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Changes in Chemical Composition of Treated and Untreated Hungry Rice "Acha" (*Digitaria exilis*)

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Abstract: This study focused on the changes in the chemical composition of treated and untreated hungry rice "Acha". Nutrient composition and antinutritional factors were studied using standard methods of analysis. The results of analyses revealed that hungry rice fermented for 108 h (FHR_{108}) had significantly higher Crude Protein (CP) (9.94%), True Protein (TP) (9.34%), True Nitrogen (TN) (1.49%), Non-Protein Nitrogen (NPN) (0.10%) and fat (3.08%) ($p<0.05$). Fermentation for 48 h (FHR_{48}) had the highest copper (Cu) (3.26 mg), manganese (Mn) (1.38 mg), zinc (Zn) (1.62 mg), phosphorus (Ph) (160.89 mg) and iodine (I_2) (103.33 mcg) than others ($p<0.05$). Untreated Hungry Rice (UTHR) had the highest tannins (0.13 mg), phytate (1.22 mg) and Trypsin Inhibitors (TI) (38.45 mg). Based on this study, cooking and fermentation increased both proximate and mineral composition in treated samples but decreased antinutritional factors in most parameters tested. Cooking and fermentation could be used by most rural and poor urban dwellers to increase nutrient content of their diets.

Key words: Hungry rice, crude protein, true protein, true nitrogen

INTRODUCTION

Cereals are the most widely cultivated and consumed crops on a global basis and are some of the earliest crops the early man planted. Cereals belong to the grass family and constitute important crops which serve as industrial raw materials and staple for the world (Enwere, 1998). FAO (1998) reported that cereals are the staple foods of over half the world's population. Cereals provide about 75% total calorie and 67% of total protein intake of people in the tropics (Ihekoronye and Ngoddy, 1985).

The geographical location and climatic condition of each area determine the kind of cereals that can be grown and utilized (FAO, 1989). The three most important cereals in the world are wheat, rice and corn. Other important ones include sorghum, oats, barley, millet and rye (Onimawo and Egbekun, 1998). In Africa, wheat and barley are important in temperate regions, such as northern Africa while the principal cereals of the tropics and warmer countries are rice, maize, sorghum and millet. Minor cereals which nevertheless, provide staple food for some African populations are teff, grown in Ethiopia and fonio or hungry rice grown in West Africa. In Nigeria, the cereals cultivated are sorghum, millet, maize, rice, wheat and hungry rice to a lesser extent (Okoh, 1998), especially in the northern parts of the country where they are the major sources of energy and protein in the diets of the people.

All cereals although of different sizes and shapes are fairly similar in nutritive value and anatomical structure. Cereals have high carbohydrate, low fat and fair protein content (Enwere, 1998). Cereals have 6% protein in rice to 12% in oats (Fox and Cameron, 1995).

Cereal proteins are deficient in lysine and tryptophan, with lysine as the first limiting essential amino acid. They are, however, rich in methionine and cystine (Eggum, 1979). The fat content of cereals range from about 1.5% in wheat to 12% in oats. The amount of moisture in cereals is between 7% in oats to 12% in wheat (Fox and Cameron, 1995). Low moisture accounts for the high keeping quality. They contain a substantial amount of B-complex vitamins. Cereals relatively contain some significant levels of toxicants. Majority of the minerals are concentrated in the seed coat (Neucere and Sumrell, 1980).

Hungry rice also called acha or fonio is probably the oldest African cereal. It is indigenous to West Africa where it is grown for its straw and edible grains. There are two main prominent species, the white acha (*D. exilis*), most widely cultivated and the black acha (*D. iburua*) is a little bigger in terms of stature and even grain size. Ibrahim (2001) reported that for thousands of years, West Africans have cultivated it across the Dry Savanna where it was believed to have been once the major food crop in this region of the world. Although, the crop has been neglected for quite sometime and a few people know of it, acha remains important in areas

scattered from Cape Verde to Lake Chad. In certain regions of Mali, Burkina Faso, Guinea and Nigeria, acha is either a staple or a major part of the diet.

Despite its ancient heritage and widespread importance, acha has received but a fraction of the attention accorded to sorghum, pearl millet and maize. Part of the reason for this neglect is because the crop is misunderstood by scientists and other decision makers. It is being referred to as hungry rice in English which is a misleading term by Europeans who knew little of the crop or the lives of those who used it. The people do not harvest the crops out of hunger but because they liked the taste. Indeed, they considered the grain exotic and in some places they reserved it, particularly for chiefs, royalty and special occasions. It also formed part of the traditional bride price. Moreover, it is still held in such esteem that some communities continue to use it in ancestor worship (NAS, 1996). They are sometimes called "Grain of Life" because the early maturing type (6-8 weeks) provide food easily in the growing season when many crops are still too immature to be harvested and the previous years production has been depleted (Ibrahim, 2001).

