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Research Paper

Effect of processing methods on the proximate composition of African yam bean (*Sphenostylis stenocarpa*) flours and sensory characteristics of their gruels

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Abstract

Background: African yam bean (AYB) could be processed into value added food products. Processing however affects the chemical, sensory and functional properties of the foods.
Objectives: This work determined the effect of processing methods on the proximate composition of African yam bean (*Sphenostylis stenocarpa*) flour and the sensory properties of its gruels.
Methods: Six kilogram of African yam bean seeds were sorted and divided into 4 portions of 1.5kg each. One portion was washed and fermented without lime for 24h, sundried for 72h and roasted (F24R). The second portion was washed, fermented with lime juice for 24h, sundried for 72h and roasted (FL24R). The third portion was washed, fermented with lime for 48h, sundried for 72h and roasted (FL48R). The last portion was washed, dried and roasted (OR) (the control). The samples were milled into flours and analyzed for proximate composition. Gruels were prepared with the flours and analyzed for their sensory properties. Statistical Packages for Social Sciences (SPSS) was used to analyze the data obtained.
Results: Sample F24R had the highest protein content (33.08%) while FL24R had the least protein content (20.96%) and was followed by FL48R (27.86%). The fat content of FL48R, F24R and OR were 3.68%, 4.90% and 5.49%, respectively. Sample FL24R had higher ash content (4.08%) than the other samples. The control (OR) on the other hand, had the highest fibre content of 6.31%. The fibre contents (4.16% - 4.28%) of the other samples were not significantly ($p>0.05$) different. FL24R had carbohydrate level of 62.26% which was significantly ($p<0.05$) different from those of the other samples. F24R had the least carbohydrate level of 54.63%. The gruel prepared from FL48R was preferred in colour (6.53) while the gruel from FL24R had the highest score for flavour (6.57). The consistency of all the gruels were similar (6.87, 6.17, 6.13, 6.97) and not significantly different ($p>0.05$).
Conclusion: Alkaline fermentation combined with roasting improved nutrient contents of AYB.

Keywords: *African Yam bean Flour, Sensory Characteristics, Proximate Composition, and Processing Methods*.

1. Introduction

The knowledge of chemical composition and organoleptic properties of locally available foods in any country is of great importance in tackling the problem of malnutrition. It has been proposed that malnutrition in developing countries can be combated using mixtures of tubers, cereals and legumes indigenous to the countries [1]. Thus, in tackling the multiple problems of food insecurity, nutrition transition and the double burden of malnutrition, it is essential to mobilize and employ indigenous foods like legumes as part of the solution [2]. This is because legumes such as cowpea, bambara groundnut and African yambeans contain 2 to 3 times the protein of cereal grains [3, 4]. Indeed, no other plant food is as rich in protein as legumes in their natural state [3, 4]. African yam bean (AYB) (*Sphenostylis stenocarpa*) is a herbaceous leguminous plant occurring throughout tropical Africa [5]. It is grown as a minor crop in association with yam and cassava. It has the potential to meet all year round protein requirement if grown on large scale [6]. Its amino acid profile is comparable to those for most edible pulses [7]. It has higher water absorption capacity than cowpea [8]. The potential of AYB in the management of many chronic non-communicable diseases has been reported [9–11]. AYB is consumed in different forms such as roasted, pottage with yam or cocoyam pudding. Processing AYB into flour allows its use in more diversified forms including gruel. AYB gruel is a well-known form in which AYB is consumed.

Anecdotally, AYB has a lot of medicinal and health benefits including the use of its gruel for treating people with chronic and severe wounds. However, processing affects the chemical and functional properties of foods.
Food processing is the transformation of raw food ingredients into edible form. Food processing has many benefits among which are increase in shelf-life, flavor, nutritive value and elimination of antinutrients, thus, adding value to foods. Liming in food processing involves treating foods with lime juice. Lime (*Citrus aurantiifolia*) which is known for its tart, tangy flavour is used to reduce the beany flavor of legumes. Roasting is a cooking method that uses dry heat, whether an open flame, oven, or other heat source. Roasting enhances flavour of foods through caramelization and maillard browning on the surface of the foods in addition to extending the shelf life of foods [12]. Organoleptic properties are the properties of foods that are assessed by the human senses of taste, smell and sight. The anti-nutrients in foods reduce the bioavailability of some nutrients [13, 14]. However, some processing methods are known to reduce or eliminate anti-nutritional factors in foods. The objective of this study was therefore, to determine the effect of fermentation with and without lime juice and the subsequent roasting on the chemical composition of African yambean flour and the sensory characteristics of the gruels prepared from the flours.

