JRIIE Journal of Research Innovation and Implications in Education
Center for Research Implications & Practice

Website:www.jriiejournal.com ISSN 2520-7504 (Online) Vol.7, Iss.2, 2023 (pp. 147 - 160)

"Dokoro" Nutrient Dense Porridge Formulated from Fruits, Legumes and Cereal

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Abstract: *The study aimed at determining the possibility of offering an alternative to the common maize meal porridge with a porridge formulated from a mixture of fruits, legumes and cereals. It was underpinned by a positivist research paradigm which followed an experimental research design. The conveniently selected panellists for product testing consisted of 30 primary school pupils who were conveniently selected in Grade 7 from one school and were willing to participate. Composite flours consisting of fruits, cereals and legumes were used to produce a porridge which was compared with unrefined maize meal porridge for acceptability. This was followed by the evaluation of nutrient composition for both dokoro and maize meal. The mean acceptance score for dokoro porridge (Mean = 7.6, SD = 0.26) was significantly higher ($p \leq 001$) than the acceptance score for maize porridge (Mean = 5.8, SD = 0.14), $t(58) = -3.75$, $p = 0.000$. Moreover, dokoro composite powder had a significantly higher content values for moisture ($p \leq 0.001$), ash ($p \leq 0.003$), protein ($p \leq 0.014$), crude fibre ($p \leq 0.001$), vitamin C, energy, zinc and iron ($p \leq 0.001$) than maize powder. The study concludes that Dokoro porridge is a healthier food product that is more acceptable and contains significantly higher nutrient values than the common maize meal porridge. It is recommended to replicate the study using a larger sample of participants of different age groups from various locations in the country to determine the potential of using the dokora product nationwide.*

Keywords: *Dokoro, Maize, Nutrients, Nutrient analysis, Organoleptic evaluations*

How to cite this work (APA):

Usai, T., Nyoka, R., Badza, F. & Mutonhodza (2023). "Dokoro" nutrient dense porridge formulated from fruits, legumes and cereal. *Journal of Research Innovation and Implications in Education*, *7*(2), 147 – 160.

1. Introduction

Provision of adequate and good nutrition is dependent on food availability, affordability and people's traditions, beliefs and values. Developed nations have a wide range and huge quantities of foods available all the year round and in all geographical locations (Kontis *et al.* (2017). In contrast, food security is a challenge in developing countries in Africa including Zimbabwe due to persistent draughts, low harvests, harvest losses, poverty and cultural beliefs. Micronutrient deficiency is widespread mostly in less developed nations (Ronto *et al.*, 2018). Nutrient deficiencies in less developed nations may be reduced by intake of locally available, traditional, cheap, nutrient dense foods. The commonly grown traditional foods are seasonal and hence perishable. Perishable food commodities including fruits, vegetables, roots and tubers, and grains may be unavailable when they are out of season. Moreover, ineffective, or inappropriate food processing technologies contribute to major nutrient losses in cereals and legumes which are major energy and protein sources in less developed nations. Unlike some of the modern processing methods, traditional food processing methods contribute to a vital body of indigenous knowledge that should be handed down from parent to child over several generations. However, indigenous knowledge on some traditional food products and their processing technologies have been either undervalued or neglected (Ceasar *et al*., 2023). This is mainly due to the shift from the consumption of traditional foods to processed modified modern foods that are predominant in modern society. Recent technology has commercially resulted in the production of fortified nutritious foods that are beyond the reach of many in developing nations. This has prompted the need to develop blending technologies and knowledge to enhance the nutritive values of local food sources inclusive of small grains, fruits and vegetables.

The blending of processed locally available fruits, legumes, and cereals may play a significant role in improving the nutrient density in food commodities on the market (Ajifolokun *et al.* 2019)). A number of cereals and legumes that are readily available have been found to have nutrient potentials that could complement one another if properly processed and blended (Spiker *et al*., 2020; Rashwan *et al*., 2021; Javed *et al*., 2022).

The formulation and development of nutritious foods from locally and readily available raw materials have received much attention from many authors (Spiker *et al*., 2020; Javed *et al*., 2022). Formulations using local foods are becoming familiar and at the household level, optimal utilization of locally accessible nutrient-dense food is demonstrated to be effective in dietary management.

The objective of this study was to offer an alternative to the common maize meal porridge with a porridge formulated from a mixture of fruits, legumes and cereals (dokoro). The study formulated dokoro product and established through experimenting its nutritional composition as well as that of maize porridge to enable comparison. The acceptability of the product was assessed. The uniqueness of this paper lies in the porridge that uses traditional and local fruits, legumes and cereals in making a porridge that is nutrient dense and more acceptable than the common maize porridge. Low-cost local foods and technology are used to produce dokoro thus making the product affordable and more accessible to low-income families. The dokoro product has the potential to reduce micronutrient deficiency in low-income families.

2. Literature Review

The dokora product was formulated and developed using nutritious cereals (millet and sorghum), fruit (baobab) and legumes (cow peas and groundnuts) that are traditional, locally and readily available in Zimbabwe and other countries South of the Sahara. The cereals, legumes and fruits are available in most, if not all geographical locations in Zimbabwe and have nutrient potentials that could complement one another if properly processed and blended (Spiker *et al*., 2020; Javed *et al*., 2022). Low-cost indigenous knowledge and technologies were used in dokora material processing, product formulation and development.

The baobab fruit is from a tree commonly found growing in tropical Asia, Africa and Southern America (George & Pamplona-Roger 2013; Assogbadjo *et al*., 2021). Mostly available nutrients in the fruit include proteins, calcium, iron, vitamin C (24mg/100g), provitamin A and vitamin E. The fruit is also rich in fibre (1.7%) (Asogwa *et al*., 2021; Evang *et al*., 2021). The juice from the fruit is called Baobab milk that can be used as infant food (George & Pamplona-Roger 2013; Asogwa *et al*., 2021; Evang *et al*., 2021).

Plums are laxative, diuretic, depurant and hypolipidemic (George & Pamplona-Roger 2013; Gupta *et al*., 2021; Rahman *et al*., 2021; Biswas *et al*., 2022). The main nutrients in plums per 100g are 11.5g carbohydrates, 1.5g fibre, 9.50mg vitamin C, 10 mg phosphorous, 4 mg calcium and potassium 172 mg. Proteins and fats are scarce in plums. They contain a balanced proportion of all minerals and vitamins with the exception of B_{12}. They also contain oxyphenisatin essential for stimulation of peristaltic action of the intestines thereby preventing constipation (Gupta *et al*., 2021; Rahman *et al*., 2021; Biswas *et al*., 2022).

