Development of Muskmelon Seed Soup Bases and Assessment of Their Nutritional Composition

Rita Adu-Amankwah [1*], Sarah Darkwa [2], Benjamin Sarfo Appau [3]
[1-2] Department of Vocational and Technical Education, University of Cape Coast, Ghana
[3] Department of Biology Education, University of Education, Winneba, Ghana

* Corresponding Author: **Rita Adu-Amankwah**

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Abstract
Muskmelon (*Cucumis melo*) is a widely cultivated fruit in tropical regions, valued for its refreshing taste and hydrating properties, however, its seeds are often discarded despite their rich nutritional potential. Limited research exists on utilizing muskmelon seeds as a soup-base, especially regarding their nutritional and mineral composition, making this study relevant for sustainable food innovation and waste reduction. Muskmelon seeds were roasted, milled into flour, and formulated into four soup-base samples, control, Prekese, Dawadawa, and Cinnamon variants. Proximate and mineral analysis were carried out on the four samples of the muskmelon soup-base. Results showed significant differences ($p < 0.05$) in most nutrients across treatments: protein ranged from 25.38-30.66%, and fat ranged from 33.29-36.35%, and fibre from 10.10-11.23%, while moisture remained low (<3%), indicating good shelf stability. Mineral analysis revealed variations, with Prekese soup exhibiting the highest iron (143.3 µg/g) and potassium (5,001.7 µg/g), and Dawadawa soup showing higher magnesium (3,310.7 µg/g). Calcium levels did not differ significantly ($p = 0.0554$) among samples. The study confirms that muskmelon seeds can be transformed into a nutrient-rich, shelf-stable soup-base comparable to traditional groundnut or egusi soups. It is recommended that muskmelon seed soup-base production be expanded for commercial and nutritional applications to enhance local food security, promote sustainable utilization of fruit by-products, and provide affordable plant-based protein alternatives.

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Keywords: Muskmelon seeds, Soup-base formulation, Nutritional composition, Food sustainability, Prekese and Dawadawa

Introduction

Muskmelon, scientifically known as *Cucumis melo*, is a widely grown member of the Cucurbitaceae family, cherished in tropical and subtropical regions for its sweet, juicy fruits like cantaloupe and honeydew (Kaur *et al*., 2021) [9]. This creeping plant produces fleshy, seed-filled fruits that are enjoyed fresh, juiced, or as part of desserts and dishes across Asia, Africa, and the Mediterranean (Chikh-Rouhou *et al*., 2023) [7]. Beyond its refreshing taste, muskmelon is valued for its hydrating and digestive benefits in many traditional food cultures. However, while the fruit is celebrated, its seeds are often discarded as waste, despite emerging research highlighting their impressive nutritional potential (Aydın, 2025; Meyer-Rochow, 2025) [3, 11]. With growing global focus on sustainability and reducing food waste, muskmelon seeds are gaining attention as a nutrient-packed ingredient that could play a key role in creating healthier, eco-friendly food products.

Historically, fruit seeds like those of muskmelon have been overlooked, thrown away during processing or consumption without recognizing their value. Yet, recent studies reveal that muskmelon seeds are rich in protein, healthy fats, fiber, minerals,

and antioxidants, making them a promising candidate for functional foods and nutraceuticals (Kumar *et al*., 2022; Meyer-Rochow, 2025) [10, 11]. This shift toward valuing underutilized plant parts reflects a broader push for sustainable food systems, where waste is minimized, and every edible component is maximized for its nutritional benefits (Aydın, 2025) [3]. Muskmelon seeds hold potential as a base for innovative, nutrient-dense products like flours, pastes, or extracts that can enhance diets while supporting circular food economies (Yadav *et al*., 2025) [17].

