EISSN: 2707-0425

East African Journal of Science, Technology and Innovation, Vol. 4 (Special Issue): August 2023

Formulation, acceptability, and chemical characteristics of mango nectar enriched with moringa *moringa oleifera, lam* leaves extract

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Abstract

Mango and Moringa are nutrient-dense foods. This study examined two mango varieties (apple and Tommy Atkin) for nectar production fortifying with Moringa leaf extract to reduce postharvest losses, food insecurity, and malnutrition. Post-harvest mango losses are high in Kenya (40-50%) and affects farmers' income and the environment and if processed into mango nectar, can address postharvest losses (PHL). Mango nectar is rich in vitamins and minerals but lacks adequate micronutrients (calcium, iron, and zinc). *Moringa oliefera* leaves are nutrient-rich and adding moringa leaf extract to mango nectar improves its nutrition. This study intended to blend mango nectar with moringa leaf extract. The developed product contained 25% mango pulp and aqueous solutions of moringa leaf extract (F1, F2, F3, F4, F5, F6, F7, and F8): 0%, 10%, 12.5%, and 15%, respectively. The nectar was pasteurized at 70°C for 10 min and was analyzed for sensory evaluation, proximate composition, vitamin A, and mineral content (Fe, Ca, and Zn). F1 (control) and F3 (apple manga nectar blended with 12.5% moringa leaf extract), and F5 and F6 (Tommy Atkin mango nectar blended with 10% moringa leaf extract) were accepted. The formulated nectar differed in protein, fiber, ash, carbohydrate, energy, vitamin A, iron, calcium, zinc, color, odor, taste, texture, mouthfeel, and overall acceptability ($p<0.05$). Moisture and fat in nectar were not significantly different ($p>0.05$). Apple blended mango nectar had more fat, vitamin A, calcium, iron, and zinc than Tommy Atkin blended nectar: 1.07 and 0.60%, 8.68 and 6.91mg/100g, 39.89 and 34.26 mg/100g, 3.14 and 2.01mg/100g, and 8.85 and 7.19mg/100g. However, Tommy Atkin blended nectar had more fiber, protein, and energy. Therefore, moringa leaf extract can be utilized to fortify ood and beverages.

Keywords: *mango fruit; moringa leaf extract; mango-moringa blended nectar; mango nectar; mango pulp*

Cite as: Sikwaya, *et al., (2023)* Formulation, acceptability, and chemical characteristics of mango nectar enriched with moringa (moringa oleifera, lam) leaves extract. *East African Journal of Science, Technology and Innovation, Vol. 4 (Special Issue).*

Received: 26/06/23
Accepted: 06/07/23
Published: 09/08/23

Introduction

Seasonal gluts and losses after harvest are the two biggest problems that make it hard to get fruits and vegetables all year long in developing countries (Jolayemi and Adeyeye, 2018). To keep fruit fresh and available during the off-season, processing it into "clarified" or "not clarified" beverages, "pulps," "purees," and "nectars," and dried fruits has become the standard (Lozano, 2006). Fruit quality is affected by agronomical (variety/cultivar, maturity, ripeness) and technical (time-temperature combination, packaging, storage) factors (Arah *et al.*, 2015; Rouphael, 2012). The mango is a well-known climacteric fruit with several varieties, although only a few numbers are significant economically and commercially. Mado, Kent, Tommy Atkin, Apple, and Julie are physicochemical and sensory cultivars common in the tropics (Wibowo *et al.*, 2015). Mango is processed into secondary products to extend its shelf life (Babarinde *et al.*, 2019). Pasteurization is a common heat treatment for acidic foods to extend shelf life and microbiological safety (Rawson *et al.*, 2011). The nutritional value of mango is enhanced by carotenoids, anthocyanin, chlorophyll, and phenols. Mango products are high in vitamins (Vit C, provitamin A, and B complex) and minerals (potassium and manganese), but lack adequate calcium, iron, zinc, and antioxidants such as phenolics and flavonoids (Lebaka *et al.*, 2021). Less than 1% of mango fruit is processed into value-added products due to a lack of value-added technologies, viable fruit markets, and competition from manufactured and imported juices (Okoth, 2013). Mango fruit value addition can help alleviate poverty by enhancing food and nutrition security (Okoth *et al.*, 2013). Postharvest technologies preserve fruit quality such as hand harvesting, chilled transportation, cleaning, cooling/refrigerated storage, drying, packaging, labeling, pulp extraction, preservation, and processing into juices, jams, concentrates, nectars, powders, and slices (Okoth *et al.*, 2013). Mango processing can reduce postharvest losses in Kenya. Mango nectar's vitamin C content is affected by maturity, harvest season, variety, processing methods, oxygen, and light (Jolayemi, 2019; Lemmens *et al.*, 2013). There is no processed mango with *Moringa oliefera* leaf in Kenya. Many Kenyan farmers cultivate *Moringa oleifera* for nutrition and wellness. *M. stenopetala, M. arborea, M. borziana, M. rivae*, and *M. longituba* are native to Kenya (Rani *et al.*, 2018). Current research indicate Moringa species have different nutritional and functional element compositions. Given its nutritious benefits, moringa oleifera leaves may also be used to fortify other products such as sauces, juices, milk, and bread (Jones *et al.*, 2007). One of the numerous commercial possibilities for moringa oleifera leaves is food fortification. Anecdotal evidence from areas where Moringa is consumed as a food and plant indicates that the leaves help people lower their risk of diabetes and hypertension while also fighting hunger (Yessuf *et al.*, 2020). Moringa oleifera leaf extract can improve mango nectar's micro-nutrients. Since there are few scientific research on the nutritional composition of mango nectar blended with moringa leaf extract in Kenya, the present study determines the acceptability of mango nectar supplemented with moringa leaf extract and its nutritional qualities.

Materials and methods

Procurement of fruits

Well-matured apple mangoes and Tommy Atkin (273 kg) were harvested when mature (firm) but not ripe or ready to eat (soft) from smallholder farmers in Machakos County. The fruit was packaged in crates and brought in a vehicle to the University of Nairobi's College of Agriculture. The fruit was picked early in the morning (6 to 8 a.m.) to minimize field heat and was collected under shade to avoid direct sunlight. Mango fruits were stored at room temperature (25±2^{o}C, 47 % relative humidity) for ripeness. Moringa leaves were obtained from smallholder farmers in Kajiado County. The leaves were packed in a wet cleaned sac and carried in a car for about 1h 30 minutes before being sprayed on the stainless-steel table to remove heat, minimize nutrient loss, and off-flavor the final product. Other Ingredients such as sugar, citric acid, stabilizer, and preservatives were purchased from Pradip Kenya, Nairobi. The chemicals used in this study were of laboratory grade. All of the items were brought to the food processing hub and pilot plant at the Department of food science, nutrition, and Technology for processing.

