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Published online: 26 Feb 2020.
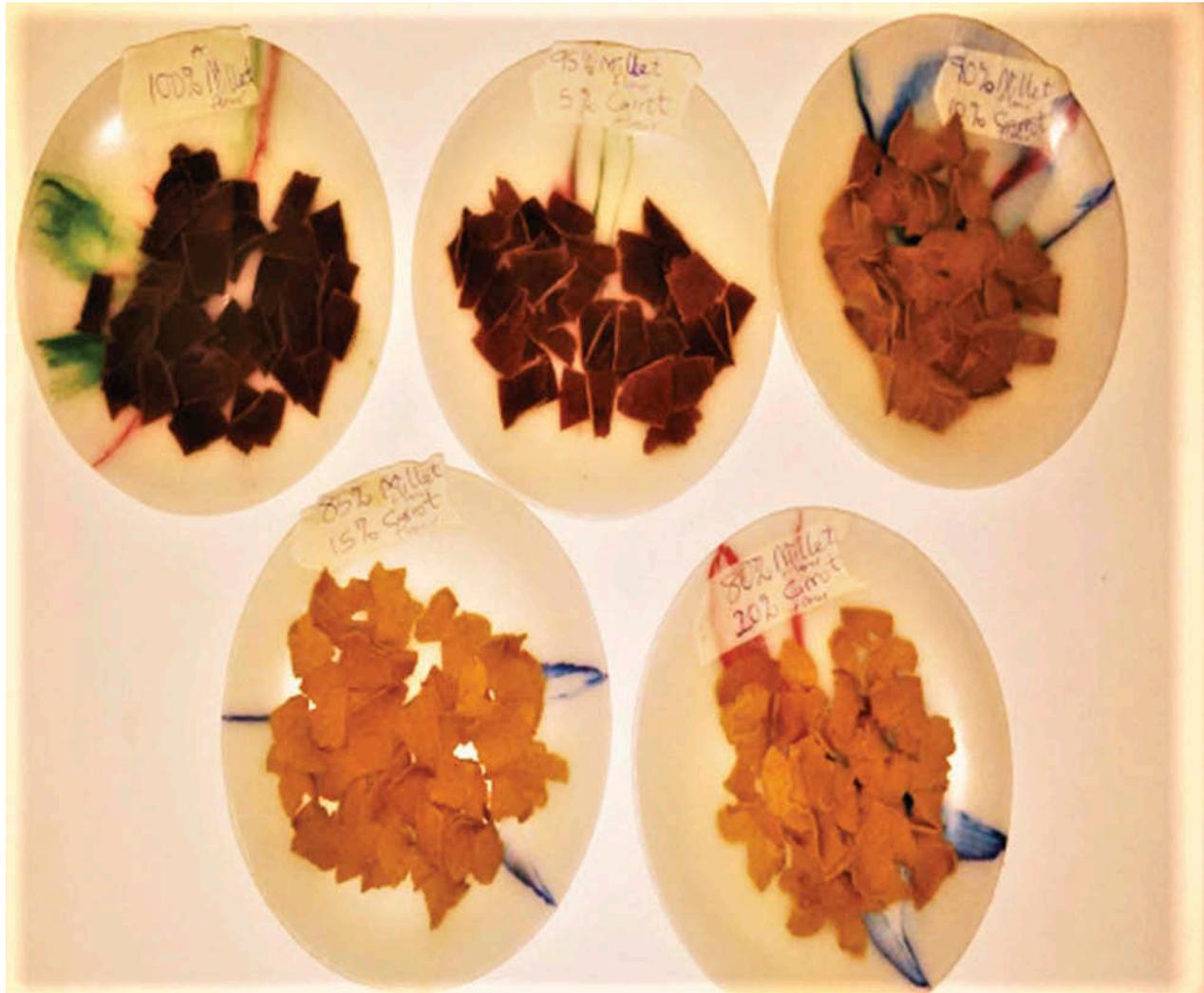
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Extruded flakes from pearl millet (*Pennisetum glaucum*) - carrot (*Daucus carota*) blended flours-Production, nutritional and sensory attributes

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Abstract: Millet flour (M) and carrot flour(C) were produced and blended in the ratios 100M:0C, 95M:5C, 90M:10C, 85M:15C and 80M:20C respectively to produce extruded flakes. The composite flours were subjected to analysis of the proximate and mineral composition, as well as functional and pasting properties. Extruded flakes were analyzed for proximate composition, total carotenoids, colour and sensory evaluation. There was no significant difference ($p > 0.05$) in the proximate, functional and pasting properties but there were significant differences ($p < 0.05$) in the mineral composition (Ca, Fe, Zn, Mg and P). Extrusion cooking significantly ($p < 0.05$) reduced moisture content from 4.5 to 3.5%, and it is also significantly ($p < 0.05$) increased the crude fibre from 2.84 to 4.53%, on the other hand, protein content decreased with the increase in carrot flour. Total carotenoids were not significantly ($p > 0.05$) affected by extrusion cooking. In terms of the lightness (L*), redness (a*) and yellowness (b*), 100% millet flakes had the least values of 50.09, 0.076 and 10.39 respectively. Sample with 85M:15C had the overall acceptance score of 7.25. In terms of colour and taste, the sample with 90M:10C had the highest scores of 8.50 and 6.50 respectively. Sample with 85M: 15C was most

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PUBLIC INTEREST STATEMENT

Our study explores the potentials of pearl millet and carrot flour in producing extruded flakes with acceptable functional and sensory qualities. This study provided some necessary information on nutrient composition and value addition via carrot flour which enrich the flakes with carotenoids aprecursor of Vitamin Athat is necessary for the consumer of the final products especially the young ones. It also enhances avariety of flakes in the market.

