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Influence of Grinding-Induced Particle Size Reduction on the Physicochemical, Functional, and Sensory Properties of Moringa oleifera Leaf Powder

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Abstract

Moringa oleifera is widely valued for its nutritional potential, yet the particle size of its leaf powder critically influences its physicochemical and functional properties. This study evaluated the effect of different particle sizes, obtained through varying grinding intensities, at Sindh Agriculture University, Tandojam. Fresh leaves were dehydrated at 40–45°C and subjected to three treatments: T₁ (pestle), T₂ (blender), and T₃ (grinding machine). The Physicochemical analyses were conducted according to AOAC (2016) methods, while functional and sensory properties were evaluated using standard analytical procedures. Alongside functional properties including water absorption capacity (WAC), oil holding capacity (OHC), particle size distribution, pH, yield, and weight loss variation, all the treatments were conducted in three replications. Results revealed significant ($P < 0.05$) differences among treatments. T₃ obtained the finest particles (20, 40, 60, 80, and 120 μm), the highest values of ash (9.02%), protein (21.19%), carbohydrates (35.71%), WAC (4.6g/g), and OHC (3.1g/g). Median values were observed in T₁ and T₂, with T₂ generally exceeding T₁ in nutritional and functional properties. Yield was lower in ground samples (30.25–31.31%) due to fine particle losses, while post-drying weight decreased progressively from T₁ (22.52) to T₃ (20.61 g). Sensory evaluation confirmed the influence of grinding intensity, with T₃ recording the highest scores (7.66) for all attributes, followed by T₂ and T₁. These results highlight superior consumer preference for the finely ground powder, supported by significant differences ($P < 0.05$) across treatments. These findings demonstrate that reducing particle size through grinding machines significantly enhances the physicochemical, nutritional, and functional properties of Moringa oleifera leaf powder (MOLP), making it highly suitable for functional foods, dietary supplements, and therapeutic formulations. Future studies should optimize grinding parameters for industrial scalability.

Keywords: Moringa oleifera, particle size distribution, grinding methods, nutritional quality, functional properties, sensory evaluation.

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Introduction

Moringa oleifera, commonly referred to as the horseradish tree, drumstick tree, or simply moringa, belongs to the family Moringaceae. It is widely cultivated across tropical and subtropical regions including India, Africa, Southeast Asia, Mexico, and southern Japan (Sugahara et al., 2018). Known for its exceptional nutritional and medicinal value, *M. oleifera* is a rich source of proteins, dietary fiber, essential minerals, vitamins, and numerous bioactive compounds such as phenolics, saponins, and polysaccharides. Its various parts—leaves, stems, roots, flowers, and seeds—are extensively utilized in animal feed, herbal teas, dietary supplements, food enhancers, and traditional medicine (Gharibzahedi et al., 2013; Yang et al., 2020; Astrini et al., 2020).

The leaves, in particular, are highly valued for their abundant concentrations of calcium, potassium, iron, and vitamins A, C, and E, along with approximately 25% protein that includes all nine essential amino acids, making them a vital plant-based protein source in regions with limited animal protein availability (Fahey et al., 2019; Vainio et al., 2018; Gupta et al., 2021). Moreover, *M. oleifera* leaves are rich in antioxidants such as quercetin, chlorogenic acid, and beta-carotene, which help reduce oxidative stress and the risk of chronic diseases (Amaglo et al., 2020). Bioactive compounds in moringa have also demonstrated anti-inflammatory, antimicrobial, hypoglycemic, and lipid-lowering activities, enhancing its potential in both nutritional and therapeutic applications (Makkar et al., 2018; Bhat et al., 2023; Guevara et al., 2021).

The particle size of plant powders is a key determinant of their technological

and functional properties, influencing hydration behavior, solubility, extractability of bioactive compounds, digestibility, and overall performance in food systems. Particle size reduction increases the specific surface area and promotes disruption of plant cell walls during milling, thereby facilitating the release of encapsulated phytochemicals and micronutrients and improving their bio-accessibility (Tafu & Jideani, 2022; Xiao et al., 2017; Barretto et al., 2022). These characteristics are particularly important in functional foods and nutraceuticals, where enhanced nutrient availability contributes to improved health benefits (González-Sarrías, & Espín, 2020). *Moringa oleifera* leaf powder (MLP) has emerged as a valuable functional ingredient because of its high nutritional value and rich content of proteins, vitamins, minerals, dietary fiber, and antioxidant phytochemicals. Its incorporation into food products has been reported to improve nutritional quality, sensory characteristics, and shelf life (Yadav et al., 2019; Bashir et al., 2018). However, the functional performance of MLP is strongly influenced by its particle characteristics, which affect properties such as dispersibility, color, texture, hydration behavior, and the release of bioactive compounds (Sanjay et al., 2022; Mishra et al., 2018).

