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Original Research Article

Proximate Composition and Sensory Attributes of Porridge Enriched with Pumpkin Seeds for Improved Zinc Intake among School Age Children

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Abstract: Micronutrient deficiencies, often termed Hidden Hunger, affect approximately 2 billion people globally, causing significant health issues without visible symptoms. Zinc deficiency is a notable concern particularly in children as it plays a crucial role in growth, immune function, and various physiological processes. This study aimed at developing a porridge enriched with pumpkin seeds to enhance zinc intake in children aged 7-9 years. Raw materials (maize and pumpkins) were acquired from local markets, processed into flours, and four different composite flours with varying proportions of maize, pumpkin flesh, and pumpkin seeds were formulated; aimed at providing 50%, 54%, 58%, and 64% of the RDA for zinc for the children. Sensory evaluation was conducted using a 5-point hedonic scale to assess colour, taste, texture, appearance, odour, and overall acceptability. The most acceptable formulation, plain maize flour and pumpkin seed flour were further analysed for proximate analysis and zinc content. Sensory evaluation revealed significant differences in appearance, colour, and texture among the formulations, with formulation I (70% maize, 20% pumpkin flesh, 10% pumpkin seeds) receiving the highest overall acceptability. Proximate analysis of the pumpkin seed flour showed high protein (38.66g) and energy content (492.74 KCal/100g) with a zinc content of 8.00 mg per 100 grams, indicating its potential to significantly contribute to dietary zinc intake. Subsequently, the composite flour exhibited significantly higher levels of protein, fat, fibre, ash, and zinc compared to plain maize flour($p<0.05$). The study successfully developed a zinc-enriched porridge with good sensory attributes and improved nutritional content. The findings suggest that incorporating pumpkin seeds into porridge can enhance zinc intake and potentially address zinc deficiency in children. Further research is recommended to explore its acceptability in diverse populations.

Keyword: Zinc, RDA, Proximate Composition, Sensory Evaluation, Pumpkin Seeds.

1.0 INTRODUCTION

Micronutrient deficiencies are a global health issue, and their symptoms aren't usually visible hence the name Hidden Hunger. Approximately 2 billion people globally are deficient in Vitamin A, Iodine, Iron, Zinc and Folate which represents an estimated 7% of the global disease burden yearly (Ritchie and Roser, 2017).

Some of the key causes of micronutrient deficiencies include low quality and micronutrient poor diets as well as frequent infections. Zinc is an essential micronutrient for almost all cells since it is important for growth and development with the highest content located in the muscle and bones. It is vital for regulating gene expression, assisting in proper immune function, in synthesis, storage and release of insulin as well as influencing the thyroid hormone. It is also important for wound healing, proper taste, behaviour and learning performance. Zinc is needed in higher amounts during the stages of growth and development such as; infancy, childhood, pregnancy and lactation (Sight and Life, 2019).

The absorption of zinc ranges from 10% to 30% and it predominantly relies on the fibre and phytate content (FAO) and 17.3% of the world's population are

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at risk of zinc deficiency mainly due to dietary inadequacy (CDC, 2019) with 90% of this population coming from Asia and Africa (Kumssa *et al*., 2015). In 2016, the Kenya Micro-Nutrient Survey (KMNS) notes indicated that children had the highest prevalence of zinc deficiency countrywide with SAC 5-14 years prevalence recorded at 80.2%. The prevalence of zinc deficiency in rural and urban areas were at 86% and 76.4% respectively and since this prevalence is way above 20%, it has raised a public health concern (Njanja, 2017). Zinc supplementation has been observed to reduce incidences of premature births, decreased childhood diarrhoea and respiratory infections and caused an increase in growth and weight gain among infants and young children (CDC,2019).

