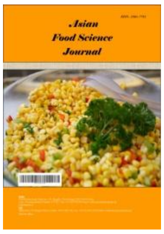

Asian Food Science Journal

20(8): 15-25, 2021; Article no.AFSJ.70238
ISSN: 2581-7752

Quality Characteristics and Sensory Properties of Noodles Produced from Blends of Wheat, Acha (*Digitaria exilis*), Bambara Groundnut, and Cocoyam Composite Flours

Horsefall D. Mepba[1], Nkechi Juliet Tamuno Emelike[1], Emmanuel Agiriga[1*] and Emmanuel Uchechi Mary[1]

[1]Department of Food Science and Technology, Rivers State University, Nkpolu Oroworukwo, Port Harcourt, Rivers State, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Authors HDM and NJTE designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors EA and EUM managed the analyses of the study. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AFSJ/2021/v20i830327
Editor(s):
(1) Dr. Amjad Iqbal, Abdul Wali Khan University Mardan, Pakistan.
Reviewers:
(1) Anteneh Tesfaye Tefera, Addis Ababa University, Ethiopia.
(2) Juan Pablo Hernandez-Uribe, Autonomous University of Hidalgo State, Mexico.
Complete Peer review History: http://www.sdiarticle4.com/review-history/70238

Original Research Article

Received 15 April 2021
Accepted 25 June 2021
Published 01 July 2021

ABSTRACT

The objective of this study was to investigate the quality characteristics and sensory properties of noodles produced from composite flours of wheat, acha, bambara groundnut, and cocoyam. Composite flours of wheat/acha, wheat/bambara groundnut, wheat/cocoyam and wheat/acha/bambara groundnut/cocoyam were formulated by substituting acha, cocoyam and bambara groundnut flours at 10, 20 and 30% each while 100% wheat flour was used as the control. The composite flours were used to produce noodles and the noodles subjected to chroma meter analysis, proximate analysis, culinary and sensory properties evaluation. Proximate analysis revealed that the noodles contained moisture content of 10.11-11.11%, 2.72-3.99% ash, 10.34-17.52% protein, 1.25-7.51% lipid, 0.56-1.64% crude fibre and 59.38-75.03% carbohydrate. There was an increase in the moisture, ash, protein, lipid and crude fibre contents with a decrease in carbohydrate as substitution with cocoyam, acha and bambara groundnut flours increased without

*Corresponding author: Email: agrimuc@gmail.com;

observed significant ($p>0.05$) differences. With the addition of acha, bambara groundnut and cocoyam composites into wheat flour, water absorption progressively increased from 1.75 (control) to 2.07ml/g (Wheat-Acha-bambara-cocoyam 60:10:20:10). There was a significant ($p<0.05$) increase in the cooking loss of the noodle samples as substitution levels of acha, Bambara groundnut and cocoyam flour increased. Cooking time decreased for wheat: acha flour noodles and increased for wheat: cocoyam flour noodles as substitution levels of acha and cocoyam flour increased. The composite flour of wheat: acha: cocoyam: Bambara groundnut flour also showed a decrease in cooking time as acha, cocoyam and Bambara groundnut flours were incorporated. There was no significant ($p\geq0.05$) difference in the L*, a* and b* values of wheat-bambara composite noodles. L* values of wheat-acha composite noodles increased significantly ($p\leq0.05$) with the increase in substitution with acha composite. Substitution of wheat flour with 10% to 30% acha flour and 10% to 20% Bambara groundnut flour resulted in noodles with acceptability sensory attributes.

Keywords: Noodles; acha; cocoyam; bambara groundnut; composite flour.

1. INTRODUCTION

Noodles are popular foods consumed throughout the world due to its convenience, ready to cook and low cost [1]. They are strips or strands cut from sheet of dough made from flour, water and either common salt or a mixture of alkaline salt [2]. Wheat flour has been extensively used for producing alimentary pastes such as macaroni, spaghetti and other noodles forms [3] and all the noodle brands currently available on Nigerian market are exclusively made from wheat flour. Noodles have also gained popularity in several parts of Africa owing to changes in lifestyle and urbanization [4]. In 2010, Nigeria became the world's 13th largest consumer of instant noodles, and proceeded to the 12th largest consumer of noodles in 2007, with the average of one billion seven hundred and sixty million serving per year as estimated by WINA [5]. WINA [5] predicted that the demand for noodles in Africa is expected to increase with population growth which has necessitated the research and development of noodles of good nutrition and acceptability from indigenous crops such as wheat, acha and *Moringa oleifera* [1], plantain, cocoyam, cassava and sweet potato [6], sweet potato, soybean and corn flour [7].

Acha (*Digitaria exilis*) also called fonio is an annual indigenous crop which is widely cultivated in West Africa. The seeds are rich in methionine and cysteine, amino acids vital to human health which are deficient in most cereals [8]. The seeds also contain 7.9% protein, 1.8% fat, 71% carbohydrate and 6.8% fibre [9]. Acha seeds can be consumed whole, milled into flour or processed into gruels, porridges, alcoholic and non-alcoholic drinks [10]. According to Mune et al. [11], substitution of wheat flour with Acha flour up to 30% has shown insignificant difference in terms of sensory qualities.