The functional characteristics of MLP are largely dependent on the milling technique and degree of size reduction. Common grinding methods, including sieving, hammer milling, jet milling, and ball milling, produce powders with distinct particle size distributions, morphologies, and surface characteristics, thereby influencing their technological performance (Zaiter et al., 2016; Bai et al., 2020; Rojas et al., 2020). Conventional

sieve-based grinding is simple and economical but generally produces powders with broader particle size distributions, whereas ball milling can generate finer and more uniform particles that improve powder homogeneity in food formulations. Nevertheless, excessive grinding may damage the powder structure and reduce important functional attributes, including water- and oil-holding capacities (Salama et al., 2022).

Previous studies have demonstrated that superfine grinding improves the flowability, hydration properties, antioxidant activity, and bioavailability of various plant powders (Sun et al., 2019; Xiao et al., 2017; Dhiman et al., 2021). In *Moringa oleifera* leaf powder, superfine grinding has also been shown to modify physicochemical, thermal, and structural characteristics. Moreover, superfine grinding reduced insoluble dietary fiber and protein contents and decreased bulk density, tap density, water-holding capacity, and oil-holding capacity, while increasing the angles of repose and slide, indicating substantial changes in powder functionality and flow behavior (Huang et al., 2020).

Therefore, this study aimed to investigate the effect of different grinding intensities resulting in varying particle sizes on the physicochemical composition and functional properties of *Moringa oleifera* leaf powder. The findings are expected to provide valuable insights for optimizing MLP processing for applications in functional foods, nutraceuticals, and pharmaceuticals.

Material and Methods

Sample collection of moringa leaves

Moringa leaves were collected from Sindh Agriculture University, Tandojam. Fresh moringa leaves were procured and

transported to the laboratory of the Institute of Food Sciences and Technology (IFST) for processing into moringa leaf powder.

All experiments were performed in triplicate under controlled laboratory conditions using standardized AOAC (2016) protocols. Particle-size measurements were conducted using calibrated sieve sets under uniform shaking conditions to ensure analytical consistency.

Processing of moringa leaves

The moringa leaves were processed and dried in a dehydration cabinet at a temperature

of 40–45°C to remove moisture content. The dried leaves were ground into powder and packed in polyethylene bags.

Experimental design and replications

The experiment was conducted in a Completely Randomized Design (CRD) with three replications. T₁ (Pestle), where dried Moringa leaves were ground manually using a pestle to obtain a coarse texture; T₂ (Blender), in which dried leaves were processed using a blender to produce a fine powder; and T₃ (Grinding Machine), where dried Moringa leaves were processed in a grinding machine to obtain a fine and uniform powder.

Yield of Moringa oleifera leaf powder

The yield of powdered Moringa leaf material was determined by weighing the dried leaves before and after processing. The dried leaves were ground using respective methods (manual pestle, blender, or grinding machine), and the resulting powder was collected and weighed. Yield percentage was calculated using the following formula:

$$\text{Yield (\%)} = \frac{\text{Weight of powdered sample}}{\text{Initial weight of dried leaves}} \times 100$$

Physico-chemical properties of moringa leaves

Physico-chemical properties such as ash content (%), moisture content (%), pH value, weight before drying (g), weight after drying (g), protein content (%), total carbohydrate content (%), particle size, water absorption capacity (%), and oil holding capacity (%) were determined according to the analyses were conducted according to AOAC (2016) procedures.

