American Journal of

Food Technology

ISSN 1557-4571

Academic
Journals Inc.

www.academicjournals.com

OPEN ACCESS American Journal of Food Technology

ISSN 1557-4571
DOI: 10.3923/ajft.2023.27.36

Research Article
Porridge Production by Blending Millet, Cowpea and Unripe Plantain Flours and the Quality Assessment

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Abstract

Background and Objective: Appearance is an important attribute of food because it evokes the initial response. Acceptability of food is also influenced by the behaviour of nutrients in food during processing and is referred to as functional properties. The research showed the effect of the colour of the products and the interactions of the different raw materials in producing an acceptable porridge. **Materials and Methods:** Millet grains were cleaned, decorticated, solar-dried and divided into two portions. One portion was toasted and the other was untoasted and separately milled into flour. Cowpea seeds *(apama)* were cleaned, solar-dried and were toasted, cracked, winnowed and milled into flour. Unripe plantain fingers were washed, peeled, sliced, solar dried and milled into flour. Untoasted and toasted millet, cowpea and unripe plantain flours were blended (70:20:10, 60:30:10 and 50:40:10), respectively to get a total of six blends designated as $DMCP_1$, $DMCP_2$, $DMCP_3$, $DTMCP_1$, $DTMCP_2$ and $DTMCP_3$. Colour and brown index, microbial and functional properties of blended flours were evaluated. Breakfast porridges prepared from the blends were evaluated for viscosity and sensory qualities. **Results:** The flours differed ($p<0.05$) in colour. The total viable count of toasted blends was lower ($p<0.05$) than the untoasted blends and ranged from 1.2×10^2-2.6×10^2. Coliform and mold were not detected. Water absorption capacity (130.74-154.50%), least gelation concentration (8-14%) swelling capacity (5.06-5.50%) and viscosity (5350-7390 cP) increased with toasting. Toasted blends showed higher ($p<0.05$) viscosity. **Conclusion:** Porridge prepared with blends containing toasted millet was rated higher in flavour, taste and overall acceptability. Acceptable porridge mix with microbial qualities within safe limits was obtained from blends of millet, cowpea and unripe plantain.

Key words: Porridge, colour, brown index, cowpea, millet, unripe plantain, gluten-free

Citation: Nwosu, A.N., F.I. Osum, C.C. Aniemena, C.S. Agbo and J.C. Ani, 2023. Porridge production by blending millet, cowpea and unripe plantain flours and the quality assessment. Am. J. Food Technol., 18: 27-36.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Millets are small grass used as cereal crops and grains for human. They are important crops in Africa and Asia's semiarid tropics (especially in Nigeria, Niger, Mali and India)[1]. Millet is a unique alternative to more often consumed grains. It is a good source of magnesium, phosphorus, manganese and copper among other essential elements. Millet is gluten-free and suitable for celiac disease sufferers. According to epidemiological studies, those who eat millet-based diets have fewer degenerative disorders like hypertension, diabetes and heart disease[2]. *Pennisetum glaucum* (pearl millet) used in the study is the most common millet specie.

Vigna sinensis is a cowpea variety, small in size and occurs in a mixture of two to three colours (light brown, ivory and light reddish purple) with white and black ringed eyes. This cowpea variety is popularly known as "*Apama*" around the Nsukka locality of Enugu State, Nigeria. The seeds are used by Nsukka indigenes to prepare local dishes like otipiri, abacha, achicha and are also mixed with rice to prepare jell of rice. It is a rich source of affordable protein[3]. *Apama* is one of the underexploited legumes in the sense that it is only used in traditional culinary preparations. In developing countries like Nigeria, better usage of legumes in addressing under nutrition and food security challenges is attracting research attention as well as addressing the challenges of dietary management of disease conditions.

Fibreis important because it aids in the prevention of diseases such as diabetes. Unripe plantain (*Musa paradisiacal)* is a major source of fiber. Unripe plantain contains in addition to fibre, potassium, calcium, sodium and magnesium among other minerals as well as vitamins A, C and K. It is also a good source of phytochemicals such as flavonoids, alkaloids and saponins among others which protect the body against oxidative damage thereby preventing certain health problems[4,5].

Porridge is a meal made from milled grains and or legumes prepared by boiling them in milk or water until thick. It is frequently prepared or served with flavours and sweeteners such as sugar or honey, it can be combined with spices and vegetables to give a savoury dish[6]. Porridge was formerly a common meal in Northern Europe and Russia. It was commonly made using barley, although it may also be produced with other grains or yellow peas, based on regional conditions. This was a common way of preparing cereal products for meals until leavened bread and baking became widespread in Europe[7].

