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Nutritional composition, Glycaemic index and Sensory attributes of some flours commonly consumed in Nigeria

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ABSTRACT

Alternative foods are being recommended as replacements for excessively starchy and sugary foods due to the rise in the prevalence of diet-related diseases globally. This study aimed to determine the proximate composition, glycaemic index (GI), and sensory attributes of processed cassava flour and some cereal flours (finger millet, black fonio, rye). Cassava flour was purchased, while the cereals were bought and processed into fine flour. Laboratory analyses were carried out to determine the proximate content of the flours using AOAC standard methods. Sensory evaluation of the flours (made into stiff porridges) was carried out using a 9-point hedonic scale. Quantitative data were analysed using SPSS; ANOVA was performed, and significant difference was accepted at $p<0.05$. The protein content of rye flour (10.55±0.03%) was significantly higher, while cassava flour recorded the lowest protein value (2.86±0.02%). Rye flour also had the highest concentration of dietary fibre (9.76±0.02%) and fat (4.14±0.02%) compared to others. Carbohydrate content in cassava flour (82.68%) was significantly ($p<0.05$) higher compared to others. GI ranged from 42.73±0.05 (cassava) to 52.73+0.07 (rye). Sensory evaluation of stiff porridges made from the flours showed that cassava flour recorded the highest overall acceptability. From the findings of this research, cereal flours are relatively better sources of protein and dietary fibre than roots/tubers like cassava, which makes them healthy alternatives to starchy staples especially in the management of over nutrition.

Keywords: cereals, flour, nutrition, glycaemic index, sensory properties

1. Introduction

Cereal is a member of the grass family (*Gramineae*) cultivated for the edible components of its grain or kernel (Luithui *et al.*, 2019). Various grains are cultivated worldwide, such as wheat, maize, sorghum, millet, and rice. These cereals have been vital crops for thousands of years, and their prosperous cultivation, preservation, and utilisation have played a noticeable role in worldwide advancement (Rajkumar and Selvakulasingam, 2019). Some cereals contain important nutrients such as folate, thiamine, niacin, dietary fibre, iron, manganese, and zinc (Laskowski *et al.,* 2019). Finger millet, rye, black fonio, maize, millet, sorghum, and rice are important cereal grains in Nigeria, providing a significant source of food and income for millions of Nigerians (Adigwe *et al.*, 2022). They are grown in greater quantities and provide more food energy worldwide than any other type of crop (Hancock, 2012). Cereal-based foods are a major source of energy, protein, vitamins and minerals for the world population.

On the other hand, cassava (*Manihot esculenta* Crantz) is a very common food crop that is important in the tropics and a major carbohydrate staple consumed in various forms. Cassava forms a base for various fermented foods in Africa, Asia, Brazil, India and America. In addition, it serves as raw material for manufacturing processed foods, animal feed, and industrial products (Taiwo 2016). Nigeria's main products of considerable domestic importance are *garr*i (*eba*), cassava flour and fufu. These are starchy and popularly eaten alongside native 'soups' prepared using indigenous vegetables and legumes.

There have been a lot of advancements in understanding the role of nutrition in the maintenance of health and disease prevention in the last ten years. The relationship between dietary intake and chronic diseases (such as diabetes and obesity) has been scrutinised (Venkat-Narayan *et al.*, 2010). People are being taught to make healthy dietary choices in order to improve health and wellbeing. In some African countries, such as Mauritius and Namibia, non-communicable diseases (NCDs) cause over 50% of all reported adult deaths (World Health Organization, 2020). In Nigeria, NCDs are estimated to account for 24% of total deaths, and the probability of dying between the ages of 30 and 70 years from the four main NCDs (cancer, diabetes, cardiovascular diseases, and chronic respiratory disease) is 20% (World Health Organization, 2014). This increase in the incidence rates of diet-related NCDs has emphasised the prevention/management of diseases using dietary intervention (Venkat-Narayan *et al.,* 2010).