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preferred in terms of crunchiness. The results indicate that pearl millet and carrot are rich in different nutrient when blended in the right proportions to make composite flour, it would produce nutrient-dense food product rich in protein, vitamin Aand minerals.

Subjects: Food Chemistry; Sensory Science; Food Analysis;

Keywords: pearl millet; carrot; extruded flakes; carotenoid; composite flour; acceptability

1. Introduction

Pearl millet (*Pennisetum glaucum)* originated from western tropical Africa and South Asia for more than 3000 years ago (Food and Agriculture Organization of the United Nations [FAO], 1992). It is the sixth most important cereal crop after wheat, rice, maize, barley and sorghum in terms of annual global production (FAO, 1992). In most developed countries, pearl millet is mostly consumed as food due to its low content of prussic acid or high content of tannins (Newman, Jennings, Vendramini, & Blount, 2010). Also, the utilisation pattern has changed because of its usage in the production of alcohol, beer making and food processing industry. Pearl millet is also consumed in the form of porridge from dry, parched grains (Ihekoronye & Ngoddy, 1985). Due to its chemical composition, pearl millet has been attributed to having several health-promoting abilities which help in reducing anaemia due to high iron content (8mg/100 g), help in dealing with constipation due to high zinc content (3.1mg/100 g). Nigeria is rich in cereals, grains and tubers: they were widely cultivated and consumed. It provides asignificant food source for adults and children. They are the primary source of energy and protein in the diet of many people. Nigeria National Food Consumption and Nutrition Status Survey (NFCNS, 2004) showed that 43% of children under five years of age were stunted, 10% wasted, 36% are underweight and 29.5% vitamin Adeficient (VAD). Some cereal-based foods commonly fed to children are inadequate to meet daily nutrients and energy requirements. Nigeria is rich in cereals and grains, but vitamin Aactivity of these foods in the form of provitamin (β-carotene) is low.

Proper nutrition is essential for the growth and development that occurs during children's firstyear of life. When developing children are fed the appropriate types and amounts of foods, their health is promoted. The use of millet—carrot composite flour in the production of extruded flake and other snacks will assist in solving the problem of Vitamin Adeficiency in Nigeria. Also, it will increase the carotenoid content of the flakes. The objective of this study is to evaluate the use and the quality attributes of millet-carrot composite flour in the production of extruded flakes.

2. Materials and method

Pearl Millet grain and Carrot fruits used for this research were obtained locally from Mile12 market in Lagos State, Nigeria.

2.1. Pearl millet flour preparation

Pearl Millet (*Pennisetum glaucum*) grains were cleaned by sorting and winnowing to remove all the contaminant. The cleaned grains were dehulled, washed and dried at 50 °C for 24 h in acabinet drier. The grains were reduced to powder using ahammer mill and sieved through 0.25 µm sieve, packed into acellophane bag and stored for further analysis (Adebayo-Oyetoro, Shotunde, Adeyeye Samuel, & Ogundipe, 2017).

2.2. Carrot flour preparation

Carrot obtained were peeled, sliced or grated and dried to an almost brittle constituency at atemperature of 40 °C in acabinet dryer. The dried brittle carrot was then milled into powder using astainless-steel milling machine. The flour was sieved through 0.25 µm sieve, packed into acellophane bag stored for further analysis (Adegunwa, Ganiyu, Bakare, & Adebowale, 2014)

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2.3. Preparation of millet—carrot flour extruder flakes

The ingredients were weighed out in the right proportion (100% M, 95M:5C, 90M:10C, 85M:15C and 80M:20C) and mixed to get adough (Table 1). After mixing, the dough was extruded using the extruder (a fabricated single screw extruder, powered by Cosmic Controls (India) Pvt. Ltd. Motor Generator (1 HP DC Motor Model), with aZhejiang Voltage Regular Transformer (Model Number: TDGC—3.50 Hz, 12A). The mixture was fed into the hopper mounted vertically above the feed of the extruder, and the extrudate was dried in an oven, cooled and packaged.

2.4. Proximate analysis

The proximate composition of the millet—carrot composite flour sample was determined according to AOAC (2006); moisture content, crude fibre and ash by gravimetric methods, protein by Kjeldahl method and fat extraction by Soxhlet method. Total carbohydrate was computed by difference.

% carbohydrate = 100 — (% moisture + % protein + % crude fiber +% fat + % ash)

2.5. Determination of the minerals

The minerals (magnesium, iron, zinc, potassium, calcium) content was determined on the ash by atomic absorption spectrophotometry. The ash samples were from the product of the ash content determination (AOAC, 2006).

3. Functional properties

3.1. Bulk density

Bulk density was determined using the method described by Wang and Kinsella (1976). 10 g of samples were weighed into a50 ml graduated measuring cylinder. The sample was packed by gently tapping the cylinder on the benchtop for several times until there was no more decrease in volume. The volume of the compacted sample was recorded, and the bulk density was calculated as follows.

Calculation:

$$Bulk density = \frac{Weight\ of\ sample(g)}{Volume\ of\ the\ sample\ after\ tapping(cm^3)}$$

3.2. Water absorption capacity (WAC) and oil absorption capacity (OAC)

WAC was determined using the method of Solsulki (1962) and described by Alamu, Maziya-Dixon, Okonkwo, and Asiedu (2014). One gram of the sample was added 15 ml of distilled water in apre-weighed centrifuge tube. The tube with its content was agitated on aflask (Gallenkamp shaker) for 2 min and centrifuged at 4,000rpm for 20 min on aSORVALL GLC-1 centrifuge (Model 06470, USA). The clear supernatant was discarded, and the centrifuge tube was weighed with the sediment. The amount of water bound by the sample was determined by difference and expressed as the weight of water bound by flour. This method was also used to determine oil absorption capacity, but the water was replaced with oil.

