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Production of noodles using cocoyam (*Colocasia esculenta*)

Asoiro, F.U., *Ezeoha, S.L. and Eke, F.U.

Department of Agricultural and Bio-resources Engineering, University of Nigeria, Nsukka, Nigeria

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Abstract

The potential of making noodles using cocoyam flour was investigated. Cocoyam (Taro) and wheat flour were prepared. The proximate compositions of 100% cocoyam (C) flour, 100% wheat (W) flour, 50:50, and 70:30 blends of cocoyam-wheat (CW) flour were determined. Noodles were produced from cocoyam and wheat flour and their blends. The mean proximate composition of 100% cocoyam flour was found to be 11.19% amylose content, 8.70% crude protein, 4.86% ash, 0.60% fat content, 5.06% moisture content (wb), 6.38% crude fiber, and 72.22% carbohydrates with a swelling volume of 17.45 mL/g. The mean textural quality characteristics of the 100% cocoyam flour noodles were 5.88% cooking loss, 9.18 N/m^2 tensile strength, 39.75 Pa elasticity, and 74.06 mm firmness with a cooking time of 4.31 mins. The 100% cocoyam noodles were rated 5.0, 3.0, 4.0, 5.0, and 4.0 for appearance, flavor, hardness, texture, and overall acceptability, respectively on a 9-point hedonic scale. In comparison with 100% wheat flour noodles with an acceptability of 7.0, the 100% cocoyam noodles had a lower score. The 50:50 cocoyam-wheat flour blend noodles, however, scored 6.0 on acceptability which was very close to that of 100% wheat noodles. This study showed that though noodles could be made from 100% cocoyam flour, a 50:50 cocoyam-wheat flour blend would make better quality noodles in terms of nutrition and overall acceptability.

1. Introduction

Cocoyam is a member of the Arum family. It grows under the forest canopy in its natural habitat. But it is usually cultivated fully exposed to the sun (Giacometti and Leon, 1994). The crop is commonly intercropped with banana, coconut palm, coffee and cocoa since cocoyam tolerate shade (Wilson, 1984). The cocoyam corm is composed of about 70-77% water, 2-3% protein, and 15-39% carbohydrate. The young leaves contain iron, calcium, thiamine, phosphorus, vitamin C, and about 2% protein (Ndon *et al*., 2003). Cocoyam is best grown in fertile soils with a pH of 4.2-7.5.

In total production, cocoyam comes third behind cassava and yam in Nigeria (Tagodoe and Nip, 1994; Mepba *et al*., 2021). The bulk of cocoyam production is in South East, Nigeria (Adedeji and Oluwalana, 2014). With the cost of cassava, rice, yam, and other food crops going up, Nigerians are desperately seeking alternatives. Cocoyam is cultivated in sub-tropical and tropical regions of the world, especially in Africa and almost all developing countries for cash income, human nutrition, and animal feed (Onwueme and Charles, 1994; Santos *et al*., 2020). Cocoyam corms can be baked or boiled and eaten in different forms as pounded food and soup thickeners; they can also be roasted in a fire or prepared as porridge (Ubalua, 2016; Mepba *et al*., 2021). Cocoyam has nutritional advantages over other tuber and root crops (Lyonga and Nzietchueng, 1986; Ohene-Asa *et al*., 2019).

Taro (*Colocasia esculenta*) and Tannia (*Xanthosoma sagittifolium*) are the two main cocoyam varieties. As a result of their high moisture content, cocoyam corms have a short shelf life and start deteriorating two weeks after harvest. They should, therefore, be processed to non-perishable forms (Aboubakar *et al*., 2008). A good way is to process them into flour (Perez *et al*., 2005). Wheat, which has been used for the production of noodles, is not abundant in Nigeria. Cocoyam is still an industrially underutilized crop (Falade and Badanga, 2021). Perhaps, cocoyam flour might be suitable for producing noodles which can lead to new product development and greater food security. A greater number of researchers have studied noodle production using Tannia (*Xanthosoma sagittifolium*) (Santos *et al*., 2020; Ogbonna, 2021;

*Corresponding author.
Email: *sunday.ezeoha@unn.edu.ng*

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Onyeodili, 2021; Nwaogu, 2021; Mepba *et al*., 2021). On the other hand, Falade and Badanga (2021) and Orhevba and Ndamani (2021) who worked recently with Taro (*Colocasia esculenta*) considered optimum noodle frying conditions and partial substitution of wheat in bread production. Establishing optimum composite blend ratios for the production of wheat-cocoyam noodles would be beneficial for the noodle industry (Falade and Badanga, 2021). This study was, therefore, aimed at assessing how possible and suitable it was to produce noodles using Taro (*Colocasia esculenta*). The objectives of the study were to determine the proximate composition of cocoyam and wheat flours used in this study; produce noodles using the cocoyam (*Colocasia esculenta*) and wheat flours and their blends; and investigate and compare some quality characteristics of the produced noodles.

