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Full Length Research

Physicochemical Properties and Acceptability of Staple-based Breakfast Cereals

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Abstract

Consumption of cereals is very essential due to the considerable amount of nutrients they provide, especially in wholesome nature. Staple-base breakfast cereals are nutrient dense, more readily available while meeting the traditional food habit of the people. The present study assessed the physicochemical and organoleptic properties of breakfast cereals produced from yellow corn, millet, sorghum, groundnuts, soybean and dates. Fermentation and boiling methods were used to process samples to flour. Applying food-to-food fortification principles, twelve ready-to-use composite gruel (50sg:50sy; 60sg:40sy; 40sg:60sy; 50m:50sy; 60m:40sy; 40m:60sy) and whole cereal (35yc:35sy:10g:20d; 50yc:30sy:10g:10d; 30yc:50sy:10g:10d; 35sg:35sy:10g:20d; 50sg:30sy:10g;10d; 30sg:50sy:10g:10d) flours were formulated and subjected to physical, chemical and sensory evaluations following standard methods. Result revealed high vitamin C (19.16-42.36 mg gruel and 22.77-39.20 mg whole cereal) and improved protein (7.86-17.5%-gruel and 8.4-8.2% whole cereals) composition in cereal products. Anti-nutrient composition of cereal flours were found to be within the acceptable limit for human, ranging from 0.06-0.58% (phytate), 0.13-0.39% (oxalate), 0.51-0.86% (tannin) to 0.91-2.21% (saponin). Higher viscosity (trough-36-634, breakdown-42-255, setback-41-683, peak-164-889 & final-88-1317 RVU) and pasting temperature (82-90°C) was observed in gruel flours while whole cereal flours recorded higher peak-time (5.2-6.9 RVU). The study revealed low microbial (7.2×10^4-2.0×10^5 cfu/g) and fungi (1.1×10^3 - 6.2×10^4 sfu/g) counts in composite cereal flours. Breakfast gruels were found to be acceptable to the taste panel members, ranking higher than the control (100% millet) in all the parameters, though not significant (P>0.05). On the other hand, no significant (P>0.05) difference was found in the taste of the control (Golden Morn) and whole cereal with 20g dates. Slight increase in weight was recorded in gruel (0.05kg) and whole cereal (0.3kg) composite flours after fortification. The potential of dates as a natural sweetener in the traditional food production was explored and culturally acceptable staple-base cereals achieved.

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INTRODUCTION

Grains are carbohydrate rich food consumed across the globe. Major grain cereals in Nigeria are rice, maize, sorghum, fonio, and millet. These grains are usually incorporated into traditional meals or processed into breakfast cereals, and usually consumed in the morning or mid-afternoon, as the case maybe. Consumption of low or moderately processed cereals is crucial for humans due to the considerable amount of energy, mineral and dietary fiber they provide (Yang *et al*., 2020). According to Lee *et al.* (2021), regular consumption of whole grain cereals contribute to numerous health benefits which include, reducing risk of heart diseases and diabetes by 20-30% (Lee *et al*., 2020). The World Health Organization in conjunction with the Food and Agricultural Organization (FAO), equally recommend regular consumption of whole grains, legumes, nuts, fruits and vegetables as healthier dietary guideline (FAO/WHO, 2019).

Globally, cereal grains are important staples and are readily available to the population. Maize (*Zea mays*) also known as corn is the third most important carbohydrate source food (Britannica, 2023) and most consumed breakfast cereal in Nigeria (Ikem *et al.,* 2023). Sorghum (*Sorghum bicolor*) the fifth most consumed cereal worldwide (FAO, 2020) has gained popularity over the years as a preferred starch component in traditional diets and infant weaning foods in Nigeria. The sudden increase in sorghum utilization is linked to its high starch composition (Farcas*et al*., 2021), slow starch digestibility (Hossain *et al*., 2022), binding agent (dos Santos *et al.,* 2022), antioxidants, anti-inflammatory and antibacterial effects (Verma and Srivastav, 2020; Punia *et al.*, 2021; Pontieri *et al*., 2021; Mohamed, 2022). Millet (*Eleusine coracana*) is the sixth most consumed cereal in Africa and Asia (Shahidi and Chandrasekar, 2013) and the least consumed in typical traditional diets, especially in the south-eastern Nigeria, possibly due to lack of awareness on its dietary benefit or cultural barrier.

