www.ajbrui.org

Afr. J. Biomed. Res. Vol. 21 (May, 2018); 147- 151

Research article

Cooked Yield and True Nutrient Retention Values of Selected Commonly Consumed Staple Foods in South-west Nigeria

Sanusi R.A, Odukoya G.M and *Ejoh S.I

Department of Human Nutrition, Faculty of Public Health, College of Medicine, University of Ibadan, Ibadan, Nigeria.

ABSTRACT

There is a dearth of information on nutrient data for cooked/ prepared foods and their nutrient retention factors in Nigeria. This study determined the cooked yield and nutrient retention factors of commonly consumed staple foods in South-West Nigeria. Proximate and mineral analysis were carried out on the raw and the cooked samples of the following staple foods: Fermented Cassava Flour (*elubo lafun* in Yoruba) (FCF), Yam Flour (*elubo isu* in Yoruba) (YF), Garri (Gr), Cowpea (CwP) and Rice (Rc). Cooked yield and true retention values of the nutrients analysed were also calculated. Crude protein content in raw samples was highest in CwP (33.5g/100g), metabolisable energy ranged from 342.3 kcal/100g in CwP to 350.0 kcal/100g in Rc; calcium and iron content was highest in Gr. In the cooked samples, crude protein ranged from 0.2g/100g in Gr to 9.3g/100g in CwP, metabolisable energy ranged from 101.5 kcal/100g in Gr to 119.2 kcal/100 g in CwP, calcium content was between 3.3 mg/100 g in CwP to 18.8mg/100g in Gr, and iron content ranged from 0.5mg/100g in Rc to 1.1 mg/100 g in Gr. The cooked yield factor ranged from 2.9 in CwP to 4.0 in Rc; percentage true retention of the nutrients in the samples were: crude protein 31.9% in Gr to 142.5% in Rc; calcium 53.0% in YF to 111.7% in FCF; iron, 58.2% in YF to 119.7% in CwP. The present study serves as a baseline for studies that focus on nutrient retention values of staple foods consumed in Nigeria and other developing countries.

Keywords: *Nutrient retention, nutrient content, food composition, cooked yield, prepared foods*

*Author for correspondence: *E-mail*: shirleyejoh@gmail.com; *Tel: +2348056014140*

Received: November 2017; Accepted: March, 2018

Abstracted by:
Bioline International, African Journals online (AJOL), Index Copernicus, African Index Medicus (WHO), Excerpta medica (EMBASE), CAB Abstracts, SCOPUS, Global Health Abstracts, Asian Science Index, Index Veterinarius

INTRODUCTION

Determining the nutrient intake of individuals and groups requires correct information on the nutrient composition of foods as consumed (Murphy *et al*. 1975); given that most foods are consumed in their cooked or prepared form (Bognár A and J Piekarski, 2000). In order to obtain reliable information between nutrient intake and health or between foods and nutrients, there has to be comprehensive food composition databases generated directly from analytical data (Leclercq *et al*. 2001). However, it is not possible to analyse all foods directly due to huge time and financial costs of chemical analysis of foods, especially cooked foods and dishes, on a routine basis (Bognár A and J Piekarski, 2000).. As a result there is a dearth of information on nutrient data for cooked/ prepared foods especially in developing countries like Nigeria.

Advances in food composition studies have now made it possible to calculate nutrient composition of cooked/ prepared food and dishes from raw food if nutrient retention factors are available (USDA, 2007). As different cooking methods bring about changes in the weight of food, which could be loss, or gain of solid, liquids or both (Murphy *et al*. 1975), it also follows that the nutrient content (retention) of the prepared foods/ dishes would vary; as has been noted in the literature (Severi *et al*. 1998). Changes in the nutrient content of foods after preparation has implications for nutrient intake of individuals and groups.

