

Effect of Different Cooking Methods on Proximate, Vitamins, Minerals and Antinutrients Composition of African Yam Bean (*Sphenostylis stenocarpa*) Seeds

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Abstract

Background: Food researchers are constantly looking for easier and faster methods to ensure optimum nutrient intake.

Objectives: The study investigated the effect of cooking methods (boiling and toasting) on the chemical composition of African yam beans (AYB).

Methodology: Flecked-brown African yam beans were divided into three portions, the first two portions were toasted and soaked boiled, the third was left raw to serve as control. The samples were evaluated for proximate, nutrients, and antinutrient composition using standard procedures. Data collected was analyzed with IBM Statistical Product for Service Solution (SPSS) software version 21 and presented with descriptive statistics (frequencies, percentages, means, standard deviation). Analysis of variance and Duncan multiple range test were used to compare and separate the means.

Results: Toasting had 0.59%, 0.53%, 0.15%, and 0.11% reductions in moisture, crude protein, fat, and crude fiber content of AYB; and 0.15%, 1.23%, and 1.45Kcal increase in ash, carbohydrate, and energy respectively. Soaked boiling reduced all the proximate contents of AYB but had 2.05% increase in moisture. Toasting had no significant effect on AYB beta-carotene but had 0.04mg, 0.02mg, 0.11mg, and 1.59mg reductions on thiamin, riboflavin, niacin, and vitamin C contents respectively. Soaked boiling reduced the content of all the vitamins studied by 6.15 μ g, 0.09mg, 0.03mg, 0.22mg, and 3.11mg respectively. Toasting reduced AYB zinc (0.02%), and sodium (0.16%) contents but increased calcium (8.04%), magnesium (1.73%), iron (0.05%) and potassium (3.46%), while soaked boiling had significant reductions (0.21mg, 10.68mg, 3.87mg, 3.64mg, 1.42mg, and 296.54mg) in zinc, calcium, magnesium, sodium, iron, and potassium contents of AYB respectively. Toasting and soaked-boiling significantly reduced saponin, tannin, alkaloids, flavonoids, and phytate by 0.08mg, 0.3mg, 0.6mg, 0.12mg, 0.15mg; and 0.14mg, 0.09mg, 0.18mg, 0.26mg, 0.25mg respectively.

Conclusion: Toasting and soaked boiling had significant effects on the chemical composition of AYB

Key words: *African yam bean, toasting, soaked-boiling, nutrients, antinutrients composition.*

Introduction

The growing population in developing countries are presently experiencing food deficits. Animal proteins essential for growth are usually unaffordable and inaccessible to many households. Foods of plant origin are always available because some grow in the wild and can be cultivated by poor subsistent farmers. The consequence is the consumption of mainly plant foods with poor protein profile. The resulting protein deficiency affects directly and indirectly the productivity of the entire population. To explore the possibilities of exploiting other plant sources to meet the increasing human needs, researchers are sourcing indigenous plant foods that can be harnessed for maximum nutrient supply. Africa is endowed with varied food crops like cowpea, rice, millet, corn, African yam bean (AYB), pigeon pea, sorghum, sesame seeds, yam, cassava, plantain, etc. Despite these rich food sources, food insecurity and malnutrition especially protein deficiency persist. This is because, in as much as some of these crops are widely used like cowpea and maize, there are some that have wide distribution but are underutilized like AYB. AYB is a climbing herbaceous plant that produce seeds which may be ellipsoid, rounded, truncated with varied sizes and color (creamy white, brownish yellow, dark brown, with black marbling, coffee color), and small spindled-shaped tubers [1]. It is found growing in tropical Africa. It can grow wild and can also be cultivated in countries like Zimbabwe, Guinea, Southern Nigeria, Togo, Ivory coast, Ethiopia, Mozambique, Tanzania, and Zanzibar. Nigeria is the highest producer of AYB [2]. It is a product of an economic plant that have both tuber and edible leguminous seeds. Countries like Ethiopia relish the tuberous part, while Nigeria, Togo, Cameroun, Cote d Ivoire enjoy the seeds [3]. Its indigenous names include Sese, Otili, Ekalu, Peu, Sunmunu (Yoruba), okpuodudu, akidi, Azma, and Uzaaku (Igbo) [4]. The seeds can be toasted, and eaten with maize and palm kernel, or with garri (toasted cassava product); or as porridge, puddings, or made into sauce. AYB seeds contains essential nutrients like proteins, carbohydrate, vitamins especially folate, minerals, and dietary fiber. Apart from its food uses, it can be used as livestock feeds, pesticides (because of its' lecithin content), and medicine for stomach aches, and acute drunkenness [5, 6]. AYB low utility stems from its hard-to-cook nature. Some studies have reported different processing methods to improve the utilization [7-9]. This study aims to investigate the effect of different processing methods (boiling and toasting), on the nutrient composition of the seeds as it will enable informed choices and encourage consumption.