Nutritionally, muskmelon seeds stand out for their high oil content (30-50%), primarily made up of heart-healthy polyunsaturated fatty acids like linoleic acid, which supports cardiovascular health (H. Zhang *et al*., 2025) [18]. They also offer substantial protein (20-30%) and dietary fiber (up to 12%), placing them in the same league as popular oilseeds like pumpkin or sunflower seeds (Ekute *et al*., 2025) [8]. These seeds are packed with essential minerals such as magnesium, phosphorus, potassium, iron, and zinc, making them a nutrient-dense ingredient for health-focused diets (Ekute *et al*., 2025) [8]. Beyond basic nutrition, muskmelon seeds contain bioactive compounds like phenolic compounds, flavonoids, and terpenoids, which provide antioxidant, anti-inflammatory, and antimicrobial benefits (Çelik *et al*., 2025) [6]. These properties make the seeds a food source and a potential contributor to overall wellness.

When compared to other oilseeds like groundnut (Arachis hypogaea) or egusi (Citrullus colocynthis), muskmelon seeds hold their own, offering similar or even superior levels of fat, protein, and fiber (Ekute *et al*., 2025) [8]. Their higher content of unsaturated fatty acids and fiber makes them suitable for the development of functional foods that promote health. In traditional medicine, muskmelon seeds have been used to ease digestive issues like constipation or diarrhea, due to their mucilage and bioactive compounds (Neupane *et al*., 2025) [13]. In

West Africa, particularly in Ghana and Nigeria, these seeds are a staple in dishes like “wrewre nkwan” or “egusi soup,” where they act as a protein-rich thickener, similar to groundnut-based preparations (Boakye *et al*., 2025) [5]. Processing methods like drying, roasting, and grinding enhance the seeds’ flavor, reduce anti-nutritional factors, and improve mineral availability, making them ideal for long-lasting soup bases (Zhang *et al*., 2024) [18].

The global push for plant-based nutrition has spotlighted ingredients like muskmelon seeds as affordable, sustainable solutions to address protein-energy malnutrition and food insecurity, especially in developing regions (Al-Hashim *et al*., 2025) [1]. These seeds offer a locally available source of protein, healthy fats, and micronutrients, reducing reliance on imported foods and supporting local economies (Munghang *et al*., 2025) [12]. Despite their potential, muskmelon seeds remain understudied as a complete soup base, particularly when compared to established oilseed soups like egusi or groundnut (Boakye *et al*., 2025) [5]. Few studies have explored their nutritional and mineral properties in such culinary applications. This study aims to fill that gap by developing a muskmelon seed-based soup formulation and evaluating its nutritional and mineral qualities, paving the way for its use as a nutrient-rich, plant-based food product.

Materials and Methods

Preparation of Muskmelon seed soup bases

Flour from muskmelon seeds was prepared as shown in Figure 1.

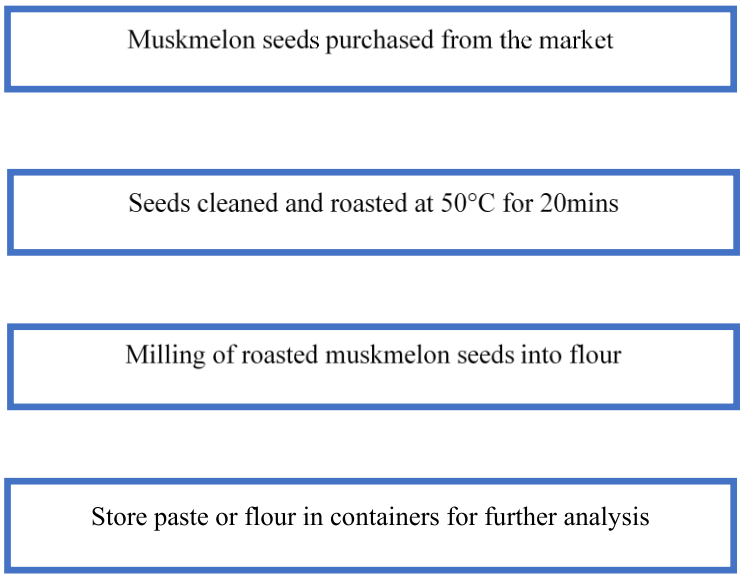

Fig 1: Preparation of flour from muskmelon seed

Preparation of four formulations of muskmelon seed soup-base Flavoured samples were prepared following the formulation in Table 1. The control sample contained only muskmelon seed flour with no added ingredients.