Composite flour is a blend of flours derived from legumes, tubers, roots and cereals with or without wheat flour, used for different food formulations[8]. The Food and Agricultural Organization (FAO) introduced the concept of composite technology in 1964 to lower the cost of support for temperate nations by promoting the use of farm products such as maize, cassava, yam and others in partial or total replacement for wheat flour[9]. According to the FAO, the use of composite flour in different food products would be cost-effective. The use of flours derived from cereals and pulses instead of wheat flour helps to improve the nutritional quality of products. This will also help to address certain health requirements of certain groups of people.

Functional properties define how components of food react during preparation and cooking as well as the impact on the taste, appearance and texture of the finished food product[10]. These properties result from the interactions among such food components with water. Functional property contributes to the quality and organoleptic attributes of food systems[11].

The research showed the effect of the colour of the products and the interactions of the different raw materials in producing an acceptable porridge.

MATERIALS AND METHODS

Study area: The study was conducted from March 13, 2017 to December 12, 2021. Duration of the study: Four years and nine months.

Procurement of raw materials: Millet, cowpea (*apama*) and unripe plantain were sourced from Ogige market in Nsukka Local Government Area, Enugu State, Nigeria. Analytical grade chemicals were obtained from the laboratories of the Departments of Food Science and Technology and Microbiology, University of Nigeria, Nsukka where analyses were carried out.

Production of flours

Production of millet flour: Millet grains (3 kg) were cleaned manually to remove extraneous materials. The cleaned grains were washed and solar dried at 40°C±2.48 and 39±1.96% relative humidity for 8 hrs. The dried millet grains were decorticated using rice dehuller (GRANTEX, M1-8B, Scotland) and divided into two portions of 1.205 kg each. The first portion was milled using an attrition mill (Leon GX160, China) to obtain flour. The second portion (1.205 kg) was toasted at 130°C for 30 min, using a locally fabricated grain toaster, allowed to cool and milled in an attrition mill (Leon GX160, China) to obtain toasted flour. The flours were packaged in polyethylene bags and kept inside a covered plastic bucket until used for production and analysis.

Production of cowpea flour: Two kilograms of cowpea seeds (*apama*) were sorted manually bad seeds and unwanted materials were discarded upon sorting. The seeds were washed in water, drained and dried using a solar drier at 42°C±3.36 and 36±2.32% relative humidity for 8 hrs. The dried seeds were toasted at 130°C for 30 min using a locally fabricated grain toaster. The seeds were cracked using an attrition mill (Leon GX160, China). The cracked seeds were winnowed manually to remove the hulls. The dehulled cowpea seeds obtained (1.612 kg) were milled into flour using an attrition mill (Leon GX160, China). The flour was packaged in a polyethylene bag and kept inside a covered plastic bucket until used for production and analysis.

Production of unripe plantain flour: Mature unripe plantain fingers (4.850 kg) were washed and peeled to obtain 4.103 kg of peeled unripe plantain fingers. The plantain fingers were manually sliced into round pieces of about 1.5 mm thick, thinly spread for easy drying and solar dried at 41°C±2.08 and 36±1.33% relative humidity until constant weight (3.221 kg) was attained. The dried unripe plantain slices were milled in an attrition mill (Leon GX160, China), to produce unripe plantain flour. The flour was sealed in a polyethylene bag and stored inside a covered plastic bucket until used for production and analysis.

Composite flour formulation composite flours were formulated from blends of millet, cowpea and unripe plantain as shown in Table 1.

Measurement of colour: The colour (hunter L*, a* and b* values) of the flour blends was assessed using a Minolta Portable Chroma-Meter (Konica Minolta, CR-410, Japan). A white piece of paper was used to standardize the instrument. The samples were loaded in the sample container and the L*, a* and b* measurements were recorded using the Hunter Lab coordinates system. The standard values L*= 53.44, a* = -24.94 and b* = 12.94 were used to measure each sample in four places. The browning index (BI) was computed using the method of Babajide *et al.*[12]:

$$BI = 100 - L^*$$

Where:
L* = Whiteness or lightness
a* = Red-Green
b* = Yellow-Blue

Microbial analysis: The pour plate method[13] was used to evaluate the total viable count, coliform count and mould count on the samples.

Total viable count: In a test tube sample (1 g) was dispersed in 9 mL ringers solution and mixed properly by agitation to obtain a 10^1 dilution, (1 mL) of the dispersion was added into another 9 mL of ringer's solution and mixed well to obtain a 10^2 dilution. The Petri dishes were duplicated for each sample and in each plate, 15 mL of sterile nutrient agar medium was pipetted and 1 mL of each sample dilution pipetted into each medium containing plate, respectively. After that, for about 10 sec, the Petri dishes were moved in a circular motion to help mix. The plates were left to set before being incubated (inverted) at 37°C for 48 hrs. The colonies produced were enumerated using the expression:

$$\text{Number of colonies (CFU mL}^{-1}\text{)} = \text{Average x dilution factor}$$

and recorded as Colony-Forming Units (CFU).