Preparation of mango pulp

Apple and Tommy Atkin mango fruits were sorted by ripeness and cleansed in continuous tap water before being weighed, peeled, deseeded, and pulped in a pulping machine fitted with a 0.5mm stainless steel screen (D.K Engineering, Kenya). The extracted pulps were subsequently pasteurized (70°C for 10 minutes) and preserved with sodium metabisulphite at 300 ppm, as recommended (FAO, 2005; Omayio *et al.,* 2022). The pasteurized mango pulp was hot filled into 5 L PET plastic bottles at 55^{o}C and then stored at room temperature (25±2^{o}C with a relative humidity of 47%) until further treatment.

Preparation of moringa leaf extract

Fresh moringa oleifera leaves (46kg) were removed from their branches, washed with tap water, chopped into little pieces, and blanched at 90^{0}C for 3 minutes. The blanched leaves were immersed in 10±2^{o}C water for 3 minutes to avoid further cooking, then crushed using a chopping boll with 200ml of water per 100g of blanched moringa leaf. The extract was recovered using a hydraulic press. The extract was filtered with a 4-layer muslin cloth to remove pomace and then frozen at -20^{0}C until further use (Naa *et al.,* 2013; Rh *et al.,* 2019b).

Preparation of blended mango-moringa nectar

Blended mango-moringa nectar was made with 25% mango pulp and 0, 10, 12.5, and 15% of moringa leaf extract, water, sugar, citric acid, carboxymethyl cellulose (CMC), and potassium metabisulphite were added to finalize the preparation in accordance with Kenyan standards (KEBS, 2016). The control contains 25% mango pulp as well as other ingredients, as detailed in Table 1. According to the flow chart (Figure 1), mango nectar blended with moringa leaf extract was pasteurized at 70°C for 10 minutes before being filled hot at 55°C in a 500ml bottle.

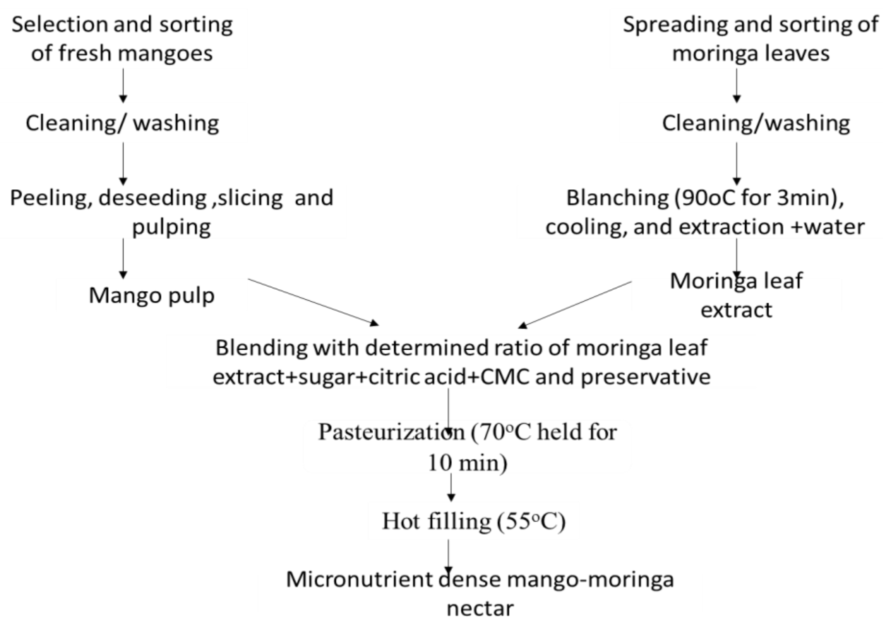

Figure 1. Flow diagram of mango-moringa blended nectar

Table 1. Different formulations of mango-moringa nectar

Treatment	Portion of ingredient (%)							
Formulations	puree	Moringa leaf extract	Water	Sugar	Citric Acid	Stabilizer	Preservative	Product Name
1	25	0	64.73	10	0.1	0.15	0.02	Control
2	25	10	54.73	10	0.1	0.15	0.02	M-mn
3	25	12.5	52.23	10	0.1	0.15	0.02	M-mn
4	25	15	49.73	10	0.1	0.15	0.02	M-mn

The mango-moringa nectar component is a 100% mixture design of developed products for both mango variety, with M-mn (mango-moringa nectar).

Sensory Evaluation of Mango-moringa Nectar

Untrained panelists (30) of both genders randomly evaluated mango-moringa nectar samples for appearance, odor, taste, texture, mouth feel, and overall acceptability. Panelists were required to record their observations on the sensory sheet using a seven-point hedonic scale (7 and 1 points showing like extremely and dislike extremely). The participants were provided with water to rinse their mouths before and after tasting. The most popular preferred formulations were then subjected to proximate and chemical analysis.

Assessments of chemical properties of mango-moringa blended nectar

Proximate composition

The moisture content was assessed using AOAC (2005) method 930.15 using a forced air oven drier (Memmert 40500-IP20-Schhutzart, Germany). Approximately 3g of the sample was weighed using the AR3130 KERN®PCB 3500 precision weighing scale (Balingen, Germany), after which it was dried on aluminum dishes for about three hours at 105°C. The moisture content was determined as a percentage of the initial sample weight lost. The ash content was determined by weighing about 10 g of sample into silica crucibles, charring them in an oven for two hours, and then ashing them for four hours in a muffle furnace set at 550±5^{o}C. The fat content was calculated using solvent extraction. According to AOAC (2005) method 960.39, a sample weighing about 1g was packed into thimbles and put into a Soxhlet extraction apparatus using petroleum ether as the solvent. According to AOAC (2005), the fiber content was measured by adding roughly 25ml of H_2SO_4 $2.O_4N$ and 1.78N of KOH to 4g of juice combined with distilled water. The volume was then raised to 200ml, and the mixture was boiled for 30 minutes before filtering through glass wool. After being dried, the glass wool will spend four hours in a muffle furnace that is heated to 600°C. The value was given as mg/100g. Kjeldahl distillatory equipment was used to determine the protein in accordance with AOAC, (2007) About 5ml of juice will be digested for 4 hours with 10ml of concentrated H_2S0_4 subscript numerals, then distilled and titrated with 0.1N NaOH in the presence of methyl orange. The outcome was noted twice and given as mg/100g. Using the different method described by (Gul & Safdar, 2009), the carbohydrate content was determined. The outcome will be expressed as mg/100g dry weight and will be carried out twice. The approach of (Fekadu et al., 2015) was used to calculate the energy. The outcome was given in terms of kcal/100g. The analysis was carried out in duplicate for every parameter. Except for moisture, all other characteristics were computed using a dry weight basis method (d.w).

pH and titratable acidity

The AOAC, (2012) method was used to determine the pH, with a few modifications. Two buffer standard solutions of acid and alkali, designated 4 and 7, were used to calibrate the pH meter. The readings of the pH were taken in duplicates after inserting the electrode into 50 ml of samples. The titratable acidity was determined using the AOAC (2012). In the presence of phenolphthalein, 10 milliliters of samples were titrated with 0.1 N NaOH; the percentage value was expressed and then carried out in duplicate.

