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FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Proximate composition and sensory evaluation of root and tuber composite flour noodles

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Abstract: Noodles are popular convenient wheat-based food consumed throughout the world. In this study, different proportions (50, 60, and 70%) of cocoyam, plantain, yam, cassava or sweet potato flour was used to replace wheat flour in the production of noodles. Proximate composition and organoleptic properties of the noodles were analyzed by standard methods. Results of the proximate composition showed that protein ranged between 10.9% for plantain noodles to 14.2% for cocoyam noodles. Fat and ash also ranged from 5.4 to 8.8% and 1.9 to 2.9% correspondingly for these nutrients. Variations in proportions of wheat flour replaced resulted in significant changes in the nutritional content of the composite flour noodles. Sensory evaluation also revealed differences in the scores for some of the attributes assessed. Generally the aroma, taste and texture of noodles did not vary with increasing proportions of tuber flours, except for the taste of cassava flour noodles and the texture of cocoyam flour noodles, in which significant differences were observed. Cassava-wheat composite flour noodles showed promising results, with its acceptability closely following the acceptability of commercial noodles used as a control.

Subjects: Preservation; Processing; Product Development

Keywords: noodles; cassava; plantain; cocoyam; yam; sweet potato; sensory evaluation

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PUBLIC INTEREST STATEMENT

The gradual gain in popularity of noodles in countries outside of Asia, cannot be overemphasized. Noodles are typically made from wheat flour. However, the potential to manufacture noodles from indigenous starchy tubers also exists. This study explored the utilization of flours from cassava, yam, cocoyam, sweet potato and plantain. Key elements such as nutritional composition and organoleptic assessment of the composite flour noodles are reported herein. Findings of the study indicate that noodles made from flours of root crops are nutritious and generally acceptable to consumers. Utilization of the crops in industrial food processing such as noodles manufactures promises to enhance their visibility and economic potential. This would certainly cascade into better productivity and improved socio-economic status for key actors along the value chain of these commodities.

1. Introduction

Noodles are one of the oldest food which forms an integral part of the diet of millions in China, Indonesia, Japan and other countries worldwide. Global demand for the product is estimated to be nearly 100 billion servings (World Instant Noodles Association [WINA], 2016). Originally a traditional cuisine in the Orient, noodles are increasingly gaining popularity in several parts of Africa. The product is originally made from durum wheat with high protein content and is characterized by thin strips cut from low moisture sheeted dough. Noodles may be produced from hard, intermediate or soft wheat flours. Whether alkaline salt is used or not, noodles are classified into 2 major types; white salted and yellow alkaline (Chen, 2003). They are convenient, simple to prepare, fast-cooking, relatively cheaper with a long shelf life.

The quality of finished noodles is generally based on appearance and texture (Chang & Wu, 2008). These properties are used as desirable yardstick for rating of noodles on all markets. The color could be white or yellow, depending on the presence of alkali salts. In all cases however, noodles required good brightness and smooth appearance. Good quality noodles should generally be firm, less sticky and less soggy after cooking. Product texture is principally affected by the structural matrix of starches, gluten, additional proteins (depending on the source of starch) and other ingredients (Chang & Wu, 2008).

The demand for noodles in Africa has been predicted to increase with population growth (WINA, 2016). In response to this expectation, the need to develop noodles from indigenous crops is imperative. Previous works have established the possibility of using flours from non-wheat sources in the production of noodles. Rice (Bhattacharya, Zee, & Corke, 1999), buckwheat flour (Ikeda et al., 2004), cassava flour (Abidin & Devi, 2013; Lateef, Bamgbose, & Salifat, 2004) and starches from potato, sweet potato (Reungmaneevaitoon, 2009), breadfruit (Akanbi, Nazamid, Adebawale, Farooq, & Olaoye, 2011), legumes and pulses (Sung & Stone, 2004) have used in noodles production. Other food materials such as seaweed have also been used, at rather low percentages, ostensibly to improve nutritional quality (Chang & Wu, 2008).

