Formerly AJFNS
Volume 7 No. 1 2007
ISSN 1684-5374
AJFAND ONLINE
AFRICAN JOURNAL OF FOOD AGRICULTURE NUTRITION AND DEVELOPMENT

EFFECT OF A TYPICAL RURAL PROCESSING METHOD ON THE PROXIMATE COMPOSITION AND AMINO ACID PROFILE OF BUSH MANGO SEEDS *(Irvingia gabonensis)*

Ekpe OO [1], Umoh IB [2] and OU Eka [3]*

Ekpe Onot

[1*]Corresponding author Email: onot_fni@email.com and/or :rooseh01@yahoo.com. Co-ordinator, Food and Nutrition Programme, Ministry of Agriculture and Natural Resources P.M.B. 1119, Calabar, Cross River State, Nigeria.

[2]Professor, Department of Biochemistry, College of Medical Sciences, University of Calabar, Nigeia.

[3]Professor, Department of Biochemistry, College of Medical Sciences, University of Calabar, Nigeria.

AJFAND ONLINE
Formerly AJFNS
Volume 7 No. 1 2007
ISSN 1684-5374
AFRICAN JOURNAL OF FOOD AGRICULTURE NUTRITION AND DEVELOPMENT

ABSTRACT

Various researchers have confirmed the view that forest and wood lands, among other natural boundaries in West Africa supply a massive amount of protein and carbohydrates to the citizens; however industrialization and urbanization has threaten many of the food species from these ecosystems. For instance Itugha known to be highly prized and delicious indigenous food is getting extinct and the possibility of it's origin and composition being lost in antiquity is high, more so data on nutrient composition of processed lrvingia products is limited.

Samples of Itugha were prepared as it is obtained in the local setting. These and fresh seeds from the same source of fruits were subjected to proximate analysis and amino acid profile determination.

The synergistic effect of pounding and fermentation (two rural processing methods) on proximate composition and amino acid profile of *Irvingia gabonensis* seeds were evaluated. Proximate analysis differed significantly ($p \geq 0.05$) between the processed product and fresh *Irvingia* seeds in crude protein, fat, ash and dietary fiber contents. Protein value was 19.4± 0.4% dry matter (DM) for the product, 7.6 ± 0.8 of (DM) for fresh seed of *var gabonensis,* Crude fat 66.60± 0.80% DM seed and 58.00± 1.0% product; ash 9.50± 0.30% DM seed and 11.60 ± 0.6% DM product. Dietary fibre was 18.20± 1.80% DM seed and 12.30±2.00% DM product. Percent sucrose in starch was 2.10 ± 3.50% DM seed and 9.60± 3.10% DM product. There were significant losses in fat, dietary fibre, moisture and carbohydrate due to processing. High moisture level in seed 5.20 ±0.6% DM compared with product 2.10± 0.8% DM is indicative of the presence of appreciable quantity of trapped water in the matrices of fresh *Irvingia* seeds which was favourable for fermentation. Amino acid profile showed significant differences ($p \leq 0.05$) in their levels in the seeds and the product. All the essential amino acids (EAA) were quantified with Leucine recording the highest value. In all, eighteen amino acids were quantified in both the fresh seed and processed product. They are Leucine 8.30± 0.11g/16g Nitrogen (N) product and 7.60 ± 0.12g/16gN seed, isoleucine 3.20± 0.04g/16gN seed and 4.50± 0.1g/16gN product; threonine 2.20± 0.30g/16gN seed and 3.10± 0.1g/16gN product, glutamic acid 13.40± 0.11g/16gN seed and 15.20 ± 0.10g/16gN product. These recorded increases. Serine 3.10± 0.04g/16gN seed and 2.80± 0.01g/16gN product was the only amino acid that recorded a decrease in level due to processing. Other amino acids were methionine, tryptophan, valine, phenylalanine, histidine, aspartic acid, cystine, proline, glycerine, alanine, tyrosine, lysine and arginine. Processing method resulted in slightly higher levels of essential nutrients in the product than the seeds. Further investigation to determine the micoflora involved in the fermentation is recommended. It would also be necessary to isolate and identify the food enzymes in the endosperm of Irvingia gabonensis. It has been observed that nutrient dense plant foodstuff are facing extinction due to urbanization and increased patronage of fast foods, as such, there is need to increase available information on their nutritive potentials to encourage utilization.

