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Evaluation of the Physicochemical and Sensory Properties of Yam-Based Semolina Fortified with Orange Fleshed Sweet Potato and Beetroot Flours

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Abstract

The physicochemical and sensory properties of yam-based semolina fortified with orange fleshed sweet potato and beetroot flours were evaluated. Yam, orange fleshed sweet potato and beetroot were processed into flours using traditional methods. These flours were used to formulate semolina by blending them in the ratios of 100:0:0 (YB1), 80:10:0 (YB2), 70:20:10 (YB3) and 50:40:10 (YB4) yam-orange flesh sweet potato-beetroot respectively. The resulting products were subjected to sensory evaluation using 9-point Hedonic Scale while the functional and pasting properties as well as the proximate composition of the most accepted composite sample were determined using standard analytical methods. The sensory acceptability of the formulated semolina significantly ($p < 0.05$) decreased with increasing substitution of yam with orange fleshed sweet potato and beetroot flours. Sample YB2 was the only sample that was slightly acceptable with an overall acceptability score of 5.18 while the rest of the composite samples were rated below average. The values recorded for functional properties of sample YB2 were 6.88 for pH, 0.668 g/cm3 for bulk density, 77.86 % for water absorption capacity and1.08 % for oil absorption capacity. The peak viscosity, trough viscosity, breakdown viscosity, final viscosity, setback viscosity, peak time and pasting temperature of the sample were 268.17 RVU, 205.83 RVU, 62.33 RVU, 338.92 RVU, 133.03 RVU, 6.45 min and 88.85 ºC respectively. The result of the proximate composition of sample YB2 were 10.45 % for moisture, 3.32 % for ash, 2.67 % for crude fibre, 1.23 % for crude fat, 2.44 % for protein and 79.96 % for carbohydrates. Improvement on the sensory qualities through modification of the product is recommended.

Keywords: Semolina, Beetroot, Flour, Physicochemical Properties, Yam.

Introduction

Yams (*Dioscorea spp.*) are staple tuber of West African origin belonging to the family *Dioscoreaceae*, in the genus, *Dioscorea* (Daramola and Amira, 2020). It is a major staple food for an estimated 60 million people in the region stretching from Nigeria to Cameroon, an area commonly referred to as "Yam Zone" of West Africa (Olumurewa *et al.*, 2019). According to Nwokorie (2017), Nigeria is by far the world's largest producer of yams, accounting for over 70–76% of the world production. The nutritional value of yam varies greatly between different species and amongst varieties of the same species. Yam contains 50 to 78% moisture, 15 to 40.61% carbohydrate, 0.087 to 8.7% protein, 0.3 to 2.7% crude fat, 0.3 to 3.8% crude fiber, and 0.5 to 2.6% ash (Achy *et al.*, 2017). As stated in the study of Tortoe *et al.* (2017), some species of yam contain appreciable amounts of phenolic compounds, alkaloids and diosgenin, a steroid saponin with probably anti-cancer and anti-inflammatory effects and play a role in reducing diabetes and obesity in humans. Fresh yams are difficult to store and are subject to post-harvest loses during storage due to its high moisture content (Idowu and Adewumi, 2021). There is therefore, a need to process it into more stable products like yam semolina.

Yam semolina locally known as "amala or elubo" is processed by peeling, slicing, blanching in hot water, steeping for a day, drying and milling. The resulting semolina when stirred in boiling water forms a thick paste which is usually consumed in accompaniment with soup (Olarenwanju *et al.*, 2021). Yam semolina is a well cherished staple all over Nigeria especially in the Southeastern and Southwestern regions. However, it is deficient in essential macro and micro nutrients but rich in carbohydrates, with high glycemic index, which can lead to obesity and susceptibility to diabetes (Ilelaboye and Ogunsina, 2018). The low nutrients composition of yam semolina can therefore be improved through fortification with other local staples that are richer in essential nutrients. Although previous studies have enriched yam semolina with flours from legumes and vegetables (Kiin-Kabari and Irechukwu, 2019; Orafa *et al.*, 2021), the use of orange fleshed sweet potato and beetroot flour has not been reported.

Orange fleshed sweet potato (OFSP) (*Ipomea batatas)* is a tuber of the herbaceous climbing plant which is one of the most important food crops and an important staple in Nigeria and other developing countries (Kure *et al.*, 2021). It is strongly emerging as the most popular, commonly cultivated and demanded specie, due to its unique properties and health benefits (Haruna, *2018*). Orange-Fleshed Sweet Potato contains significant amounts of β-carotene, starch, dietary fiber, minerals, vitamins (especially vitamins C, B6 and folate), as well as antioxidants, such as phenolic acids, anthocyanins, and tocopherol (Tiruneh *et al.*, 2021). Babatunde *et al.* (2019) noted that OFSP varieties are gaining great attention as a means of reducing common health-related problems associated with vitamin A deficiency in low-income communities because it is believed to be the least expensive source of dietary vitamin A available to poor families.

Red beetroot (*Beta vulgaris* L.) is an agricultural commodity that has root characteristics that are bulging and similar to tubers, which are often referred to as beets. Red beet is a beetroot variety with dark red tuber color (Aulia and Sunarharum, 2020). Beetroot comes in different colors (red, yellow. white, multi-coloured) sizes and shape (round, long cylindrical and huge sugar and mangle beets) (Hailu and Mekonnen, 2017). Beetroot has been reported to contain powerful antioxidants, such as betalain that helps prevent oxidative damage to cells, thereby reducing the risk of cancer and cardiovascular diseases (Ceclu and Nistor, 2020). Kale *et al.*, (2018) reported that beetroot has low fat and calorie, and it is a good source of fibre, folate, iron, potassium, flavonoids and vitamin C. Beetroot has lots of nutritional and health benefits. It is useful in the treatment of several health problems including anaemia, constipation, haemorrhoids, as well as heart problems (Ceclu and Nistor, 2020). Notwithstanding the nutritional and health benefits of beetroot, is still an underutilized and unexploited crop in Nigeria.