Epidemiological studies have demonstrated that a high intake of carbohydrates with a high glycaemic index produces greater insulin resistance and thus greater risk of Type II diabetes than the intake of low GI carbohydrates does. Additionally, high GI and glycaemic load of overall diet are associated with greater risk of coronary heart disease in both men and women. Animal models have also revealed that high GI foods promote insulin resistance, fat synthesis and the risk of hypertension and obesity (Brand-Miller, 2014). Evidence from medium term studies suggest that replacing high GI carbohydrates with low GI foods will improve both blood sugar and blood lipid levels in people with diabetes, in addition to reducing hypoglycaemic episodes (Willett *et al.*, 2012).

However, one sustainable agricultural approach to reduce malnutrition among people at the highest risk (i.e. resource-poor women, elderly people, infants and children) is to enrich major staple food crops with micronutrients through nutritional enrichment strategies; this includes the production of composite flours using micronutrient rich cereals (WHO and FAO, 2003). The concept of glycaemic index (GI) was proposed by Jenkins *et al.* (2002) to characterise the rate of carbohydrate absorption after a meal. GI is defined as the area under the glucose response curve after the consumption of 50g of carbohydrate from a test food divided by the area under the curve after the consumption of 50g of carbohydrate from a control food, either white bread or glucose (Wolever *et al.*, 2011). There is a need for more research into the GI of our locally consumed foods to produce data that can effectively enable the use of GI along with other dietary recommendations in treating, managing and preventing diseases like diabetes.

Furthermore, sensory evaluation is key in determining the acceptability of food products to consumers. No matter how potent a product is, it will not be incorporated into their diets if it is not palatable and appealing to consumers. Consumer acceptability and, consequently, their consumption and purchasing behaviour are heavily influenced by sensory factors, especially flavour and health considerations. Therefore, this study sought to determine the proximate composition, GI and sensory properties of some flours (cassava, finger millet, black fonio and rye) commonly consumed in Nigeria.

2. Methodology

This research design was experimental, and a quantitative approach was employed.

Sample Collection and Preparation

The four samples were purchased from three different locations in Nigeria: cassava flour (Calabar), rye (Jos), black fonio, and finger millet (Benue). All samples were conveyed to the Department of Human Nutrition and Dietetics, University of Calabar, Calabar, for sample preparation. First, a botanist from the Department of Plant and Ecological Studies, University of Calabar identified and authenticated the samples. The cereal samples (finger millet, black fonio and rye) were prepared by sorting, selecting, and then washing them thoroughly under running water to remove any surface dirt, debris, or other contaminants before draining. The samples were sun-dried for three days before grains were ground into a fine powder using a miller (Retsh ZM 200 miller, Germany). The flours were placed and sealed in labelled ziploc bags and sent to the laboratory for analysis. The purchased cassava flour was also opened and put in a clean ziploc bag. These steps were taken to ensure that the samples were in a consistent state for analysis and to minimise any potential variability in the results due to differences in moisture content or other factors.

Laboratory analyses

Determination of Moisture Content

Moisture content was determined using the standard method of the Association of Official Analytical Chemists (AOAC, 2010); 2g of the sample was weighed into a dried crucible. The sample was put into a moisture extraction oven at 105°C and heated for 3hours. The dried samples were put into a desiccator, allowed to cool, and reweighed. The difference in weight was calculated as a percentage of the original sample.

$$\% \text{ moisture} = \frac{\text{Weight of original sample - weight of dry sample}}{\text{Weight of original sample}} \times 100$$

Determination of Protein

Protein content was determined using the Kjeldahl method (AOAC, 2010).

Digestion: One gram of the protein sample was weighed and introduced into the bottom of a 500ml Kjeldahl flask, then 20ml of concentrated H_2SO_4 was added and mixed gently by swirling under tap water. Exactly 10g of anhydrous Na_2SO_4 and 1g of $CuSO_4$ were mixed together and 3g of mixture was introduced into the flask. Anti-bumping chips were added into the mixture and the Na_2SO_4 and $CuSO_4$ mixture in the Kjeldahl as catalyst. The entire mixture in the Kjeldahl flask was gently heated in a fume cupboard until charred particles disappeared and a clear green solution was obtained. The digest mixture was made up to 100ml with distilled water.