Legumes are seeds of plants from the Family Fabaceae (beans, peas, and lentils), consumed globally for their nutritional (proteins, fiber, carbohydrates, vitamins, and minerals) and health benefits (Çakir *et al.,* 2019; Samtiya *et al*., 2021). Legumes such as soybean (*Glycine max*) and groundnut (Arachis hypogaea*)* remain the cheapest source of plant protein and healthy fatty acids for majority of the population in Nigeria. Generally, legumes contain anti-nutrients which possibly, hinder their maximum use in traditional dishes. However, moderate consumption of anti-nutrients in cereals and legumes has been associated with numerous health benefits (Petroski and Minich, 2020). In addition to protein (22-30%/100g) and fatty acid (44-56%), groundnut contains appreciable amount of vitamins, minerals and dietary fiber (Atli, 2023).On the other hand, dates (*Phoenix dactylifera*) are fruit from date palm, valued for its natural sweetness and excellent source of vitamins, minerals, dietary fiber and antioxidants (Richter and Elliott, 2022). Dates fruits are produced in the northern region of Nigeria and consumed across the 36 states of the country (Zaka, 2021).

Staple foods constitute a major portion of the diet of a given population, well familiar and desired by the people. Staple grains like maize, sorghum, millet and soybean are cultivated in Nigeria. In fact, Nigeria is the largest producer of maize in Africa, recorded up to 11 million metric tons in 2019 (Adedotun, 2022). The impact is indeed felt by the common man, as fresh maize is now consumed all through the season (January-December) across Nigeria for the past 5 years. Also, production of sorghum and soybean have equally increased (FAO, 2022; Sasu, 2023) in Nigeria. According to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) (ICRISAT, 2021), Nigeria accounts for 41% of the total groundnut production in West Africa. Obviously, maize, sorghum, soybean and groundnut are readily available in Nigeria. Availability is one of the key components of food and nutrition security. It is not proper that, with the availability of staples, majority of Nigerians still rely on imported processed cereals as regular breakfast. These available staples could provide additional healthier and culturally acceptable diets for the people of Nigeria, when processed in diverse forms.

Granted, research in the utilization of maize, sorghum, and soybean as complementary infant weaning food and traditional diets is well established (Ezekiel*et al.,* 2022; Gwer *et al.,* 2020; Egbujie and Okoye, 2019; Sengev*et al.,* 2016; Agugo *et al*., 2013), but, potentials of staples in diverse food production cannot be exhausted. There is limited research in the area of food-to-food fortification in traditional food production. Therefore, the present study aimed at determining phytochemical composition, microbial count and acceptability of cereal-legume based composite gruel and whole cereal flours sweetened with dates.

MATERIALS AND METHODS

Procurement of Food Materials

The major food materials, sorghum, soybean, millet, maize (yellow) and dates were procured from Ekpoma main market, Edo State, Nigeria.

Equipment/facility

Equipment (gas cooker, Electrothermaloven (model DHG), Laboratory dry oven (DNG-9140), Healthy breaking wall extraction machine (MOWHOOT6 8000 Br), metal pots, 2&5 millimeter plastic and stainless sieves, muslin cloth, transparent plastic buckets, measuring cups& spoons, ceramic plates and trays, blender, black and white nylon (polyethylene bags), and airtight plastic containers) in the food processing laboratory of Department of Human Nutrition and Dietetics, Ambrose Alli University Ekpoma were used for sample processing.

Processing Method

Gruel flour samples (composed of sorghum-soybean and millet-soybean)

Chaff and dirt were thoroughly removed from 500g of food material (sorghum/millet) using a plastic tray. Cleaned grains (sorghum/millet) were steeped in clean transparent plastic bucket with water covering the sample, and washed every 24 h. After 48 h, wet sample was drained in a stainless sieve, spread lightly on a black nylon and dried on a pave inside the drying circuit of the Faculty of Life Sciences. Sample was removed from drying circuit at 5pm each day and spread on laboratory work surface to continue drying under room temperature (27 ± 2°C) (to avoid further fermentation), during solar drying, sample was covered with clean muslin cloth to further reduce environmental contamination. After 72 h of drying (solar cum room temperature), dried sample was milled into flour with local milling machine, sieved with muslin cloth (2 mm) and packaged in air tight plastic container.