Sorghum is cultivated throughout Africa and Asia. Its flour is used to make infant food, flat cakes and bakery products. Its main nutrient composition per 100g includes carbohydrates 16.3g, protein > 3,22g, fibre 2.7 g and fat 1.18g. (Keyata *et al*., 2021; Rashwan *et al*., 2021)). It also contains vitamin B complex, vitamin C, potassium, phosphorous, magnesium, calcium and iron. Compared to maize, sorghum is richer in protein lysine and tryptophan and provitamin A (Thompson *et al*., 2013; Keyata *et al*., 2021; Rashwan *et al*., 2021).

Millet is a small edible grass grown worldwide. It has excellent tolerance to drought conditions, medium rainfall, temperature range 11˚C to 27˚C and soil pH of 5.0 to 8.2 (Ceasar *et al*., 2023). Millet chemical composition differs with genotype, geographical growing environment storage and processing/treatment. Most millet types have72% to 79.5% carbohydrates (71.6% starch, 3.7 dietary fibre, 1.2% to 1.8% reducing sugars and 0.03% non-reducing sugars), 6.7g/100g to 12.3g/100g protein, 1.3% to 1,8% crude fat, phosphorous 320mg/100g, calcium 350g/100g, iron 3.6mg/100g and magnesium137mg/100g (Lansakara *et al*., 2016; Ceasar *et al*., 2023). The proteins contain approximately 44% amino acids (lysine, tryptophan, threonine, leucine and phenylalanine). The vitamins in millet include thiamine, riboflavin, niacin and vitamin A (Athwale *et al*., 2015; Lansakara *et al*., 2016; Ceasar *et al*., 2023). The millet seed has varied uses in Zimbabwe such as bird feed, porridge, thick porridge (sadza), fermented beverages (maheu) and malt for beer making.

Groundnuts are highly nutritious and a source of energy. The proportion of some groundnut nutrients per 100g are carbohydrates 7.64g, fats 49.2g, protein 25.8g, vitamin E 13mg, calcium 92mg, iron 4.58mg and fibre 8.5g. (Khan *et al*., 2021; Oguntuase *et al*., 2022). Due to their low carbohydrates, nuts are well tolerated by diabetics. Other beneficial substances present in groundnuts include vitamins (B_1, B_2, B_6, E, pantothenic acid and folates) and phytochemicals (ellagic acid, flavonoids and phenolic compounds) (George & Pamplona-Roger 2013; Khan *et al*., 2021; Oguntuase *et al*., 2022).

Cowpeas is a legume. The combination of legumes and grains provides biologically high-quality protein that contains all essential amino acids in required proportions (Khrisanapant *et al*., 2021). Cowpeas are rich in proteins whose quality is equal or superior to that of meat in quality and quantity. The nutrient composition of cowpeas per 100g are protein 23.4g, carbohydrates 45.1g, fat 0.85g, sodium 16.0mg, calcium 240g, phosphorous 301mg, iron 10.4mg. Most vitamins are present in cowpeas except vitamin A. Other essential substances found in cowpeas include flavonoids, phenolic compounds and antioxidants that can inhibit tumor growth, reduce blood sugar levels and neutralize harmful free radicals in the body thereby reducing oxidative stress and inflammation linked to cancer (George & Pamplona-Roger 2013; Khrisanapant *et al*., 2021; Yıldırım, 2021).

Indigenous knowledge and traditional low-cost technologies were employed in processing legumes, fruits and cereals that were used in dokoro product formulation and development. Baobab fruit's hard shell was hand cracked, seed removed, the pulp then sun dried and finally ground and sieved obtain a fine powder. Plums are sundried into prunes that are then pounded into powder. The processing of cereals involves roasting, dehulling and milling. Dehulling removes protein inhibitors, roasting treatment improves cereal digestibility, reduces anti-nutritional inhibitors and improves mineral bioavailability (Athwale *et al*., 2015; Khrisanapant *et al*., 2021; Yıldırım, 2021 Ceasar *et al*., 2023). Groundnuts processing involves shelling, roasting the pounding into a paste.

3. Methodology

The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research participants were approved by Midlands State University Ethics Committee. Written informed consent was obtained from all parents of participant pupils, Midlands District Education Officer and school principals. Informed written consent was also obtained from each participant.

Preparation of flours from ingredients

Cereals (millet and sorghum), legumes (cowpeas and groundnuts) and fruits (baobab and plums) obtained from the local market, were traditionally processed into powder/paste using low-cost indigenous knowledge and technologies of drying, roasting, soaking, pounding/milling and dehulling. The overall production processes are illustrated in flow charts. One formulation was produced which was a mixture of *Panicum milicaeuem*, *Sorghum bicolor*, *Arachis hypogea*, *Vigna unguniculata*, *Ziziphus mauritania* and *Adonsonia digitata* at various percentages as shown in Table 1.

The *Adonsonia digitate* (baobab) powder was produced as summarised in Figure 1. Mature ripen fresh fruits harvested from baobab tree were sourced from the local market. The hard shell of the fruit was cracked by *panga* (large knife) to enable separation of seeds from pulp. The desired pulp was sun dried, pounded using mortar and pistil (duri and *mutswi*) into a mixture of fibre and powder. Sieving was used to separate fibre from powder. The powder was then used in the production of dokoro product.

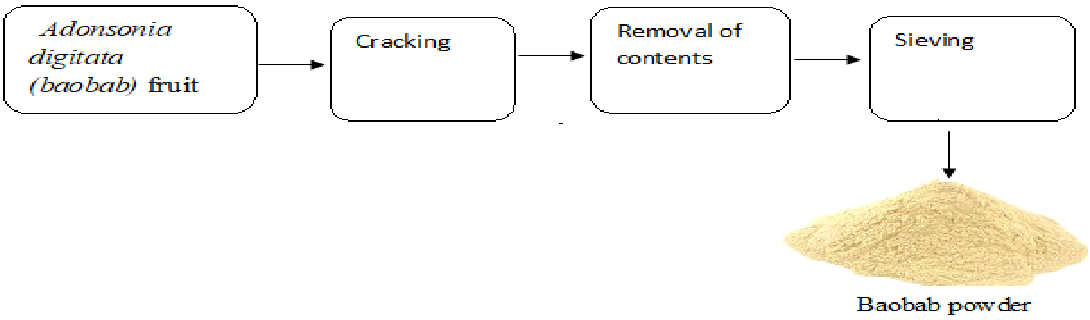

Figure 1: Flow chart showing the production of *Adonsonia digitate* (**baobab) powder**

Ziziphus mauritana powder was prepared as shown in Figure 2. The ripen fruits harvested from the fruit tree were sourced from local market. The fruits were graded to remove those that were rotten, the graded fruits were water cleaned then sundried for 3 to 5 days on clean surfaces. The sun-dried fruit was pounded into a coarse flour using mortar and pistil. Sieving was not necessary to preserve fruit fibre.