In West Africa, farmers devote approximately 300,000 hectares to its cultivation which supply food to 3-4 million people (Ibrahim, 2001). It is grown in poor, sandy or ironstone soils and in areas of low rainfall. Consequently, the crop is popular in parts of northern Nigeria where the soil is unable to support adequate growth of some of the more popular cereals like maize, sorghum and millet (Okoh, 1998). It is commonly grown in Plateau State. They are perhaps the world's fastest maturing cereal, producing grains 6-8 weeks after they are planted. However, some varieties are late maturing from 165-180 days.

It is one of the world's best tasting cereals. Acha has tiny grains and is used in a variety of ways. The grain is milled into flour and used for porridge and local beverages. It can also be prepared in various other forms for human consumption (Okoh, 1998). Ibrahim (2001) observed that it can be made into porridge and cous cous, ground and mixed with flours to make breads, popped and even brewed for beer. It has been described as food substitute for semolina-the wheat product used to make spaghetti and other pastas. The Hausas prepare cous cous from acha. In Togo, a famous beer (tchapalo) is brewed from it and acha is prepared with beans in a dish that is reserved for special occasions. Some people have made side-by-side comparisons of dishes made with acha and common rice and have greatly preferred acha. The grains are efficiently digested by farm animals while the straw and chaff can also be fed to farm animals.

It is one of the most nutritious of all grains. In gross nutritional composition, acha differs little from wheat. Temple and Bassa (1991) stated the proximate composition as follows; 6.9% protein, 2.10% fat, 87.48% carbohydrate, 1.02% crude fibre and 2.44% mineral salts. However, Anyika (2003) indicated crude protein of 5.75, fat 3.35, 1.08 total ash, 6.83 moisture and 83.38% carbohydrate.

White acha (*D. exilis*) husked grain contained 8% protein and 1% fat (NAS, 1996) and black acha contained 11.8% protein (NAS, 1996). The white acha contained 7.3% methionine plus cystine. The amino acid profile compared to that of whole-egg protein showed that except for the low score of 46% for lysine, the other scores were high: 72% for isoleucine; 90-100 for valine, tryptophan, threonine and phenylalanine; 127 for leucine; 175 for total sulphur and 189% for methionine. Thus, acha has important potential not only as a survival food, but as a complement for standard diets (NAS, 1996).

The objective of this study is to evaluate the changes in the chemical composition of treated and untreated hungry rice "Acha" (*Digitaria exilis*).

MATERIALS AND METHODS

Sources of materials: Hungry Rice (HR) was bought (5 kg) from Jos in Plateau State, Nigeria.

Preparation and treatment of samples: Hungry rice grains were sorted to remove foreign materials and washed severally in order to remove sand. The untreated sample (UTHR) was then dried, milled and stored in labelled polyethylene bag prior to laboratory analysis. Cooked sample (COHR) and fermented samples (0, 12, 24, 36, 48, 60, 72, 96 and 108 h) were treated accordingly (Fig. 1).

Chemical analysis: Proximate and mineral compositions were determined by AOAC (1995). True protein was obtained by multiplying True Nitrogen (TN) by 6.25. Non-Protein Nitrogen (NPN) was determined by the method of Singh and Jambunathan (1981). True Protein Nitrogen (TPN) was obtained by difference (TN-NPN). Trypsin inhibitor was determined by the method described by Kakade *et al*. (1974). Tannins content was determined spectrophotometrically using the method of Price *et al*. (1980). Phytate was estimated by modified method of Latta and Eskin (1980). Oxalate was determined by the method described by Oke (1978). Cyanide was determined enzymatically using the method of Cooke (1978).

Data analysis: Data were analyzed using the computer programme statistical software package (SAS, 2003). Analysis of variance (ANOVA), Standard Error of the Mean (SEM) and Least Significant Difference (LSD) were used to separate the mean differences among samples ($p<0.05$).