Table 1. Mixing ratio		
Samples	**Millet flour (%)**	**Carrot flour (%)**
A	100	0
B	95	5
C	90	10
D	85	15
E	80	20

3.3. Swelling power and solubility

The Swelling power and solubility were determined using the method described by Leach, McCovwen, and Schoch (1959) and Alamu etal. (2014). One gram of sample was weighed into 100 ml conical flask, 15 ml of distilled water was added and mixed gently at low speed for 5 min, the slurry was heated in thermostatted water (THELCO, Model 83, USA) for 40 mins. The tubes containing the paste were centrifuged at 2,200rpm for 20 min using acentrifuge. The supernatant was decanted immediately after centrifuging into apre—weighed can and dried at 100 °C to constant weight. The weight of the sediment was taken and recorded.

$$\text{Swelling power} = \frac{\text{Weight of sediment}}{\text{Sample Weight} - \text{Weight of soluble}}$$

$$\text{Solubility index}(\%) = \frac{\text{Weight of soluble}}{\text{Weight of sample}}$$

3.4. Least gelation capacity (LGC)

Least gelation capacity was determined by the method described by Coffman and Garcia (1977). Ten suspensions of flour blends (2%, 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18%, 20%) (w/v) in 5 ml of distilled water was prepared in test tubes. The test tubes containing the suspension were heated in aboiling water bath (THELCO, model 83, USA) for 1hour. The tubes and content were cooled rapidly under running cold water and then cooled rapidly further for 2 hours at 4 °C. Next, the tubes were inverted to see if the content would fall or slip off. The LGC is that concentration when the sample from the inverted test tube does not fall or slip off.

3.5. Dispersibility

The method described by Kulkarni, Kulkarni, and Ingle (1991) was adopted. About 10 g of each flour blend was weighed into 100 ml measuring cylinder, and distilled water was added to reach avolume of 100 ml. The set up was stirred vigorously and allowed to settle for 3 h. The volume of settled particles was recorded and subtracted from 100. The difference was recorded as % dispersibility.

3.6. Pasting properties

Pasting properties were determined using the Rapid Visco Analyzer (Newport Scientific). For this, 3.5 g of the sample was weighed to the nearest 0.01 g into aweighing vessel before transfer into the test canister. 2.5 ml of distilled water was dispensed into the test canister. The sample was transferred unto the water surface in the canister. The paddle was placed into the canister, and its blade was rigorously jogged through the sample ten times. Jogging was repeated to ensure that the samples remaining on the water surface or the paddle were dissolved. The paddle and canister assembly were inserted firmly into the paddle coupling so that the paddle is appropriately centred. The measurement cycle was initiated by depressing after initiation and terminated automatically. From the recorded viscosity, the following parameters were read: peak viscosity, breakdown, set back, final viscosity, peak time, and pasting temperature. (IITA, 2001)

3.7. Determination of total carotenoids

Carotenoids were extracted according to Kimura, Kobori, Rodriguez-Amaya, and Nestel (2007). Six grams of the sample was mixed with 5 g of hyflosupercel (celite, afiltration aid) and 15 ml of 70% methanol (v/v) and filtered through aBuchner funnel with filter paper. The residue was extracted two more times with 15 ml acetone-petroleum ether 1:1 (v/v), the extracts were then transferred to 500 ml separatory funnel. About 5 ml of 10% KOH in methanol (v/v) was added and the mixture allowed to stand for 1.5 h, partition was achieved by adding 15 ml of petroleum ether and 20 ml of 20% NaCl (w/v) and mixing gently. The hypophasic (lower) layer was discarded. The epiphasic (upper) layer was washed three times with 20 ml of distilled water to remove excess acetone, filtered through asmall funnel containing 3 g anhydrous sodium sulphate to remove residual water. The funnel was plugged with glass stopper to hold sodium sulphate. The filtrate was made up to 100 ml with petroleum ether, and the absorbance was measured at 450 nm, the

wavelength of maximum absorption for β-carotene in petroleum ether (Kimura, Kobori, Rodriguez-Amaya, & Nestel, 2007). The total carotenoids were expressed as β-carotene equivalents (µg/100 g) of fresh weight.

$$\text{Total carotenoids content}(\mu g/g) = \frac{A \times \text{volume (ml)} \times 10^4}{A_{1cm}^{1\%} \times \text{sample weight}}$$

Where: A= Absorbance

   Volume = Total volume of extract

   $A_{1cm}^{1\%}$ = Absorption coefficient of β-carotene in petroleum ether (2,592)

3.8. Colour analysis
The colour parameters of extruded flakes which are lightness L*, redness α*, and yellowness b* were measured using aColorimeter. The surface of the extruded samples was brought in contact with the lens of the Colour meter to detect the colour parameters.

3.9. Sensory evaluation
Sensory evaluation of the flakes made from millet-carrot flour blends was conducted using twenty-panel members. These panellists were familiar with the quality attributes of flakes. The samples were coded and presented in identical containers. Anine-point hedonic scale, as described by Ihekoronye and Ngoddy (1985), was used. The scale ranged from like extremely (9) to dislike extremely (1). Overall acceptability and degree of likeness for sensory attributes of colour, flavour, texture, taste, mouthfeel by panellist were evaluated.

3.10. Statistical analysis
Each analytical determination was carried out in duplicate. Data obtained were subjected to analysis of variance (ANOVA) using the statistical package for social sciences (SPSS) version 21.0 software (SPSS inc. Chicago, IL) at $p < 0.05$. Means were separated using Duncan's multiple range test.