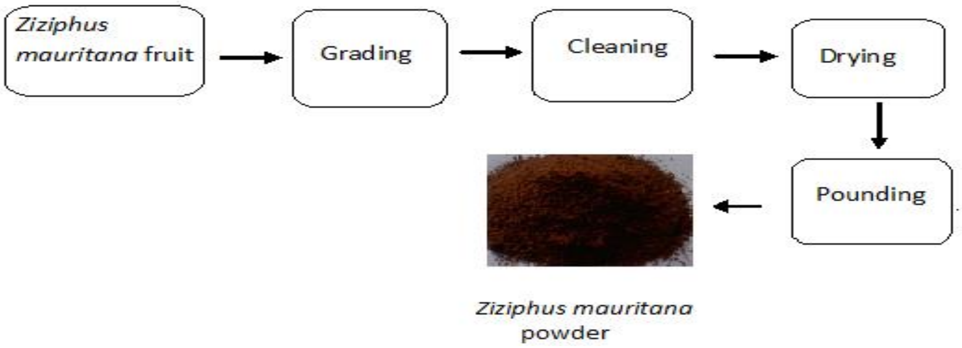

Figure .2: Flowchart showing the production of *Ziziphus mauritana* coarse powder

Millet *(Panicum milicaeuem)* grain processing into flour included dehulling, roasting, fermentation, drying and milling/grinding (Figure 3). The millet grains were graded and cleaned by winnowing. The cleaned grains were roasted to improve millet digestibility, reduce anti-nutritional inhibitors (phytates, tannis and cyanide). The roasted millet was soaked in water for fermentation to further reduce nutritional inhibitors, increase amino nitrogen, lysine and tryptophan content. (Athwale *et al*., 2015). The fermented millet was sun-dried, dehulled and finally milled into fine flour. Milling was carried out to preserve nutrients and improve minerals' (calcium, iron, phosphorous, zinc and potassium) bioavailability (Lansakara *et al*., 2016; Ceasar *et al*., 2023).

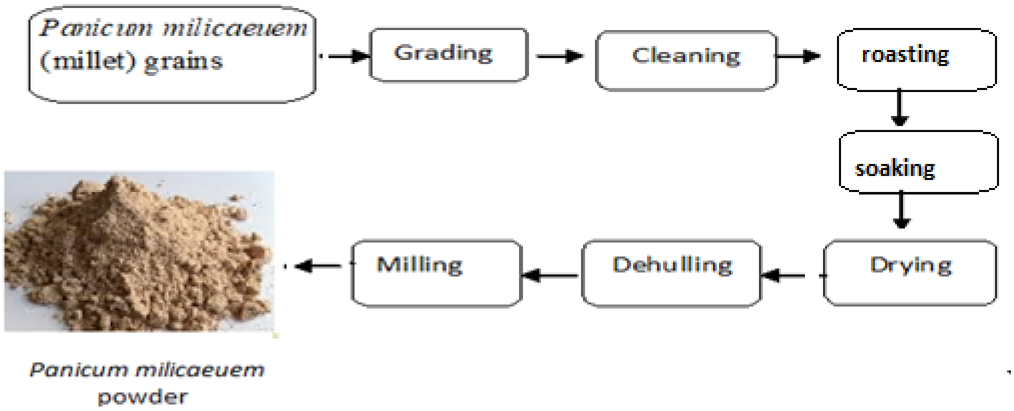

Figure 3: Flowchart showing the production of millet powder

Sorghum bicolor grains were processed into flour following the procedure used in millet processing described above. The grain was cleaned, dehulled, roasted, fermented, dried and milled into flour as shown in Figure 4.

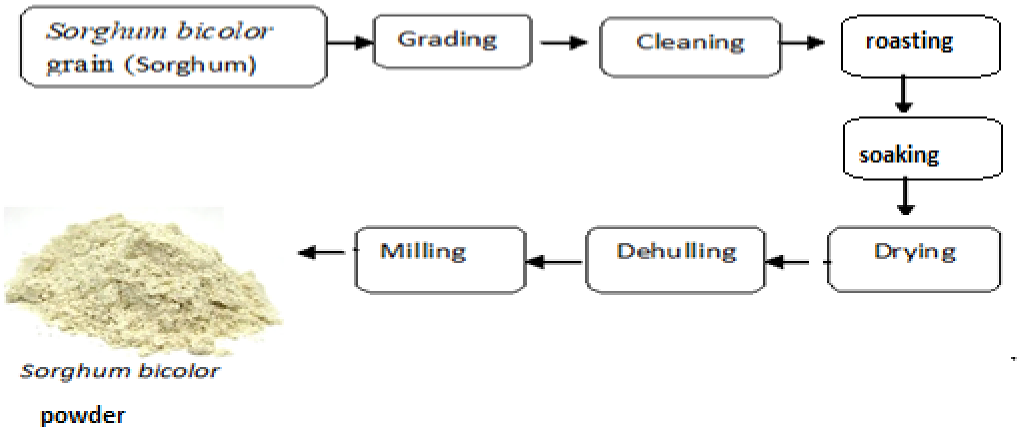

Figure.4: Flow chart showing the Production of *sorghum bicolor* powder

The *Arachis hypogea* was produced as illustrated in Figure 5. The nuts were unshelled from the pods mechanically by hand. Hand powered machines could also be used when large quantities of the nuts are required. The shelled nuts were graded to remove rotten ones then roasted to improve nutrient bioavailability and remove aflatoxins. The nuts were then dehulled and pounded into a peanut butter.

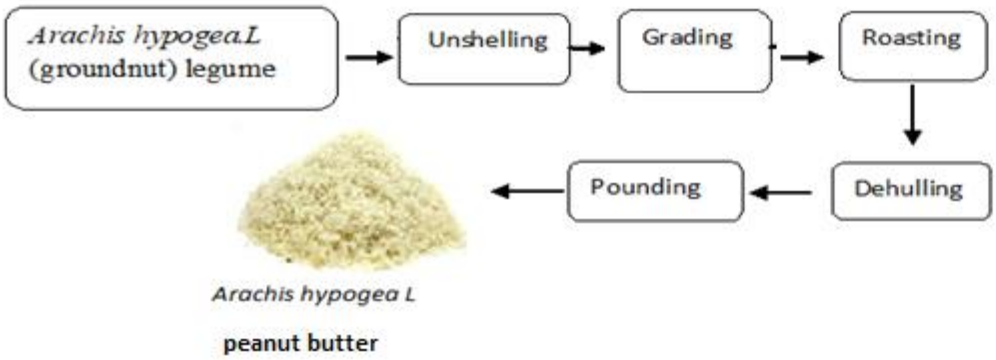

Figure 5: Flowchart showing the production of groundnut (peanut) butter

*Processing of Vigna unguniculata (*cowpeas*)* seeds into powder included pre-treated of the seed (grading, cleaning and drying), heat treatment / roasting, dehulling and milling (Figure. 6). roasting was done to produce a homogenous product with low levels of nutrient inhibitors, improve bioavailabilty of amino acids (lysine, methionine and cysteine), improve palatability, digestibility, flavour and to increase the flour's storage shelf life (Yıldırım, 2021).