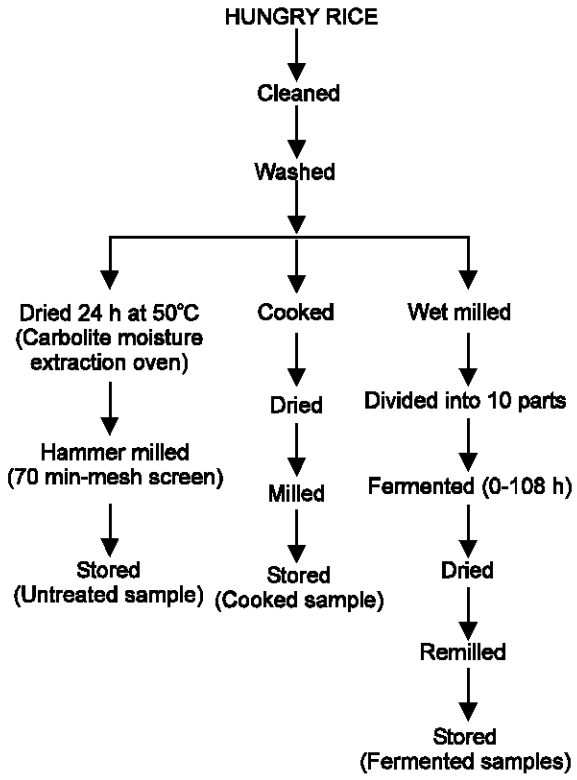

Fig. 1: Processing of hungry rice

RESULTS AND DISCUSSION

Table 1 presents the proximate composition of untreated and treated hungry rice. Moisture content of various flours of hungry rice differed. The range was from 9.25% to 10.80%. The 60 h sample had the highest (10.80%) which was significantly different from those of the other fermentation periods ($p<0.05$). The untreated, the unfermented and 48 h samples had comparable values ($p>0.05$). The 72, 96 and 108 h (10.15%) as well as 24 h sample (10.16%) had similar values ($p>0.05$).

Crude protein values ranged from 7.18-9.94%. Cooked, unfermented, 12 and 24 h samples had similar values ($p>0.05$) and those of 36 and 48 h samples were comparable ($p>0.05$). The differences in values for untreated hungry rice, 60 and 72 h samples were not significant ($p>0.05$). True protein values were lower than those for the untreated (7.79%) up to 72 h of fermentation (7.06-7.75%). Beyond 72 h there were increases up to 108 h (8.05-9.34%). The 108 h sample was the highest (9.34%) ($p<0.05$). The true protein nitrogen varied. It ranged from 1.06-1.49%. Again, the 108 h sample that had highest crude protein also had highest true protein N (1.49%). The UTHR had comparable values with FHR 60, 72 and 84 h samples ($p>0.05$). The non protein N values for all flours were virtually the same ranging from 0.07-0.10%.

Ash values differed. The range was from 1.18-3.60%. The 36h sample had highest value (3.60%) and the 12h sample had the least (1.18%). The UTHR had lower value than the 36h sample (2.01 vs 3.60%) ($p<0.05$). The other samples had values between 1.68 and 1.88%. Fat values were a function of fermentation times. From 12-108 h fermentation, fat increased from 2.18-3.08%. The cooked hungry rice and 108 h fermented sample had comparable fat values (3.05 and 3.08%).

Fibre values varied. Significant increase was only for 36 h sample (3.33%) ($p<0.05$) compared to others. The 24, 48 and 108 h fermentation periods had no effect on fibre content of hungry rice (2.15 and 2.18) as against the control (2.15%). The Carbohydrate (CHO) levels for all treatments did not vary significantly ($p>0.05$). The values ranged from 72.91-76.46%.

The lower moisture levels for Cooked Hungry Rice (COHR) and its 36 h fermented flour (9.92 and 9.25%) (Table 1) have some nutrition implications. It is true that flours that have low moisture keep longer than those that have high moisture (Ihekoronye and Ngoddy, 1985). The 10.02-10.80% moisture content of the other flours is encouraging.

The comparable lower crude protein values for cooked hungry rice (7.53%) with those of fermentation from 24-48 h suggests that reduction due to cooking and fermentation from 24-48 h when compared with the control (UTHR) might be due to loss of non-protein N. On the other hand, the increases in crude protein from 84-108 h appear to suggest that these periods were optima for production in hungry rice of high quality protein. The lower true protein for both cooked and fermented flours as against the control (7.79%) except for 84, 96 and 108 h (8.05, 8.52 and 9.34%, respectively) was solely due to removal of non-protein N. The higher values for 84, 96 and 108 h flours suggests these as optima times to produce high quality protein from hungry rice. However, Wang and Hesseltine (1981) reported that fermentation process usually did not significantly change the protein content and amino acid composition of the substrate.

The lower ash for all the flours regardless of treatment except for the 36 h (3.60%) as compared with control (2.01%) might be due to loss of vegetative parts of the grains during processing. The decreases in fat as the fermentation time increased might be due to (a) cereal (hungry rice) does not contain much fat as source of energy rather to maintain cell wall integrity (Chikwendu, 2003) and (b) some of the little amounts of fat it contained might have been used for microflora metabolism (Obizoba and Atii, 1994).

The increases in fibre except for the 72 h flour as compared with control (1.78%) might be due to high hydrolysis of complex CHO to simpler absorbable sugar to liberate more fibre. The comparable CHO (73.71-76.46%) might be due to increase in fibre or use by microlfora as source of energy.

