, the loss was more with microwave and pressure cooking which implied that these methods of cooking should be regulated in order to optimise nutrient intake from rice.

Introduction

Rice (*Oryza sativa* L.) is an economic crop which is important in household food security, ceremonies and nutrition diversification (Perez *et al.*, 1987). It is considered the main staple food in most of the countries and according to World Health Organization (WHO), it is an important cereal crop that feeds more than half of the world's population (WHO, 2005).

Nigeria produces rice in virtually all the ecological zones of the country and is the largest producer in West Africa. Before Nigeria's independence in 1960, rice was a luxury eaten only during festivals and anniversaries but rice consumption dramatically increased in the 1970s creating a substantial increase in demand, which outstripped local supply. Besides the demand from households, which keeps rising, there is increase in the number of fast food joints that is also growing with increasing urbanization. More products like spaghetti, rice crisps and other industrial uses are constantly being developed for rice or are being expected and these will also drive up the demand for rice.

Local consumption of rice is estimated at six million metric tonnes per year while the local production capacity stands at 2.8 million metric tonnes per year necessitating an import which has been estimated to cost $7 million per day thus making Nigeria the largest importer of rice in the world (WARDA, 2008). In Nigeria, rice is mostly consumed in the form of milled rice, boiled, jollof, fried or rice paste (tuwo shinkafa) with or without stew or soup. It is cooked by boiling in water, or first boiled for a few minutes (parboiling), the cooking broth is drained and then water is added to cook to soft edible rice.

Processing of food is generally a prerequisite for improving the digestibility and palatability of foodstuffs. The methods involved in the processing of foods vary widely, and the nutritive value of food may be improved or diminished depending on the methods employed. Recently, both domestic and industrial cooking utilizes media that conserve time and energy such as microwave and pressure cooker. Thermal treatment has been identified as major determinant in vitamin availability in foods due to the fact that most vitamins are heat labile. The main vitamins present in rice are the B-vitamins. They are generally present in higher levels in brown rice than in milled rice. For example, about 81% of the

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thiamine in the rice caryopsis is present in the bran layers, 11% in the embryo and 8% in the endosperm (Juliano, 1985).

Although there are several reports on the effect of processing and storage on the nutrient content as well as nutrient availability in rice and rice products, one of such reports by Ebuechi and Oyewole, 2007 was on the effect of cooking and soaking on nutrient composition of indigenous rice varieties in Nigeria, they observed that soaking and cooking improved the protein, fat and fibre content of rice. They explained that the process of parboiling rice results in the inward infusion of water-soluble vitamins to the endosperm, thus caused increased in the amounts of B-vitamin. It has also been reported that the content of thiamine decreases when rice is stored (Juliano, 1985)

Cooking methods employed in food preparation has been found to lead to nutrient loss. Nutrients may be lost during cooking in two ways: first, by degradation which can occur by chemical changes such as oxidation and secondly by leaching into the cooking medium (Berechet and Segal, 2007). However the safety of the foods processed by microwave has aroused some public interest, this includes concern on whether harmful chemicals would be formed or nutritional quality of food would be lowered during microwave cooking (Murcia *et al.*, 1999). As a result of cooking, foods which are otherwise rich in some essential nutrients may have lost them or such nutrients may not be available when the food is consumed.

There are little or no information on the effect of various cooking methods on the loss or retention of water soluble vitamins in some rice varieties grown in Nigeria, and considering the fact that thiamine deficiency disease (Beriberi) is endemic among rice consuming societies, .it is therefore important to know the impact of cooking on nutrient especially water soluble vitamin status of rice. The objective of this study was to investigate the effect of cooking methods on nutrient content of some rice varieties grown in Nigeria. This study will provide information on the best cooking practices that will ensure adequate nutrient intake from rice.

Materials and Methods

Materials

Rice (*Oryza sativa* L.) used for this study include “Damboto”, “C.P Variety Hybrid” (CPVH), “Mai Adolai” (MA), and “Yai China” (YC) were collected from Kebbi State, while “Erinmo” rice was from Osun State, Nigeria. The samples were those planted in 2013 season and collected from the farmers at the mill after the husks has been removed. All the rice samples were hand-picked, washed thoroughly with distilled water, and dried at 50^{o}C and then packed in cellophane kept in freezer until used.