Figure.6: Flowchart showing the production of cowpea powder

Preliminary formulations of dokoro

Composite flours consisting of baobab fruit, Indian plum, finger millet, sorghum, cowpeas and groundnuts in the ratios of A 2:2:5:6:3:2; B 1:3:4:7:2:3; C 3:1:7:4:3:2 respectively were prepared by weighing the ingredients using the analytical balance and mixing in separate glass jars. The preliminary formulations for the dokoro samples are presented in Table 1.

Table 1: Preliminary formulations of 'Dokoro' porridge.

Porridge Ingredients	Ingredient Composition variation of porridge formulation (g)		
	A	B	C
Baobab fruit	10	5	15
Indian plum	10	15	5
Millet	25	20	35
Sorghum	30	35	20
Cow peas	15	10	15
Groundnuts	10	15	10
Total quantities	100	100	100

Porridge preparation

Clean tap water (500 ml) was boiled in an electric kettle and 250 g of the composite flour 'A' was added to the saucepan followed by 20ml of cold water poured while stirring to produce a paste. The boiled water was then added to the sauce pan as stirring continued to avoid lumps. A pinch of salt was added and the mixture was allowed to boil for 10 minutes. The procedure was repeated for samples B and C. The porridge was served in a flat plate and allowed to cool down before serving and performing sensory evaluations.

The panellists for testing the products consisted of conveniently sampled 30 primary school children in grade 7 with 15 girls and 15 boys. The children were from one school and their parental and self-consent to participate was sought through signed consent forms. The participants were assigned numbers from 1 up to 30. The numbers were corresponding to the numbers on the score sheet where the participants had to indicate the product acceptance scores of the 3 samples labelled A, B and C. Each sample was ranked by each of the 30 participants on a 10-point acceptance scale where 1 represents the lowest acceptance score and 10 the highest acceptance score. The participant had to put an x in the appropriate column for the acceptance scores. The formulation with the highest mean acceptance score was compared with the common maize meal porridge for the mean acceptance score and nutrient composition.

Nutrient profiling of dokoro (A) and Maize meal

Nutritional profiling was done in order to measure the amount of nutrient content present in Dokoro powder and maize meal powder. Nutrients were evaluated by different methods. Specific nutrients analysed included proteins, fats, energy content, vitamin C, fibre, zinc, iron, ash and moisture.

Determination of carbohydrates

The titration method described by International Official Method of Analysis AOAC (2023) was used in determining the concentration of reducing sugars in the samples. A 10 grams mass of the powdered sample was dissolved in dilute hydrochloric in a burette and then titrated into a flask containing boiling copper sulphate solution and a methylene blue indicator. The reducing sugars in the carbohydrate solution reacted with the copper sulphate present in the flask. Once all the copper sulphate in the solution reacted, further addition of reducing sugars caused the indicator to change colour from blue to white. The volume of sugar solution required to reach the end point was recorded. A calibration curve was prepared by carrying out the experiment with a series of standard solutions of known carbohydrate concentration. The method was repeated three times at each concentration and an average value was calculated.

Determination of energy value

The energy content was measured using the bomb calorimeter. A 5g sample of the powder was placed in a calorimeter. The resultant temperature rise was measured and recorded. The amount of heat produced was determined by multiplying the observed temperature rise by the energy equivalence of the calorimeter to obtain the calorific value (heat of combustion). The procedure was repeated three times and an average value was calculated.

$$Dokoro\ caloric\ value\ (Hg) = \frac{temperature\ rise\ x\ energy\ equivalence}{weight\ of\ sample} \qquad Equation\ 1$$

The determination of moisture content

Oven drying method described by International Official Method of Analysis AOAC (2016) was used to determine moisture content in the powder sample. The method involves heating a sample until all water has been removed. Ten grams (10g) of samples were measured using Sartorius analytical balance. The samples were placed in oven dried crucibles and were heated for three hours (3hours) at 105°C. The samples were cooled in desiccator to room temperature. Re-drying and reweighing were repeated until constant masses were attained. The samples moisture contents were calculated as the weight loss during heating. Calculation of percentage moisture contents were carried out using Equation 2 shown below.

$$Dokoro\ moisture\ content\ (\%) = \frac{loss\ in\ weight\ of\ sample}{weight\ of\ original\ sample}\ x\ 100 \qquad Equation\ 2$$

An average value was obtained since the samples were in triplicate.

The determination of ash content

The ash contents of powdered samples were determined using the International Official Method of Analysis AOAC (2016) method. The method involves heating a dry solid sample in a micro-furnace until in turns into powder. One gram powder samples were placed in weighed, clean and oven dried crucibles. The crucibles were placed in micro-furnace that was set at 550°C for six hours. The crucibles were then cooled to room temperature in a desiccator prior to reweighing. The samples' ash contents were calculated using Equation 3 below.

$$Dokoro\ ash\ content\ (\%) = \frac{weight\ of\ ash}{weight\ of\ original\ sample\ (1g)}\ x\ 100 \qquad Equation\ 3$$

The same procedure was followed for maize meal powder.