Keywords: Pounding, Fermentation, Amino acids, Proximate, *Irvingia* .

AJFAND ONLINE Formerly AJFNS Volume 7 No. 1 2007 ISSN 1684-5374
AFRICAN JOURNAL OF FOOD AGRICULTURE NUTRITION AND DEVELOPMENT

L'EFFET D'UNE METHODE DE TRAITEMENT TYPIQUEMENT RURALE SUR LA COMPOSITION RAPPROCHÉE ET LE PROFIL DE L'ACIDE AMINÉ DU NOYAU DE LA MANGUE SAUVAGE (*Irvingia gabonensis)*

Ekpe OO, Umoh IB et OU Eka

Résumé

Le effet synergétique du pilage et de la fermentation (deux méthodes rurales de traitement) sur la composition rapprochée et le profil de l'acide aminé des graines d'*Irvingia gabonensis* a été évalué. L'analyse rapprochée a différé considérablement ($p \geq 0.05$) entre le produit traité et les graines fraîches d'*Irvingia* dans les protéine crues, les graisses, la cendre et les teneurs diététiques en fibre. La teneur en protéine était 19,4± 0.4% des matières sèches (m.s.) pour le produit, 7,6 ± 0,8 de m.s pour la graine fraîche de *var gabonensis*, les graisses crues 66,60± 0,80% de m.s. pour la semence et 58,00± 1,0% pour le produit; la cendre 9,50± 0,30% de m.s. pour la semence et 11,60 ± 0,6% de m.s pour le produit. La fibre diététique était 18,20± 1,80% de m.s pour la graine et 12,30±2,00% de m.s pour le produit. Le pourcentage de la saccharose dans l'amidon était 2,10 ± 3,50% de m.s pour les graines et 9,60± 3,10% de m.s pour le produit. Suite au traitement, il y a eu des pertes significatives dans les grasses, les fibres diététiques, l'humidité et l'hydrate de carbone. Le niveau élevé d'humidité dans les graines 5,20 ±0.6% de m.s par rapport au m.s du produit 2,10± 0,8% est une indication de la présence d'une quantité appréciable d'eau qui stagne dans les matrices de graines fraîches *d'Irvingia*, et cette eau a été favorable à la fermentation. Le profile de l'acide aminé a montré des différences significatives ($p \leq 0,05$) dans leurs niveaux dans les graines et dans le produit. Tous les acides aminés essentiels (AAE) ont été quantifiés, la leucine enregistrant la valeur la plus élevée. Dans l'ensemble, dix-huit acides aminés ont été quantifiés aussi bien dans la graine fraîche que dans le produit traité. Ces acides sont comme suit : la leucine 8,30± 0,11g/16g, le produit azote (N) et la graine 7,60 ±0,12g/16gN, l'isoleucine 3,20± 0,04g/16gN graine et 4,50± 0,1g/16gN produit; thréonine 2,20± 0,30g/16gN graine et 3,10±0,1g/16gN produit, acide glutamique 13,40± 0,11g/16gN graine et 15,20 ± 0.10g/16gN produit. Ces acides ont enregistré des accroissements. La sérine 3,10± 0,04g/16gN graine et 2,80± 0,01g/16gN produit était le seul acide aminé qui a enregistré une diminution de niveau à cause du traitement. Les autres acides aminés étaient la méthionine, le tryptophane, la valine, la phénylalanine, l'histidine, l'acide aspartique, la cystine, la proline, la glycérine, l'alanine, la tyrosine, la lysine et l'arginine. La méthode de traitement a abouti à des niveaux légèrement plus élevés de nutriments essentiels dans le produit par rapport aux graines. Une enquête plus approfondie visant à déterminer les microflores impliquées dans la fermentation est recommandée. Il serait aussi nécessaire d'isoler et d'identifier les enzymes alimentaires dans l'endosperme de *Irvingia gabonensis*.