Materials and methods

Study design: Experimental method was employed.

Study area: The study was conducted in the Food laboratory of the Department of Human Nutrition and Dietetics, College of Applied Food Sciences and Tourism, Michael Okpara University of Agriculture Umudike and Analytical laboratory of the National Root Crop Research

Institute Umudike, Abia State Nigeria. Both institutions are domicile in Umuahia the capital city of Abia State, with an area of 5,834 square kilometers in the South-Eastern part of Nigeria.

Source, and Identification of Materials: Speckled brown variety of AYB was purchased from a local market Ndioro in Abia state. A crop Scientist E.N. in the Institution's Crop and Soil Science department identified the crop as African yam bean *Sphenostylis stenocarpa* seeds.

Samples Preparation: Speckled brown AYB seeds were hand sorted to remove extraneous materials, washed properly with distilled water, and drained on a colander. The AYB seeds (1200g) was divided into three portions of 400g each and coded as TAYB, BAYB and RAYB, where TAYB = toasted AYB seeds, BAYB = boiled AYB seeds, and RAYB = raw AYB seeds. TAYB was toasted in a saucepan over a cooking gas burner at 191°C for 45 minutes and allowed to cool then milled into fine flour with a Saint Donkey Powder Crusher with 5mm sieve. SBAYB was soaked for 18 hours in 600ml tap water (to reduce the cooking duration), boiled on a gas burner at temperature of 191°C without draining soak water until it becomes soft when pressed between two fingers. The sample was allowed to cool at room temperature for 1 hour, then oven dried at 50°C to a constant weight in a Uniscope Laboratory Oven (SM9023 Surgifriend Medigals England), and then milled into fine flour. RAYB was oven-dried at 50°C for 24 hours, milled into fine flour in a Powder Crusher (Saint Donkey) with 5mm sieve. The three samples were properly package into clean sterile air-tight polyethene bags ready for analysis.

Evaluation of chemical composition of the samples

The proximate composition - moisture, protein, ash, fat, and crude fiber contents of the three AYB samples were determined using standard procedures [10], Total carbohydrate was obtained by difference as: 100 - % (moisture + ash + protein + fat + crude fiber). Minerals (zinc, calcium, magnesium, sodium, iron, and potassium), vitamins (beta-carotene, thiamin, riboflavin, niacin, ascorbic acid), and antinutrients (saponin, tannin, flavonoids, phytate, alkaloids) were evaluated with standard procedure [10]

Statistical data Analysis: IBM Statistical Product for Service Solution (SPSS) was used to analyze the data obtained from the study and presented with descriptive statistics as means and standard deviation, Analysis of variance (ANOVA) was used to compare the means, differences were determined with Duncan's Multiple Range Test, and significance was accepted at $p < 0.05$.