The determination of crude fat content

The Soxhlet method and diethyl-ether organic solvent were used to extract fat from powder samples. The method ensures intimate contact between sample and the extraction solvent. A volume of 150ml of diethyl-ether was placed in each of 250ml round bottom flasks. The flasks were then fitted to the Soxhlet extraction units. Extractor thimbles were dried and weighed before addition of 3g powder samples. The thimbles were connected to Soxhlet units and cooling water was allowed to circulate. Heating mantles were used to boil the organic solvent for six hours. After fat extraction, the thimbles were disconnected, oven dried at 70°C, cooled to room temperature in a desiccator and then weighed. Equation 4 below was used to calculate the samples' percent crude fat. The procedure was first done using a sample of known fat content to ensure the reliability of the instrument in measuring the fat content.

$$Dokoro\ crude\ fat\ (\%) = \frac{weight\ of\ extracted\ fat}{weight\ of\ original\ sample} x\ 100 \qquad Equation\ 4$$

Determination of crude fibre content

The powdered samples' crude fibre contents were determined by the digestion method described in International Official Method of Analysis (AOAC) (2016). One gram powder samples were placed in each of three round bottom flasks. A volume of 50ml of 0.25M sulphuric acid were added to the samples and the mixtures were boiled for 30 minutes. The hot solutions were filtered. The filtration residues were boiled in 0.13M sodium hydroxide for 10 minutes. The solutions were filtered and the residues were washed first with distilled water, followed with 1.0% hydrochloric acid and finally twice with ethanol. The residues were oven dried at 105°C for 12 hours. Drying of ashed samples were conducted in muffle furnace at 550°C for 3 hours. The ashed samples were cooled in desiccator to room temperature and were reweighed. The loss in weight during ashing was used to calculate samples' crude fibre contents using Equation 5 below.

$$Dokoro\ crude\ fibre\ content\ (\%) = \frac{weight\ of\ residue - weight\ of\ ash}{weight\ of\ original\ sample\ (1g)} x\ 100 \qquad Equation\ 5$$

The determination of crude protein

The Kjeldahl method was used to determine powder samples crude protein content (International Official Method of Analysis AOAC, 2016). The method determines the percentage nitrogen in a sample. Nitrogen is a major component in the protein molecular structure. The method involves digestion of protein in a sample using sulphuric acid, neutralization with a base, steam distillation to release ammonia which is absorbed in 40% boric acid to form ammonia-boric compound and finally titrating the compound using 0.125M of hydrochloric acid. The volumes of titrating acid are used to calculate percentage nitrogen in a sample using Equation 5.

One gram of powder samples was measured using analytical balance and was placed in each of three 100 ml Kjeldahl flasks. A volume of 25 ml of concentrated sulphuric acid was added to each sample. A mixture of 0.5 g of sodium sulphate and 0.5 g of copper sulphate was added to elevate the boiling point of sulphuric acid and speed up the digestion reaction. The samples' digestion was carried at 298 °C until clear solutions were formed. The digested solutions were cooled, transferred into 100 ml volumetric flasks and diluted with distilled water. Ten millilitres of diluted samples were pipetted into a conical flask and neutralised by addition of 10 ml of 40 % sodium hydroxide. The neutralised samples were steam distilled and the released ammonia was collected in 10 ml of 40 % boric acid to which few drops of methyl red indicator were prior added. The distillation was terminated when methyl red indicator turned green. The ammonia- boric compound and a blank were titrated using 0.125 M of hydrochloric acid and the volumes of titrating acid were recorded. The Equation 5 below was used to calculate percent nitrogen (N %) released from each sample. The conversion factor of 6.25 was used to convert samples' percent nitrogen (N %) into samples' percentage crude protein.

$$Nitroten\ (\%) = \frac{M\ x\ (V1 - V0)}{1000\ x\ mg} x \frac{14}{M} x100 \qquad Equation\ 5$$

M = Molarity of Hydrochloric acid

V_1 = Volume of hydrochloric acid for sample titration

V_0 = Volume of hydrochloric acid for blank titration

mg = mass of sample

14 = atomic weight of nitrogen

Determination of iron and zinc

The iron and zinc contents in powder food samples were determined by flame atomic absorbance method using Flame Atomic Spectrometer (FAAS). The powder samples were prepared for mineral analysis by wet digestion using 3.0M nitric acid and 30.0 % hydrogen peroxide. The digested samples were filtered using Whatman No. 1 filter paper. The filtrates were analysed for iron and zinc using FAAS (AOAC, 2016). The FAAS was first calibrated with prepared iron and zinc standard solutions. The food powder sample to be analysed was then dissolved in an aqueous solution. The solution was placed in the instrument where it was heated to vaporize and atomize the minerals. A beam of radiation was passed through the atomised sample and the absorption of radiation was measured at specific wavelengths corresponding to the mineral of interest.

Determination of vitamin C content

Vitamin C was analysed by High performance liquid chromatography. The sample mixture to be separated and analyzed was introduced, in a discrete small volume (typically microliters), into the stream of mobile phase percolating through the column. The components of the sample moved through the column at different velocities, which were functions of specific physical interactions with the sorbent (also called stationary phase). The time at which a specific analyte elutes (emerges from the column) is called its retention time. The retention time measured under particular conditions was considered as an identifying characteristic of a given analyte (AOAC, 2016).

Nutrients composition data were analysed using Statistical Package for the Social Sciences (SPSS) version 26 to determine the mean scores, standard deviations and possible differences in nutrient composition between maize and dokoro samples by independent sample t-test. All tests and p values were two- sided and considered statistically significant at $\alpha = 0.05$.

Sensory analysis of dokoro product and maize meal porridge

Sensory tests were conducted in order to measure the consumer acceptance of the product. Dokoro product and maize porridge were coded S215 and S010 respectively for sensory evaluation. During the evaluation procedure, samples from maize meal porridge and Dokoro porridge were taken, coded, and placed into two different containers. Distilled water was placed in another container and the other left empty for spitting. Sufficient amounts of each sample were provided for the evaluations. Instructions were given to panellists on how to conduct sensory evaluations. A two-sample test statistical treatment was done to show the difference between the two products.

4. Results and Discussion

Table 2: Mean Nutrient composition for dokoro and maize meal (mean ± standard deviation for the triplicate samples for each nutrient)

Nutrient	Dokoro powder	maize meal powder	p-values
Moisture	10.8 ± 0.21 %	8.7 ± 0.15 %	p≤0.001
Ash	2.5 ± 0.15 %	1.3 ± 0.10 %	p≤0.003
Protein	10.5± 0.15 %	9.4 ± 0.11 %	p≤0.014
Crude fibre	4.97 ± 0.17 %	1.6 ± 0,10 %	p≤0.001
Carbohydrates	68.7 ± 0.20 %	72.8 ± 0,20 %	p≤0.003
Fat	2.5 ± 0.20 %	3.6 ± 0.06 %	p≤0.002
Vitamin C	40.1 ± 0.07 mg/100 g	6.8 ± 0.06 mg/100g	p≤001
Energy	1519.5 ± 0.29 KJ/100g	1485.8 ± 0.36 KJ/100g	p≤001
Zinc	2.7 ± 0.01 mg/100g	1.35 ± 0.06 mg/100g	p≤0.001
Iron	4.2 ± 0.01 mg/100 g	2.7 ± 0.06 mg/100g	p≤0.001

(Independent sample t-test at 5% significance level indicate very small (≤0.003) p-values for most nutrients.