Moisture content was analyzed using the oven-drying method at 65 °C until a constant weight was obtained, while ash content was determined by incinerating 2–3 g of sample in a muffle furnace at 550 °C until a white or grey residue appeared. Protein content was estimated using the Kjeldahl method, with nitrogen values multiplied by the conversion factor 6.25, whereas carbohydrate content was calculated by difference from other proximate components. The pH of the powders was measured using a calibrated digital pH meter by mixing 1 g of sample with 10 mL of distilled water, stirring for 15 minutes, and recording the filtrate's pH. Weight loss was determined by comparing the initial weight of 100 g of fresh leaves to the final dried weight after oven treatment.

Particle size distribution was evaluated using sieve analysis. For each treatment, 100 g (gram) of powder was placed on a sieve stack ranging from 20 µm (micrometer) to 120 µm and shaken mechanically for 2 to 3 minutes. The retained material on each sieve was weighed and expressed as a percentage of the total sample. Functional properties were assessed through water absorption capacity (WAC) and oil holding capacity (OHC). WAC was measured by mixing 1 g of powder with 10 mL of distilled water, allowing it to stand for 30 minutes, decanting the excess water, and weighing

the residue. OHC was determined by mixing 1 g of powder with 10 mL of refined vegetable oil, letting it stand for 30 minutes, centrifuging at 3000 rpm (revolutions per minute) for 20 minutes, and temperature at centrifuge was maintained 4°C, discarding the supernatant, and weighing the sediment. WAC and OHC were calculated as the percentage of water or oil retained relative to the sample weight; however, for each treatment, three replications were used.

Sensory analysis

The sensory characteristics of *Moringa oleifera* leaf powder samples were evaluated following the procedure described by [Kannangara et al. \(2018\)](#) with slight modifications. A semi-trained sensory panel was recruited from the Institute of Food Sciences and Technology, Sindh Agriculture University, 70060, Tandojam, Sindh, Pakistan. Panelists were selected based on their willingness to participate, good general health, absence of known food allergies related to the test samples, and familiarity with sensory evaluation procedures.

Sensory evaluation was conducted in a clean, well-ventilated laboratory under uniform lighting and controlled ambient temperature (approximately 22–25°C) to minimize environmental influences on perception. Samples were coded with random three-digit numbers and presented in a randomized order to eliminate presentation bias. Drinking water was provided to panelists for palate cleansing between sample evaluations.

The samples were evaluated for color, aroma, texture, mouthfeel, taste, and overall acceptability using a nine-point

hedonic scale, where 1 = dislike extremely and 9 = like extremely. Color was assessed based on visual appearance and uniformity, aroma on the intensity and pleasantness of odor, texture on powder consistency and mouthfeel, taste on overall flavor perception, and overall acceptability on the panelists' overall preference for each sample. Individual scores were recorded independently, and the mean values were used for statistical analysis. Sensory evaluation of the moringa leaf powder was conducted by a panel of five judges from the Food Sciences department. A 9-point hedonic scale was used to evaluate the texture, aroma, color, and overall acceptability of the different powder formulations. This method is consistent with the approach described by [Lawless & Heymann \(2019\)](#).

Statistical analysis

The recorded data were subjected to statistical analysis using Statistics 8.1 software ([Statistix, 2006](#)). One-way Analysis of Variance (ANOVA) was applied to compare the treatment results for significant differences ($P < 0.05$).

Results

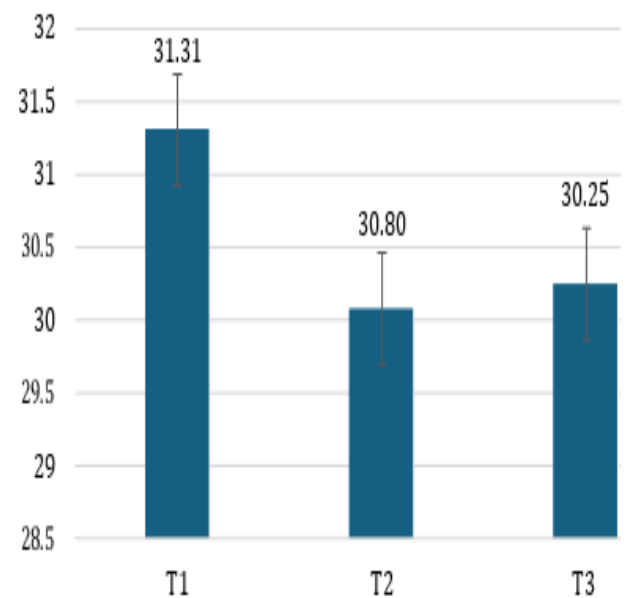
The yield percentage of *Moringa oleifera* leaf powder differed significantly among the various grinding treatments (Fig. 1). Among the processed samples, the highest yield was observed in T₁ (pestle) at 31.31%, followed by T₂ (blender) at 30.80%, while the lowest yield was recorded in T₃ (grinding machine) at 30.25%. The decrease in yield in the processed treatments is likely due to physical loss during grinding and particle size reduction. Statistical analysis indicated a highly significant difference ($P < 0.05$) among treatments, confirming the impact of grinding methods on the

final yield.