Soybean grains (1kg) were picked to remove chaff and dirt in a plastic tray, shared into two equal parts. A portion (500g) was steeped in a clean plastic bucket overnight, washed and boiled (wet heat treatment) for 45 mins. The sample was poured into a metal sieve to cool, thereafter, soy sample was washed to remove seed coat, spread lightly in an oven tray and dried at 60°C for 24 h in the laboratory oven (DNG-9140). Sample was milled into powder to obtain soy milk powder using a Healthy breaking wall extraction machine (MOWHOOT6 8000 Br), and packaged in an airtight container.

Whole cereal flour samples (composed of yellow maize-soybean-groundnut-date and sorghum-soybean-groundnut-date). Half a kilogram (500g) of dry grain (sorghum/yellow corn) was cleaned to remove dirt and debris, steeped in clean transparent plastic container with lid for 16 h to soften the kernel. Thereafter, it was washed and boiled for 60 minutes on a gas cooker and allowed to drain and cool in a stainless sieve. Thereafter, the boiled sample was spread lightly on a black nylon and dried under the sun and at room temperature for 48 h. Dried sample was milled into flour using a local milling machine and packaged in an airtight plastic container. The second portion (500g) of fermented soybean seed was toasted (dry heat treatment) over a heat (gas cooker) for 60 mins, dehulled and blended, and packaged in an airtight plastic container.

Groundnut (200g) was toasted over a low gas heat for 20 minutes while dates (200g) were cleaned, washed and dried for 48 h in Electrothermal oven (model DHG), at 60°C, ground into flour and stored in an airtight plastic container for further use.

Formulation of Cereals

Ten to twenty gram (10-20g) of each composite flour sample (12) was packaged, properly coded and sent to the laboratory for chemical, physical and microbial analysis. Bulk of the composite flours was reconstituted to gruel or whole cereals with boiled water (100°C) for the sensory (organoleptic) evaluation.

Chemical Analysis

Two to ten (2 -10)g of flour sample (gruel/whole cereal) was subjected to chemical analysis to determine protein and phyto-chemicals (phytate, oxalate, tannin, saponin and Vitamin C) compositions, using the standard methods of the Association of Official Analytical Chemists (AOAC, 2010). Microbial growth count was determined using the standard method of Cheesbroug (2006). Pasting properties was determined using the Rapid Visco Unit (RVU) apparatus as described by Gamel *et al.,* 2012.

Sensory Evaluation

Thirty (30) trained taste panel members from the Faculty of Life Sciences evaluated the samples. Gruel and whole cereal samples were evaluated for taste, aroma, appearance, texture and general acceptability. Ten gram (1 table spoon) of sample was placed in a clean ceramics bowl and served to taste panel members one at a time. Clean water was provided for rinsing of mouth after evaluating each sample. Ranking was based on 9-point Hedonic scale where 1- represents disliked extremely and 9- liked extremely (Maren, 2021).

Statistical Analysis

A one-Way Analysis of variance (ANOVA) was used to determine mean variations from the triplicate scores generated from chemical laboratory analysis, on Excel Spread sheet. Duncan Multiple Range Test (DMRT) was used to rank means of various parameters (taste, texture, aroma, appearance & general acceptability) obtained from organoleptic evaluation.

RESULTS AND DISCUSSION

Protein and phytochemicals properties

The formulation of composite cereal flours, the protein and phytochemical composition of staple- based complementary cereals are shown in Tables 1 and 2. Protein composition of composite cereal flours ranged from 6.38-18.2g. This finding conformto the range reported in fermented maize and defatted baobab seed flour blends (Ezekiel, Adedeji and Umuokeke, 2022) and higher than the range reported in complementary millet, soya bean and *Moringa oleifera* leaf Flour blends (Gwer *et al.,* 2020). Vitamin C content of flour samples ranged from 19.16-42.36 g (gruel) and 22.77-39.23g (whole cereal), higher than the range reported in similar researches (Gwer *et al.,*2020; Ezekiel *et al*., 2022; Sengev *et al.,* 2016). The observed high vitamin C content could be attributed to the variation in the food (sorghum, yellow maize, and soybean) components and the fermentation process applied. An indication that regular consumption of staple-base cereals could help individuals meet daily vitamin C requirement in addition to boosting the immune system (Carr and Maggini, 2017). Anti-nutrient composition found in composite flour samples were generally low and within tolerable limit for plant foods. Phytate (0.06-0.21g), oxalate (0.16-0.38g) and tannin (0.59-0.8g) composition of cereals conform to the range reported in millet-soybean- *Moringa oleifera* leaf complementary food (Gwer*et al.,*2020).The observed low ant-nutrients in cereals could be linked to fermentation and boiling methods applied in sample processing. The level of anti-nutrient found in gruel and whole cereal composite flours could be beneficial to health (Petroski