4. Results and discussion
The results of the proximate composition of millet-carrot composite flour samples are shown in Table 2. The moisture contents of composite flour ranged from 8.00 to 8.16%. Sample 100M:0C (100% millet flour) had the highest moisture content (9.47%) while sample 95M:5C had the lowest. There were significant differences between the moisture content of the samples at $p < 0.05$. The samples are within the range recommended for flours to have astable shelf life (Iwe etal., 2017).

Table 2. Proximate composition of millet-carrot composite flour					
Sample/ Parameter	100M:0C	95M:5C	90M:10C	85M:15C	80M:20C
Moisture (%)	9.47 ± 0.05[d]	8.00 ± 0.00[a]	8.54 ± 0.05[b]	8.16 ± 0.23[a]	8.97 ± 0.04[c]
Ash (%)	1.19 ± 0.08[a]	2.44 ± 0.20[b]	2.40 ± 0.57[b]	2.97 ± 0.24[b]	2.69 ± 0.33[b]
Fat (%)	2.46 ± 0.10[c]	1.86 ± 0.04[a]	2.21 ± 0.06[b]	1.86 ± 0.15[a]	1.86 ± 0.10[a]
Crude Fibre (%)	2.05 ± 0.76[a]	3.21 ± 0.01[b]	3.59 ± 0.04[b]	2.92 ± 0.05[ab]	3.35 ± 0.57[b]
Protein (%)	10.50 ± 0.64[c]	10.28 ± 0.01[c]	9.02 ± 0.37[a]	9.56 ± 0.00[b]	9.76 ± 0.10[b]
Carbohydrate (%)	74.85 ± 0.05[b]	74.22 ± 0.37[b]	74.35 ± 0.83[b]	74.54 ± 0.08[b]	73.01 ± 0.42[a]

Mean values with the same alphabet in arow are not significantly different (p > 0.05).
Values are mean ± standard deviation of duplicate determination.
M—Millet C—Carrot.

The ash content of the composite flours was not significantly different from each other, and the ash contents of the samples ranged from 1.19% to 2.97% for sample 100M:0C and 85M:15C respectively. Sample 100M:0C had the least value of 1.19%, this indicated that millet-carrot flour with the higher value of ash was beneficial as suggested by Legesse (2013) that the ash content indicates an estimate of the mineral content of the products. The difference in the ash content for sample 100M:0C and the millet-carrot composite flour was obviously due to the introduction of the carrot flour, which has high ash content. The ash content of typical carrot powder was reported to be 5.05% (Humaira, Malik, Jalal, Afshan, & Mir, 2013).

The fat content ranged from 1.86% to 2.46%, samples 95M:5C, 85M:15C and 80M:20C had similar fat values while samples 100M:0C and 90M:10C showed no significant difference ($p > 0.05$). The reduction in fat content may be as aresult of the inclusion of carrot flour into the blends. Few studies have reported that carrot powder has amoderately low value of fat content (Humaira etal., 2013; Shyamala & Jamuna, 2010).

The Crude fibre contents of the samples were low, ranging from 2.05% to 3.59%. Sample 90M:10C had the highest values, while 100M:0C had the lowest values; the inclusion of carrot flour significantly improved the fibre content of the composite flour. There was asignificant difference among the samples at ($p < 0.05$). The total carbohydrate content of the flour samples ranged from 73.01% to 74.85% The increased fibre and the lower carbohydrate content of composite flours have several health benefits, as it will aid in the digestion in the colon and reduce constipation (Elleuch etal., 2011; Jideani & Onwubali, 2009). According to well-documented studies, it is now accepted that dietary fibre plays asignificant role in the prevention of several diseases such as; cardiovascular diseases, diverticulosis, constipation, irritable colon, cancer and diabetes (Elleuch etal., 2011; Slavin, 2005).

The protein content of the flour samples ranged from 9.02 to 10.50%. Samples 100M:0C and 95M:5C were significantly different ($p < 0.05$). However, 100% of millet flour had the highest protein content. The value obtained for 100% millet flour compared favourably with the report of Omah and Okafor (2015) who stated that millet grains are known to contain an appreciable quantity of protein of about 11%.

Meanwhile, the carbohydrate content of the composite flour was lower when compared to 100% millet flour, though it was significantly different ($p < 0.05$) from samples 95M:5C, 90M:10C, and 85M:15C while samples 80M:20C had the lowest carbohydrate content of 73.01%. The reduction in carbohydrate may be due to replacement of millet flour (an excellent carbohydrate source) with carrot flour at different ratios.

Results of proximate analysis of millet-carrot composite flours recorded lower moisture, higher ash, fat, crude fibre, protein and carbohydrate contents when compared with the work of Zakari, Hassan, and Abbo (2010) who worked on millet-bambara groundnut composite flour.

The results of the functional properties of millet-carrot composite flours are shown in Table 3. The bulk densities ranged from 0.70 to 0.75 g/cm^3. The low bulk density would require more packaging space since the lesser the bulk density, and the more packaging space is required (Agunbiade & Ojezele, 2010). Bulk density is ameasure of the heaviness of aflour sample (Oladele & Aina, 2009). There was no significant difference ($p > 0.05$) in the bulk densities among the samples, although samples 95M:5C and 100M:0C had higher values of 0.75 and 0.73, respectively. Bulk density is also critical in determining the packaging requirement, raw material handling and application in wet processing in the food industry (Adebowale, Adegoke, Sanni, Adegunwa, & Fetuga, 2012).