Cooking methods for rice samples

The samples were prepared as outlined below;

Raw Sample: the rice kernels ground into powder and then sieved with No 72 mesh size (Griffin and George Ltd., London).

Conventional cooked: The rice kernels were placed in the stainless steel bowl, one cup (300mL) of distilled water was added (rice water ratio 1:3 w/v) and the rice was boiled to soft edible cooked rice.

Parboiling: The rice kernels were placed in the stainless steel bowl, one cup (300 mL)of distilled water was added (rice water ratio 1:3 w/v) and cooked until the rice began to gelatinize. The cooking water was drained off, and another half cup (150 mL) of distilled water was added to the precooked rice and boiled to soft edible cooked rice.

Pressure cooked: The rice kernels were placed in pressure pot, one cup (300 mL) of distilled water was added (rice water ratio 1:3 w/v) and cooking was done under a steam pressure of 6895 Pa on an electric stove to soft edible cooked rice.

Microwave cooked, the rice kernel were placed in ceramic plate, one cup (300 mL) of distilled water was added and put in a domestic microwave oven (Model BRE799GMSSE, 800W power output, 20 litre capacities, Breville, UK) and boiled to soft edible cooked rice.

The samples were stored in plastic containers with screw cap and kept in the freezer until used.

Proximate composition

The moisture, ash and protein content of the samples in triplicate were determined by the methods of analysis of Association of Official Analytical Chemists AOAC (2000) procedure. The fat content was determined by soxhlet extraction method while carbohydrate was determined by difference.

$$\text{Carbohydrate} = 100 - (\text{moisture} + \text{ash} + \text{fibre} + \text{protein} + \text{fat})$$

Energy value was estimated from the proximate analysis by Atwater principle (James 1996).

$$\text{Energy Value (kJ/g)} = (\text{carbohydrate x 17 kJ}) + (\text{Protein x 17 kJ}) + (\text{fat x 37 kJ}).$$

Determination of mineral content

The samples (2.0 g) were digested with nitric and perchloric acids (HNO_3 / $HClO_3$: 4:1, v/v) in presence of hydrogen peroxide in a fume cupboard until colourless solution was obtained, the solution was poured into standard flask and made up to 50 mL with distilled water. The solution was taken for mineral determination using Atomic Absorption Spectrophotometer (Alpha 4 Model, FisonsChem-Tech Analytical, UK).

Determination of vitamins

The content of water soluble vitamins such as thiamine, pyridoxine, folate and ascorbic acid (Vitamin C) in the samples were simultaneously determined using a reverse phase High Performance Liquid Chromatography with UV detector set at 254 nm using method of Khor and Tee (1996) with modifications.

The cooked samples (2.0 g) were weighed into 200 mL Erlenmeyer flask and homogenized with 30 mL of 0.1M Hydrochloric acid. The mixture was homogenized using a homogenizer at medium speed for 1min. The supernatant was washed with methanol added and the mixture was heated at 40°C for 5 min, the mixture was filtered through ashless filter paper and centrifuged for 10 min at 1800 rpm. The supernatant was sonicated and 20 µL were injected into the column and separated. Peaks were identified by comparison of the retention time to that of the known standards and the value of vitamins was obtained from computer printout (Chemstation software).

Preparation of standard

The stock standard solutions of thiamine and pyridoxine were prepared by dissolving 50 mg of the standard in 0.1 M hydrochloric acid in 25 mL standard flask and made up to mark with the acid. For preparation of folic acid and ascorbic acid, 0.1 M sodium hydroxide and deionized water was used. The working standards were prepared from the stock standard solutions by taking 0.1, 0.2, 0.3, 0.4, 0.5 mg/mL of the stock into 10 mL standard flask and made up to mark with appropriate solvent. The solutions were sonicated for 30 min and 20 µL of various concentrations of vitamin standards were injected into the HPLC column separately and the retention times were noted. The solutions of the standards were mixed in equal proportion and 20 µL was injected into the column. The retention time of each vitamin in the complex mixture was noted and used to identify the vitamins in the sample. The detection limit for the vitamins was 0.05 mg/mL.The retention time for ascorbic acid, pyridoxine, thiamine and folic acid were 2.268, 3.279, 4.025 and 4.888, respectively, while correlation coefficients based on the concentration (mg/mL) versus peak area (mAU) were found to be > 0.999.