Table 1. Formulation of composite cereal flours/

Sample	Food Material					
Gruel		Sorghum	Millet	Soybean		Proportion (%)
A		50	-	50		50sg:50sy
B		60	-	40		60sg:40sy
C		40	-	60		40sg:60sy
D		-	50	50		50m:50sy
E		-	60	40		60m:40sy
F		-	40	60		40m:60sy

Whole Cereal	Sorghum	Yellow corn	Soybean	groundnut	Date	Proportion (%)
A	-	35	35	10	20	35yc:35sy:10g:20d
B	-	50	30	10	10	50yc:30sy:10g:10d
C	-	30	50	10	10	30yc:50sy:10g:10d
D	35	`-	35	10	20	35sg:35sy:10g:20d
E	50	-	30	10	10	50sg:30sy:10g:10d
F	30	-	50	10	10	30sg:50sy:10g:10d

* sg-sorghum; sy-soybean; m-millet.
* yc- yellow corn; sg-sorghum; sy-soybean; g-groundnut; d-dates

Table 2. Protein and phytochemical composition of staple- based complementary cereals.

Sample	Parameter					
Gruels	Protein (%)	Vitamin C (mg/100g)	Phytate (%)	Oxalate (%)	Tannin (%)	Saponin (%)
SS-A	7.86±0.01	27.5±0.03	0.08±0.01	0.32±0.02	0.74±0.02	1.31±0.02
SS-B	8.06±0.03	20.36±0.03	0.3±0.01	0.39±0.01	0.77±0.02	1.44±0.01
SS-C	17.5±0.00	42.54±0.06	0.07±0.02	0.28±0.01	0.78±0.01	1.36±0.01
SM-D	8.56±0.02	23.25±0.03	0.11±0.02	0.21±0.01	0.76±0.02	0.91±0.03
SM-E	6.83±0.03	34.94±0.02	0.58±0.03	0.15±0.02	0.54±0.03	1.11±0.02
SM-F	16.31±0.03	19.16±0.01	0.155±0.01	0.29±0.01	0.86±0.01	1±0.01
P-value	**0.05**	**0.008**	**0.009**	**0.009**	**0.012**	**0.008**
Whole cereals						
YCSGD-A	8.4±0.12	38.43±0.03	0.21±0.02	0.16±0.02	0.65±0.03	2.15±0.01
YCSGD-B	14.9±0.01	29.41±0.03	0.17±0.01	0.26±0.03	0.59±0.03	2.16±0.02
YCSGD-C	15.7±0.02	27.05±0.01	0.1±0.01	0.13±0.01	0.66±0.01	2.21±0.01
SSGD-D	9.6±0.03	31.85±4.35	0.13±0.01	0.38±0.02	0.51±0.01	1.27±0.01
SSGD-E	16.3±0.11	27.25±0.02	0.19±0.01	0.26±0.02	0.8±0.02	1.53±0.02
SSGD-F	18.2±0.1	25.32±0.03	0.06±0.00	0.24±0.01	0.69±0.01	1.41±0.01
P-Value	**0.07**	**0.06**	**0.121**	**0.178**	**0.183**	**0.172**

***Mean on the same column is not significant at P>0.05**
Gruel samples: SS-A(50sg:50sy); SS-B(60sg:40sy);SS-C(40sg:60sy);SM-D(50m:50sy); SM-E(60m:40sy);SM-F (40m:60sy). Whole cereal samples:YCSGD-A(35yc:35sy:10g:20d);YCSGD-B(50yc:30sy:10g:10d);YCSGD-C(30yc:50sy:10g:10d);SSGD-D(35sg:35sy:10g:20d);SSGD-E(50sg:30sy:10g:10d);SSGD F(30sg:50sy:10g:10d).

and Minich, 2020).