Coliform and mold count: The method used for the total viable count was applied in the coliform count and mold count evaluation, except that MacConkey Agar (MAC) was used to prepare the medium for the coliform count and the incubation period lasted for 72 hrs at 25°C while, Sabouraud dextrose agar (SDA) was used for mold count and the incubation period was 48 hrs at room temperature (27°C).

Functional properties

Water absorption capacity (WAC): The modified method of Gandhi and Srivastava[14] was used to evaluate water absorption capacity. In weighed centrifuge tubes, 1 g of the sample was dispersed in distilled water (10 mL) and left to

Table 1: Composite flour formulation from untoasted millet, toasted millet, cowpea and unripe plantain

	Millet	Cowpea	Plantain	Sample code
Decorticated	70	20	10	$DMCP_1$
	60	30	10	$DMCP_2$
	50	40	10	$DMCP_3$
Decorticated and toasted	70	20	10	$DTMCP_1$
	60	30	10	$DTMCP_2$
	50	40	10	$DTMCP_3$

DMCP: Decorticated millet, cowpea and unripe plantain flour blends and DTMCP: Decorticated and toasted millet, cowpea and unripe plantain flour blends stand for 30 min. The sample was centrifuged (Lab AIDS) at 2,000 rpm for 30 min. The tube was weighed after the supernatant was removed. The water absorption capacity (grams of water per gram of sample) was calculated using the expression:

$$\text{WAC} = \frac{W_2 - W_1}{W_0}$$

Where:
W_0 = Weight of dry sample (g)
W_1 = Weight of tube and dry sample (g)
W_2 = Weight of tube plus sediment (g)

Least gelation concentration: The method of Onwuka[15] was used for the determination of gelation concentration. In test tubes, sample suspensions of 4-20% (w/v) were prepared with 5 mL distilled water. The sample test tubes were heated in a boiling water bath (Serological water bath, BST/SWB 14, India) for 1 hr before being quickly cooled under running tap water. The test tubes were then cooled for another 2 hrs at 4°C. The concentration at which the sample from the inverted test tube did not fall or slip was designated as the least gelation concentration.

Swelling capacity: The method given by Makanjuola *et al.*[16] was used to determine swelling capacity. In a 300 mL measuring cylinder, ten grams of the sample were weighed. Into the sample, distilled water (150 mL) was added and left to stand for 4 hrs. The final volume after swelling was recorded and the percentage of swelling was computed as follows:

$$\text{Swelling capacity (\%)} = \frac{\text{Final volume} - \text{Initial volume}}{\text{Initial volume}} \times \frac{100}{1}$$

Viscosity of porridge: The viscosity of porridge samples was determined using a Brookfield viscometer. Analysis was carried out immediately after cooking the porridge (90 to 95°C). Samples viscosity was determined with a standard Dial Reading Brookfield rotational viscometer (Ametek, RVT series, USA). Each sample (40 g) was dispersed in 200 mL of distilled water and made up to the 250 mL mark. The spindle (no. 7) was fixed and the speed was selected (100 rpm). The pointer was adjusted to be at 0 reading when clutched down. The viscometer was switched on and the reading was taken after 10 rotations for each of the samples to obtain the dial reading used in calculating the viscosity as:

$$\text{Viscosity} = \text{Dial reading} \times 400 \text{ (cP)}$$

400 = Factor for 100 rpm for spindle number 7.

Preparation of porridge: The porridge was cooked according to the method of Yadav *et al.*[17]. A 5:1 water-to-sample ratio was used to make a dispersion of each sample. Half the quantity of water was used initially to reconstitute the samples and was heated for 5 min on the burner with continuous stirring until slurry was formed, then the remaining half of the water was added and the mixture was stirred continuously for 10 min. Then burner was turned off, while, stirring was continued for 60 sec to avoid the formation of lumps.

Sensory evaluation: Sensory evaluation of the product was conducted using twenty panelists made up of students and staff of the Department of Food Science and Technology, University of Nigeria, Nsukka. The samples were sweetened with sucrose coded and presented in identical containers. Samples were evaluated for taste, appearance, flavour, mouth-feel (graininess, heaviness, slipperiness) aftertaste and overall acceptability using a nine-point Hedonic scale ranging from 9 (liked extremely) to 1 (disliked extremely) as described by Ihekoronye and Ngoddy[18].

Experimental design and data analysis: The research was laid out on a Complete Randomized Design (CRD) using a Statistical Package for Service Solution (SPSS) software version 23 and the method of Steel *et al.*[19] for Analysis of Variance (ANOVA). Duncan's New Multiple Range Test (DNMRT) was used to differentiate the means. Statistical significance was accepted at a 5% level of significance ($p<0.05$).