Mots-clés: Pilage, fermentation, acides aminés, rapproché, *Irvingia*.

INTRODUCTION

Irvingia gabonensis is a non-timber forest product, made up of tree trunk (stem), leaves, roots and fruits. The fruit comprises a fleshy part and the nut, which consists of a hard shell and the kernel/seed. Its seeds have an outer brown testa (hull) and two white cotyledons. It belongs to the genus *Irvingia, species Irvingia gabonensis.* Two varieties have been identified in Nigeria; *Var gabonensis* and *Var excelsa* [1]. *Irvingia gabonensis* common names are bush mango, African mango, wild mango or Dikanut plant and the local name is Kuwing (Agoi). *Irvingia* seeds constitutes an important part of the rural diet in Nigeria. The sun-dried seeds are ground into flour and used as soup thickeners. The white cotyledons are roasted and eaten in the Bwemba community of Uganda; roasted seeds confer flavour and aroma on foods especially vegetables [2]. It is the food gum component of the seeds that serves as a thickening agent in water (especially hot water) [3].

Seeds are a prominent feature in the peasants dietary especially in the developing countries and oilseeds are becoming valuable sources of nutrients for man, especially in countries where the diet is plant-based. Ignorance of their food value has resulted in their wastage in terms of economic returns or/and post harvest loses. Much work has been done on some Nigerian seeds and legumes including *Irvingia gabonensis* seeds. Solvent extraction of *Var gabonensis* seed yielded between 68% to 75% fat [4]. Other reports on this seed nutrients content indicated that it contains 8.65% protein, 14.1% carbohydrate, 2.1% moisture, 1.4% crude fibre, 16.8% ash and 38.9% dietary fibre [5,6].

Reports on the nutrients composition of indigenous processed products from oilseeds are limited. So far, melon (*citrullus vulgaris*) flour has been reported to have high protein content $33.25 \pm 0.9\%$ compared to egg protein and $56.22 \pm 0.8\%$ fat [7].

This study was therefore aimed at increasing the body of available information on nutrient composition, with particular reference to proximate composition and amino acid profile of *Irvingia gabonensis* seed and a processed product called “Itugha” by Agoi Ibami Community of Nigeria. Itugha is a very popular indigenous foodstuff obtained using a typical traditional food processing technique involving pounding and fermentation used together as a unit process.

MATERIALS AND METHODS

Sample Preparation

Fresh seeds were obtained from fruits collected from the Agoi Ibami forest in Cross River State, Nigeria. The fruits collected and heaped to ferment, took between two to three weeks at a temperature range from $26^oC – 29^oC$. The fermented fruits were depulped to obtain the seeds, which were then cracked to release the white cotyledons. With the aid of a pestle and mortar, cotyledons (without the hull) were pounded for about one hour on the first day. Pounding was repeated every day for five days by which time the gummy component of the mashed *Irvingia* mass was lost.

Formerly AJFNS
AJFAND ONLINE Volume 7 No. 1 2007 ISSN 1684-5374
AFRICAN JOURNAL OF FOOD AGRICULTURE NUTRITION AND DEVELOPMENT

After each day's pounding, the mash was stored away in a native gourd (*Lagenaria sicereria*) container. At the end of six (6) days, when the "drawness" was completely lost, the mash was molded manually into round or oblong shapes of convenient sizes. These products were wrapped with *Piper umbellantum* ("Ansumsum'') leaves and placed over the fire place for two- three days to smoke dry. Samples of the processed product from *Irvingia gabonensis* (*Var gabonensis*) seed and the fresh seeds were then used for laboratory analysis.

Laboratory Analysis

Moisture, ash, crude protein, crude fat extract and crude fiber levels were analyzed in the fresh seed and the processed food product using the AOAC methods [8]. Dietary fiber and starch contents were determined using the method of Theander and Westerland [9]. Amino acids were analyzed by the method of Basha et al [10] with a slight modification.