Food fortification refers to the practice of deliberately increasing the content of essential nutrients in a food irrespective of whether the nutrients were originally in the food before processing or not, so as to improve the nutritional quality of the food supply and to provide a public health benefit with minimal risk to health. The levels of fortification depend on the nutritional needs of the population, amount consumed and regulations in the country (Awoyale *et al.*, 2010; Kiin-Kabari and Irechukwu, 2019). This research work took into cognizance the possibility of fortifying yam semolina by incorporating orange fleshed sweet potato flour and beetroot flour. Addition of these nutrient dense ingredients to yam semolina is hoped to improve its nutritional composition. In addition, production of semolina from yam-orange fleshed sweet potato-beetroot flours will also increase their domestic and industrial utilization, thereby improving the socio-economic status of Nigeria's local farmers. In this study, the physicochemical and sensory properties of yam-based semolina fortified with orange fleshed sweet potato and beetroot flours were evaluated.

Materials and Methods

Source of Material

Tubers of white yam and beetroots were purchased from Eke Ekwuluobia Market while orange flesh sweet potato was purchased from Eke Awka Market both in Anambra State. All the materials were packaged in a clean polyethylene bag and taken to the Food Processing Laboratory of Department of Food Technology, Federal Polytechnic Oko, Anambra State; for further processing and analysis.

Sample Preparation

Preparation of Yam Flour

Yam tubers were processed into flour following the method described in the study of Orafa *et al.* (2021). The yam tubers were washed to removed sand, dirt and other adhering materials. The yam tubers were peeled manually with sharp stainless kitchen knife, sliced directly into water containing 0.2 % sodium metabisulphite for 5 min (in order to prevent browning reaction). The sliced yam was removed and placed in a sieve to remove excess water. The yam slices were dried in a cabinet dryer at 60˚C for 10 hours and milled using hammer mill. The resulting flour sieved and packaged in polythene bags prior to use.

Preparation of Orange Fleshed Sweet Potato Flour

Orange fleshed sweet potato flour was produced following the method described by Kure *et al.* (2021) with slight modification. Orange fleshed sweet potatoes were properly washed and peeled manually with knives while keeping them in water to prevent enzymatic browning. The tubers were trimmed and sliced thinly (manually) and dried using a cabinet dryer at 60°C for 9 hours. The dried chips were milled and then sieved to obtain flour of uniform size. The resulting flour was packaged in polythene bags prior to use.

Preparation of Beetroot Flour

Beetroot flour was made from fresh beetroot following the method described in the study of Aulia and Sunarharum (2020) with slight modification. Beetroots were washed and blanched at 85˚C for 3 minutes before peeling and slicing using kitchen knife. Beetroot slices were dried using a cabinet dryer at 60°C for 12 hours. The dried beetroot chips were grinded and sieved to obtain fine flour. The resulting flour was packaged in an airtight container prior to further use.

Formulation of Semolina

Semolina samples were formulated by blending yam, orange fleshed sweet potato and beetroot flours in the ratios of 100:0:0, 80:10:10, 70:20:10 and 60:30:10 respectively. These samples were properly mixed and packaged in airtight plastic containers. The packaged semolina samples were properly labeled and stored at room temperature prior to further use.

Reconstitution of Semolina

Reconstituted semolina was prepared as described in the study of Kiin-Kabari and Irechukwu (2019) with slight modification. 200 g of the semolina was poured into 800 mL of boiling water with continuous stirring until a smooth, thick mixture is formed. The mixture was covered to simmer for about 5 minutes. It was further stirred, packed and wrapped in a warmer flask until needed for sensory analysis.

Sensory Evaluation

Sensory evaluation was performed using the method of Iwe (2014). A panel of 10 students (male and female) was used for the sensory evaluation of the reconstituted semolina. The different blends of the semolina were evaluated by panelists after it was reconstituted in hot water for colour, taste, texture, moldability, flavour and general acceptability. The scoring was based on a 9 Point Hedonic Scale ranging from 1 (extremely dislike) to 9 (extremely like) and 5 (neither like nor dislike). The samples were presented in identical containers coded with 3-digit random numbers with each sample having a different number. The samples were presented all at once with a good soup. Water was also given to the panelists for rinsing of mouth after each testing in order to avoid bias.

Analysis of Functional Properties

The functional properties of the most accepted composite semolina sample were determined using the methods described in the study of Idowu *et al.*, (2013).

Determination of pH

The pH of the semolina sample was determined by mixing 10g of the samples with 25 ml of distilled water, stirring thoroughly and measured with a pH meter at 20°C.

Determination of Bulk Density

A 10-ml graduated measuring cylinder was weighed and filled with the sample, and the bottom of the cylinder was gently tapped on the laboratory bench several times until there is no further diminution of the sample level after filling to the 10 ml mark. The bulk density was calculated as follows:

Bulk density (g/ml) = $\frac{Weight\ of\ sample\ (g)}{Volume\ of\ sample\ (cm3)}$

Determination of Water Absorption Capacity

One (1) gram of the sample was weighed into a conical graduated centrifuge tube, a warring whirl mixer was used to mix the sample, and 10 ml of distilled water was added and thoroughly mixed for 30 seconds. The sample was allowed to stand for 30 minutes at room temperature and then centrifuged at 5000×*g* for 30 minutes. The volume of free water (supernatant) was read directly from the graduated centrifuge tube. The water absorbed (total minus free) was multiplied by the density of water (1 g/ml).

Determination of Oil Absorption Capacity

One (1) gram of the sample was weighed into a conical graduated centrifuge tube, a warring whirl mixer was used to mix the sample, and 10 ml of vegetable oil was added and thoroughly mixed for 30 seconds the sample was allowed to stand for 30 minutes at room temperature and then centrifuged at 5000×*g* for 30 minutes. The volume of free oil (supernatant) was read directly from the graduated centrifuge tube. The oil absorbed (total minus free) was multiplied by the density of oil (1 g/ml).

Determination of Pasting Properties

Pasting characteristics of the most accepted composite semolina sample was determined with a Rapid Visco Analyzer (RVA), as reported in the study of James *et al.* (2018). The pasting properties determined included: pasting temperature, peak viscosity, peak time, hot and cold viscosity breakdown, set back, and final viscosity which are read from the pasting profile with the aid of thermocline for windows software connected to a computer. Three and a half (3.5) gram of the samples was weighed into a dried empty canister, and then 25 ml of water was dispensed into the canister containing the sample. Paddle was placed inside the canister; this was placed centrally onto the paddle coupling and then inserted into the RVA machine. The measurement cycle was initiated by pressing the motor tower of the instrument. The profile was seen as it is running on the monitor of the computer connected to the instrument. The 13-minutes profile was used, and the time–temperature regime was also used. The result obtained was expressed as RVU (Relative Visco Analyzer Unit).