The dispersibility of 100% millet flour was higher than the millet-carrot composite flours, and there was no significantly different ($p > 0.05$) from sample 95M:5C. It means that values recorded

Table 3. Functional properties of millet-carrot composite flour					
Sample/ Parameter	100M:0C	95M:5C	90M:10C	85M:15C	80M:20C
Bulk Density (g/cm^3)	0.73 ± 0.02[a]	0.75 ± 0.04[a]	0.70 ± 0.01[a]	0.70 ± 0.02[a]	0.71 ± 0.05[a]
Dispersibility (%)	70.50 ± 2.12[c]	70.00 ± 0.00[c]	60.50 ± 0.71[b]	56.50 ± 2.12[a]	56.00 ± 0.00[a]
WAC (g/g)	1.12 ± 0.04[a]	1.27 ± 0.04[ab]	1.39 ± 0.11[b]	1.50 ± 0.10[b]	1.49 ± 0.13[b]
OAC (g/g)	2.50 ± 0.21[ab]	2.63 ± 0.18[ab]	2.38 ± 0.08[a]	2.56 ± 0.12[ab]	2.93 ± 0.25[b]
LGC (%)	6.01 ± 0.01[a]	6.00 ± 0.01[a]	8.01 ± 0.01[b]	9.95 ± 0.08[b]	13.99 ± 0.01[c]
SP (%)	4.25 ± 0.25[a]	4.61 ± 0.30[ab]	4.65 ± 0.14[ab]	4.99 ± 0.04[b]	5.05 ± 0.17[b]
Solubility (%)	12.50 ± 0.71[a]	17.50 ± 0.71[a]	17.50 ± 3.54[a]	17.50 ± 3.54[a]	16.00 ± 1.41[a]

Mean values with the same alphabet in arow are not significantly different (p > 0.05).

Values are mean ± standard deviation of duplicate determination.

M—Millet C—Carrot.

SP—Swelling Power WAC— Water Absorption Capacity OAC—Oil Absorption Capacity.

LGC—Least Gelation Concentration.

for dispersibility decreased with the increasing proportion of carrot flour in the blends. Generally, the dispersibility values recorded were relatively high, which suggests that it will quickly reconstitute to give fine constituent dough (Adebowale etal., 2012; Adebowale, Sanni, & Onitilo, 2008).

The water and oil absorption capacities were higher in the composite flours when compared to 100% millet flour. Water absorption capacity describes flour-water association ability under limited water supply (Singh, 2001). Water absorption capacity values were between 1.12 and 1.50, and the low values recorded suggest that these flours may find application in baked products. Meanwhile, the oil absorption capacity values were between 2.38 and 2.93. Although there was no significant difference (p > 0.05) among the samples, higher values were observed in the composite flours, except for sample 90M:10C.

The Least gelation concentration and swelling powers also followed similar trends with the composite flours having higher values than the 100 % Pearl millet flour. However, there was no difference between sample 100M:0C and 95M:0C, sample 80M:20C recorded highest least gelation concentration and swelling power (13.99 and 5.05, respectively). Moorthy and Ramanujan (1986) reported that the swelling power of flour granule is an indication of the extent of associative forces within the granules.

Water solubility measures the number of free molecules leached out from the starch granules in addition to excess water and thus reflects the extent of starch degradation (Onwuka, 2005). The solubilities of the flours ranged between 12.50 and 17.50, and no significant difference (p > 0.05) was observed among the samples. Functional properties of millet-carrot composite flours compared favourably with that of millet-wheat flours reported by Adegunwa etal. (2014).

The results (Table 4) showed significant differences (p < 0.05) of minerals content among all the samples. Calcium content increased in the composite flours (39.95 to 62.08mg/100 g) while 100% millet flour had the least calcium content (24.64mg/100 g). Sample 80 M:20 C had the highest calcium value. The values of calcium found in these flours may be adequate for bone and teeth development in infants.

On the other hand, the iron content in 100% millet flour was higher (7.41mg/100 g) than in the composite flours whose values ranged from 3.04 to 7.09mg/100 g. The decrease in iron content observed in the composite flours could be attributed to the very low iron content found in fresh carrots (0.80mg/100 g) as reported by Okafor (2010). Iron is the functional component of

Table 4. Mineral composition of millet-carrot composite flour					
Sample/ Parameter (mg/100 g)	100M:0C	95M:5C	90M:10C	85M:15C	80M:20C
Ca	24.64 ± 0.53[a]	41.01 ± 0.15[c]	39.95 ± 0.19[b]	61.21 ± 0.13[d]	62.08 ± 0.03[e]
Fe	7.41 ± 0.09[e]	4.75 ± 0.18[b]	3.04 ± 0.06[a]	5.39 ± 0.04[c]	7.09 ± 0.09[d]
Zn	6.41 ± 0.12[b]	6.82 ± 0.03[c]	3.75 ± 0.06[a]	7.64 ± 0.02[d]	7.68 ± 0.08[d]
Mg	139.06 ± 0.06[b]	148.15 ± 0.10[c]	117.71 ± 0.04[a]	159.70 ± 0.43[d]	221.31 ± 0.04[e]
K	299.06 ± 0.01[b]	322.96 ± 0.04[c]	293.99 ± 0.11[a]	388.25 ± 0.06[d]	492.81 ± 0.10[e]

Mean values with the same alphabet in arow are not significantly different (p > 0.05).
Values are mean ± standard deviation of duplicate determination.
M—Millet C—Carrot.

haemoglobin and other vital compounds used in respiration, immune function and cognitive development (Ndubuisi, 2009).

Values for zinc contents varied from 3.75 to 7.68mg/100 g. There was asignificant difference (p < 0.05) among the samples except for sample 85M:15C and 80M:20C, which had the highest zinc contents of 7.64mg/100 g and 7.68mg/100 g, respectively. Zinc is essential in many metabolic reactions and may play an essential role in immunity, alcohol metabolism, sexual development and reproduction.