Table 1: Chemical compositions of untreated, cooked and fermented hungry rice

Composition (%)	UTHR	COHR	FHR_0	FHR_{12}	FHR_{24}	FHR_{36}	±SEM
Moisture	10.33^{b}	9.92^{d}	10.35^{b}	10.25^{b}	10.16^{e}	9.25^{d}	±0.015
Crude protein	8.29^{d}	7.53^{gh}	7.18^{j}	7.25^{j}	7.38^{hi}	7.63^{fg}	±0.069
True protein	7.79^{d}	7.06^{g}	6.63^{j}	6.82^{j}	6.93^{h}	7.17^{g}	±0.081
True nitrogen	1.25^{cd}	1.13^{g}	1.06^{j}	1.09^{j}	1.11^{h}	1.15^{g}	±0.013
Non protein nitrogen	0.08^{b}	0.07^{c}	0.07^{c}	0.07^{c}	0.07^{c}	0.07^{c}	±0.000
Ash	2.01^{b}	1.72^{fg}	1.88c	1.18^{de}	1.68^{g}	3.60^{a}	±0.019
Fat	2.62^{f}	3.05^{a}	2.18^{j}	2.28^{j}	2.35^{h}	2.48^{g}	±0.018
Fibre	1.78^{f}	2.02^{c}	2.15^{b}	1.95^{d}	2.15^{b}	3.33^{a}	±0.016
CHO	75.12^{c}	75.76^{b}	76.25^{a}	76.46^{a}	76.29^{a}	73.71^{f}	±0.082
Composition (%)	FHR_{48}	FHR_{60}	FHR_{72}	FHR_{84}	FHR_{96}	FHR_{108}	±SEM
Moisture	10.45^{b}	10.80^{a}	10.15^{c}	10.02^{f}	10.15^{c}	10.15^{e}	±0.015
Crude protein	7.75^{f}	8.00^{d}	8.25^{d}	8.56^{c}	9.06^{b}	9.94^{a}	±0.069
True protein	7.29^{f}	7.52^{e}	7.75^{de}	8.05^{c}	8.52^{b}	9.34^{a}	±0.081
True nitrogen	1.17^{f}	1.20^{e}	1.24^{de}	1.29^{c}	1.36^{b}	1.49^{a}	±0.013
Non protein nitrogen	0.07^{c}	0.08^{b}	0.08^{b}	0.08^{b}	0.08^{b}	0.10^{a}	±0.000
Ash	1.72^{fg}	1.83^{cd}	1.68^{g}	1.76^{ef}	1.68^{g}	1.77^{ef}	±0.019
Fat	2.78^{e}	2.82^{de}	2.85^{cd}	2.88^{c}	2.97^{b}	3.08^{a}	±0.018
Fibre	2.18^{b}	2.02^{c}	1.78^{f}	2.02^{c}	1.86^{e}	2.15^{b}	±0.016
CHO	75.12^{c}	74.53^{d}	75.34^{c}	74.76^{d}	74.27^{e}	72.91^{g}	±0.082

Values are means of triplicate determinations ±SEM, Means with different superscripts in the same column differed ($p<0.05$)

UTHR = Untreated Hungry Rice | COHR = Cooked Hungry Rice | FHR_0 = 0 h Fermented Hungry Rice

FHR_{12} = 12 Fermented Hungry Rice | FHR_{24} = 24 h Fermented Hungry Rice | FHR_{36} = 36 h Fermented Hungry Rice

FHR_{48} = 48 h Fermented Hungry Rice | FHR_{60} = 60 h Fermented Hungry Rice | FHR_{72} = 72 h Fermented Hungry Rice

FHR_{84} = 84 h Fermented Hungry Rice | FHR_{96} = 96 h Fermented Hungry Rice | FHR_{108} = 108 h Fermented Hungry Rice

Table 2 summarizes the mineral composition of untreated and treated hungry rice. Cooking hungry rice caused 0.01% decrease in iron (2.14-2.13 mg). There were also decreases in Fe as fermentation time increased except for the 12 h sample (2.28 vs 3.08 mg). The highest decrease was the 84 h (2.28 vs 1.93 mg) and lowest was the 108 h (2.28 vs 2.27 mg). The 24, 36, 48, 72 and 96 h fermented samples had different but comparable Fe values (2.08, 2.11, 2.18, 2.17 and 2.18 mg, each). Cooked rice had higher Calcium (Ca) than the untreated rice (29.35 vs 19.84 mg). Fermentation had varied effect on Ca levels. The 36, 84, 96 and 108 h fermented flours had increases in Ca when compared with the unfermented sample (22.60 vs 23.34, 25.34, 23.78 and 22.90 mg, each). However, the 12 and 72 h samples had comparable values (20.27 and 20.80 mg, respectively). Twenty four hours (24 h) sample had the highest decrease when compared with the control (22.60 vs 19.25 mg).

Cooking reduced sodium in rice as against the untreated (1.29 vs 1.25 mg). On the other hand, fermentation caused varied effect on Na levels. It caused increases in 12, 36, 60 and 72 h samples (1.51, 1.41, 1.39 and 1.40 mg, respectively). It caused comparably higher decreases in 24, 48 and 108 h samples (1.05, 1.08 and 1.05 mg each). The 84 h sample had the least decrease (1.33 vs 1.30 mg). Cooking decreased Copper (Cu) in hungry rice when compared with the untreated sample (0.85 vs 1.30 mg). The decrease was significant ($p<0.05$). Fermentation had different effects on Cu levels. It decreased Cu during 12, 36, 72 and 96 h fermentation periods (1.10 vs 1.03, 0.89, 0.61 and 1.05 mg, each). It increased Cu during 24, 48, 84 and 108 h periods (3.02, 3.26, 2.05 and 1.7 mg, respectively). The 60 h sample had equal value with the control (1.10 mg).

