NUTRITIONAL, PHENOLIC AND SENSORY PROPERTIES OF TAPIOCA PRODUCED FROM BLENDS OF COCOYAM, PLANTAIN, TURMERIC AND DATE FRUITS

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Abstract
In an attempt to encourage the utilization of natural resources and formulation of new food products, blends of tapioca were produced from cocoyam, plantain, turmeric and date fruits. The mineral composition, phenolic content, pasting characteristics and sensory qualities of the tapioca blends were determined. The ranges of values of iron, calcium and zinc in the tapioca blends were 0.32-0.85 mg/100 g, 3.64-5.63 mg/100 g and 0.92-1.03 mg/100 g respectively. Addition of turmeric and date fruits significantly increased (p≤0.05) the total phenolic content of the tapioca blends compared to 100% cocoyam or plantain tapioca counterpart. Pasting viscosities of the tapioca blends generally reduced when substituted with turmeric and/or date fruits. The peak time and pasting temperature ranged from 4.22-7.04 min and 74.29-79.21 °C respectively. Cocoyam tapioca (100%) was rated highest in all the sensory attributes examined. All the blends were however generally liked by panelists. Nutritious and acceptable tapioca may be produced from blends of cocoyam, plantain, turmeric and date fruits as this would enhance their utilization and better household economies.

Keywords: tapioca blends, phenolic content, pasting properties, product development

Introduction
Cocoyam is a very popular root crop; it ranks third in importance after cassava and yam among the root and tuber crops cultivated in Nigeria. Its corms are rich sources of starch and widely consumed in homes, especially during the period preceding the new yam harvests in Nigeria. It is usually eaten same way as yam, either boiled, roasted, pounded, fried,. The corm also serve as substitute to yam, but it is not as highly valued as yam. Although cocoyams are neglected tuber crops in many parts of the world, their nutritional value is high. They contain digestible starch, good quality protein, vitamin C, thiamin, riboflavin, niacin and high scores of proteins and essential amino acids ((Niba, 2003; Ndabikunze et al. 2011; Bamidele et al., 2014). Cocoyam is a good base for infant foods, because of the high digestibility of its starch, reasonable content of calcium and phosphorus for bone building, B-complex vitamins and provitamin A (Ndabikunze et al. 2011). Composite flour incorporating cocoyams has been used in extruded products such as noodles and macaroni (FAO, 2004).

Plantain (Musa spp) is a tropical fruit that constitute one of the staple food crop in West and Central Africa. It is an important tuber crop in the tropical and sub-tropical regions of the world. It provides high carbohydrate, with annual production estimated to be about 2.11 metric tonnes (Oluwamukomi and Akinsola, 2015). Of the annual production figure, about 35-60% of it is lost due to poor post-harvest handling, poor storage facilities and technologies for new food products development (FAO, 2004).

Dates consisting mainly of carbohydrates (namely the sugars; sucrose, glucose, and fructose), is a delicious fruit with a sweet taste and fleshy mouth feel. The sugars in dates are easily digested and metabolized to release energy for various cell activities. Dates are also a good source
of fiber, and contain many important vitamins and minerals, including significant amounts of calcium, iron, fluorine, and selenium (Al-Shahib and Marshall, 2003; Khan et al., 2008). Dates have also been shown to contain antioxidants and antimutagens. Studies have shown that dates and their aqueous extracts have demonstrated the free radical scavenging activity, antimutagenic, inhibition of free radical-mediated macromolecular damages, and immunomodulatory activities (Allaith, 2008; Saafi et al., 2009). The market for dates and their products could be increased significantly if researches are conducted to explore their health benefits, as well as the use of their functional components to add values to food products.

Turmeric (*Curcuma longa*) is a perennial herb. The bright yellow colour and the peppery flavor of this crop is perhaps its major characteristics. Tumeric has been reported to have anti-inflammatory actions and helps in wound healing (Chainani-Wu, 2003; Lantz and Timmermann, 2005).