Annexure (A)

The physicochemical and functional properties of *Moringa oleifera* leaf powder were significantly influenced by different grinding treatments. Statistical analysis confirmed that all evaluated parameters exhibited highly significant differences ($P < 0.01$), with grinding intensity being a decisive factor in modifying nutritional and functional attributes.

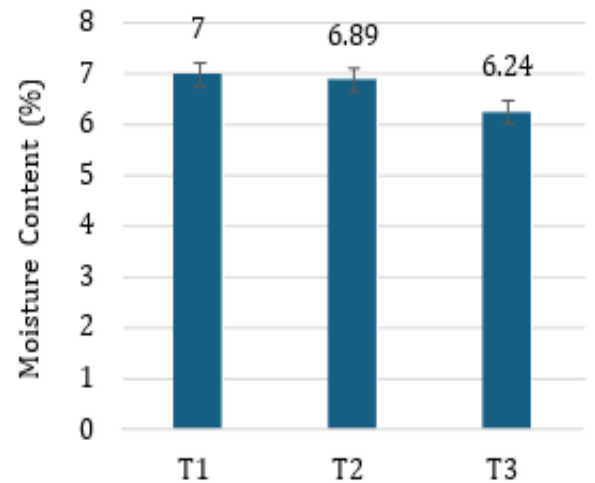
Moisture content varied significantly among treatments. The highest value was seen in T₁ (7.00%), followed by T₂ (6.89%), while T₃ recorded the lowest (6.24%), indicating that finer grinding enhances moisture loss and improves storage stability of moringa leaf powder (Fig. 2a). Ash content showed non-significant variation ($P > 0.05$) among treatments, where the highest value was recorded in T₃ (9.02%), followed by T₂ (8.89%), while T₁ exhibited the lowest value (8.80%), suggesting that finer grinding slightly increase mineral concentration.



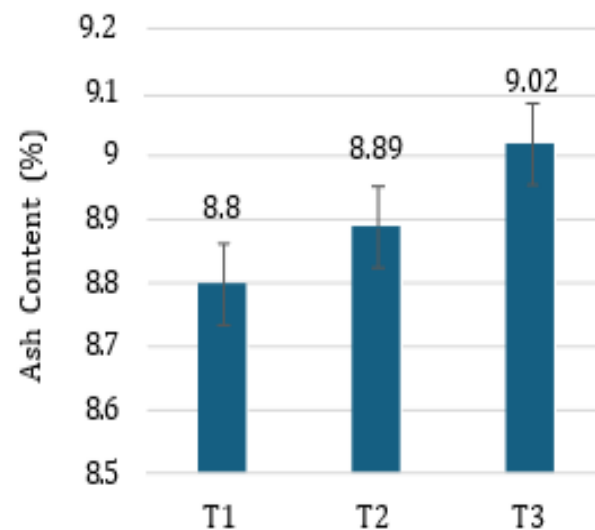
(Fig. 2b). Protein content differed significantly among treatments, with the highest value seen in T₃ (21.19%), followed