2. Materials and methods

Samples of wheat and cocoyam (Taro or *Colocasia esculenta*) used in this study were bought from Nsukka urban market, Enugu state, Nigeria. They were packed in plastic bags and brought to the Agricultural and Bioresources Engineering Department at the University of Nigeria, Nsukka, and stored at room temperature.

2.1 Flour preparation

The corms were cleaned by washing, converted into 1.5 mm thick slices, milled into flour after sun-drying using a corona manual grinder (UN970HL168M6CNAFAMZ), and sifted with a 200 µm sieve (Retsch-Allee) and packaging. The wheat sample was also milled into flour. Figure 1 shows a photograph of cocoyam after milling.

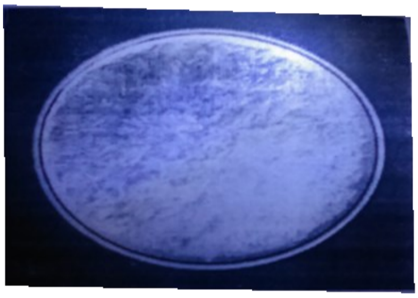

Figure 1. Cocoyam flour.

2.2 Proximate analysis

Standard methods (Association of the Official Analytical Collaboration (AOAC) International, 2000) were used to determine the crude protein, fiber, fat, ash and moisture contents of the flours. Total carbohydrate was determined using equation (1) by Carpenter (2010).

$$\text{Total carbohydrate (\%)} = 100 - (\%\text{ash} + \%\text{fat} + \%\text{fiber} + \%\text{protein} + \%\text{moisture}) \quad (1)$$

2.3 Determination of swelling volume

A mass of 0.45 g of the flour samples, mixed with 12.5 mL of water was properly stirred; the mixture was equilibrated at 25°C for 5 mins; then heated to 95°C and left for 30 mins; cooled in an ice bath for 1 min, and centrifuged at 3000 rpm for 5 mins. The swelling ratio (mL/g) of the flour was determined by measuring the volume of the resultant gels. The weight of the swollen starch sediment was measured after removing the supernatant. Swelling power (SP) was estimated as the ratio of the weight of wet sediment to the initial weight of dry flour (g/g). The supernatant was dried to constant weight at 130°C for 4 hrs. Solubility (g/g) was expressed as a ratio of the weight of dry flour to the initial weight of flour (Crosbie *et al.*, 1992). Swelling volume was calculated with equation (2).

$$\text{Swelling volume} = \text{weight of wet sediment / Initial weight of dry sediment} \quad (2)$$

2.4 Determination of amylose content

The milled samples were ground into very fine powder. Starch extraction was achieved using ammonia solution and water. Starch dispersion into ethanol was done and 0.1 M solution of hydroxide was used for gelatinization. 0.1 M citric acid was used to treat an aliquot part of the gelatinized starch and iodine was added until a neutral grey solution was obtained (Sefa-Dedeh and Sackey, 2002). A refrigerator was used to chill the solution for 20 mins at a temperature of 18°C. This method is susceptible to variation in temperature and in time between staining and analysis, so temperatures were maintained at 18-20°C and time at 20-30 mins (Gilbert and Spragg, 1964).

2.5 Process of preparing cocoyam and wheat noodles

The handmade process of preparing noodles was followed in making 100% wheat noodles, 100% cocoyam noodles, 50:50 cocoyam-wheat noodles, and 70:30 blend noodles. For making blend noodles, cocoyam flour and wheat flour were mixed; and distilled water was added to the mixture. The pot was coated with oil to ensure the noodles didn't stick to the pot; the mixture was steamed in boiling water for 10-20 mins resulting in a noodle block. The noodle was cooled with water and the top was coated with oil; then the noodle was removed from the pot. The noodle was cut into desirable shapes and dried. Figure 2 shows a sample photograph of noodles before cutting

2.5.1 Determination of cooking loss

Cooked noodles were drained for 5 mins and the weight was measured. The volume of the drained water

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Figure 2. Photograph of noodles before cutting.

was noted; 20 mL of the drained water was dried at 105°C until constant weight. Cooking loss (%) was computed on the basis of the dry weight of noodles (Crosbie *et al*., 1992).