Tapioca; a starch based white flour with neutral flavour is traditionally produced from cassava roots. It is in the form of irregular lumps of partly gelatinized starch (Okigbo, 1980). It became popular in the Southern part of Nigeria during the 20th century, mostly among the inhabitants of Lagos and its environs (Nweke et al., 2002). Tapioca is gluten-free, cholesterol-free and nut-free starchy flour wrenched out from cassava roots. The flour is a common ingredient in many gluten-free manufactured foods, its strong gelling power makes it highly useable as a thickening agent in the sweet and savory foods. Tapioca has several advantages; it has relatively low production cost, long shelf life and is used in the production of many foods such as dough. It can also be added to ground meat products like burger patties or chicken nuggets, as a binder and stabilizer. Researchers have investigated several ways of enriching cassava products by fortifying them with protein rich legumes and ways to produce tapioca from root crops other than cassava (Kolapo and Sanni, 2009; Samuel et al., 2006). Samuel et al. (2012) produced enriched tapioca from cassava and varying proportions of soybean flour.

Cocoyam has been reported as a rich source of starch for food and industrial applications. It has been advanced that with appropriate processing techniques, cocoyam corms can be transformed into new food products (Owusu-Darko et al., 2014). In this vein, this study advances the utilization of cocoyam and plantain, natural sweetener –date, and spice-turmeric (with additional phytochemical beneficial effect) for the production of tapioca that is different from the native cassava starch.

**Materials and Methods**

**Procurement of Raw Materials**

Fresh cocoyam tubers, unripe matured plantain, fresh turmeric roots and date fruits were purchased from the King’s market, Ado-Ekiti, South-west, Nigeria. The materials were then transported to the laboratory at the Federal University Oye-Ekiti, Oye-Ekiti, Nigeria, for preparation and subsequent analysis.

**Production of Turmeric Powder**

Turmeric roots were washed thoroughly in water and then boiled for about 45 minutes to soften and remove its raw odour. The boiled roots were then sliced into smaller sizes to facilitate drying. The roots were later dried at 50°C in a hot air oven (Model HS60, Czechoslovakia) and then ground into fine powder using a Marlex Electroline blender (Dabhel, Daman (UT) and sieved using 250 µm mesh size sieve.

**Production of Date Fruit Powder**

Date Fruits were deseeded, washed, drained and sun-dried for 6 hours. Thereafter the fruits were dried in a hot air oven. The dried date fruits were then milled and sieved into fine powder. The date fruit was used as
sweetener instead of sugar.

Production of Cocoyam and Plantain Starch
Fresh cocoyam tubers were washed, peeled manually, re-washed, chopped to about 1 cm³ cubes and then transferred into a Warring laboratory blender (HGBTWTS3, Torrington, CT, USA). One litre of water was added to 500 g of the chopped tubers and ground at a high speed for 5 minutes. The suspension was then filtered using a double cheese cloth. The filtrate was allowed to stand for 4 hours to facilitate the sedimentation of starch and the top liquid was decanted and discarded. The sediment was re-suspended in 1 l of water and the process repeated twice to obtain pure cocoyam starch. Plantain starch was also produced by replacing cocoyam in the aforementioned process. The sediment were then dewatered and dried separately at room temperature by spreading in a tray.

Formulation and production of various blends of Tapioca
Blends of enriched tapioca were formulated by mixing various ratios of cocoyam and plantain starch with different proportions of turmeric and date fruit powder. Table 1 shows the various blend formulations. The damp blends were granulated with the use of a sieve spread over a hot pan and roasted thereafter to form a coarse granulated product in the form of lumps of partially gelatinized starch known as tapioca.

Determination of Mineral Composition of Tapioca Blends
The acid digestion method described by Sharifi et al., (2017) was used for the extraction of minerals from the tapioca blends. Potassium was analysed using Flame photometer (PF7, Jenway, UK) while atomic absorption spectrometer AAS (Alpha 4 model, Buck scientific Ltd USA) was used to estimate other minerals.