Data Analyses

All analysis were done in triplicates. Data were analyzed by calculating mean and standard deviation. Student t-test was used to test effect of pounding and fermentation on the proximate and amino acid profile of *Irvingia gabonensis* seeds and significance was accepted at $p \leq 0.05$.

RESULTS

Data on proximate composition % DM , amino acid profile g/16g Nitrogen of *lrvingia gabonensis* (bush mango) seeds and processed product are shown in Tables 1 and 2, respectively. The values as presented in the tabulated results are mean of 3 determinations $\pm$ standard deviation. P_values are also indicated.

Processing method increased some parameters of the proximate composition as in the case of crude protein (7.60±0.80% DM seed to 19.40±0.4% DM product) and % sucrose (2.10±3.5% DM seed to 9.60±3.10% DM product).

There was a decrease in crude fat content of seed from 66.60±0.80% DM to 58.00±1.00% DM processed product. Most of the crude fat was lost as "oil drip" during drying Itugha at the fireplace and to the leaves used for wrapping products. This increase "oil drip" was accompanied with development of spicy aroma and flavour. Moisture level decreased due to processing. Dietary fiber and ash contents also recorded decreases in values. Crude fibre content of *Irvingia* seed and 'Itugha' were 1.9±0.4g% DM and 1.8±0.2g% DM respectively. The values are comparative showing that processing had not effect on crude fibre. Therefore the recorded decrease in dietary fibre can then be attributed to microbiological metabolism of lingo-polysaccharides.

The amino acid profile indicated the presence of eighteen amino acids and 'Itugha' had desirable pattern of essential amino acids. Some amino acids recorded increases while others were low in their levels.

DISCUSSION

Pounding is a size reduction unit operation in which impact forces were used in the disruption of *Irvingia* seed matrices, rupturing cell walls thereby rendering the final product porous in texture. This disruption of cells and the resulting increase in surface area promoted oxidative degradation and higher rates of microbiological and enzymatic activity [11]

High dietary fibre of the seeds (18.20 ± 1.0% DM) as shown in Table 1, indicated the presence of reasonable quantity of trapped water. Water (bound) can be held by the hydrophilic polysaccharides of the fibre. This water is unavailable and has very low chemical activity [12]. The water in fresh *Irvingia* seed could possibly be bound water, so crushing the seeds by repeated pounding dismembered the matrices, disrupted the cells and made the water in the mash very much available for biochemical reactions involved in fermentation process. Consequently, moisture level as high as 5.20 ± 0.60% DM in the seed was favorable for the fermenting substrate, to facilitate fermentation process more so as the porous texture of the mash made the trapped water very mobile. Hook reported that moisture level of a food influenced the texture and that the more ordered the endosperm structure the lower the rate of moisture movement [13]. Stenvert and Kingswood suggested that for a soft porous endosperm structure (as the mashed *Irvingia* seeds mass) water movement was very rapid, and so pounding and fermentation increased the availability of bound water, whether the water was held in fibre matrices and/or was trapped within cell wall lumen (14). The porous texture of the final product (as a result of the processing method) increased loss of water during drying thus resulting in a moisture content as low as 2.10 ± 0.8% DM in the processed product. The pH of the mass of crushed Irvingia seed also affected its water holding capacity. This is inferred, as pH affects the swelling of polysaccharides. This lower moisture content of the product than the seed could also be attributed to microbial biochemical reactions. The lower moisture level is advantageous as it is known that, the lower the moisture content of a food the longer the shelf-life as moisture content also determines the keeping qualities of seeds, nuts, and fatty products.

Low carbohydrate content and moderately high dietary fibre content lend credence to the presence of high pectic substances or complex carbohydrates. Consequently, the increase in percent sucrose due to processing can be attributed to microbial enzyme hydrolysis of these complex carbohydrates in the fresh *Irvingia* seed during fermentation.