Pumpkin seeds have gained popularity as an alternative medicine in recent times and are used in healthy nutrition. They are rich in magnesium, phosphorus, copper, manganese, iron and zinc and the World Health Organization (WHO, 2011) recommends its consumption to obtain zinc-10.07mg per 129gms (Health Benefit Times, 2019). Pumpkin seeds represent the base for reducing and controlling nutrition deficiencies from lack of sufficient intake of micronutrients such as β-carotene, B-complex vitamins, iron and zinc (Hu *et al*., 2013) and pumpkin seed powder can be used as nutrition supplements in the production of instant food mixes such as porridge and soup (Dhiman *et al*., 2017). Applequist *et al*., (2006) suggested that the flesh and outer skin as well as the seeds of pumpkins can be consumed as food; making it a unique fruit.

Porridge has been a common staple food used throughout Africa. It has been widely used in countries such as Malawi as a part of the USAID's strategies in prevention and treatment of moderately acute malnutrition (USAID, 2017). According to Labuza (2000), sensory evaluation of a food product is defined as the examination of a food's different attributes through the human sense; sight, smell, taste and mouth feel to be able to determine its overall acceptability. Organoleptic properties refer to the sensory characteristics of a product. Organoleptic testing involves visual examination, touch, and smell. Both sensory evaluation and organoleptic testing have gained popularity in new food production due to their effectiveness in assessing product acceptability. This research aimed at developing a product that would increase the dietary zinc intake for children aged 7-9 years through the use of porridge enriched with pumpkin seeds. The study evaluated the proximate composition and sensory attributes of the porridge developed.

2.0 MATERIALS AND METHODS

2.1 Acquisition of Raw Materials

Maize grains were purchased from local vendors and stored at 25℃ while pumpkin fruits were purchased from Marikiti market in Nairobi.

2.2 Preparation of the Samples

Maize grains were carefully sorted, run through cold water then air dried for 6 hours. The grains were then milled into fine flour. Pumpkin fruits were thoroughly washed, de-seeded and thinly sliced. The seeds were also washed then both the flesh, and the seeds were placed in an oven to dry to a moisture level <13% at 70℃ for 24 hours. The dried flesh and seeds were then transported to a local posho mill for milling. The flours were sieved (1.0mm aperture) then stored at 25℃.