Determination of Phenolic Content of Tapioca Blends
The total phenolic content was determined by using Folin–Ciocalteu reagent assay (Singleton and Rossi, 1965) as described by Kamaayi et al. (2020). Exact 0.1g sample was mixed with water (46 ml). 1 ml of Folin–Ciocalteu reagent was added and mixed thoroughly. 3 ml of sodium carbonate (7%) was added to the mixture. The absorbance was measured at 760 nm using spectrophotometer. A standard curve was prepared using gallic acid in ethanol to cover a range of 0–100 μg/ml. The concentration of total phenolic compounds in the extracts was determined as mg gallic acid equivalent.

Determination of Pasting Properties of Tapioca Blends
The pasting characteristics were determined using a Rapid Visco Analyser (Newport Scientific Pty Ltd. Warriewood NSW 2102, Australia) hooked on to a work station. Moisture content of the blends was first determined to obtain correct sample weight and amount of water required for the test. An aqueous suspension of sample (6 %, w/w; 28 g total weight) was prepared and spunned at 75 rpm. The temperature-time conditions included a heating step from 50°C to 100°C at 6 minutes (min) (after an equilibration time of 1 min at 50 °C, a holding phase at 100 °C for 5 min, cooling step from 100 to 50 °C for 2 min. Viscosity was expressed in centipoises (cP) (IITA, 2001).

Sensory Evaluation of Tapioca Blends
Cocoyam-Plantain tapioca blend/samples enriched with dates and turmeric were evaluated for sensory properties by ten semi-trained panelists selected based on their familiarity with tapioca and their consistency in scoring. A nine-point Hedonic scale from like extremely to dislike extremely was used. The samples were evaluated for colour, taste, flavour and overall acceptability.
Statistical analysis

All determinations were carried out in triplicates and were analysed using Analysis of Variance (ANOVA) and mean separated by New Duncan Multiple range test using SPSS 21 computer programme. Significance was accepted at 5 % level of probability.

Results and Discussion

Mineral Content of Tapioca Blends

The result of the mineral composition of the tapioca blends from cocoyam, plantain, dates and turmeric is as shown in Table 2. The mineral elements analysed varied significantly (p≤0.05). The most predominant mineral element in the blends is potassium followed by calcium and zinc. The highest value of potassium observed in the tapioca blends agreed with the observation of Coronell-Tovar et al. (2018) that potassium is the most predominant mineral element in most of Nigeria’s agricultural products. Coronell-Tovar et al. (2018) also reported potassium to be the most abundant mineral element in cocoyam corm flour. Calcium is important for good bone and tooth health in adults and children while potassium and sodium are important in regulating body fluid. Potassium content of the blends ranged from 10.31 mg/100g to 29.88 mg/100g in the sample A (100% Cocoyam tapioca) and sample F (45:45 Cocoyam-plantain tapioca sweetened with 10 % date fruit) respectively. Addition of date fruit to the tapioca significantly increased the potassium content of Samples C, D and E. Date fruit has been reported to contain high levels of selenium, copper, potassium and magnesium (Barreveld, 1993). Calcium is important for good bone and tooth health in adults and children while potassium and sodium are important in regulating body fluid. Potassium content of the blends ranged from 10.31 mg/100g to 29.88 mg/100g in the sample A (100% Cocoyam tapioca) and sample F (45:45 Cocoyam-plantain tapioca sweetened with 10% date fruit) respectively. Addition of date fruit to the tapioca significantly increased the potassium content of Samples C, D and E. Date fruit has been reported to contain high levels of selenium, copper, potassium and magnesium (Barreveld, 1993).