Results and Discussion

The proximate composition and mineral analysis of rice sample is presented in Table 1. The moisture content ranged from 8.8% in "Mai Adolai" to 14.1% in "Erinmo", the value agreed with the average value reported in most literature for white rice. The factor of moisture content is paramount in maintenance of quality in rice during storage, because its level controls the rate of deterioration and infestation of the grains. Commonly accepted moisture content for 'safe' storage are 13% for less than 6 months' storage and 12% for long term storage (Ebuehi and Oyewole, 2007). It follows that "Mai Adolai" rice variety may have a longer shelf life compared to the other rice varieties due to the lower moisture content. Moisture content of any sample depends on the age, freshness and agronomic practice during cultivation, increased moisture content in rice may to likely affect the milling characteristics and palatability of cooked rice (Oko *et al*., 2012).

The ash ranged from 0.88% to 1.67%, "Erinmo" recorded the least while the highest was reported for 'Damboto'. Ash is the inorganic residue remaining after the water and the organic matter have been removed by heating in the presence of oxidizing agents which provides measure of the total amount of minerals in foods. This value agreed with the average value reported by Anderson for wild rice and other related cereals (Anderson, 1976).

The highest fat content was reported for CPVH (5.9%) and the least for Erinmo (2.9%). The fat content ranged from 0.5 to 3.5%, was reported for local rice in Nigeria (Oko and Ugwu, 2011), also fat content ranged from 5.16 to 6.14% has been reported for some unpolished rice (Anjum *et al.*, 2007). The fat content in milled rice have been reported lower than the range obtained in this work because milling of rice removes the outer layer of the grain where most of the fats are concentrated (Frei and Becker, 2003).

The effect of excess intake of dietary fat has some well-established health implications especially for the overweight. The consumption of excess amounts of saturated fats has been recognized as the most important dietary factor aiding increased level of cholesterol. Besides the cholesterol implications due to high fat intake, obesity is a factor in the causation of disease (Wardlaw and Kessel, 2002). In this regard, the samples of rice analyzed in this work could be said to be better preferred. However, rice lipids, commonly denoted as oil ('rice bran oil') due to its liquid character at room temperature, are characterized by a high nutritional value. The high

Table 1. Proximate and mineral composition of rice samples (mg /100 g dry weight basis)

Parameters	CPVH	Damboto	Erinmo	Mai Adolai	Yai china
Moisture	13.5 ± 0.9[a]	13.9 ± 0.1[a]	14.1 ± 0.1[a]	8.8 ± 0.9[b]	10.3 ± 1.1[b]
Ash	1.49 ± 0.03[b]	1.67± 0.02[a]	0.88 ± 0.01[d]	1.49 ± 0.07[b]	1.16 ± 002[c]
Ether Extract	5.9 ± 0.2[a]	4.1 ± 0.2[c]	1.9 ± 0.1[e]	5.5 ± 0.6[b]	5.5 ± 0.1[b]
Protein	6.4 ± 0.3	6.6 ± 0.4	6.1 ± 0.2	6.1 ± 0.2	6.6 ± 0.3
Carbohydrate	72.6 ± 1.0[c]	74.8 ± 0.5[b]	77.1 ± 0.3[ab]	78.2 ± 1.1[a]	76.5 ± 0.3[b]
Energy (kJ)	1561± 22	1535± 10	1484± 9	1637± 12	1616± 14
Zinc	2.8 ± 0.7[b]	4.5± 0. 1[a]	0.80 ± 0.1[c]	2.7 ± 0.7[b]	3.4 ± 0. 9[a]
Iron	5.4 ± 1.3[b]	4.2 ± 0.9[bc]	10.6 ± 1.0[a]	7.3 ± 0. 8b	9.3 ± 0.2[ab]
Copper	1.9 ± 0.2[a]	0.2 ± 0.1[c]	0.3 ± 0.1[bc]	0.4 ± 0.1[b]	0.8 ± 0.1[b]
Calcium	31.8 ± 0.6[c]	41.7 ± 3.0[b]	31.2 ± 1.7[c]	28.6 ± 4.3[c]	47.6 ± 0.5[a]