Pasting properties

Trough viscosity of gruel flour samples ranged from 11 -170 RVU (SSG) to 400-634 RVU (SM) (Table 3). This is lower than the range reported in varieties of corn starch (Moses and Olanrewaju, 2018), but higher than the range reported in cereal-legume based complementary foods (Egbujie and Okoye, 2019; Olagunju-Yusuf *et al*., 2020). Contrarily, trough viscosity of whole cereals (35-58 RVU YCSGD; 29-42 WCSW; and 30- 46 SSGD) conforms to the range reported in similar researches (Egbujie and Okoye, 2019; Olagunju-Yusuf

Table 3. Pasting properties of staple-based complementary cereals.

Sample	**Parameters (RVU)**						
Gruels	**Trough**	**Break down viscosity**	**Final viscosity**	**Peak viscosity**	**Set Back**	**Peak Time**	**Pasting temperature**
SS-A	204±72.5	170±9.5	639±14	412±0.57	397±5	5.1±0.07	90.5±0.0
SS-B	36±1.52	176±39.5	88±21	223±43	41±17.5	6.8±0.03	88.8±0.35
SS-C	121±0.0	42±1.73	302±6	164±2.08	179.3±5.85	4.9±0.07	92.6±0.32
SM-D	400±2	123±4.5	765±0.5	523±6.5	365±1.52	4.9±0.03	87±0.05
SM-E	634±2	255±2.51	1317±15.5	889±4.5	683±13.5	4.9±0.03	84±0.05
SM-F	517±2	182±4.5	880±3.05	706±5.5	439±8.32	4.5±0.05	82±0.4
p-value	**0.007**	**0.005**	**0.006**	**0.05**	**0.011**	**0.005**	**0.009**
Whole Cereals							
YCSGD-A	48±0.5	6±0.0	87±8.5	54±0.5	39±9	6.9±1.08	-
YCSGD-B	58±3	8±0.0	97±3.51	66±3	38±1.52	6.9±0.1	-
YCSGD-C	35±2.51	11±7	59±1.52	47±8.5	22±0.5	6.7±0.05	-
SSGD-D	40±0.5	8±2.64	54±0.0	48.6±3.05	13±0.57	5.2±0.03	-
SSGD-E	46±3.5	11±7	48±2.08	47±8.5	23±0.57	6.1±0.39	52±0.95
SSGD-F	30±0.5	3 ±0.5	47±0.5	33±1	17±0.0	6.6±0.19	-
P-value	**0.006**	**0.02**	**0.009**	**0.009**	**0.011**	**0.008**	**-**

*** Mean on the same column is not significant at P>0.05**.
Gruel samples: SS-A(50sg:50sy); SS-B(60sg:40sy);SS-C(40sg:60sy);SM-D(50m:50sy); SM-E(60m:40sy);SM-F(40m:60sy).
Whole cereal samples: YCSGD-A(35yc:35sy:10g:20d); YCSGD-B(50yc:30sy:10g:10d); YCSGD-C(30yc:50sy:10g:10d);SSGD-D(35sg:35sy:10g:20d);SSGD-E(50sg:30sy:10g:10d);SSGD F(30sg:50sy:10g:10d)

et al., 2020). The decrease in trough viscosity of the whole cereals is an indication that whole cereal samples cannot withstand breakdown on cooling (Bolarinwa *et al*., 2015). This could be attributed to processing (boiling) method and possibly the fiber content of cereals.

Higher range of 11-255 RVU break down viscosity was found in gruels than whole cereals 3-11 RVU. Sorghum based cereals recorded least break down viscosity in both the gruel and whole cereals. This finding is contrary to the range eported in sorghum-bambara nut blends (Olagunju- Yusuf *et al*., 2020) but conforms to the range reported in sorghum, African yam bean and crayfish blends (Egbujie and Okoye, 2019). With low breakdown viscosity, whole cereals paste could be stable on heating and cooling temperatures (Ohizua *et al.,* 2017), an indication that staple-based whole cereals could be consumed hot or cooled as desired. Final viscosity of gruels (88-1317RVU) were higher than the range found in whole cereals (46 -97 RVU). This finding is similar to the range reported in cereal-legume based complementary foods (Olagunju- Yusuf *et al*., 2020; Chhabra *et al.,* 2018). Moses and Olanrewaju (2018) reported higher (2648 -3095 RVU) range of final viscosity in corn starch flours. Again, higher peak (164-889 RVU) and setback (41- 683RVU) viscosities were recorded with gruels as against 33-66 RVU (peak) and 13-39 RVU (setback) for whole cereals. This conforms to the range reported in cereal flours (Coulibaly *et al.,* 2022; Shivananda *et al*., 2015; Chhabra *et al*., 2018) and cereal-legume based complementary foods (Olagunju-Yusuf *et al*., 2020; Egbujie and Okoye, 2019; Assam *et al.,* 2018). This finding could be an indication of high swelling capacity of gruel samples compared to whole cereals. However, the observed low peak viscosity in whole cereal is advantageous and could be linked to the processing (fermentation and boiling) methods used.