Phenolic Content of Tapioca Blends

The Total Phenolic Content (TPC) of enriched cocoyam-plantain tapioca ranged from 0.13 to 14.67 (mg/100 g) in samples A and E respectively (Figure 1). The highest TPC observed in sample E may be due to higher percentage of turmeric inclusion in the blend. Turmeric has been reported to contain reasonably high phytochemicals. Phenolics and terpenoids among other compounds have been identified in turmeric. The Total Phenolic Content (TPC) of aqueous and ethanol extracts of some turmeric varieties ranged from 4.52 to 16.07% (Tanvir et al., 2017). Inclusion of date fruits in the cocoyam-plantain tapioca may also have contributed to the increased TPC observed in enriched tapioca blends when compared to samples A and B. In a review conducted recently, Alfaris et al. (2021) reported high TPC in date fruits. The range of 2.89-141.35 mg GAE/100 g dw sample of TPC have been reported in some varieties of date fruits (Biglaris et al., 2008). Saafi et al. (2009) also reported ranges of values from 209.42 to 447.73 mg GAE/100 g fresh wt in some varieties of date fruits grown in Tunisia. Cocoyam has been reported to contain 145.31 and 9.39 mg gallic acid equivalent GAE/100 g dry sample of flavonoid and total phenol respectively (Dilworth et al., 2012). Oxidative stress is the leading cause of certain physiological disorders in the body due to oxidative damage. In order to maintain proper physiological function of the body, it is necessary to maintain a very good balance between the free radical and antioxidant concentration in the diet (Tanvir et al., 2017).

Pasting Profile of Tapioca Blends

The pasting properties of enriched cocoyam-plantain tapioca blends are depicted in Table 3. Pasting, according to Zeng et al. (1996) generally refers to changes in starch viscosity as a result of heating, which are the changes in viscosity before, during and after gelatinization. The
pasting properties varied significantly (p \leq 0.05) among the blends. Samples A (100% cocoyam tapioca) and B (100% plantain tapioca) generally showed higher viscosities than their turmeric and date fruits enriched tapioca samples/blends. However, samples C (70/20 cocoyam/plantain) and D (20/70 cocoyam/plantain) tapioca exhibited higher breakdown viscosity than samples A and B. The peak viscosity of the blends ranged from 2088.33 cp in sample F to 3720.50 cp in sample A. Higher peak viscosity has been linked to starches’ resistance to swelling and rupturing (Otegbayo et al., 2013). The peak viscosity is the maximum viscosity developed soon after the heating period (Adebawale et al., 2019). The lower peak viscosity tapioca blends relative to higher peak viscosity tapioca blends (100% cocoyam or plantain tapioca) is expected. This is due to effects of turmeric and/or date fruits. This shows that the enriched blends would not form a very thick paste like the 100% cocoyam or plantain tapioca. Peak viscosity is an indication of binding property of the cooked starch. It also gives information of the likely viscous load to resist during mixing (Adebawale et al., 2019). The peak viscosity of cocoyam and plantain tapioca obtained in this study is slightly lower than the values of 377.83 RVU and 272.47 RVU reported for cocoyam and plantain starches respectively (Oluwamukomi and Akinsola, 2015). This may be as a result of the partial gelatinization of the starch granules during roasting.

The time during which the peak viscosity is measured is termed the peak time, and it is an indication of the cooking time. The peak time of plantain tapioca is significantly (p \leq 0.05) higher than that of cocoyam tapioca, and this is also reflected in the enriched blends of cocoyam-plantain tapioca. The peak times in this study were higher than the time reported for differently processed tapioca from some cassava varieties (Adebawale et al., 2019). The peak time of plantain tapioca compared favourably with 7.00 min reported by Olatunde et al. (2017). When starch is heated in water, the starch granules swell and the viscosity changes as the starch gelatinizes. The temperature at which the viscosity begins to rise is termed the pasting temperature. The pasting temperature gives information about the minimum temperature needed to get the starch cooked. It also gives direct information about the energy requirement in cooking starch sample. The pasting temperature of the cocoyam-plantain enriched tapioca varied significantly (p \leq 0.05) with values ranging from 74.29°C to 79.21°C. The range of values (73.10-77.53°C) was reported for soy-substituted cassava tapioca (Otegbayo et al., 2013).