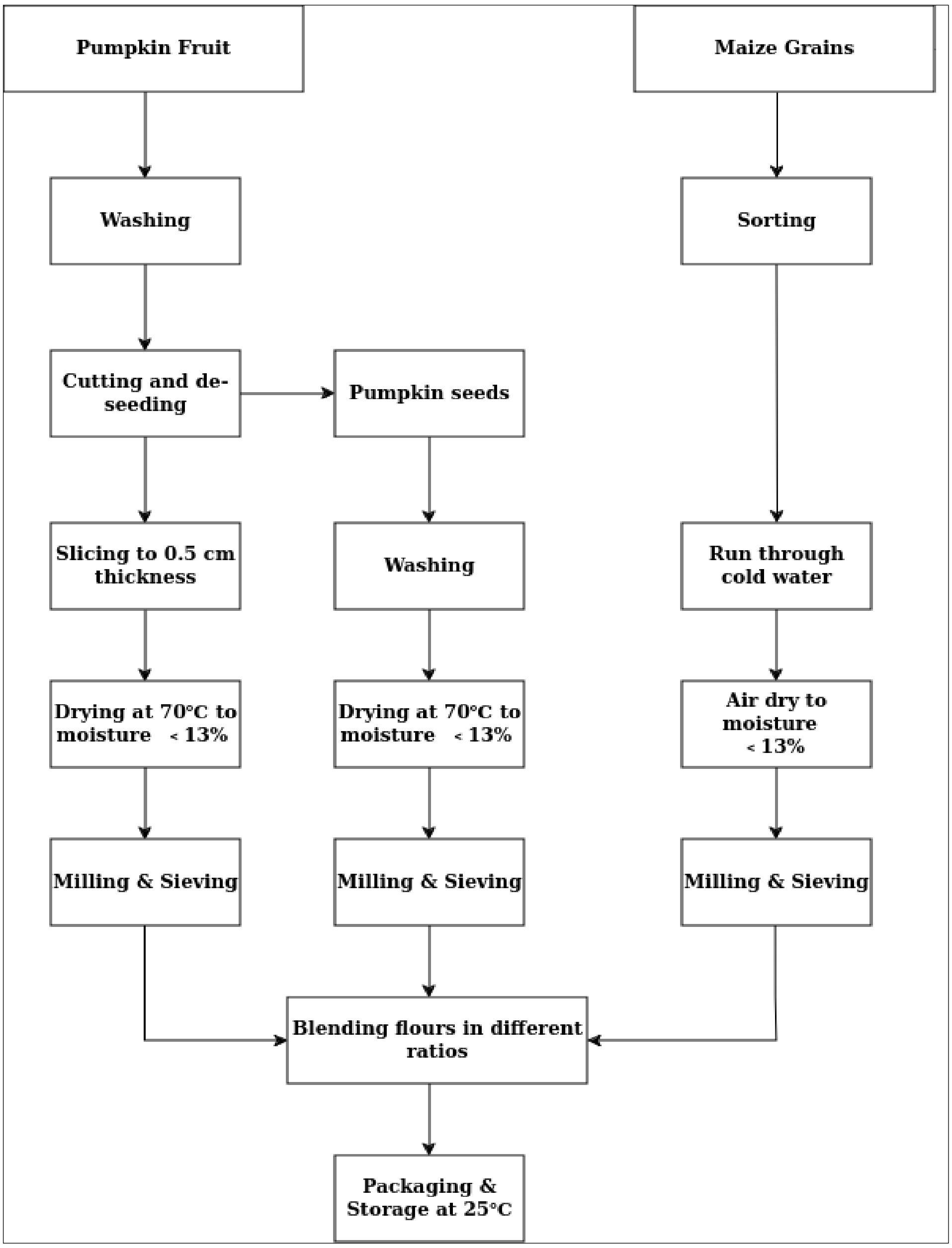

Figure 1: Flowchart diagram for preparation of flours

2.3 Formulation of Flours

Flour formulation was done at the University of Nairobi Pilot Plant. The formulations were developed to ensure the pumpkin seeds provided the Recommended Dietary Allowance (RDA) for zinc for children aged 7-9 years as per WHO recommendations(FAO/UNU/WHO, 2001). Nutrisurvey linear programming software, integrated with WHO's Recommended Dietary Allowance (RDA) for zinc, was utilised to formulate the flours. These formulations aimed to provide 44.64%, 48.21%, 51.79%, and 57.14% of the RDA for zinc in children. The software facilitated the development of four distinct formulations with varying proportions of maize and pumpkin seeds, maintaining a constant amount of pumpkin flesh. These formulations are detailed in Table 1.

Table 1: Formulation of Composite Flours

Formulation	Proportions (%)		
	Maize	Pumpkin flesh	Pumpkin seeds
I	70	20	10
II	65	20	15
III	60	20	20
IV	55	20	25

2.4 Analytical Methods

2.4.1 Sensory Evaluation of the Porridge

The formulated flours were prepared into a porridge. Half a kilogram of each flour was measured using a kitchen scale and then mixed with half a litre of cold water then added to a litre of boiling water. The porridge was then cooled to 40℃ then poured into cups labelled Ⅰ, Ⅱ, Ⅲ and Ⅳ. The porridge was then given to panellists alongside a cup of water and an evaluation sheet. The qualities investigated were colour, taste, texture, appearance, odour and overall acceptability. A 5-point hedonic scale was used with 5-like very much and 1-dislike very much. The most acceptable flour was then analysed for proximate composition and zinc content.

2.4.2 Determination of Proximate Composition

The maize flour, pumpkin seed flour and the most accepted flour formulation were all analysed for total moisture, ash, crude fibre, crude protein, crude fat and zinc contents according to the AOAC methods(AOAC, 2000).

