Nutritional Value and Sensory Acceptability of *M. oleifera* Fortified Finger Millet Porridge for Children with Cerebral Palsy in Nairobi County, Kenya

Janet Kajuju Malla¹,², Sophie Ochola¹, Irene Ogada¹,³ & Ann Munyaka¹

¹ Department of Food, Nutrition and Dietetics, Kenyatta University, P.O. BOX 43844-00100 Nairobi, Kenya
² Department of Human Nutrition and Dietetics, Technical University of Kenya, P.O. BOX 52428-00200 Nairobi, Kenya
³ Department of Applied Human Nutrition, Mount Saint Vincent University, Canada

Correspondence: Janet Kajuju Malla, Department of Human Nutrition and Dietetics, Technical University of Kenya, Nairobi, Kenya. Tel: 254-720-813-556. E-mail: janetmalla66@gmail.com

Received: August 12, 2021  Accepted: September 15, 2021  Online Published: October 7, 2021
doi:10.5539/jfr.v10n5p36  URL: https://doi.org/10.5539/jfr.v10n5p36

Abstract

Nutritional deficiencies and other nutritional comorbidities commonly affect children with cerebral palsy. Interventions through fortification to enhance nutrient densities of foods for these groups may improve their intakes and consequently their nutritional and health status. This study was undertaken to determine the nutritional value and sensory acceptability of a finger millet porridge fortified with *Moringa oleifera* leaf powder. Standard methods approved by the Association of Official Analytical Chemists were adopted for determination of nutrient and anti-nutrient content of samples. Sensory evaluation was conducted according to the method of Larmond (1977). Statistical analysis was conducted with the aid of Statistical Package for Social Sciences software version 20. One-way analysis of variance with a post-hoc test of Least Significant Difference to separate the means was used to compare the nutrient and anti-nutrient content of samples. Independent t-test was used to test difference in mean sensory scores between fortified and control porridge. The results showed that *M. oleifera* leaf powder had significantly higher contents of protein and β-carotene, which were the target nutrients for fortification of the fermented finger millet flour. Fermentation reduced the levels of anti-nutrients in finger millet flour. Fortification of the fermented finger millet flour with *M. oleifera* leaf powder at the ratio of 9:1 significantly improved the protein and β-carotene content of the fortified flour and did not significantly affect the sensory acceptability of the fortified porridge. This study confirmed the potential for *M. oleifera* as suitable fortificant in finger millet porridge formulations to improve both protein and β-carotene intake in target populations.

Keywords: acceptability, β-carotene, cerebral palsy, finger millet, *Moringa oleifera*, protein

1. Introduction

Undernutrition, growth failure, and micronutrient deficiencies are nutritional comorbidities that commonly affect neurologically impaired children (Marchand and Motil, 2006). Appropriate nutritional interventions may improve linear growth, weight, health, and quality of life and reduce the frequency of hospitalization in these children (Marchand and Motil, 2006). According to Boateng et al. (2019), improving the quality of diets is one of the most cost-effective strategies for improving public health and reducing morbidity and mortality in many populations more so in children with cerebral palsy where feeding difficulties compromise their food intake thereby leading to nutritional deficiencies.

One of the main ways to provide additional nutrients to populations at risk of nutrient deficiencies is fortification (Boateng et al., 2019). Food fortification is an important nutrition intervention to fight micronutrient deficiencies and to reduce their incidence in many populations (Rowe, 2020). In particular, food-to-food fortification is an approach that uses an interesting local resource (plant or animal) to fortify another food. This approach consists of selecting and associating foods (a common staple and a fortifying food) in such a way as to optimize the nutritional value and enhance nutrient intake (Ohanenye et al., 2021; Tenye et al., 2020). The fortifying agent is selected based on some criteria e.g. it must be readily available, and easily accessible besides containing useful...
amounts of micronutrients. The rate of fortification varies considerably, between 1% and 50% depending on the compatibility of the vehicle (the staple food) and the fortificant (Chadare et al., 2019). For both classical food fortification and food-to-food fortification, the main objective is to improve the nutritional quality of the fortified food without compromising its sensory acceptability (Chadare et al., 2019; Johnson, Mannar and Ranum, 2004). The Food and Agricultural Organization is currently promoting the use of indigenous and/or underutilized crops readily found in various localities as an economically sustainable strategy for enhancing food security and addressing common deficiencies in local populations.

Although finger millet is currently categorized as a neglected and underutilized species (Opole, 2019), it remains a staple food and therefore a source of food security for a large segment of low-income population groups in East Africa and a suitable vehicle for food-to food fortification interventions in the region (Gull, Jan, Nayik, Prasad & Kumar, 2014; Sircar and Chadra, 2019). Finger millet is also reported to be rich in important nutrients including carbohydrates, proteins, calcium, iron and zinc which coupled with its excellent storage qualities makes it a popular complementary food (Dinesh, Kumar and Singh, 2014). In many local communities, finger millet porridge is a common food for both children and adults. Finger millet’s nutritive value is however compromised by the presence of anti-nutrients such as phytates, phenols and tannins, as well as poor digestibility of millet proteins, which militate against its utilization in human nutrition particularly in neurologically impaired (NI) children. Processing technologies such as compositing, fermentation, malting, etc. can mitigate the effects of these anti-nutrients and significantly improve the bioavailability of finger millet proteins and minerals (Nkhata, Ayua, Kamau & Shingiro, 2018; Si, Cg, 2020; Dayakar, Malleshi, Annor &Patil, 2016). In particular, fermentation improves flavor and nutritional properties and helps to preserve food products (Ramashia et al., 2019).

*M. oleifera* has also been receiving increasing attention from the food processing industries owing to its high content of important nutrients including proteins, minerals such as calcium and iron and vitamins such as carotenoids and vitamin C as reported by some studies (Boetang et al., 2018; Fuglie & Sreeia, 2011; Ndubuaku et al., 2015; Witt, 2013). Cereal processors have shown interest in the enrichment of their products with a low cost, local source of vitamins and minerals such as *M. oleifera* leaf powder (Singh et al., 2018). A study by Isingoma et al. (2018) reported that enrichment of millet flour with *M. oleifera* leaf powder (MoLP) improved the nutritional value of the porridge. According to Shiya, Rumisha, Oriyo, Kilima and Massaga (2019), the nutritional potential in *M. oleifera* leaf powder makes it an important ingredient in improving nutrient diversification in complementary food for children. The leaves provide significant quantities of the key nutrients including calcium, iron, vitamin A (carotenoid) and vitamin C. In addition, *M. oleifera* leaves are rich in all essential amino acids. On the other hand, moringa tree is a tropical plant grows well on all type of soils, although humus-rich forest soil is the most ideal. Although it is affected by water stress, the plant tolerates drought conditions (Agbogidi & Ilondu, 2012).