Table 1: Sample Formulation of Control and flavoured Muskmelon Seed Soup-Base (g)

Ingredients	Control/no flavour - T1	Prekese - T2	Dawadawa - T3	Cinnamon -T4
Muskmelon flour	800	800	800	800
Turkey berry powder	100	100	100	100
Onion powder	50	50	50	50
Pepper powder	10	10	10	10
Powdered ginger	15	15	15	15
Salt	5	5	5	5
Prekese powder	-	20	-	-
Dawadawa powder	-	-	20	-
Cinnamon powder	-	-	-	20
Total	980	1000	1000	1000

In table 1, three flavoured formulations and one control soup base were used. The flavours included; prekese, dawadawa, and cinnamon powders. The formulation and processing steps are shown in Table 1 and Figure 2. For the prekese sample, 800 g of muskmelon seed flour, 100 g of turkey berry, 50 g of onion, 10 g of pepper, 15 g of ginger, 20 g of prekese powder, and 0.5 g of salt were mixed to form a fine blend. For the dawadawa sample, 800 g of muskmelon seed flour, 100 g of turkey berry, 50 g of onion, 10 g of pepper, 15 g of ginger, 20 g of dawadawa powder, and 5 g of salt were blended into a uniform mixture. For the cinnamon sample, 800 g of muskmelon seed flour, 100 g of turkey berry, 50 g of onion, 10 g of pepper, 15 g of ginger, 20 g of cinnamon powder, and 5 g of salt were processed into a smooth blend.

Proximate Analysis of Samples

The proximate analyses protocol was adopted from the AOAC (2008) standard methods.

Moisture Content

A clean, dry crucible was weighed, and 3 g of each sample was placed into it in triplicate. The crucibles were dried in an oven at 60°C overnight. After drying, they were cooled in a desiccator and reweighed. The loss in weight was recorded as the moisture content.

Determination of ash content

A dry porcelain dish was weighed, and 2 g of each sample was added in triplicate. The dishes were placed in a muffle furnace at 500-600°C for about eight hours. After cooling in a desiccator, the dishes were reweighed to determine ash content.

Determination of crude protein

2g of sample was digested with 20 mL sulfuric acid and a selenium catalyst. The digest was heated for four hours until clear, cooled, and diluted to 50 mL with distilled water. Ten milliliters of the digest were distilled with sodium hydroxide, and the ammonia released was collected in boric acid. The distillate was titrated with 0.01 M H_2SO_4 until a green-to-pink color change. Two blanks were also analyzed. Total nitrogen was calculated, and protein was obtained using a factor of 6.25.

%Total Nitrogen (%N) = Sample titre value – Blank titre value X 0.1 x0.01401 x 100 sample weight X 10

% Protein =%N x 6.25

Determination of crude fat

10 g of dried sample was placed in a thimble and extracted with 150 mL of petroleum ether for six hours at 60°C. After extraction, the solvent was evaporated, and the flask was dried and weighed. Fat content was calculated as:

%Crude fat=Weight of oilSample weightx100%

Determination of crude fibre

Crude fibre was determined according to AOAC (2008) protocols. One gram of sample was boiled with 100 mL of 1.25% H_2SO_4 for 30 minutes, filtered, and rinsed. The residue was boiled again with 100 mL of 1.25% NaOH for 30 minutes, filtered, and washed with hot water and methanol. The residue was dried at 105°C overnight, then ashed at 500°C for four hours. After cooling, the crucible was reweighed, and crude fibre was calculated as:

% Crude fibre = weight loss through ashingSample weight ×100

Determination of carbohydrate

The total carbohydrate estimate was obtained by subtracting the sum of moisture, ash, protein, fat and crude fiber from hundred and expressed as a percentage.

Mineral Analysis of Selected Elements

Preparation of sample solution for the determination

Before elemental analysis, organic matter was destroyed by acid oxidation to obtain clear sample solutions for analysis.