2. Materials and methods

2.1. Collection of samples

The cream coloured African yam bean (*Sphenostylis stenocarpa*) seeds and lime fruit were purchased from Oye Igbo-Eze market, Orba in Enugu State, Nigeria. Six (6) kg of the seeds were sorted and divided into four portions of 1.5kg each.

2.2. Preparation of AYB flour for gruel and chemical analysis

One portion of the sorted AYB seeds was washed and fermented in tap water (1:3, seed: water) for 24h at ambient temperature. The water was changed every six hours. At the end of the 24h fermentation, the seeds were sun dried (30 ± 2^{o}C) for 72h, placed in frying pan and then roasted on fire until the seeds were cracked. The seeds were cooled, milled (Thomas Willy mill, model ED-5) and sieved through 70mm mesh screen. The flour was coded as F24R. The second portion of the seeds was washed and soaked in lime juice diluted to 300ml with tap water (1:3, seed: lime juice) at ambient temperature for 24h and treated as previously described. The lime juice was changed every six hours. The flour was coded as FL24R. The third portion was fermented in lime juice (300ml) for 48h. This was treated like the second portion and coded as FL48R. The fourth portion was washed, drained, sundried (30 ± 2^{o}C) for 72h and roasted in a fry pan and then treated as the other samples. The flour obtained was coded as OR. All the samples were stored in air tight polythene bags until used. The flow chart for the preparation of African yambean flours is shown in Fig. 1.

2.3. Preparation of gruel from African yam bean flour

Gruel was prepared from each of the AYB flour samples. The ingredients for the gruel preparation were flour (400g), water (2.5 litres) and sugar (0.01kg).
Five hundred (500) ml of water was used to reconstitute the flour. Two (2) litres of water was brought to boil. The boiled water was added gradually to the reconstituted flour with continuous stirring to avoid formation of lumps. The mixture was simmered for 5 minutes and stirred continuously till cooked. Sugar was then added and stirred.

2.4. Sensory evaluation

Gruels prepared from the flour samples were evaluated for colour, consistency, flavor and overall acceptability using preference method as described by Ihekoronye and Ngoddy [16]. A 30 member panel consisting of lecturers and postgraduate students of the Department of Home Science, Nutrition and Dietetics, University of Nigeria Nsukka, were randomly selected for the sensory evaluation. The gruel samples were presented in 3-digit coded soup plates and assessed on 9 point Hedonic scale where 1 represented disliked extremely and 9 liked extremely. The order of presentation of the samples to the panelists was randomized. The evaluation was carried out in a sensory evaluation laboratory under white light. Tap water was provided for the panelists to rinse their mouths in between evaluation.