Table 2 shows significantly higher nutrient values for dokoro than maize except carbohydrates and fats. The small p-values ($p < 0.05$) show that the differences in the nutrient values are significant. Dokoro composite powder had a significantly higher content values for moisture (p≤0.001), ash (p≤0.003), protein (p≤0.014), crude fibre (p≤0.001), vitamin C, energy, zinc and iron (p≤0.001) than maize. Contrary, maize meal powder had a significantly higher values of carbohydrates (p≤0.003) and fats (p≤0.002) which were 72.8% and 3.6% respectively compared to corresponding amounts of 68.6% and 2.5% in dokoro composite powder.

Texture and aroma differences

The type of porridge has an effect on textural attributes (Figure 7). Dokoro porrridge had a lower texture value than maize porridge. Consistency of maize porrridge was better than that of dokoro porridge. Aroma was better in dokoro porrridge. Both samples managed to have the same mouth fill.

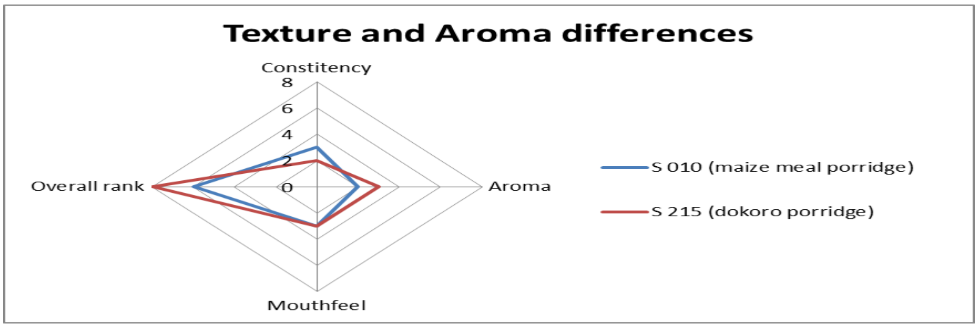

Figure 7: Texture and Aroma differences

Taste differences

The graph below shows the taste changes of the different type of porridge. The porridges tasted differently (Figure 8). Taste of dokoro porrridge was more preffered compared to maize meal porridge. The t-test at 5% significance level showed that dokoro porridge tasted better than maize meal porridge.

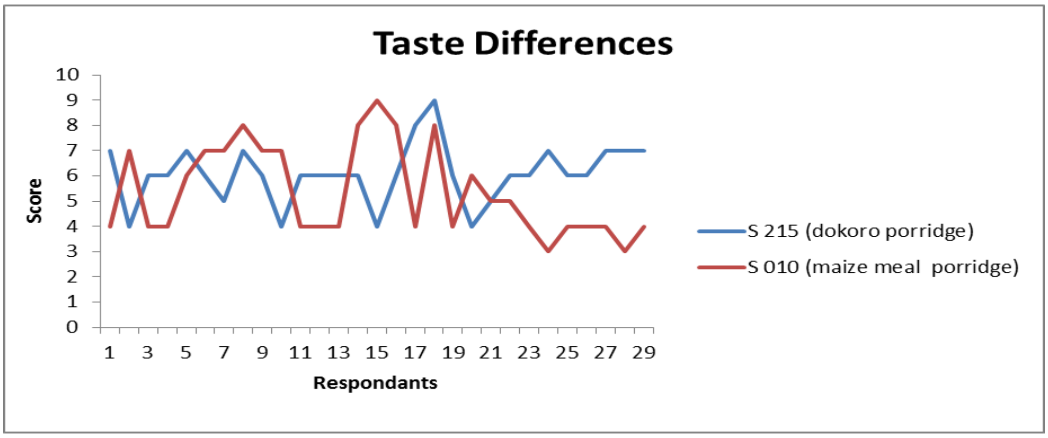

Figure 8: Taste differences

Colour differences

The porridges preferences to colour with respondents varied (Figure 9). Maize meal porridge was more preferred.

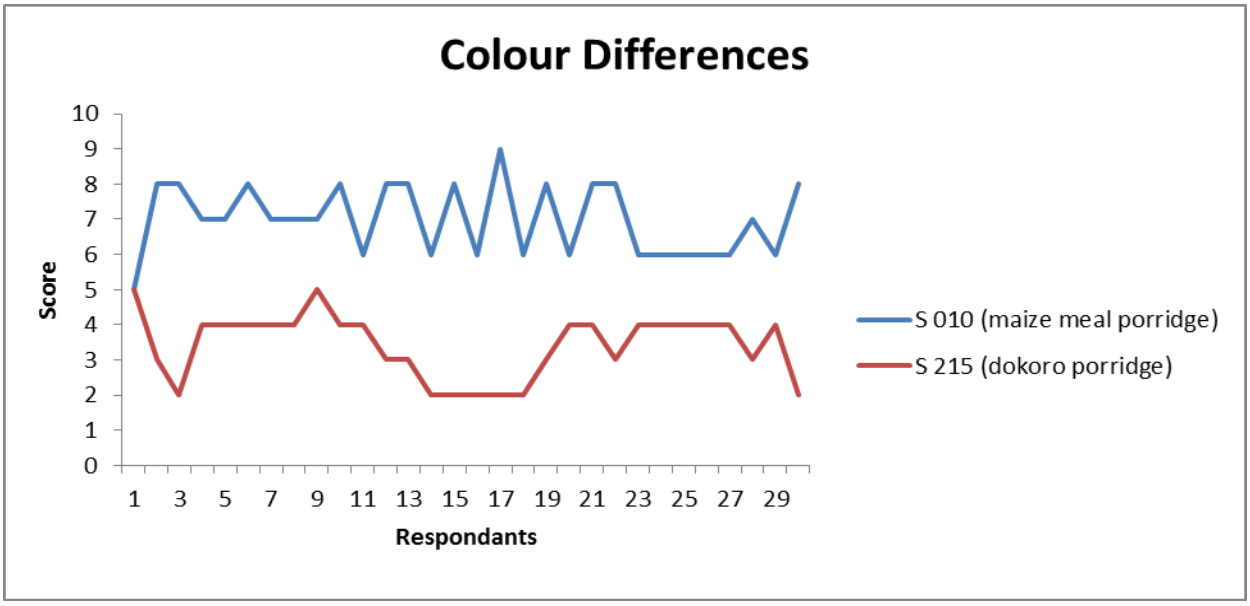

Figure 9: Porridge colour difference preferences

Dokoro had a significantly higher score of acceptance Mean = 7.6, SD = 0.26, p≤001) (than maize (Mean = 5.8, SD = 0.14), t (58) = -3.75, p = 0.000) due to the presence of different fruits, cereals and legumes. Each of the ingredients of dokoro influenced the overall acceptability of dokoro. As participants become more familiar to the product, Torrico *et al*., (2019) observed that the product acceptability increases. The acceptance of dokoro product in the study shows that the product could be an alternative to commonly used maize meal porridge and this could significantly mitigate the nutrient deficiencies among children who form the majority of people who take porridge in the morning according to the African society tradition. The roasting treatments subjected to the grains and ground nuts during processing could have imparted special characteristics and improve organoleptic that resulted in a higher acceptance score of dokoro over maize,