by T₁ (20.71%) and T₂ (20.65%), indicating that mechanical grinding may improve protein availability through better particle size reduction (Fig. 2). Carbohydrate content also varied significantly among treatments, where the highest value was recorded in T₃ (35.71%), followed by T₁ (34.76%), while T₂ exhibited the lowest value (34.04%), suggesting that grinding intensity influences carbohydrate estimation in moringa leaf powder (Fig. 2d). Similarly, pH value differed significantly among treatments, with the highest value observed in T₁ (6.34), followed by T₂ (6.27), whereas T₃ recorded the lowest value (6.15), indicating that finer grinding slightly reduces pH and may influence the chemical stability of the powder (Fig. 2e). Weight loss after drying also varied among treatments, where the highest dried weight was recorded in T₁ (22.52 g), followed by T₂ (21.36 g), while T₃ exhibited the lowest value (20.61 g), indicating that finer grinding enhances moisture removal during drying and reduces the final weight of moringa leaf powder (Fig. 2f). Water absorption capacity (WAC) varied significantly among treatments. The highest value was seen in T₃ (4.6 g/g), followed by T₂ (4.2 g/g), while T₁ recorded the lowest (3.9 g/g), indicating that finer grinding enhances the water absorption ability and functional properties of moringa leaf powder (Fig. 2g). Similarly, oil holding capacity (OHC) differed significantly among treatments. The highest value was recognized in T₃ (3.1 g/g), followed by T₁ (2.5 g/g), while T₂ recorded the lowest (2.4 g/g), suggesting that mechanical grinding improves the oil-binding capacity of moringa leaf powder due to increased surface area and finer particle size (Fig. 2).

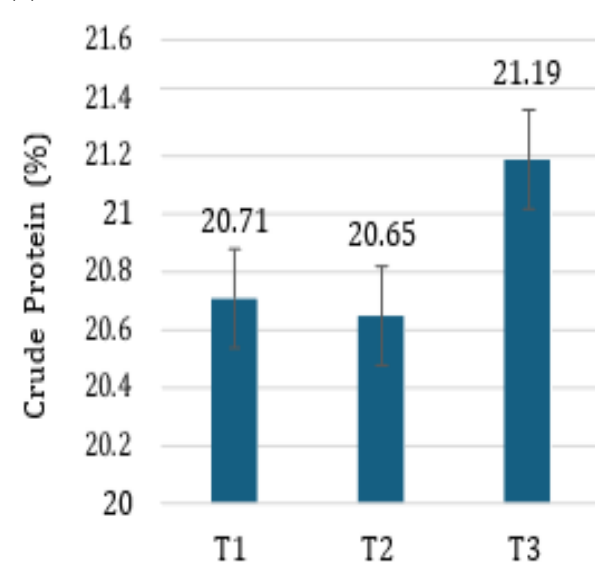
(a)



(b)



(c)



(d)

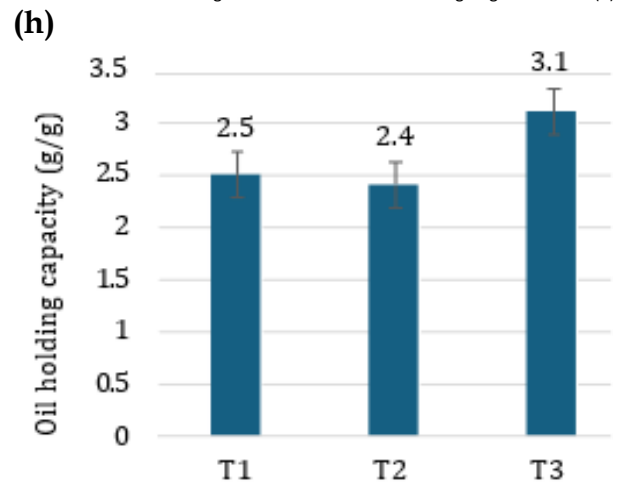
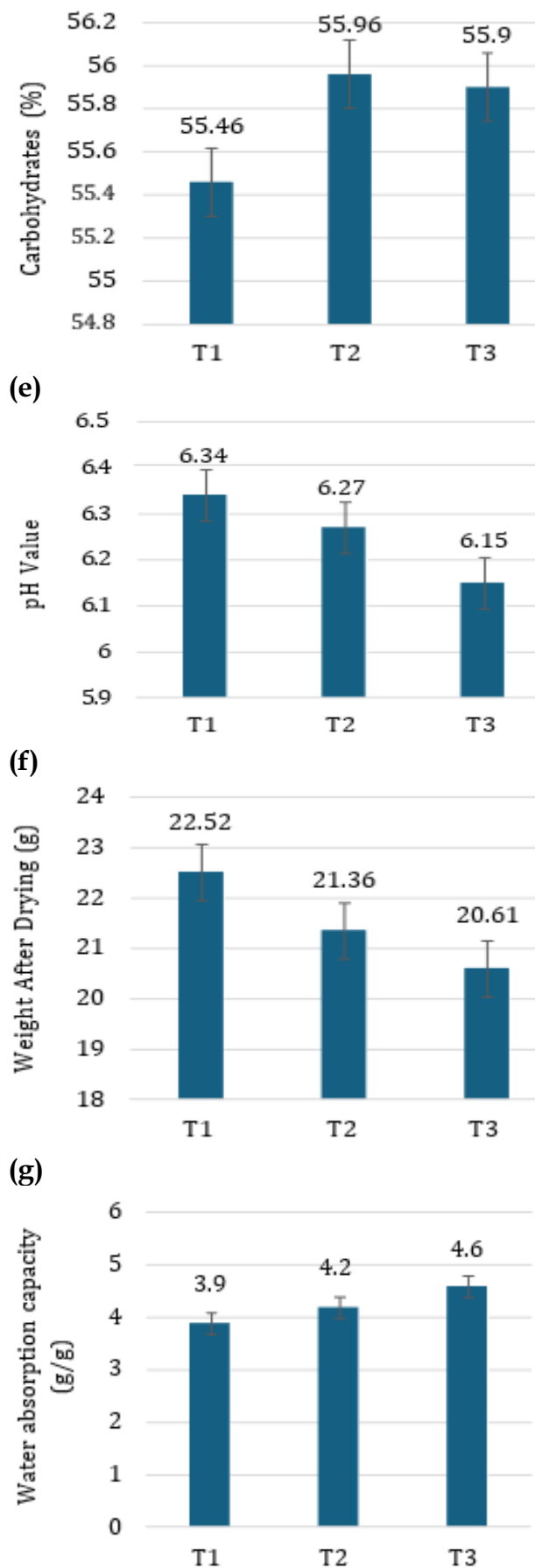