Distillation: Ten millilitres of 2% boric acid were measured into a 25ml beaker, and a methyl red indicator was added. Exactly 10ml of the digest was placed in the distillation flask, and 30ml of 40% NaOH was slowly added from a syringe to 10ml of the digest. The heating system was switched on and done continuously for 25 minutes. The receiver beaker was removed, and the distillate was filtered with 0.1N HCl until the endpoint.

Determination of Fat Content

The fat content was determined using the Soxhlet extraction method, according to AOAC (2010). A 500ml capacity round bottom flask was filled with 300ml petroleum ether and fixed to the Soxhlet extractor; 2g of sample was placed in a labelled thimble. The extractor thimble was sealed with cotton wool. Heat was applied to reflux the Soxhlet apparatus for six hours. The thimble was removed carefully, and the petroleum ether was recovered for reuse. When the flask was free of petroleum ether, it was removed and dried at 105ºC for 1 hour in an oven. The flask was removed from the oven, cooled in a desiccator and weighed. The weight of fat extract was expressed as a percentage of the weight of the analysed sample and is given by the expression below:

$$\% \text{ Fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times \frac{100}{1}$$

Determination of Ash

Ash determination was carried out according to AOAC's (2010) procedure. Two grams of sample were placed in a silica dish, ignited, cooled and weighed. The dish and sample were ignited gently and then at 550ºC in a muffle furnace for 3 hours until a white or grey ash was obtained. The dish and contents were cooled in a desiccator and weighed.

$$\% \text{ Ash} = \frac{W_3 - W_1}{W_2 - W_1} \times \frac{100}{1}$$

where,

W_1 = weight of dish

W_2 = weight of dish + sample before ashing

W_3 = weight of dish + sample after ashing

Determination of Dietary Fibre

Dietary fibre was determined by the enzymatic-gravimetric method, as described by Wichchukit and O'Mahony (2015). Five (5) grams of each sample was cooked at 100ºC with heat stable α-amylase for 30 minutes (in 100ml of distilled water) to gelatinize, hydrolyse and de-polymerise the starch. The gelatinized hydrolysed sample was incubated at 60^oC with protease (to solubilise and de-polymerise proteins) and amyloglucosidase then filtered. The residue was further rinsed with water, leaving the soluble fibre (SF) in the filtrate solution and the insoluble fibre (IDF) trapped in the filter as residue.

Insoluble Dietary Fibre (IDF): The insoluble component collected from the filter (residue) was dried, weighed and duplicated. One duplicate was analysed for protein and the other for ash; the IDF was obtained as the weight of residue less weight of protein and ash, i.e. IDF = Residue – (protein + ash).

Soluble Dietary Fibre (SDF): Four vol. of 95% ethyl alcohol was added to the filtrate to precipitate the other soluble component (SDF) from the initial filtration solution. This was rinsed with water, then collected by filtration, dried, weighed and duplicated. Also, one duplicate of the SDF was analysed for protein and the other for ash; the soluble fibre (SDF) was obtained as the weight of residue less weight of protein and ash, i.e. SDF = Residue – (protein + ash).

Total dietary fibre is calculated as the sum of IDF and SDF: TDF = IDF + SDF.

Determination of Crude Fibre

Two grams of the sample with one gram of asbestos was put into 200ml of 1.25% H_2SO_4 and boiled for 30 minutes. The solution and the content were poured into a Buchner funnel equipped with muslin cloth and secured with an elastic band. This was allowed to filter, and the residue was put into 200ml boiled NaOH. Boiling was allowed to continue for 30 minutes, then transferred to the Buchner funnel and filtered. It was then washed twice with alcohol, and the material obtained was washed three times with petroleum ether. The residue obtained was put in a clean, dry crucible and dried in the moisture extraction oven to a constant weight. The dried crucible was removed, cooled and weighed. The difference in the weight was calculated as the percentage of the original sample.