As illustrated in Table 2, Dokoro composite powder had significantly higher values for moisture (p≤0.001) and ash (p≤0.003) than the common maize meal powder. Dokoro could have a shorter storage life than maize meal porridge due to the high moisture content. The higher ash content in dokoro composite flour is due to the presence of significant amounts of minerals. The increase in ash in composite flours was also observed in Ajifolokun *et al.* s' study of composite maize porridge in 2019, wheat-cassava flour blends study by Masamba and Jinazali in 2014 and in Oladunmoye *et al.*'s study of wheat, cassava, maize and cowpea composite flours in 2010. Furthermore, dokoro composite porridge had significantly higher content values for protein (p≤0.014), crude fibre (p≤0.001), vitamin C, energy, zinc and iron (p≤0.001). The high amount of protein, energy, zinc and iron are significant qualities in the dokoro porridge as they aid in averting protein-energy malnutrition. The results are in line with observations in studies by Ajifolokun *et al.* 2019) which revealed that compositing various food products increase the overall intake of nutrients. The blending of fruits, legumes and cereals to produce dokoro also increased the intake of nutrients (dietary fiber, folate, iron, vitamins and magnesium) (Bruins *et al*., 2018 Spiker *et al*., 2020; Javed *et al*., 2022).

Legumes (groundnuts and cowpeas) in the dokoro composite porridge supply zinc and vitamin B12, protein, iron, thiamine, niacin, fat, phosphorous and riboflavin (Khan *et al*., 2021; Khrisanapant *et al*., 2021; Yıldırım, 2021; Oguntuase *et al*., 2022). The study by Ee, *et al.* (2018) revealed that roasting cereals and legumes increased the bioavailability of protein, fat, carbohydrate and ash contents, whereas the moisture and crude fiber contents decreased due to roasting. The decrease in moisture increases the shelf life of the product, hence, roasting that was done to the raw materials during preparation of the product was critical. The roasting also improved dokoro product's digestibility and reduced anti-nutritional inhibitors (Ceasar *et al*., 2023).

Higher quantities of zinc and iron in dokoro porridge (Table 2) is due to baobab, sorghum and millet blending. The higher quantity of vitamin C in dokora is mainly due to the baobab fruit as well as the Indian plum powders that were added (Asogwa *et al*., 2021; Evang *et al*., 2021). The abundance of vitamin C (Table 2) makes dokoro a good source of the antioxidant which prevents detrimental reactions in the red blood cells and the lungs where oxygen levels are high (Rahman *et al*., 2021; Biswas *et al*., 2022). The high energy content in dokora is mainly due to carbohydrates in cereal-millet and sorghum (Keyata *et al*., 2021; Rashwan *et al*., 2021; Lansakara *et al*., 2016; Ceasar *et al*., 2023) and the fat in groundnuts (Khan *et al*., 2021; Oguntuase *et al*., 2022). According to United States Department of Agriculture (USDA) (2015), whole grain cereals are a major source of energy in the diet and they also contain thiamine and cellulose which provides dietary fibre that prevents constipation.

Dokoro product appears to be a very important product that is suitable school going children mostly in low-income families. The high energy content (Table 2) enables it to meet the energy demands for most learners who have to walk long distances on their way to school and back home. Another important attribute of dokoro is its high protein content (Table 2) which makes it suitable for children who are growing as proteins play a significant role in growth. The iron content offers dokoro an important property in cognitive development, thereby making dokoro a vital product for the developing children.

5. Conclusion and Recommendations

5.1 Conclusion

The mean acceptance score for dokoro porridge (Mean = 7.6, SD = 0.26) was significantly higher (p≤001) than the acceptance score for maize porridge (Mean = 5.8, SD = 0.14), t(58) = -3.75, p = 0.000. Moreover, dokoro composite powder had significantly higher content values for moisture (p≤0.001), ash (p≤0.003), protein (p≤0.014), crude fibre (p≤0.001), vitamin C, energy, zinc and iron (p≤0.001) than maize (Table 2). Contrary, maize meal powder had a significantly higher values of carbohydrates (p≤0.003) and fats (p≤0.002). The study showed that the blending of cereals (millet and sorghum), legumes (cowpeas and groundnuts), and fruits (baobab and plums) produced a nutrient *dokora* product in which nutrients of source materials complemented each other. This study has been able to contribute to the knowledge in the area of food science by proving empirically the higher acceptability and higher nutrient content of dokoro porridge over the common maize meal porridge.

The study concludes that Dokoro porridge is a healthier food product that is more acceptable and contains significantly higher nutrient values than the common maize meal porridge. The dokora product has the potential to be an alternative to the maize meal porridge.

5.2 Recommendation

It is recommended to replicate the study using a larger sample of participants of different age groups from various locations in the country to determine the potential of using the dokora product nationwide.

Acknowledgements

We wish to acknowledge and thank the staff at Bindura University of Science Education for assisting with equipment, calibration of equipment and ensuring accuracy in the sample testing process. We are also grateful for the unwavering support by Midlands State University in ensuring the success of all processes that resulted in the completion of the project.

References

Ajifolokun, O.M., Basson, A.K., Osunsanmi, F.O., and Zharare, G.E. (2019) Nutritional Composition and Organoleptic Properties of Composite Maize Porridge. *Journal Food Process Technology*, 10: 798.

AOAC. (2016). Official methods of analysis. (20th ed.). Washington, DC: Association of Official Analytical Chemists.

Asogwa, I. S., Ibrahim, A. N., & Agbaka, J. I. (2021). African baobab: Its role in enhancing nutrition, health, and the environment. *Trees, Forests and People*, *3*, 100043.

Assogbadjo, A. E., Chadare, F. J., Manda, L., & Sinsin, B. (2021). A 20-year journey through an orphan African baobab (Adansonia digitata L.) towards improved food and nutrition security in Africa. *Frontiers in Sustainable Food Systems*, *5*, 675382.

