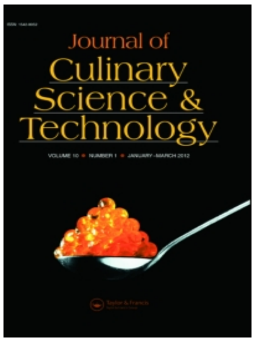

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Quality Characteristics of Noodles Produced from Wheat Flour and Modified Starch of African Breadfruit (*Artocarpus altilis*) Blends

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ABSTRACT

Wheat flour and modified-starch from African breadfruit (MS) were used in ratios of 100:0; 90:10; 80:20; 70:30; 60:40 and 50:50 to produce noodles. Chemical composition, culinary and sensory attributes of the noodles were investigated. The protein, fat, ash, crude fiber, moisture and calorific values of the flour noodles ranged from 4.76 to 0.33%, 0.35 to 0.57%, 0.83 to 0.57%, 0.53 to 0.57%, 8.03 to 0.15% and 349.51 to 355.81 kcal/100 g respectively. Moisture content increased with increasing addition of MS and later reduced. Addition of MS flour up to 30% had no significant effect on the overall acceptance of noodles. The results showed that MS flour can be incorporated up to 30% for noodles to improve the nutrient value without affecting the acceptability. There were no significant difference ($p < 0.05$) in the sensory attributes of the noodles up till 30% level of inclusion with MS.

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Culinary science; food product development; food technology; sensory evaluation

Introduction

Noodles are widely consumed throughout the world and their global consumption is second only to bread (Yadav, Yadav, Kumari, & Khatkar, 2014). Noodles have become more widely accepted by consumers far beyond the shores of Asia, where it is a staple food (Onigbogi, Sanni, Hou, & Shittu, 2014), particularly in Nigeria. This sudden increase in the popularity of noodles and current trends in its consumption pattern in Nigeria, where wheat production is extremely poor and is a non-traditional food, suggests that noodles will continue to grow rapidly in popularity. This is because instant noodles are convenient foods and easy-to-cook with affordable prices; have good sensory appeal and increase consumer interest. The noodles are also known to have a relatively long shelf life. The acceptance and consumption pattern is so high to the extent that vendors now prepare it in different delicacies with eggs, minced meat, and spiced in motor

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parks and bus stop as take away snacks. This high consumption scenario of noodles in Nigeria may imply that this food category will continue to gain rapid popularity in both rural and urban communities.

The nation, Nigeria, has been ranked as the 12th highest consumer of noodles in the world by the World Instant Noodles Association (WINA, 2013), though her struggles with the problem in the international wheat market due to dwindling production arising from the adverse effect of climate change is still on course. This has made the price of wheat in the world market increase without control and the situation may remain like that for a long time. The Nigerian government estimated her wheat importation bill in 2011 to be worth $4.2billion, and this affected the hard earned foreign reserves due to the sudden fall in world crude oil prices, hence, the introduction of 10% substitute policy of wheat flour for baked products in the country with high quality cassava flour (Onigbogi et al., 2014). It is on this that the policy should be extended to instant noodles production using some other less utilized flours and starches, such as the African breadfruit flour and starch. In general, noodles are prepared from wheat flour. However, some studies reported that the use of wheat flour could partly be substituted with other flours such as sweet potato flour (Ginting & Yulifianti, 2015), cassava flour (Onigbogi et al., 2014; Purwandari, Hidayati, Tamam, & Arifin, 2014; Sanni, Bamgbose, & Sanni, 2004), corn grit or maize (Obadina, Oyewole, & Archibong, 2011), and food starches (Akanbi, Nazamid, Adebowale, Farooq, & Olaoye, 2011; Vipa, Patcharee, Warunee, & Rasamee, 2002).