The magnesium and potassium contents followed the same trend, showing significant differences among the samples. According to Ndubuisi (2009), magnesium provides bone strength, aids enzyme, nerve and heart functions, while potassium aids nerve impulse transmission, and it is aprimary intracellular fluid. Composite flour composed of 90% millet and 10% carrot flour recorded the lowest magnesium and potassium value (117.71mg/100 g and 293.99mg/100 g respectively) while flour with 80% millet and 20% carrot had the highest values for both parameters (221.31mg/ 100 g for magnesium and 492.81mg/100 g for potassium).

Table 5 shows the result of pasting properties of the millet-carrot composite flours, the mean value of peak viscosity ranged from 46.17 to 80.59 RVU with sample 100M:0C having the highest peak value. There was no significant difference (p.>0.05) in the peak viscosity and the peak time of all the samples. Peak viscosity is the ability of starch to swell freely before their physical breakdown (Adebowale etal., 2008). High peak viscosity indicates high starch content, and this could explain the reason for 100M:0C flour had the highest peak viscosity. Meanwhile, the peak time, which is ameasure of the cooking time ranged between 5.07 to 5.27 minutes and flour with 85M:15C had the highest peak time while sample 80M:20C had the least. Although, there was no significant difference (p > 0.05) in the peak time of all samples. There was asignificant decrease (p < 0.05) in breakdown value as the rate of substitution of carrot flour in millet flour increases, 100M flour (32.21 RVU) had the highest value of breakdown while 80M:20C flour (16.34 RVU) had the lowest value of breakdown viscosity. The trough is the minimum viscosity value in the constant temperature phase of the rapid visco-analyzer (RVA) pasting profile, and it measures the ability of the paste to withstand breakdown during cooling (Adegunwa etal., 2014). It ranged from 29.83 to 48.38 RVU with decreasing values, and no significant difference (p > 0.05) observed in the composite flours when compared to 100M:0C flour.

The final viscosity is ameasure of the stability of the granules, sample100M:0C flour recorded the highest value (157.67 RVU) while sample 80M:20C had the lowest values(77.67 RVU). There was no significant difference (p > 0.05) between sample 85M:15C and 80M:20C.

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Table 5. Pasting properties of millet-carrot composite flour					
Sample/ Parameter	100M:0C	95M:5C	90M:10C	85M:15C	80M:20C
Peak viscosity (RVU)	80.59 ± 7.90[c]	66.50 ± 1.06[bc]	54.67 ± 1.65[ab]	60.67 ± 2.60[ab]	46.17 ± 10.02[a]
Trough viscosity (RVU)	48.38 ± 5.59[b]	39.46 ± 1.36[ab]	34.42 ± 2.60[a]	40.67 ± 0.12[ab]	29.83 ± 6.72[a]
Breakdown viscosity (RVU)	32.21 ± 2.30[b]	27.04 ± 2.42[b]	20.25 ± 0.95[a]	20.00 ± 2.47[a]	16.34 ± 3.30[a]
Final viscosity (RVU)	157.67 ± 8.84[d]	121.59 ± 0.59[c]	96.04 ± 1.12[ab]	105.58 ± 10.61[bc]	77.67 ± 15.79[a]
Setback viscosity (RVU)	109.29 ± 3.24[c]	82.13 ± 1.94[b]	61.63 ± 3.71[a]	64.92 ± 10.49[a]	47.84 ± 9.07[a]
Peak time (min)	5.17 ± 0.05[a]	5.10 ± 0.04[a]	5.14 ± 0.19[a]	5.27 ± 0.09[a]	5.07 ± 0.00[a]
Pasting temperature (°C)	81.55 ± 1.20[a]	82.78 ± 0.60[ab]	84.45 ± 0.60[b]	84.45 ± 0.57[b]	84.45 ± 1.77[b]

Mean values with the same alphabet in arow are not significantly different (p > 0.05).
Values are mean ± standard deviation of duplicate determination.
M—Millet C—Carrot.

Setback viscosity ranged from 47.84 to 109.29 RVU, also with lower values observed in the composite flours. The higher the setback, the lower the retrogradation of the flour paste during cooling and the lower the stalling rate of the product made from the flour. The pasting temperature increased in the composite flours; sample 90M:10C and 85M:15C had the highest values (84.45°C) while sample 100M:0C had the lowest value (81.55°C). There was asignificant difference (p < 0.05) among the samples. The pasting temperature indicates the minimum temperature required for cooking the samples. Ahigher pasting temperature indicates higher water-binding capacity, higher gelatinisation tendency and lower swelling properties of starch-based flour due to the high degree of association between starch granules (Adebowale etal., 2012). Results of pasting properties of millet-carrot composite flours compared favourably with the work of Adegunwa etal. (2014).

4.1. Proximate composition and total carotenoids of millet-carrot extruded flakes
Table 6 shows the proximate composition of millet-carrot extruded flakes. The results show that composite flour had high moisture content and extrusion significantly affected all the composite

Table 6. Proximate composition of millet-carrot extruded flakes					
Sample/ Parameter	100M:0C	95M:5C	90M:10C	85M:15C	80M:20C
Moisture (%)	3.54 ± 0.03[a]	3.76 ± 0.06[b]	3.89 ± 0.03[c]	4.03 ± 0.04[d]	4.59 ± 0.01[e]
Ash (%)	1.92 ± 0.04[a]	2.97 ± 0.08[b]	1.87 ± 0.05[a]	3.57 ± 0.49[c]	2.78 ± 0.11[b]
Fat (%)	3.28 ± 0.04[c]	2.65 ± 0.09[a]	2.83 ± 0.08[b]	2.59 ± 0.06[a]	3.01 ± 0.05[b]
Crude Fibre (%)	2.84 ± 0.01[a]	3.71 ± 0.01[b]	4.14 ± 0.04[c]	4.47 ± 0.04[d]	4.53 ± 0.04[d]
Protein (%)	7.75 ± 0.06[c]	7.64 ± 0.04[c]	6.66 ± 0.25[b]	7.49 ± 0.06[c]	5.71 ± 0.16[a]
Carbohydrate (%)	80.68 ± 0.02[b]	79.28 ± 0.07[ab]	80.62 ± 0.21[b]	77.87 ± 0.45[a]	78.39 ± 1.68[a]

Mean values with the same alphabet in arow are not significantly different (p > 0.05).
Values are mean ± standard deviation of duplicate determination.
M—Millet C—Carrot.