2.5.2 Determination of tensile strength

Testing for tensile strength was carried out using a tensile tester according to Bhattacharya *et al*. (1999).

2.5.3 Determination of elastic recovery

A constant load of 50 N was used to compress noodle strands for 5 mins. The strands were allowed to recover for 5 mins after removing the loads. The thickness of the strands was measured before compression and after compression and recovery (Saowbhagya and Ali, 2001). Equation (3) was used to compute elastic recovery (ER).

$$ER(\%) = 100 \times \frac{e_2 - e_1}{e - e_1} \quad (3)$$

Where e = strands thickness (mm) prior to compression, e_1 = strands thickness (mm) after compression and e_2 = strands thickness (mm) after recovery.

2.5.4 Determination of firmness

From elastic recovery, firmness was calculated from equation (4), as described by (Saowbhagya and Ali, 2001).

$$\text{Elastic recovery} = 100(e - e_1) \quad (4)$$

Where e = strands thickness (mm) prior to compression and e_1 = strands thickness (mm) after compression.

2.5.5 Determination of sensory properties

The sensory properties were evaluated on a 9-point hedonic scale (1 representing dislike extremely, and 9 for like extremely) by a taste panel of 5 members based on flavor, hardness, appearance, texture, and overall acceptability (Hatcher *et al*., 2009).

3. Results and discussion

3.1 The proximate composition of cocoyam flour and its blends

The proximate composition of 100 g cocoyam (C) flour, 50 g cocoyam (C) flour, 50 g wheat (W) flour, 70 g cocoyam flour,30 g wheat flour, and 100 g wheat flour are shown in Table 1.

The range of protein content of noodles was 11-14% (Lateef *et al*., 2004). The 50:50 CW and 100% W flours had higher protein contents compared to 100% C and 70:30 CW flours. The fat content of the 100% C, 50:50 CW, and 70:30 CW were quite lower than that of 100% W flour.

The total ash content of food products shows the mineral content which can indicate quality. It is often used to assess the genuineness of food products (Kirk and Sawyer, 1991). The 100% C flour had the highest amount of ash compared to 70:30 CW and 50:50 CW flour followed by the 100% W flour. This indicates that 100% C flour contains a high amount of minerals. The carbohydrate content was 72.22%, 70.79%, 71.82%, and 63.31% for 100% C flour, 50:50 CW flour, 70:30 CW and 100% W flour, respectively. The 100% C flour had the highest carbohydrate content. Akonor *et al*. (2017) reported values of 13.91% and 70.72% for crude protein and carbohydrate respectively for 50:50 CW blend.

The moisture content of non-fried noodles that is less than 14% is desirable for long-term storage (Codex Alimentarius Commission (CAC), 2006). The reason is that low moisture content inhibits microbial growth and reduces deteriorative activities that lower flour quality (Aquilera *et al*., 1995). Basically, 50:50 CW had the least moisture content.

Amylose contents can be classified as low (2-20%),

Table 1. Proximate composition of cocoyam and wheat flours and their blends.

Flour Type	Amylose content (%)	Swelling Vol. (mL/g)	Crude protein (%)	Ash (%)	Fats content (%)	Moisture content (%)	Crude fiber %	Carbohydrate %
100% C	11.19±0.01^a	17.45±0.35^a	8.7±0.05^a	4.86±0.06^a	0.60±0.02^a	5.06±0.08^a	6.38±0.04^a	72.22±0.09^a
50:50 CW	21.93±0.12^b	13.93±0.24^b	11.6±0.15^b	2.77±0.05^b	0.89±0.06^b	7.07±0.09^b	4.71±0.05^b	70.79±0.09^b
70:30 CW	13.4± 0.14^c	15.68±0.11^c	8.81±0.06^a	2.92±0.01^b	0.81±0.03^b	5.3±0.08^a	5.39±0.04^c	71.82±0.11^c
100% W	29.96±0.11^d	12.91±0.06^d	13.3±0.15^d	0.77±0.03^c	2.16±0.06^c	13.36±0.06^c	1.33±0.03^d	63.31±0.08^d

Values are presented as mean±SD. Values with different superscripts within the same column are statistically different ($p<0.05$). C: cocoyam, W: wheat, CW: cocoyam-wheat blend.

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intermediate (20-25%) and high (25%). The 100% W flour had high amylose content while 50:50 CW flour had intermediate amylose content and 100% C flour with 70:30 CW had low amylose content. The 100% C flour had the highest swelling volume, followed by 70:30 CW flour, 50:50CW, and 100% W flour.