Mean ± Standard deviation of triplicate analysis
Values in row with the different superscript were significantly different at $p \leq 0.05$

proportion of unsaturated fatty acids, accounting for up to 80%, causes the liquid consistency of the oil. Because of its high level of un-saturation, rice bran oil is known to have blood cholesterol lowering effects (Oko *et al*., 2012).

Carbohydrate is the major micronutrient in cereal grains; it ranged from 72.6 in CPVH to 78.2% in "Mai adolai". The value is within the range reported for local rice varieties in Nigeria by Eggum (1982) and Edeogu *et al*. (2007). The local varieties were very rich in carbohydrate just like other cereals. The energy content ranged from 1484 to 1637 kJ /100 g, showing that rice is a good source of energy which is mainly supplied by carbohydrate. The complex carbohydrate in rice digests slowly allowing the body to utilize the energy released over a long period which is nutritionally efficient. The energy requirement of an adult is 2200 kJ/day, this indicated that consumption of these rice samples could support energy requirement for normal growth and body metabolism.

Protein content ranged from 6.1 to 6.6%, "Yai china" and "Damboto" recorded higher values though the values were not significantly different ($P \leq 0.05$) among the varieties. Protein content of 7.3% and 6.95% was reported for both Ofada and Aroso (Ebuech and Oyewole, 2007) whereas protein range of 1.58 to 6.22% was reported for some rice varieties grown in South-Eastren, Nigeria (Oko and Ugwu, 2011). It implies that the samples being investigated compares favourably with protein content of other rice varieties.

The result of mineral content (mg/100 g) (Table 1) indicated that zinc ranged from 2.8 mg in "Erinmo" to 4.5 mg in "Damboto", iron from 4.2 mg in "Damboto" to 10.6 in "Erinmo", calcium from 28.6 mg in 'Mai Adolai to 47.6 mg in 'CPVH" whereas copper was only significantly higher in CPVH (1.9 mg). The result indicated that 'Erinmo' recorded least value for zinc but highest value for iron whereas reverse was the case with 'Damboto' this variation could be explained to be due to factors of soil, vegetation and farming practices each samples were subjected to, for instance, the rate of fertilizer application and the native fertility of paddy fields have been shown to affect the mineral element levels of rice (Ibukun *et al*., 2008). The iron content of local rice indicated, by implication that consumption of 100g of "Damboto" rice will provide about 40% of the recommended dietary allowance for iron. This is of tremendous benefit in ameliorating diet related health challenges especially in Nigeria where iron deficiency anaemia is prevalent. However, bioavailabilty of iron in plant foods have been reported to be affected by dietary factors such as phytate, tannins, fibre, polyphenol and calcium which are inhibitory and presence of meat or fish and organic acids (ascorbic acid, lactic acid) which enhanced bioavailability (Fairweather –Tait, 1999). Iron is an essential micronutrient that plays a vital role in oxygen transport, oxidative metabolism, cellular proliferation and many other physiological processes. It is a redox metal and participates in most of the reversible one-electron oxidation-reduction reactions by switching between the two oxidation states, ferrous and ferric. This redox activity of iron can produce free radicals responsible for cell signaling processes and iron mediated toxicity. (Nair and Iyengar 2009) Calcium helps in formation of strong bones and teeth, and zinc helps in the formation of bone and teeth, protein synthesis in the body.