Results

Soak-boiling significantly ($p < 0.05$) increased the moisture content of African yam beans by 2.05% (from 9.96% to 12.01%) and reduced the crude protein, fat, crude fiber, ash, carbohydrates, and energy values by 7.63%, 1.73%, 1.22%, 2.5%, 37.08%, and 194.41Kcal respectively (table 1). Toasting significantly ($p < 0.05$) reduced AYB moisture content, crude protein, fat, and crude fiber by 0.59%, 0.53%, 0.15%, 1.22%, respectively and increased the ash, carbohydrates, and energy by 0.15%, 1.23%, and 1.45Kcal respectively.

Table 1 Proximate composition of toasted, soaked-boiled, and raw African yam bean seeds (%).

| Sample | Moisture | Crude protein | Fat | Crude fiber | Ash | Carbohydrates | Energy• (Kcal) |
|--------|---------------------------|---------------------------|--------------------------|--------------------------|--------------------------|---------------------------|----------------|
| RAYB | 9.96 ^b ± 0.25 | 19.66 ^a ± 0.40 | 3.81 ^a ± 0.05 | 3.08 ^a ± 0.03 | 4.69 ^b ± 0.03 | 58.8 ^b ± 0.43 | 348.13 |
| TAYB | 9.37 ^b ± 0.36 | 19.13 ^b ± 0.20 | 3.66 ^b ± 0.02 | 2.97 ^b ± 0.09 | 4.84 ^a ± 0.02 | 60.03 ^a ± 0.58 | 349.58 |
| SBAYB | 12.01 ^a ± 0.10 | 12.03 ^c ± 0.02 | 2.08 ^c ± 0.09 | 1.86 ^c ± 0.02 | 2.19 ^c ± 0.04 | 21.72 ^c ± 1.38 | 153.72 |
| LS | *** | *** | *** | *** | *** | *** | |

Values are means ± SD of triplicate determinations; means with similar superscripts on a column are not significantly different ($p > 0.05$). RAYB = raw African yam bean; TAYB = toasted African yam bean; SBAYB = soaked-boiled African yam bean; * = calculated; LS = Level of significance, * = significant at $\alpha = 0.05$, *** = highly significant at $\alpha = p < 0.001$.

Toasting had no significant effect on the beta-carotene content of African yam bean, but reduced the thiamin, riboflavin, niacin, and ascorbic acid by 0.04mg, 0.02mg, 0.11mg, and 1.59mg respectively (table 2). Soaked-boiling reduced beta-carotene, thiamin, riboflavin, niacin, and ascorbic acid of African yam bean by 6.15µg, 0.09mg, 0.03mg, 0.22mg, and 3.11mg respectively.

Table 2 Vitamins composition of toasted, soaked-boiled, and raw African yam bean seeds.

| Sample | Beta-carotene (µg) | Thiamin (mg) | Riboflavin (mg) | Niacin (mg) | Ascorbic acid |
|--------|---------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| RAYB | 82.05 ^a ± 0.35 | 0.12 ^a ± 0.00 | 0.06 ^a ± 0.01 | 0.33 ^a ± 0.01 | 5.40 ^a ± 0.10 |
| TAYB | 82.05 ^a ± 0.47 | 0.08 ^b ± 0.01 | 0.04 ^b ± 0.01 | 0.22 ^b ± 0.01 | 3.81 ^b ± 0.10 |
| SBAYB | 75.90 ^b ± 0.71 | 0.03 ^c ± 0.01 | 0.03 ^c ± 0.01 | 0.11 ^c ± 0.01 | 1.29 ^c ± 0.10 |
| LS | *** | *** | *** | *** | *** |

Values are means ± SD of triplicate determinations; means with similar superscripts on a column are not significantly different ($p > 0.05$). RAYB = raw African yam bean; TAYB = toasted African yam bean; SBAYB = soaked-boiled African yam bean; LS = Level of significance, * = significant at $\alpha = 0.05$, *** = highly significant at $\alpha = p < 0.001$.