Fig. 2 (a-h). Moisture content (%), ash content (%), protein content (%), carbohydrate content (%), pH value, weight loss after drying (g), water absorption capacity (g/g), and oil holding capacity (g/g) of *Moringa oleifera* leaf powder as affected by different grinding treatments.

The particle size distribution of *Moringa oleifera* leaf powder was significantly influenced by the different grinding treatments. Statistical analysis indicated significant differences ($P < 0.05$) among treatments. Particle size distribution at $20\ \mu\text{m}$ varied significantly ($P < 0.05$) among treatments. The highest value was recognized in T_3 (7.65%), followed by T_1 (4.46%), while T_2 recorded the lowest (1.95%), indicating that mechanical grinding produced a higher proportion of fine particles compared with manual processing (Fig. 3a). Similarly, particle size distribution at $40\ \mu\text{m}$ differed significantly among treatments. The highest value was recorded in T_1 (41.30%), followed by T_2 (18.66%), while T_3 showed the lowest value (16.35%), suggesting that pestle grinding resulted in a greater accumulation of medium-sized particles (Fig. 3b). Particle size distribution at $60\ \mu\text{m}$ also varied significantly among treatments, where the highest value was distinguished in T_2

(36.79%), followed by T₃ (34.50%), while T₁ recorded the lowest (30.75%), indicating that mechanical grinding improved the production of finer particles (Fig. 3c). Likewise, particle size distribution at 80 μm exhibited significant differences among treatments. The highest value was recorded in T₃ (19.32%), followed by T₂ (14.73%), while T₁ presented the lowest value (5.90%), indicating that increased grinding intensity produced a higher proportion of larger retained particles (Fig. 3d). Similarly, particle size distribution at 120 μm differed significantly among treatments. The highest value was distinguished in T₃ (22.18%), followed by T₂ (13.87%), while T₁ recorded the lowest (5.59%), suggesting that mechanical grinding generated a greater proportion of coarse particle fractions due to high-speed grinding action (Fig. 3e).