Bambara groundnut (*Vigna subterranea* (L.)) is a relatively rich source of dietary protein, especially when animal proteins are very limited or unavailable [11]. Mbata et al. [12] reports that when compared to other food legumes, Bambara groundnut is rich in iron and the protein contains high lysine and methionine and can therefore complement cereals in making foods such as noodles [13]. The production of a widely accepted food such as noodle using Bambara groundnut or in blends with other cereals can be highly beneficial in enhancing food security.

Cocoyam (*Xanthosoma sagittifolium*) is a herbaceous perennial crop belonging to the family Araceae. It is commonly called *taro* and ranks third in importance after yam and cassava in terms of production value in Nigeria [14]. Cocoyam as one of the staple food is a rich source of nutrients. Pandukur and Amienyo [15] reported that cocoyam contains carbohydrate content of 13-29%, protein 1.4-3.0% and that the leaves are rich sources of vitamin B6, vitamin C, niacin, thiamin and riboflavin. Mwenye et al. [16] also reported that cocoyam is a rich source of minerals such as iron, phosphorus, zinc, potassium, copper and manganese. Cocoyam is used as a source of food for human and livestock. It can be processed and consumed as soup thickener, fufu, roasted in fire and boiled. Cocoyam can also be used for the production of alcohol, medicines, flour and starch [17]. The flour of the cocoyam can also be used for the preparation of soups, biscuit, breads and puddings [18].

Wheat is graduating to the status of staple food in Nigeria where it is extensively used in a number of baked goods. Domestic wheat production remains relatively small and expenditure on wheat imports is high. A number of Nigerian cereal, legume and tuber crops such as acha, Bambara groundnut and cocoyam are produced in commercial quantities but are grossly under-utilized because information on their nutritional contributions and food applications are scanty in literature. Utilization of locally available inexpensive crops like Acha, Bambara groundnut, and cocoyam that can substitute a part of wheat flour without impairing noodles acceptability will be of utmost importance in restoring food security in Nigeria. This will also contribute to reducing the dependence on wheat flour in Nigeria and many non-wheat growing areas. The aim of this study therefore was to determine the quality and sensory attributes of noodles made from blends of wheat, acha, bambara groundnut and cocoyam composite flours.

2. MATERIALS AND METHODS

Bambara groundnut and acha grains were procured from Mile 3 market, Port Harcourt. Wheat flour was collected from Crown Flour Mills Ltd Port Harcourt while cocoyam tubers were purchased from Rumuchakara village, Choba, Port Harcourt.

2.1 Sample Preparation

2.1.1 Preparation of bambara groundnut flour, Acha and cocoyam flour

Bambara groundnut *(Vigna subterranea)* and acha *(Digitaria exilis)* were sorted, cleaned and milled into flour using hammer mill. Cocoyam flour was obtained as described by Adane et al. [19] with some modifications. Briefly, cocoyam *(Xanthosoma sagittifolium)* tubers were peeled, washed, sliced and oven dried in a conventional air oven (Gallen kamp Co. Ltd London England) into chips at 75^{0}C for 8 hours. The cocoyam chips were milled into flour using Bastak 1900 hammer mill smart (Turkey). The flours (bambara groundnut, acha, and cocoyam) were stored in air tight plastic sample containers at room temperature.

2.1.2 Preparation of composite Flours

Samples (500g) wheat-acha-bambara-cocoyam composite flours were formulated by replacing 100% wheat flour by 0 to 30% of acha, bambara and cocoyam flour (Table 1).

2.2 Noodle Production

Noodles were produced according to the method described by Causgrove [20] with some modifications. Flour sample were mixed with 2% cooking salt (NaCl) and 40% water to form strong dough. The dough was allowed to rest for 15 minutes, and rolled into sheet of about 5 mm thick. With continuous rolling, the dough sheet was gradually reduced into 1.3-1.0 mm thickness, and extruded into noodle strands using a pair of cylindrical slitter. The noodles were cooked in steam for 5 minutes, dried at 80^{o}C for 6 hours, cooled to 20^{o}C and packed in polyethylene pouches.

Table 1. Formulation of composite flours from wheat, acha, Bambara groundnut and cocoyam

Samples	WF	AF	BGF	CF
A	100	0	-	-
B	90	10	-	-
C	80	20	-	-
D	70	30	-	-
E	90	-	10	-
F	80	-	20	-
G	70	-	30	-
H	90	-	-	10
I	80	-	-	20
J	70	-	-	30
K	70	10	20	0
L	70	10	10	10
M	70	0	20	10
N	60	10	20	10

2.3 Chemical Analysis of Noodles

The proximate Composition (moisture, crude fat, crude fibre, protein and total ash) were analyzed using AOAC [21]. The total carbohydrate was determined by subtracting the sum of the moisture, crude fat, crude fibre, protein and total ash from 100%.

CHO = 100 – (Moisture + Fat + Ash + Protein + Crude fibre)

2.4 Culinary Properties of Noodles

2.4.1 Optimum cooking time

Optimum cooking time was determined according to the method described by Shere et al. [22] with slight modification. Forty grams (40 g) of noodles were dispersed in 250 ml boiling water. For every 30 seconds, a piece of noodle was held between transparent plastic slide and pressed gently until the white colour of noodle at the central portion of strand disappears. Optimum cooking time was achieved when the centre of noodles become transparent.