Table 2. Water soluble vitamin content of raw and conventional cooked rice varieties (mg/kg dry weight)

Sample	Ascorbic acid		Pyridoxine		Thiamine		Folic acid()	
	mg / kg DW						µg / kg	
	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked
Danboto	10.6 ± 0.8^{a}	5.60 ± 0.8^{a}	534 ± 9.0^{a}	479 ± 4.3^{b}	126 ± 4.6^{c}	106 ± 4.0^{d}	64 ± 2.8^{c}	63 ± 5.8^{b}
Mai Adolai	3.3 ± 0.9^{b}	0.40 ± 0.02^{c}	306 ± 10^{c}	305 ± 2.8^{e}	113 ± 3.6^{d}	95 ± 5.0^{e}	62 ± 1.5^{c}	56 ± 2.2^{c}
YaiChina	2.6 ± 0.02^{b}	1.90 ± 0.1^{c}	354 ± 13^{b}	295 ± 3.2^{e}	119 ± 7.0^{d}	118 ± 9.0^{c}	73 ± 6.0^{b}	65 ± 1.5^{b}
CPVH	2.9 ± 0.03^{b}	0.50 ± 0.01^{c}	340 ± 11^{bc}	324 ± 4.5^{d}	163 ± 3.0^{b}	150 ± 4.0^{b}	88 ± 2.3^{a}	79 ± 3.5^{a}
Erinmo	2.6 ± 0.4^{b}	1.70 ± 0.2^{b}	316 ± 14^{c}	313 ± 6.3^{d}	215 ± 2.6^{a}	189 ± 12^{a}	74 ± 5.0^{b}	65 ± 2.5^{b}

Mean ± Standard deviation of triplicate analysis
Values in the column with the same superscript are not significantly different at $p \leq 0.05$

The result of water soluble vitamins (mg/ kg) in both raw and samples subjected to conventional cooking is presented in Table 2. The ascorbic acid content ranged from 2.6 in CPVH to 10.6 mg and 0.4 to 5.60 mg/kg for raw and cooked samples, respectively. The ascorbic acid level of rice is low compared to fruits and vegetables. Ascorbic acid was not detected in fragrant, siam and Basimati rice (Mohd *et al*., 2015) Ascorbic acid (vitamin C) is one of the most sensitive vitamins. For this reason it is often used to evaluate the influences of food processing on vitamin contents. Cooking losses depend upon degree of heating, leaching into the cooking medium, surface area exposed to water and oxygen, pH and other factors (Eitenmiller and Landen, 1999). On the retention of ascorbic acid (Figure 1), it was revealed that CPVH and Erinmo rice were drastically affected by pressure cooking as both recorded less than 10% ascorbic acid retention.

The mean percentage ascorbic acid retention (Table3) showed this trend; parboiling > conventional cooking > microwave > pressure cooking. From the Table, it was also revealed that ascorbic acid is the least stable of all the vitamins investigated, all cooking method appreciably affected its retention. However, pressure and microwave cooking caused less than 33% retention of ascorbic acid. The trend of ascorbic acid retention reported in this work did not agree with the trend observed in vegetables where conventional cooking caused a higher loss of ascorbic acid than microwave and pressure cooking (Uherova *et al*., 1993).

Evidence of ascorbic acid playing a key role in decreasing the incidence of degenerative diseases is considered to be strong. Low ascorbic acid levels have been associated with fatigue and increased severity of respiratory tract infections (Johnston *et al*., 1998), while high intake of vitamin C from food had been shown to raise serum HDL-cholesterol and

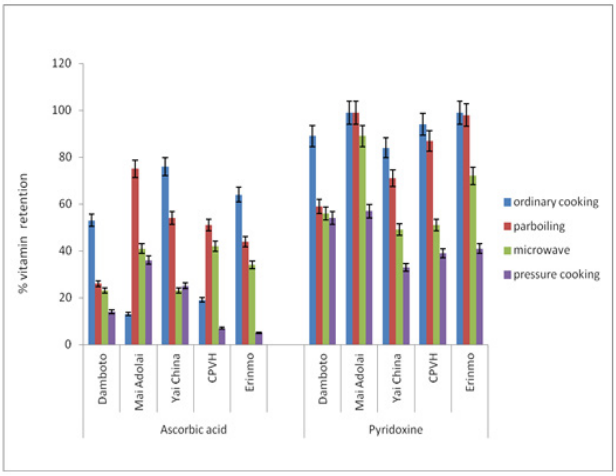

Figure 1.Effect of cooking methods on the retention of ascorbic acid and pyridoxine content of rice varieties