2.4.3 Determination of Moisture Content

Moisture content was determined by taking 15gms of the sample flours and dividing them into three equal parts on aluminium dishes. The dishes were placed in a hot oven at 105℃ for four hours and the total moisture was determined as the total weight lost due to drying.

2.4.4 Determination of Crude Protein

Crude protein was determined as the total nitrogen content using the Kjeldahl method where 3gms of the individual sample flours were accurately weighed and divided into three nitrogen-free papers folded and placed in Kjeldahl flasks. A 5gm Kjeldahl catalyst ($K_2SO_4 + CuSO_4$) in the ratio 9:1 was added followed by sulphuric acid. The flask was then tilted and heated until the frothing stopped. The solution was then boiled until it was clear, cooled and distilled with water up to 75%. Several drops of an indicator were added to flasks containing 50 ml of 0.1N HCl solution and placed on a Kjeldahl distillation and then rotated and heated until NH_3 was distilled. The excess 0.1N HCl was titrated and distilled with $NAOH$ solution.

$$\boldsymbol{Protein}\% = \frac{(\boldsymbol{X}-\boldsymbol{Y})\times\boldsymbol{N}\times\mathbf{1.4007}\times\mathbf{6.25}}{\boldsymbol{W}}$$

Where:

$X = Volume\ of\ the\ tire\ sample$

$Y = \boldsymbol{Volume\ of\ blank}$

$N = Normality\ of\ HCl$

$W = Initial\ weight\ of\ the\ sample$

$1.4007 = Weight\ of\ atomic\ nitrogen$

$$6.25 = \frac{1}{nitrogen\ content\ of\ proteins} = \frac{1}{16}$$

2.4.5 Determination of Crude Fat

Approximately 9gms of the sample flours were weighed onto 3 paper filters and placed in the extraction thimble. Petroleum ether was added, and the sample was heated for 15 hours in a soxhlet apparatus. The bottle was then placed in an oven at 85℃ for complete evaporation. The bottle was then allowed to cool and the residual matter weighed as the crude fat.

$$Fat\ \% = \frac{Residue}{Initial\ weight\ of\ the\ samples} \times 100$$

2.4.6 Determination of Crude Fibre

Crude fibre of a sample was determined by AOAC methods (AOAC,2005). Approximately 3gms of the sample flours were weighed into two beakers. A few drops of boiling water together with 1.25% dilute sulphuric acid were added and the solution was boiled for 30 minutes, and the contents were filtered using a filter cloth. The residual matter was then washed using boiling water. The residuals and the filter cloth were transferred into a beaker and 1.25% NaOH solution and some water was added to make up 200ml of the solution. The solution was then boiled on a hotplate for half an hour and the contents washed with hot water then using a small amount of 9% ethyl alcohol. The residual matter was then placed on a porcelain dish and dried in an oven at 105℃ until a constant weight is achieved. The residue was then allowed to cool, weighed then ignited. The contents were cooled in a desiccator and weighed. Crude fibre content was calculated as:

$$Crude\ fibre\% = \frac{(W1 - W2)}{W} \times 100$$

Where:
W1 = Weight of the dish and the contents (in grams)
W2 = Weight of the dish containing the ash
W = Initial weight of the sample

2.4.7 Determination of Total Ash

Total ash was determined by taking 6 gms of the sample flours and dividing them into 3 equal parts. The dishes were then placed in a furnace at 550℃ overnight. They were then cooled to room temperature and the ash percentage calculated as:

$$Ash\% = \frac{Leftover\ ash}{Initial\ weight\ of\ the\ samples} \times 100$$

2.4.8 Calculation of Soluble Carbohydrates

Soluble carbohydrates were calculated as:

$$100 - (Crude\ fibre + Crude\ protein + Crude\ fat\ Total\ ash + \ Moisture\ Content$$