**Sensory attributes of Tapioca Blends**

The sensory attributes of blends of cocoyam, plantain, date fruits and turmeric tapioca is depicted in Table 4. The sensory parameters evaluated varied significantly (p\leq0.05) among the tapioca blends. The taste of sample A is most preferred among the blends, while the sample D is least preferred. The colour and flavour of sample E were least accepted. This may be due to the yellowish colour impacted on the blend by the turmeric included. In addition, the Panelists may not be familiar with yellow coloured tapioca which could have affected their sense of judgments. Sample A was found to be most preferred to other blends in all the sensory qualities examined. Generally, the scores obtained for the overall acceptability of the tapioca blends showed that they were all the blends were liked by the panelists implying that acceptable enriched tapioca can be produced from blends of cocoyam, plantain, turmeric and date fruits.

**Conclusion**

Incorporation of turmeric and date fruits in blends of cocoyam and plantain tapioca significantly improved the total
phenolic and some mineral content of tapioca. The pasting viscosities of the tapioca blends decreased with addition of turmeric and date fruits, but were generally not inferior to cocoyam or plantain tapioca in flavour and overall acceptability. Nutritious, healthy and acceptable tapioca may be produced from blends of cocoyam, plantain, turmeric and date fruits.

References


Table 1: Formulation of Enriched Cocoyam-Plantain Tapioca

<table>
<thead>
<tr>
<th>Sample</th>
<th>Cocoyam Tapioca (g)</th>
<th>Plantain Tapioca (g)</th>
<th>Turmeric (g)</th>
<th>Date Fruit (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>-</td>
<td>100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C</td>
<td>70</td>
<td>20</td>
<td>2.5</td>
<td>7.5</td>
</tr>
<tr>
<td>D</td>
<td>20</td>
<td>70</td>
<td>2.5</td>
<td>7.5</td>
</tr>
<tr>
<td>E</td>
<td>45</td>
<td>45</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>F</td>
<td>45</td>
<td>45</td>
<td>-</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 2: Mineral Composition (mg/100g) of Tapioca Blends

Values are means of triplicates ± Standard deviation. Values on the same column with different superscripts are significant (P≤0.05).

<table>
<thead>
<tr>
<th>Sample</th>
<th>Manganese</th>
<th>Iron</th>
<th>Calcium</th>
<th>Zinc</th>
<th>Selenium</th>
<th>Potassium</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.02±0.01</td>
<td>0.32±0.03</td>
<td>4.04±0.01</td>
<td>0.97±0.02</td>
<td>0.51±0.02</td>
<td>10.31±0.04</td>
</tr>
<tr>
<td>B</td>
<td>0.02±0.02</td>
<td>0.41±0.02</td>
<td>5.63±0.04</td>
<td>0.92±0.06</td>
<td>0.62±0.02</td>
<td>13.97±0.06</td>
</tr>
<tr>
<td>C</td>
<td>0.05±0.01</td>
<td>0.76±0.08</td>
<td>3.64±0.02</td>
<td>1.03±0.06</td>
<td>0.37±0.01</td>
<td>19.04±0.04</td>
</tr>
<tr>
<td>D</td>
<td>0.05±0.01</td>
<td>0.40±0.01</td>
<td>3.79±0.03</td>
<td>1.00±0.01</td>
<td>0.43±0.02</td>
<td>23.95±0.06</td>
</tr>
<tr>
<td>E</td>
<td>0.03±0.01</td>
<td>0.37±0.01</td>
<td>3.93±0.03</td>
<td>1.01±0.01</td>
<td>0.65±0.02</td>
<td>17.52±0.10</td>
</tr>
<tr>
<td>F</td>
<td>0.14±0.01</td>
<td>0.85±0.01</td>
<td>4.53±0.08</td>
<td>1.02±0.01</td>
<td>0.54±0.02</td>
<td>29.88±0.13</td>
</tr>
</tbody>
</table>

Table 3: Pasting Profile of Tapioca Blends

Values are means of triplicates ± Standard deviation. Values on the same column with different superscripts are significant (P≤0.05).