RESULTS AND DISCUSSION

Graded composites of processed flours: Composites of the processed flours blended in different ratios was shown in Fig. 1.

Colour and brown index of blends of decorticated untoasted millet, toasted millet, cowpea and unripe plantain flours: The colour and brown index of the blends was shown in Table 2. The L* coordinates ranged from 74.14 to 80.39, a* coordinates ranged from 0.78 to 1.86 and b* coordinates ranged from 12.60 to 14.65. In all the L*, a* and b* values, significant ($p<0.05$) differences were observed among the samples. This is because the blends contain varying levels of all the raw materials. Expectedly as the level of millet decreased the lightness coordinate L* increased because of the effect of toasting. Samples containing toasted millet ($DTMCP_1$, $DTMCP_2$ and $DTMCP_3$) showed lower L* coordinate values (74.14, 76.23 and 77.24) when compared to samples

Fig. 1: Photographic presentation of graded composites of processed flours

$DMCP_1$: Decorticated untoasted millet: Cowpea: Unripe plantain (70:20:10), $DMCP_2$: Decorticated untoasted millet: Cowpea: Unripe plantain (60:30:10), $DMCP_3$: Decorticated untoasted millet: Cowpea: Unripe plantain (50:40:10), $DTMCP_1$: Decorticated toasted millet: Cowpea: Unripe plantain (70:20:10), $DTMCP_2$: Decorticated toasted millet: Cowpea: Unripe plantain (60:30:10) and $DTMCP_3$: Decorticated toasted millet: Cowpea: Unripe plantain (50:40:10)

Table 2: Colour and brown index of graded composites of untoasted millet, toasted millet, cowpea and unripe plantain flours

Samples	L*	a*	b*	BI
$DMCP_1$	77.54 ± 0.36^c	1.86 ± 0.03^e	14.02 ± 0.06^d	22.46 ± 0.36^c
$DMCP_2$	79.18 ± 0.92^d	1.71 ± 0.05^d	14.36 ± 0.12^e	20.82 ± 0.92^b
$DMCP_3$	80.39 ± 0.40^e	1.51 ± 0.03^c	14.65 ± 0.04^f	19.61 ± 0.40^a
$DTMCP_1$	74.14 ± 0.26^a	1.10 ± 0.13^b	12.60 ± 0.18^a	25.86 ± 0.26^e
$DTMCP_2$	76.23 ± 0.69^b	0.85 ± 0.56^a	12.81 ± 0.05^b	23.77 ± 0.69^d
$DTMCP_3$	77.24 ± 0.32^c	0.78 ± 0.04^a	13.62 ± 0.06^c	22.76 ± 0.32^c

Values are means of 3 replications±SD, Means within the same column with different superscripts are significantly different ($p<0.05$), $DMCP_1$: Decorticated untoasted millet: Cowpea: Unripe plantain (70:20:10), $DMCP_2$: Decorticated untoasted millet: Cowpea: Unripe plantain (60:30:10), $DMCP_3$: Decorticated untoasted millet: Cowpea: Unripe plantain (50:40:10), $DTMCP_1$: Decorticated toasted millet: Cowpea: Unripe plantain (70:20:10) ,$DTMCP_2$: Decorticated toasted millet: Cowpea: Unripe plantain (60:30:10), $DTMCP_3$: Decorticated toasted millet: Cowpea: Unripe plantain (50:40:10), L*, a* and b*: Hunterlab color coordinate system and L*: Whiteness, a*: Red-Green, b*: Yellow-Blue and BI: Brown index

containing untoasted millet. This is attributed to the influence of the presence of the toasted millet.

The results of the a* and b* coordinates seem to indicate that the blends contain more yellow-blue pigments than red-green pigments. The positive a* values indicate the predominance of red colour over green and subsequently positive b* values indicate the predominance of yellow over the blue colour in all the samples[20], documented L* values that ranged from 79.58 to 86.99 for blends of pigeon pea, sweet potato and unripe cooking banana flours. These values were comparable to the L* values ranging from 74.14 to 80.39 obtained in the present study although the raw materials differ. The appearance of the product was slightly adversely affected by toasting.

Samples containing toasted millets ($DTMCP_1$, $DTMCP_2$ and $DTMCP_3$) showed higher ($p<0.05$) brown index with values of 25.86, 23.77 and 22.76, respectively, when compared to samples $DMCP_1$, $DMCP_2$ and $DMCP_3$ which recorded values of 22.46, 20.82 and 19.61, respectively. With the addition of millet flour, the brown index increased. This was an indication that untoasted and toasted millet flours exhibited the highest brown index.