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Table 7. Total carotenoid content of extruded millet-carrot composite flakes

Sample/ Parameter	100M:0C	95M:5C	90M:10C	85M:15C	80M:20C	CF	RC
Total carotenoid (µg/g)	0.25 ± 0.10^{a}	0.62 ± 0.06^{a}	0.83 ± 0.11^{ab}	1.46 ± 0.01^{b}	4.36 ± 0.30^{c}	7.43 ± 0.08^{d}	29.34 ± 0.65^{e}

Values are mean ± standard deviation of duplicate determination.

Mean values with the same alphabet in arow are not significantly different ($p > 0.05$).

M—Millet C—Carrot CF—Carrot flour RC— Raw (Fresh) carrot.

flakes. The increasing values were as aresult of the increase in the proportion of carrot flour in the blends. There was asignificant difference (p < 0.05) within all the samples, 100M:0C flakes had the least moisture content while 80M:20C flakes had the highest value. Higher moisture contents of the composite flours could be attributed to the high moisture predominant in raw carrots which were reported to be about 86% (Gopalan etal., 2007). However, the values recorded (3.54 to 4.59%) were lower than those of millet-wheat chin-chin reported by Adegunwa etal. (2014). Sanni, Adebowale, and Tafa (2006) also reported that the lower the moisture content of aproduct to be stored, the better the shelf stability of such products. Hence, low moisture ensures higher shelf stability of dried products.

Ash content indicates an estimate of the mineral content of products; flakes produced from sample 85M:15C flour had the highest ash content of 3.57% while samples with blending ratio 90M:10C and 100M:0C had the lowest values (1.87% and 1.92%). There was no significant difference between the ash content of the sample (p > 0.05). This suggests that incorporation of carrot flour into flour blends could enhance the mineral intake of consumers of such products (e.g. composite flakes) since carrot is known to contain appreciable mineral content. Gopalan etal. (2007) reported that carrots contain 80mg/100 g of Ca, 2.2mg/100 g of Fe and 53mg/100 g of P.

The fat contents ranged from 2.59 to 3.28%, sample 100M:0C had the highest fat content and 85M:15C had the lowest fat content. There was no significant difference (p > 0.05) among the samples. The high-fat content of millet flour could be because millet is rich in germ, which is rich in oil (Manley, 2000).

Crude fibre values increased as the proportion of carrot flour increased in the blends, while 100% millet flakes to have the lowest crude fibre content (2.84%) and 80M:20C (4.53%) with highest crude fibre. There was no significant difference between crude fibre content samples at (p > 0.05). Fibre aids in lowering blood cholesterol level and slows down the process of absorption of glucose, thereby helping in keeping blood glucose level in control (Anderson, Baird, and Richard (2009).

The protein content ranged from 5.71 to 7.75%, sample 100M:0C had the highest protein content while 80M:2C had the lowest. Observable differences were only noticed in samples 90M:10C and 80M:20C (6.66 and 5.71% respectively), while other samples were not significantly different (p > 0.05). Highest protein content in 100% millet chin-chin was also reported by Adegunwa etal. (2014), among other millet-wheat composite chin-chin.

The total carbohydrate content of the flour sample ranged from 77.87% to 80.68%, sample 100M:0C flakes had the highest carbohydrate, followed by the sample 85M:15C. There was no significant difference between the samples at (p > 0.05). The high carbohydrate values of these flours can be attributed to the carbohydrate values of their raw materials which were not so much affected by processing.

Carotenoids have been extensively studied due to their essential biological functions for humans and also as natural pigments (Gull, Prasad, & Kumar, 2015). From Table 7, extrusion did not affect the total carotenoid level of the composite flakes as no significant difference was observed in most of the samples. Although, there was an apparent increase in total carotenoid values as more carrot flour was incorporated into the blends. The carotenoid content of raw carrots was significantly higher than other samples (29.34), followed by carrot flour (7.43) and flakes composed of 80% millet and 20% carrot (4.36), while the other samples were not significantly different (p > 0.05) from each other. These results compared with that of Mridula (2011) who worked on wheat/ defatted soy/carrot composite biscuits.

4.2. Colour properties of millet-carrot composite flour extruded flakes
Colour is one of the most critical quality attributes of food products (Aly & Seleem, 2015). From Table 8, the trend showed that extrusion increased the colour profile of the composite flakes, all

Table 8. Colour properties of millet-carrot extruded flakes			
Sample	L*	a*	b*
100M:C	50.09 ± 0.07a	0.76 ± 0.02a	10.39 ± 0.00a
95M:5C	54.62 ± 0.07e	1.48 ± 0.03b	21.30 ± 0.07b
90M:10C	52.71 ± 0.02d	3.15 ± 0.05d	23.93 ± 0.01d
85M:15C	50.50 ± 0.02b	2.78 ± 0.02c	23.22 ± 0.04c
80M:2C	50.87 ± 0.0c	3.75 ± 0.04e	24.31 ± 0.01e
Carrot flour	50.42 ± 0.00b	9.37 ± 0.0f	31.73 ± 0.0f
Raw carrot	57.32 ± 0.07f	32.20 ± 0.01g	57.23 ± 0.08g