<table>
<thead>
<tr>
<th>Sample</th>
<th>Peak viscosity (cP)</th>
<th>Trough (cP)</th>
<th>Breakdown (cP)</th>
<th>Final viscosity (cP)</th>
<th>Setback viscosity (cP)</th>
<th>Peak Time (min)</th>
<th>Pasting Temp (℃)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3720.50±1.90</td>
<td>2318.70±0.65</td>
<td>408.20±0.62</td>
<td>3761.10±0.16</td>
<td>1148.20±0.22</td>
<td>4.22±0.03</td>
<td>79.21±0.07</td>
</tr>
<tr>
<td>B</td>
<td>2476.67±41.02</td>
<td>2019.00±73.04</td>
<td>392.67±1.15</td>
<td>3613.67±1.15</td>
<td>2508.00±2.08</td>
<td>7.04±0.04</td>
<td>74.29±0.47</td>
</tr>
<tr>
<td>C</td>
<td>2576.00±11.00</td>
<td>1905.67±30.02</td>
<td>607.00±2.00</td>
<td>1275.67±1.53</td>
<td>472.6±1.18</td>
<td>77.3±0.06</td>
<td>79.11±0.03</td>
</tr>
<tr>
<td>D</td>
<td>1934.33±37.22</td>
<td>1905.67±16.92</td>
<td>682.33±0.58</td>
<td>2860.67±1.15</td>
<td>974.00±1.00</td>
<td>7.04±0.05</td>
<td>78.15±0.04</td>
</tr>
<tr>
<td>E</td>
<td>2182.33±27.57</td>
<td>1980.00±5.29</td>
<td>195.00±1.00</td>
<td>3172.00±2.00</td>
<td>1185.00±1.00</td>
<td>5.24±0.04</td>
<td>78.16±0.01</td>
</tr>
<tr>
<td>F</td>
<td>2088.33±25.01</td>
<td>1967.00±11.00</td>
<td>111.67±1.15</td>
<td>2795.00±1.00</td>
<td>1815.33±1.53</td>
<td>5.24±0.05</td>
<td>78.16±0.01</td>
</tr>
</tbody>
</table>

Table 4: Sensory Characteristics of Tapioca Blends

Values are means of triplicates ± Standard deviation. Values on the same column with different superscripts are significant (P≤0.05).

<table>
<thead>
<tr>
<th>Sample</th>
<th>Taste</th>
<th>Colour</th>
<th>Flavour</th>
<th>Overall Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6.70±0.82</td>
<td>7.50±0.53</td>
<td>6.40±0.52</td>
<td>7.30±0.48</td>
</tr>
<tr>
<td>B</td>
<td>6.60±0.70</td>
<td>6.00±0.94</td>
<td>5.90±0.74</td>
<td>6.30±0.46</td>
</tr>
<tr>
<td>C</td>
<td>6.10±0.74</td>
<td>6.50±0.70</td>
<td>6.70±0.82</td>
<td>6.50±0.53</td>
</tr>
<tr>
<td>D</td>
<td>5.90±0.32</td>
<td>5.80±0.79</td>
<td>6.50±0.97</td>
<td>6.20±0.63</td>
</tr>
<tr>
<td>E</td>
<td>6.00±0.94</td>
<td>5.70±0.82</td>
<td>5.90±0.88</td>
<td>6.40±0.52</td>
</tr>
<tr>
<td>F</td>
<td>6.10±0.90</td>
<td>6.10±0.32</td>
<td>6.50±0.53</td>
<td>6.30±0.48</td>
</tr>
</tbody>
</table>

Figure 1: Phenolic Content of Tapioca Blends