Total soluble solid (TSS)

TSS was determined using a hand-held refractometer in line with the AOAC (2012) method (SK106-SATO, Japan). The reading in degree brix was taken directly after a drop of samples was placed on the refractometer's display. Readings were done in duplicate.

Determination of Beta-carotene

The beta-carotene (Provitamin A) was determined using modified spectrophotometric techniques as described by Mustapha and Babura (2009). A standard curve was constructed using beta-carotene standards with concentrations of 0–2.4 μg/mL using a Hitachi 2900 UV/VIS spectrophotometer (Tokyo, Japan) set at 450 nm. One gram of each dried sample was put in a mortar and pestle and little quantities of acetone were added until a colorless residue was formed. After that, 25 mL of the extract was transferred to a flask with a round bottom, and bath water was used to evaporate the acetone at 60^0C. The evaporated sample was dissolved in 1 mL petroleum ether, then used a silica gel column to elute with pet ether and collect in a 25 mL volumetric flask. The provitamin A concentrations were calculated after measuring the absorbance at 450 nanometers using a standard curve made using a Hitachi 2900 UV/VIS spectrophotometer (Tokyo, Japan) against pet-ether as a blank. The findings of the two extractions were represented as mg per 100 g of dry weight sample.

Minerals content

Calcium, zinc, and iron concentrations were assessed in line with AOAC, (2012) method using a Buck Scientific model 210 VGP atomic absorption spectrophotometer (Fort Point, USA), with minor modifications. Around 10g of juice was dried in the oven for two hours and then placed in a muffle furnace set at 550±5^oC for four hours. Following that, 20% HCL was used for digestion, and distilled water was added to the digested material up to a volume of 50ml. The value was reported as mg/100g d.w.

Data analysis

The sensory, proximate composition, and physicochemical data were entered into Microsoft Excel (2015). Sensory analysis packages in XLSTAT for Excel (Addinsoft, 2021; Vidal, 2020) were used for product characterization, panel analysis, sensory profiling, and statistical analysis. The proximate and chemical data were analyzed using one-way ANOVA in STAT software.

Results

Proximate composition of Moringa leaf extract

The proximate analysis of *Moringa oleifera* leaves extracts (F.M.O.L.E) (Figure 2). Moisture, ash, fat, fiber, protein, carbohydrates, and energy showed statistically significant ($p<0.0001$) differences: 97.22±0.09%moisture, 9.68±0.13%ash, 0.79±0.01%fat, 10.54±0.47%crude fiber, 21.09±1.01% crude protein, 56.95±0.56% carbohydrates, and 321.51±1.06 kcal/100g dw.

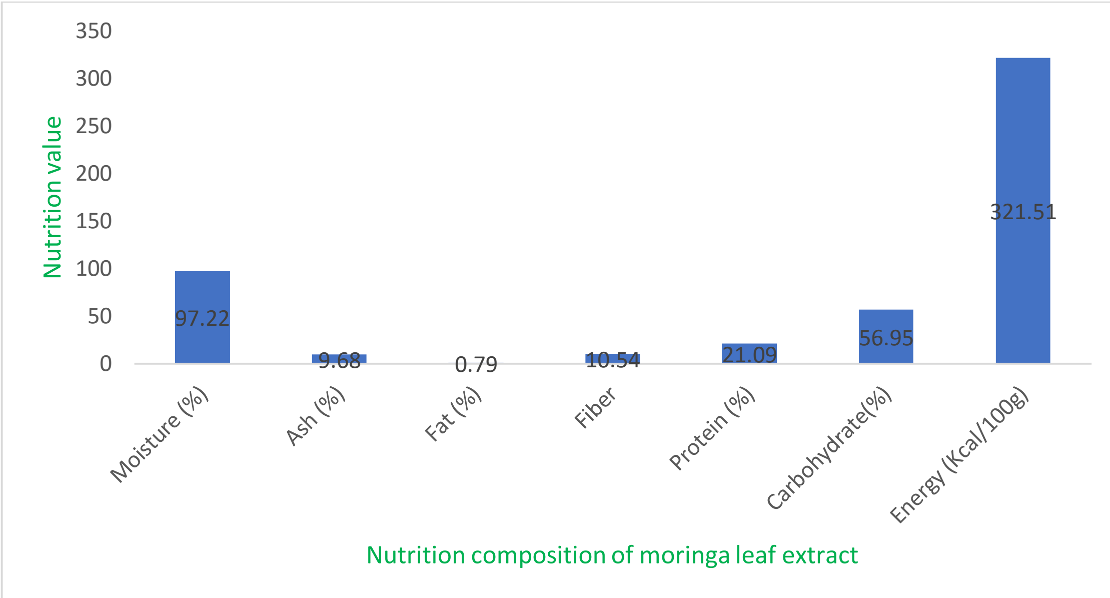

Figure 2. Nutritional composition of moringa leaf extract

Chemical and minerals of moringa leaf extract

The chemical and mineral content of moringa leaf extract showed significant ($p<0.0001$) differences (Figure 3): pH (5.91±0.04), TTA (0.18±0.004), TSS (3.07±0.06%), Vit A(11.42±0.84mg/100gdw), calcium(910.18±15.90mg/100gdw), Iron (90.26±1.80mg/100g dw) and Zinc(28.88±1.25mg/100gdw)