African breadfruit (*Artocarpus altilis*) is grown in the high rain forest parts of some African countries, particularly in southern Nigeria. It is strategic in alleviating hunger in these places due to its availability during the periods when some other staples are out of season or under cultivation (Nwabueze, Iwe, & Akobundu, 2008). Apart from cereals, roots, and tubers that are major staples of some Africans, breadfruit is another commonest staple in the regions. It remains a partially tapped food because it has not gone beyond rural consumption as boiled, fried, or pound as thick porridge without being given full commercial utilization, despite its nutritious status. It remains a potential food for low-income groups of society in developing countries. It has an advantage over the cereals, roots, and tubers in that it yields twice or thrice the minerals and vitamins as cereals, roots, and tubers (Amusa, Kehinde, & Ashaye, 2002). However, its starch has been reported to have some physical and organoleptic properties similar to wheat flour and also provide other nutritional and functional properties that can be beneficial to human health (Akanbi, Nazamid, & Adebowale, 2009), among which is its high dietary fiber content. An increased consumption of dietary fiber in the daily diet has been recommended by nutritionists for improved health. The fiber that is predominantly presented in breadfruit is non-starch polysaccharide, which is a type of insoluble fiber (Hall, Thomas & Johnson, 2005). Dietary fibers promote beneficial physiological effects, including laxation, lowering blood cholesterol, and blood glucose attenuation (Mann, 2002). Starch comprises of amylose and amylopectin, is a predominant component of breadfruit flour, and may help to improve the appearance and structure of its food products. Akanbi et al. (2009) reported that breadfruit starch contained high amylose (22.5%) and amylopectin (77.5%) fractions, and also studies have shown that moderately high amylase foods are helpful in reducing risk factors for diabetes and cardiovascular diseases (Behall & Howe, 1995). Likewise, high amylopectin presence in food has been reported to have an increasing effect on human insulin levels (Behall, Scholfield, & Canary, 1988), thereby lowering the blood sugar. The relatively low glycemic index (GI) of its carbohydrate makes African breadfruit an ideal food for diabetics and blood sugar will be under proper control. The GI of a particular food type indicates the food type's effect on a person's glucose (also called blood sugar) level. So, low GI foods have a slower rate of digestion and absorption of glucose. Other nutritional benefits of the breadfruit flour in comparison with wheat flour have been documented previously (Malomo, Eleyinmi, & Fashakin, 2011).

Diversification of breadfruit utilization into variety of food products such as instant noodles may be among the useful tools to support the National Agricultural Transformation Agenda and promote food security in Nigeria. More especially, the use of the modified starch from breadfruit could enhance health benefits with respect to its high dietary fiber content and relatively low GI of its carbohydrates; it also contributes to functional food properties of breadfruit. In an effort to expanding the food industry, research activities, consumer awareness, and genuine food policy should be tailored at sourcing locally available raw materials that can be used for production of high quality foods.

Therefore, this study was performed to identify the quality characteristics and sensorial attributes of noodles prepared from African breadfruit modified-starch with wheat flour blends.

Materials and methods

Materials

Matured African breadfruit (*Artocarpus altilis*) samples were obtained from a local farm at Oja-odan axis of Yewa-South Area, Ogun State, Nigeria. Wheat flour (Honeywell, Lagos, Nigeria), common salt (Dangote Iodized salt), ascorbic acid, vegetable oil, and guar gum were purchased a super market in Sango, Ogun State.

Methods

Isolation of starch from African breadfruit

Breadfruit starch was isolated using the method described by Agboola, Akingbala, and Oguntimi (1990), with some modifications in sieving and dying time. Sorted and cleaned breadfruit samples were washed under running tap water, peel manually, and pulp grated; the grated pulp was suspended in 5 l of distilled water for 24 h to allow the starch to come out of the grated pulp. The extracted starch was allowed to sediment for 4 h, supernatant was decanted off, and the starch was washed with 5 l distilled water twice in order to remove proteins and fiber. The resulting wet starch was spread in the chamber of solar dryer and dried for 2 days till moisture content of 10% was attained. The starch cake obtained was milled to powder with 10 mm sieve hammer mill, packaged in airtight polythene, and stored in refrigerator till required for processing and analysis.

Preparation of modified starch

Modified starch (MS) was prepared according to the procedure described by Collado, Mabesa, Oates, and Corke (2001). The isolated starch was adjusted to between 27 to 30% moisture and equilibrated at 4 to 5°C (39.2–41.0°F) overnight in refrigerator. It was later removed and placed in oven for 3 h at 110°C (230°F) and cooled to room temperature (25 ± 2°C or 73.4 –77°F) and dried at 50°C (122°F), equilibrate for 4 h and sealed in polythene.