In Nigeria, while a lot of studies have documented the nutrient content of commonly consumed staple foods (Olaoye *et al*. 2015; Adepoju, 2012; Adepoju *et al*. 2010), these are mostly carried out on the raw food material. Where studies on nutrient content of prepared foods and dishes have been reported, no information is usually given about the quantities (yield) of the food after preparation (Olayiwola *et al*. 2013; Onabanjo and Oguntona, 2003). Very little information is available on the cooked yield and nutrient retention factors of foods as consumed (prepared form). Cooked yield is said to be the change in weight of food that occurs because of food preparation and processing such that there are gains or losses in moisture (such as water) and/ or solids (such as fat) (Vásquez-Caicedo *et al*. 2008) . Hence the weight that remains after the food preparation is termed the yield factor (Vásquez-

Caicedo *et al*. 2008). Nutrient retention refers to the proportion of nutrient retained relative to the amount of nutrient present in a known weight of the raw food (i.e. before cooking) (Murphy *et al*. 1975). Cooked yield and nutrient retention factors represent percentage adjustments in weight or nutrients which account for the effect of cooking on the weight or nutrient content of a given food. Nutrient retention factors of local dishes indigenous to particular populations like Nigeria, is difficult to determine when the following information are not available: nutrient content of raw ingredients, quantity of edible portion of raw ingredient, the yield (quantity after preparation), nutrient content of the prepared food, cooking time, and temperature.

In the recently published West African Food Composition Table by Food and Agricultural Organisation (Stadlmayr *et al*. 2012), most of the data collected were for raw foods. Nutrient content values for the cooked foods (majorly boiled), were derived using yield factors and nutrient retention factors from other sources outside Africa: Europe and USA, specifically (Stadlmayr *et al*. 2012).Given that cooking methods and food ingredients used in Africa are quite diverse, yield and nutrient retention factors from Europe or USA may not be suitable in estimating nutrient content of prepared dishes from local raw ingredients (Stadlmayr *et al*. 2012).There is an urgent need, therefore, to derive yield factors and nutrient retention factors for local foods and dishes indigenous to African countries like Nigeria, as this will both assist in dietary assessment/ nutrient intake studies and be relevant in food composition database activities. The aim of this study was therefore to derive cooked yield and nutrient retention factors of commonly consumed staple foods in South-West Nigeria.

MATERIALS AND METHODS

Study protocol was reviewed and approval given at the Department of Human Nutrition.

Sample procurement and preparation

Five commonly consumed staple foods were purchased from three different raw food vendors in *Bodija* market, a major market in Ibadan, Oyo state, South West Nigeria The foods included: fermented cassava flour (*elubo lafun* (Yoruba)), yam flour (*elubo isu* (Yoruba)), Garri, Rice, and Cowpea. A total of 20 samples were analysed, four per food item; 3 samples per food item from different vendors; a composite of the three samples (equal proportions ratio 1:1:1) of each food item formed the fourth sample for each food item.

Samples were sorted (by removing bad grains) and cleaned (by winnowing) to remove dirt. Edible portions of each sample were divided into two portions, 100g each. The first portion was analysed in its raw form; while the second portion of raw food sample was set aside for cooking using traditional household preparation method.

Cassava flour and yam flour were cooked into a stiff pudding; while cowpea and rice were boiled plain (without salt).Weight of food samples were taken after cooking.

Cooking methods

Cassava flour and yam flour: The traditional method of preparation in South-West Nigeria was employed. A 100g of flour, was gradually added to 500ml of boiling water (100ºC) in an aluminium pot. The mixture was continuously stirred to avoid formation of lumps, until a smooth consistency, slightly fluffy pudding (porridge) was achieved. Cooking time was 10 minutes.

Cowpea and Rice: 100g of cowpea and rice respectively, were boiled so that all of the water was absorbed. Ratio of cowpea to water was - 1g: 5.4mL and for rice it was 1g: 4.8mL. Average cooking time for cowpea was 45 minutes. Average cooking time for rice was 30 minutes.
Cooking was done using a hot plate at 300 ºC

Preparation of samples for analysis

Each food sample was homogenised using a Panasonic grinder (model: MX-795N) to blend to fine texture. Homogenised cooked samples were dried in an air oven, at 60°C for 20 hours, to remove moisture and thereafter stored in plastic air tight containers (bowls) before analysis.

Determination of cooked yield and nutrient retention factors

Cooked yield and true retention were calculated using the formula described in the USDA Table of Nutrient Retention Factors, Release 6 (USDA, 2007) as indicated below;

$$\text{Yield (\%)} = \frac{\text{Weight of cooked sample}}{\text{Weight of raw sample}} \times 100$$

*True Retention (%) = (Nc*Gc) / (Nr*Gr) * 100*
Nc = nutrient content per g of cooked food,
Gc = Weight of cooked food (g),
Nr = nutrient content per g of raw food, and
Gr = Weight of food before cooking (g).