$$\%\ \text{Crude fibre} = \frac{\text{Weight of oven dried sample} - \text{weight of sample after incineration}}{\text{Weight of sample taken}} \times \frac{100}{1}$$

Determination of Carbohydrate

The carbohydrate content was determined by difference according to AOAC (2010), as follows:

% Carbohydrates = 100 - (% moisture + % fat + % ash + % protein + % dietary fibre)

Determination of Energy value

The values obtained for protein, fat and carbohydrate were used to calculate the energy value of the samples using the Atwater formula as described by FAO (2003) and the value is expressed as kilocalories (kcal):

Protein content (%) = P

Fat content (%) = F

Carbohydrate content (%) = C

Energy value (Kcal/100g) = P x 4.0 + F x 9.0 + C x 4.0

Glycaemic Index Determination

This was determined using a rapid *in vitro* assessment method developed by Goni *et al.* (1997) using GOD-PAD glucose kit (Laborlab, Brazil) and the colour reaction was measured in a UV/VIS spectrophotometer, model DU 70 (Beckman, USA), at λ = 505 nm. Exactly 2g of sample was first homogenised with a miller of 15000 rpm and 40 ml buffer at 37^{o}C. Orthophosphoric acid and 2ml of pepsin solution were added and placed in a shaking water bath at 37^{o}C for 1 hour. The solution was later adjusted to a pH of 6.8±0.2 with 58% KOH; 2ml amylase solution was added and transferred, then put in 500ml flask with 400ml buffer solution at 37^{o}C and placed inside a shaking water bath at 37^{o}C. A 40ml solution was extracted, and sugar concentration was determined using spectrometry method. Glucose digestion rate was expressed through the percentage of glucose in each sample (mg glucose x 100 mg^{-1} sample) at each time interval (0, 30, 60, 90, 120, 150, and 180 minutes). Hydrolysis curves were built (disregarding the value at time 0), and the area below the hydrolysis curves was calculated (Auc).

The carbohydrate concentration values were plotted on a graph, and the glucose area under the curve (AUC) was determined.

Hydrolysis index (HI) = $\frac{Auc}{Aus} \times \frac{100}{1}$

where Auc is the area under the curve of the sample

Aus is the area under the curve of the reference sample (white bread)

in vitro GI = 39.71 + 0.549 x HI

Sensory evaluation

The sensory evaluation was conducted using a 9-point hedonic scale (Wichchukit & O'Mahony, 2015), and a panel of 20 members. The sensory evaluation panel comprised academic and non-academic staff of the Department of Human Nutrition and Dietetics. The coded stiff porridge samples were given to the panellists to assess for colour, aroma, taste, texture, and general acceptability. The process was carried out in the Department's sensory booths. Each sensory evaluation was rated on a 9-point hedonic scale, which was graded thus:

9 - Extremely desirable

8 - Very much desirable

7 - Moderately desirable

6 - Slightly desirable

5 - Neither desirable nor undesirable

4 - Slightly undesirable

3 - Moderately undesirable

2 - Very much undesirable

1 - Extremely undesirable

Preparation of stiff porridges from the flours

The procedure was as follows -

1. Clean tap water was put in a pot and allowed to boil.
2. One (1) cup of each flour was measured and poured gently into the boiling water separately.
3. This was then stirred properly to allow the flour to dissolve in the water and form a thick paste. Stirring was continued for about 10 minutes until cooked to form a stiff porridge
4. The fire was turned off, and the pot was taken off the heat.
5. The v stiff porridges were then allowed to cool before serving them in clean bowls.

An indigenous soup 'ogbono' (usually slimy and prepared with some leaves and meat) was served with the porridge to the panellists for the sensory evaluation. After tasting each stiff porridge, the panellists recorded their results on the 9-point hedonic scale printed out for each one of them. There was no interaction or conversation between the panellists. Each panellist was given water to rinse their mouth after trying each stiff porridge to eliminate the carry-over effect.