Hydrogen peroxide-sulfuric acid digestion

A digestion mixture containing 420 mL of sulfuric acid, 14 g of lithium sulfate, 0.42 g of powdered selenium, and 350 mL of hydrogen peroxide was prepared. Oven-dried powdered samples (0.100–0.200 g) were weighed into 100 mL Kjeldahl flasks. Each sample received 4.4 mL of the digestion reagent and was digested at 360°C for two hours. Blank digestions were run using the same reagents without samples. After digestion, the digests were transferred and diluted to 100 mL with distilled water.

Phosphorus colorimetric determination using the ascorbic acid method

Phosphorus was determined colorimetrically using the ascorbic acid method. Reagent A contained 12 g ammonium molybdate dissolved in 20 mL distilled water, mixed with 0.2908 g potassium antimony tartrate in 1 L of 2.5 M H_2SO_4. The solutions were combined and diluted to 2 L. Reagent B was prepared by dissolving 1.56 g of ascorbic acid in every 200 mL of reagent A. A 100 µgP/mL stock solution was prepared, and working standards (0-1.0 µgP/mL) were made. 2 mL of the digested sample were pipetted into 25 mL flasks, followed by 10 mL of distilled water and 4 mL of reagent B. The solution was made up to 25 mL with distilled water and mixed. After 15 minutes, absorbance was read at 882 nm using a spectrophotometer. A standard curve was plotted

from the standards, and phosphorus concentration was read from the graph.
µg P /g sample=C x Diluton FactorSample weight

Determination of Potassium and Sodium
Potassium and sodium were determined using a flame photometer. Working standards (0-10 µg/mL) were prepared, and their emissions were used to plot calibration curves. Sample solutions were aspirated, and their emissions were converted to concentrations using the curves.
µg K or Na /g sample=C x solution volumeSample weight
Determination of Calcium and Magnesium by EDTA titration
Calcium and magnesium were determined by complexometric titration using 0.005 M EDTA. Ten milliliters of sample solution were diluted with 150 mL distilled water. For total Ca and Mg, hydroxylamine hydrochloride, potassium ferrocyanide, potassium cyanide, and 1 mL triethanolamine (TEA) were added, followed by five drops of Eriochrome Black T indicator. The mixture was titrated with 0.005 M EDTA.
For calcium alone, the same procedure was used with calcon indicator. Magnesium content was obtained by subtracting calcium from total hardness.
% Ca=0.005 x 40.08 x TSample weight
% Mg=0.005 x 24.32 x TSample weight
Where T = titre value

Determination of Iron, Copper and Zinc using Atomic Absorption Spectrophotometer
Iron, copper, and zinc were analyzed using an atomic absorption spectrophotometer (AAS). Standard solutions of 1, 2, and 5 µg/mL were prepared for calibration. The standards were aspirated to plot calibration curves, and concentrations of Fe, Cu, and Zn in the digested samples were read directly.
µg Fe,Cu,Zn /g sample=C x solution volumeSample weight

Results and Discussion
Proximate analysis of the Muskmelon Seeds Soup-Base
The proximate composition of the muskmelon seed soup-base samples showed significant differences in dry matter, moisture, protein, fat, fibre, and carbohydrate content. Dry matter was highest in the control (98.36%) and lowest in the Prekese sample (97.4%), while moisture followed an inverse trend, ranging from 1.64% in control to 2.6% in Prekese ($p = 0.0058$), confirming that all samples were low-moisture powders suitable for shelf stability, as supported by comparative research from (Ojieh *et al*., 2008; Onyejiaka *et al*., 2023) [14, 16]. Ash content, indicating mineral presence, showed no significant difference among samples (3.58-3.69%), consistent with previous findings that spice inclusion did not markedly alter overall mineral concentration (Bassey *et al*., 2020) [4]. Protein levels were significantly different ($p < 0.0001$), with the Dawadawa blend containing the highest amount (30.66%), followed by Prekese (27.50%), Cinnamon (26.47%), and Control (25.38%), a trend attributed to the high protein content of locust beans in Dawadawa. Fat content also varied significantly ($p < 0.0001$), ranging from 36.35% in Prekese to 33.29% in Dawadawa, aligning with documented melon seed oil content (26.6%) and indicating that spice blends and formulation differences impacted lipid concentration. Fibre levels differed significantly ($p < 0.0001$), with Prekese again highest (11.23%) and Control lowest (10.10%), a result likely influenced by fibrous spice components, and consistent with reports that melon seed products enriched with plant materials contain higher crude fibre than extruded or defatted forms (Onyejiaka *et al*., 2023) [16].