Chemical analysis

Proximate analysis: Analysis for moisture (Method 967.08), crude protein (Method 988.05), crude fat (Method 2003.06), ash (Method 942.05), crude fibre (Method 958.06), were carried out on both raw and cooked forms of samples using standard procedures of the official methods of analysis described (AOAC, 2005). All analyses were carried out in duplicate. Carbohydrate was determined by difference and energy (metabolisable) was determined using the Atwater factor (Energy value = % carbohydrate×4 + % fat×9 + %protein×4).

Mineral elements (calcium, iron, magnesium and zinc) were also determined on the raw and cooked staple foods. 1.0gm of the sample was weighed into a porcelain crucible. This was transferred into the muffle furnace (UNISCO: model SM9080) set at 550ºC and left for about 4 hours when it had turned to white ash. The crucible and its content were cooled to room temperature in a desiccator. The ashed samples were transferred into volumetric flasks by carefully washing with conc. HNO_3. All washings were transferred into a volumetric flask (through a funnel), repeated the washing procedure twice with deionized water. Individual mineral (Ca, Mg, Fe, Zn) was determined using Bulk scientific atomic absorption spectrophotometer (model 210/21/VGP).

Statistical Analysis: Mean values of duplicate determinations with their standard deviations, were calculated using Microsoft Excel 2007. *t*-test and ANOVA in the Statistical Package for the Social Sciences (SPSS) version 17 software were used for the analysis.

RESULTS

Cooked yield of the selected staple foods: The cooked yield factors calculated for the food samples are given in Table 1. Results showed that the different staples had varying weight yield after cooking irrespective of the fact that they were cooked such that all the moisture were absorbed. Rice had the highest mean yield value (4.04±0.03) compared to other staple foods.

Proximate and mineral composition of the selected staple foods: Table 2 shows the proximate composition, energy and selected mineral content of the raw and cooked staple foods. Moisture content of the cooked foods were significantly higher than in the raw food samples ($p<0.05$); there was no significant difference in the fibre content of raw and cooked rice ($p>0.05$), however cooking caused a significant decrease in all other macronutrients. There was also significantly lower ($p<0.05$) mineral content in the cooked samples than in the raw samples. Cowpea had the highest protein content in its raw and cooked state. Raw cassava flour had significantly higher carbohydrate content (84.15 g/100 g) than all the other staple foods except raw *garri*

True nutrient retention of the selected staple foods: Tables 3 and 4 show the percentage true retention of nutrients in the staple foods after cooking. The percentage retention of crude protein in the staple foods varied from 31.90 – 142.52%; rice had the highest percentage retention and garri had the lowest. The true retention of crude fat was highest in cowpea and lowest in rice, 125.49% and 36.57%, respectively. There was significant difference in the retention of crude protein between the foods analysed with the exception of fermented cassava and yam flour and between yam flour and cowpea ($p>0.05$). The retention of crude lipid in cowpea was the highest (125.49%) and it was significantly different from all the other staples foods ($p<0.05$). Rice had the highest retention of crude fibre and it was significantly different from all other foods. Yam flour had the lowest retention of calcium, magnesium and iron (Table 4).

Table 1:
Cooked yield factor of the selected staple foods

S/n	Food	Weight of raw sample (g)	Weight of cooked sample (g)	Yield factor Mean (CV)
1	Fermented cassava flour	100	292	2.92 (0.01)
2	Yam flour	100	314	3.14 (0.04)
3	Garri	100	354	3.54 (0.02)
4	Cowpea	100	290	2.90 (0.05)
5	Rice	100	404	4.04 (0.03)

yield factor expressed as ratio cooked to raw sample. Rice had the highest yield (duplicate analysis). N = 4 for each staple food

Table 2:
Proximate (g), metabolisable energy (kcal/100 g) and selected mineral compositions of the raw and cooked staple foods