Noodles preparation

Noodle samples were prepared as described by Collado and Corke (1996) reported by Yadav et al. (2014), with modifications through the introduction of steaming of noodles after extrusion. Experimental samples of the instant noodles were prepared with 100% wheat flour (WF) (control) and respective blends of WF with MS prepared at 10, 20, 30, 40, and 50% levels of substitution. The WF:MS blends were mixed with common salt (2 g/100 g flour), ascorbic acid (0.05 g/100 g flour), guar gum (0.25 g/100 g flour), and purified water (33 ml/100 g flour). Dough of desirable consistency was prepared by mixing 100 g flour with purified water in a laboratory dough mixer. The noodles were prepared by extruding the dough using 1.2 mm die through a hand-operated extruded machine (Sanco, New Delhi, India). The noodles were then steamed for 15 minutes at 100°C and pre-cooled at −4°C (24.8°F) for 6 h, subsequently frozen at −5°C (23°F) for 8 h, and then air-dried at 40°C (104°F) in the cabinet dryer until about 12% moisture content was reached. Dried noodles were equilibrated at room temperature and then packed in polyethylene bags and stored at room temperature (25 ± 2°C or 73.4–77°F) prior to analysis.

Analytical determination

Cooking properties of noodles

Cooking time. Noodles (10 g) were cooked in 200 ml of boiling distilled water in a 250 ml beaker. Noodles were cooked until disappearance of white core, as judged by squeezing between two glass slides (Yadav et al., 2014).

Cooked weight. The cooked weight of noodles was determined as described by Galvez and Resurreccion (1992) with minor modifications. Noodles (10 g) were soaked in 300 ml water for 5 min and then cooked in water bath for 5 min. The beaker was covered with aluminum foil to minimize the loss of water due to evaporation. The cooked noodles were drained for about 2 min, rinsed with distilled water in a Buchner funnel, and cooked weight was determined by weighing wet mass of noodles.

Cooking loss (g/100 g). Distilled water (1 l) was brought to a boil in a 2-liter saucepan with the lid onto prevent any water loss. When the water started boiling, a 100 g portion of noodles was added. The cooking temperature (that is the water temperature) was maintained at 98–100°C throughout the cooking process. The cooking period began as soon as the noodles were put into the boiled water and were cooked for 3 minutes or until no white core was observed after compressing. The noodles were then removed from the sauce pan, rinsed, and cooled in running cold water for a minute. Cooking loss was measured by evaporating the cooking water to dryness in oven at 100°C, as described by standard method (A.A.C.C., 2000).

$$\text{Cooking loss} = \frac{\textit{weight of cooked noodles} - \textit{weight of uncooked noodles}}{\textit{weight of uncooked noodles}}$$

Water uptake percentage (g/100 G). The water uptake is the difference in the weight of cooked noodle versus uncooked noodles, expressed as the percentage of weight of uncooked noodles (Galvez & Resurreccion, 1992). Cooked noodles were rinsed with cold water and drained for 30 seconds then weighed to determine the cooking gain. The analysis indicates the amount of water absorbed by the noodle during cooking process.

Determination of chemical composition of noodles

Moisture, protein (Kjeldahl nitrogen x 5.7), fat, crude fiber, and ash contents were determined using methods (A.O.A.C., 2004). Carbohydrate was determined by difference [100- (% moisture + % protein + % fat + % fiber + % ash)] and energy value was calculated using the Atwater factor (4 x carbohydrate + 9 x fat + 4 x protein).

Sensory evaluation of cooked noodles

The sensory panel comprised of 35 semi-trained members including 18 females and 17 males in the age group of 18–25 years. The members were not professional sensory analysts, but they were made acquainted with the use of hedonic scale to be used for sensory analysis. Purified drinking water was used to cleanse the mouth before testing the samples. The sensory evaluation was carried out in order to get consumer response for overall acceptability of the MS-incorporated instant noodle compared to the control. The noodle samples were cooked as described earlier. Panelists were given approximately 5 g of each of the 6 samples; 5 sample containing different levels of MS and the control (100% WF). Each of the samples was numbered using the random three-digit numbering system. The attributes evaluated were color, firmness, shape, appearance, aroma, taste, and overall acceptability. Panelists were asked to indicate their preference on a 9-point Hedonic scale with degree of liking: 1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely.

Statistical analysis

The data collected for culinary measurements, chemical composition, and sensory evaluation were analyzed using Statistical Package for Social Science for windows (SPSS version 16.0, SPSS Inc., Chicago, IL, USA) by applying analysis of variance (ANOVA). Means were separated with multiple range test (Duncan, 1955) at $p < 0.05$. Pearson's correlation matrix was determined on the result of proximate composition with same statistical package.