Determination of Proximate Composition

The proximate composition of the most accepted composite semolina sample was determined by the standard methods described by the AOAC (2012).

Statistical Analysis

All measurements were carried out in triplicate. The data generated was analyzed using statistical program SPSS (version 25.0) and significant difference was compared by Analysis of Variance test (ANOVA) following Duncan's multiple range tests at the significance level of 5%.

Results and Discussion

Sensory Qualities of Semolina Produced from Blends of Yam, Orange Fleshed Sweet Potato and Beetroot Flours

The mean scores for the sensory evaluation of semolina produced from blends of yam, orange fleshed sweet potato and beetroot flours is presented in Table 1. The mean scores for colour of the semolina ranged from 5.30 – 7.10. Significant difference ($p < 0.05$) existed amongst the samples except for samples YB3 and YB4 which were statistically the same ($p > 0.05$). The results showed that the colour of the samples was greatly influenced by incorporation of orange fleshed sweet potato and beetroot flour. The colour of the control sample (YB1) was the most preferred while that of the sample produced from70:20:10 yam-orange fleshed sweet potato-beetroot blend (YB3) was the least preferred. All the semolina samples enriched with orange fleshed sweet potato and beetroot had a dark brown colour, thus, the reason it was rated low by the panelists. Similar observation was made by Orafa *et al.* (2021), who noted that inclusion of carrot powder in yam-base semolina greatly influenced the colour of the end product. They attributed this change in colour to the presence of carotenoids in raw material used to enrich the semolina. The high score adjudged for the colour of the control sample agrees with the findings of Karim *et al.* (2015) who observed that plain plantain semolina was highly preferred than those enriched with moringa leaf powder. Colour is an important characteristic of a food product that consumers check for before making their choice (Awolu *et al.*, 2020). Food products with less attractive colour are not usually appreciated by consumers. The low scores adjudged for the colour of the composite semolina is an indication that the panelists did not appreciate the colour of the product.

Table 1: Sensory qualities of semolina produced from blends of yam, orange fleshed sweet potato and beetroot flours

Samples	Colour	Taste	Texture	Moldability	Flavour	Overall Acceptability
YB1	$7.10^{a}\pm2.28$	$8.40^{a}\pm0.97$	$8.10^{a}\pm0.99$	$7.90^{a}\pm1.73$	$7.90^{a}\pm1.20$	$7.88^{a}\pm0.69$
YB2	$6.30^{b}\pm1.77$	$6.00^{b}\pm1.76$	$4.90^{b}\pm2.60$	$3.80^{b}\pm2.04$	$4.90^{b}\pm2.47$	$5.18^{b}\pm1.67$
YB3	$5.30^{c}\pm2.31$	$4.60^{c}\pm1.65$	$4.60^{b}\pm2.32$	$4.00^{b}\pm1.70$	$5.30^{b}\pm1.83$	$4.82^{b}\pm1.24$
YB4	$5.60^{c}\pm2.55$	$5.20^{c}\pm2.35$	$3.90^{b}\pm2.28$	$2.70^{b}\pm1.34$	$5.90^{b}\pm1.37$	$4.67^{b}\pm1.35$

*Values are means ± standard deviations of sensory evaluation. Means with the different superscripts in the same column are significantly different ($p < 0.05$).

Key: **YB1**: 100:0:0 yam-orange fleshed sweet potato-beetroot blends; **YB2**: 80:10:10 yam-orange fleshed sweet potato-beetroot blends; **YB3**: 70:20:10 yam-orange fleshed sweet potato-beetroot blends; **YB4**: 50:40:10 yam-orange fleshed sweet potato-beetroot blends.

Taste is an important driver of consumers' choice of a product (Lowengart, 2010). There were some significant differences ($p < 0.05$) in the scores for the taste of the formulated semolina. The mean score for taste ranged from 4.60 – 8.40 with sample YB3 having the least score while sample YB1 had the highest score. The degree of likeness of the taste of the products decreased with increasing substitution of yam flour with orange fleshed sweet potato flour. Similar decrease in score for taste of yam-based semolina enriched with carrot powder was also reported by Orafa *et al.* (2021) although they reported scores higher than the ones obtained in the present study.

Texture is generally described as one of the most important quality characteristics that affects consumer acceptance of manufactured food products (Olapade *et al.*, 2021). The mean scores for the texture of the formulated semolina ranged from 3.90 – 8.90 with sample YB1 having the highest score and sample YB4 having the least score. The result showed that no significant difference ($p > 0.05$) existed in the taste of samples YB2, YB3 and YB4 but the significantly differed ($p < 0.05$) from that of sample YB1. The texture of all the samples containing both oranges fleshed sweet potato flour and beetroot flour were generally disliked as their mean scores were below average. The panelists observed that whole yam semolina sample had a smooth texture than composite semolina samples. These observations are not in agreement with the findings of Ogbonnaya *et al.* (2018) who noted that the texture of paste made from cassava, cooking banana and African yam bean were not adversely affected by the blending ratios as they all compared well with the control sample. The variations of these results are probably due to the differences in the raw materials used.

Moldability is an attribute used to describe the ability of a reconstituted flour to mold (Awoyale *et al.*, 2020). The results showed that no significant differences ($p > 0.05$) existed amongst samples YB2, YB3 and YB4 in terms of moldability but they differed significantly

($p < 0.05$) from that of sample YB1. The moldability score of the samples ranged from 2.70 – 7.90. Sample YB1 had the highest score (7.90) while sample YB4 had the least score of 2.70. Slightly higher moldability scores ranging from 5.11 - 7.66 were reported for stiff paste made from different species of yam flours (Makanjuola and Coker, 2019). The ability of the formulated semolina to mold decreased with increasing substitution of yam flour with orange fleshed sweet potato and beetroot flours. Similar observation was made by Kiin-Kabari and Irechukwu (2019) for yam-based semolina enriched with African yam bean flour. The panelists also noted that the inability of the composite semolina to mold was due to their adhesive nature. Otoo *et al.* (2018) reported that moderate adhesiveness is a desirable feature of paste-like foods.

The flavour score of the sample YB1 was statistically higher ($p < 0.05$) than those of samples YB2, YB3 and YB4 which were statistically the same ($p > 0.05$). The mean scores ranged from 4.90 in sample YB2 to 7.90 in the control sample (YB1). These values are similar to 4.36 – 7.86 reported for reconstituted paste prepared from blends of plantain and moringa leaf powder (Harim *et al.*, 2015). The sensory scores of flavour of the composite semolina as evaluated by the panelists which are on the average indicated that the flavour of the products were not too good.