Utilizing indigenous crops such as cassava, yam, sweet potato cocoyam and plantain, in noodles production will contribute to reducing the dependence on wheat flour in many non-wheat growing areas. Additionally, it would also contribute to promoting the suitability of the crops as industrial raw materials. These commodities present a good source of carbohydrates which is suited for producing noodles. Some contain dietary fiber, carotenoids (in sweet potato) and minerals that may enhance the nutritional potential of noodles (Lebot, 2009). Application of flours from these crops in the manufacture of noodles will also increase the taste variants of noodles, which is quite limited in Africa and the Middle East (WINA, 2016). The aim of this study therefore was to determine the nutritional composition and organoleptic properties of instant noodles made from wheat-cocoyam, wheat-plantain, wheat-yam, wheat-cassava and wheat-sweet potato composite flours.

2. Methodology

2.1. Materials

Flours from cocoyam (*Xanthosoma spp*), water yam (*Dioscorea alata*), plantain (unripe) (*Musa sapientum*), cassava (*Manihoc esculenta*) and sweet potato (*Ipomoea batatas*) were used. These crops were obtained from a local root crops market and processed into flour. Wheat flour and other ingredients were also purchased from a retail supermarket.

2.1.1. Processing of flours from root crops

The crops were washed, manually peeled with a sharp stainless steel knife and washed thoroughly with potable water before further processing. The peeled tubers were sliced thinly before spreading on racks and drying at 60°C in an air-oven for 12 h. The dry slices were milled in a hammer mill (Christy and Norris Ltd., Surrey, UK) into a smooth and free-flowing flour to pass through a 250 µm sieve. The flour from each crop was then packaged separately into flexible HDPE bags, sealed and stored at room temperature.

2.1.2. Composite flour

Flour from each root crops was made into composite with wheat flour at 50, 60 and 70% substitution levels. These proportions were mixed using a high-speed blender (Waring, E8420) to obtain a uniform composite flour.

2.2. Processing of noodles

Composite flour was mixed with salt, water, and other ingredients and kneaded into a stiff dough which was extruded with a noodles maker. The noodles were then cut into strands of about 20 cm long. The strands were dried at 55°C overnight in an air oven, cooled to room temperature and packaged into flexible polypropylene bags and sealed. Commercial noodles, produced from 100% wheat flour, was used as the control.

2.3. Proximate composition

The noodles were analyzed, in triplicates, for moisture, crude protein, crude fat, ash using approved methods 925.10, 923.03, 920.85 and 920.87 of the Association of Official Analytical Chemists (AOAC, 1990). Carbohydrate was estimated by difference.

2.4. Sensory evaluation of cooked noodles

Noodles made from the composite flours were evaluated by 40 untrained panelists, who regularly patronize noodles or pasta and had previous experience in sensory evaluation. The panelist evaluated the products based on how much they liked the appearance, color, aroma, taste, texture and overall acceptability. A 9-point hedonic scale (1 representing *dislike extremely* and 9 representing *like extremely*) was used for the evaluation. The evaluation was carried out in 5 sessions in which samples were presented to panelists following a randomized design matrix (XLSTAT 2012, Statsoft, France). Panelists were provided with a piece of unsalted cracker and still water to refresh their palate after tasting each sample. Commercial noodles made from wheat flour was used as a control.

2.5. Statistical analysis

Data obtained from the study were compared by ANOVA (SPSS 17.0.1 SPSS Inc.) and statistically significant means were separated by Duncan's Multiple Range Test. Statistical significance was set at 95% confidence interval. Results were reported as mean \pm standard error.