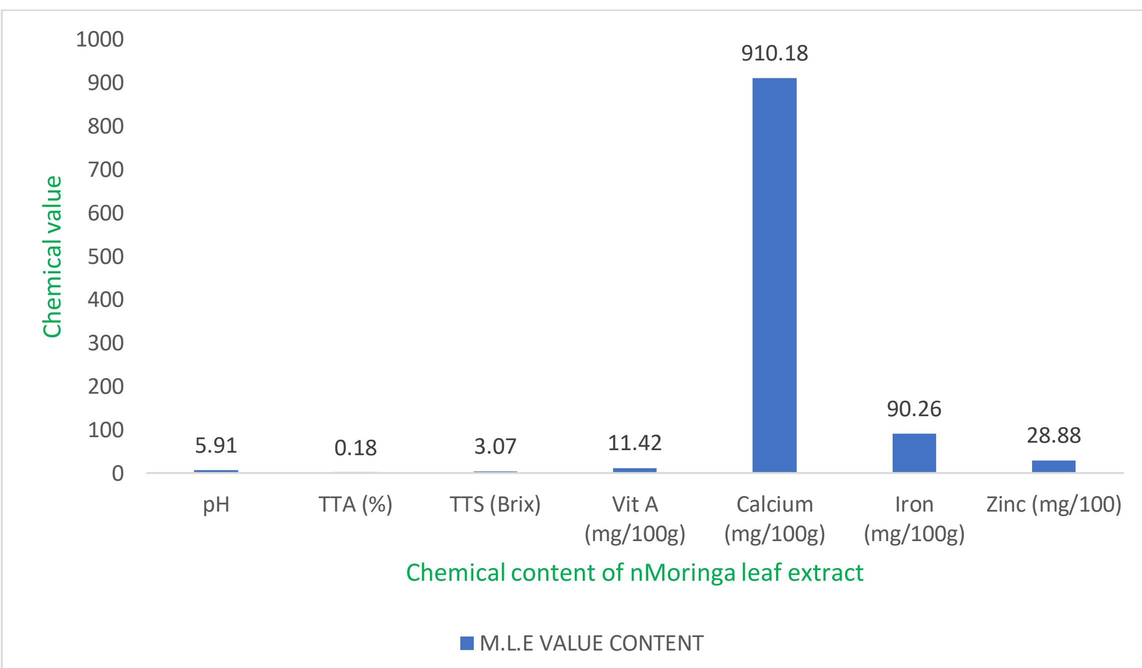

Figure 3. Chemical characteristic of moringa leaf extract

Sensory evaluation of mango nectar enriched with moringa leaf extract

The sensory data presented in Table 2 for the unblended and blended mango-moringa nectar revealed significant differences (P<0.05) in color, odor, taste, texture, mouth feel, and overall acceptability among the samples. According to the mean scores for apple mango nectar compared to the blended with moringa leaf extract: color (4.48±1.60 -6.73±0.57), odor (3.45±1.64-6.09±1.18), taste (4.52±1.56-6.12±1.22), texture (5.06±1.52-5.82±1.42), mouth feel (4.64±1.69-5.82±1.74) and overall acceptability (4.73±1.38-6.27±0.94) and for Tommy Atkin mango nectar compared to the blended with moringa leaf extract for color (3.21±1.65-6.27±0.94), odor (3.30±1.63-6.15±1.06), taste (4.38±1.77-5.88±1.41), texture (4.64±1.73-5.79±1.27), mouth feel (4.82±1.67-5.58±1.48) and overall acceptability (4.30±1.57-6.06±0.83), showed that the unblended mango nectar had the highest mean score compared to the blended, and increasing amount of moringa leaf extract generally resulted in lower scores for each sensory parameter. All panelists, however, approved of F3 (apple mango nectar enriched with 12.5% moringa leaf extract) and F6 (Tommy Atkin mango nectar supplemented with 10% moringa leaf extract).

Table 2 . Sensory scores for the formulated mango-moringa blended nectar

Product	Sensory attributes					
	Color	Odor	Taste	Texture	Mouth feels	Overall acceptability
F1	6.73±0.57 [c]	6.09±1.18 [b]	6.12±1.22 [b]	5.82±1.42 [b]	5.82±1.74 [c]	6.27±0.94 [b]
F2	4.48±1.48 [b]	3.12±1.60 [a]	4.06±1.80 [a]	4.58±1.75 [a]	4.61±1.77 [abc]	4.30±1.53 [a]
F3	4.48±1.60 [b]	3.45±1.64 [a]	4.52±1.56 [a]	5.06±1.52 [ab]	4.64±1.69 [abc]	4.73±1.38[a]
F4	3.82±1.61 [ab]	3.55±1.79 [a]	4.12±1.69 [a]	4.82±1.33 [ab]	4.36±1.82 [ab]	4.33±1.57 [a]
F5	6.27±0.94 [c]	6.15±1.06 [b]	5.88±1.41 [b]	5.79±1.27 [b]	5.58±1.48 [bc]	6.06±0.83 [b]
F6	3.21±1.65 [a]	3.30±1.63 [a]	4.38±1.77 [a]	4.64±1.73 [a]	4.82±1.67 [abc]	4.30±1.57 [a]
F7	3.64±1.80 [ab]	3.45±1.79 [a]	4.21±1.63 [a]	4.18±1.59 [a]	4.09±1.91 [a]	4.21±1.54 [a]
F8	3.24±1.90 [a]	3.21±1.93 [a]	4.15±1.91 [a]	4.67±1.65 [a]	4.39±1.71 [ab]	4.03±1.69 [a]
p value	<0.0001	<0.0001	<0.0001	<0.0001	0.000	<0.0001

Values (means± standard deviation) with different superscripts along a column are statistically different (Turkey's test). Where: F1: Apple mango nectar control (enriched with 0%moringa leaf extract), F2: Apple mango nectar enriched with 10% moringa leaf extract, F3: Apple mango nectar enriched with 12.5% moringa leaf extract, F4: Apple mango nectar enriched with 15% moringa leaf extract, F5: Tommy Atkin mango nectar control (enriched with 0%moringa leaf extract), F6: Tommy Atkin mango nectar enriched with 10% moringa leaf extract, F7: Tommy Atkin mango nectar enriched with 12.5% moringa leaf extract and F8: Tommy Atkin mango nectar enriched with 15% moringa leaf extract.

Proximate composition of mango nectar blended with moringa leaf extract

The nutritional content of mango nectar blended with moringa leaf extract is characterized in terms of moisture, ash, protein, fiber, fat, carbohydrate, and energy content (Table 3). The results revealed that there was no significant (p>0.05) difference in moisture and fat content, but there were significant (p<0.05) differences in ash, fat, fiber, protein, carbohydrate, and energy.

The addition of 10% moringa leaf extract to Tommy Atkin mango nectar increased the ash from1.16±0.06% to 1.41±0.09%, fat from 0.44±0.04% to 0.60±0.04%, fiber from 3.47±0.04% to 3.81±0.02%, protein from 2.48±0.08% to

4.13±0.02% and energy from 413.20±1.87 kcal/100g to 424.98±1.78 kcal/100g content, while decreasing the moisture from 87.39±0.20% to 87.26±0.07% and carbohydrate from 90.96±0.50% to 89.01±0.54% content. The addition of 12.5% moringa leaf extract to apple mango nectar caused a modest decrease in moisture from 87.59±0.41% to 86.45±0.25% and carbohydrate from 90.96±0.50% to 89.01±0.54% content while increasing ash from 1.16±0.06% to 1.41±0.09%, fat from 0.44±0.04% to 0.60±0.04% fiber from 3.29±0.1% to 3.57±0.05%, protein from1.85±0.06% to 2.68±0.09%, and energy from 392.86±0.65kcal/100g to 394.66±0.91kcal/100g content (Table 4).

Table 3. Proximate composition of Tommy Atkin Mango nectar enriched with Moringa extract

Product	Moisture (%)	Ash (%)	Fat (%)	Fiber (%)	Protein (%)	Carbohydrates (%)	Energy (Kcal/100g)
F5	87.39±0.20[a]	1.16±0.06[b]	0.44±0.04[a]	3.47±0.04[a]	2.48±0.08[a]	90.96±0.50[b]	413.20±1.87[a]
F6	87.26±0.07[a]	1.41±0.09[a]	0.60±0.04[b]	3.81±0.02[b]	4.13±0.02[b]	89.01±0.54[a]	424.98±1.78[b]
T statistic	0.8759	-2.9971	-3.2435	-10.7973	-27.9022	3.2730	-5.6086
P value	0.7633	0.0478	0.0417	0.0042	0.0006	0.0410	0.0152

Values are means ± SD. Means with different superscript letters along the columns are significantly different at p<0.05. Where: F5: Tommy Atkin mango nectar (0% moringa leaf extract) and F6: Tommy Atkin mango nectar blended with 10%moringa leaf extract.