Table 3 shows that toasting had no effect on the zinc content of African yam bean, it increased the calcium, magnesium, iron, and potassium contents by 8.04mg, 1.73mg, 0.05mg, and 3.46mg respectively, and reduced the sodium content from 6.08mg to 5.62mg (0.46mg). Soaked-boiling significantly reduced the zinc, calcium, magnesium, sodium, iron, and potassium contents of African yam beans by 0.21mg, 10.68mg, 3.87mg, 3.64mg, 1.42mg, and 296.54mg respectively.

Table 3 Minerals composition of toasted, soaked-boiled, and raw African yam bean seeds (mg/100g).

| Sample | Zinc (mg) | Calcium (mg) | Magnesium (mg) | Sodium (mg) | Iron (mg) | Potassium (mg) |
|--------|--------------------------|---------------------------|---------------------------|--------------------------|--------------------------|----------------------------|
| RAYB | 0.53 ^a ± 0.01 | 38.74 ^b ± 2.32 | 9.47 ^b ± 0.05 | 6.08 ^a ± 0.28 | 3.79 ^b ± 0.01 | 773.87 ^b ± 2.57 |
| TAYB | 0.51 ^a ± 0.01 | 46.78 ^a ± 2.33 | 11.20 ^a ± 1.39 | 5.62 ^b ± 0.26 | 3.84 ^a ± 0.13 | 777.33 ^a ± 0.92 |
| SBAYB | 0.32 ^b ± 0.02 | 28.06 ^c ± 0.00 | 5.60 ^c ± 1.39 | 2.44 ^c ± 0.08 | 2.37 ^c ± 0.00 | 477.33 ^c ± 0.92 |
| LS | *** | *** | *** | *** | *** | *** |

Values are means ± SD of triplicate determinations; means with similar superscripts on a column are not significantly different ($p > 0.05$). RAYB = raw African yam bean; TAYB = toasted African yam bean; SBAYB = soaked-boiled African yam bean; LS = Level of significance, * = significant at $\alpha = 0.05$, *** = highly significant at $\alpha = p < 0.001$.

Table 4 shows that toasting and soaked-boiling significantly reduced all the antinutrients studied. Toasting significantly reduced saponin, tannin, alkaloids, flavonoids, and phytate by 0.08mg, 0.3mg, 0.6mg, 0.12mg, and 0.15mg respectively. Soaked-boiling reduced saponin, tannin, alkaloids, flavonoids, and phytate by 0.14mg, 0.09mg, 0.18mg, 0.26mg and 0.25mg respectively.

Table 4 Antinutrients composition of toasted, soaked-boiled, and raw African yam bean seeds.

| Sample | Saponin (mg) | Tannin (mg) | Alkaloid (mg) | Flavonoid (mg) | Phytate (mg) |
|--------|--------------------------|--------------------------|--------------------------|--------------------------|---------------------------|
| RAYB | 0.25 ^a ± 0.01 | 0.13 ^a ± 0.01 | 0.31 ^a ± 0.03 | 0.41 ^a ± 0.02 | 0.42 ^a ± 0.01 |
| TAYB | 0.17 ^b ± 0.01 | 0.10 ^b ± 0.01 | 0.25 ^b ± 0.01 | 0.29 ^b ± 0.01 | 0.27 ^{ab} ± 0.13 |
| SBAYB | 0.11 ^c ± 0.01 | 0.04 ^c ± 0.00 | 0.13 ^c ± 0.01 | 0.15 ^c ± 0.02 | 0.17 ^b ± 0.00 |
| LS | *** | *** | *** | *** | * |

Values are means ± SD of triplicate determinations; means with similar superscripts on a column are not significantly different ($p > 0.05$). RAYB = raw African yam bean; TAYB = toasted African yam bean; SBAYB = soaked-boiled African yam bean; LS = Level of significance, * = significant at $\alpha = 0.05$, *** = highly significant at $\alpha = p < 0.001$.