lowers serum triglyceride concentration (Ness *et al.,* 1996). The content of pyridoxine ranged from 306 to 534 mg/kg; 'Damboto' recorded significantly higher value (534 mg/kg) while 'Mai Adolai' had the least value (306 mg/kg). Pressure cooking recorded the least mean percentage retention of pyridoxine (44.7%), followed by microwave cooking (63.5%) and the highest was found in conventional cooking (93.6%). The high pyridoxine retention in conventional cooking indicated that the vitamin is stable to cooking; this could be adduced to the fact that physiologically active Vitamin B6 appears in food under six forms of chemical compounds; pyridoxal, pyridoxol and pyridoxamine and their phosphate compounds such as pyridoxamine -5- phosphate, pyridoxol -5-phosphate and pyridoxal -5- phosphate. Each of these forms has different solubility and heat stability.

The content of thiamine in raw rice (Table 3) ranged from 113 to 215 mg/kg, 'Erinmo' recorded the highest significant value ($p \leq 0.05$), and the least for 'Mai Adolai'. Thiamine was not detected in white Basimati rice (Mohd *et al*., 2015) but 0.38

Table 3. Mean percentage retention of vitamins due to various cooking methods (%)

Vitamins	conventional	parboiling	Microwave	Pressure
Ascorbic acid	44.5 ± 27[b]	49.8 ± 17[a]	32.4 ± 9.0[c]	17.5 ± 12[d]
Pyridoxin	93.3 ± 6.6[a]	86.8 ± 16[b]	63.2 ± 16[c]	44.7 ± 10[d]
Thiamine	89.5 ± 6.2[a]	70.9 ± 15[b]	54.4 ± 2.2[c]	67.9 ± 25[b]
Folic acid	91.1 ± 4.0[a]	87.9 ± 4.2[a]	55.2 ± 16[b]	79.8 ± 16[a]

*Mean ± SD –mean and standard deviation of the values obtained for vitamins from rice varieties due to cooking methods
Values across the row with the same superscript were not significantly different p ≤0.05

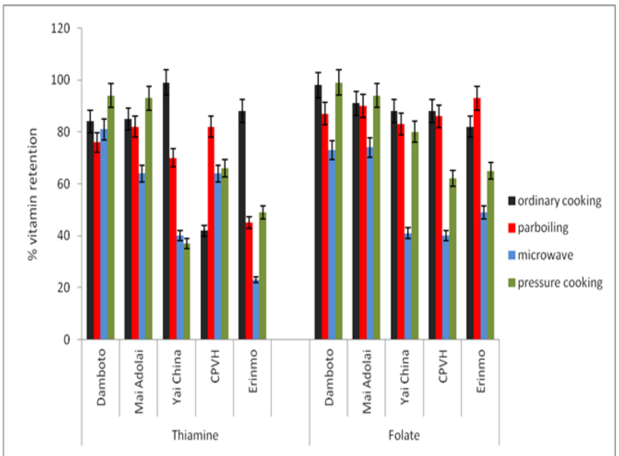

Figure 2.Effect of cooking methods on retention of thiamine and folate content of rice varieties

g/100g was reported for husked rice (unpolished rice). Labiedzinka and Szefer, (2006) had observed that wild rice; brown rice and parboiled rice are viable sources of thiamine. Thiamine like ascorbic acid is a nutrient that is highly susceptible to thermal degradation and leaching, for this reason thiamine is employed as an indicator of cooking losses of vitamins in food.

Effect of cooking methods on thiamine retention (Figure 2) showed that microwave cooking mostly affected varieties like ‘Mai Adolai’ and ‘Erinmo’, and on the overall, microwave recorded the least mean percentage retention value among the cooking methods,, parboiling and pressure cooking were not significantly different ($P \leq 0.05$) whereas conventional cooking leads to a higher retention of thiamine. The trend of thiamine loss in this study is consistent with the observation of Berechet and Segal (2007) who reported different degrees of retention of thiamine in microwave cooked dishes and meat, the explanation was that under alkali pH, the destruction of thiamine under heat processing is higher than in acid pH, Under heat treatment, thiamine is broken down into pyrimidinic and thyazol nucleus losing also the vitamin activities. Therefore, rice cooking by microwave and pressure cooker may not be ideal among population where Beri-beri – a thiamine deficiency disease is endemic.