Irvingia gabonensis seed had ash content of 9.5 ± 0.3% DM and the product of processing had 11.6 ± 0.6% DM as ash. Processing method resulted in higher ash content and this high value predicts the presence of an array of mineral elements as well as high molecular weight elements [15]. This requires investigation to ascertain specific mineral elements, as they are very essential for tissue functioning and a necessity in the dietary requirement for human nutrition. The result also indicated an increased protein content as a result of the processing method. Fresh *Irvingia* *gabonensis* seed contained 7.60 ± 0.8% DM as protein and the processed product's value was 19.40 ± 0.4% DM as protein. The increase in protein level due to processing was significant at ($p \leq 0.5$) and could be attributed to increased microbial nitrogen during fermentation as a result of increased production of single cell proteins. This typical rural processing method has enhanced the food value of *Irvingia* seed, by increasing the protein content of the seed from 7.60 ± 0.8% DM to 19.40 ± 0.4% DM in the *Irvingia* based product. Thus indicating the importance of this traditional food processing technique in food handling, which should be encouraged and improved. Another possibility for the observed protein increase on processing *Irvingia gabonensis* seed could be attributed to the presence of food yeast in the final product. This requires microbiological investigation.

The seed contained 66.60 ± 0.8% DM crude fat and the processed product 58.00 ± 1.0% DM crude fat. Although a decrease in the fat content of the product was observed, this was thought mainly to be due to the method of sample handling employed during the analysis. The processed product was fairly oily/fatty. Oil drip during drying for both sample production and preparation for analysis was significant, as such much of it would have been lost.

Table 2 shows the amino acid profile of the seed and the processed product. All the essential amino acids recorded increase in values due to processing effect. For the amino acids that recorded increases due to processing, this could be attributed to their microbial synthesis during fermentation. For instance, Leucine was the most abundant essential amino acid in the product 8.30 ± 0.11g/16gN while the seed recorded 7.60 ± 0.1g/16gN. This was followed by lysine 7.60 ± 0.1g/16gN in the product and 5.80 ± 0.1g/16g N in the seed. This food product could effectively complement grains/cereals as lysine is the limiting amino acid in this food group. Valine, 3.0± 0.01g/16 N in the seed and 4.6 ± 0.01g/16g N in the product was significant in its level. Of all the detected and quantified amino acids, Glutamic acid was the most abundant in both the Irvingia seeds and the processed product, having also recorded an increase due to processing. It seed content was 13.4 ± 0.11g/16g N and the product 15.2 ± 0.1g/16g N. Serine was the only amino acid that recorded a marginal decrease in value due to processing, 3.10 ± 0.04g/16g N in the seed and 2.80 ± 0.01g/16g N in the product. The decrease was not significant ($p \leq 0.05$).The unit process of drying *Irvingia* seed mash into "Itugha" was at temperatures above 100^{O}C. Thus, heating amino acids and sugar together which is known to produce furans, pyrroles and pyrazines and the fact that some amino acids can also be converted non enzymatically to carbonyl compounds used for formation of volatiles, can account for the recorded decrease in levels of some amino acids. This observed decrease could be attributed to degradation of α-amino acids, by-products of which must have been used for formation/production of volatiles [16]. There are other reports on amino acid composition of some lesser known tree crops, chemical composition and functional properties of raw, heat-treated and partially proteolysed wild mango (*Irvingia gabonensis*) seed flour [17, 18]. There is need to improve upon methods of processing and utilization of kernels of *Irvingia gabonensis* (*Var*. gabonensis and Var excelsa) to lend credence to it's domestication and commercialization drive [19, 20].

CONCLUSION

The high nutritive quality of the *Irvingia gabonensis* (*Var gabonensis)* based product as compared with its seeds implies that appropriate food processing technique is another approach to improve plant foods' quality. Since storage is one of the major problems associated with handling fresh *Irvingia* seeds, processing these seeds fresh using pounding and fermentation, not only arrest spoilage but also improves its nutritive value. This should then encourage farmers to respond positively to Agroforestry's campaign for increased *Irvingia gabonensis* plantation establishment, and value adding activities to obtain products of higher nutritional quality and longer shelf-life [21, 22]. In the entire process, the seed cracking to extract the cotyledons was most laborious and difficult. From Gabon to Cameroon and Nigeria, people utilize different techniques to extract these *Irvingia* kernels. As was the case with this work, fruits were allowed to ferment and the kernel extracted wet. Alternatively, they can be extracted from fruits in the fresh state or fruits are fermented and sun-dried before extracting. For the fresh fruits sharp knives are used to cut the fruit open while in the fermented and/or dried state, heavy objects (especially stones) are used to crack the nut. All these methods are hazardous and so the vegetative propagation of *Irvingia gabonensis* should be directed towards varieties whose nuts slip open naturally [23].