Athawale,G.H., Thorat, A.D., & Shukla, R.M. (2015). Development of finger millet and flaxseed crackers. *Food Science Research Journal*, 6(2):400-403.

Biswas, S. C., Kumar, P., Kumar, R., Das, S., Misra, T. K., & Dey, D. (2022). Nutritional Composition and Antioxidant Properties of the Wild Edible Fruits of Tripura, Northeast India. *Sustainability*, *14*(19), 12194.

Bruins, M.J., Bird, J.K., Aebischer, C.P., and Eggersdorfer, M. (2018). Considerations for Secondary Prevention of Nutritional Deficiencies in High-Risk Groups in High-Income Countries. *Nutrition,* 10(1): 47.

Ceasar, S. A., Maharajan, T., Krishna, T. A., & Ignacimuthu, S. (2023). Finger millet (Eleusine coracana (L.) Gaertn). In *Neglected and Underutilized Crops* (pp. 137-149). Academic Press.

Ee, K.Y., Ng, W.J., Cheong, S.M., Soo, C.C., Yap, J.W., et al. (2018). Physicochemical Characteristics, Antioxidant and Antibacterial Activities of Selected Raw and Roasted Legumes. Food and Nutrition Open Access, 1(1):102.

Evang, E. C., Habte, T. Y., Owino, W. O., & Krawinkel, M. B. (2021). Can the supplementary consumption of baobab (Adansonia digitata L.) fruit pulp improve the hemoglobin levels and iron status of schoolchildren in Kenya? Findings of a randomized controlled intervention trial. *European Journal of Nutrition*, *60*, 2617-2629.

George, D., & Pamplona-Roger, M.D. (2013). Encyclopedia of foods and their healing power, A Guide to Food Science and Diet Therapy. Education and health Library. Safeliz.

Gupta, V., Prabhakar, P. K., Gharde, S., Nimbaria, A., Sharma, V., & Rawat, A. (2021). Foam mat drying of Jujube (Ziziphus mauritiana) juice: Process optimisation, physico-functional, phenolic content and antioxidant analysis. *Journal of the Institution of Engineers (India): Series A*, *102*, 1013-1025.

Javed, A., Ameer, S., Talib, H., Bashir, I., & Jamshaid, M. (2021). Evaluating Concept of Healthy Eating in Relation with Physical Activity and Dietary Habits Among University Students. *Pakistan Armed Forces Medical Journal*, *71*(5), 1603-06.

Keyata, E. O., Tola, Y. B., Bultosa, G., & Forsido, S. F. (2021). Optimization of nutritional and sensory qualities of complementary foods prepared from sorghum, soybean, karkade and premix in Benishangul-Gumuz region, Ethiopia. *Heliyon*, *7*(9), e07955.

Khan, M. M. H., Rafii, M. Y., Ramlee, S. I., Jusoh, M., & Al-Mamun, M. (2021). Bambara groundnut (Vigna subterranea L. Verdc): A crop for the new millennium, its genetic diversity, and improvements to mitigate future food and nutritional challenges. *Sustainability*, *13*(10), 5530.

Khrisanapant, P., Leong, S. Y., Kebede, B., & Oey, I. (2021). Effects of hydrothermal processing duration on the texture, starch and protein in vitro digestibility of cowpeas, chickpeas and kidney beans. *Foods*, *10*(6), 1415.

Kontis, V., Bennett, J.E., Mathers, C.D., Li, G., Foreman, K., and Ezzati, M. (2017). Future life expectancy in 35 industrialised countries; projections with Bayesian Model ensemble. *The Lancet*, (389): 1323-1335.

Lansakara, L.H.M.P.R., Liyanage, K.A., Perera, K.A., Wijewardana, I., Jayawarden, B.C., & Vidanararachi, J.K. (2016). Nutrritional composition and health related functional properties of Eleusinecoracana (Finger Millet). *Procedia food science*, 6(4): 344-347.

Masamba K, Jinazali H (2014) Effect of cassava flour processing methods and substitution level on proximate composition, sensory characteristics and overall acceptability of bread made from wheat-cassava flour blends. *African Journal of Food Agriculture and Nutrition Development*, 14: 2190-2203.

Oguntuase, S. O., Ijarotimi, O. S., Oluwajuyitan, T. D., & Oboh, G. (2022). Nutritional, antioxidant, carbohydrate hydrolyzing enzyme inhibitory activities, and glyceamic index of wheat bread as influence by bambara groundnut substitution. *SN Applied Sciences*, *4*(4), 121.

Oladunmoye, O.O., Akinoso, R., Olapade, A.A. (2010) Evaluation of some physical chemical properties of wheat, cassava, maize and cowpea flours for bread making. *Journal of Food Quality*, 33: 693-708.

Rahman, A., Harunsani, M. H., Tan, A. L., Ahmad, N., Hojamberdiev, M., & Khan, M. M. (2021). Effect of Mg doping on ZnO fabricated using aqueous leaf extract of Ziziphus mauritiana Lam. for antioxidant and antibacterial studies. *Bioprocess and Biosystems Engineering*, *44*, 875-889.

Rashwan, A. K., Yones, H. A., Karim, N., Taha, E. M., & Chen, W. (2021). Potential processing technologies for developing sorghum-based food products: An update and comprehensive review. *Trends in Food Science & Technology*, *110*, 168-182.

Ronto, R., HY Wu, J., and Singh, G.M. (2018). The global nutrition transition:trends, disease burdens and policy interventions. *Public Health Nutrition*, 21(12): 2267-2270.

Spiker, M., Reinhardt, S., & Bruening, M. (2020). Academy of Nutrition and Dietetics: revised 2020 standards of professional performance for registered dietitian nutritionists (competent, proficient, and expert) in sustainable, resilient, and healthy food and water systems. *Journal of the Academy of Nutrition and Dietetics*, *120*(9), 1568-1585.

Thompson J., Manore, M., & Vaughan, L.A. (2013). *The Science of Nutrition*. 3rd Ed. New York, United States of America: Benjamin Cummings.

Torrico, D.D., Fuentes, S., Viejo, C.G., Ashman, H., & Dunshea, F.R. (2019). Cross-cultural effects of food product familiarity on sensory acceptability and non-invasive physiological responses of consumers. *Food Research International*, 115: 439-450.

United States Department of Health and Human Services and United States Department of Agriculture. (2015). *2015-2020 Dietary Guidelines for Americans*. 8th Edition, U.S. Government Printing Office, December.

Yıldırım, A. (2021). Moisture diffusivity, hardness, gelatinization temperature, and thermodynamic properties of ultrasound assisted soaking process of cowpea. *Journal of Food Process Engineering*, *44*(11), e13863.