Folate content ranged from 62 to 88 µg / kg (Table 3), the highest significant value was reported for ‘CPVH’ while the least value was reported for ‘Mai Adolai’ rice. The range reported in this work compares favourably with the range of 51 to 98 µg / 100g reported for three varieties of rice including fragrant rice (Mohd *et al*., 2015) but higher that 25 µg / 100g reported for Basmati rice (Chew *et al*., 2012).

The result of folate retention (Figure 2) indicated that folate is relatively stable to heat treatment because except for microwave cooking which recorded significantly lower mean percentage retention (55.2 %), there was no significantly different in mean percentage folate retention among other cooking methods. The lower percentage folate retention observed due to microwave cooking agrees with the range of 51 and 56% folate reduction reported for spinach and broccoli as a result of cooking by microwave (Mckillop *et al*., 2002).

Exposure of food to microwave energy, though believed to conserve nutrient because of shorter cooking time, caused high temperature and increased gelatinization of rice which could exposed the food to heat intensity. Leichter *et al.* (1978) reported that folate loss is as a result of leaching and not degradation of folate molecule, thus it is highly dependent both on the food in question and method of cooking.

The loss of vitamins during cooking has been attributed to a combination of leaching and chemical destruction (Geetanjali *et al*., 2010). During parboiling, a tangible amount of the vitamins have dissolved in the water and were disposed off alongside the liquor, therefore causing a reduction in the available vitamins in the samples (Zhang and Hamauzu, 2004). In pressure cooking, the steam is not allowed to leave the pressure pot which causes the pressure sitting on the content. A pile up of the pressure causes a rise in the temperature of the boiling water making it boil at a temperature greater than 100°C which causes an increase in the rate of the reaction.

While Microwave make use of electromagnetic waves produced by a magnetron and are able to penetrate foods and cause an increase of temperature. The high frequency microwave field oscillating at 2450 MHz in the microwave oven influences the vibration energy in the water molecule and other dipoles to cause frictional heating while materials other than water may be dipolar or may behave as dipoles due to the stress of the electric field, water usually dominates, probably because it is pervasive and at high concentration in most foods (Rynanen, 2002)

However, it is noteworthy to mention that heat is not the only factor that acts negatively on vitamins throughout cooking, so do water, oxygen and oxidizing agents. Ascorbic acid, for instance, can react with oxygen thus forming dehydroascorbic acid. This compound has the same vitaminic activity as ascorbic acid, but it is very sensitive to oxidizing agents and can be hydrolyzed so as to form diketogulonic acid, which lacks vitaminic activity. On the contrary, antioxidants, either natural or added, can protect this alteration. Light, pH and the presence of metallic ions are factors which can increase vitamin loss by beginning or helping degrading reactions Interactions during treatment of foods can be also caused by the presence of other vitamins and food components, either natural, added or as a result of the degradation of other nutrients (enzymes, free radicals, sulphur anhydride, etc. (Ruiz-Roso, 1998).

From the results, it can be inferred that various cooking methods investigated have the ability to destroy some important nutrients especially water soluble vitamins. Microwave and the pressure cooking showing the highest destructive ability on all the vitamins present in rice varieties investigated; therefore it will not be nutritionally advisable to cook rice either with microwave or pressure cooker.

Conclusion

This study revealed that microwave and pressure cooking that help in conservation of time and energy lead to significant loss of vitamins compared to conventional cooking which wastes time and energy. It is therefore important to encourage the best cooking practices that will ensure retention of vitamins otherwise rice diet cooked or warmed with modern technological devices like microwave should be complemented with food sources such as fruits and vegetables for a balanced vitamin nutriture.

Conflict of Interest:

There is no conflict of interest declared by the author

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