Table 1: Proximate Composition of Fresh Bush Mango Seed and Processed Food Product Samples (% Dry Matter)

Constituent	Fresh Irvingia Seed	Processed product
Moisture	5.20 ± 0.60	2.10 ± 0.80
Dry Mater	94.80 ± 2.10	97.90 ± 1.10
Ash	9.50 ± 0.30	11.60 ± 0.60
Crude Protein	7.60 ± 0.80	19.40 ± 0.40
Crude Fat	66.60 ± 0.80	58.00 ± 1.00
Crude Fiber	1.90 ± 0.40	1.80 ± 1.00
Dietary Fiber	18.20 ± 1.80	12.30 ± 0.20
% Sucrose (starch)	2.10 ± 3.50	9.60 ± 3.10

Values are means of three independent determinations ± Standard deviation.
Significance was accepted at $P \leq 0.05$

Formerly AJFNS
AJFAND ONLINE
Volume 7 No. 1 2007
ISSN 1684-5374
AFRICAN JOURNAL OF FOOD AGRICULTURE NUTRITION AND DEVELOPMENT

Table 2: Amino Acid Profile of Fresh Bush Mango Seeds and Processed Product (g/16gN of Sample)

Amino Acid	Fresh Irvingia Seed	Processed Product
Leucine	7.60 ± 0.12	8.30 ± 0.11
Isoleucine	3.20 ± 0.04	4.50 ± 0.10
Methionine	1.30 ± 0.09	1.40 ± 0.03
Threonine	2.30 ± 0.30	3.10 ± 0.10
Tryptophan	1.50 ± 0.05	1.60 ± 0.05
Valine	3.00 ± 0.01	4.60 ± 0.01
Phenylalanin	2.10 ± 0.20	2.30 ± 0.20
Histidine	1.70 ± 0.11	1.90 ± 0.10
Lysine	5.80 ± 0.10	7.60 ± 0.10
Aspartic acid	4.80 ± 0.10	5.10 ± 0.10
Cystine	2.20 ± 0.10	2.40 ± 0.10
Serine	3.10 ± 0.04	2.80 ± 0.01
Glutamic acid	13.40 ± 0.11	15.20 ± 0.10
Proline	2.40 ± 0.06	3.40 ± 0.10
Glycine	3.90 ± 0.11	5.40 ± 0.10
Alanine	3.20 ± 0.01	3.60 ± 0.01
Tyrosine	1.50 ± 0.16	1.70 ± 0.20
Arginine	6.10 ± 0.13	6.70 ± 0.14

Mean of three determination ± standard deviation.
Significant difference was accepted at $P \leq 0.05$

REFERENCES

1. **Okafor JC and G Ujor** Varietal differences in *Irvingia gabonensis*. Paper Presented at the ICRAF Pre-collection meeting, IITA Ibadan 1994:5.

2. **Ousseynou N. and T Nicodeme** International Institute of Tropical Agriculture and the Rockefeller Foundation. A paper on Utilization and marketing of *Irvingia gabonensis* produce in the humid forest of Cameroon 1994: 80.

3. **Ndjouenkeu R, Goycoolea FM, Morris ER and JO Akingbala** Okra (*hibiscus esculentus*) dika nut (*Irvingia gabonensis*) polysaccharides. *Car. polym*. 1996; 29: 263 – 269.

4. **Onwuka ND, Peczak R and A Babuchowski** The Characteristics indices and the major fatty acid components of oils from the less common oil seeds I. Pentaclethra macrophy and Irvingia gabonensis. Rivista Italiana delle Sostanze Grasse 1984; 61 : 569 – 572.