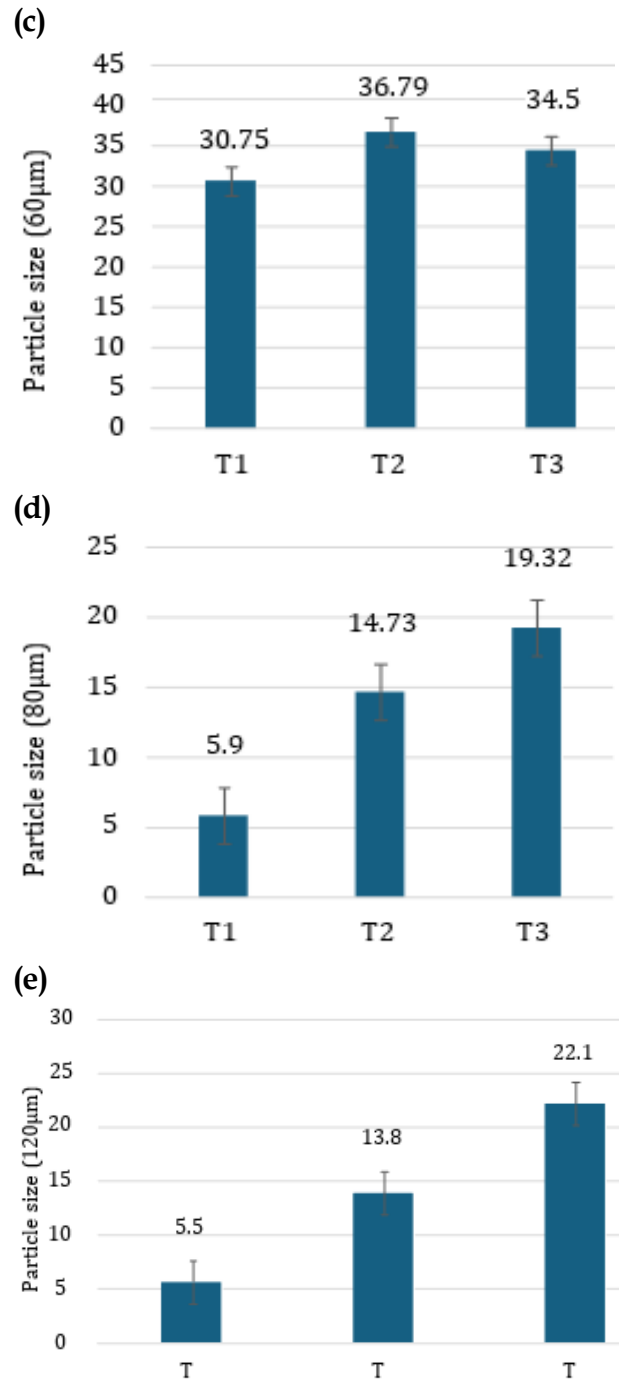
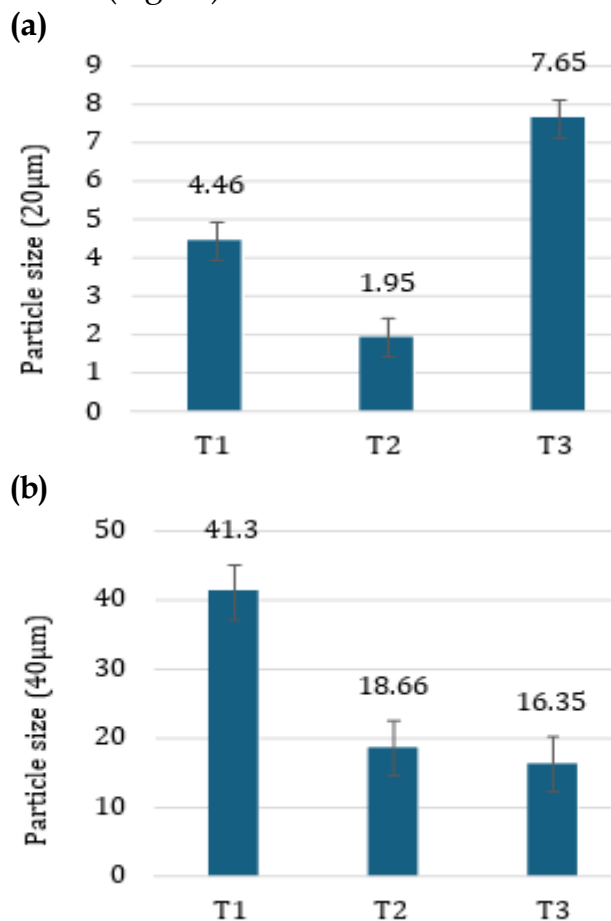