Manganese (Mn) in hungry rice was reduced by cooking with reference to the control (15.91 vs 18.09 mg). Fermentation equally caused varied effect on Mn. There were decreases in Mn during 24, 72, 84 and 108 h fermentation (16.63, 15.25, 16.73 and 16.46 mg, respectively). The 60 h sample had highest Mn (20.84 mg) followed by the 12 and 96 h samples (19.85 and 18.90 mg). The 24, 72, 84 and 108 h samples had comparable values ($p>0.05$). Cooking slightly increased Mg (1.22 vs 1.21mg) when compared with the untreated samples. There were increases due to fermentation during 48, 60 and 96 h periods (1.38, 1.29 and 1.28 mg, respectively) as against the unfermented (1.19 mg). The decreases in the 12, 72 and 84 h were equal (1.06, 1.05, 1.06 mg) as well as those of the 24, 36 and 108 h samples (1.10, 1.15 and 1.12 mg, each).

Zinc was increased by cooking (1.49 vs 1.12 mg). Fermentation increased Zn except slight decrease for the 84 h sample (1.05 vs 1.08 mg). The 48 h sample had significantly higher value (1.62 mg) ($p<0.05$). Phosphorus (P) increased due to cooking (147.51 vs 126.50 mg). Equally, fermentation increased P except for the 24 and 84 h samples (123.35 and 123.55 vs 126.37 mg). Cooking increased Potassium (K) in hungry rice (138.33 vs 141.75 mg). Varying fermentation periods caused much decreases during 12, 24, 60, 84, 96 and 108 h samples when compared with the unfermented sample (139.44, 138.89, 133.56, 127.00, 139.68 and 121.64 mg, respectively) ($p<0.05$). It caused increases

Table 2: Chemical compositions of untreated, cooked and fermented hungry rice

Composition	UTHR	COHR	FHR_0	FHR_{12}	FHR_{24}	FHR_{36}	±SEM
Iron (mg/100 g)	2.14^{de}	2.13^{de}	2.28^{b}	3.08^{a}	2.08^{ef}	2.11^{de}	±0.036
Calcium (mg/100 g)	19.84^{fg}	29.35^{a}	22.60^{cd}	20.27^{fg}	19.25^{g}	23.34^{c}	±0.060
Sodium (mg/100 g)	1.29^{de}	1.25^{e}	1.33^{cd}	1.51^{a}	1.05^{g}	1.41^{b}	±0.023
Copper (mg/100 g)	1.30^{e}	0.85^{g}	1.10^{e}	1.03^{efg}	3.02^{b}	0.89^{fg}	±0.064
Manganese (mg/100 g)	18.09^{bcd}	15.91^{e}	17.95^{cd}	19.85^{ab}	16.63^{de}	18.00^{bcd}	±0.647
Magnesium (mg/100 g)	1.21^{c}	1.22^{c}	1.19^{cd}	1.06^{fg}	1.10^{ef}	1.15^{de}	±0.017
Zinc (mg/100 g)	1.12^{efg}	1.49^{b}	1.08^{fg}	1.33^{c}	1.10^{fg}	1.26^{cd}	±0.038
Phosphorus (mg/100 g)	126.50^{d}	147.51^{b}	126.37^{d}	138.40^{c}	123.35^{d}	165.84^{a}	±2.027
Potassium (mg/100 g)	138.33^{c}	141.75^{c}	151.44^{b}	139.44^{c}	138.89^{c}	150.45^{b}	±2.876
Iodine (mcg)	102.20^{b}	101.55^{cd}	101.95^{b}	101.05^{e}	101.15^{de}	101.22^{cde}	±0.136
Composition	FHR_{48}	FHR_{60}	FHR_{72}	FHR_{84}	FHR_{96}	FHR_{108}	±SEM
Iron (mg/100 g)	2.18^{bcd}	2.00^{fg}	2.17^{cde}	1.93^{g}	2.18^{bcd}	2.27^{bc}	±0.036
Calcium (mg/100 g)	22.35^{cde}	21.05^{def}	20.80^{efg}	25.34^{b}	23.78^{bc}	22.90^{c}	±0.060
Sodium (mg/100 g)	1.08^{g}	1.39^{bc}	1.40^{b}	1.30d^{e}	1.16^{f}	1.05^{g}	±0.023
Copper (mg/100 g)	3.26^{a}	1.10^{e}	0.61^{h}	2.05^{c}	1.05^{ef}	1.71^{d}	±0.064
Manganese (mg/100 g)	18.84^{bc}	20.84^{a}	15.25^{e}	16.73^{de}	18.9^{bc}	16.46^{de}	±0.647
Magnesium (mg/100 g)	1.38^{a}	1.29^{b}	1.05^{g}	1.06^{fg}	1.28^{b}	1.12^{e}	±0.017
Zinc (mg/100 g)	1.62^{a}	1.12^{efg}	1.50^{b}	1.05^{g}	1.21^{de}	1.18^{def}	±0.038
Phosphorus (mg/100 g)	146.72^{b}	128.88^{d}	149.40^{b}	123.55^{d}	137.26^{c}	127.78^{d}	±2.027
Potassium (mg/100 g)	160.89^{a}	133.56^{cd}	166.29^{a}	127.00^{de}	139.68^{c}	121.64^{e}	±2.876
Iodine (mcg)	103.33^{a}	101.55^{c}	101.00^{e}	101.00^{e}	101.00^{e}	101.05^{e}	±0.136