	Fermented cassava flour		Yam flour		Garri		Cowpea		Rice	
	RW	CKD	RW	CKD	RW	CKD	RW	CKD	RW	CKD
Moisture	10.65 0.02)	69.14 (0.00)	10.47 (0.04)	71.26 (0.00)	9.71 (0.03)	73.69 (0.01)	8.94 (0.06)	68.72 (0.01)	11.42 (0.04)	73.10 (0.01)
Crude protein	1.31 (0.09)	0.28 (0.13)	2.52 (0.16)	0.54 (0.09)	2.22 (0.13)	0.20 (0.07)	33.47 (0.09)	9.34 (0.04)	8.40 (0.02)	2.97 (0.06)
Crude lipid	0.39 (0.08)	0.05 (0.37)	1.02 (0.31)	0.09 (0.21)	0.43 (0.06)	0.07 (0.27)	1.04 (0.15)	0.44 (0.06)	0.81 (0.05)	0.08 (0.45)
Crude fibre	1.71 (0.05)	0.53 (0.07)	1.78 (0.01)	0.61 (0.02)	2.33 (0.07)	0.62 (0.11)	3.10 (0.22)	1.02 (0.11)	0.18 (0.32)	0.12 (0.04)
Ash	1.80 (0.16)	0.72 (0.17)	2.03 (0.07)	0.76 (0.04)	1.36 (0.08)	0.40 (0.07)	3.70 (0.11)	0.97 (0.34)	0.53 (0.07)	0.15 (0.17)
Carbohydrate	84.15 (0.00)	29.37 (0.00)	81.87 (0.01)	26.75 (0.00)	83.48 (0.01)	25.03 (0.02)	49.76 (0.07)	19.48 (0.04)	78.66 (0.01)	23.60 (0.03)
Energy	346.38 (0.00)	119.05 (0.00)	346.77 (0.00)	109.94 (0.00)	348.44 (0.01)	101.58 (0.02)	342.26 (0.00)	119.17 (0.03)	350.48 (0.02)	106.94 (0.03)
Calcium	19.49 (0.11)	7.43 (0.08)	60.91 (0.04)	10.26 (0.04)	64.82 (0.06)	18.82 (0.16)	8.75 (0.11)	3.34 (0.07)	27.53 (0.07)	6.81 (0.11)
Magnesium	34.98 (0.27)	8.13 (0.16)	28.82 (0.23)	5.63 (0.06)	39.36 (0.27)	9.10 (0.21)	41.71 (0.17)	11.43 (0.06)	74.80 (0.10)	20.10 (0.11)
Iron	2.12 (0.21)	0.65 (0.36)	2.95 (0.15)	0.56 (0.48)	4.15 (0.11)	1.15 (0.28)	1.64 (0.09)	0.68 (0.11)	3.61 (0.04)	0.53 (0.28)
Zinc	1.47 (0.12)	0.29 (0.14)	2.41 (0.36)	0.42 (0.18)	1.87 (0.22)	0.64 (0.26)	1.07 (0.12)	0.29 (0.05)	2.99 (0.09)	0.77 (0.13)

RW – Raw; CKD – Cooked. *Values are mean scores of duplicate analysis of four replicates per sample (eight readings each).*

Table 3:
True retention (%) of proximate values of the selected staple foods

Foods	Crude protein	Crude lipid	Crude fibre	Ash	Carbohydrate
Cassava flour	63.04^{a} (0.22)	37.78^{a} (0.36)	90.05^{a} (0.04)	116.62^{a} (0.04)	101.92^{a} (0.01)
Yam flour	67.87^{ab} (0.08)	30.02^{ab} (0.40)	106.82^{a} (0.05)	117.20^{a} (0.04)	102.50^{a} (0.04)
Garri	31.90 (0.15)	58.15^{ab} (0.30)	93.36^{a} (0.07)	105.04^{a} (0.10)	106.03^{a} (0.00)
Cowpea	81.73^{b} (0.13)	125.49 (0.24)	98.83^{a} (0.20)	76.55 (0.36)	113.73 (0.06)
Rice	142.52 (0.05)	36.57^{ab} (0.40)	302.23 (0.38)	109.8^{a} (0.14)	121.24 (0.03)

Values with the same letter within the same column are not significantly different (p>0.05) (ANOVA)