Table 4. Proximate composition of Apple Mango nectar enriched with Moringa extract

product	Moisture (%)	Ash (%)	Fat (%)	Fiber (%)	Protein (%)	Carbohydrates (%)	Energy (Kcal/100g)
F1	87.59±0.41[b]	1.43±0.11[a]	1.05±0.04[a]	3.29±0.1[a]	1.85±0.06[a]	94.18±0.07[b]	392.86±0.65[a]
F3	86.45±0.25[a]	1.66±0.08[b]	1.07±0.06[b]	3.57±0.05[b]	2.68±0.09[b]	93.63±0.18[a]	394.66±0.91[b]
T statistic	3.7472	-15.6003	-0.6047	-8.7104	-32.1098	8.4274	-3.4100
P value	0.0322	0.0020	0.3034	0.0065	0.0005	0.0069	0.0381

Values are means ± SD. Means with different superscript letters along the columns are significantly different at p<0.05. Where: F1: Apple mango nectar (0% moringa leaf extract) and F3: Apple mango nectar blended with 12.5%moringa leaf extract.

Vitamin A and mineral content of mango nectar blended with moringa leaf extract

Compared to the control (F1 and F5), the addition of moringa leaf extract increased calcium, zinc, and iron significantly (P <0.05) for Tommy Atkin and apple mango nectar respectively. The incorporation of 10% and 12.5% moringa leaf extract considerably improved the amounts of vitamin A from 6.91 ± 0.25 to 8.68 ± 1.07mg/100g for apple mango nectar and 1.44 ± 0.09 to 1.87 ± 0.05mg/100g for tommy Atkin mango nectar, calcium from 20.51 ± 0.86 to 39.89 ± 1.51mg/100g for apple mango nectar and 22.72 ± 0.84 to 34.26 ± 0.79mg/100g for Tommy Atkin, zinc from 8.31 ± 0.38 to 8.85 ± 0.27mg/100g for apple mango nectar and 6.79 ± 0.10 to 7.19 ± 0.19mg/100g for Tommy Atkin mango nectar, and iron from 0.70 ± 0.05 to 3.14 ± 0.15mg/100g for apple mango nectar and 0.93 ± 0.03 to 2.01 ± 0.02mg/100g for Tommy Atkin mango nectar, respectively for unblended and blended mango nectar (Table 5 and Table 6).

Table 5. Vitamin and mineral content of Tommy Atkin Mango Nectar enriched with Moringa extract (g/100g dry matter content)

product	Vitamin A	Calcium	Iron	Zinc

F5	1.44 ± 0.09^{a}	22.72 ± 0.84^{a}	0.93 ± 0.03^{a}	6.79 ± 0.10^{a}
F6	1.87 ± 0.05^{b}	34.26 ± 0.79^{b}	2.01 ± 0.02^{b}	7.19 ± 0.19^{b}
T statistic	-18.0278	-22.9488	-54.0494	-4.8813
P value	0.0015	0.0009	0.0002	0.0197

Values are means ± SD. Means with different superscript letters along the columns are significantly different at p<0.05. Where: F5: Tommy Atkin mango nectar (0% moringa leaf extract) and F6: Tommy Atkin mango nectar blended with 10%moringa leaf extract.

Table 6. Vitamin and mineral content of Apple Mango Nectar enriched with Moringa extract (g/100g dry matter content)

product	Vitamin A	Calcium	Iron	Zinc
F1	6.91 ± 0.25^{a}	20.51 ± 0.86^{a}	0.70 ± 0.05^{a}	8.31 ± 0.38^{a}
F3	8.68 ± 1.07^{b}	39.89 ± 1.51^{b}	3.14 ± 0.15^{b}	8.85 ± 0.27^{a}
T statistic	-3.3117	-14.8591	-30.5425	-2.2141
P value	0.0402	0.0022	0.0005	0.0786

Values are means ± SD. Means with different superscript letters along the columns are significantly different at p<0.05. Where: F1: Apple mango nectar (0% moringa leaf extract) and F3: Apple mango nectar blended with 12.5%moringa leaf extract.

Discussion

Proximate composition of moringa leaf extract

In general, the proximate composition varies significantly (P<0.05) between moringa leaf extract and mango nectar blended with moringa leaf extract. The findings on the moisture content of moringa leaf extract were consistent with those of Obiajulu, (2020), who found 97.580% moisture content for unboil moringa leaf Extract. The moisture content of the present research, however, was greater than that of Fombang and Mbofung, (2017), who reported a moisture content of 79.9% for fresh moringa leaves and 77.9% for blanched moringa leaves, respectively. The extraction method (aqueous extraction) might be the reason for the high moisture content in moringa leaf extracts. The fat content was consistent with the results of Obiajulu, (2020), who reported a fat content of 0.835% for Moringa leaf Extract. Sunday et al., (2016) obtained similar results on fresh Curcuma longa extract. The extract's fat content is especially advantageous since *Moringa oleifera* oil is an essential oil. The ash and fiber levels were close to those reported by Fombang and Mbofung (2017), who found ash and fiber values of 8.4% and 7.7% for blanched moringa leaves, and 9.5% and 8.3% for fresh moringa leaves respectively. However, the ash and fiber content of this research were much greater than that of Obiajulu's (2020), who found an ash content ranged from 0.485-1.455% and a fiber content of 0% in an unboil moringa leaf extract. *Moringa oleifera* leaves contain 33.3% crude protein, making them an important crop for alleviating malnutrition (Moyo *et al.,* 2011) . These results confirmed the findings of the present investigation. However, the protein content of the present study was more than that reported by Onyekwere, (2014) and Obiajulu who found 18.92±0.02% and 0.630±0.01% crude protein content in moringa leaf extract, respectively. The carbohydrate content of this study was consistent with the result of Onyekwere, (2014), who found 57.01 0.01% carbohydrate.