Results and discussion

Culinary attributes of wheat flour-modified starch noodles

Table 1 shows chemical composition of wheat and African breadfruit flour in terms of percentage protein, fat, fiber, ash and carbohydrate contents (Malomo, Eleyinmi & Fashakin, 2011) with their respective energy values in kcal/100g. Wheat flour has a higher protein (15.30%), fat (2.60%), carbohydrate (76.50%) contents and energy value (388.87kcal/100g) than African breadfruit flour with 3.35, 0.51, 73.50% and 311.96 kcal/100g respectively for protein, fat, carbohydrate contents and energy value. However, African breadfruit has more fiber and ash than wheat flour. The results of culinary properties of noodles prepared from different blends of WF and MS are shown in Table 2. The cooking parameters like cooking time, cooked weight, cooking loss, and water uptake were assessed for different flour noodle blends. There was significant ($p < 0.05$) differences observed in the cooking time, cooked weight, cooking loss, and water uptake of the instant noodles evaluated. A good quality noodle should have a short cooking time with little loss of solids in the cooking

Table 1. Chemical composition of wheat flour and African breadfruit flour.

	Flour	
Parameter	African breadfruit	Wheat
Protein (%)	3.35 ± 0.05	15.30 ± 0.36
Fat (%)	0.51 ± 0.05	2.60 ± 0.36
Fiber (%)	3.67 ± 0.08	0.30 ± 0.03
Ash (%)	2.67 ± 0.04	0.61 ± 0.04
CHO (%)	73.50 ± 0.70	76.50 ± 0.36
*Energy value	311.96 ± 2.90	388.87 ± 4.46

Source: Malomo et al. (2011). *calculated in kcal/100g.

Table 2. Culinary attributes of the wheat flour–modified starch instant noodles.

	Cooking attributes			
	Cooking time	Cooked weight	Cooking loss	Water uptake
Sample WF: MS	(min)	(g)	(%)	(g /100 g)
100:0	8.35 ± 0.12^{a}	28.7 ± 0.20^{d}	8.78 ± 0.05^{bc}	173.01 ± 0.15^{c}
90:10	7.50 ± 0.18^{b}	30.1 ± 0.02^{c}	9.79 ± 0.01^{ab}	180.03 ± 0.40^{b}
80:20	7.35 ± 0.23^{b}	32.3 ± 0.15^{b}	9.79 ± 0.01^{ab}	182.39 ± 0.30^{b}
70:30	7.26 ± 0.03^{b}	36.2 ± 0.01^{b}	9.79 ± 0.02^{ab}	185.42 ± 0.20^{b}
60:40	6.89 ± 2.03^{cb}	38.0 ± 0.04^{b}	9.80 ± 0.04^{a}	190.41 ± 0.10^{a}
50:50	6.50 ± 0.04^{cb}	40.6 ± 0.02^{a}	9.80 ± 0.04^{a}	192.00 ± 0.01^{a}

Values are means ± standard deviations of triplicate values; Values with same superscript are not significantly different at $p < 0.05$ within the column; WF = wheat flour; MS = modified starch of African breadfruit. Chemical composition of wheat flour-modified starch noodles.

water. The cooking time for all blend flour noodles was significantly ($p < 0.05$) lower than that of control (100% WF) sample and the mean values of the cooking time ranged from 6.50 (WF 50:MS 50) to 7.50 min (WF 90:MS 10), with 50:50 blend flour noodle showing minimum value and control showing the maximum value, indicating that the cooking time decreased as the level of inclusion of MS increased. This result is in agreement with the findings of Yadav et al. (2014), where the cooking time of three different composite noodle made for sweet potato, *colocasia*, and water chestnut flour blends were in the range of 6.5 to 8.0 min. Ingredients other than wheat flour, such as MS, may cause discontinuity in the gluten network (Manthey, Chakraborty, Peel, & Pederson, 2004), resulting in the faster moisture penetration and therefore leading to decreased optimum cooking time.