2.4.2 Cooking loss

Cooking loss was determined according to the method described by Shere et al. [22] with slight modification in which 10 g sample of noodles was placed into 300 ml boiling distilled water in a 500 ml beaker. After boiling for appropriate optimum cooking time for a particular noodle sample, the cooking water was collected in an aluminum dish and placed in oven at 105°C and evaporated to dryness.

The residue was weighed and reported as a percentage of starting material.

Cooking Loss (%) =
$$Dried\ residue\ in\ cooking\ wat/\ noodle\ weight\ before\ cooking\ x\ 100$$

2.4.3 Water absorption of noodles

Water absorption was determined by the ratio of the weight of cooked noodles to the weight of raw noodles as described by AACC method [23].

Water Absorption (%) =

$$Weight\ of\ cooked\ noodles - weight\ of\ raw\ noodles/\ weight\ of\ raw\ noodles \times 100$$

The result of water absorption was expressed in ml/g.

2.5 Sensory Evaluation

A 10-member semi trained panelists evaluated the prepared noodles for their attributes of colour, taste, texture, flavor/aroma and overall acceptability. Panelists rated the noodles on a nine point hedonic scale of 9 = liked extremely, 5= liked and 1 = disliked extremely [24].

2.6 Experimental Design

A split-plot arrangement fitted with a complete randomization design with samples = whole unit (Treatments) = subunits was used for analysis of physicochemical and rheological properties of flours, colour properties, proximate composition and effects of treatments on the culinary properties of noodles. A randomized complete block design was used for the evaluation of sensory data.

2.7 Data Analysis

Data for all determinations were subjected to analysis of variance (ANOVA) as outlined by Wahua [25]. The significant differences (P≤0.05) among treatment means was identified using Fisher's least significant difference (LSD) test.

3. RESULTS AND DISCUSSION

3.1 Colour Properties of the Dried Noodles

Table 2 shows the colour properties of dried composite flour noodles as measured by Minolta chroma meter. L* value of the noodles ranged from 37.90-67.59 with wheat: acha flour noodles showing the highest while wheat: cocoyam flour noodles had the highest L* value. There was an increase in the L* value of wheat:acha flour noodles as the substitution with acha flour increased. On the other hand, L* value of wheat: Bambara groundnut flour noodles, wheat: cocoyam flour noodles and wheat: acha: cocoyam: Bambara groundnut flour noodles recorded an increase in the L* value as substitution with cocoyam and Bambara groundnut increased. Olapade and Ogundeji [26] reported a similar L* value (60.04) for spaghetti made from 90% acha and 10% Bambara composite flour. The decrease in L* value of the noodles with increase in cocoyam flour substitution is probably due to the relatively dark colour of the species of cocoyam used in the composite flour production. Falade and Okarfo [27] previously reported that *Xanthosoma sagittifolium* cultivar of cocoyam has a relatively low L* value. a* value of the noodles ranged from 2.78-53.61 with the highest values recorded for wheat: cocoyam flour noodles (3.54-53.61) while wheat: acha flour noodles had the lowest (2.78-3.78). b* values of the noodles ranged from 15.03-25.11 with wheat: cocoyam flour noodles having the lowest values (15.03-20.19) while wheat: cocoyam: acha: Bambara groundnut flour noodle had the highest (19.05-25.11). Noodle color is one of the most important quality characteristics because it is the first attribute perceived by consumers [20]. Asian noodle color may be white or yellow depending upon the noodle type, but it should be bright [20]. Specifications for noodle color and texture vary by noodle type. Preferred characteristics are determined by consumer desires and expectations in each market [20].

3.2 Proximate Composition of the Dried Noodles

Table 3 shows the proximate composition of the dried composite flour noodles. Moisture content of the noodles increased with an increase in the proportions of acha, Bambara and cocoyam flours; however no significant (p<0.05) difference was observed across the treatments. Moisture content of all the noodles was below 11% which is below the Codex standard moisture specification (14.0% maximum) for instant non fried noodles [27]. This implies that the products will have reasonable shelf stability as low moisture content enhances the keeping properties of food products because it prevents the growth of micro-organisms [6].

Ash content of the noodles increased with the increase in acha, bambara and cocoyam substitution but there was no significant (p≥0.05) difference in the ash content across all the treatments. Noodles produced from wheat and cocoyam flour blends had the highest ash content with a range of 2.72-3.99%.