2.4.9 Calculation of Total Energy

Total energy of the sample flours was:

$$Total\ energy = Carbohydrates(g) + Protein(g) + Fat(g)$$

2.4.10 Determination of Zinc Content

Zinc content of the sample flours was analysed through the Atomic Absorption Spectrometry (Jorhem, 2000). 2gms of the sample flours were weighed into 2 equal parts, burnt to constant weight and the ash extruded using 10 ml of water mixed with HCl in the ratio 1:1 and the extract transferred into a 50 ml volumetric flask made up to the mark. Dilutions were made and the elements were analysed against the standard.

2.5 Statistical Analysis

Statistical analysis was conducted using SPSS version 20. Nutrient contents were converted to a dry weight basis (dwb), and data obtained was presented in the form of mean ± standard deviation (*SD*). Further analysis involved the use of ANOVA and T-tests, with Tukey's Honest Significant Difference post hoc test used to identify significantly different means. Statistical significance was assessed at a 95% confidence level ($p < 0.05$).

3.0 RESULTS AND DISCUSSION

3.1 Sensory Evaluation of the Porridge Samples

Based on the Tukey test; there were significant differences in the appearance of the porridge samples ($p<0.05$). Samples Ⅰ and Ⅳ were rated significantly higher than samples Ⅱ and Ⅲ, which received lower scores. This suggests that the proportion of maize flour used in Sample Ⅰ and Ⅳ contributed positively to the appearance, making it more acceptable to the panellists.

Samples Ⅰ and Ⅳ were significantly different from samples Ⅲ and Ⅱ ($p<0.05$) in terms of colour. Sample Ⅰ was formulated with a higher proportion of maize flour compared to the other formulations hence the high colour acceptability score. These findings concurred with those of a study conducted by Liomba *et al*., (2018) which reported that complementary food substituted with a higher amount of maize had a higher colour acceptability score. Colour is crucial in the overall appearance of food and it is one of the main factors that contribute to the attraction of individuals to food (Rodger, 1995).

The results showed that the taste of the sample porridges did not vary significantly ($p>0.05$). The panellists however rated sample Ⅱ as good followed by samples Ⅰ and Ⅳ while sample Ⅲ rated the poorest with a ranking of 2.9 as shown on Table 2. According to Liomba *et al*., (2018), taste is a vital parameter during the evaluation of the sensory attributes of food. A product may be appealing and high in energy; but if the taste isn't good the product will be most likely unacceptable. Porridges formulated using lower proportions of pumpkin seed flour were found to be tastier and more colourful than those with higher amounts of pumpkin seed flour.

The sensory evaluation for odour showed that samples Ⅰ, Ⅲ, and Ⅳ were not significantly different from each other ($p>0.05$). However, sample Ⅱ was significantly different from samples Ⅰ and Ⅳ, receiving a lower odour acceptability score. Sample Ⅰ and Ⅳ were rated equally high, an indication that the odour did not significantly vary between these samples. These results suggest that while the odour was an important factor, it did not vary significantly among most of the samples.

The texture of the porridge samples showed significant differences across all samples ($p<0.05$). Sample Ⅰ was rated highest for texture, while sample Ⅲ had the lowest rating. This indicates that the texture was a significant differentiator among the samples, with sample Ⅰ being preferred due to its better texture compared to the others. The overall acceptability of the porridge samples varied from 2.9 to 3.8 with composite porridge containing 10% of pumpkin seed meal(sample Ⅰ) having the best overall score followed by samples Ⅳ, Ⅱ while sample Ⅲ was rated the poorest. Food formulations with addition of higher maize proportions were found to be tastier and having good colour than those with less maize flour, indicating that the pumpkin seed flour proportions had an effect on the overall acceptability of the porridge developed.