Chemical and minerals of moringa leaf extract

The chemical and mineral composition of moringa leaf extract differed significantly (P<0.05). The pH of the moringa leaf extract shown in this investigation was somewhat higher than the pH reported by Shah et al., (2015), who found a pH ranged from 5.45 to 5.6. The TTA findings were in line with those of Rh et al., (2019), who found that moringa leaf extract has a TTA of 0.11±0.04 and a higher TSS value than the current study. The TSS and TTA of moringa leaf extract were, however, marginally lower than those reported by Noaman *et al.,* (2022), who found 4±0.00 and 0.66±0.006 for TSS and TTA, respectively. The vitamin A content of moringa leaf extract was close to that reported by Obiajulu, (2020), who found 10.346 mg/100g in moringa leaf extract boiled for 15 minutes, but significantly higher than that found by Naa *et al.,* (2013), reported 5.98 mg/100g. The mineral content of moringa leaf extract is significantly higher than that reported by Onyekwere, (2014), who found 2.09g/100g for Ca, 0.005g/100g for Zinc, and 0.03g/100g for Iron but significantly higher than that found by Naa *et al.,* (2013b). Moringa leaves have been analyzed for their mineral content, and the results showed that they contain high quantities of the following elements: sodium (289.34), potassium (33.63), phosphorus (105.23), iron (9.45), zinc (1.63), cobalt (0.88), calcium (486.23), and manganese (5.21) mg/100 grams Sohaimy *et al.,* (2015) while Rajput et al., (2017) reported that Calcium (2032), potassium (1545), and iron (26.69) mg/100 g. This variation might be due to differences in sample sources, ecological factors, agricultural practices, and the extraction method of moringa leaf extracts. The proximate analysis results and mineral content indicate that Moringa leaf extract could improve food's nutritional value and act as a functional ingredient.

Acceptability of mango nectar blended with moringa leaf extract

The results of the sensory analysis revealed that the unblended mango nectar had the greatest score compared to the blended nectar and that increasing amounts of moringa leaf extract resulted in generally lower scores for each sensory characteristic. This might be due to the fact that the majority of respondents were unfamiliar with the flavor of moringa leaf extract and green vegetable juice. The decreased sensory acceptability of mango nectar with increased moringa leaf extract percentage in the formulation might potentially be attributed to lipoxidase enzyme producing an unpleasant (distinctive) smell from *moringa oleifera* leaves oil and generate unpleasant taste due to its tannin content (Ardhanareswari, 2019) . Soares et al., (2020) reported that bitterness in food is connected to tannin and causes a bitter feeling in the mouth after ingestion. Similar findings indicated that the addition of *M. oleifera* through several food samples decreased sensory acceptability (Boateng *et al.,* 2019) .These findings agreed with those of Noaman *et al.,* (2022) ,who found that increasing the amount of moringa leaf extract in a function beverage (pineapple, carrot, and ginger flavor) resulted in a flavor that panelists disliked, and that reducing the amount of moringa leaf extract to the bare minimum resulted in a juice with the highest mean score for overall acceptability. Rh *et al.,* (2019b) showed that a beverage containing more than 15% moringa leaf extract (MLE) blended with beetroot juice generated more moringa flavor, however, beverages containing less than 15% moringa leaf extract didn't offer a taste as satisfying as the prepared beverage. Moringa infusion green tea was developed, and it was reported that moringa leaves infusion tea blended with tulsi tea obtained the lowest score (77.5) when compared to unblended tulsi tea (82.4) (Kumar et al. 2018). In this research, the addition of more than 12.5% moringa leaf extract resulted in a decrease in overall acceptability. Mango nectar with a moderate amount of MLE (10% and 12.5%) supplementation provided high consumer acceptability. In general, all of the formulated mango nectars improved in all sensory attributes except color and odor in the mango nectar created from mango pulp (25%) and moringa leaf extract (15%). Mango nectar blended with 10% and 12.5% moringa leaf extract (F6 and F3) was the most acceptable blended nectar as well as the control (F1 and F5) for both apple and Tommy Atkin mango fruit variety.

Nutritional composition of mango-moringa blended nectar

The nutritional content of mango nectar blended with moringa leaf extract is characterized in terms of moisture, ash, protein, fiber, fat, carbohydrate, and energy content. Except for moisture and fat content, there were significant differences in the ash, fiber, protein, carbohydrate, and energy contents of both mango nectar blended at different levels of interaction ($p < 0.05$). Mango nectar blended with moringa leaf extract had a significantly higher nutritional value than unblended mango nectar. This might be attributed to moringa leaf extract having the highest nutritional content as observed in this study. The results showed that increasing the proportion of moringa leaf extract in the formulation from 10% to 12.5% reduced the moisture content of the blended mango nectar.

This was in agreement with Akelom *et al.,* (2022), who found that cactus pear fruit-based jellies enhanced with moringa leaf extract had lower levels of moisture content. Compared to the unblended mango nectar, the blended formulation contained the most ash (control). This finding of increasing ash content levels with increasing moringa leaf extract proportions was consistent with the findings of Manaois, (2013) who found increasing ash content levels with increasing moringa oleifera substitution in the formulations. Shiriki *et al.,* (2015) also found a substantial increase in ash content in supplemental food produced from maize, soybean, and peanut with *M. oleifera* leaf powder supplementation. The addition of *M. oleifera* leaf extracts to mango nectar resulted in a high protein content. Similarly, Sengev et al., (2013), reported that *M. oleifera* leaf powder increased the protein content of bread and biscuits, respectively. Yessuf *et al.,* (2020), also reported a high protein content with the addition of moringa leaf extract to a moringa-carrot and moringa-avocado drink. The modest fat content of *M. oleifera* leaves may explain the observed little change in crude fat of the formulated mango nectar (Ogbe and Affiku, 2011). This result indicated that the crude fiber content of mango nectar increased as the amount of moringa leaf extract added to the nectar increased. Shiriki *et al.,* (2015) reported an increased level of fiber in the diet when *moringa oleifera* leaf powder was added. The presence of a significant amount of crude fiber in *M. oleifera* leaves may explain the enhanced crude fiber content in the formulated mango nectar. In contrast, a decrease in carbohydrate content was seen in the blended mango nectar as the amount of moringa leaf extract increased; this could be because moringa leaf extract had a lower carbohydrate content (Shiriki *et al.,* 2015). Also, the apparent higher carbohydrate contents obtained from unblended samples (control) when compared to the blended sample (F3 and F6) may be the result of low moisture contents in the blended samples, rather than a high carbohydrate content than the control, which obviously has a significantly low moisture content. The carbohydrate content reported in this investigation was comparable to those by Aderinola, (2018). The addition of moringa leaf extract boosted the vitamin A content of mango nectar. This result was in accord with those of Bassey *et al.,* (2020), who reported that the vitamin A content of *Moringa oleifera* leaf extract boosted vitamin A of Zobo beverages juice. Compared to the control, the addition of moringa leaf extract increased calcium, zinc, and iron significantly ($P < 0.05$). This finding revealed that the calcium, zinc, and iron content of all formulated mango nectar increased significantly as the proportion of moringa leaf extract in the formulation increased. Glover-Amengor *et al.,* (2017) reported that *moringa oleifera* is a superior mineral source. This finding is in line with those reported by Aderinola, (2018), who investigated the nutritious value of smoothies incorporating moringa leaves as a supplement: Pineapple (43.5%), Banana (38.5%), Apple (13.5%) and Moringa leaves (4.5%), respectively. This could be because moringa leaf extract had a good amount of minerals.