3. Results and discussion

3.1. Proximate composition

Proximate composition of noodles made from composite flours indicates that it contains good levels of proteins and minerals and low amount of fat (Table 1). The protein content of the noodles ranged from 11 to 14%. Generally noodles made from cassava had lower protein content compared to sweet potato and cocoyam flours, which had the highest protein content. Protein content of the noodles were higher than cassava composite flour noodles (Lateef et al., 2004) but comparable to egg noodles supplemented with green seaweed (Chang & Wu, 2008). Fat content of the noodles was quite low for noodles made from the 5 root tuber flours. Fat in cocoyam, and yam flour noodles did not differ significantly ($p > 0.05$) from one substitution levels to the other. However, in plantain, cassava and sweet potato flour noodles, significant differences ($p < 0.05$) were observed in fat content when the level of substitution varied. For plantain and sweet potato, higher substitution resulted in increased fat content. Only noodles from cassava showed a reverse of this trend, in which higher proportions of cassava yielded noodles with lower fat content. As content of noodles made from cassava was also lowest, compared to the others. Total ash reflects the mineral content of food products and can be regarded as the general measure of quality. It is often a useful criterion in identifying the authenticity of food product (Kirk & Sawyer, 1991).

Compared to the others, cocoyam flour noodles was observed to have the highest amount of ash, with a mean of 2.7%. This indicates that noodles from cocoyam flour may contain high amounts of minerals. Apart from yam and cocoyam in which a clear trend was not established, the amount of

Table 1. Proximate composition of composite flour noodles

| Sample | Moisture (%) | Protein (%) | Fat (%) | Ash (%) | Carbohydrate (%) |
|--------|--------------------------|---------------------------|--------------------------|--------------------------|---------------------------|
| CCY50 | 5.35 ± 0.03 ^b | 13.91 ± 0.21 ^b | 7.31 ± 0.04 ^a | 2.73 ± 0.01 ^b | 70.72 ± 0.28 ^b |
| CCY60 | 6.56 ± 0.11 ^c | 14.26 ± 0.02 ^b | 7.65 ± 0.09 ^a | 2.49 ± 0.01 ^a | 69.05 ± 0.18 ^a |
| CCY70 | 4.74 ± 0.03 ^a | 13.19 ± 0.01 ^a | 7.43 ± 0.08 ^a | 2.91 ± 0.01 ^c | 71.74 ± 0.04 ^c |
| PLF50 | 6.82 ± 0.17 ^a | 12.54 ± 0.11 ^b | 8.08 ± 0.06 ^a | 2.29 ± 0.01 ^a | 70.27 ± 0.32 ^a |
| PLF60 | 7.75 ± 0.17 ^b | 12.27 ± 0.39 ^b | 8.08 ± 0.02 ^a | 2.40 ± 0.01 ^b | 69.51 ± 0.55 ^a |
| PLF70 | 7.07 ± 0.01 ^a | 10.90 ± 0.06 ^a | 8.81 ± 0.18 ^b | 2.58 ± 0.01 ^c | 70.65 ± 0.25 ^a |
| YF50 | 7.74 ± 0.10 ^a | 13.23 ± 0.05 ^b | 7.82 ± 0.05 ^a | 2.54 ± 0.01 ^a | 68.68 ± 0.09 ^a |
| YF60 | 7.45 ± 0.26 ^a | 13.37 ± 0.02 ^b | 7.71 ± 0.23 ^a | 2.54 ± 0.01 ^a | 68.95 ± 0.48 ^a |
| YF70 | 8.86 ± 0.06 ^b | 11.59 ± 0.14 ^a | 8.09 ± 0.16 ^a | 2.86 ± 0.01 ^b | 68.62 ± 0.25 ^a |
| CS50 | 5.89 ± 0.01 ^a | 11.98 ± 0.01 ^b | 7.78 ± 0.11 ^b | 1.88 ± 0.02 ^a | 72.78 ± 0.13 ^a |
| CS60 | 5.88 ± 0.04 ^a | 11.58 ± 0.07 ^b | 7.75 ± 0.19 ^b | 1.98 ± 0.01 ^b | 72.82 ± 0.09 ^a |
| CS70 | 6.17 ± 0.24 ^a | 11.11 ± 0.15 ^a | 5.40 ± 0.28 ^a | 2.05 ± 0.01 ^c | 75.28 ± 0.36 ^b |
| SP50 | 6.51 ± 0.01 ^a | 13.91 ± 0.21 ^b | 7.98 ± 0.01 ^b | 2.25 ± 0.01 ^a | 69.36 ± 0.21 ^a |
| SP60 | 6.89 ± 0.01 ^b | 14.07 ± 0.04 ^b | 7.28 ± 0.03 ^a | 2.30 ± 0.01 ^b | 69.47 ± 0.01 ^a |
| SP70 | 7.70 ± 0.05 ^c | 12.74 ± 0.01 ^a | 8.26 ± 0.19 ^b | 2.54 ± 0.01 ^c | 68.78 ± 0.22 ^a |