Statistical analysis

Laboratory results generated from this study were analysed using the Statistical Package for Social Science (SPSS) version 20.0. In order to compare the nutrient values and check for significant differences among groups, a one-way analysis of variance (ANOVA) was used. The results were expressed as mean ± SEM for 3 determinations, and statistical significance was accepted at $p<0.05$ (95 % confidence level). Values obtained from the 9-point hedonic scale were used to calculate the mean scores of the sensory evaluation for the organoleptic properties of the stiff porridges for aroma, colour, taste, texture and general acceptability on a Microsoft Excel sheet.

3. Results

Proximate composition and energy values of the edible flours

The macronutrient content and the calculated energy values for the cassava and cereal flours are shown in Tables 1a and 1b. The flours had a significant content of protein, with rye flour having the highest concentration of protein (10.55 ± 0.03%), while cassava flour recorded the least (2.86 ± 0.02%). Carbohydrate values ranged from 71.11 ± 0.04% (in rye) to 82.68 ± 0.00% (in cassava flour), and all the values significantly differed among themselves ($p<0.05$). For energy values, both black fonio and rye flours had statistically similar ($p>0.05$) values of 363KiloJoules (KJ), while finger millet flour had the lowest energy value (353.68 ± 0.20KJ). Ash content ranged from 1.78 ± 0.02% in black fonio flour to 2.17 ± 0.01% in rye flour. Notably, cassava flour had a significantly ($p<0.05$) lower glycaemic index (GI) value (42.73 ± 0.05), while rye flour recorded the highest GI (52.73 ± 0.07). In Table 1b, the dietary fibre results are presented. Once again (as seen in the case of crude fibre), rye flour had a significantly higher concentration of total dietary fibre - TDF (9.76 ± 0.02%), while cassava recorded the least TDF (7.91 ± 0.01%). Rye flour also had the highest value for insoluble dietary fibre (IDF), which was 5.78 ± 0.00%, but on the other hand, black fonio flour had the highest soluble dietary fibre (SDF) content of 4.25 ± 0.03%.

TABLE 1a: Proximate composition of the edible flours (in %)

Flours	Moisture	Ash	Protein	Crude fibre	Fat	Carbo-hydrate	Energy (kilojoules)	Glycaemic index
Cassava	9.83 ±0.01	1.79 ±0.01	2.86 ±0.02	2.86 ±0.02	1.59 ±0.01	82.68 ±0.00	356.40 ±0.02	42.73 ±0.05

Finger millet	10.26 ±0.02*	1.86 ±0.02*	8.65 ±0.05*	8.65 ±0.05*	1.79 ±0.01*	75.66 ±0.15*	353.68 ±0.20*	46.32 ±0.59*
Black fonio	10.17 ±0.01*,[a]	1.78 ±0.02[a]	7.37 ±0.03*,[a]	7.37 ±0.03*,[a]	3.85 ±0.01*,[a]	74.63 ±0.02*,[a]	363.16 ±0.40*,[a]	48.40 ±0.01*,[a]
Rye	9.69 ±0.01*,[a,b]	2.17 ±0.01*,[a,b]	10.55 ±0.03*,[a,b]	10.55 ±0.03*,[a,b]	4.14 ±0.02*,[a,b]	71.11 ±0.04*,[a,b]	363.42 ±0.02*,[a]	52.73 ±0.07*,[a,b]

Values are expressed as mean ±SEM, n -= 3. * = significantly different from cassava flour at p<0.05,
a = significantly different from finger millet flour at p<0.05, b = significantly different from black fonio flour at p<0.05

TABLE 1b: Dietary fibre content of the edible flours

Flours	Insoluble dietary fibre (%)	Soluble dietary fibre (%)	Total dietary fibre (%)
Cassava	4.28 ± 0.02	3.65 ± 0.02	7.91 ± 0.01
Finger millet	4.85 ± 0.01*	3.78 ± 0.02*	8.61 ± 0.01*
Black fonio	5.46 ± 0.03*,[a]	4.25 ± 0.03*,[a]	9.65 ± 0.02*,[a]
Rye	5.78 ± 0.00*,[a,b]	3.98 ± 0.02*,[a,b]	9.76 ± 0.02*,[a,b]

Values are expressed as mean ±SEM, n -= 3. * = significantly different from cassava flour at p<0.05,
a = significantly different from finger millet flour at p<0.05, b = significantly different from black fonio flour at p<0.05

Sensory evaluation of stiff porridges prepared from various flours of cassava, finger millet, black fonio and rye.