Table 2: Sensory evaluation of the developed porridge samples

Attributes	Samples			
	Ⅰ	Ⅱ	Ⅲ	Ⅳ
Appearance	$4.3±0.62^{a}$	$3.9±0.45^{ab}$	$3.0±0.77^{b}$	$4.1±0.56^{a}$
Colour	$4.4±0.53^{a}$	$4.2±0.67^{b}$	$3.3±0.87^{ab}$	$4.1±0.78^{a}$
Odour	$4.3±0.55^{a}$	$3.8±0.65^{b}$	$4.0±0.34^{a}$	$4.3±0.56^{a}$
Taste	$4.1±0.51^{a}$	$4.3±0.67^{a}$	$3.4±0.39^{b}$	$4.3±0.28^{b}$
Texture	$4.2±0.45^{a}$	$3.7±0.56^{b}$	$3.1±0.72^{c}$	$4.1±0.44^{b}$
Overall Acceptability	$3.8±0.69^{a}$	$3.6±0.57^{b}$	$2.9±0.76^{c}$	$3.7±0.56^{b}$

Mean ± Standard deviation (n=9). Means in the same row followed by the same letter are not significantly different at p<0.05

3.2 Proximate Composition of the Flours

3.2.1 Proximate Composition of the Pumpkin Seed Flour

The moisture content in the pumpkin seed flour (5.77%) was close to the findings reported by Sharma and Lakhawat(2017) who reported the moisture content of pumpkin seed flour as 5.47% but higher than that reported in a study conducted in Kitui County where the moisture content of the pumpkin seeds was reported as 4.70%(Mbijiwe *et al*., 2021).

The protein content in the pumpkin seed flour was 38.66g. These findings were similar to 37.33g reported by Dhiman *et al*., (2018) and 37.48g reported by Mbijiwe *et al*., (2021); an indication that pumpkin seeds could significantly contribute to the recommended dietary intake for proteins. The carbohydrate content of the pumpkin seed flour was 13.66%. These values were lower than the findings of studies which reported the carbohydrate content as 29.34% and 27.35%(Mbijiwe *et al*., 2021, Karanja *et al.*, 2013).

The energy value of pumpkin seed flour was found to be 492.74 KCal/100g. The high amounts of energy present in the pumpkin seed flour is attributable to the high amounts of fat present in the seeds(31.50%) mainly because fats contain higher amounts of calories per gram(Nikiema *et al*., 2011). The fat content reported was similar to the findings of a review in which the fat content was reported as 31.75%(Devi *et al*., 2018). Fat is a crucial macronutrient in complementary food formulation because it increases the energy density of the formulated diet (WHO, 2009).

The ash content was found to be 3.71%, which is similar to the findings of Marcel *et al*., (2021) but lower than those reported by Mbijiwe *et al*., (2021). Ash content indicates the total mineral content of a food, with higher values reflecting greater mineral content (Oppong *et al*., 2015). Further analysis of the ash revealed a zinc content of 80.00 ppm, higher than those reported in Indonesia, which reported 68.90 ppm. The difference could be attributed to the variations in growing methods used for pumpkin seeds (Syam *et al*., 2023).The fibre content was 6.72%, demonstrating that pumpkin seed flour is an excellent source of dietary fibre. These findings were higher than those reported by Mbijiwe *et al*., (2021) 5.37% and 5.48% reported by Tuslinah *et al.*, (2018).

3.2.2 Proximate Composition of the Flours

The moisture content of the maize flour and composite flour were within the acceptable levels of a maximum of 15%(Codex Standards 154-1985) as presented in Table 4. Addition of pumpkin flesh and seeds into the maize flour significantly improved the protein, fibre and ash content of the flour. The composite flour had significantly higher proportions of protein in comparison to plain maize flour ($p<0.05$). The high protein content in the composite flour indicates that both the pumpkin flesh and seeds contained significant amounts of protein in comparison to plain maize flour; similar to findings in a previous study where pumpkin flesh and seeds were observed to improve the protein content of a sorghum-based porridge and were reported to be a good source of protein for making new food products (Mbijiwe *et al*., 2021; Pham *et al*., 2017).