Discussion

Soaked boiling significantly ($p < 0.05$) increased the moisture contents of AYB seeds. The increased value was higher than 11.95% reported [11]. This increase in moisture content could be attributed to the seed's absorption of water during soaking and boiling. There was also significant decrease in the crude protein, fat, and crude fiber of African yam beans when soaked and boiled. This is in

consonance with the report that soaking and cooking significantly reduces the chemical composition of legumes [12]. It is important to recall that foods are processed to make the nutrients therein more available. Toasting increased the ash, and carbohydrate content of African yam beans but reduced the crude fiber, fat, protein, and moisture content of African yam beans. There was report that roasting (a process of low temperature with long duration contrary to toasting – higher temperature of short duration) had no effect on total dietary fiber and B-glucan of barley [13]. Other work reported that processing methods influences the proximate composition of AYB [11]. The decrease in the crude protein by these processing methods (toasting and soaked boiling) could be attributed to the loss of soluble protein fractions into boiling water and denaturation of protein components. The study proteins range were lower than 19.8% reported by Ene-Obong and Obizoba [7]. Pulses have low fat value which reduced significantly with boiling. The increase in ash content by toasting is indicative of increased mineral values. Higher ash contents have more mineral values [14]. The low carbohydrate content of in the boiled AYB sample could be attributed to leaching of the components into the cooking water. This is in consonance with the report that the reduction of carbohydrate content was less pronounced when the cooking water was not drained before analysis [15]. Toasting had no significant effect beta-carotene content of African yam beans, while boiling decreased significantly the beta-carotene value of the seeds. Both processes (boiling and toasting) reduced the B vitamins (thiamin, riboflavin, niacin) and C contents of AYB. This is expected as vitamins are water soluble and can leach into boiling water or lost during heating. The beta-carotene range was within the range (56.67 to 93.33 g/100g) reported by Abioye et al. [16]. Toasting significantly ($p < 0.05$) increased calcium, iron, and potassium contents of AYB but had little or no effect on zinc, magnesium, and sodium. Boiling reduced significantly the zinc, calcium, magnesium, sodium, iron, and potassium contents of African yam beans. It has been explained that minerals could leach into boiling water [17]. The zinc content of the study AYB was low compared to that reported by Ameh [18]. This could be due to analytical procedure used, reagents, variety, and soil type. The calcium value of toasted AYB was higher than 43.2mg reported in Ene-Obong and Obizoba [7]. Calcium is an important nutrient in bone and teeth structure. The significantly low sodium content of the boiled AYB is a plus to diet therapy of hypertensive people. Boiled AYB could be incorporated as part of low sodium diet. The high potassium value of both boiled and toasted AYB is an important information in management of blood pressure. Legumes have high potassium content [16]. Cooking method (boiling and toasting) significantly reduced the antinutrients composition of AYB. This is desirable in food use of AYB, as low levels of antinutrients have phytochemical activities which are necessary for good health. Antinutrients are known to interfere with nutrient assimilation [19]. Saponin at high level has a hemolytic effect on red blood cells [20]. Boiling has a very significant effect on the tannin content of AYB. This study tannin content was very low compared to the range 6.67 to 15.00mg reported in Abioye et al. [16]. The alkaloids are poisonous and can cause paralysis and irritation to digestive system [21]. Processing methods are used to reduce its contents in foods. This study alkaloids were significantly reduced by boiling and toasting. The reduction in antinutrients of the study samples could be attributed to their heat-labile nature which resulted in losses during heat treatment [22]. The study phytate was lower than reported in Abioye et al. [16]. This could be due to variety differences.

Conclusion

African yam bean is a high protein rich legume. It is rich in potassium, carbohydrates, and calcium. The toasted and boiled African yam bean had low fat and moisture contents, an indication of good storage quality. The reduction of all the antinutrients studied by toasting and soaked boiling will improve nutrient bioavailability as antinutrients are known to chelate essential nutrients. The low sodium content of soaked boiled African yam bean as well as the mineral profile of the toasted and soaked boiled African yam bean is very essential in diet planning for different health condition. The use of African yam bean in meals could alleviate malnutrition of significant nutrients in developing countries. Its use in many recipes will support nutrient intake, and nutrition security of many households.

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