Food acceptance plays a crucial role in the success of nutrition interventions that seek to introduce new food commodities (Nicklaus, 2011). For a nutrition intervention to be successful, the majority of the target population must accept and consume the food commodities in quantities sufficient to improve their nutritional health (Miller and Welch, 2013). Given the unique sensory characteristics (color, taste, and odor) of MoLP, sensory acceptability is a critical factor when designing dietary interventions incorporating MoLP (Boeteng, Nyarko, Asante & Steiner-Asiedu, 2018). This study assessed the nutritional value and sensory acceptability of *M. oleifera-* fortified finger millet porridge formulated for nutritional intervention among children with cerebral palsy in Nairobi, Kenya.

2. Materials and Methods

2.1 Production of Fermented Finger Millet Flour

Finger millet was purchased from the local markets and sorted for quality following the East African Standards Specifications for Finger Millet grains (EAS 758:2011 ICS 67.060). The grains were then milled to obtain flour. The flour was mixed with warm water at the ratio of 1:2 respectively, then covered with a muslin cloth and incubated at 25-30°C for 48 hours (Sharma & Kapoor, 1996). The water was drained and the paste spread into sheets then dried in the oven for 12 hours at 115°C.

2.2 Production *M. oleifera* Leaf Powder

Fresh *M. oleifera* leaves were cleaned with clean water to remove dirt and other impurities. They were then washed in 1% saline solution (NaCl) for 3 minutes to remove microbes logged on the surfaces followed by rinsing in clean water to remove the saline solution. Afterward, the leaves were blanched in steam for 3 minutes to inactivate enzymes and preserve color followed by cooling in ice water for 5 minutes and spreading out on
racks for 20 minutes to drain off the water. The leaves were then solar dried on racks at 50º C to a uniform moisture content of 7.5% followed by milling into a powder using a kitchen blender. The dried M. oleifera leaf powder was packaged in translucent polythene bags and stored at room temperature until used for nutrient analysis and porridge fortification.

2.3 Formulation of Fortified Flour

The Pearson square method of Wagner and Stanton (2009) was used to determine the proportion for mixing which was established at the ratio of 9:1, FFm to MoLP respectively. The product formulation was aimed at providing adequate protein which was the targeted primary nutrient.

2.4 Preparation of Porridges

Standard recipes were followed during the preparation of the control and experimental porridge samples. One hundred grams of flour and 1000 mL of clean water were weighed in sufuria (sauce pan) followed by stirring to form a homogenous slurry. Exactly 25 g of sugar was added to the slurry to improve the taste while 10g of oil was added to enhance vitamin A absorption. The slurry was cooked for 10 minutes in medium heat while stirring continuously to form a thick gruel and then kept in thermo-flasks ready to be served to the sensory panelists. Samples of the porridges were coded and cooled to 40 ºC before each exercise of sensory evaluation. Laboratory analysis samples were let to cool to room temperature before storing under deep freezing at -20 ºC. Nutrient analysis of the porridge samples was conducted within a span of 3 weeks from the preparation date.

2.5 Analysis of Nutrients

2.5.1 Determination of Nutrient Content of M. Oleifera Leaf Powder, Fermented and Unfermented Millet Flour and the M. oleifera- Fortified Millet Flour

The content of protein, fat, moisture, and ash was determined by the methods of the Association of Official Analytical Chemists [AOAC, 2005]. The carbohydrate content was calculated by difference method as described by FAO (2010).

2.5.2 Determination of Moisture

Moisture content was determined using the oven drying as described by AOAC (2005) in method number 925.10. Samples (5g) were placed into pre-weighed dry crucibles then heated in a hot air oven (Gellenkamp, UK) at 105 ºC for 3 hours. Samples were cooled and weighed after every 30 minutes until weight change was not recorded after 3 successive measurements. Measurements were taken using an electronic balance (NBY323/64: Avery East Africa). The dried samples' final weights were taken and the moisture content of the samples was calculated as:

\[
\% \text{MC} = \frac{(\text{Wt of crucible + fresh sample}) - (\text{wt of crucible + dry sample})}{(\text{wt of fresh sample}) \times 10}
\]  

2.5.3 Crude Fat Analysis

Crude fat was determined by soxhlet extraction as outlined by AOAC (2005) in method number 920.39. One gram dried sample was weighed into an extraction thimble and covered with absorbent cotton. 50 mL solvent (petroleum ether) was added to a pre-weighed flask. Both thimble and flask were attached to the extraction unit. The sample was then subjected to extraction with solvent for 30 minutes followed by rinsing for 1.5 hrs. Afterward, the solvent was vacuum evaporated from the flask to the condensing column. Extracted fat in the flask was placed in an oven at 110ºC for 1 hr to evaporate the solvent. The weight of extracted lipid was determined by subtracting the weight of the empty flask from the total weight of flask + fat after drying. Crude fat was calculated using the following formula:

\[
\% \text{Crude fat (db)} = \frac{(\text{Extracted fat / dried sample weight})}{\text{x 100}}
\]  

2.5.5 Crude Protein Analysis

The amount of protein was determined by Kjeldahl digestion method as described by AOAC (2005) in method number 920.87. One gram of each sample was weighed and digested in concentrated sulphuric acid with one Kjeldahl tablet before neutralizing using 40% sodium hydroxide and distilling. The resulting solution was then titrated with 0.1N hydrochloric acid using a mixed indicator (methyl red and bromocresol green). The percentage of nitrogen (N) was then determined by the equation

\[
\% \text{nitrogen} = (S - B) \times N \times 0.014 \times D \times \frac{100}{W \times V}
\]

Where D = dilution factor, N= Normality of acid, T= titre value = (S-B), W = weight of sample, S= Volume of acid required to titrate sample B= Volume of acid required to titrate blank 0.014 = constant value. Crude protein was obtained by multiplying the corresponding total nitrogen (N) content by a conversion factor of 6.25. Thus:
Crude protein (%) = %Nitrogen × 6.25

2.5.6 Ash Content Determination
The total content of ash in samples was determined by dry ashing according to method number 923.03 by AOAC (2005). Samples (5g) were weighed in dry crucibles and carbonized on a hot plate then heated on a muffle furnace (Nerberthem: model; L9/11/C6, Germany) for 8 hours at 600 °C after which they were cooled in a desiccator and weighed. The % ash content was calculated by the difference in weight after cooling the samples to ambient temperatures. The % ash content in the sample was calculated as follows:

\[ \text{Crude ash\%} = \frac{(w_1 - w_2)}{(\text{Weight of sample})} \times 100 \]  

Where: \(w_1\) = weight of empty crucible, and \(w_2\) = weight of crucible with ash.