The cooked weight varied from 30.1 to 40.6 g among the composited noodles. Highest cooked weight (40.6 g) value was recorded in the 50:50 blend noodle, while the lowest cooked weight was 30.1 g in the noodle substituted with 10% MS. Cooking loss values among the noodle samples containing blends of MS were not significantly different ($p < 0.05$). The cooking loss ranged from 9.79 to 9.80%, which was more than the value recorded for the cooking loss (8.78%) of the control. Cooking loss is an indicator to noodles resistance to cooking (Nagao, 1996), so low levels are preferable. The higher cooking loss in the blend noodles is in agreement with the observations made on noodles prepared with incorporating sweet potato in refined wheat flour (Collins & Pangloli, 1997) and wheat flour blends with sweet potato, *colocasia*, and water chestnut flours (Yadav et al., 2014).

The water uptake varied from 180.03 to 192.00 g/100 g, indicating that it increases with increasing level of addition of MS to the flour blends. The highest water uptake of 192.0 g/100 g was observed in the case of 50:50 blend noodle, whereas 90:10 WF–MS blend noodle showed the lowest (180.03 g/100 g) water uptake. Water uptake indicates the degree of noodle hydration and may affect the eating quality of noodles, as insufficient water uptake may result in producing noodles with hard and coarse texture, and excess water uptake results in too soft and sticky noodles (Yadav et al., 2014). Cooked weight, cooking loss, and water uptake of WF–MS noodles were higher than that of 100% WF (control) sample. These results were in contrast to the previously reported relation between cooking loss and water uptake (or water absorption) of noodle (Oh, Seib, & Chung, 1985), where cooking loss negatively correlated to water absorption. It may be an indication of strong structure or more cohesive WF–MS noodle, as absorption of more water resulted in minimal cooking loss.

Table 3 presents the chemical composition of instant WF–MS noodles. The mean moisture content of the noodle samples ranged from 7.43 to 7.67%, with the noodle formulated and prepared as 70% WF:30% MS having the highest moisture content of 7.67%. There are no significant difference between the moisture content of the noodle samples at $p < 0.05$.

Generally, there were significant differences in the mean ash, fat, fiber, and protein contents of the noodle sample. The ash content ranges from 0.65 to 1.92%, with the noodle sample 90%WF:10%MS having the highest ash content, while the lowest ash content was recorded in noodle sample 50% WF:50%MS. The values obtained for the ash content in the present study, however, contradict the earlier findings reported for ash in noodle produced from cassava (Sanni et al., 2004) and breadfruit starch–wheat flour noodles (Akanbi et al., 2011), where the addition of cassava flour and breadfruit starch led to increased ash content values. The fat content ranged from 0.20 to 0.37% and decreased with increasing addition of MS. The result obtained for fat is not surprising because the fat content of WF (control) exceeded those of MS. Starch has little or no fat, depending on the method of extraction and quantity of fat in the parent material; the fat quantity in starch could be as low as 0.20%, whereas WF has some fat, which is higher than that of MS. The fat content in the composited noodles will reduce based on the interaction between amylose and the fat contents of the composited flour to form amylose-lipid complex. Hence, these complexes reduced the quantity of oil available for determination during analysis (Nebesny, Roscika, & Tkaczyk, 2005). The result also supports the findings of Akanbi et al. (2011) and Iwaoka, Yukio, Kasumi, and Takayuki (1994), where it was reported that

Table 3. Chemical compositions of noodles from wheat flour–modified starch blends.

	Noodles formulation (WF: MS)					
Parameter	100:0	90:10	80:20	70:30	60:40	50:50
Moisture (%)	$7.23^{a} \pm 0.65$	$7.46^{a} \pm 0.08$	$7.56^{a} \pm 0.15$	$7.67^{a} \pm 0.15$	$7.63^{a} \pm 0.15$	$7.43^{a} \pm 0.31$
Ash (%)	$2.10^{a} \pm 0.45$	$1.92^{a} \pm 0.42$	$0.83^{b} \pm 0.57$	$0.73^{b} \pm 0.10$	$0.70^{b} \pm 0.57$	$0.65^{c} \pm 0.31$
Fat (%)	$1.74^{a} \pm 0.19$	$0.37^{b} \pm 0.61$	$0.33^{b} \pm 0.57$	$0.26^{c} \pm 0.57$	$0.23^{c} \pm 0.57$	$0.20^{c} \pm 0.00$
Fiber (%)	$1.12^{d} \pm 0.42$	$2.13^{c} \pm 0.34$	$3.37^{b} \pm 0.57$	$3.56^{b} \pm 0.57$	$4.27^{a} \pm 0.57$	$4.83^{a} \pm 0.57$
Protein (%)	$10.20^{a} \pm 0.32$	$7.63^{b} \pm 0.61$	$4.76^{c} \pm 0.52$	$4.30^{c} \pm 0.10$	$3.60^{d} \pm 0.14$	$2.80^{a} \pm 0.04$
$^{+}$CHO (%)	$77.6^{c} \pm 0.01$	$80.49^{a} \pm 0.10$	$83.15^{ab} \pm 0.01$	$83.48^{ab} \pm 0.02$	$83.57^{ab} \pm 0.11$	$84.09^{a} \pm 0.10$
*Energy value	$366.9^{a} \pm 0.12$	$355.8^{ab} \pm 0.21$	$354.61^{ab} \pm 0.12$	$353.46^{ab} \pm 0.13$	$350.75^{c} \pm 0.12$	$349.36^{d} \pm 0.10$