The overall acceptability of food products gives a general idea of the panelist's total impression towards the food (Olapade *et al.*, 2021). The scores for overall acceptability ranged from 4.67 to 7.88 (Table 1) with sample YB4 having the least score while sample YB1 had the highest score. There was no significant difference ($p > 0.05$) between the overall acceptability of all the composite samples but they differed significantly ($p < 0.05$) from that of the control. Olapade *et al.*, (2021) reported that texture, taste and color have the greatest effect on the overall acceptability of food. Thus, the low scores recorded for the taste, colour and texture of all the composite samples may have been the reason for their low acceptability. The results in Table 1, therefore showed that incorporation of both oranges fleshed sweet potato flour and beetroot flour in yam flour affected the sensory acceptability of the semolina adversely. It was based on this sensory evaluation that the sample which followed the control in terms of overall acceptability (i.e sample YB2) was selected for further analysis.

Functional Properties of Semolina Produced from Blends of Yam, Orange Fleshed Sweet Potato and Beetroot Flours

The functional properties of a material are parameters that determine its application and end-use (Adeleke and Odedeji, 2010). It indicates how the food materials under examination will interact with other food components directly or indirectly, affecting the processing applications, food quality, and ultimate acceptance (Awoyale *et al.*, 2020). According to Nielsen (2010), food composition such as carbohydrate, proteins and fats influences these properties. The functional properties of the semolina formulated from blends of yam, orange fleshed sweet potato and beetroot flours are presented in Table 2.

The pH value of the semolina sample was 6.88. This value is higher than values ranging from 5.00 – 5.60 reported by Idowu and Adewumi (2021) for semolina produced from different species of sweet potato. Kiin-Kabari and Irechukwu (2019) reported slightly lower pH of 6.14 – 6.25 for semolina prepared from blends of yam and African yam bean. The variations in these pH values could be due to differences in the raw materials used. The value obtained for pH in the present study suggests that the composite semolina is less acidic and will be fit for people who need diets that are less acidic.

Table 2: Functional properties of semolina from blends of 80 % yam, 10 % orange fleshed sweet potato and 10 % beetroot flours.

Parameters	Values
pH	6.88±0.00
Bulk Density (g/cm3)	0.668±0.01
Water Absorption Capacity (%)	77.86±0.01
Oil Absorption Capacity (%)	1.08±0.01

*Values are means ± standard deviations of triplicate determinations.

Bulk density is a measurement of how heavy a flour sample is and it is used to calculate the amount of packaging required. The particle size and moisture concentration play a role in determining the bulk density of flours (Adense *et al.* 2021). As shown in Table 2, the bulk density of the formulated semolina was 0.668 g/cm^3. This value falls within the range of 0.56 – 0.84 g/cm^3 reported by Olu *et al.* (2012) for soy-poundo yam flour but higher than 0.33 – 0.49 g/cm^3 reported by Olarenwaju *et al.* (2021) for flours produced from different species of yam. Bulk density according to Kraithong *et al.* (2018) is a determinant of food expansion and an indication of the porosity of food products. Formulation with a higher tapped bulk density will be the densest and those with the lowest tapped bulk densities would be less dense hence would occupy more space per unit weight requiring more packaging material or space. Presence of fibres also contributes to bulkiness in a sample (Adegbite *et al.*, 2020). The water absorption capacity of the semolina sample was 77.86 %. The results of Oladeji *et al.* (2013) revealed higher water absorption capacity ranging from 160.20 – 236.40 % for yam, cocoyam, breadfruit and plantain instant flours. The varied results could be attributed to differences in the raw materials used. The water absorption capacity is a term which describes the ability of the flour to absorb or take in water during processing (Idowu *et al.*, 2013). Low water absorption capacity value of the samples is an indication of intact starch granules in the raw flour. It is desirable as it will help to increase the energy density and nutrient content of food (Adeoti and Osundahunsi, 2017).
The oil absorption capacity of the semolina sample was 1.08 %. This value is lower compared to 120.00 – 192.00 5 reported for semolina prepared from sweet potato (Afolabi *et al.*, 2021). The oil absorption capacity is a measure of the ability of food material to absorb oil. High oil absorption capacity is desired in the retention of flavor, improvement of

palatability, an extension of shelf life of bakery products, baked goods, meat extenders, doughnuts, pancakes, and soup mixes (Okpala *et al.*, 2013; Awoyale *et al.*, 2020). Additionally, the oil absorption capacity also makes the meal suitable in facilitating enhancement in flavour and mouthfeel when used in food preparation (Adegunwa *et al.*, 2017).

Pasting Properties of Semolina Produced from Blends of Yam, Orange Fleshed Sweet Potato and Beetroot Flours

Pasting properties shows the way starch and starch-based products behaves during heat treatment in the presence of water. Pasting properties are essential for many applications of starch in the food industries, such as thickeners and sizing agents because they influence the texture, stability and digestibility of starchy foods (Olumurewa *et al.*, 2019). The pasting properties of semolina produced from blends of yam, orange fleshed sweet potato and beetroot is presented in Table 3.

Table 3: Pasting properties of semolina from blends of 80 % yam, 10 % orange fleshed sweet potato and 10 % beetroot flours.

Parameters	Values
Peak Viscosity (RVU)	268.17±0.13
Trough Viscosity (RVU)	205.83±0.04
Breakdown Viscosity (RVU)	62.33±0.01
Final Viscosity (RVU)	338.92±0.11
Setback Viscosity (RVU)	133.03±0.02
Peak Time (min)	6.45±0.00
Pasting Temperature (°C)	88.85±0.00

*Values are means ± standard deviations of triplicate determinations.

Peak viscosity of the semolina sample was 268.17 RVU. The results obtained in this study fell within the range reported by Olarenwaju *et al.* (2021) who reported values ranging from 1783 – 3682 RVU for flours prepared from different yam species; but lower than the values (915 – 1789 RVU) reported by Olumurewa *et al.* (2019) for instant flours made from yam and plantain. The variation might be as a result of the differences in the raw materials. Peak viscosity can also be referred to as the maximum viscosity developed during or soon after the heating, and it is often correlated with the final product quality and also provides an indication of the viscous loads likely to be encountered during mixing (Kinto *et al.*, 2015). Peak viscosity also measures the ability of starch to swell freely before their physical breakdown (Awolu and Olofinlae, 2016). According to Adebowale *et al.* (2017), high peak viscosity had been reported to influence the water binding capacity of starch granules and also increases the strength of paste formed during processing. The relatively high peak viscosity exhibited by flours is indicative that the flour may be suitable for products requiring high gel (Adegbite *et al.*, 2020).