Values are means of triplicate determinations ±SEM, Means with different superscripts in the same column differed ($p<0.05$)

UTHR = Untreated Hungry Rice | COHR = Cooked Hungry Rice | FHR_0 = 0 h Fermented Hungry Rice

FHR_{12} = 12 Fermented Hungry Rice | FHR_{24} = 24 h Fermented Hungry Rice | FHR_{36} = 36 h Fermented Hungry Rice

FHR_{48} = 48 h Fermented Hungry Rice | FHR_{60} = 60 h Fermented Hungry Rice | FHR_{72} = 72 h Fermented Hungry Rice

FHR_{84} = 84 h Fermented Hungry Rice | FHR_{96} = 96 h Fermented Hungry Rice | FHR_{108} = 108 h Fermented Hungry Rice

in 48 and 72 h samples (160.89 and 166.29 vs 151.44 mg). Iodine decreased in cooked hungry rice from 102.20-101.55 mcg. Fermentation had the same effect during some periods. It increased iodine only in 48 h samples (103.33 mcg).

The decreases in iron due to cooking (2.14 vs 2.13 mg) and fermentation beyond 24 h might be attributed to loss in medium of fermentation or use by fermenting microflora for metabolism (Anyika, 2006). The increase in Ca due to cooking (19.84-29.35 mg) and through all the fermentation periods except for 12, 24, 60 and 72 h might be due to low tannins and phytate content (Table 2) of the flours. It is known that both tannins and phytate form complex insoluble salts which make Ca unavailable. It is also known that fermentation, particularly hydrolyzes bonds among phytin or tannins-protein-enzymes to free Ca or P to increase their bioavailability (Obizoba and Anyika, 1994; Obizoba and Atii, 1994). The mixed values in both Mn and Mg due to cooking and fermentation might be explained as follows -cooking decreased Mn (18.09-15.91 mg) and fermentation increased them suggesting fermentation had an edge over cooking as the best domestic food processing technique to increase these nutrients in hungry rice.

The lower sodium levels are of interest. Diabetics and hypertensive patients who require low Na diet would use more of these flours. The increases in copper for the 24, 48, 84 and 108 h showed that these were the optima fermentation periods to release more Cu from its organic complex compounds by microflora enzymes (Obizoba and Atu, 1993). The higher increase in Zn due to cooking (1.49 vs 1.12 mg) as against those due to fermentation except 48 and 72 h (1.62 and 1.50mg) demonstrated that cooking had an edge over fermentation to increase Zn in hungry rice. The lower Zn for the 84 h flour (1.05 mg) as compared with its control (1.08 mg) night be due to use for metabolism (Chikwendu, 2003) or hungry rice in the first place is a low source of the nutrient.

The increases in P and K due to cooking (126.50-147.51 and 138.33-141.75 mg, respectively) suggest that cooking is a good domestic food processing technique to increase the nutrient in hungry rice. On the other hand, the increase in P except in the 24 and 84 h showed that these periods were not beneficial with respect to P in hungry rice. The lower values for K in fermented flours except for those of 48 and 72 h indicates these periods were not conducive enough for the release of K from its organic complex salts or the nutrient was used for microflora needs (Obizoba and Atii, 1994).The insignificant increases in I_2 in some flours due to fermentation strongly suggests that it was not beneficial to use fermentation as food processing method to upgrade I_2 in hungry rice. The generally low mineral contents observed could have been due to leaching and physical separation from the grains during milling (IFT, 1975).

Table 3 depicts the antinutrient composition of untreated and treated hungry rice. Cooking and fermentation