Table 4:
True retention (%) of mineral values of the selected staple foods

Foods	Calcium	Magnesium	Iron	Zinc
Cassava flour	111.73^{a} (0.06)	69.66^{a} (0.12)	88.84^{a} (0.28)	57.63^{a} (0.09)
Yam flour	52.96 (0.07)	64.13^{a} (0.21)	58.23^{ab} (0.40)	60.93^{ab} (0.33)
Garri	101.93^{ab} (0.09)	87.53^{ab} (0.29)	96.17^{ac} (0.18)	118.90^{c} (0.12)
Cowpea	111.22^{a} (0.05)	82.35^{a} (0.22)	119.75^{ac} (0.02)	80.15^{b} (0.09)
Rice	99.69^{b} (0.05)	113.36^{b} (0.04)	58.81^{ab} (0.22)	103.26^{c} (0.08)

Values with the same letter within the same column are not significantly different (p>0.05) ANOVA

DISCUSSION

Determining the yield and nutrient retention factors of commonly consumed staple foods in Nigeria is of utmost importance. This is because by using retention factors of ingredients in a recipe, it is possible to have accurate estimates of the nutrient value of prepared foods (USDA, 2007). The nutrient retention factor represents percentage adjustments in nutrients which account for the effect of cooking on the nutrient content of a given food (Vásquez-Caicedo *et al*. 2008). In this study the yield and true nutrient retention factors were calculated after the determination of the proximate and mineral compositions in the raw and cooked forms. Nutrient content of cooked foods is important in order to have precise information of the nutrient intake of individuals and groups (Murphy *et al*. 1975). The proximate composition of raw fermented cassava flour (elubo lafun) and garri analysed in this study was within the range reported in previous studies by (Adepoju *et al*. 2010; Ayankunbi *et al*. 1991). However the proximate content values were far lower than the values reported for raw fermented cassava flour and garri (fermented) (Akindahunsi *et al*. 1999); but carbohydrate content reported in this study was higher. This could have been due to difference in analytical methods, or source of food materials and other post-harvest conditions. Similarly ash values for garri reported in a recent study (Olaoye *et al*. 2015) were higher than values obtained in this study, but the crude fibre content obtained from raw garri in this study was higher than values reported (Olaoye *et al*. 2015), and the crude protein, carbohydrate and fat were within the same range that were reported by the same authors.

In the present study all the cooked samples of the staple foods had lower proximate and mineral values. The form of cooking employed in this study was that in which moisture was gained for all the foods, however it also resulted in the loss of nutrients from the foods. A gain in moisture could have led to diffusion of the nutrients. Proximate values for cassava flour and garri samples, were within the same range as that of a previous study (Ayankunbi *et al*. 1991). However, some other findings showed increase in the crude protein, crude lipid, crude fibre and ash content of cooked cassava flour (lafun) that had been fermented for three days prior to cooking than in the raw product (Adepoju *et al*. 2010). Proximate and mineral contents of cooked yam flour (amala) in this study were also much lower and therefore not in agreement with the previously reported values of a similar study done in Nigeria (Adepoju, 2012).

In the light of these findings, the staple foods especially cowpea and rice (except for crude lipid) showed high retention and even full retention of the macronutrients after cooking, while the root and tuber staples (cassava flour, yam flour and garri), had about 30 to 50% retention of their crude protein and crude lipid content. All the staples showed full retention of carbohydrate contents. The retention of the minerals varied between and within the staples; however cowpea showed a better retention profile for all the minerals reported. This could imply that the cooking method used in this study had a considerable effect on the retention of the macronutrients in the staple foods. It is difficult to have an agreement on nutrient content and especially retention values for staple foods because there are very few similar studies to compare with. Most of the studies from Nigeria only report the nutrient content in the raw and cooked samples and there are incomplete descriptions of methods used for cooking. Furthermore, weight of samples before and after cooking was not also reported, so that a retention value could not be derived, thereby making it difficult to compare findings adequately.

In conclusion, cooking (by boiling) of the foods resulted in the loss of nutrients and this could have caused diffusion of the nutrients due to increased moisture content. However, cowpea and rice had the highest retention of all the macronutrients (except crude lipid in rice) after cooking. Mineral contents of cowpea were retained more than in any of the other staples. The retention of nutrients in the staples cooked depends on the amount of water, time and the nature of the food in question.