Values with the same superscript(s) are not significantly different ($p < 0.05$) along the rows; WF = wheat flour; MS = modified starch of African breadfruit; +calculated by difference; *calculated in kcal/100 g breadfruit starch has very low fat content. The fiber content ranges from 2.13 (90%WF:10%MS) to 4.83% (50%WF:50%MS). It was noted that, the fiber content of the composite noodle samples increased with increase in addition of MS. This suggests that MS may be contributing additional fiber to the flour blends with increasing inclusion to wheat. The result is in agreement with earlier findings (Sanni et al., 2004; Olaoye & Onilude, 2008; and Akanbi et al., 2011). Olaoye and Onilude (2008) reported similar results for crude fiber content of blends of wheat and breadfruit flour used for the production of baked products. Studies have shown that crude fiber is best obtained from foods than supplement and can reduce incidence of chronic constipation, heart diseases associated with high cholesterol, diverticular disease, and reduce the risk of colon cancer (Ode, Lazovski, Stern, & Madar, 1993; and Reddy, 1999).

The mean protein content of noodles samples ranged from 2.80 (50% WF:50%MS) to 7.63% (90%WF:10%MS). Increasing amount of MS in the blends caused a decrease in the protein content of the noodle samples. The lower protein content of MS in comparison with WF may be because of the absence of gluten-forming proteins abundant in WF. This trend shows that the lower the percentage of WF in the blend, the lower the protein content of the noodle samples. This statement is in agreement with the findings of Olaoye and Onilude (2008) and Akanbi et al. (2009), where it was confirmed that the protein content of WF exceed that of breadfruit starch. Since the carbohydrate content of noodle samples was calculated by difference, the resultant variation in carbohydrate content may be attributed to the differences in the contents of other constituents. The same goes with the energy value that calculated using the Atwater factor comprising summation of the proportion of carbohydrate, protein, and fat multiplying by individual constituent factor.

Correlation matrix of chemical composition of noodles

Table 4 shows the Pearson's correlation matrix of proximate composition of instant WF–MS noodles. The result indicates that moisture, fat, and protein

Table 4. Pearson's correlation matrix of proximate composition of instant WF–MS noodles.

	Moisture	Ash	Fat	Fiber	Protein	CHO	Calorific value
Moisture	1.000						
Ash	−0.366	1.000					
Fat	−0.578*	−0.519*	1.000				
Fiber	−0.266	−0.328	−0.813*	1.000			
Protein	−0.237	−0.216	−0.742*	−0.871*	1.000		
CHO	−0.524*	−0.419	−0.963*	−0.076	−0.022	1.000	
Energy value	−0.145	−0.236	−0.067	−0.417	−0.053	−0.120	1.000

CHO = Carbohydrate; *significant at $p < 0.05$.

contents respectively correlate inversely with the carbohydrate content of the instant noodle samples. Conversely, the carbohydrate content correlates directly with the fiber content, both at a 0.05 level of significance. The energy value does not correlate with proximate composition, at any level. These findings are in agreement with the earlier report put forward on instant cassava–wheat-soybean flour noodles (Sanni et al., 2004)