2.74 Determination of Total Carbohydrate
The total percentage carbohydrate content in the flour samples was determined by the difference method. This was calculated as described by Sultana et al. (2017):

\[ \% \text{ carbohydrate} = 100 - (\% \text{ moisture} + \% \text{ crude fiber} + \% \text{ protein} + \% \text{ lipid} + \% \text{ ash}) \]

2.5.8 Vitamin A
Vitamin A content of samples was determined as β-carotene (its precursor in plants) using UV–VIS Spectrophotoscopy method. For the extraction of β-carotene, 50 mL of acetone–hexane mixture containing 0.1% BHT was added to 5g sample and the mixture was shaken for 10 minutes, centrifuged and decanted to a separating funnel. The supernatant was saponified by the addition of 25 mL of 0.5M methanolic potassium hydroxide, before shaking and allowing to settle for 30 minutes and then washing with 100 mL portions of distilled water. The aqueous layer was discarded continuously. The extract was then dried by filtering over anhydrous sodium sulphate. The filtrate was concentrated in a rotary evaporator at 45°C and reconstituted in methanol to 50 mL. Different concentrations of standard solution were prepared using 95% UV β-carotene. A stock solution of (100 μg/mL) was made by dissolving 0.01 g of β-carotene standard into 10 mL hexane, which was then increased to 100 mL. The working standard solution was used to prepare standard solutions of various concentrations. The absorbance (A) of each concentration was measured using the UV–Vis Spectrophotometry at a wavelength of 545 nm (Gupta et al., 2005).

2.5.9 Determination of Tannins
Tannin in samples was extracted with 50% methanol and quantified using Folin Denis Reagent as described by (Swain, 1979). Sample extract (1 mm) was pipetted into a 50-mL volumetric flask, before adding distilled water (20 mL), Folin-Denis reagent (2.5 mL), and 17% Na2CO3 (10 mL) and mixing. The mixture was then made up to mark with distilled water, and thoroughly mixed, then allowed to stand for 20 min until a bluish-green color developed. Standard solutions of tannic acid in the range of 0–10 ppm were treated in a similar manner as the 1 mL sample above and was used to obtain a standard curve. The absorbances of the tannic acid standard solutions, as well as samples, was obtained using UV-VIS spectrophotometer at 760 nm.

\[ \text{Tannin(}mg/g\text{)} = \frac{([A]_S - A_b \text{} - \text{intercept})/(\text{Slope} \times d \times W)}{1} \times 1 \]  

Where \(A_s\) is the sample absorbance, \(A_b\) is the blank absorbance, \(d\) is the density of the solution (0.791 g/mL), \(W\) is the weight of the sample in gram, and \(1\) is the aliquot.

2.5.10 Determination of Phytyates
The Wheeler and Ferrel (1971) indirect colorimetric method was employed for phytate content determination. Five grams of the sample was extracted with 3% trichloro acetic acid. The phytyates were precipitated as ferric hydroxide and soluble sodium phytate by adding sodium hydroxide. The precipitate was dissolved in hot 3.2 N HNO and the absorbance read immediately at 480 nm. The standard solution was prepared from Fe (NO3)3 and the iron content was extrapolated from a Fe (NO)3 standard curve. The phytate concentration was calculated from the iron concentration determined for the samples, assuming a 4:6 iron:phosphorus molecular ratio.

2.5.11 Determination of Total Phenolic Compounds
The total phenolic compounds were determined according to the Folin–Ciocalteu colorimetric method using gallic acid as the standard as described by Horvat et al. (2020). Absorbance was measured by spectrophotometer (Hitachi, Tokyo, Japan) at 765 nm. The results were quantified using external calibration and expressed as μg of gallic acid equivalent (GAE) per g of dry matter.
2.5.12 Determination of Oxalate Content

Oxalate was determined according to AOAC (2005) method. One gram of the sample was weighed in a 100-mL conical flask. The 70 mL of H2SO4 (3M) was added and the solution stirred intermittently with a magnetic stirrer for about 1 hour, followed by filtering using Whatman No. 1 filter paper. The sample filtrate /extract (25 mL) was collected and then titrated against hot (80–90°C) 0.1 N KMnO4 solution to the point where a faint pink coloration appears and persists for at least 30 sec. The oxalate concentration in each sample was calculated: 1 mL 0.1 permanganate = 0.006303 g oxalate.

2.6 Sensory Analysis

The sensory acceptability of the porridge samples was tested among a group of 50 untrained panelists consisting of randomly selected caregivers of children with CP in the reproductive age 15–49 years who had signed an informed consent form. The sample size was based on the recommendation for affective consumer tests which is 50 -100 (Civille et al., 2018; Gacula, 2018). The study objectives and the sensory evaluation procedure were explained to the panelists and they were informed about the importance of giving honest and independent opinions after sampling the porridges. The method of Larmond (1977) was employed during the sensory evaluation. Each of the panelists was provided with two coded porridge samples in own tables in a spacious, well-lit and well-ventilated room and required to rate each attribute on a five-point facial hedonic scale (1 = extremely dislike; 5 = extremely like). The tables were placed wide apart such that it was not possible for panelists to communicate with each other in order to enhance the independence of opinions among panelists. Each panelist was given two sensory questionnaires, one questionnaire for each coded sample. The exercise was conducted during the morning hours between 9.00am and 12.00 noon. Serving of samples was done at a uniform temperature (45°C) and equal quantities (30 mL) of each coded sample were provided for each panelist. Each panelist was provided with a glass of lukewarm water for rinsing the mouth in between samples. The panelists were instructed to pause for a minute from tasting and scoring one sample before proceeding to the next. The researcher was available throughout the sensory evaluation sessions to assist the study participants when required. Scores were averaged to obtain an overall rating for each attribute including overall acceptability.

2.7 Statistical Analysis

Data analysis was conducted with the aid of Statistical Package for Social Sciences (SPSS) software version 20. One-way analysis of variance (ANOVA) with a post-hoc test of Least Significant Difference (LSD) to separate the means was used to compare the nutrient and anti-nutrient content of samples. Sensory acceptability was described in terms of mean hedonic scores for the different sensory test parameters. Independent t-test was used to test difference in scores between fortified and control porridge.

3. Results

3.1 Nutrient Content of Porridge Flour Samples

Except for carbohydrates, the MoLP flour had the highest contents of both proximate and β-carotene, followed by the fortified flour while the fermented finger millet flour had the least contents of the nutrient (Table 1). The initial ANOVA results showed that significant differences existed in both the proximate and β-carotene content between the flour samples (p-value < 0.001). Post hoc analysis revealed that the MoLP had significantly higher content of protein, crude fat, ash and β-carotene than the finger millet flour samples except for carbohydrates. Furthermore, except for carbohydrate, which improved, fermentation of the finger millet flour compromised both its proximate and β-carotene content but not significantly (p>0.05). The fortified porridge flour had significantly higher contents (p<0.05) of both proximate and β-carotene than the non-fortified flour samples except carbohydrates (Table 1).