Peak time of gruel flour samples (4.5- 5.1 RVU) were slightly lower than the range observed in whole cereal samples (5.2 -6.9 RVU) with the exception of sample B (60% sorghum: 40% soybean). Peak time for both the gruel and whole cereal flour samples were low and do not conform to the range reported by Assam *et al.* (2018). This finding is an indication that composite gruel flour samples will cook faster than the whole cereal blends, possibly due to the wholesomeness of the food components. The pasting temperature (82°C-92.6°C) of gruels was high. Similarly, high pasting temperature (75-95°C) have been reported in cereal-legume based complementary blends (Ezekiel *et al.,* 2022; Olagunju-Yusuf *et al*., 2020; Egbujie and Okoye, 2019). This is an indication that gruel flour samples could be resistance to swelling and need to be reconstituted on high temperature (boiling point). With the exception of SSGD-B (52°C) sample, no pasting temperature was recorded with whole cereals. This could be attributed to the retrogradation of starch resulting from the boiling of yellow corn and sorghum during processing.

Microbial count

The microbial count is presented in Table 4. It was found that the bacterial count for whole cereals ranged from 2.0 x $10^4$to 2.5 x 10^5cfu/g for YCSGD-A and SSGD-E, respectively, while fungi count ranged from 1.8 x 10^3 to 7 .1 x 10^5sfu/g. This

Table 4. Microbial count in staple-based complementary cereals.

Sample	Mean total microbial count	
Gruels	**Bacterial (cfu/g)**	**Fungi (sfu/g)**
SS-A	ND	3.4 x10^3
SS-B	ND	4.5 x 10^4
SS-C	ND	1.8 x 10^3
SM-D	ND	7.1x 10^5
SM-E	ND	ND
SM-F	ND	ND
Whole cereals		
YCSGD-A	2.0 x 10^4	1.5 x10^3
YCSGD-B	ND	ND
YCSGD-C	2.0 x 10^5	1.3 x 10^4
SSGD-D	ND	6.7 x 10^3
SSGD-E	2.5 x 10^5	1.9 x 10^4
SSGD-F	ND	ND

*Gruel: SS-A(50sg:50sy); SS-B(60sg:40sy); SS-C(40sg:60sy); SM-D(50m:50sy); SM-E(60m:40sy); SM-F(40m:60sy).
*Whole cereal samples: YCSGD-A(35yc:35sy:10g:20d); YCSGD-B(50yc:30sy:10g:10d); YCSGD-C(30yc:50sy:10g:10d)**;** SSGD-D(35sg:35sy:10g:20d); SSGD-E(50sg:30sy:10g:10d); SSGD F(30sg:50sy:10g:10d)
*ND= Not determined

finding corresponds with the range reported in previous researches (Agugo *et al.,* 2020; Mwangi *et al*., 2019; Ijah *et al*., 2014).The high microbial and fungi counts observed in the composite flours could be attributed to the handling of food materials during processing, especially the blending aspect. Bacteria and fungi counts for most cereals and gruels were not determined. However, the range observed in staple-based cereal samples were within safe level for human consumption, according to the International Commission on Microbiological Specifications for Foods (ICMSF, 1996) and the Microbiological Guidelines for Foods (MGF, 2014).

Organoleptic properties

Staple-based gruels and whole cereals were acceptable to the taste panel members, ranking above 5.0 in all the parameters tasted (Table 5). Gruel sample with 40% sorghum and 60% soybean ranked highest in all the parameters though not significant (P>0.05). Gruel produced from 100% millet was not acceptable to the taste panel members ranking below 5-points in all the parameters and was significantly (P<0.05) lower than gruel samples in texture, aroma and general acceptability. Ranks obtained for the staple-based breakfast cereals (gruels and whole cereals) conform to the level reported in similar research (Assam *et al*., 2018). On the other hand, whole cereal samples were liked by the taste panel members, ranking above 5.0 in almost all the parameters. Whole cereals with 20 g dates (YCSGD-A and SSGD-D) were more acceptable though significantly (P<0.5) different with the control sample (Golden Morn) in appearance. The acceptability of staple-based breakfast cereals could be attributed to the food-to-food fortification process applied.