Conclusion

The vital components found in moringa leaf extract make it a good choice for nutritional supplements. As a result, it can be a cost-effective nutrient-rich choice in the fight against micronutrient deficiencies and malnutrition. The study found that F3 and F6 formulations were acceptable, whereas the ratio of 25:10% Tommy Atkin mango pulp-moringa leaf extract and 25:12.5% apple mango pulp was the best in terms of color, odor, taste, texture, mouth feel, and overall acceptability. In this study, mango nectar was developed from mango pulp with the supplementation of moringa leaf extract. The results indicated improvement in the contents of ash, protein, fat, fiber, vitamin A and minerals in the mango nectar blended with moringa leaf extract (10 and 12.5%) in the formulation. However, an excessive amount of moringa leaf extract in the formulation lowered the sensory acceptability of blended mango nectar. The 25% mango pulp and 10% and 12.5% moringa leaf extract resulted in a significant improvement in Tommy Atkin and apple mango nectar nutritional qualities and in higher sensory acceptability. Thus, this finding suggested that processing can reduce postharvest losses of mango fruits, enhance their nutritional value with supplementation of nutritionally rich food items such as *moringa oleifera* and their product can help to improve household food security and support the mitigation of malnutrition in the population. In addition, this study revealed that apple mango nectar blended with moringa leaf extract provided more vitamins and minerals compared to Tommy Atkin mango nectar blended with moringa leaf extract. To make the mango-moringa nectar more pleasing to consumers, mango flavor should be added in the right proportions to maintain the mango flavor and taste. Moringa leaf extract enhanced the antioxidants and nutrients in mango nectar.

Acknowledgments

The authors would like to acknowledge financial support from the SAP project. We express gratitude to the Department of Food Science, Nutrition and Technology, for the technological collaboration during this study.

References

Addinsoft. (2021). XLSTAT statistical and data analysis solution. *New York, USA.*

Aderinola, T. A. (2018). *Nutritional, Antioxidant, and Quality Acceptability of Smoothies Supplemented with Moringa Oleifera Leaves*. https://doi.org/10.20944/preprints201811.0402.v1

Akelom, K. M., Bisetegn, T. Y., & Bereka, T. Y. (2022). Development and optimization of cactus pear fruit jelly supplemented with Moringa oleifera leaf extract. *Heliyon*, *8*(6). https://doi.org/10.1016/j.heliyon.2022.e09587

AOAC. (2005). *Official methods of analysis of the association of official's analytical chemist, 17th Edn.*

AOAC. (2007). Official methods of analysis of the association of official's analytical chemist, 18 Edn. *Association Official Analytical Chemist, International, Gaithersburg, MD*.

AOAC. (2012). Official methods of analysis of the association of official's analytical chemist, 18th Edn. *Association of Official Analytical Chemists*.

Arah, I. K., Amaglo, H., Kumah, E. K., & Ofori, H. (2015). Preharvest and postharvest factors affecting the quality and shelf life of harvested tomatoes: A mini-review. In *International Journal of Agronomy* (Vol. 2015). Hindawi Publishing Corporation. https://doi.org/10.1155/2015/478041

Ardhanareswari, n. p. (2019). daya terima dan kandungan gizi dim sum yang disubstitusi ikan patin (pangasius sp.) dan pure kelor (moringa oleifera) sebagai snack balita. *ardhanareswari. media gizi indonesia*, *14*(2), 123–-131. https://doi.org/10.204736/mgi.v14i2.123-131

Babarinde, G. O., Olatunde, S. J., & Adebiyi-Olabode, A. (2019). Quality attributes and phytochemical properties of fresh juice produced from selected mango varieties. *Ceylon Journal of Science*, *48*(1), 31. https://doi.org/10.4038/cjs.v48i1.7585

Bassey, S. O., David-Oku, E., & Ehumile, M. (2020). Assessment of Nutritive and Preservative Impact of Enriching Zobo (Hibiscus sabdariffa Calyx) Drink with Moringa Extract. *European Journal of Nutrition & Food Safety*, 76–84. https://doi.org/10.9734/ejnfs/2020/v12i130186

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. In *Nutrition and Food Science* (Vol. 49, Issue 3, pp. 393–406). Emerald Group Holdings Ltd. https://doi.org/10.1108/NFS-07-2018-0192

Chethan Kumar, P., Azeez, S., & Roy, T. K. (2018). Development of moringa infusion for green tea and its evaluation. In *J. Hortl. Sci* (Vol. 13, Issue 2). www.cbi.eu/market-information/tea/trends

FAO. (2005). *General standard for fruit juices and nectars (CODEX STAN 247-2005)*.

Fombang, E. N., & Mbofung, C. M. F. M. F. (2017). The Effect of Steam Blanching and Drying Method on Nutrients, Phytochemicals and Antioxidant Activity of Moringa (Moringa oleifera L.) Leaves. *American Journal of Food Science and Technology*, *5*(2), 53–60. https://doi.org/10.12691/ajfst-5-2-4

Glover-Amengor, M., Aryeetey, R., Afari, E., & Nyarko, A. (2017). Micronutrient composition and acceptability of Moringa oleifera leaf-fortified dishes by children in Ada-East district, Ghana. *Food Science and*

Nutrition, *5*(2), 317–323. https://doi.org/10.1002/fsn3.395

Jolayemi, O. S. (2019). Variation in Nutritional Properties of Mango (Mangifera indica) Juice Based on Varietal Difference and Thermal Holding Time. *Acta Universitatis Cibiniensis. Series E: Food Technology*, *23*(1), 43–54. https://doi.org/10.2478/aucft-2019-0006

Jolayemi, O. S., & Adeyeye, O. A. (2018). Assessment of Nutrient and Storage Stabilizing Potential of Ginger and Garlic on Composite Fruit Smoothies. *Asian Food Science Journal*, *4*(3), 1–15. https://doi.org/10.9734/afsj/2018/44109

Jones, M. S., Harrach, B., Ganac, R. D., Gozum, M. M. A., dela Cruz, W. P., Riedel, B., Pan, C., Delwart, E. L., & Schnurr, D. P. (2007). New Adenovirus Species Found in a Patient Presenting with Gastroenteritis. *Journal of Virology*, *81*(11), 5978–5984. https://doi.org/10.1128/jvi.02650-06

Lebaka, V. R., Wee, Y. J., Ye, W., & Korivi, M. (2021). Nutritional composition and bioactive compounds in three different parts of mango fruit. In *International Journal of Environmental Research and Public Health* (Vol. 18, Issue 2, pp. 1–20). MDPI AG. https://doi.org/10.3390/ijerph18020741

Lozano, J. E. (2006). Processing of fruits: Ambient and low temperature processing. Fruit Manufacturing Scientific Basis, Engineering Properties, and Deteriorative Reactions of Technological Importance. *New York, NY, USA: Springer-Verlag New York Inc.*, 21–54.