Table 1. Nutrient Contents of Samples (Mean values, dwb; N=3 ± SE)

| Nutrient          | Descriptives | ANOVA test |
|-------------------|--------------|------------|
|                   | Nutrient content (Mean ± SE ); N=3 | df | f-value | p-value |
|                   | FFmF         | UFmF       | Mo-FFmF  | MoLP     |
| Moisture (%)      | 10.03± 1.12  | 14.77 ± 0.69 | 9.26 ± 0.24 | 11.61±1.07 | 3,8 | <0.001 |
| Protein (%)       | 8.98 ± 12.9a | 10.18 ± 0.62a | 13.76± 1.19b | 20.05±0.62c | 3,8 | 25,652 |<0.001|
| Total Fat (%)     | 0.7 ± 0.06a  | 2.00 ± 0.58a | 9.10 ± 0.35b | 14.70±0.92c | 3,8 | 130.104 |<0.001|
| Carbohydrates (%) | 77.0 ± 1.76a | 67.41 ± 0.53ab | 68.83 ± 1.14ab | 19.90 ± 1.96c | 3,8 | 314.9 |<0.001|
| Ash (%)           | 2.62 ± 0.05a | 3.06 ± 0.06a | 3.29 ± 0.12a | 13.74 ± 0.71b | 3,8 | 223.977 |<0.001|
| β-carotene (mg/100)| 1.08 ± 0.02a | 1.19 ± 0.00a | 1.42 ± 0.00a | 12.59 ± 0.08c | 3,8 | 18929.579 |<0.001|

Key
3.2 Anti-nutrient Content of Porridge Flour Samples

The MoLP had the highest content of anti-nutrients followed by the unfermented finger millet flour while the fermented finger millet flour samples had the least content of anti-nutrients (Table 2). The initial ANOVA test results showed the differences in the content of anti-nutrients between the flour samples were significant (p < 0.001). Post-hoc (LSD) analysis revealed that MoLP had significantly higher levels of anti-nutrients than both the fermented and unfermented finger millet flour samples. Furthermore, fermentation significantly reduced the levels of anti-nutrients in the finger millet flour (p<0.05). Fortification of the fermented finger millet flour with MoLP also resulted in a significant increase in the levels of anti-nutrients but the levels were still much lower compared to the unfermented finger millet flour (Table 2).

### Table 2. Anti-nutrients’ composition of samples (Mean values, N=3 ± SE)

| Anti-nutrient  | FFmF  | UFmF  | Mo-FFmF | MoLP  |
|----------------|-------|-------|---------|-------|
| Tannins        | 182.29 ± 10.2a | 893.00 ± 0.04b | 292.03 ± 0.01c | 1835.4 ± 4.39d |
| Phytates       | 185.96 ± 0.00a | 606.67 ± 0.00b | 295.33 ± 0.02c | 1054.00 ± 0.06d |
| Oxalates       | 27.57 ±0.00a   | 62.53.0 ±0.00b | 305.60 ± 0.00c | 1680.89 ± 0.00d |
| Total phenols  | 1029.53± 0.0a  | 2716.33 ±0.07b | 1546.00± 0.02c | 10598.33 ±0.8d  |

Key:
- FFmF ∞ Fermented Finger Millet Flour; UFmF ∞ Unfermented Finger Millet Flour;
- Mo-FFmF ∞ *Moringa oleifera* Fortified Fermented Finger Millet Flour;
- MoLP ∞ *Moringa oleifera* Leaf Powder; SE-Standard Error
- Superscripts with different letters in the same row show values that are significantly different at α = 0.05

3.3 Sensory Acceptability

The means score per attribute for both porridge samples showed that both the porridge samples were acceptable [i.e. a score above 4.0 which represented moderate like] (Table 3). The overall sensory rating of the two porridge samples was not significantly different [t (52) = -0.212; p = 0.883] although the control porridge had a better overall acceptability score than the fortified porridge (Table 3).

### Table 3. Hedonic scores for color, texture, taste and overall acceptability on fortified porridge and Non-fortified porridge

| Test variable     | Mean hedonic scores for porridge from (Mean±SD) | Statistics |
|-------------------|-----------------------------------------------|------------|
|                   | Fortified Flour (Mo-FFmF)                     | Non-fortified Flour (FFmF) | t-value | df | p-value |
| Color             | 4.74 ± 0.45                                   | 4.37 ± 0.49 | 2.896   | 52 | 0.006* |
| Texture           | 4.63 ± 0.49                                   | 4.44 ± 0.58 | 1.268   | 52 | 0.210 |
| Taste             | 4.44 ± 0.51                                   | 4.67 ± 0.47 | -1.537  | 52 | 0.130 |
| Overall acceptability | 4.52 ± 0.75                               | 4.56 ± 0.51 | -0.212  | 52 | 0.833 |

*Significant at p<0.05

4. Discussion

4.1 Nutrient Contents of Porridge Flours

The target/focus nutrients for fortification of the finger millet flour in this study were protein and β-carotene. The results show that MoLP had significantly higher contents of both protein and β-carotene than the Finger millet flour sample. Furthermore, the contents of these nutrients in the fortified flour (Mo-FFmF) were significantly improved as compared to their content in both the non-fortified flour samples (FFmF and UFmF). The results
The protein content value of 20.05 ± 0.62% obtained in the current study for *M. oleifera* leaf powder is in agreement with that reported by Ntita (2017) who reported a value of 20.42%. Kayi (2013), reported crude protein content in dried *M. oleifera* leaves to range from 16.2% to 30.3% while Sahay et al. (2017) reported protein content of *M. oleifera* leaves to be 23.78%, while Isitua et al. (2015) reported 24.3% and 11.5% protein and ash respectively in MoLP. Both findings are within the range of current results. A more recent study by Rauf et al. (2020) reported a protein and ash content of 27.9% and 10.8 % respectively, with the reported protein content value being slightly higher than that observed in the current study, while Olugboye and Oluyemisi (2016) reported 15.04% crude protein content and 9.85% ash content in MoLP.

The β-carotene content values of *M. oleifera* reported in the literature vary widely with 5.23mg /100g being reported by Sengay et al. (2013), 37.8mg/100g by Sahay et al. (2017), 13.56 mg /100g by Makkar and Becker (1997) and 18.4mg/100g by Chan Yee (2018). The current study value of 12.59 mg/100g for β carotene falls within this literature range. Current findings of 1.19mg/100g β-carotene content of finger millet, are below the 6.0mg/100g reported by Ramashia et al. (2019).

The moringa-fortified flour showed significant improvements in both its protein and β-carotene content relative to the non-fortified finger millet flour samples. This indicates its potential as a nutritious porridge flour that could mitigate protein and vitamin A deficiencies in children with cerebral palsy who often suffer risk of inadequate intake of the two nutrients owing their challenges in feeding.