3.2 Textural characteristics of cocoyam and wheat noodles

Textural characteristics of cooked noodles of 100% C, 50:50 CW, 70:30 CW, and 100% W flours are shown in Table 2. The texture of cooked noodles often determines consumer's acceptance. This study evaluated noodle texture based on tensile strength, firmness, and elastic recovery. The tensile strength of noodles measures breaking strength. According to Seib *et al.* (2000), and as shown in Table 3, these textural properties correlate well with each other (r = 0.79 – 0.99) and indicate noodles breakdown resistance, cooking tolerance, and quality (Bhattacharya *et al.*, 1999).

The value of tensile strength was high for 100% W flour (18.6 N/m^2) and low for 100% C flour (9.2 N/m^2). The 50:50 CW had a comparable value for tensile strength (13.2 N/m^2) followed by the 70:30 CW flour (11.6 N/m^2). Noodles prepared from 100% C flour could break easily because of their lowest tensile strength.

Other characteristics of the quality of noodles namely translucency, color, absence of sticky surface, mechanical strength, uniformity of appearance and integrity, are reflected by elasticity and firmness (Saowbhagya and Ali, 2001). Elastic recoveries of noodles were: 39.8% for 100% C flour, 42.0% for 50:50 CW flour, 38.3% for 70:30 CW flour, and 48.8% for 100% W flour. Firmness of noodles was 74.1% for 100% C flour, 80.4% for 50:50 CW flour, 79.3% for 70:30 CW flour, and 88.7% for 100% W flour. Noodles with high elastic recovery and firmness reflect good quality and low cooking loss (Chen *et al.*, 2002).

3.3 Correlation of proximate composition of flours and textural properties of the noodles

The correlation matrix of the proximate composition of flours and the textural properties of the noodles is shown in Table 3. The amylose content of the flours was strongly and negatively correlated with the flours' swelling volume, ash, crude fiber, carbohydrate contents, and the noodles' cooking loss (r > 0.90); but positively and strongly correlated with the flours' crude protein and fats contents, and the noodles' tensile strength, elastic recovery, and firmness (r > 0.90).

The positive correlation of flour' amylose content with noodles' tensile strength could be attributed to the strong hydrogen bonding between amylose molecules in the high amylose starch granules and vice versa

Table 2. Textural characteristics of cocoyam and wheat flour noodles.

Flour type	Cooking loss (%)	Cooking time (mins)	Tensile strength (N/m^2)	Elastic recovery	Firmness (mm)
100% C	5.88±0.04^a	4.31±0.01^a	9.18±0.04^a	39.75±0.07^a	74.06±0.08^a
50:50 CW	5.41±0.01^{bd}	4.86±0.01^{bc}	13.25±0.07^b	42.0±0.42^b	80.4±0.28^b
70:30 CW	5.65±0.07^c	4.18±0.06^a	11.66±0.08^c	38.3±0.14^c	79.27±0.05^c
100% W	5.25±0.07^d	5.06±0.08^c	18.58±0.03^d	48.75±0.07^d	88.65±0.07^d

Values are presented as mean±SD. Values with different superscripts within the same column are statistically different (p<0.05). C: cocoyam, W: wheat, CW: cocoyam-wheat blend.

Table 3. Correlation matrix of the proximate composition of flours and the textural properties of the noodles.

	AC	*SV*	*CP*	*ASH*	*FATS*	*MC*	*CF*	*CARB*	*CL*	*CT*	*TS*	*ER*	*F*
AC	1												
SV	-0.95	1											
CP	0.99	-0.94	1										
ASH	-0.91	0.94	-0.86	1									
FATS	0.91	-0.8	0.87	-0.91	1								
MC	0.94	-0.83	0.92	-0.88	0.99	1							
CF	-0.95	0.88	-0.92	0.95	-0.99	-0.99	1						
CARB	-0.91	0.79	-0.88	0.88	-0.99	-0.99	0.98	1					
CL	-0.96	0.99	-0.95	0.94	-0.82	-0.85	0.9	0.81	1				
CT	0.95	-0.88	0.98	-0.75	0.78	0.85	-0.83	-0.8	-0.89	1			
TS	0.97	-0.93	0.93	-0.97	0.97	0.97	-0.99	-0.95	-0.94	0.85	1		
ER	0.94	-0.8	0.94	-0.81	0.95	0.99	-0.95	-0.97	-0.82	0.9	0.93	1	
F	0.94	-0.93	0.89	-0.99	0.95	0.94	-0.98	-0.93	-0.94	0.79	0.99	0.88	1

AC: amylose content, SV: swelling volume, CP: crude protein, MC: moisture content, CF: crude fiber, CARB: carbohydrate, CL: cooking loss, CT: cooking time, TS: tensile strength, ER: elastic recovery, F: firmness.