Microbial count of raw materials and blends: The microbial count of untoasted millet, toasted millet, cowpea and unripe plantain flours and blends was shown in Table 3. Total viable counts of samples ranged from 1.2×10^2 (TOMIL) to 2.6×10^2 ($DMCP_1$ and $DMCP_2$). The difference in total viable count in the blends can be attributed to the handling of the materials during processing this implies that some of the samples were more prone to microbial contamination than others. Toasted sample blends had a lower total viable count than the untoasted sample blends. Though the observed microbial count for all the samples was generally low. Generally, heat treatment such as toasting reduces micro-organisms and enzyme activity and improves keeping the quality of food

Table 3: Microbial count of raw materials and blends

Samples	Total viable count (TVC)	Coliforms	Mold
UNTOMIL	1.8×10^2	ND	ND
TOMIL	1.2×10^2	ND	ND
COP	1.6×10^2	ND	ND
PLAN	2.0×10^2	ND	ND
$DMCP_1$	2.6×10^2	ND	ND
$DMCP_2$	2.6×10^2	ND	ND
$DMCP_3$	2.4×10^2	ND	ND
$DTMCP_1$	2.0×10^2	ND	ND
$DTMCP_2$	1.7×10^2	ND	ND
$DTMCP_3$	1.5×10^2	ND	ND

Values are means of 2 replications, ND: Not detected, UNTOMIL: Decorticated untoasted millet, TOMIL: Decorticated toasted millet, COP: Toasted dehulled cowpea, PLAN: Unripe plantain, $DMCP_1$: Decorticated untoasted millet: Cowpea: Unripe plantain (70:20:10), $DMCP_2$: Decorticated untoasted millet: Cowpea: Unripe plantain (60:30:10), $DMCP_3$: Decorticated untoasted millet: Cowpea: Unripe plantain (50:40:10), $DTMCP_1$: Decorticated toasted millet: Cowpea: Unripe plantain (70:20:10), $DTMCP_2$: Decorticated toasted millet: Cowpea: Unripe plantain (60:30:10) and $DTMCP_3$: Decorticated toasted millet: Cowpea: Unripe plantain (50:40:10)

Table 4: Selected functional properties of blends of untoasted millet, toasted millet, cowpea and unripe plantain flours (%)

Sample	WAC	LGC	SC
$DMCP_1$	130.74 ± 0.45^a	8 ± 0.00	5.06 ± 0.04^a
$DMCP_2$	135.49 ± 0.61^b	8 ± 0.00	5.10 ± 0.07^a
$DMCP_3$	142.33 ± 1.87^c	10 ± 0.00	5.14 ± 0.04^a
$DTMCP_1$	146.74 ± 2.88^d	10 ± 0.00	5.33 ± 0.07^b
$DTMCP_2$	149.77 ± 0.27^d	12 ± 0.00	5.42 ± 0.06^{bc}
$DTMCP_3$	154.50 ± 3.82^e	14 ± 0.00	5.50 ± 0.11^c

Values are the mean of 3 replications±SD, Means within the same column with different superscripts are significantly different ($p<0.05$), WAC: Water absorption capacity, LGC: Least gelation concentration and SC: Swelling capacity, $DMCP_1$: Decorticated untoasted millet: Cowpea: Unripe plantain (70:20:10), $DMCP_2$: Decorticated untoasted millet: Cowpea: Unripe plantain (60:30:10), $DMCP_3$: Decorticated untoasted millet: Cowpea: Unripe plantain (50:40:10), $DTMCP_1$: Decorticated toasted millet: Cowpea: Unripe plantain (70:20:10), $DTMCP_2$: Decorticated toasted millet: Cowpea: Unripe plantain (60:30:10) and $DTMCP_3$: Decorticated toasted millet: Cowpea: Unripe plantain (50:40:10)

products[21]. However, total viable counts of flours and blends were within acceptable limits of 10^7 CFU g^{-1} for flours[22].

Coliform was neither detected in the raw materials nor the blends suggesting that the water used for processing was potable. There were no environmental or faecal contaminations. There was also no mold growth in the blends. This might be explained to be as a result of the low moisture levels of the samples. From the result of this research, it was expected that the flours and blends will be shelf-stable.