### 4.2 Anti-nutrient Content of Flour Samples

In the current study, *M. oleifera* leaf powder showed a significantly higher content of anti-nutrients than the finger millet flour samples. There is a wide variation of the levels of anti-nutrients reported in literature for both *M. oleifera* and finger millet. Reported values for phytate content in *M. oleifera* vary between 42.7 to 3500mg/100g; those of tannin levels range from 374 to 6480mg/100g while those of total phenols vary between 1200 to 4831 mg/100g (Devisetti et al., 2016; Leone et al., 2015; Oladeji et al., 2017; Uchenna et al., 2015). Current study values for contents of phytates (1054.00 ± 0.06) and tannins (1835.4 ± 4.39) in *M. oleifera* fall within the range of values reported in literature while that of total phenols are higher. On the other hand, the anti-nutrient levels reported in literature for finger millet vary between 0.679 - 851.4 mg/100g for phytates, 0.301 - 989mg/100g for tannins and 0.91 – 680mg/100 for total phenols (Abubakar et al., 2015; Arjun et al., 2014; Samtiya et al., 2020; Singh et al., 2018; Siwela et al., 2007). Our findings for both phytates and tannins are within this range while values for total phenols are higher. The levels of anti-nutrients in plants and crops are influenced by a number of factors including geographical regions, farming practices and method of analysis. Our findings for oxalate content of finger millet are within the range of 21-270 mg/100g reported in literature (Chanhan & Sarita, 2018; Ravindran et al., 1991) while the findings for oxalate content in Moringa oleifera are close to those reported in several studies (Stevens et al., 2016; Agbogidi et al., 2012; Shiriki et al., 2015).

In the current study, fermentation of the finger millet flour was observed to reduce the levels of anti-nutrients significantly with reductions of 79.6%, 69.3%, 55.9% and 62.1% realized for tannins, phytates, oxalic acid and total phenols respectively. Findings from previous studies on the effect of fermentation on the levels of anti-nutrients in foods vary widely. A study by Raboy (2000) reported a decrease in 49.2% and 66.5% phytic acid after germination and fermentation, respectively. Antony and Chandra (1998) reported that fermentation of finger millet flour using endogenous grain microflora showed a significant reduction of phytates by 20% and tannins by 52% at the end of 24 hours. There was a simultaneous increase in mineral availability (calcium-20%, phosphorous-26%, iron-27% and zinc-26%) (Pragya, 2020). Fermentation of cereal flours is a scientifically proven strategy that reduces the levels of anti-nutritional factors in foods and enhances the bioavailability of certain micronutrients (Saleh et al., 2013; Subastri et al., 2015).

The high levels of the anti-nutrients in *M. oleifera* pose a possible bottleneck in the nutritional applications of the
plant. The anti-nutritional factors can affect the digestibility of proteins, can have an effect on carbohydrates’ digestion and may inactivate vitamins (Adamu et al., 2018). When ingested, tannins form complexes with proteins, which cause the inactivation of many digestive enzymes and decrease protein digestibility (Joye, 2019; Su & Chen, 2020). Phytic acid, is the main phosphorus store in mature seeds of finger millet. It forms complexes with metal ions and inhibits their absorption and is reportedly a major factor behind the deficiency of zinc (Samtiya et al., 2020; Raboy, 2000; Pragya, 2012). Phenolic compounds decrease the bioavailability of amino acids, cause loss of body weight, loss of appetite, breathing problems and cardiac complications (Samtiya et al., 2020), but most of them are destroyed during processing treatments. One limitation of the fortified porridge was with regard to its oxalate content, which was increased. above its levels in both fermented and unfermented finger millet flours, however, this could be mitigated variation of the process to introduce fermentation after blending of flour. Fermentation of the already blended flour, as opposed to the pure finger millet flour, could be necessary to achieve a greater reduction of antinutrients in the fortified porridge.

4.3 Sensory Acceptability of the M. oleifera Fortified Finger Millet Porridge

The results for sensory evaluation showed that fortification of the finger millet flour with MoLP at the ratio of 9:1 respectively did not significantly affect both taste and overall acceptability of the porridge. Other studies have reported an inverse relationship between M. oleifera addition and sensory acceptability of porridges (Boateng et al., 2019; Olaitan et al., 2014) with taste/flavor being the sensory property mostly affected (Ntila et al., 2019; Oyeyinka et al., 2018). Contrary to the current study finding that the fortified porridge had a better rating for color, other previous studies reported a negative effect of M. oleifera fortification on the color rating of porridges attributing the resultant greenish color of porridges due to M. oleifera addition as one of the underlying reasons for decreased sensory acceptability of foods formulated with M. oleifera (Boateng et al., 2019). Sensory acceptance of a food product is an important indicator of the actual use of the product, i.e., whether the product will be purchased and consumed. However nutritious a product is, if not accepted and consumed by the ultimate beneficiaries, the technological development goes in vain (Boateng et al., 2018; Rajeswari et al., 2013). Nekitising (2018) has proposed the repeated taste exposure strategy to promote positive acceptance over time. For instance, some studies reported that children increased their intake of vegetables after five exposures (Holley et al., 2017).

5. Conclusion

The results of the current study showed that M. oleifera leaves are highly nutritious and suitable agent for food-to-food fortification of local staples to enhance their nutrient density. The study has also revealed that fortifying the finger millet porridge with MoLP at the rate of 10% significantly improved its nutrient content particularly the protein and β-carotene content without significantly compromising its sensory acceptability. Consumption of the fortified flour porridge by children with CP could therefore improve the protein and vitamin A status in this population who are at risk of protein and vitamin A deficiency due to the feeding challenges that characterize their condition. There is however a need to explore more product formulation and processing methods, in order to enhance both the sensory acceptability and nutritional potential of Moringa-based foods.

Acknowledgments

The authors would like to thank the National Research Fund (Kenya) for financial support. We acknowledge the important roles played by Dr. Grace Nyambati, (Technical University of Kenya), Ms. Teresiah Ndunda (Technical University of Kenya), Prudence Njiru (Kenya Industrial Research Development Institute), Norman Wachira (Kenya Forestry Research Institute), John Gachoya (Kenyatta University), Felix Ondiek, Maurice Wagaki, David Mwilu, Lynette Nyawira, and Dan Macharia of the research team.

References

Abubakar, A., Bala, S., Audu, E. A., Mohammad, S., & Gero, M. (2015). Characterization and the Anti-nutritional Composition of Unprocessed Finger Millet (Eleusine coracana). p. 8.

Adamu, A., Sabo, U., Gwarzo, G., & Belonwu R. (2018). Nutritional status in cerebral palsy: A Cross-sectional comparative survey of children in Kano, Nigeria. Niger Postgrad Med J., 25(3), 156. https://doi.org/10.4103/npmj.npmj_67_18

Agbogidi, O., & Ibondu, E. (2012). Moringa oleifera Lam: Its Potentials as a Food Security and rural Medicinal Item. JBioInnov., 1(6), 156-67.