The sensory evaluation results for the edible flours are reported in Table 2. Cassava flour stiff porridge was the most generally acceptable (8.16 ± 0.26), and this was statistically different from the others; finger millet stiff porridge, on the other hand, was the least acceptable (4.32 ± 0.53). Mean scores for aroma ranged from 5.32 ± 0.47 (finger millet stiff porridge) to 6.89 ± 0.30 (cassava flour stiff porridge), and both were quite statistically different at p<0.05. For colour, cassava flour stiff porridge scored highest (7.42 ± 0.21), closely followed by rye stiff porridge (6.26 ± 0.30), with finger millet flour stiff porridge recording the lowest (4.63 ± 0.53). Cassava flour stiff porridge tasted best (6.74 ± 0.26), and this score was statistically similar (p>0.05) to the taste scores for black fonio and rye flour stiff porridges; finger millet stiff porridge had the poorest taste score (5.11 ± 0.39). Mean values for texture ranged from 4.84 ± 0.43 (finger millet stiff porridge) to 7.11 ± 0.34 (cassava flour stiff porridge).

TABLE 2: Sensory properties of the edible flours made into stiff porridges

Flours	Aroma	Colour	Taste	Texture	Overall Acceptability
Cassava	6.89 ±0.30	7.42 ±0.21	6.74 ±0.26	7.11 ±0.34	8.16 ±0.26
Finger millet	5.32 ±0.47*	4.63 ±0.53*	5.11 ±0.39*	4.84 ±0.43*	4.32 ±0.53*
Black fonio	6.32 ±0.32[a]	6.11 ±0.35*[,a]	6.16 ±0.24[a]	6.16 ±0.43[a]	6.32 ±0.45*[,a]
Rye	6.21 ±0.26	6.26 ±0.30*[,a]	6.26 ±0.21[a]	4.89 ±0.44*[,b]	6.26 ±0.60*[,a]

4. Discussion

The proximate analysis shows the macronutrient composition of the three cereal flours (finger millet, black fonio and rye) and cassava flour samples. The flours were powdered, hence the low percentage of moisture reported in this study. Due to the low moisture content, they can be preserved longer because the threat of moulds is greatly reduced when moisture is absent or low. Water is crucial for life maintenance, and so it is one of the most commonly used metrics to predict how a food product will be better processed and how long it will last on the shelf (Akinsanmi *et al*., 2015); the shelf life of a food product expresses its measure of stability and susceptibility to microbial contamination. The findings show that rye flour had the highest ash concentration, with black fonio and cassava flour having the lowest values. This is similar to the result reported by Nayik *et al*. (2023) for some cereal flours comprehensively discussed in their handbook. A food's Ash content indicates its mineral content level (Ndife *et al*., 2019). This suggests that rye may be a very rich source of essential minerals (the other aspect of this work focuses on the analyses of specific micronutrients in edible flours). Both crude fibre and dietary fibre were analysed in this study. Rye flour still had significantly higher concentrations of both, while cassava flour had really low values, probably partly because of its level of processing. Research has shown that a high-fibre diet may contribute to reducing the risk of cardiovascular diseases, colonic cancers and diabetes. These cereal flours are a considerable source of dietary fibre since they can contribute significantly to the recommended dietary allowance (RDA) of fibre for children (19-25%), adults (21-38%), pregnant (28%) and lactating mothers (29%) (Adamu *et al*., 2016). All the flours in this study had significant amounts of IDF and SDF; the classification of dietary fibre also stems from water solubility. Broadly, there are two main types of dietary fibre: soluble and insoluble. The main sources of soluble fibre are fruits and vegetables. Conversely, cereals and whole-grain products provide sources of insoluble fibre. However, most naturally available high-fibre foods contain variable amounts of soluble and insoluble fibre (Barber *et al*., 2020). Both IDF and SDF reduce the risk of some types of cancers, such as colon and breast cancers, while IDF supports the maintenance of digestive health and SDF functions in the prevention of coronary heart disease (CHD). In addition, a high intake of SDF appears to have additional metabolic benefits, including improved GI of carbohydrate-rich foods and consumer lipid profiles (Isken *et al*., 2010; Russell *et al*., 2016).