Manaois, R. V.; Morales A. V. & Abilgos-Ramos R. G.; (2013). Acceptability, shelf life, and nutritional quality of moringa-supplemented rice crackers. *Philippine Journal of Crop Science (Philippines)*, *38*(2), 1–8.

Moyo, B., Masika, P. J., Hugo, A., & Muchenje, V. (2011). Nutritional characterization of Moringa (Moringa oleifera Lam.) leaves. *African Journal of Biotechnology*, *10*(60), 12925–12933. https://doi.org/10.5897/ajb10.1599

Naa, P., Otu, Y., Kwesi Saalia, F., & Amankwah, E. A. (2013a). *Characterization of Fresh Moringa oleifera Beverage*. *21*. www.iiste.org

Naa, P., Otu, Y., Kwesi Saalia, F., & Amankwah, E. A. (2013b). *Optimizing Acceptability of Fresh Moringa oleifera Beverage*. *21*. www.iiste.org

Noaman, Z. M., Ashoush, I. S., Mahdy, S. M., & Yousef, E. E. (2022). Enhancement of sensory, physicochemical, and antioxidant properties of moringa functional beverages. In *Egyptian J. of Nutrition: Vol. XXXVII* (Issue 1).

Obiajulu, E. I. A. I. S. (2020). Effects of Boiling Time on the Antioxidant Activity of Moringa Leaf Extract. *International Journal of Research Studies in Biosciences*, *8*(3), 18–26. https://doi.org/10.20431/2349-0365.0803003

Ogbe, A. O., & Affiku, J. P. (2011). Proximate study, mineral and anti-nutrient composition of Moringa oleifera leaves harvested from Lafia, Nigeria: Potential benefits in poultry nutrition and health Animal reproduction and Breeding strategy View project. In *Article in Journal of Microbiology* (Vol. 12, Issue 1). https://www.researchgate.net/publication/284534105

Okoth E. M., Sila D.N., Onyango C. A., Owino, W.O., Musembi S.M, & Mathooko F.M (2013) Evaluation of physical and sensory quality attributes of three mango varieties at three stages of ripeness, grown in the lower eastern province of Kenya-part 1. In *Journal of Animal &Plant Sciences* (Vol. 17). http://www.m.elewa.org/JAPS;

Omayio, D. G., Abong', G. O., Okoth, M. W., Gachuiri, C. K., & Mwang'ombe, A. W. (2022). Effect of pulping methods on the physicochemical properties of the Kenyan red and white-fleshed guava pulp. *JSFA Reports*, *2*(3), 131–142. https://doi.org/10.1002/jsf2.35

Onyekwere, N. (2014). Phytochemical, Proximate and Mineral Composition of Leaf Extracts of Moringa oleifera Lam. from Nsukka, South-Eastern Nigeria. In *IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS* (Vol. 9, Issue 1). www.iosrjournals.orgwww.iosrjournals.org

Rajput, H., Prasad, S., Srivastav, P., Singh, N., Suraj, L., & Chandra, R. (2017). Chemical Science Review and Letters Chemical and Phytochemical Properties of Fresh and

Dried Moringa Oliferiea (PKM-1) Leaf Powder. *Chem Sci Rev Lett*, *6*(22).

Rani, N. Z. A., Husain, K., & Kumolosasi, E. (2018). Moringa genus: A review of phytochemistry and pharmacology. In *Frontiers in Pharmacology* (Vol. 9, Issue FEB). Frontiers Media S.A. https://doi.org/10.3389/fphar.2018.00108

Rawson, A., Patras, A., Tiwari, B. K., Noci, F., Koutchma, T., & Brunton, N. (2011). Effect of thermal and non-thermal processing technologies on the bioactive content of exotic fruits and their products: Review of recent advances. In *Food Research International* (Vol. 44, Issue 7, pp. 1875–1887). https://doi.org/10.1016/j.foodres.2011.02.053

Rh, K., Yogita, C., Mp, G., Aj, H., & Ak, S. (2019). Development of health drink from fruit and vegetables (Beetroot, Pineapple, and Moringa leaves). *~ 776 ~ The Pharma Innovation Journal*, *8*(4), 776–780. www.thepharmajournal.com

Rouphael, Y., C. M., B. A., L. C., G. F., & C. G. (2012). Vegetable quality is affected by genetic, agronomic, and environmental factors. *Journal of Food, Agriculture, and Environment*, *10*, 680 – 688.

Sengev, A. I., Abu, J. O., & Gernah, D. I. (2013). Effect of *Moringa oleifera* Leaf Powder Supplementation on Some Quality Characteristics of Wheat Bread. *Food and Nutrition Sciences*, *04*(03), 270–275. https://doi.org/10.4236/fns.2013.43036

Shah, M. A., Bosco, S. J. D., & Mir, S. A. (2015). Effect of Moringa oleifera leaf extract on the physicochemical properties of modified atmosphere packaged raw beef. *Food Packaging and Shelf Life*, *3*, 31–38. https://doi.org/10.1016/j.fpsl.2014.10.001

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

Soares, S., Brandão, E., Guerreiro, C., Soares, S., Mateus, N., & de Freitas, V. (2020). Tannins in food: Insights into the molecular perception of astringency and bitter taste. In *Molecules* (Vol. 25, Issue 11). MDPI AG. https://doi.org/10.3390/molecules25112590

Sohaimy, S. A. el, Hamad, G. M., Mohamed, S. E., Amar, M. H., & Al-Hindi, R. R. (2015). Biochemical and functional properties of Moringa oleifera leaves and their potential as a functional food. In *Global Advanced Research Journal of Agricultural Science* (Vol. 4, Issue 4).

Sunday, R., Onyeka, C., Afolayan, M., Onwatogwu, J., & Oshagbemi, B. (2016). Phytochemical Properties and Effect of Temperature on Proximate and Mineral Composition of Curcuma Longa Linn. Rhizomes Ethanolic Extract. *International Journal of Biochemistry Research & Review*, *15*(4), 1–6. https://doi.org/10.9734/ijbcrr/2016/31642

Vidal, N. P., Manful C. F., Pham T. H., Stewart P., Keough. D., & Thomas. R.H. (2020). The use of XLSTAT in conducting principal component analysis (PCA) when evaluating the relationships between sensory and quality attributes in grilled foods. *MethodsX*, *7*(100835).

Wibowo, S., Grauwet, T., Gedefa, G. B., Hendrickx, M., & van Loey, A. (2015). Quality changes of pasteurized mango juice during storage. Part II: Kinetic modeling of the shelf-life markers. *Food Research International*, *78*, 410–423. https://doi.org/10.1016/j.foodres.2015.09.001

Yessuf, A. M., Srinivasan, B., & Chinna Eranna, B. (2020). Development of functional drink from the leaves of Moringa Stenopetala. In *An International Research Journal), www.chemistry-journal.org* (Vol. 10, Issue 8). www.chemistry-journal.org