Table 2. Colour properties of the dried noodles

Treatment	L*	a*	b*
Wheat: Acha flour			
100:0	60.23^{ab}	3.54^{a}	20.19^{a}
90:10	58.22^{ab}	3.78^{a}	19.68^{a}
80:20	63.22^{a}	3.40^{a}	20.42^{a}
70:30	67.59^{a}	2.78^{a}	18.83^{a}
LSD = 5.0			
Wheat: Bambara flour			
100:0	60.23^{a}	3.54^{a}	20.19^{a}
90:10	59.04^{a}	3.82^{a}	21.15^{a}
80:20	60.86^{a}	4.00^{a}	22.46^{a}
70:30	57.12^{a}	3.82^{a}	22.16^{a}
LSD= 4.6			
Wheat: cocoyam flours			
100:0	60.23^{a}	3.54^{d}	20.19^{a}
90:10	53.61^{b}	53.61^{a}	17.80^{a}
80:20	45.72^{c}	45.72^{b}	16.51^{ab}
70:30	37.90^{d}	37.90^{c}	15.03^{ab}
LSD = 2.5			
Wheat: acha: Bambara: cocoyam flour			
100:0:0:0	60.23^{a}	3.54^{a}	20.19^{a}
70:10:20:0	60.96^{a}	4.52^{a}	25.11^{a}
70:10:10:10	50.97^{b}	6.69^{a}	22.46^{a}
70:0:20:10	49.32^{b}	6.53^{a}	21.02^{a}
60:10:20:10	46.14^{b}	6.37^{a}	19.05^{ab}

abc Means in the same columns not followed by the same superscript are significantly different (P≤0.05)

Ash content is an indication of the amount of minerals contained in foods [28]. Ash values of the noodles from this study falls within the range (1.88-2.73%) reported by Akonor et al. [6] for root and tuber composite flour noodles.

Although there was no significant ($p \geq 0.05$) difference in protein content across the treatments, protein content of the noodles increased with the increase in Bambara groundnut, acha and cocoyam composite. This justified the addition of Bambara groundnut to the composite flour which was intended to improve the protein content [29]. Wheat-Acha-Bambara-Cocoyam composite noodles which had the highest protein content (10.54-17.52%) could be probably due to the incorporation of Bambara groundnut flour. It is also due to attendant synergistic effects of protein complementation as reported by Iwe et al. [30] Protein content of the noodles from this study is within the values (10.07-14.44%) reported by Orisa and Udofia [1] for noodles produced from wheat, cowpea, acha and moringa oleifera leaf powder.

Generally, the fat content of the noodles from this study was low (1.25-7.51%). Similarly, wheat-acha-Bambara-cocoyam composite noodles which had the highest fat content (1.25-7.51%) could be probably due to the incorporation of Bambara groundnut flour. The low fat content of the noodles from this study may be due to the fact that cereals, legumes and tubers store energy in the form of starch rather than lipids [30]. Fat content of the noodles from this study is low when compared to the values (10.0-16.54%) for fried noodles made from soybean-wheat composite flour [31]. Fried noodles contain about 15 – 20% oil and are more susceptible to oxidation resulting in rancidity [31].

Crude fibre content of the noodles increased with the increase in acha, bambara and cocoyam substitution, however, no significant ($p \geq 0.05$) difference was observed across the treatments. Anankware, et al. [32] previously reported that fiber content of composite flour increased as the percentage inclusion of cocoyam flour increased. Ayo and Andrew [33] also reported that the crude fibre of varying compositions of acha and bambara groundnut flour product increased from 2.6 to 3.6% with increasing bambara groundnut. Crude fibre slows down the release of glucose into the blood and decreases intercolonic pressure hence reducing the risk of colon cancer [30].

Carbohydrate content of the noodles ranged from 59.38% to 75.04% with the control having the highest carbohydrate (75.04%) while wheat-acha-bambara-cocoyam composite noodles (60/10/20/10%) had the lowest carbohydrate content (59.38%). There was a significant difference ($p \leq 0.05$) in the carbohydrate content of the noodles except wheat-acha and wheat-cocoyam composite noodles. In line with Iwe et al. [30], the carbohydrate content of the products of these composite flour samples is an indication that they can serve as good sources of energy.

3.3 Culinary Properties of the Composite flour Noodles

Table 4 shows the culinary properties of the composite flour noodles. The optimum cooking time ranged from 4.21 minutes (Wheat-Acha composite noodles 70:30) to 5.55 minutes (Wheat-Bambara composite noodles 70:30). Cooking time decreased for wheat: acha flour noodles and increased for wheat: cocoyam flour noodles as substitution levels of acha and cocoyam flour increased. The composite flour of wheat: acha: cocoyam: Bambara groundnut flour also showed a decrease in cooking time as acha, cocoyam and Bambara groundnut flours were incorporated. A significant difference was only observed for wheat: acha composite flour noodles in which cooking time for 100% wheat noodles was significantly ($p<0.05$) different from noodles made from wheat-acha flour blends. Optimum cooking time refers to the time in minutes to gelatinize the starch marked by disappearance of central white core in the noodles strand [34]. The decrease in cooking time as acha and cocoyam flour substitution increased might be due to the dilution of gluten in dough. This confirms the earlier report by Shere et al. [22] that indicated the dilution of wheat gluten with spinach puree decreased composite noodles cooking time. This increase in cooking time as Bambara groundnut flour substitution increased could be probably due to the inherent properties of Bambara groundnut Omeire et al. [8] also observed an increase in cooking time of noodles when four defatted legume flours (soybean, groundnut, bambara nut and melon seeds) were processed into flour and used in fortifying cassava-wheat composite flour for noodle production.