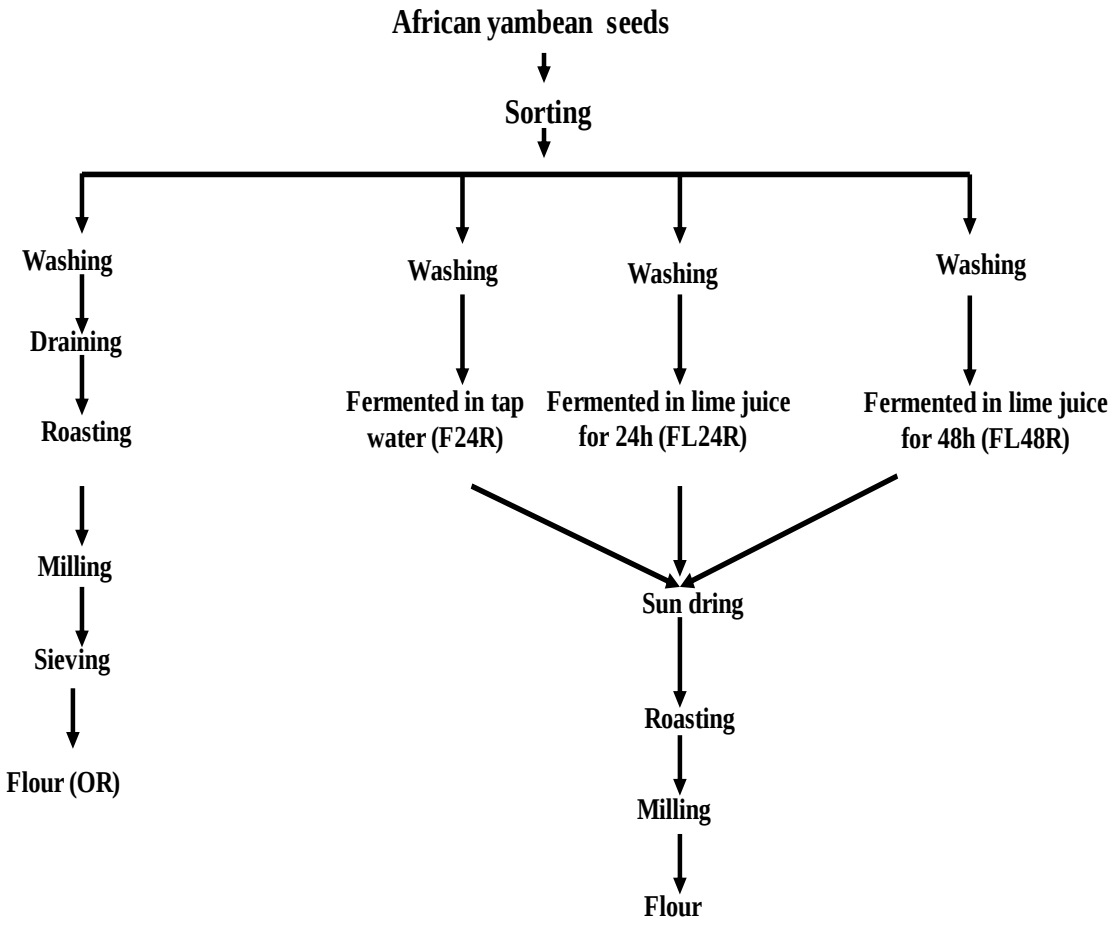

Fig. 1: Flow Chart for the Preparation of African Yam bean Flours

2.5. Analytical methods

Crude fibre, moisture and ash contents of the samples were determined using AOAC [15] methods. Fat and protein contents were determined by solvent extraction and micro Kjeldahl method, N x 6.25, respectively. Carbohydrate content was estimated by difference.

2.6. Statistical analysis

Statistical Package for Social Sciences (SPSS), version 17 was used to analyze the data obtained. Analysis of variance (ANOVA) was used to analyze the data. Means (where significantly different) were separated by the least significant difference (LSD) test. Significance was accepted at $p < 0.05$.

3. Results

3.1. Proximate composition

Table 1 presents the proximate composition (dry matter basis) of the AYB flours. The AYB flour fermented in tap water (F24R) had the highest protein content (33.0%) while the AYB flour fermented in lime juice for 24h (FL24R) had the least protein content (20.96%). The protein content of AYB flour fermented in lime juice for 48h (FL48R) was 27.86%, a value which was higher than 24.19% for the control. The FL48R had fat content of 3.68% which was significantly ($p<0.05$) lower than the fat content of the other samples. The FL24R had 5.46% fat while the F24R had 4.90% fat which was lower than that of the control. Samples FL24R and OR had the highest fat contents, values were not significantly ($p>0.05$) different. The ash contents of the samples which varied from 3.11 to 4.08% were not significantly different ($p > 0.05$). Sample F24R had the least ash content (3.11%), while sample FL24R had 4.08% ash which was the highest among the samples. Crude fibre contents of the treated samples (4.11 – 4.08%) were not

significantly different (p>0.05). These values were however significantly lower (p<0.05) than that of the control which was 6.31%. The carbohydrate content of the samples which ranged from 54.63% - 60.88% showed that sample FL24R had the highest value of 65.26%, which differed significantly (p < 0.05) from those of the other samples. Sample F24R had the least carbohydrate content of 54.63%, a value which was significantly (p>0.05) different from those of the other samples. Samples OR and FL48R were not significantly (p>0.05) different in their carbohydrate contents.

Table 1: Effect of Treatments on Proximate Composition (% Dry Matter Basis) Of African Yam bean Flours

Samples	Protein	Fat	Ash	Crude fibre	CHO
F24R	33.08 [a]	4.90[b]	3.11 [a]	4.28[b]	54.63 [c]
FL24R	20.96[d]	5.46[a]	4.08 [a]	4.24[b]	65.26 [a]
FL48R	27.86[b]	3.68[c]	3.84[a]	4.16[b]	60.46[b]
OR	24.19[c]	5.49[a]	3.13[a]	6.31[a]	60.88[b]
LSD	3.23	0.56	1.02	2.03	4.38

Values are means of triplicate determinations. Means with different superscripts in the same column were different significantly (P< 0.05). F24R- AYB fermented in tap water for 24hrs & roasted, FL24R- AYB fermented in lime water for 24hrs & roasted, FL48R- AYB fermented in lime water for 48hrs &roasted, and OR- AYB only roasted (control).