Generally, cereals are known to contain a significant amount of protein, as seen in this study. According to Nayik *et al*. (2023), protein content in cereals ranges from 6–15%. Foods must include essential amino acids; the human body can synthesise additional (non-essential) amino acids. The fundamental amino acid with the lowest supply in relation to the need is known as the limiting amino acid. In grains, lysine is the limiting amino acid (Tufail *et al*., 2021). In order to augment the limiting amino acids in cereals, they are sometimes combined with other foods to make up for the lack of amino acids. As for the carbohydrate content, most cereals and tubers are staple foods with high carbohydrate content. This is confirmed by the results reported in the study. Cassava, a root tuber had significantly higher content of carbohydrate than the cereal flours. The results here agree with the report of Nayik *et al*. (2023) which says grains contain roughly 75% carbohydrate. High carbohydrate intake along with a sedentary lifestyle may be associated with obesity and sometimes diabetes (Park *et al*., 2020); hence consumption of high carb foods must be moderate to prevent storage of excess calories as fat by the body. Regarding energy, the flours had similar energy values (about 90 Kcal/100g) which can contribute significantly to the RDA for both males and females which is about 2,000 Kcal, based on the quantity consumed. Furthermore, concerning GI, the glycaemic load (GL) is determined by multiplying the dietary GI by the aggregate sum of carb in the meal (Jenkins *et al*., 2002). It computes a meal's total glycaemic impact. In a new WHO/FAO study on nutrition and chronic conditions, lower glycaemic index dinners were related to a general betterment in glycaemic control in people with diabetes mellitus (Nayik *et al*., 2023). The flours in this study had average GI values which is similar to what is reported by Atkinson *et al.* (2021) where most cereals were reported to either have medium or high GI values.

The flours were also evaluated for organoleptic properties namely: colour, taste, aroma, texture and general acceptability; they varied in palatability and acceptability as reported by the 20-man panel. Food colour is an important sensory property, which can considerably enhance acceptability. According to Spence (2015), taste refers to "the proximal sense that requires direct contact of food with stimuli on the tongue to determine the quality of the ingested food." Modifications in food's flavour which improve palatability, greatly increases a product's acceptability. The flours were prepared into stiff porridges and eaten with soups so what was most important was their texture. Cassava flour scored highest in texture and in overall acceptability probably because it was more processed than the others (bought off the shelf) and has more starch; this gives cassava flour a finer and much better texture. This means that some processing techniques may also be used to process the cereal flours in order to improve their texture and produce better stiff porridge.

5. Conclusion

The global challenge of the malnutrition requires immediate attention and solutions must be proffered to diet-related problems which are presently on the increase. People should be taught and encouraged to make healthy dietary choices as this will have an impact on their wellbeing in the long run. In many countries, varieties of crops serve as food but some are grossly underutilised due to poor nutrition knowledge. This (poor access), in addition to poor lifestyle habits, is increasing the prevalence of NCDs. The results of this study show that cereals can be processed into less-starchy flours which can be eaten as stiff porridges with native soups. These cereals are relatively richer in protein, fibre and lower in starch, than similar staples. The sensory evaluation revealed that despite the fact that the cassava flour was most acceptable, the cereal flours also had high overall acceptability scores and so can be incorporated into menus especially for those on therapeutic or restrictive diets. This could prove to be quite useful in the prevention and management of many NCDs, alongside other lifestyle adjustments.

Conflict of Interest: None

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Authors' contributions: Author EO – Conceptualisation, Investigation, Resources, Writing original draft. Author CO – Supervision, Project administration, Formal analysis, Writing – review and editing. Authors MK and SS – Data curation, Validation, Writing – review and editing.

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