Selected functional properties of the blends of untoasted millet, toasted millet, cowpea and unripe plantain flour: Selected functional properties of the blends of untoasted millet, toasted millet, cowpea and unripe plantain were shown in Table 4. The flour blends showed significant ($p<0.05$) differences in functional properties. The water absorption capacity of the blends ranged from 130.74% in $DMCP_1$ to 154.50% in $DTMCP_3$. Water absorption capacity is of the essence in the preparation of porridge and high absorption capacity is an indication of product cohesiveness[23]. The water absorption capacity of flour is dependent on various parameters which include amylose/amylopectin ratio, inter and intra-molecular forces and particle size[24]. In the present study as the proportion of cowpea increased in the blends water absorption capacities of the blends also increased which negates the report of Olapade *et al.*[25] that the water absorption capacity of blends of plantain and cowpea decreased with an increase in cowpea flour inclusion and reported values that ranged from 150 to 170%. The toasted samples also recorded higher levels of water absorption capacity due probably to their relatively low moisture content which made them have a high attraction for water. The observed trend can be a reflection of the functional property of the individual flours.

The least gelation concentration (LGC) of the blends increased with an increase in the proportion of cowpea flour in the blend and ranged from 8-14%. Generally, the toasted samples recorded higher LGC values than the untoasted samples. The observed differences in the least gelation concentration of the blends may be attributed to the relative ratios of proteins, carbohydrates and lipids in the flours and the blends[26]. High protein concentration improves the relationship between binding forces, which improves the ability of the flour to gel[26,27] reported LGC values that ranged from 6-8% for blends of cowpea and unripe plantain flours. The observed range of LGC in the sample blends suggests that the blends may be useful in food systems like porridge which require thickening and gelling especially samples $DMCP_3$ and $DTMCP_3$.

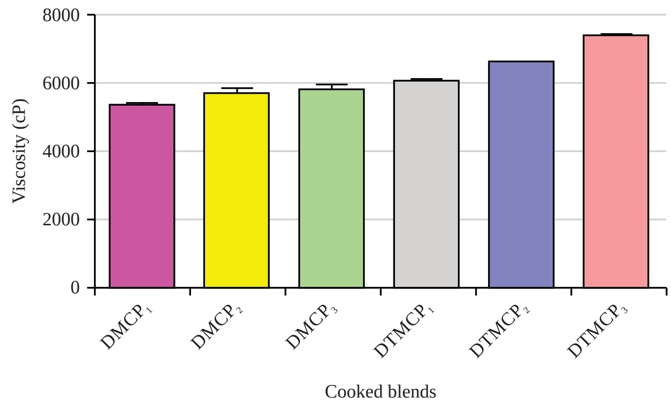

Fig. 2: Viscosity of cooked blends

$DMCP_1$: Decorticated untoasted millet: Cowpea: Unripe plantain (70:20:10), $DMCP_2$: Decorticated untoasted millet: Cowpea: Unripe plantain (60:30:10), $DMCP_3$: Decorticated untoasted millet: Cowpea: Unripe plantain (50:40:10), $DTMCP_1$: Decorticated toasted millet: Cowpea: Unripe plantain (70:20:10), $DTMCP_2$: Decorticated toasted millet: Cowpea: Unripe plantain (60:30:10) and $DTMCP_3$: Decorticated toasted millet: Cowpea: Unripe plantain (50:40:10)

Table 5: Mean sensory scores of blends of untoasted millet, toasted millet, cowpea and unripe plantain flours used for breakfast porridge production

Samples	Appearance	Taste	Flavour	Graininess	Heaviness	Soapiness	After taste	Overall acceptability
$DMCP_1$	6.15 ± 1.14^{a}	6.75 ± 0.72^{d}	6.20 ± 0.77^{b}	4.75 ± 1.02^{c}	5.00 ± 0.79^{ab}	6.05 ± 0.99^{b}	3.80 ± 1.01^{ab}	6.90 ± 0.72^{b}
$DMCP_2$	5.85 ± 0.88^{a}	6.45 ± 0.78^{cd}	5.70 ± 0.73^{ab}	4.60 ± 0.68^{bc}	5.45 ± 0.94^{bc}	5.20 ± 1.11^{a}	4.25 ± 1.21^{bc}	6.45 ± 0.89^{b}
$DMCP_3$	6.90 ± 1.25^{b}	6.05 ± 0.99^{abc}	5.35 ± 0.81^{a}	3.85 ± 0.93^{a}	6.35 ± 1.04^{d}	5.70 ± 0.73^{ab}	5.35 ± 0.75^{d}	6.40 ± 0.68^{b}
$DTMCP_1$	5.80 ± 0.89^{a}	5.80 ± 0.70^{a}	8.05 ± 0.83^{c}	4.20 ± 0.70^{ab}	4.85 ± 0.67^{a}	5.55 ± 0.76^{ab}	3.45 ± 0.83^{a}	6.45 ± 0.94^{b}
$DTMCP_2$	6.05 ± 0.51^{a}	6.40 ± 0.82^{bcd}	7.95 ± 0.76^{c}	4.50 ± 0.61^{bc}	5.85 ± 0.67^{cd}	5.85 ± 0.67^{b}	4.45 ± 0.76^{c}	6.95 ± 0.89^{b}
$DTMCP_3$	7.65 ± 0.67^{c}	5.90 ± 7.88^{ab}	8.05 ± 0.94^{c}	5.00 ± 0.73^{c}	6.30 ± 0.73^{d}	5.60 ± 0.82^{ab}	5.05 ± 1.03^{d}	6.84 ± 0.83^{b}