Antony, U., & Chandra, T. (1998). Antinutrient reduction and enhancement in protein, starch and mineral availability in fermented flour of fingermillet (Eleusine coracana). J Agric Food Chem., 46(7), 2578-82. https://doi.org/10.1021/jf9706639
AOAC. (2005). *Official Methods of Analysis* (18th ed.). Washington, D.C: Association of Official Analytical Chemists.

Arjun, D., Kumar, R., & Chaurasia, S. (2014). Finger millet for nutritional security and Source of food. *Adv Food Sci Technol.*, 2(3), 184-90.

Baker, C. (1952). The determination of oxalates in fresh plant materials. *Analyst.*, 77, 340-4. https://doi.org/10.1039/an9527700340

Boateng, L., Ashley, I., Ohemeng, A., Asante, M., & Steiner, M. (2018). Improving Blood Retinol Concentrations with. *Yale J Biol Med.*, 91, 83-94.

Black, R. E., Allen, L. H., Bhutta, Z. A., Caulfield, L. E., de Onis, M., … Ezzati, M. (2008). Maternal and child undernutrition: global and regional exposures and health consequences. *The Lancet.*, 371(9608), 243-60. https://doi.org/10.1016/S0140-6736(07)61690-0

Boateng, L., Nortey, E., Ohemeng, A. N., Asante, M., & Steiner-Asiedu, M. (2019). Sensory attributes and acceptability of complementary foods fortified with Moringa oleifera leaf powder. *Nutr Food Sci.*, 49(3), 393-406. https://doi.org/10.1108/NFS-07-2018-0192

Boateng, L., Nyarko, R., Asante, M., & Steiner-Asiedu, M. (2018). Acceptability of Complementary Foods That Incorporate Moringa oleifera Leaf Powder among Infants and Their Caregivers. *Food Nutr Bull.*, 39(1), 137-48. https://doi.org/10.1177/037957211708656

Chadare, F. J., Idohou, R., Nago, E., Affonfere, M., Agossadou, J., … Fassinou, T. K. (2019). Conventional and food-to-food fortification: An appraisal of past practices and lessons learned. *Food Sci Nutr.*, 7(9), 2781-95. https://doi.org/10.1002/fsn3.1133

Chan, Y. (2018). *Micronutrients in Moringa oleifera and their Potential in Food Fortification.* University of Toronto.

Chauhan, E. S., & Sarita. (2018). Exploration of Gluten-Free Baked Food Products Incorporated by Germinated Finger (Eleusine Coracana) and Pearl (Pennisetum Glaucum) Millets: A Therapeutic Approach. *Int J Health Sci.*, 8(3), 232-43. https://doi.org/10.21048/ijhsnd.2018.55.3.18666

Civille, G., Stone, H., Derhmaer, A., & Eggert, J. (2018). *Sensory Evaluation Guide for Testing Food and Beverage Products.* Sensory Evaluation Division. Food Technology [Internet]. Institute of Food Technologists. Retrieved from http://aufsi.auburn.edu/recommendedmethods/06B01.pdf

Dayakar, R. B., Malleshi, N. G., Annor, G. A., & Patil, J. V. (2016). Nutritional and health benefits of millets. In R. B. Dayakar, N. G. Malleshi, G. A. Annor & J. V. Patil (Eds.), *Millets value chain for nutritional security: a replicable success model from India* (pp. 24-48). Wallingford: CABl. https://doi.org/10.1079/9781780648309.0024

Devisetti, R., Srerama, Y. N., & Bhattacharya, S. (2016). Processing effects on bioactive components and functional properties of moringa leaves: development of a snack and quality evaluation. *J Food Sci Technol.*, 53(1), 649-57. https://doi.org/10.1007/s13197-015-1962-5

Dinesh, A., Kumar, R., & Singh, C. (2014). Finger millet for nutritional security and Source of food. *Adv Food Sci Technol.*, 2(3), 184-90.

Fuglie, L., & Sreeja, K. (2011). *Cultivation of moringa*. Retrieved from http://moringafarms.com/161/cultivationofmoringa/Access

Gacula, M. C. (Ed.). (2004). *Descriptive sensory analysis in practice*. Trumbull, Connecticut, USA: Food & Nutrition Press, Inc. https://doi.org/10.1002/9780470385036

Gull, A., Jan, R., Nayik, G. A., Prasad, K., & Kumar, P. (2014). Significance of Finger Millet in Nutrition, Health and Value added Products: A Review. *J Environ Sci Comput Sci Eng Technol.*, 3(3), 1601-8.

Gupta, S., Lakshmi, J. A., Manjunath, M. N., & Prakash, J. (2005). Analysis of nutrient and antinutrient content of underutilized green leafy vegetables. *LWT Food Sci Technol.*, 38, 339-345. https://doi.org/10.1016/j.lwt.2004.06.012

Hall, A., Drake, L., & Bundy, D. (2001). Public health measures to control helminth infections. In U. Ramakrishnan (Ed.), *Nutritional Anemias* (pp. 215-40). Boca Raton, Flo: CRC Press. https://doi.org/10.1201/9781420036787.ch11

Holley, C., Farrow, C., & Haycraft, E. (2017). Systematic review of methods for increasing vegetable
consumption in early childhood. *Curr Nutr Rep.*, 6(2), 157-70. https://doi.org/10.1007/s13668-017-0202-1

Horvat, D., Šimić, G., Drezner, G., Lalić, A., Leden’can, T., … Tucak, M. (2020). Phenolic Acid Profiles and Antioxidant Activity of Major Cereal Crops. *Antioxidants*, 9(527), 12. https://doi.org/10.3390/antiox9060527

Isingoma, E. B., Mbogua, S. K., & Karuri, E. G. (2018). Performance of Nutritionally Optimised Millet Porridges as Complementary Food for Children from Low Socio-Economic Status Households in Bujenje County, Western Uganda. *J Nutr Health Food Sci.*, 6(1), 1-13. https://doi.org/10.15226/jnhfs.2018.001123

Isitua, C. C., Sanchez-Muros, M. J., Jaramillo, C. J., & Dutan, F. (2015). Phytochemical and nutritional properties of dried leaf powder of Moringa oleifera Lam. from machala el oro province of ecuador. *Asian J Plant Sci Res.*, 5(2), 8-16.

Johnson, Q., Mannar, V., & Ranum, P. (2004). FORTIFICATION HANDBOOK: VITAMIN AND MINERAL FORTIFICATION OF WHEAT FLOUR AND MAIZE MEAL.

Joye, I. (2019). Protein digestibility of cereal products. *Foods*, 8(6), 199. https://doi.org/10.3390/foods8060199

Kaiy, K. K. (2013). *A study on Moringa oleifera leaves as a supplement to West African weaning foods*. Hamburg University of Applied Sciences.