The carbohydrate contents of the composite and maize flours differed significantly ($p<0.05$). The composite flour had significantly lower amounts of carbohydrates in comparison to the maize flour. The results implied that pumpkin seed flour cannot be relied upon as a good source of carbohydrate as compared to maize flour. The energy contents in both flours did not vary significantly ($p>0.05$). The maize and composite flours had 362.93 and 360.60 KCal/100g respectively. These findings were slightly lower than the standard (400KCal/100g) set by the Codex Alimentarius for the formulation of supplementary foods(KEBS & CAC, 1991).

The crude fibre content in the composite flour was significantly greater than the fibre contents of the maize flour ($p<0.05$). The increase in crude fibre recorded in the composite flour may be as a result of higher levels present in the flesh and seeds. A previous study conducted by Shitu *et al.*, (2007) stated that although crude fibre cannot be digested by the human digestive system; they are of significant importance to the colon and heart since they have the capability to delay the release of gastric juice as well as in improving the bulkiness of food.

The composite flour had significantly higher amounts of ash compared to the maize flour ($p<0.05$). An increase in the ash content showed that the composite flour may contain substantially higher amounts of minerals than maize flour. The proportion of ash in food is a depiction of the mineral contents in the particular food (Omotoso, 2006). These findings were supported by Iken and Amusa (2010) who reported that cereals have higher carbohydrate and less mineral content. The zinc content in the composite flour was significantly higher than that of maize flour ($p<0.05$). The low amount of zinc in maize flour could be a reason why communities that are heavily reliant on maize in complementary feeding for children suffer from micronutrient deficiencies (Liomba *et al*., 2018). The formulated flour developed has high protein, fibre, fat, ash and zinc contents in comparison to plain maize flour and it has the potential for increasing the dietary zinc, fibre and protein for children aged 7-9 years and can therefore serve as an adequate complementation of the children’s normal diet.

Table 3: Proximate Composition of Pumpkin seed Flour

Flour	Moisture (%)	Protein (g/100g)	Carbohydrate (%)	Fat (%)	Fibre (%)	Ash (%)	Energy (KCal/100g)	Zinc (Ppm)
Pumpkin seed	5.77±0.11	38.66± 0.04	13.66±0.52	31.50±0.16	6.72±0.02	3.71±0.32	492.74±0.80	80.00±0.30

Values are means of two replicates ± SD, on dry weight basis

Table 4: Proximate Composition of the Flours

Flour	Moisture (%)	Protein (g/100g)	Carbohydrate (%)	Fat (%)	Fibre (%)	Ash (%)	Energy (KCal/100g)	Zinc (Ppm)
Maize flour	10.39±0.39	9.12±0.14	71.87±0.07	4.33±0.11	2.83±0.13	0.92±0.13	362.93±3.58	25.16±0.50
Composite flour	11.61±0.25	51.82±0.04	17.77±0.30	9.14±0.10	7.73±0.06	1.95±0.05	360.60±1.94	29.56±0.60
p-value	0.07	0.00*	0.00*	0.01*	0.00*	0.00*	0.50	0.01*

Values are means of two replicates ± SD, on dry weight basis
**significant by T-test atp<0.05*

4.0 CONCLUSION

Sample I had the best scores in terms of appearance, colour, texture, taste as well as overall acceptability. Incorporation of pumpkin seed in the maize meal blend increases the content of zinc in the composite flour and this sample contributed to 52.79% of the RDA for zinc for children 7-9 years. This study provides valuable data essential in the implementation of nutritional programmes by providing a cost-effective way to alleviate zinc deficiency among school-age children. It is therefore recommended that utilisation of pumpkin seeds in complementary feeding should be promoted in the communities as well as in school feeding programmes to increase dietary zinc intake among school-age children.

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