The present study serves as a baseline for studies that focus on nutrient retention values of staple foods consumed in Nigeria. However, more studies in this direction are urgently needed for more staple foods consumed in Nigeria, with clear cooking methods, recipes employed and weights of the foods before and after they have been cooked. This would facilitate the comparison of reports across the country and would contribute to building consensus on nutrient retention values of staple foods that can be included in the Nigerian and AFROFOODS food composition database. Furthermore, the results of this study will assist in dietary assessment/ nutrient intake studies in Nigeria.

REFERENCES

Adepoju O. T. (2012): Effects of processing methods on nutrient retention and contribution of white yam (Dioscorarotundata) products to nutritional intake of Nigerians. Afr J Food Sci. 6(6), 163-167.

Adepoju O. T., Adekola Y. G., Mustapha S. O., Ogunola S. I. (2010): Effect of processing methods on nutrient retention and contribution of cassava (Manihotspp) to nutrient intake of Nigerian consumers. AJFAND. 10(2). Retrieved from http://www.ajol.info/index.php/ajfand/article/view/53353. Accessed on 10 May, 2015.

Akindahunsi A. A., Oboh G., Oshodi A. A. (1999). Effect of fermenting Cassava with Rhizopusoryzae on the chemical composition of its flour and Gari products. Rivista ItalianaDelleSostanze Grasse, 76, 437–440.

Ayankunbi M. A., Keshinro O. O., Egele P. (1991): Effect of methods of preparation on the nutrient composition of some cassava products—Garri (eba), "Lafun" and "Fufu." Food Chem. 41(3), 349–354.

Bognár A., Piekarski J. (2000): Guidelines for recipe information and calculation of nutrient composition of prepared foods (dishes). J Food Comp Ana. 13(4), 391–410.

Leclercq C., Valsta L. M., Turrini A. (2001): Food composition issues-implications for the development of food-based dietary guidelines. Public Health Nutr. 4, 677–682.

Murphy E. W., Criner P. E., Gray B. C. (1975): Comparisons of methods for calculating retention of nutrients in cooked foods. J. Agri. Food Chem. 23(6), 1153–1157.

Official Methods of Analysis of AOAC International 18th Edition (2005): W. Horwitz, (Ed) and GW. Latimer, Jr., (Asst. Ed). AOAC Arlington, VA, Washington DC.

Olaoye O. A., Lawrence I. G., Cornelius G.N., Ihenetu M. E. (2015): Evaluation of quality attributes of cassava product (gari) produced at varying length of fermentation. Am J Agric Sci. 2(1), 1–7.

Olayiwola I. O., Funmi F., Abdul-Rasaq A. A., Onabanjo O., Sanni A., Afolabi W. (2013): Chemical, mineral composition and sensory acceptability of cocoyam-based recipes enriched with cowpea flour. Food Sci. Nutr. '1(3), 228-234.

Onabanjo O. O., Oguntona R. B. (2003): Iron, Zinc, Copper, and Phytate content of standardized Nigerian Dishes. J. Food Comp.Ana. 16, 669-676.

Severi S., Bedogoit G., ZoboJi G. P., Manzierjl A. M., Poljl M., Gatti G., Battistioi N. (1998): Effects of home-based food preparation practices on the micronutrient content of foods. Eur J Cancer Prev. 7, 331-335.

Stadlmayr B., Charrondiere U. R., Enujiugha V. N., Bayili R. G., Fagbohoun E. G., Samb B., Addy P., Barikmo I., Ouattara F., Oshaug A., Akinyele I., Annor G. A., Bomfeh K., Ene-Obong H., Smith I. F., Thiam I., Burlingame B. (2012): West African food composition table. Rome Food Agric Organ U N. Available from: http://fst.futa.edu.ng/866/5519-866.rtf.. Accessed Sept 20, 2016.

U.S. Department of Agriculture (USDA) (2007): USDA Table of Nutrient Retention Factors, Release 6. Retrieved from the Nutrient Data Products and Services Page: Agricultural Research Service, 2007: http://www.ars.usda.gov/Services/docs.htm?docid= 9448.

Vásquez-Caicedo A. L., Bell S., Hartmann B. (2008): Report on Collection of Rules on Use of Recipe Calculation Procedures Including the Use of Yield and Retention Factors for Imputing Nutrient Values for Composite Foods (D2. 2.9). www.eurofir.net. Accessed on May 10, 2015.