The Trough viscosity is sometimes referred to as shear thinning, holding strength or hot-paste viscosity is a period when the samples were subjected to a period of constant temperature and mechanical shear stress. It is an index of starch stability to heating (Kinto *et al.*, 2015). The value for trough of the sample was 205.83 RVU. Bamidele *et al.* (2015) reported higher trough values ranging from 222.96 to 236.35 RVU for cassava-cocoyam semolina. The differences in raw materials, packaging materials and processing methods may be responsible for these variations. According to Ayo-Omogie and Ogunsakin (2013) trough viscosity measures the ability of the paste or gel formed to withstand breakdown during cooling.

Breakdown viscosity of the semolina sample also regarded as a measure of paste stability was 62.33 RVU. This fell within the range of 0.36 – 83.34 RVU reported by Afolabi *et al.* (2021) for sweet potato flours processed using different methods but lower compared to range of 157 – 786 RVU reported by Awolu *et al.* (2020) for semolina produced from blends of cassava and sorghum flours. Breakdown viscosity describes the ability of the floury product to withstand heating and shear stress during cooking, and high breakdown viscosity is associated with a decreased ability of starch to withstand heating and shear tress (Adebowale *et al*., 2017; Ohizua *et al*., 2017). Olumurewa *et al* (2019) reported that flour sample with low breakdown values indicates high stability. This suggests that the formulated semolina may be stable during heat treatment.

The final viscosity of the composite semolina sample was 338.92 RVU. The value obtained is lower compared to the values (2464 – 4332 cP) reported by Olarenwaju *et al.* (2021) for semolina produced from different yam cultivars. The difference might be as a result of variations in the product formulation. Final viscosity is defined as the quality of particular starch-based flour ability to form a viscous paste after cooking and cooling (Bamidele *et al.*, 2015). Olarenwaju *et al.* (2021) have reported the use of starches with high viscosity value in pharmaceutical companies especially as tablet binders.

The setback viscosity gives an idea of the retrogradation tendency of starch in the flour sample after 50°C (Ohizua *et al*., 2017). Higher setback value means reduced dough digestibility while lower setback during cooling of paste indicates lower tendency for retrogradation (Olarenwaju *et al.*, 2021). The value for setback viscosity obtained in this study was 133.03 RVU. This is higher than 89.46 – 94.86 RVU reported for cassava-cocoyam semolina (Bamidele *et al.,* 2015). The differences in the raw materials could be the reason for the varied results.

Peak time represents the total time taken by each formulation to attain its respective peak viscosity (Adegbite *et al.*, 2020). The peak time recorded for the sample was 6.45 min. The values obtained are similar to the peak time reported by Princwill-Ogbonna and Ezembaukwu (2015) for Aerial yam flour (4.07 – 5.66) and Oluwamukomi and Adeyemi (2015) for poundo yam (7.00 min).

The pasting temperature provides an indication of the minimum temperature required for sample cooking, energy cost involved and another components stability. It also gives an indication of the gelatinization time during processing (Donaldben *et al.*, 2020). The pasting temperatures of the semolina sample was 88.85°C. The result obtained is similar to that recorded by Princwill-Ogbonna and Ezembaukwu (2015) on Aerial yam flour which ranged from 82.45°C to 88.25°C but lower than that recorded by Ayo and Gidado (2017) on acha-carrot composite flours which ranged from 93.45°C to 94.45°C. The varied results may be due to differences in flour composition.

Proximate Composition of Semolina Produced from Blends of Yam, Orange Fleshed Sweet Potato and Beetroot Flours

The results of the proximate composition of semolina produced from blends of yam, orange fleshed sweet potato and beetroot flours are presented in Table 4. The moisture content of the formulated semolina was 10.45 %. The percentage moisture content obtained in this study is higher than range of values (6.91 – 7.57 %) reported by Orafa *et al.* (2021) for semolina formulated from blends of yam and carrot flours. Kiin-Kabari and Irechukwu (2019) also reported lower moisture content (5.00 – 6.83 %) for yam-African yam bean composite semolina. The variations in these results may be attributed to the differences in the raw materials used. Moisture is being used as quality factor for preservation, quality factor for standard, convenience in packaging or shipping, compositional standards, and computations of the nutritional value of foods (Nielsen, 2010). Moisture content requirement of certain food may differ from one particular food to another. The moisture content obtained in this study was slightly higher than 10% maximum level recommended by Standard Organization of Nigeria (SON) (Sanni *et al.* 2005). This implies that the formulated semolina may likely be less shelf stable if stored for too long. Thus, to maintain the keeping quality of the formulated semolina, it should be stored in airtight packaging materials of low air and moisture permeability.

Table 4: Proximate composition of semolina from blends of 80 % yam, 10 % orange fleshed sweet potato and 10 % beetroot flours

Parameters	Values (%)
Moisture	10.45±0.01
Ash	3.25±0.01
Crude Fibre	2.67±0.03
Crude Fat	1.23±0.12
Crude Protein	2.44±0.01
Carbohydrate	79.96±0.03

*Values are means ± standard deviations of triplicate determinations.

Ash content of a food is a measure of the amount of mineral composition present in the food. They are necessary in combating infections and for other metabolic activities in infants and children (Olapade *et al.*, 2021). The value obtained for ash content in the present study was 3.25 %. This value fell within the range of 2.00 – 3.50 % reported by Orafa *et al.* (2021) for yam-based semolina enriched with carrot flour but higher than 0.46 – 2.58 % reported by Ogbonnaya *et al.* (2018) for cassava-cooking banana-African yam bean fufu. The ash content in the present study also tallies with the values (3.13 – 3.50 %) of Kiin-Kabari and Irechukwu (2019) for yam-African yam bean composite flours. Plantain semolina enriched with moringa leaf powder recorded low ash content ranging from 1.71 – 2.93 % (Karim *et al.*, 2015). The variation in some of these results was due to the differences in their formulation. The high ash content of the sample in the present study suggests that they may contain high mineral elements.