Mean values with the same alphabet in arow are not significantly different (p > 0.05).
Values are mean ± standard deviation of duplicate determination.
M—Millet C—Carrot.
L*—Lightness a*—redness b*—yellowness.

exhibiting noticeable difference (p < 0.05). The lightness (L*) value for 100% millet flakes was the least (50.09). However, the L* values of the composite flakes were higher, ranging between 50.50 and 54.62, but lower when compared to raw carrots (57.32) which ranked highest. Meanwhile, the a* (redness) value ranged from 0.76 to 32.20, showing significant differences (p < 0.05) in all the samples. Least redness was observed in 100% millet flakes, but the values increased gradually as the proportion of carrot flour increased, while 100% carrot flour had asignifcantly high a* value of 9.37 when compared to the composite flours but not as high as redness of raw carrot (32.20).

Similarly, the b* (yellowness) values showed significant difference (p < 0.05) among all the samples with the least value recorded for 100% millet flour and raw carrots having the highest (57.23). The high b* values observed in all samples containing carrot could be due to the carotenoid pigment naturally present in carrots. The differences in the results recorded for the samples could be attributed to the differences in the concentration of carrot flours in each of the blends. Results of the colour profile were in line with those of Gull etal. (2015) who worked on the effect of millet flour and carrot pomace on cooking qualities, colour and texture of developed pasta.

4.3. Sensory evaluation of millet-carrot composite flour extruded flakes
The results of sensory evaluation in Table 9 indicated that all samples had appreciable scores for likeness for all parameters evaluated. However, the composite flakes were more preferred as they ranked higher in their values. Flakes made from 90M:10C flour was most preferred in terms of colour with amean sensory score of 8.10. The increase in the degree of likeness of the colour may be as aresult of changes in the appearance that could be due to the increasing proportion of carrot

Table 9. Sensory evaluation of millet-carrot extruded flakes					
Sample/ Parameter	100M:0C	95M:5C	90M:10C	85M:15C	80M:20C
Colour	6.60 ± 1.10[a]	6.60 ± 1.05[a]	8.10 ± 0.79[b]	7.05 ± 1.82[a]	650 ± 1.79[a]
Taste	5.85 ± 1.66[a]	6.05 ± 1.90[a]	6.50 ± 1.79[a]	5.80 ± 1.58[a]	5.85 ± 1.69[a]
Texture	6.45 ± 1.54[a]	6.40 ± 1.31[a]	6.45 ± 2.28[a]	6.45 ± 1.32[a]	5.95 ± 1.67[a]
Crunchiness	6.55 ± 1.88[a]	6.60 ± 1.57[a]	6.00 ± 2.36[a]	7.10 ± 1.52[a]	5.95 ± 2.42[a]
Flavour	6.25 ± 1.71[a]	6.40 ± 1.47[a]	6.55 ± 1.76[a]	5.90 ± 1.86[a]	6.55 ± 1.57[a]
Overall acceptability	6.60 ± 1.05[a]	6.70 ± 0.98[a]	7.20 ± 1.36[a]	7.25 ± 1.02[a]	6.65 ± 1.79[a]

Mean values with the same alphabet in arow are not significantly different (p > 0.05).
Values are mean ± standard deviation of duplicate determination.
M—Millet C—Carrot.

flour. Flakes made from 90M:10C flour had the preferred taste while the texture of samples 100M:0C, 90M:10C and 85M:15C was the most preferred sensory attribute with rating score 6.45. The crunchiness of flakes produced from sample 85M:15C(7.10) was most preferred but was less preferred in term of flavour (5.90).There was no significant (p > 0.05) difference in the samples in term of taste, texture, crunchiness, flavour and overall acceptability.

The degree of likeness of the extruded flakes increased as carrot flour incorporation increased. The high sensory ratings indicate that the extruded flakes are of good quality and were accepted by the panellists. These results conformed with the work of Omah and Okafor (2015) who worked on extruded snacks from blends of millet, pigeon pea and cassava cortex flours as well as Okafor (2010) who evaluated extruded snacks from Bambara/hungry rice and carrot composite flours.

5. Conclusion

The study revealed that pearl millet and carrot composite flour are rich in magnesium, potassium, calcium, iron, zinc and other macronutrients. Thus, the flour blends are suitable for the production of nutrient-dense flour-based products in bakery and confectionery industries. The study further revealed that the sample with carrot flour produced aflake with an attractive appearance, which aids its acceptability in addition to its increased total carotenoids. The implication is that millet and carrot can be used to produced flake that is more nutritious than cornflakes that is available in the markets. Also, the carrot is useful as flake fortificant and the food product from millet-carrot flour would help to alleviate the problems of protein-energy malnutrition (PEM) and some micronutrient malnutrition in developing countries, especially Nigeria. Therefore, it could be recommended that up to 10% carrot powder could be adopted in flake making processes without affecting the quality adversely. Addition of the carrot powder will help in increasing the carotenoid in the flakes which is aprecursor of vitamin A.Finally; the study revealed that use of extrusion cooking process is useful in the production of extruded cereal-fruit based flakes because the quality of the product will not be adversely affected.

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Cover Image
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Citation information
Cite this article as: Extruded flakes from pearl millet (*Pennisetum glaucum*) - carrot (*Daucus carota*) blended flours- Production, nutritional and sensory attributes, L. A. Adebanjo, G. O. Olatunde, M. O. Adegunwa, O. C. Dada & E. O. Alamu, *Cogent Food & Agriculture* (2020), 6: 1733332.

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