Table 3. Proximate composition of the dried composite flour noodles

Treatment	Moisture (%)	Ash (%)	Protein (%)	Lipid (%)	Fiber (%)	Carbohydrates (%)
Wheat: acha flour						
100:0	10.10^{a}	2.72^{a}	10.34^{a}	1.25^{a}	0.56^{a}	75.03^{a}
90:10	10.57^{a}	2.77^{a}	10.72^{a}	1.37^{a}	0.67^{a}	73.90^{a}
80:20	10.41^{a}	2.82^{a}	11.24^{a}	1.91^{a}	0.82^{a}	72.80^{a}
70:30	10.49^{a}	2.89^{a}	12.36^{a}	3.00^{a}	0.92^{a}	70.34^{a}
LSD = 8.1						
Wheat: Bambara flour						
100:0	10.10^{a}	2.72^{a}	10.34^{a}	1.25^{a}	0.56^{a}	75.03^{a}
90:10	10.64^{a}	3.05^{a}	13.91^{a}	4.75^{a}	1.14^{a}	66.49^{b}
80:20	10.41^{a}	3.22^{a}	14.74^{a}	5.22^{a}	1.26^{a}	65.15^{b}
70:30	11.10^{a}	3.42^{a}	15.37^{a}	5.82^{a}	1.34^{a}	62.95^{b}
LSD = 7.3						
Wheat: cocoyam flour						
100:0	10.10^{a}	2.72^{a}	10.34^{a}	1.25^{a}	0.56^{a}	75.03^{a}
90:10	10.90^{a}	3.21^{a}	12.78^{a}	2.45^{a}	1.22^{a}	69.44^{a}
80:20	10.89^{a}	3.58^{a}	12.42^{a}	2.09^{a}	1.11^{a}	69.91^{a}
70:30	11.11^{a}	3.99^{a}	10.95^{a}	1.95^{a}	0.79^{a}	71.21^{a}
LSD = 7.9						
Wheat: acha: Bambara: cocoyam flour						
100:0:0:0	10.10^{a}	2.72^{a}	10.34^{a}	1.25^{a}	0.56^{a}	75.03^{a}
70:10:20:0	10.14^{a}	2.65^{a}	16.78^{a}	6.29^{a}	1.41^{a}	62.82^{b}
70:10:10:10	10.12^{a}	3.69^{a}	17.03^{a}	6.85^{a}	1.35^{a}	60.96^{b}
70:0:20:10	10.39^{a}	2.68^{a}	16.60^{a}	6.52^{a}	1.32^{a}	62.49^{b}
60:10:20:10	10.50^{a}	3.48^{a}	17.52^{a}	7.51^{a}	1.64^{a}	59.38^{b}
LSD = 8.7						

abc Means in the same columns not followed by the same superscript are significantly different ($P \leq 0.05$)

The result shows that there were significant ($p \leq 0.05$) differences in the cooking loss among all the noodle samples. The cooking loss ranged from 3.18 g – 9.23 g with the control and wheat-cocoyam composite noodle (70:30) having the least and highest values respectively. There was a significant ($p<0.05$) increase in the cooking loss of the noodle samples as substitution levels of acha, Bambara groundnut and cocoyam flour increased. This may be due to the poor formation of protein complex which might have resulted from the poor protein content and lack of gluten forming proteins (glutenin and gliadine) [8].

The water absorption result indicated that there was no significant ($p \geq 0.05$) difference among all samples and the control. Wheat-bambara composite noodle (70:30) had the least water absorption (1.64 ml/g) while sample Wheat-Acha-bambara-cocoyam (60:10:20:10) had the highest water absorption (2.07 ml/g). With the addition of acha and cocoyam composites into wheat flour, water absorption progressively increased from 1.75 (control) to 2.07ml/g (Wheat-Acha-bambara-cocoyam 60:10:20:10). The addition of acha and cocoyam flours probably enhanced the interaction between starch granules and protein matrix resulting in better quality noodles. Eke-Ejiofor and Allen [35] also reported that increase in water absorption of flours could be attributed to the presence of high amount of carbohydrates (starch) and fiber content and this could also result from the hydrophobic nature of carbohydrate and fiber. This finding is in agreement with Shere et al. [22] who reported an increase in water absorption capacity of wheat, breadfruit and cassava starch composites as substitution with breadfruit and cassava starch increased. Increase in water absorption for noodles produced from wheat-acha-bambara-cocoyam (60:10:20:10) could also be attributed to the relative high fiber content (1.64%) of the samples [22]. Water absorption is an important characteristic in deciding the cooking quality of noodles and it is an indication of quantity of water absorbed by the noodles during cooking [36,37].