Notes: CCY: Cocoyam flour, PLF: Plantain flour, YF: Yam flour, CS: Cassava flour, and SP: Sweet potato flour. 50, 60 and 70 represent the percentage of tuber flour in the final composite.

For noodles from the same flour, means with different superscripts are significantly different ($p < 0.05$).

ash increased in the plantain, cassava and sweet potato noodles when the proportion of root tuber flour increased from 50 to 70%. The ash levels in these noodles were higher than those obtained in previous studies for different noodles (Chang & Wu, 2008; Lateef et al., 2004; Sung & Stone, 2004) but comparable to 1.3–2.3% reported for breadfruit-starch wheat composite noodles (Akanbi et al., 2011). For the various kinds of flours, significant differences ($p < 0.05$) in ash were recorded from one substitution level to the other. The carbohydrate content of noodles from the various flours was 73.6, 70.5, 70.1, 69.2 and 68.7 correspondingly for cassava, cocoyam, plantain, sweet potato and yam.

Moisture content of the noodles was generally less than the 14% required by the Codex Alimentarius Commission (CAC) for non-fried noodles (CAC, 2006), which makes it desirable for long term storage. Low moisture content enhances the keeping properties of food products because it prevents the growth of micro-organisms. It also reduces the incidence of physical and chemical reactions that are likely to cause deterioration and lower flour quality (Aguilera, Del Valle, & Karel, 1995; Van Hal, 2000). Basically, cocoyam noodles contained the least moisture (mean of 5.5%) whereas yam had the highest amount (8.0%).

3.2. Sensory evaluation

Results from the sensory evaluation studies are summarized in Table 2. The results generally show significant variations in the sensory attributes for the various noodle samples. Commercial noodles made from wheat flour (used as control), obtained the highest score for all the attributes assessed. Unlike a previous study by Chang and Lii (1987), in which low sensory scores were obtained for tuber starch noodles, the scores recorded in the present study were ≥ 5 , an indication that the products were well accepted.

Visual appearance (including color and brightness) is a key quality index in noodles which influences purchasing decisions (Hatcher, Dexter, & Fu, 2009). Panelists generally rated the appearance of noodles made from cocoyam, plantain and sweet potato relatively lower than cassava and yam flour noodles. In plantain noodles, reducing the proportion of wheat flour resulted in lower score for appearance. A contrary trend was however noticed in noodles made from the other composite flours. Cassava and yam flour noodles received higher scores than noodles made from sweet