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(Kemashalini *et al*., 2018). The negative correlation of amylose content with swelling volume was reported for rice flour (Kemashalini *et al*., 2018); and could be attributed to the close intact of high amylose chains with starch granules. A high concentration of amylose and strong chemical bonds reduces the swelling power by developing an extensive network (Ahmed *et al*., 2016; Hu *et al*. 2022). Ahmed *et al*. (2016) reported that noodles made from high-amylose rice flour showed greater tensile strength, elastic recovery, and firmness; but lower cooking loss.

The negative correlation of protein with cooking loss is attributable to higher disintegration of starch and protein network when the protein content is low (Ahmed *et al*., 2016). An increase in protein concentration, also, leads to stiff protein-starch complexes (Ahmed *et al*., 2016; Hu *et al*. 2022). Rice flours with higher amylose content were reported to be prone to cooking loss due to greater expansion (Thomas *et al*., 2013). The negative correlation of protein and fat contents with ash content was already reported for rice (Rasool *et al*., 2015). The negative correlation of protein with swelling volume is because protein is known to inhibit the swelling of starch granules (Anuonye *et al*., 2016).

3.4 Sensory properties

The sensory properties of the noodles are shown in Table 4. Noodles made from 100% W flour (used as control), had the highest score for all the attributes assessed. In appearance, flavor, texture, and the 50:50 CW noodle had a significantly equal score with 100% W noodle. In overall acceptability, however, it had a significantly lower score. Visual appearance is a good quality index in noodles which affects purchasing decisions (Hatcher *et al*., 2009). Noodles from 100% C flour had a comparatively low score for appearance. The trend of scores for appearance is attributed to the bright appearance of noodles from 100% W flour and 50:50 CW flour.

Panelists showed greater preference for noodles made from 50:50 CW flour and 100% W flour followed by 100% C flour. The texture of noodles is a strong quality indicator of cooked noodles and it is influenced by the origin of starch used (Chang and Wu, 2008). Noodles from 100% W flour were preferred by most panelists because of their higher hardness values.

The scores for overall acceptability for noodles from 100% C flour had the lowest score. Noodles made from 50:50 CW flour had a higher value and was liked by the panelists. Akonor *et al*. (2017) reported a value of 5.25 for the acceptability of 50:50 CW blend; while Adedeji (2017) reported a value of 7.1 for a 60:40 CW blend. Both reports, however, did not specify the cocoyam variety studied. Ohene-Asah *et al*. (2019) reported an acceptability score of 5.0 for a 50:50 CW muffin that was not significantly different from the control (100% W).

4. Conclusion

The mean proximate composition of 100% cocoyam (*Colocasia esculenta*) flour was protein (8.70%), ash (4.86%), fat (0.60%), fiber (6.38%), carbohydrate (72.22%) and moisture (5.06%). Cocoyam (*Colocasia esculenta)* flour can be successfully blended with wheat flour to produce noodles. The 50:50% cocoyam-wheat composite flour noodles had good quality both in nutritional and sensory properties, proximate composition and physicochemical properties. The cooking loss and cooking time of 50:50 CW blend noodles were not significantly different from those of 100%W noodles. There were no significant differences in the appearance, flavor and texture of both the 50:50 CW and 100% W noodles.

Conflict of interest

The authors declare no conflict of interest.

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Table 4. Sensory properties of cocoyam and wheat noodles.

Properties	100% C Noodles	100% W Noodles	50:50 CW Noodles	70:30 CW Noodles
Appearance	5.0±0.55[a]	8.0±0.45[b]	7.0±0.71[b]	6.0±0.45[a]
Flavor	3.0±0.55[a]	6.0±0.45[b]	5.0±0.45[b]	4.0±0.45[a]
Hardness	4.0±0.45[a]	8.0±0.45[b]	6.0±0.45[c]	5.0±0.45[d]
Texture	5.0±0.45[a]	7.0±0.45[b]	6.0±0.45[b]	5.0±0.45[a]
Overall acceptability	4.25±0.50[a]	7.25±0.45[b]	6.0±0.52[c]	5.0±0.45[c]

Values are presented as mean±SD of 5 replicates. Values with different superscripts within the same column are statistically different ($p<0.05$). C: cocoyam, W: wheat, CW: cocoyam-wheat blend.

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