Table 4. Culinary properties of the composite flour noodles

Treatment	Cooking time (min)	Cooking loss (%)	Water absorption (ml/g)
Wheat: acha flour			
100:0	5.22^{a}	3.18^{d}	1.75^{a}
90:10	4.52^{b}	4.72^{c}	1.80^{a}
80:20	4.36^{b}	5.62^{b}	1.65^{a}
70:30	4.21^{bc}	6.79^{a}	1.96^{a}
LSD = 0.30			
Wheat: Bambara flour			
100:0	5.22^{a}	3.18^{d}	1.75^{a}
90:10	5.40^{a}	5.59^{b}	1.76^{a}
80:20	5.48^{a}	6.54^{a}	1.70^{a}
70:30	5.55^{a}	4.82^{c}	1.64^{a}
LSD = 0.32			
Wheat: Cocoyam flour			
100:0	5.22^{a}	3.18^{d}	1.75^{a}
90:10	5.15^{a}	6.44^{c}	1.69^{a}
80:20	5.05^{a}	7.90^{b}	1.70^{a}
70:30	5.29^{a}	9.23^{a}	1.93^{a}
LSD = 0.44			
Wheat: acha: Bambara: cocoyam flour			
100:0:0:0	5.22^{a}	3.18^{d}	1.75^{a}
70:10:20:0	5.25^{a}	6.88^{b}	1.77^{a}
70:10:10:10	5.02^{a}	5.31^{c}	1.97^{a}
70:0:20:10	5.11^{a}	7.79^{a}	1.80^{a}
60:10:20:10	5.08^{a}	7.26^{b}	2.07^{a}
LSD= 0.42			

abc Means in the same columns not followed by the same superscript are significantly different (p≤0.05)

Table 5. Mean sensory scores of cooked composite flour noodles

Cooked composite noodles	Colour	Aroma	Taste	Texture	Overall acceptability
Wheat: acha					
100:0	7.5^{b}	7.5^{b}	8.0^{a}	8.0^{a}	8.0^{a}
90:10	7.0^{c}	7.5^{b}	7.5^{b}	8.0^{a}	7.5^{b}
80:20	8.0^{a}	5.5^{e}	7.5^{b}	6.5^{d}	7.0^{c}
70:30	6.0^{e}	6.5^{d}	7.0^{c}	5.0^{f}	6.0^{e}
Wheat: Bambara nut					
90:10	8.0^{a}	7.5^{b}	7.5^{b}	8.0^{a}	8.0^{a}
80:20	7.5^{b}	7.0^{c}	7.0^{c}	7.5^{b}	7.5^{b}
70:30	7.0^{c}	7.5^{b}	6.5^{d}	7.0^{c}	6.5^{d}
Wheat: cocoyam					
90:10	6.0^{e}	7.5^{b}	6.0^{e}	6.5^{d}	6.5^{d}
80:20	5.5^{e}	6.5^{d}	5.5^{f}	5.0^{f}	5.5^{f}
70:30	4.5^{f}	6.0^{e}	5.0^{g}	4.5^{g}	5.0^{f}
Wheat:acha:Bambara:cocoyam					
70:10:20:0	7.5^{b}	6.0^{e}	6.5^{d}	7.0^{c}	7.0^{c}
70:10:10:10	7.0^{c}	6.0^{e}	6.0^{e}	7.0^{c}	6.5^{d}
70:0:20:10	5.5^{e}	5.0^{f}	6.0^{e}	6.0^{e}	6.5^{d}
60:10:20:10	6.0^{d}	5.0^{f}	6.0^{e}	6.0^{e}	6.0^{e}
LSD= 0.49					

abc Means in the same columns not followed by the same superscript are significantly different (P≤0.05)

3.4 Sensory Evaluation of Cooked Composite Flour Noodles

The mean sensory scores of the cooked composite noodles is shown in Table 5. The average sensory scores for colour of the cooked composite noodles ranged from 4.0 (wheat-cocoyam composite noodle 70:30) to 8.00 (wheat-acha 80:20 and wheat-bambara 90:10). The colour of the noodles varied significantly ($p \leq 0.05$) among all the treatments. Wheat-cocoyam composite noodle 70:30 was the least preferred in terms of colour. This could be probably due to the unattractive colour of the cooked noodle which was attributed to the colour of cocoyam flour. Colour is one of the major variables governing food acceptance [8]. Since colour relies on the sense of sight, the colour of the noodles was one of the outstanding parameters in the decision of the panelists [8].

The values for the texture of the noodle samples ranged between 4.50 and 8.00. Wheat-cocoyam composite noodle 70:30 had the lowest score (4.50) while samples wheat-acha composite noodles 90:10, wheat-bambara 90:10 and the control (100% wheat noodles) had the highest score for texture (8.00) and were significantly different ($p<0.05$) from other samples. The relatively low texture values obtained when cocoyam and acha constituents exceeded 10% could be probably due to interference the composite flour constituents in gluten development. Omeire et al. [8] had a similar report that the difference in texture of the noodle samples could be attributed to the presence of gluten in wheat flour which formed elastic dough resulting to noodles with good texture and better structure.

The sensory score for aroma of the noodle samples ranged from 5.0 to 7.5. The control (100% wheat noodles), wheat-acha composite 90:10, wheat-bambara 70:30, wheat-bambara 90:10, and wheat-cocoyam 90:10 composite noodles had the highest score for aroma (7.50) and are significantly different ($p \leq 0.05$) from other samples, while wheat-acha-bambara-cocoyam 60:10:20:10 had the lowest score for aroma (5.0). This result agrees with Orisa and Udofia [1] who attributed the low aroma score of wheat-cowpea-acha-moringa oleifera leaf to 25% acha flour inclusion. Individual constituents of composite flours impact their characteristic aroma on the aroma perception of finished products made from the flours. Anggraeni and Saputra [36] reported of having an improved aroma on cooked noodles with dried unripe banana composite flour.