Values are mean of 20 replications±SD, Values within the same column with different superscripts are significantly different ($p<0.05$), $DMCP_1$: Decorticated untoasted millet: Cowpea: Unripe plantain (70:20:10), $DMCP_2$: Decorticated untoasted millet: Cowpea: Unripe plantain (60:30:10), $DMCP_3$: Decorticated untoasted millet: Cowpea: Unripe plantain (50:40:10), $DTMCP_1$: Decorticated toasted millet: Cowpea: Unripe plantain (70:20:10), $DTMCP_2$: Decorticated toasted millet: Cowpea: Unripe plantain (60:30:10) and $DTMCP_3$: Decorticated toasted millet: cowpea: unripe plantain (50:40:10)

The swelling capacity of sample blends containing toasted samples differed ($p<0.05$) significantly in comparison to the blends containing untoasted samples. The values varied from 5.06 for sample $DMCP_1$ to 5.50 for sample $DTMCP_3$ with toasted samples recording higher scores. Generally, there was an increase in swelling capacity with an increase in the proportion of cowpea flour. Reduction in the moisture level of samples due to toasting increased the sample's affinity for water, thus encouraging greater uptake of water in the toasted samples compared to the untoasted samples. The swelling capacity of blends depends on particle size, raw materials used and unit operations employed. The swelling capacity observed in the present study shows that porridge produced from the blends will have the required consistency for porridge made for elderly adults which is the target group. This was lower than the values of 7.03 to 9.89%, reported by Eke-Ejiofor and Kporna[28] for cowpea and Acha flour blends. This may be because of the differences in processing methods used, the disparity in raw material combination and also the particle size of the raw materials.

Viscosity of cooked blends of untoasted millet, toasted millet, cowpea and unripe plantain flours: The viscosity of cooked blends was represented in Fig. 2. Viscosity ranged from 5350 cP for sample $DMCP_1$ to 73904 cP for sample $DTMCP_3$. Significant ($p<0.05$) differences existed amongst blends in viscosity. It was noticed that toasted samples were higher in viscosity than untoasted samples. Viscosity also increased with an increase in the proportion of cowpea flour. Wanink *et al.*[29] made a similar observation with roasted whole grains which increased in viscosity from 11.300 cP to 47.600 cP. The ability of cowpea flour to gel easily also influenced the viscosity of the blends. No observed quantitative guide exists on the consistency of porridge that should be accepted. The World Health Organization[30] recommendation that porridge should not drop from a spoon is subjective implying that the consistency of a good quality porridge varies with individual preferences. However, it is generally accepted that the consistency of porridge for adults should be thick (highly viscous). The blends in the present study produced highly viscous porridges.

Sensory quality of breakfast porridge made from the blends: Table 5 showed the mean sensory scores for appearance, taste, flavour, mouth-feel (graininess, heaviness and soapiness), aftertaste and general acceptability of the porridge prepared from the blends. The mean sensory score for appearance ranged from 5.80 for sample $DTMCP_l$ to 7.65 for sample $DTMCP_3$. There was no significant ($p>0.05$) difference in all the samples in appearance scores except samples $DMCP_3$ and $DTMCP_3$ which differed ($p<0.05$) significantly from each other and from other samples. Appearance is an important attribute of food because it evokes initial acceptance or rejection. Samples $DMCP_3$ and $DTMCP_3$ containing the highest levels of cowpea flour were rated higher with scores of 6.90 and 7.65, respectively than the other samples in appearance. This suggested that the higher level of cowpea flour inclusion in the blend had a positive impact on the appearance of the porridge. Panelists appreciated the colour more probably because the cowpea was dehulled before milling into flour.

Scores for taste ranged from 5.80 for $DTMCP_1$ to 6.75 for $DMCP_1$. Significant ($p<0.05$) differences existed amongst samples. Sample $DMCP_2$ and $DTMCP_2$ (6.45 and 6.40, respectively) did not differ ($p>0.05$) significantly in taste both samples contain 60% millet, 30% cowpea and 10% unripe plantain respectively. While sampling $DMCP_l$ which contains the least level of cowpea and the highest level of millet was observed to be the most preferred as evidenced by the score of (6.75). According to Meilgaard *et al.*[31] some factors influence taste perception, these factors include age, hunger, health condition, adaptation to a given taste and taste medium.