Larmond, E. (1977). *Laboratory Methods for Sensory Evaluation of Food*. Ottawa: Research Branch, Canada Department of Agriculture Canada Communication Group, Publishing Centre. p. 19-63.

Leone, A., Spada, A., Battezzati, A., Schiraldi, A., Aristil, J., & Bertoli, S. (2015). Cultivation, Genetic, Ethnopharmacology, Phytochemistry and Pharmacology of Moringa oleifera Leaves: An Overview. *Int, J Mol Sci.*, 16(12), 12791-835. https://doi.org/10.3390/ijms160612791

Makkri, H. P. S., & Becker, K. (1997). Nutrients and antiquity factors in different morphological parts of the Moringa oleifera tree. *The Journal of Agricultural Science*, 128(3), 311-322. https://doi.org/10.1017/S00228124.97004292

Uchenna, M. N., Nwankwo, V. U., Kayode, P. B., & Juliana, U. (2015). Anti-nutrient, vitamin and other phytochemical compositions of old and succulent moringa (Moringa oleifera Lam) leaves as influenced by poultry manure application. *Afr J Biotechnol.*, 14(32), 2501-9. https://doi.org/10.5897/AJB2015.14848

Marchand, V., & Motil, K. J. (2006). Nutrition Support for Neurologically Impaired Children: A Clinical Report of the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition. *J Pediatr Gastroenterol Nutr.*, 43(1), 13. https://doi.org/10.1097/01.mpg.0000228124.93841.ea

Miller, B. D. D., & Welch, R. M. (2013). Food system strategies for preventing micronutrient malnutrition. *Food Policy*, 42, 115-28. https://doi.org/10.1016/j.foodpol.2013.06.008

Ndubuaku, U. M., Uchenna, N. V., Baiyeri, K. P., & Ukonze, J. (2015). Anti-nutrient, vitamin and other phytochemical compositions of old and succulent moringa (Moringa oleifera Lam) leaves as influenced by poultry manure application. *Afr J Biotechnol.*, 14(32), 2501-9. https://doi.org/10.5897/AJB2015.14848

Nekitsing, C. (2018). Developing Healthy Food Preferences in Preschool Children Through Taste Exposure, Sensory Learning, and Nutrition Education. *Curr Obes Rep.*, 7, 60-7. https://doi.org/10.1007/s13679-018-0297-8

Nicklaus, S. (2011). Children’s acceptance of new foods at weaning. Role of practices of weaning and of food sensory properties. *Appetite*, 57(3), 812-5. https://doi.org/10.1016/j.appet.2011.05.321

Nkhata, S. G., Ayua, E., Kamau, E. H., & Shingiro, J-B. (2018). Fermentation and germination improve nutritional value of cereals and legumes through activation of endogenous enzymes. *Food Sci Nutr.*, 6(8), 2446-58. https://doi.org/10.1002/fsn3.846

Ntila, S., Ndhlala, A. R., Kolanisi, U., Abdelgadir, H., & Siwela, M. (2019). Acceptability of a moringa-added soft porridge for caregivers in Hammanskraal, Gauteng province and Lebowakgomo, Limpopo province, South Africa. *South Afr J Clin Nutr.*, 32(3), 51-7. https://doi.org/10.1080/16070658.2018.1449377

Ntila, S. L. (2017). The potential of Moringa oleifera (Lam.) leaves for use in complementary foods to combat child food and nutrition insecurity among South African rural and peri-urban communities [PhD Thesis]. University of KwaZulu-Natal.

Ohaneye, I. C., Emenike, C. U., Mensi, A., Medina-Godoy, S., Jin, J., … Ahmed, T. (2021). Food fortification
technologies: Influence on iron, zinc and vitamin A bioavailability and potential implications on micronutrient deficiency in sub-Saharan Africa. *Scientific African, 11*, e00667. https://doi.org/10.1016/j.sciaf.2020.e00667

Olaitan, N., Eke, M., & Uja, E. (2014). Moringa Oleifera Leaf Powder and Pearl Millet (Pennisetum Glauccum) Flour. *Int J Eng Sci.*, 3(11), 59-63.

Oladje, O., Taiwo, K., Ishola, M., & Oladeji, B. (2017). Nutritional and Quality Characteristics of White Maize Ogi Flour Enriched with Moringa oleifera Seed. *Biotechnol J Int.*, 18(1), 1-11. https://doi.org/10.1007/BF01093221

Olugboyega, K., & Oluymesii, O. (2016). PROXIMATE ANALYSIS, MINERALS, AND ANTI-NUTRITIONAL FACTORS OF MORINGA OLEIFERA LEAVES. *17*(1), 4.

Opole, R. (2019). Opportunities for Enhancing Production, Utilization and Marketing of Finger Millet in Africa. Kenya Agricultural and Livestock Research Organization, Kakamega, Kenya. *Afr J Food Agric Nutr Dev.*, 19(01), 13863-82.

Oyeyinka, A. T., & Oyeyinka, S. A. (2018). Moringa oleifera as a food fortificant: Recent trends and prospects. *J Saudi Soc Agric Sci.*, 17(2), 127-36. https://doi.org/10.1016/j.jssas.2016.02.002

Raboy, V. (2000). Low phytic acid grains. *Food Nutr Bull.*, 21(4), 423-7. https://doi.org/10.1177/156482650002100416

Rajeswari, R., Bharati, P., Naik, K. R., & Naganur, S. (2013). Dehydration of amaranthus leaves and its quality evaluation. *Karnataka J Agric Sci.*, 26(2), 276-80.

Ramashia, S. E., Anyasi, T. A., Gwata, E. T., Meddows-Taylor, S., & Jideani, A. I. O. (2019). Processing, nutritional composition and health benefits of finger millet in sub-saharan Africa. *Food Sci Technol.*, 39(2), 253-66. https://doi.org/10.1590/fst.25017

Rathore, T., Singh, R., Kamble, D., Upadhyay, A., & Thangalakshmi, S. (2019). Review on finger millet: Processing and value addition. *Pharma Innov J.*, 8(4), 283-91.

Rauf, S., Salim, A., & Rahman, N. (2020). Development of Instant Powder with the Addition of Moringa Oleifera Leaf Powder as Complementary Food for Infants 6-12 Months Old. *Syst Rev Pharm.*, 11(7), 4.

Ravindran, G. (1991). Studies on millets: Proximate composition, mineral composition, and phytate and oxalate contents. *Food Chem.*, 39(1), 99-107. https://doi.org/10.1016/0308-8146(91)90088-6

Rowe, L. A. (2020). Addressing the Fortification Quality Gap: A Proposed Way Forward. *Nutrients, 12*(12), 3899. https://doi.org/10.3390/nu12123899

Sahay, S., Yadav, U., & Srinivasamurthy, S. (2017). Potential of Moringa oleifera as a functional food ingredient: A review. *Int J Food Sci Nutr.*, 2(5), 31-7.