3.2. Sensory characteristics

The sensory characteristics of gruels prepared from African yambean flours are presented in Table 2. Sample FL48R received the highest score for colour (6.53) while sample FL24R had the least score of 4.83 for colour. Sample F24R (5.87) was scored higher than sample FL24R for colour. The samples fermented in lime juice (FL24R & FL48R) were however scored higher than the control (OR) and the sample fermented in ordinary water (F24R) for flavour. Sample FL24R which was rated highest (6.57) was closely followed by sample FL48R with a score of 6.00. Samples OR and F24R received scores of 5.67 and 5.50, respectively for flavour. The consistency of the samples fermented in lime juice was liked slightly with FL24R receiving 6.17 and FL48R 6.13on a 9 point Hedonic scale. On the other hand sample F24R being liked moderately had a score of 6.87, while the control had the highest score of 6.97 for consistency.
The score for overall acceptability of the gruels varied with samples and ranged from 4.93 to 6.03. Sample FL48R had the lowest score of 4.93 while sample FL24R that was liked moderately had a score of 5.30.

Table 2: Sensory Properties of Gruels Prepared from African Yam bean Flours

Samples	Colour	Flavour	Consistency	Degree of acceptability
F24R	5.87 [a]	5.50[b]	6.87 [a]	5.17 [b]
FL24R	4.83[b]	6.57[a]	6.17 [a]	5.30[b]
FL48R	6.53[a]	6.00[a]	6.13 [a]	4.93[c]
OR	6.10 [a]	5.67[b]	6.97 [a]	6.03 [a]
LSD	1.04	0.33	0.70	0.13

Means (n = 30) with different superscripts in the same column were significantly different (P< 0.05). Gruels were evaluated on a 9-point Hedonic scale (1 = disliked extremely and 9 = liked extremely). Abbreviations are as defined in Table 1.

4. Discussion

4.1. Proximate composition

The higher protein content of sample F24R could be attributed to the fermentation used for its preparation. Fermentation has been reported to cause increase in crude protein content of AYB and cowpea flours [17]. The higher protein value (27.86%) of sample FL48R when compared to that of FL24R (20.96%) indicated that fermenting AYB in lime water for longer period increased the protein content. Several studies [18-20] had reported increases in the amount of protein content as a result of liming. The high protein content showed that AYB could be important in reducing protein deficiency in prevalent areas.
The lower fat content of sample FL48R (3.68%) may be due to metabolic activities of microorganisms during the fermentation and length of fermentation employed [21]. It has been reported that fat content decreased as fermentation time increased. However, the reduced fat contents of the fermented samples would enhance their keeping quality due to reduced likelihood of becoming rancid. The ash contents of the treated samples were higher than that of the control; this implies that fermentation probably caused the release of some bound minerals in the AYB. In addition to fermentation the lime treated samples FL24R (4.08%) and FL48R (3.48%) had the highest ash content. Lime may have enhanced the release of bound minerals on the AYB. Ash is an indication of mineral content of food. Thus the consumption of lime treated AYB gruel contributes to improved mineral status.
The low fibre contents of the fermented samples (4.16 to 4.28%) when compared to that of the control (6.33%) was in agreement with previous studies [22, 23] that showed decrease in crude fibre during seed fermentation. The decrease in

the carbohydrate content of fermented samples in relation to the control might be due to utilization of carbohydrates by microorganisms during fermentation for energy production as documented in the earlier studies [24], [25]. The high carbohydrate content of FL24R (65.26%) and FL48R (60.46%) when compared to F24R (54.63%) suggested that liming contributed to the increase in their carbohydrate contents. The carbohydrate content of F24R could also be attributed to its high protein content since carbohydrate was determined by difference.

4.2. Sensory characteristics of the gruels

The higher rating for the colour of the gruel made from sample FL48R might be due to the brown colour imparted by fermentation and roasting processes [26]. This association is in line with the reports [16], [27] that fermentation and roasting improves colour by imparting brown colour to the product. The carbohydrates may have been hydrolysed into reducing sugars such as glucose which probably participated in mailard reaction during the roasting process [28]. Caramelization of the sugars may have occurred during the roasting.
The preference of flavor of the treated samples to the control was in agreement with previous studies [16], [29], [30] on the importance of processing to improve traditional foods. Mailard reaction products contribute to flavor of foods [16]. The higher preference for the flavor of lime treated gruel might be attributed to masking of beany flavor of AYB by the synergistic effect of roasting and fermentation in lime water. Lime is known to improve flavor of grains such as legumes and cereals. The consistency of the treated gruels was comparable with that of the control.

5. Conclusion

It was observed from this study that AYB could be fermented in water and in lime juice to increase its nutrient content and produce acceptable gruels.

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