Table 2: Proximate Analysis of Muskmelon Seed Soup-Base Samples

Sample	Dry Matter (%)	Moisture (%)	Ash (%)	Protein (%)	Fat/oil (%)	Fibre (%)	Carbohydrate (%)
Control	98.36 ± 0.253^{a}	1.64 ± 0.238^{b}	3.6 ± 0.08^{a}	25.38 ± 0.277^{d}	35.31 ± 0.233^{b}	10.1 ± 0.129^{c}	23.99 ± 0.454^{a}
Prekese	97.4 ± 0.24^{b}	2.6 ± 0.238^{a}	3.63 ± 0.1^{a}	27.5 ± 0.234^{b}	36.35 ± 0.259^{a}	11.23 ± 0.095^{a}	18.69 ± 0.467^{c}
Dawadawa	97.55 ± 0.256^{b}	2.45 ± 0.274^{a}	3.69 ± 0.08^{a}	30.66 ± 0.238^{a}	33.29 ± 0.235^{d}	10.83 ± 0.101^{b}	19.09 ± 0.442^{c}
Cinnamon	97.7 ± 0.273^{b}	2.3 ± 0.258^{a}	3.58 ± 0.08^{a}	26.47 ± 0.261^{c}	34.49 ± 0.225^{c}	10.83 ± 0.072^{b}	22.34 ± 0.472^{b}
p-value	0.0058	0.0058	0.4634	<0.0001	<0.0001	<0.0001	<0.0001
Significance	Yes	Yes	No	Yes	Yes	Yes	Yes

Values are expressed as mean ± standard deviation (n = 3). Means in the same column with different superscript letters differ significantly at $p < 0.05$.

Mineral composition of the Muskmelon Seeds Soup-Base
The analysis of mineral content in the muskmelon seed soup-base samples revealed significant differences in most mineral elements. However, calcium levels showed no significant variation ($p = 0.0554$), suggesting that the condiments had minimal impact on this mineral. Phosphorus levels were highest in the control sample (8,176.0 µg/g) and lowest in the Dawadawa sample (6,896.5 µg/g; $p = 0.0005$), indicating that condiment addition may influence phosphorus retention or release during processing. This aligns with previous research on Citrullus lanatus, a related species, which showed similar effects (Olubi *et al*., 2021) [15]. Potassium was significantly higher in the Prekese sample (5,001.7 µg/g) compared to the control (4,364.0 µg/g; $p = 0.0013$), likely due to Prekese's natural mineral content or its ability to enhance potassium release from the seed matrix, consistent with studies on other Cucurbitaceae seeds (Olubi *et al*., 2021) [15]. Sodium levels increased in the Prekese sample (2,737.1 µg/g) compared to the control (1,981.2 µg/g; $p < 0.0001$), but the sodium-to-potassium ratio remained below 1 across all samples, aligning with nutritional guidelines for balanced mineral intake (Bassey *et al*., 2020) [4]. Zinc content was highest in the Prekese sample (114.25 µg/g) and lowest in the Cinnamon sample (94.65 µg/g; $p < 0.0001$), suggesting that Prekese may either contribute zinc or improve its extraction, a pattern observed in condiment-enhanced foods (Bassey *et al*., 2020) [4]. Copper levels also varied significantly ($p < 0.0001$), ranging from 63.48 µg/g in the control to 103.91 µg/g in the Cinnamon sample, indicating that cinnamon may either supply copper or facilitate its release, as seen in other spice-enhanced formulations (Bassey *et al*., 2020) [4]. Calcium content showed no significant differences across samples ($p = 0.0554$), with values ranging from 20,881 to 24,944 µg/g, suggesting that condiments had little effect on this mineral.