Saleh, S. A., Chen, J., Zhang, Q., Shen, Q. (2013). Millet Grains: Nutritional Quality, Processing, and Potential Health Benefits. In S. M. A. Saleh, Q. Zhang, J. Chen, & Q. Shen (Eds.), *Comprehensive Reviews In Food Scienceand Food Safety* (pp. 281-95). https://doi.org/10.1111/1541-4337.12012

Samtiya, M., Aluko, R. E., & Dhewa, T. (2020). Plant food anti-nutritional factors and their reduction strategies: an overview. *Food Prod Process Nutr.*, 2(6). https://doi.org/10.1186/s43014-020-0020-5

Schiele, J., Pietsch, B., Ceresa, A., & Fitzet, C. (2004). Method for the Determination of b-Carotene in Supplements and Raw Materials by Reversed-Phase Liquid Chromatography: Single Laboratory Validation. *JAOAC Int.*, 87(5), 1071-82. https://doi.org/10.1093/jaoac/87.5.1070

Sengev, A., Abu, J. O., & Gernah, D. (2013). Effect of Moringa oleifera Leaf Powder Supplementation on Some Quality Characteristics of Wheat Bread. *Food Nutr Sci.*, 4, 270-5. https://doi.org/10.4236/ins.2013.43036

Sharma, A., & Kapoor, A. C. (1996). Levels of antinutritional factors in pearl millet as affected by processing treatments and various types of fermentation. *Plant Food Hum Nutr.*, 49, 241-252. https://doi.org/10.1007/BF01093221

Shija, A. E., Rumisha, S. F., Oriyo, N. M., Kilima, S. P., & Massaga, J. J. (2019). Effect of Moringa Oleifera leaf powder supplementation on reducing anemia in children below two years in Kisorawe District, Tanzania. *Food Sci Nutr.*, 7(8), 2584-94. https://doi.org/10.1002/fsn3.1110

Shiriki, D., Igoyor, M. A., & Gernah, D. I. (2015). Nutritional Evaluation of Complementary Food Formulations from Maize, Soybean and Peanut Fortified with Moringa oleifera Leaf Powder. *Food Nutr Sci.*, 06(05),
494-500. https://doi.org/10.4236/fns.2015.65051

Singh, C. E., & Sarita, S. (2018). Effects of Processing (Germination and Popping) on the Nutritional and Anti-Nutritional Properties of Finger Millet (Eleusine Coracana). Curr Res Nutr Food Sci J., 6(2), 566-72. https://doi.org/10.12944/CRNFSJ.6.2.30

Singh, V., Arulanantham, A., Parispogula, V., Arulanantham, S., & Biswas, A. (2018). Moringa olifera: Nutrient Dense Food Source and World’s Most Useful Plant to Ensure Nutritional Security, Good Health and Eradication of Malnutrition. Eur J Nutr Food Saf., 8(4), 204-214. https://doi.org/10.9734/EJNFS/2018/42468

Singh, V. (2012). Finger millet for food and nutritional security. Afr J Food Sci., 6(4). Retrieved from http://www.academicjournals.org/AJFS/abstracts/abstracts/abstract2012/29%20Feb/Singh%20and%20Raghuvanshi.htm

Si, K., CG, B., VC, R., & Swathi, B. (2016). Anti-Nutritional Factors in Finger Millet. J Nutr Food Sci., 06(03). https://doi.org/10.4172/2155-9600.1000491

Sircar, R., Lal, A., & Chandra, S. (2019). Value Addition by Finger Millet (Eleusine coracana L.) to Increase the Nutritional Value and Fight the Nutritional Challenges. p. 4.

Siwela, M., Taylor, J. R. N., de Milliano, W. A. J., & Duodu, K. G. (2007). Occurrence and Location of Tannins in Finger Millet Grain and Antioxidant Activity of Different Grain Types. Cereal Chem J., 84(2), 169-74. https://doi.org/10.1094/CCHEM-84-2-0169

Stevens, C., Ugese, F., Oititoju, G., & Baiyeri, K. (2016). Proximate and anti-nutritional composition of leaves and seeds of Moringa oleifera in Nigeria: a comparative study. Agro-Sci., 14(2), 9. https://doi.org/10.4314/as.v14i2.2

Sultana, A., Amin, M. N., Miah, M. Y., Rase, Md. M. A., Aziz, M. T., … Sharmin, F. (2017). Determination of Proximate Composition and Amino Acid Profile of Jackfruit Seed and Utilization of Its Seed Flour for Development of Protein Enriched Supplementary. Cell Biol., 5(6), 57-65. https://doi.org/10.11648/j.cb.20170506.11

Swain, T. (1979). Phenolics in the environment. Rec Adv Phytochem., 12, 617-40. https://doi.org/10.1007/978-1-4684-3372-2_19

Subastri, A., Ramamurthy, C., Suyavaran, A., Mareeswaran, R., Mandal, P., … Rellegadla, S. (2015). Nutrient profile of porridge made from Eleusine coracana (L.) grains: effect of germination and fermentation. J Food Sci Technol., 52(9), 6024-30. https://doi.org/10.1007/s13197-015-1713-7

Su, B., & Chen, X. (2020). Current Status and Potential of Moringa oleifera Leaf as an Alternative Protein Source for Animal Feeds. Front Vet Sci., 7, 53. https://doi.org/10.3389/fvets.2020.00053

Szypulka, J., DeVries, J. W., Bhandari, S., Bui, M. H., Ji, D., … Konings, E. (2005). Determination of β-Carotene in Supplements and Raw Materials by Reversed-Phase High Pressure Liquid Chromatography. J AOAC Int., 88(5), 1279-91. https://doi.org/10.1093/jaoac/88.5.1279

Teye, E., Deha, C. I., Dadzie, R., & MacArthur, R. L. (2020). Delivering the Nutritional Needs by Food to Food Fortification of Staples Using Underutilized Plant Species in Africa. Int J Food Sci., 1-8. https://doi.org/10.1155/2020/8826693

Wagner, J., & Stanton, T. (2009). Formulating Rations with the Pearson Square. Colorado State University. Retrieved from http://www.ext.colostate.edu/UBS/LIVESTK/01618.html

Wheeler, E. L., & Ferrel, R. E. (1971). A method for phytic acid determination in wheat and wheat fractions. Cereal Chem., 48(3), 312-20.

Witt, K. (2013). The nutrient content of moringa oleifera leaves. ECHO Res Note.

Yang, R-Y., Chang, L-C., Hsu, J-C., Weng, B. B. C., Palada, C., … Chadha, M. L. (2006). Nutritional and Functional Properties of Moringa Leaves – From Germplasm, to Plant, to Food, to Health.

Copyrights

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (http://creativecommons.org/licenses/by/4.0/).