Table 2. Organoleptic testing of noodles from different root and tuber flours

| Sample | Attribute score | | | | |
|---------|-------------------------|------------------------|-------------------------|------------------------|------------------------|
| | Appearance | Colour | Aroma | Taste | Texture |
| CCY50 | 4.8 ± 0.1 ^a | 5.0 ± 0.2 ^a | 5.3 ± 0.2 ^a | 5.5 ± 0.4 ^a | 5.6 ± 0.4 ^a |
| CCY60 | 5.6 ± 0.1 ^b | 5.8 ± 0.2 ^b | 5.5 ± 0.2 ^a | 5.9 ± 0.3 ^a | 5.5 ± 0.2 ^a |
| CCY70 | 5.3 ± 0.1 ^{ab} | 5.1 ± 0.1 ^a | 5.3 ± 0.2 ^a | 5.8 ± 0.4 ^a | 6.4 ± 0.2 ^b |
| PLF50 | 5.5 ± 0.2 ^a | 4.9 ± 0.4 ^a | 5.3 ± 0.3 ^a | 5.9 ± 0.3 ^a | 5.9 ± 0.2 ^a |
| PLF60 | 5.3 ± 0.2 ^a | 5.1 ± 0.2 ^a | 5.4 ± 0.3 ^a | 5.4 ± 0.3 ^a | 5.6 ± 0.2 ^a |
| PLF70 | 5.1 ± 0.3 ^a | 4.9 ± 0.2 ^a | 5.3 ± 0.1 ^a | 5.3 ± 0.3 ^a | 5.5 ± 0.2 ^a |
| YF50 | 6.6 ± 0.1 ^{ab} | 6.6 ± 0.1 ^a | 6.5 ± 0.1 ^a | 6.1 ± 0.3 ^a | 6.1 ± 0.3 ^a |
| YF60 | 6.9 ± 0.1 ^b | 6.9 ± 0.2 ^b | 6.3 ± 0.1 ^a | 6.3 ± 0.2 ^a | 6.3 ± 0.2 ^a |
| YF70 | 6.4 ± 0.2 ^a | 6.9 ± 0.1 ^b | 6.6 ± 0.3 ^a | 6.5 ± 0.2 ^a | 6.7 ± 0.3 ^a |
| CS50 | 7.8 ± 0.2 ^a | 8.0 ± 0.3 ^a | 7.4 ± 0.2 ^a | 7.6 ± 0.1 ^b | 7.6 ± 0.1 ^a |
| CS60 | 7.8 ± 0.2 ^a | 7.9 ± 0.2 ^a | 7.1 ± 0.2 ^a | 7.3 ± 0.1 ^a | 7.6 ± 0.4 ^a |
| CS70 | 8.0 ± 0.2 ^a | 8.1 ± 0.2 ^a | 7.3 ± 0.2 ^a | 7.2 ± 0.2 ^a | 7.4 ± 0.3 ^a |
| SP50 | 5.7 ± 0.2 ^a | 6.2 ± 0.1 ^a | 6.0 ± 0.3 ^{ab} | 6.6 ± 0.4 ^a | 5.9 ± 0.1 ^a |
| SP60 | 6.1 ± 0.2 ^a | 6.1 ± 0.3 ^a | 6.2 ± 0.2 ^b | 5.9 ± 0.3 ^a | 6.1 ± 0.1 ^a |
| SP70 | 6.1 ± 0.2 ^a | 6.1 ± 0.2 ^a | 5.6 ± 0.3 ^a | 6.1 ± 0.3 ^a | 6.0 ± 0.1 ^a |
| Control | 8.5 ± 0.2 | 8.5 ± 0.2 | 8.2 ± 0.3 | 8.4 ± 0.1 | 8.4 ± 0.3 |

Notes: CCY: Cocoyam flour, PLF: Plantain flour, YF: Yam flour, CS: Cassava flour, SP: Sweet potato flour. 50, 60 and 70 represent the percentage of tuber flour in the final composite. Different superscript letters are significantly different ($p < 0.05$).

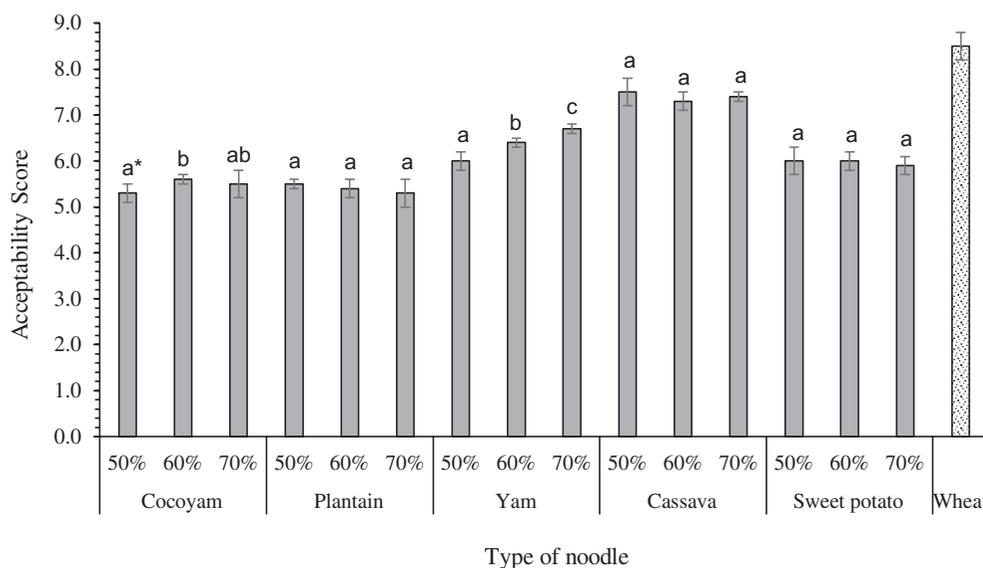
potato, cocoyam and plantain flour. Whereas increasing amounts of cassava or yam resulted in higher rating for appearance and colour, changes in the proportion of the other flours did not significantly ($p > 0.05$) affect these organoleptic indices. The observed trend for appearance and color may be attributed to the fact that noodles from cassava and yam flours appeared brighter compared to noodles made from the other flours.