The rating for flavour varied from 5.35 to 8.05. There were significant ($p<0.05$) differences among samples in flavour. The mean sensory scores show that all porridge samples were acceptable to the panelists. However, the samples containing toasted millet $DTMCP_1$, $DTMCP_2$ and $DTMCP_3$ were preferred with scores of 8.05, 7.95 and 8.05, respectively which were significantly ($p<0.05$) higher than those of the samples containing untoasted millet $DMCP_1$, $DMCP_2$ and $DMCP_3$ which scored 6.20, 5.70 and 5.35, respectively.

The toasting of the millet probably impacted positively on the flavour of the samples hence the observed higher flavour score. Maillard reaction takes place during toasting, the sugars in the aleurone layer react with the amino acids in the millet to produce a product with a highly pleasant and delectable aroma[32]. Toasting also reduced the beany flavour associated with cowpeas. Thus, the samples containing toasted millet with its nutty flavour and also toasted cowpea became the most preferred by the panellists as evidenced by the higher sensory scores. The flavour of a food is described as the delicate yet complicated interplay of taste and smell that gives each person a pleasant or unpleasant sensory experience. Although the appearance of the meal elicits an initial reaction, it is the taste that eventually decides whether a consumer accepts or rejects it.

The physical feeling in the mouth created by food or drink is referred to as mouth-feel. It can also be referred to as texture[33]. Mouth-feel descriptor words include among many others graininess, heaviness and slipperiness (soapiness) as used in the present study.

Graininess is the degree to which a sample contains small grainy particles. The samples used in the study were purposefully not sieved after milling. The samples generally recorded low acceptability ranging from 3.85 for sample $DMCP_3$ to 5.00 for sample $DTMCP_3$. There were significant ($p<0.05$) differences amongst the samples in graininess. Not sieving the flours affected the mouth-feel and the sensory scores for mouth-feel because normally many porridge-type foods are smooth in the mouth but the samples used in the present study lack that smoothness[34].

Heaviness refers to the weight of the product perceived when first placed on the tongue. Sensory scores ranged from 4.25 for sample $DTMCP_1$ to 6.35 for sample $DMCP_3$. Significant ($p<0.05$) differences were recorded amongst samples in heaviness. As the proportion of millet flour increased heaviness also increased. As a result, the two sample blends containing the highest level of millet flour $DMCP_3$ and $DTMCP_3$ scored 6.35 and 6.30, respectively. The heaviness experienced is expected as the samples were also observed to have a high viscosity (resistance to flow). The heaviness is acceptable when the targeted group is the elderly as a result they are not expected to take breakfast porridge that is of a light (not heavy) consistency. For example in the formulation of complementary foods the viscosity (heaviness) of the food is increased as the child increases in age and development.

Scores for soapiness ranged from 5.20 for sample $DMCP_2$ to 6.05 for sample $DMCP_1$. Significant ($p<0.05$) differences existed amongst samples in soapiness. Soapiness (slipperiness) refers to the degree to which the product slides over the tongue. One of the qualities of a good porridge is the ability to slide over the tongue. Samples were acceptable to panelists.

The aftertaste is the lingering taste remaining in the mouth after eating or drinking. Significant ($p<0.05$) differences existed amongst porridge samples in the aftertaste. Average sensory scores for aftertaste varied from 3.45 for sample $DTMCP_1$ to 5.35 for sample $DMCP_3$. The aftertaste score was observed to increase with the increased addition of cowpea in the blend. This was probably due to the beany flavour associated with cowpeas. The cowpea used in the present study was toasted and toasting is believed to have helped in reducing this beany flavour.

Mean sensory scores for overall acceptability ranged from 6.40 for sample $DMCP_3$ to 6.95 for sample $DTMCP_I$. There was no significant (p>0.05) difference among samples in overall acceptability. This showed that the samples were all acceptable. Although, samples containing toasted millet were preferred and so received higher sensory ratings.

CONCLUSION

Acceptable porridge mix with microbial qualities within safe limits was obtained from blends of millet, cowpea and unripe plantain. The composite flours can also be used in other food formulations such as snacks.

SIGNIFICANCE STATEMENT

To a great extent, Nigeria still depends on imported foods, while there are some under-utilized agricultural crops that can be used to ensure food security. One way of improving the nutritional status of the populace is by encouraging complementation which can be achieved by the use of composite flour formulations in food preparations. From this research, a novel product was added to the academic society it was established that the different treatments given to the raw materials and blending them in different proportions affected the colour and functional properties of the resultant product. It also helped to establish through the microbial qualities of the product that the handling of the raw materials was under aseptic conditions and municipal water supply potable.

ACKNOWLEDGMENT

The authors wish to acknowledge the assistance of the laboratory staff of the Department of Food Science and technology and the Department of Micro Biology, University of Nigeria Nsukka.

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