The taste scores of the noodles varied significantly ($p \leq 0.05$) across the treatments, and ranged from 5.0 (wheat-cocoyam 70:30) to 8.0 (control). The taste score of the control (8.00) was followed by that of wheat-acha 90:10 and wheat-bambara 90:10 (7.50). Samples wheat-acha 90:10 and wheat-bambara 90:10 were also significantly different ($p \leq 0.05$) from other samples. The variation in taste could be probably due to variation in noodle flour composition [36]. Wheat-bambara composite noodles 90:10 and the control were the best accepted and were significantly different ($p \leq 0.05$) from other samples in terms of overall acceptability while sample wheat-cocoyam composite noodle 70:30 was the least preferred. Wheat-cocoyam composite noodle 70:30 was also the least preferred by the panelists in terms of colour and taste which are very important in the acceptability of any food sample; therefore this may have contributed to the least preference of the noodles. Wheat-acha 90:10 and wheat-bambara composite noodles 80:20 had the same overall acceptability score and varied significantly from other samples. This signified that noodle produced by substituting part of wheat with 10% acha and Bambara groundnut up to 20% was acceptable. Omeire et al. [8] reported that acceptable noodles can be produced by up to 25 % substitution of wheat with acha and soyabean. Cocoyam substitution at 10 % was liked slightly both in colour, taste and general acceptability probably due to the dark colour of the flour. Composite noodles wheat-acha-bambara-cocoyam 70:10:20:0 had an overall acceptability score of 7.0 indicating that the noodle was liked moderately by the sensory panelists.

4. CONCLUSION

This study has showed that substituting wheat flour with flours of acha and bambara groundnut will improve the food use of these currently underutilized Nigerian crops, encourage mass cultivation of these crops and ultimately improve Nigerian food security status. The research study also showed that acceptable noodles with good shelf stability, improved nutritional and culinary qualities can be produced by the substitution of wheat flour with 10% to 20% acha and bambara groundnut flours. Substitution of wheat flour with 10% to 30% acha flour and 10% to 20% Bambara groundnut flour resulted in noodles with improved quality and acceptability. This depicts that these indigenous crops will be very beneficial to pasta, pastry, baking and confectionary industries, and helps reduce cost of wheat importation in Nigeria. It is therefore recommended that the substitution of wheat flour with 10% to 20% acha flour, 10% to 20% Bambara groundnut flour, and less than 10% cocoyam flour be used for the production of noodles with a high potential of acceptability.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Orisa CA, Udofia US. Proximate and mineral compositions of noodles made from *Triticum durum*, *Digitaria exilis*, *Vigna unguiculata flour and Moringa oleifera* powder. J. Food Sci. Eng. 2019;9:276-286. Available:https://doi.org/10.17265/2159-5828/2019.07.003.
2. Adedeji TO. Chemical composition and organoletpic properties of cocoyam starch wheat flour blend noodles. Arch. Food. Nutri. Sci. 2017;1:058-062.
3. Akanbi TO, Hazamid S, Adebowale AA, Farooq A, Olaoye AO. Breadfruit starch-wheat flour noodles: preparation, proximate compositions and culinary properties. Int. Food Res. J. 2011;18:1283-1287.
4. Ando K. Instant noodles as earth food, the answer to food crisis. Retrieved from world instant noodles submit, world instant noodles association (WINA); 2010. website:https://instantnoodles.org.
5. WINA. World instant noodles association global demand. instantnooddles.org /en/noodles/market.html; 2018.
6. Akonor PT, Tortoe C, Buckman ES, Hagan L. Proximate composition and sensory evaluation nof root and tuber composite flour noodles. Cogent Food Agric. 2017;3:1292586.
7. Olorunsogo ST, Adebayo SE, Orhevba BA, Awoyinka TB. Physicochemical properties of instant noodles produced from blends of sweet potato, soybean and corn flour. Food Res. 2019;3(5):391-399.
8. Omeire GC, Umeji OF, Obasi NE. Acceptability of noodles produced from blends of Wheat, Acha and Soybean composite flours. Nig. Food J. 2014;32(1):31-37.
9. Oburuoga AC, Anyika JU. Nutrient and anti-nutrient composition of mung bean (*Vigna radiate*), acha (*Digitaria exilis*) and crayfish (*Astacus fluviatilis*) flours. Pak. J. Nutr. 2014;11(9):743-746.
10. Coda R, Di Cagno R, Edema MO, Nionelli L, Gobetti M. Exploitation of acha (*Digitaria exilis*) and iburu (*Digitaria iburua*) flours: chemical characterization and their use for sourdough fermentation. Food Microbiol. 2010;27(8):1043-1050.
11. Mune MA, Mbome-Lap EI, Minka SR. Improving the nutritional quality of cowpea and Bambara bean flours for use in infant feeding. Pak. J. Nutr. 2007;6:660-664.
12. Mbata TI, Ikenebomeh MJ, Ezeibe S. Evaluation of mineral content and functional properties of fermented maize (generic and specific) flour blended with bambara groundnut. Afri. J. Food Sci. 2009;3:107-112.
13. Chude C, Atowa C, Okpalanuwaekwe EO. Quality evaluation of noodles produced from fermented bambara groundnut (Vigna Subterranean (L) Verdc.) Flour. Food Sci. Qua. Mgt. 2018;73.
14. Adeyeye SAO, Oluwatola OJ. Quality and sensory properties of pounded Cocoyam from different varieties of Cocoyam. Pacific J. Sci. Tech. 2015;16(2):251-256.
15. Pandukur SG, Amienyo CA. Effect of *Azadirachta indica* extract on the radical growth of some test fungi isolated from two cocoyam varieties (*Colocosia esculenta* L.) corms and cormels in some markets in Plateau State, Nigeria. J. Phytopathol. Pest Manag. 2016;3(1):46-59.
16. Mwenye OJ, Labuschagne MT, Herselman L, Benesi IRM. Mineral composition of Malawian Cocoyam (*Colocasia esculenta* and *Xanthosoma sagittifolium*) genotypes. J. Bio. Sci. 2011;11:331-335.
17. Ijioma JC, Effiong JB, Ogbonna MO, Onwuamaoka EA. "Determinants of