The results indicate that panelists were generally indifferent to the aroma of noodles from plantain and cocoyam flours. These noodles received a mean score of 5.3 and 5.4 respectively (“neither like nor dislike”). Panelist were more inclined towards the aroma of noodles made from cassava flour, and this obtained a mean score of 7.3 (“like moderately”). Following cassava flour were noodles made from yam flour and sweet potato flour. Except for sweet potato noodles, variation in the proportion of wheat flour replaced did not significantly affect the aroma of composite flour noodles. The taste of all the test samples was liked “very much” except for cocoyam and plantain samples, which were rated very low (<6.0). Analysis of variance showed that increased proportions of tuber flours did not affect ($p > 0.05$) the taste of noodles, except for cassava flour noodles where significantly lower ($p < 0.05$) scores were recorded. The evaluation further revealed that panelist liked the texture of the noodles formulated from 70% cocoyam and all the samples made from yam and cassava. Although lower scores were obtained for all the composite flour noodles, the texture of cassava noodles was comparable to the “control”. The texture of noodles, according to Chang and Wu (2008), is a key quality index for assessing cooked noodles, and it is affected by the source of starch used. This may explain the differences observed in texture scores for noodles made from the various composite flours. Similar differences in sensory attributes have been reported by Lateef et al. (2004), who produced instant noodles from cassava-wheat composite flour.

Overall acceptability scores for noodles from tuber flours ranged from 5.3 (neither like nor dislike) for cocoyam flour noodles, to 7.5 (like very much) for cassava flour noodles (Figure 1). Generally, preference for noodles were rated in an order of cassava flour > yam flour > sweet potato flour > cocoyam flour > plantain

Figure 1. Acceptability of composite flour noodles.

*Comparisons within noodles made from the same flour.



flour. Acceptability of noodles was observed to reduce with increasing proportion of tuber flour but a direct reverse of this trend was noticed in yam flour noodles. No clear trend was established in the case of cocoyam noodles. Even though notable differences in preference were observed between the “control” and composite flour noodles, cassava flour noodles closely trailed the “control” in its acceptability. Acceptability of noodles made from these root tuber flours was higher than other cassava-wheat-soybean noodles (Lateef et al., 2004), breadfruit-konjac-pumpkin flour noodles (Purwandari et al., 2014), and comparable to noodles made from wheat-sweet potato composite flour (Reungmaneevaitoon, 2009).

4. Conclusion

Noodles made from flours from local tubers had good nutritional properties. The noodles had no less than 11% protein. Sweet potato noodles had the highest amount of protein while plantain noodles had the highest amount of fat and ash. Cassava noodles were comparatively lower in these nutrients. Sensory evaluation also showed that the noodles had acceptable attributes, some of which compare well with noodles made from wheat flour. Noodles made from cassava flour was quite promising, showing higher acceptability rating compared to noodles from the other crops. The study indicates that noodles of acceptable nutritional and sensorial properties could be produced from composite flours made from wheat and starchy tuber crops.

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Competing Interest

The authors declare no competing interests.

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