Table 3: Chemical compositions of untreated, cooked and fermented hungry rice

Composition	UTHR	COHR	FHR_0	FHR_{12}	FHR_{24}	FHR_{36}	±SEM
Tannins (mg/100 g)	0.13^{a}	0.12^{ab}	0.11^{bc}	0.11^{bc}	0.10^{c}	0.10^{c}	±0.004
Phytate (mg/100 g)	1.22^{a}	1.12^{e}	1.11^{e}	1.17^{cd}	1.12^{e}	1.20^{b}	±0.004
Trypsin-TI (mg/g)	38.45^{a}	1.25^{e}	1.22^{f}	2.43^{b}	1.15^{h}	2.04^{d}	±0.008
Oxalate (mg/100 g)	1.14^{c}	1.11^{e}	1.12^{de}	1.18^{a}	1.17^{ab}	1.16^{b}	±0.004
Cyanide (mg/100 g)	0.07^{cd}	0.08^{bc}	0.05^{ef}	0.03^{gh}	0.02^{h}	0.05^{ef}	±0.005
Composition	FHR_{48}	FHR_{60}	FHR_{72}	FHR_{84}	FHR_{96}	FHR_{108}	±SEM
Tannins (mg/100 g)	0.06^{e}	0.06^{e}	0.08^{d}	0.06^{e}	0.05^{e}	0.06^{e}	±0.004
Phytate (mg/100 g)	1.11^{e}	1.16^{d}	1.18^{c}	1.12^{e}	1.20^{b}	1.16^{d}	±0.004
Trypsin-TI (mg/g)	1.07^{h}	1.07^{h}	2.22^{c}	1.22^{f}	1.16^{g}	1.17^{g}	±0.008
Oxalate (mg/100 g)	1.14^{c}	1.12^{de}	1.12^{de}	1.17^{ab}	1.11^{e}	1.13^{cd}	±0.004
Cyanide (mg/100 g)	0.06^{de}	0.07^{cd}	0.11^{a}	0.09^{b}	0.04^{fg}	0.04^{fg}	±0.005

Values are means of triplicate determinations ±SEM, Means with different superscripts in the same column differed ($p<0.05$)

UTHR = Untreated Hungry Rice | COHR = Cooked Hungry Rice | FHR_0 = 0 h Fermented Hungry Rice
FHR_{12} = 12 Fermented Hungry Rice | FHR_{24} = 24 h Fermented Hungry Rice | FHR_{36} = 36 h Fermented Hungry Rice
FHR_{48} = 48 h Fermented Hungry Rice | FHR_{60} = 60 h Fermented Hungry Rice | FHR_{72} = 72 h Fermented Hungry Rice
FHR_{84} = 84 h Fermented Hungry Rice | FHR_{96} = 96 h Fermented Hungry Rice | FHR_{108} = 108 h Fermented Hungry Rice

caused decreases in tannins. Fermentation reduced tannins much more than cooking, particularly in the 96 h sample. Cooking decreased phytate (1.12 vs 1.22 mg). Fermentation had mixed effect on phytate levels. It caused increases in most periods, the highest increases were in 36, 72 and 96 h samples (1.20 and 1.18 vs 1.11 mg). Cooking reduced trypsin inhibitor drastically from 38.45-1.25 mg. Fermentation increased trypsin inhibitor in the 12, 36 and 72 h samples (2.43, 2.04 and 2.22 mg, respectively). It caused much more decreases during 48 and 60 h periods (1.07 mg, each). Cooking decreased oxalate (1.14 vs 1.11 mg). Fermentation increased oxalate except for 96 h ample 1.11 vs 1.12 mg, where the decrease was very slight. Cooking slightly increased cyanide (0.07 vs 0.08 mg). Fermentation had mixed effect. It slightly decreased cyanide in 24, 36, 96 and 108 h samples (0.03, 0.02 and 0.04 vs 0.05 mg). It increased the cyanide in 48, 60, 72 and 84 h samples (0.06-0.11 mg).

The low levels of tannins due to cooking and fermentation showed that the antinutrient could be reduced to safe level in foods using these two cheap domestic food processing techniques to reduce tannins in foods The lower values might be due to breakdown of tannin-protein and tannin-enzyme complexes by enzymes of fermenting organisms and subsequent leaching out of free tannins (Obizoba and Atii, 1994). The low phytate due to cooking showed it as a good promising method to reduce it in foods. On the other hand, the increases in phytate due to fermentation were not a surprise. Other workers had observed similar increases in germinated and fermented products (Udofia, 2005; Mefoh, 2008).

The increases in oxalate followed the same trend as phytate. The reason for oxalate increase is difficult to explain. It might be due to poor analytical procedure that was not able to separate oxalate from other materials that formed complex salt with it. The lower cyanide levels regardless of treatments might be that cyanide was not in appreciable amount in hungry rice or that the little it contained was hydrolyzed and leached into cooking or fermentation media (Obizoba and Atii, 1994).

Conclusion: Based on this study, cooking and fermentation increased both proximate and mineral composition in treated samples but decreased antinutritional factors in most parameters tested. Cooking and fermentation could be used by most rural and poor urban dwellers to increase nutrient content of their diets.

REFERENCES

Anyika, J.U., 2003. Iron and phosphorus utilization in rats fed soaked and dehulled bambara groundnut supplemented with sorghum or crayfish. Pl. Food Hum. Nutr., 58: 53-61.

Anyika, J.U., 2006. The effect of fermentation on the chemical composition of baobab seeds (*Adansonia digitata Linn*). Nig. J. Nutr. Sci., 27: 95-100.

AOAC, 1995. Official methods of Analysis. Association of Official Analytical Chemists, Washington D.C. 1995.