Crude fibre content of 2.67 % was recorded in the present study. The results collaborated with the findings of Orafa *et al.* (2021) who reported fibre content ranging from 1.60 – 4.65 % for composite semolina prepared from blends of yam and carrot flours. Although the fibre content recorded for the semolina was not too high, it can contribute together with other fibre sources to the required daily intake of fibre since fiber consumption has been linked to decreased incidence of heart disease, various types of cancer and diverticulosis. Dietary fiber is also reported to have some beneficial effects on the muscles of the large and small intestine. It is well known that soluble fibres generally increase transit time through the gut, slow emptying of the stomach and slow glucose absorption (Ufot *et al.*, 2018; Oluwajuyitan and Ijarotimi, 2019).

The formulated semolina had low fat content of 1.23 %. This is in an agreement with the findings of Oladeji *et al.* (2013) who reported lower fat content ranging from 1.00 – 1.70 % for semolina flours prepared from cocoyam, breadfruit and plantain. Orafa *et al.* (2021) also reported similar fat content (1.18 – 1.41 %) for yam semolina enriched with carrot flour. Semolina prepared from composite flours of yam and African yam bean had slightly higher fat content (3.00 – 4.88 %) than the one obtained in the present study (Kiin-Kabari and Irechukwu, 2019). The low-fat content of the samples is an indication that they could be stored for a long period without the problem of peroxidation which is a major cause of fat instability.

The crude protein content of the semolina produced from blends of yam, orange fleshed sweet potato and beetroot flours was 2.44 %. This value is significantly higher than 1.53% (1.53g/100g) given as the average protein content of *Dioscorea spp* (USDA, 2014). This implies that addition of orange fleshed sweet potato and beetroot flours in the formulation slightly improved the protein content. The value is lower compared to 3.52 – 10.36 % reported by Karim *et al.* (2015) for plantain semolina fortified with moringa leaf powder. The varied results were due to differences in the raw materials used. Protein is important because cost of certain commodities may be based on the protein content, functional property, biological activity and amino acid composition (Nielsen, 2010). Bristone *et al.* (2018) noted that protein content of food is also important in solving protein- energy malnutrition especially in the developing countries where substantial staple foods are majorly cereals and tubers.

The semolina sample contained total carbohydrate content of 79.96 %. This value fell within the range of 71.25 – 82.09 % reported by Orafa *et al.* (2021) for yam-carrot semolina. Kiin-Kabari and Irechukwu also reported similar range of values (62.82 – 80.78 %) for yam-African yam bean semolina. Carbohydrates are the most important and readily available sources of metabolizable energy. They are known to be important in brain, heart, nervous, digestive function and immune system. The high carbohydrate content of the samples suggests a high energy content of the flour and high-energy foods tend to have a protective effect in the optimal utilization of other nutrients (Adanse *et al.,* 2021).

Conclusion

The results of this study have shown that incorporation of orange fleshed sweet potato and beetroot flour in yam-based semolina adversely affected the sensory attributes of the sample. The degree of likeness of the products decreased with increasing addition of these flours. However, the sample produced from 80% yam flour, 10% range fleshed sweet potato flour and 10% beetroot flour was the only sample rated quite above the average. The results of the functional and pasting properties revealed that aside being used in preparation of semolina, the composite flour have the potentials of being used in production of pastry and confectionery products. The moisture and fat contents of the sample were generally low which made it desirable. The semolina flour can provide the body with energy when consumed because of its high carbohydrate content. When incorporated into food system, the utilization of these raw materials will help to reduce postharvest losses associated with these roots and tubers. The study recommends modification in the product formulation in order to improve its sensory acceptability.

References

Achy, J. Y., Ekissi, G. S. E., Koffi, P. K. B., Koné, F. M. T. and Kouamé, L. P. (2017). Effect of boiling and baking times on the functional properties of aerial yam (Dioscorea bulbifera) flours cv Dugu-won harvested in Côte d'Ivoire. *International Journal of Agronomy and Agricultural Research (IJAAR).* 10(2): 1-12

Adanse, J., Bigson, K., Dare, N. J. and Glago, P. (2021). Proximate and Functional Properties of Water Lily (*Nymphaea Lotus*), Coconut (*Cocos Nicifera*) and Wheat (*Titricum Aestivum*) Flour Blends. J Food Tech Food Chem 3(1): 104-121.

Adebowale, A. A., Owo, H. O., Sobukola, O. P., Obadina, O. A., Kajihausa, O. E., Adegunwa, M. O. and Tomlins, K. (2017). Influence of storage conditions and packaging materials on some quality attributes of water yam flour. *Cogent Food & Agriculture*, *3*(1), 1385-1390.

Adegbite, J. A., Afolabi, O. and Oladapo, A.S (2020). Functional and Pasting Properties of Weaning Food Formulated from Locally Sourced Food Commodities. *International Journal of Innovative Research and Advanced* Studies 7(8): 131-138.

Adegunwa, M. O., Adelekan, E. O., Adebowale, A. A., Bakare, H. A., & Alamu, E. O. (2017). Evaluation of nutritional and functional properties of plantain (Musa paradisiaca L.) and tiger nut (Cyperus esculentus L.) flour blends for food formulations. *Cogent Chemistry*, *3*(1), 1–15.

Adeleke, P. O. and Odedeji, K. K. (2010). Physical, Functional and Sensory Properties of Yam Flour 'Elubo' Obtained from Kuto- Market Abeokuta. B.Sc Thesis Department of Food Science And Technology, College Of Food Science And Human Ecology University Of Agriculture, Abeokuta Ogun State, Nigeria. Pp. 1-40.

Adeoti, O. A. and Osundahunsi, O. F. (2017). Nutritional Characteristics of Maize-based Complementary Food Enriched with Fermented and Germinated *Moringa Oleifera* Seed Flour. *Int J Food Sci Nutr Diet.* 6(2), 350-357.

Afolabi, K. A., Taiwo, K. A., Morakinyo, T. A., and Badiora, O. A. (2021). Studies on Physico-chemical, Mineral, and Sensory properties of Sweet Potato Flour. *European Journal of Applied Sciences*, 9(3). 94-109.

AOAC, (2012). Official methods of Analysis. 19th edition. Association of official Analytical chemists. Washington, D.C., U.S.A; 2012.