5. **Eka OU** Proximate Composition of seeds of bush mango tree and some properties of Dika fat*Nig. J. Nutri Sci*, 1980; 1:33 – 36.

6. **Okolo HC** Indigenous Manufacturing of selected Nigerian foods in packaged form for defence usage. Paper presented at first Ministry of Defence TRADOC Seminar Benin City, 1987: 20.

7. **Abaeku AM, Olukoya DK, Okochi VI and EO Akinrimisi** Biochemical changes in fermented melon (egusi) seed (*Citrullus vulgaris*). *J. Ind. Micro*. 1990; 6 : 211 – 214.

8. **AOAC** Official Method of Analysis 15th edn. AOAC Washington DC, USA 1993.

9. **Theander O and EA Westerlund** Studies on Dietary fibre 3. Improved procedures for Analysis of Dietary Fibre, *J. Agric Food Chem*. 1986; 34: 330 – 336.

10. **Basha SMM,Cherry JP and CT Young** Changes in free amino acids, Carbohydrates and proteins of maturing seeds from various peanut (*Arachis hypogaea*) Cultivars. *Cereal Chem*. 1976; 53: 586 – 597.

11. **Fellows PJ** *Food processing Technology – principles and practices* 2nd edn. New York: Ellis Horwood 1990: 493.

12. **Robertson JA and MA Eastwood** An Investigation of the experimental conditions which could affect Waterholding capacity of dietary fibre. *J. Sci. Food Agric*. 1981; 32:819-825.

13. **Hook SCW, Rone GT and T Fearn** The Conditioning of wheat moisture content on the milling performance of UK wheat with reference to wheat texture *J. Sci. Food Agric* 1982; 32 : 655 – 662.

14. **Stenvert NL and K Kingswood** Factors influencing the rate of moisture penetration into wheat during tempering *Cereal Chem*. 1977; 54 : 627 – 637.

15. **Eyo ES, Mohme H and H Abel** *The Composition of Carbohydrates and Proteins in the seed of Irvingia gabonensis, Cucumeropsis manni and Mucuna sloami from Nigeria:* In Plant Research and Development Germany Institute for Scientific Co-operation 1981; 107 – 113.

16. **Hara Y, Luo SS and RL WickRemaisinghe.** *Food Reviews International* 1995; 11:450.

17. **Amubode FO and BL Fetuga.** Amino acid composition of some lesser known tree crops. *Food Chem.* 1984; 13: 299 – 307.

18. **Giami SY, Okonkwo VI and MO Akusu** Chemical Composition and Functional properties of raw, heat-treated and partially proteolyses wild mango (*Irvingia gabonensis*) seed flour. *Food Chem.* 1994; 49 : 247 – 243.

19. **Leakey RRB and MN Izac-A** *Linkages between domestication and commercialization of non-timber forest products: implications for agro forestry.* In Leakey RRB, Temu AB, Melnyk M and P Vantomme Domestication and Commercialization of Non-timber forest, products for agro forestry. Non-wood forest products 9. FAO Rome. Italy 1996: 1-7.

20. **Ejiofor MAN, Onwubuke SN and JC Okafor.** Developing improved method of processing and utilization of kernels of *Irvingia gabonensis* (*Var gabonensis* and *Var excelsa*) *Int. Tree Crops J.* 1987; 4: 283 – 290.

21. **ICRAF** *Medium Term Plan 1998 – 2000,* ICRAF Nairobi 1997; 340.

22. **Leakey RRB** *Agroforestry Biodiversisty in farmer systems*. eds. Collins WW and CO Qualset. CRC Press NY USA 1999: 127 – 145.

23. **Ladipo DO, Foundoun JM and N Ganga** *Domestication of bush mango (Irvingia Spp): Some exploited intra-specific variations in West and Central Africa* In Leakey RRB, Temu MB, Melnyk M and P Vatomme Domestication and commercialization of non-timber forest products for Agro forestry Non-Wood products No. 9 FAO Rome Italy 1996: 193-205