Sensory evaluation of noodles from wheat flour–modified starch blend

The result of the sensory evaluation of instant WF–MS noodles are shown in Table 5, in terms appearance or color, firmness, taste, aroma, slipperiness, and overall acceptability. Sample sensory attributes of the instant noodles showed that blends 90:10, 80:20, and 70:30 (WF:MS) were not significantly ($p < 0.05$) different in terms of color, firmness, taste, slipperiness, and general acceptability. In terms color, noodle sample (90:10, 80:20, and 70:30) were not significantly different from the control (100%WF) noodle sample. Noodle sample (50:50) was least rated in terms of the color. This may not be unconnected with the off-white color impacted by the MS. Firmness implies the amount of force required to bite through the flour noodle strands. Firmness values of all the flour blend noodles were lower (5.10–7.40) than that of control (7.60) sample. Cooked flour noodles should be neither too firm nor too soft (Galvez & Resurreccion, 1992). Higher value of firmness in 100% WF noodle (control) could be as a result of the higher gluten content of the wheat flour. Higher gluten content of wheat flour has been reported to be responsible for the firmness of noodles (Chompreeda, Resurreccion, Hung, & Beuchat, 1987). This is in agreement with the recent findings of Yadav et al. (2014) of noodle firmness. The taste of noodles samples were not significantly different ($p < 0.05$), though noodle sample with 50:50 WF and MS blend was rated highest as the most preferred noodle in terms of its aroma. Slipperiness may be defined as the extent to which the product slides across the tongue (Yadav et al., 2014). Slippery surface texture is desirable in flour noodles. Slipperiness decreased steadily with increasing addition of MS. Noodle sample with 90:10 WF–MS blend recorded the highest slipperiness value

Table 5. Sensory attributes of noodles with wheat and modified-starch blends.

Sample WF: MS	Color	Firmness	Taste	Aroma	Slipperiness	Overall acceptability
100:0	8.80^{a}	7.60^{a}	6.50^{c}	6.90^{b}	8.80^{a}	7.50^{a}
90:10	8.60^{a}	7.40^{a}	6.15^{bc}	5.90^{b}	8.80^{a}	7.42^{a}
80:20	8.75^{a}	7.30^{ab}	6.24^{b}	6.20^{a}	7.30^{ab}	7.38^{ab}
70:30	8.70^{a}	7.25^{ab}	6.42^{b}	6.40^{a}	6.80^{b}	7.10^{ab}
60:40	6.30^{b}	5.90^{c}	6.22^{a}	6.59^{a}	5.21^{c}	5.26^{c}
50:50	6.00^{b}	5.10^{d}	6.60^{a}	5.61^{bc}	4.11^{c}	4.80^{d}

Values in the columns with the same superscripts are not significantly different at $p < 0.05$; WF = wheat flour; MS = modified starch of African breadfruit.

(8.80) as the control (100% WF) noodle sample, while lowest slipperiness value was recorded in 50:50 noodle sample. Noodle sample WF 80:MS 20 has the highest level of overall acceptability while noodle sample WF 50:MS 50 has the lowest level of acceptance. This might not be unconnected with the increased levels of the MS in the noodle sample.

Conclusion

It can be concluded that, from the present study, instant noodles were produced from blends of WF and MS of African breadfruit. It was however, observed that as the levels of addition of MS increased in WF, there is a steady increase in carbohydrate and fiber contents. The 100% wheat noodle (control) sample was highly rated and accepted and closely followed by noodle sample with 90:10, 80:20 and 70:30 formulations. It can therefore be stated that the level of WF substitution with MS for noodle production without affecting the acceptability is 30%. Apart from value addition, most snack foods being cereal based are monotonous with respect to their nutritional quality. Use of abundant supplies of breadfruit starch in countries like Nigeria to substitute partially for WF in noodles will not only reduce the excessive dependence on imported wheat but also improve the imbalance of nutrients through consumption of products based upon composite flour mixtures.

Not only that, economically there would decline in huge spending for importing wheat, which is not grown in Nigeria, and so more foreign reserves would be conserved, especially now that the country is facing serious economic challenges due to mismanagement of finances. With the inclusion of MS in noodles production, the cost of noodles may be brought down to more affordable prices for the target consumers; there would be more sales and more returns on investment for the noodle manufacturers. The use of MS in the formulation of noodles may promote MS-composite noodles with comparable attributes to some of the already existing noodles. This would encourage more cultivation and utilization with value addition to African breadfruit in Nigeria. Consequently, there may be employment and income generation; the youths will be engaged from unwarranted unrests and agitations.

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