Aulia, F. and Sunarharum, W. B. (2020). Beetroot (*Beta vulgaris* L. var. *rubra* L.) flour proportion and oven temperature affect the physicochemical characteristics of beetroot cookies. *International Conference on Green Agro-industry and Bioeconomy,* 475: 1-7.

Awolu, O. O. and Olofinlae, S. J. (2016). Physicochemical, functional and pasting properties of native and chemically modified water yam (*Dioscorea alata*) starch and production of water yam starch to based yoghurt. *Starch/ Stärke*. 2016; 68:1–8.

Awolu, O., Iwambe, V., Oluwajuyitan, T., Adeloye, J. M. and Ifesan, B. (2020): Quality Evaluation of '*Fufu*' Produced from Sweet Cassava (*Manihot Esculenta*) and Guinea Corn (*Sorghum Bicolor*) Flour. *Journal of Culinary Science & Technology*, 1: 1-33

Awoyale, W. B., Maziya-Dixon, L. O., Shittu, S. and T. A. (2010). Nutritional and sensory properties of "amala" supplemented with distiller's spent grain (DSG). *Journal of Food Agriculture Environment*, 3: 66-70.

Ayo, J. A. and Gidado, F. E. (2017). Physicochemical, Phytochemical and Sensory Evaluation of Acha-Carrot Flours Blend Biscuit. *Current Journal of Applied Science and Technology,* 25(5): 1-15.

Ayo-Omogie, H. N., and Ogunsakin, R. (2013). Assessment of chemical, rheological and sensory properties of fermented maize-cardaba banana complementary food. *Food and Nutrition Sciences*, *4*, 844–850.

Babatunde, R. O., Adeyemi, O. and Adegbanke, E. A. (2019). Orange fleshed sweet potato (OFSP) and productivity: the case study of smallholders in Kwara State, Nigeria. *Agricultura Tropica et Subtropica;* 52(3-4). 105-111.

Bamidele, O. P., Fasogbon, M. B., Oladiran, D. A. and Akande, E. O. (2015). Nutritional composition of *fufu* analog flour produced from Cassava root (*Manihot esculenta*) and Cocoyam (*Colocasia esculenta*) tuber. *Food Science & Nutrition*; 3(6): 597–603.

Bristone, C., Okafor, C. J., Badau, M. H. and Kassum, A. L. (2018). Quality Evaluation of Nigerian Indigenous Based Food (*Upursah:* i.e. "Tiger nut composites flour") from Tiger Nut, Sorghum, Sweet Potato and Soybean. *Direct Research Journal of Agriculture and Food Science* 6(8): 182-196.

Ceclu, L. and Nistor, O. (2020). Red Beetroot: Composition and Health Effects - A Review. *J Nutri Med Diet Care* 6:043. 1-9

Daramola, A. S. and Amira, P. O. (2020). A Comparative Evaluation of The Proximate Analysis, Mineral Contents and Phytochemical Screening of *Dioscorea Dumetorum* (Bitter Yam). *European Journal of Biology and Biotechnology* 1(3): 1-3

Donaldben, N. S., Tanko, O. O. and Hussaina, T. O. (2020). Physico-chemical Properties of Starches from Two Varieties of Sweet Potato and Yam Tubers Available in Nigeria. *Asian Food Science Journal,* 14(4): 28-38.

Hailu, Z. and Mekonnen, D. (2017). Effects of yeast and oxygen on quality attributes of wine produced from ethiopian beetroot, *J. Chem. Eng. Process Technol*. 8(2): 329-335.

Haruna, S. A. (2018). The influence of drying temperature on the selected properties of flour produced from orange fleshed sweet potato. *International Journal of Engineering and Technical Research,* 7(7): 338-341.

Idowu, D. O. and Adewumi, H. O. (2021). Evaluations of some Selected Yam Flour Production Variables on Drying Time and Final Moisture Content of Sliced Dried Yam. *Direct Research Journal of Agriculture and Food Science* 9: 344-349

Idowu, O.A.; Olaoye, O.A.; Sogotemi, C.M.and Ajayi, B. (2013). Quality assessment of flours and *amala* produced from three varieties of sweet potato *ipomea batatas. International Journal of Food and Nutritional Sciences;* 2(4): 1-10.

Ilelaboye, N. O and Ogunsina, T. I. (2018). Proximate Composition, Functional Properties and Sensory Evaluation of Stiff Dough (Amala) Prepared from *Okara* Fortified Plantain-Sorghum Flours. *Asian Food Science Journal 5(1): 1-10.*

Iwe, M. O. (2014). Current trends in sensory evaluation of foods. Revised Edition. Rojoint Communication Services Ltd. Uwani Enugu, Nigeria, 144-145.

James, S., Akosu, N., Maina, Y. C. (2018). Effect of addition of processed bambara nut on the functional and sensory acceptability of millet-based infant formula. *Food Sci Nutr.*; 6:783–790.

Kale, R. G., Sawate, A. R., Kshirsagar, R. B., Patil, B. M. and Mane, R. P. (2018). Studies on evaluation of physical and chemical composition of beetroot (*Beta vulgaris* L.). *International Journal of Chemical Studies* 6: 2977-2979.

Karim, O., Kayode, R., Oyeyinka, S. and Oyeyinka, A. (2015). Physicochemical properties of stiff dough "amala" prepared from plantain (*musa paradisca*) flour and moringa *(moringa oleifera)* leaf powder. *Hrana u zdravlju i bolesti,* 4(1): 48-58.

Kiin-Kabari, D. B. and Irechukwu, F, (2019). Evaluation of Yam Paste (*Amala*) Produced from Composite Flour Blends of Yam *(Dioscorea Rotundata)* and African Yam Bean *(Sphenostylis stenocarpa)* Flour. *African Journal of Food Science and Nutrition* 1(3): 17-25.

Kiinto, K. D. B., Eketo, E. J. and Giami, S. Y. (2015). Functional and Pasting Properties of Wheat/Plantain Flours Enriched with Bambara Groundnut Protein Concentrate. *International Journal of Food Science and Nutrition Engineering.*; 5(2):75–81.

Kraithong, S, Lee, S. and Rawdkuen, S. (2018). Physicochemical and functional properties of Thai organic rice flour. *Journal of Cereal Science* 79(4): 1-5.

Kure, O. A., Ariahu, C. C. and Eke, M. O. (2021). Effect of Incorporating Orange Flesh Sweet Potato Flour, Starch and Non-starch Residue Flour to Wheat on the Quality Characteristics of Cookies. *American Scientific Research Journal for Engineering, Technology, and Sciences 77*(1): 200-220.