Chikwendu, N.J., 2003. The effects of germination on the chemical composition and microbial quality of groundbean (*Kerstingiella geocarpa*) flours. Nig. J. Nutr. Sci., 24: 17-22.

Cooke, R.D., 1978. An enzymatic assay for the total cyanide content of cassava (*Manihot esculanta crantz*). J. Sci. Food Agric., 29: 345-352.

Eggum, B.O., 1979. The nutritional value of rice in comparison with other cereals. In: Proceedings of Workshop on Chemical Aspects of Rice Grain Quality. Los Banos, Laguna, Philippine, IRRI., pp: 91-111.

Enwere, N.J., 1998. Foods of plant origin. Afro.-Orbis Pub. Ltd., Nsukka, Nigeria.

FAO, 1989. Utilization of Tropical Foods: Cereals. FAO Food and Nutrition. Paper 47/1, Rome Italy.

FAO, 1998. Carbohydrates in human Nutrition. FAO Food and Nutrition Papers No. 66. Rome, Italy.

Fox, B.A. and A.G. Cameron, 1995. Food Science, Nutrition and Health. 6th Edn. Arnold, a member of the Hodder Headline Group.

Ibrahim, A., 2001. Hungry rice (Acha): A neglected cereal crop NAQAS Newsletter. A quarterly newsletter: 1: 4-5.

Institute of Food Science (IFT), 1975. Minutes of sensory evaluation division business meeting at the 35th Annual meeting of the Institute of Food Technologists, Chicago, June 10, 1975.

Ihekoronye, A.I. and P.O. Ngoddy, 1985. Integrated Food Science and Technology for the Tropics. Macmillan Publishers Ltd. London 1st Edn.

Kakade, N.L., J.J. Rackis, J.E.G. McChee and C. Puski, 1974. Determination of Trypsin Inhibitor Activity of soy products: A collaboratory analysis of improved procedure. Cereal Chem., 51: 376.

Latta, M. and M. Eskin, 1980. A simple and rapid colorimetric method for phytake determination. J. Agric. Food Chem., 28: 1213-1315.

Mefoh, N.C., 2008. The consumption pattern, nutritive value and organoleptic attributes of processed Moringa oleifera and Afzelia africana leaves and dishes. Unpublished Ph.D. Thesis. Dept. of Home Science, Nutrition and Dietetic, UNN.

NAS (National Academy of Sciences), 1996. Lost Crops of Africa: Volume I: Grains. Washington, D.C.: National Academy Press.

Neucere, N.J. and G. Sumrell, 1980. Chemical composition of different varieties of grain sorghum. J. Agric. Food Chem., 28: 19-21.

Obizoba, I.C. and L.N. Atu, 1993. Production and chemical evaluation of some food condiments of Nigeria. Pl. Food Hum. Nutr., 44: 249-254.

Obizoba, I.C. and J.V. Atii, 1994. Evaluation of the effect of processing techniques on the nutrient and antinutrient contents of pearl millet (*Pennisetum glaucum*) seeds. Pl. Food Hum. Nutr., 45: 23-34.

Obizoba, I.C. and J.U. Anyika, 1994. Nutritive value of baobab milk (gubdi) and mixtures of baobab (*Adansonia digitata L.*) and hungry rice, acha (*Digitaria exilis*) flours. Pl. Food Hum. Nutr., 46: 157-165.

Oke, O.L., 1978. Oxalate acid in plants and in nutrition. World review of nutrition and dietetics s. Kargel Basel (Ed) pp: 262.

Okoh, P.N., 1998. Cereal grains. In: Nutritional Quality of Plant Foods. Osagie, A. U. and Eka, O.U. (Eds.) Published by the Post harvest Research Unit, Uniben, Nigeria, pp: 32-52.

Onimawo, I.A. and K.M. Egbekun, 1998. Comprehensive Food Science and Nutrition, Revised Edn, Ambik Press Ltd. Benin City, Nigeria.

Singh, U. and R. Jambunathan, 1981. Relationship between non-protein nitrogen and total nitrogen in chickpea (*Cicer arietunim L*) seed. J. Agric. Food Chem., 29: 423-424.

Price, M.L., A.E. Hagerman and L.G. Butler, 1980. Tannin content of cowpea, chickpea, pigeon pea and mungbean. J. Agric. Food Chem., 28: 459-461.

Statistical Analysis System (SAS), 2003. SAS system for windows version 8.0 SAS Institute Inc. Cary, North Caroline, USA.

Temple, V.J. and J.D. Bassa, 1991. Proximate chemical composition of 'Acha' *(Digitaria exilis*) grain. J. Sci. Food Agric., 56: 561-563.

Udofia, U.S., 2005. Effect of traditional processing techniques on leafy vegetable and starchy staples consumed in Akwa Ibom State, Nigeria. Ph.D. Thesis. Dept. of Home Science, Nutrition and Dietetics, UNN.

Wang, H.L. and C.W. Hesseltine, 1981. Use of microbial cultures: Legumes and cereal products. Food Technol., 35: 79-83.