adoption of selected NRCRI cocoyam technologies among farmers in Umuahia South local government area of Abia State, Nigeria," Am. Int. J. Contemp. Res. 2014;4(6).
18. Ogukwe CE, Amaechi PC, Enenebeaku CK. Studies on the flowers and stems of two Cocoyam varieties: *Xanthosoma sagittifolium* and *Colocasia esculenta.* Nat. Prod. Chem. Res. 2017;5:263. DOI:10.4172/2329-6836.j
19. Adane T, Shimelis A, Negussie R, Tilahun B, Haki GD. Effect of processing method on the proximate composition, mineral content and antinutritional factors of Taro (*Colocasia esculenta*, L.) grown in Ethiopia. Afri. J. Food. Agri. Nutr. Dev. 2013;13(2):7383-7398.
20. Causgrove P. Wheat and flour testing methods. "A guide to understanding wheat and flour quality" Wheat marketing center, inc., Oregon; 2004.
21. AOAC Association of Official Analytical Chemists International. 17th Edition. Washington DC, USA. 2000;2.
22. Shere PD, Devkatte AN, Pawar VN. Studies on production of functional noodles witsh Incorporation of Spinach Puree. Int. J. of Curr. Microbiol. App Sci. 2018;7(6):1618-1628.
23. AACC. Approved methods of the American society of Cereal Chemists. St. Paul Minnesota; 1995.
24. Iwe MO. Handbook of sensory methods and analysis. Rojoint communication services Ltd. Enugu. 2010;75-78.
25. Wahua TAT. Applied statistics for scientific studies. T.E.N., Port Harcourt; 1999.
26. Olapade AA, Ugokwe PU, Ozumba AU, Solomon HM, Olatunji O, Adelaya SO. Physico-chemical properties of premixes for preparation of akara. Nig. Food J. 2005;22:55.
27. Falade KO, Okafor AC. Physical, functional, and pasting properties of flours from corms of two Cocoyam (*Colocasia esculenta and Xanthosoma sagittifolium*) cultivars. J. Food Sci. Tech. 2014;52(6):3440–3448.
28. Akubor PI, Fayashe TO. Chemical composition, functional properties and performance of Soybean and Wheat flour blends in instant fried noodles, *South* Asian J. Food Tech. Envir. 2018;4(2):690-699.
29. Awolu OO, Oyebanji OV, Sodipo MA. Optimization of proximate composition and functional properties of composite flours consisting wheat, cocoyam (*Colocasia esculenta*) and bambara groundnut (*Vigna subterranea)* Int. Food Res. J. 2017;24(1):268-274.
30. Iwe MO, Onyeukwu U, Agiriga AN, Yildiz F. Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour, Cogent Food Agric. 2016;2:1. DOI:10.1080/23311932.2016.1142409
31. Gulia N, Dhaka V, Khatka BS. Instant noodles: Nutritional aspects. Crit. Rev Food Sci. Nutr. 2014;54(10):1386–1339.
32. Anankware J, Ojinnaka MC, Shadrrack DM, Odinkemere-Davidson VN. Formulation, proximate analysis and quality evaluation of cocoyam-wheat cake enriched with palm larvae (*Rhynchophorus phoenicis*). Act. Sci. Nutri. Health. 2018;2(11):19-25.
33. Ayo JA, Andrew E. Effect of added Bambara groundnut on the quality of acha-date palm based biscuit. Int. J. of Biotech. Food Sci. 2016;4(3):34–38.
34. De Pilli T, Derossi A, Severini C. Cooking quality characteristics of spaghetti based on soft wheat flour enriched with oat flour. Int. J. Food Sci. Tech. 2013;48(11):2348-2355.
35. Eke-Ejiofor J, Allen JE. The physicochemical and pasting properties of high quality cassava flour and tiger nut composite blends in chin-chin production. Am. J. Food Sci. Tech. 2019;7:13-21.
36. Anggraeni R, Saputra D. Physicochemical characteristics and sensorial properties of dry noodle supplemented with unripe banana flour. Food Res. 2018;2(3):270–278.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/70238