Generally, control sample (Golden Morn) was more acceptable to the taste panel members, ranking above 8.0 in all the parameters tasted, though not significant (P>0.05) in general acceptability with whole cereal samples. This finding could be attributed to the processing (fermentation, boiling and drying) methods applied in sample preparation and possibly due to the fact that the panel members are already familiar with Golden Morn. Notwithstanding, ranks obtained in the staple-based whole cereal samples conform to the range reported in maize-groundnut-ginger blend (Ijarotimi, 2022) and maize-soybean-banana blends (Ezeokeke and Onuoha, 2016), but higher than the range reported in maize-soybean-pumpkin composite flour (Assam *et al*., 2018).

Conclusion

The present research generated ready-to-use culturally acceptable breakfast cereals with high vitamin C composition, especially from, sorghum-based cereals. Fermentation and boiling processing methods improved the phytochemical, pasting and organoleptic properties of staple-based breakfast cereals. Interestingly, food-to-food fortification resulted in a slight higher yield in composite form, from 1.5kg (grain) to1.55 kg (composite flour) for gruels and from 1.9 kg (grain) to2.2 kg (composite flour) for whole cereals. In other words, food-to-food fortification could be viable in the production of less toxic and affordable plant based foods. This research exposed the potential of dates as a natural sweetener in cereal based food

Table 5. Organoleptic properties of staple-based complementary cereals

Sample	Parameters				
	Taste	Texture	Aroma	Appearance	General Acceptability
SS-A	5.6[ab]	5.6[ab]	6.5[ab]	6.28[ab]	6.09[ab]
SS-B	6.23[ab]	6.14[ab]	6.61[ab]	5.95[ab]	6.3[ab]
SS-C	6.62[a]	6.47[ab]	7.19[a]	7.04[a]	6.9[ab]
SM-D	5.04[ab]	6.14[ab]	5.48[ab]	5.42[ab]	6[ab]
SM-E	6.04[ab]	6.3[ab]	6.5[ab]	6.42[ab]	6.3[ab]
SM-F	5.71[ab]	5.76[ab]	6.31[ab]	6.23[ab]	6[ab]
Control-G	6.28[ab]	6.23[ab]	6.47[ab]	6.6[ab]	6.7[ab]
Control-H	4.28[ab]	4.1[bc]	4.28[bc]	4.9[ab]	4.5[bc]
Whole Cereals					
YCSGD-A	7.15[ab]	6.6[ab]	6.1[ab]	5.15[bc]	7.05[ab]
YCSGD-B	6.1[ab]	6.3[ab]	5.8[bc]	5.8[ab]	6.15[ab]
YCSGD-C	6.7[ab]	6.4[ab]	6.25[ab]	6.55[ab]	6.4[ab]
SSGD-D	7.75[ab]	7.1[ab]	7.05[ab]	5.5[bc]	7.05[ab]
SSGD-E	6.35[ab]	6.8[ab]	5.55[bc]	5.75[ab]	6.1[ab]
SSGD-F	6.4[ab]	6[ab]	5.45[bc]	4.95[bc]	6.3[ab]
CONTRO-G	8.7[ab]	8.4[a]	8.59[a]	8.3[a]	8.7[a]

*** Mean on the same column with same letter is not significant at P>0.05**.
Gruel samples: SS-A (50sg:50sy); SS-B(60sg:40sy);SS-C(40sg:60sy);SM-D(50m:50sy); SM-E(60m:40sy);SM- F(40m:60sy); Control-G(00 % Sg); Control-H(100% M)
Whole cereal samples: YCSGD-A(35yc:35sy:10g:20d); YCSGD-B(50yc:30sy:10g:10d);YCSGD-C(30yc:50sy:10g:10d);SSGD-D(35sg:35sy:10g:20d);SSGD-E(50sg:30sy:10g:10d);SSGD-F(30sg:50sy:10g:10d);Control-G (100%Goldenmorn).

formulation. There is need for further research to ascertain the shelf life of the most acceptable (SS-C, YCSGD-A & SSGD-D) staple-based breakfast cereals.

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