Lowengart, O. (2010). Heterogeneity in consumer sensory evaluation as a base for identifying drivers of product choice. *J Bus Manag*. (2010) 16:37–50.

Makanjuola, O. M. and Coker, O. J. (2019). Assessment of sensory, functional and pasting properties of different yam cultivar flours subjected to the same processing condition. *GSJ,* 7(10): 672-687

Nielsen, S. S. (2010). Food Analysis, Food Science Texts Series, Fourth edition, Purdue University, West Lafayette, IN, USA. p. 87-214. DOI10.1007/978-1-4419-1478-1_6.

Nwokorie, E. C. (2017). Acceptability of Roast *Dioscorea Rotundata* With Fortified *Gongronema Latifolium* Sauce for Consumption in Nigeria Restaurants. *International Journal of Innovative Research and Advanced Studie;* 4(1): 27-33.

Ogbonnaya, M., Onumadu, K. S. and Nwogu, O. G. (2018). Proximate Composition and Sensory Evaluation of Blends of Cassava Fufu, Cooking Banana (*Musa saba*) and African Yam Bean (*Sphenostylis stenocarpa*) Composite Flours and Paste. *International Institute of Academic Research and Development* 4(1): 45-50.

Ohizua, E. R., Adeola, A. A., Idowu, M. A., Sobukola, O. P., Afolabi, T. A., Ishola, R. O., and Falomo, A. (2017). Nutrient composition, functional and pasting properties of unripe cooking banana, pigeon pea, and sweet potato flour blend. *Food Sciences and Nutrition*, *5*, 750–762.

Okpala, L., Okoli, E., and Udensi, E. (2013). Physicochemical and sensory properties of cookies made from blends of germinated pigeon pea, fermented sorghum, and cocoyam flours. *Food Science & Nutrition*, *1*(1), 8–14.

Oladeji, B. S., Akanbi, C. T. and Gbadamosi, S. O. (2013). Comparative studies of physico-chemical properties of yam (*Discorea rotundata)*, cocoyam (*Collocasia taro*), breadfruit (*Artocapus artilis*) and plantain (*Musa parasidiaca*) instant flours. *African Journal of Food Science* 7(8): 210-215.

Olapade, A. A., Obomeghei, A. A. and Ebabhamiegbebho, P. A. (2021). Production, Formulation, Proximate Composition and Sensorial Attributes of Complementary Food from Pearl Millet (*Pennisetum glaucum*), African Yam Beam (*Sphenostylis stenocarpa* Hoechst ex. A. Rich) and Tiger Nut (*Cyperus esculentus*). *International Journal of Innovative Science, Engineering & Technology* 8(5): 209-218.

Olarenwaju, B. J., Jesufemi, O. E., Oyedunni, E O., Micheal, A. O. and Ademola, A. D. (2021). Effect of processing methods on functional, pasting properties of flours and sensory evaluation of "Amala" made from different yam cultivars. *GSC Advanced Research and Reviews*, 07(01): 123–132

Olu, M., Ogunmoyela, O. A. B., Adekoyeni, O. O., Jimoh, O., Oluwajoba, S.O and Sobanwa, M. O. (2012). Rheological and Functional Properties of Soy-Poundo Yam Flour. *International Journal of Food Science and Nutrition Engineering*, 2(6): 101-107.

Olumurewa, J. A. V., Ibidapo, P. O. and Adebileje, J. F. (2019). Evaluation of functional and pasting properties of instant pounded yam/plantain flour. *Adv Obes Weight Manag Control.* 9(1):1–6.

Oluwajuyitan, T. D., and Ijarotimi, O. S. (2019). Nutritional, antioxidant, glycaemic index and antihyperglycaemic properties of improved traditional plantain-based (*Musa ABB)*, dough meal enriched with tigernut (*Cyperus esculentus*) and defatted soybeans (*Glycine max*) cake for diabetic's patients. *Heliyon Elsevier*, *5*(4), e1504–e1509.

Oluwamukomi, M. O. and Adeyemi, A. O. (2015). Physicochemical, Pasting and Sensory properties of "Poundo-yam" enriched with defatted soy flour. *J. Applied Tropical Agriculture*; 20(1):89-95.

Orafa, N. P., Samuel, O. B. and Daagema, A. A. (2021). Quality Evaluation of Yam (*Dioscorea rotundata*) and carrot (*Daucus carota* L.) Flour Blends for Production of Stiff Dough and Biscuits. *Asian Food Science Journal* 20(3): 18-29.

Otoo, G. S., Essuman, E. K., Gyimah, V. and Bigson, K. (2018). Quality attributes of *fufu*: Instrumental and sensory measureme. *Scientific African* 1: 1-7

Princewill-Ogbonna, I., and Ezembaukwu, N. (2015). Effect of various processing methods on the pasting and functional properties of Aerial yam (Dioscorea bulbifera) flour. *British Journal of Applied Science and Technology, 9(5)*, 517-526.

Sanni, L., MaziyaDixon, B., Akaanya, J., Okoro, C.I., Alaya, Y., Egwuonu, C.V., Okechukwu, R., Ezedinma, C., Akoroda, M., Lemechi, J., Okoro, E., and Dixon, A. (2005). *Standards for Cassava Products and Guidelines for Export*. IITA, Ibadan, Nigeria, pp. 93.

Tiruneh, Y., Urga, K., Bekerie, A. and Weledesemayat, G. T. (2021). Effect of treatment on beta carotene retention of orange fleshed sweet potato grown in Hawassa, Ethiopia. *Journal of Nutrition and Food Science;* 11(799): 1-4.

Tortoe, C., Dowuona, S., Akonor, P. T. and Dziedzoave N. T. (2017). Examining the physicochemical, functional and rheological properties in flours of farmers' 7 key yam (*Dioscorea* spp.) varieties in Ghana to enhance yam production. Cogent Food & Agriculture, 3(1): 1371564.

Ufot, E. I., Effiong, C. F. and Edima-Nyah, A. P. (2018). Physical Properties, Nutritional Composition and Sensory Evaluation of Cookies Prepared from Rice, Unripe Banana and Sprouted Soybean Flour Blends. *International Journal of Food Science and Biotechnology* 3(2): 70-76.

United States Department of Agriculture (USDA) (2014). National Nutrient Database available online at www.nutrition-and-you.com.