Magnesium levels were highest in the Dawadawa sample (3,310.7 µg/g) and lowest in the Cinnamon sample (2,920.3 µg/g; $p = 0.0001$), likely reflecting the mineral richness of fermented locust beans used in Dawadawa (Olubi *et al*., 2021) [15]. Iron content also differed significantly ($p < 0.0001$), with the Prekese sample showing the highest levels (143.3 µg/g) and the Cinnamon sample the lowest (112.16 µg/g), indicating that Prekese may enhance iron availability, consistent with prior studies on condiment-influenced nutrient profiles (Olubi *et al*., 2021) [15]. These results demonstrate that muskmelon seed soups can serve as a valuable source of both macro- and micro-minerals in the diet. The variations across treatments show the significant role of seasoning and processing in shaping the mineral composition and, consequently, the nutritional potential of these soups.

Table 3: Mineral Composition of Muskmelon Seed Soup-Base Samples (µg/g)

Sample	P (µg/g)	K (µg/g)	Na (µg/g)	Zn (µg/g)	Cu (µg/g)	Ca (µg/g)	Mg (µg/g)	Fe (µg/g)
Control	8176.0 ± 0.16^{a}	4364.0 ± 0.84^{b}	1981.2 ± 0.22^{c}	108.26 ± 0.28^{b}	63.48 ± 0.86^{c}	21434 ± 0.58^{a}	3214.0 ± 0.67^{ab}	125.5 ± 0.19^{c}
Prekese	7507.8 ± 0.63^{b}	5001.7 ± 0.27^{a}	2737.1 ± 0.15^{a}	114.25 ± 0.22^{a}	65.29 ± 0.94^{c}	24944 ± 0.97^{a}	3077.7 ± 0.14^{b}	143.3 ± 0.15^{a}
Dawadawa	6896.5 ± 0.53^{c}	4576.9 ± 0.69^{b}	2292.4 ± 0.47^{b}	108.15 ± 0.21^{b}	83.36 ± 0.96^{b}	23936 ± 0.3^{a}	3310.7 ± 0.52^{a}	139.56 ± 0.18^{b}
Cinnamon	7314.4 ± 0.34^{b}	4367.8 ± 0.53^{b}	2159.3 ± 0.85^{b}	94.65 ± 0.33^{c}	103.91 ± 0.88^{a}	20881 ± 0.03^{a}	2920.3 ± 0.57^{c}	112.16 ± 0.16^{d}
p-value	0.0005	0.0013	<0.0001	<0.0001	<0.0001	0.0554	0.0001	<0.0001
Significance	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes

Values are expressed as mean ± standard deviation (n = 3). Means in the same column with different superscript letters differ significantly at $p < 0.05$.

Conclusion

The study demonstrated that muskmelon (Cucumis melo) seeds can be effectively developed into a nutrient-dense soup base with nutritional and mineral value. The proximate analysis revealed that the soup-bases were rich in protein, fat, fibre, and essential minerals such as potassium, magnesium, and iron, with variations among the different formulations. The Dawadawa-based soup showed the highest protein and magnesium content. The Prekese formulation was high in fat, zinc, and iron. All samples had low moisture content, which indicates good storage stability and suitability for dry soup-base production. These findings confirm that muskmelon seeds, when properly processed and fortified with traditional condiments, can serve as a valuable plant-based ingredient for developing affordable, shelf-stable, and nutritionally balanced food products.

It is recommended that muskmelon seed soup-base production be explored for large-scale food formulation and commercial processing, particularlyfi in regions seeking plant-based alternatives to traditional oilseed soups. Research should evaluate the sensory quality, consumer acceptability, and shelf-life stability of the developed soup-bases to ensure market readiness. Additionally, nutritional intervention programs could incorporate muskmelon seed products as sustainable, locally sourced options to combat protein-energy malnutrition and promote food security in developing communities.

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