Fig. 3 (a-e). Particle size distribution (%) of *Moringa oleifera* leaf powder at 20 μm , 40 μm , 60 μm , 80 μm , and 120 μm as affected by different grinding treatments

Five trained panelists evaluated *Moringa* leaf powder processed under different particle size treatments for sensory attributes using a 9-point hedonic scale. The sensory evaluation of *Moringa oleifera* leaf powder presented clear

variation among the different grinding treatments. Color scores were highest in T₂ (7.60), followed by T₃ (7.33) and T₁ (7.20), indicating that improved grinding produced a more uniform and appealing green color (Fig. 4a). Aroma scores differed significantly, with T₃ (8.20) recording the highest value, followed by T₂ (7.00) and T₁ (7.00), suggesting that finer grinding enhanced aroma release (Fig. 4b). Taste scores were highest in T₃ (8.20), followed by T₂ (7.60) and T₁ (7.40), indicating improved flavor uniformity and palatability with mechanical grinding (Fig. 4c). Texture evaluation presented the highest score in T₃ (8.20), followed by T₂ (7.60) and T₁ (7.60), reflecting smoother and more uniform powder consistency with finer grinding (Fig. 4d). Overall acceptability was also

highest in T₃ (8.20), followed by T₂ (7.60) and T₁ (7.20), demonstrating that grinding intensity positively influenced the overall sensory quality and consumer preference of moringa leaf powder (Fig. 4e).

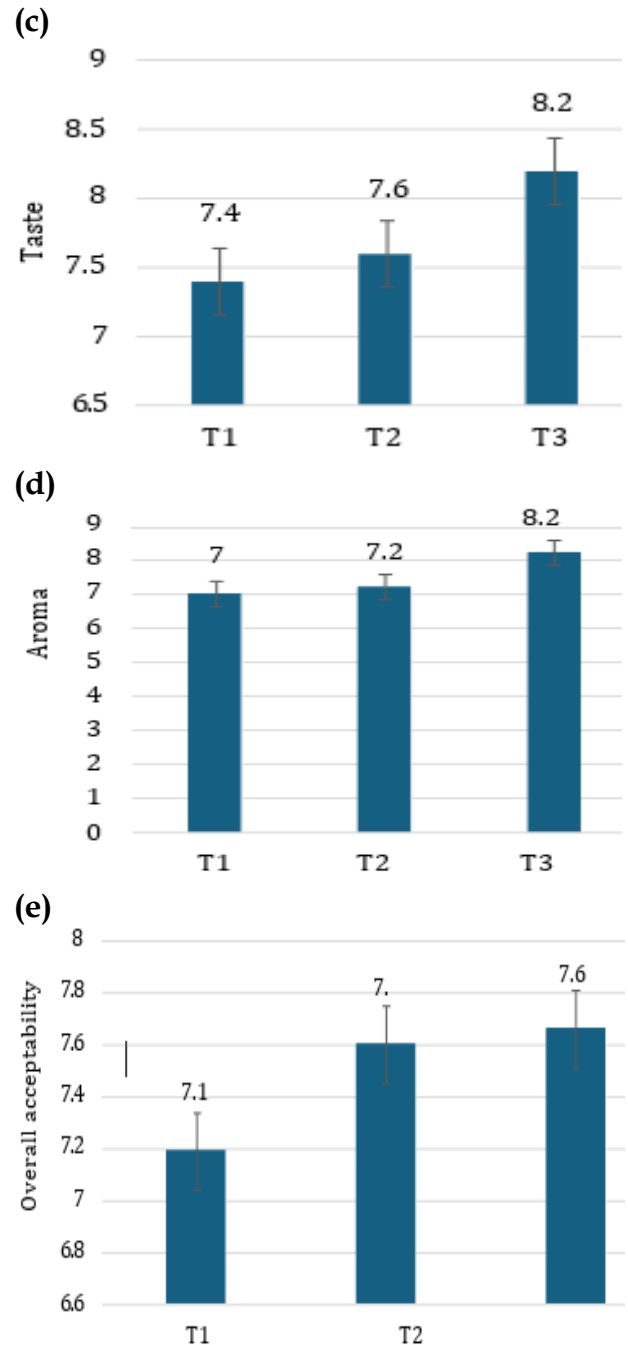
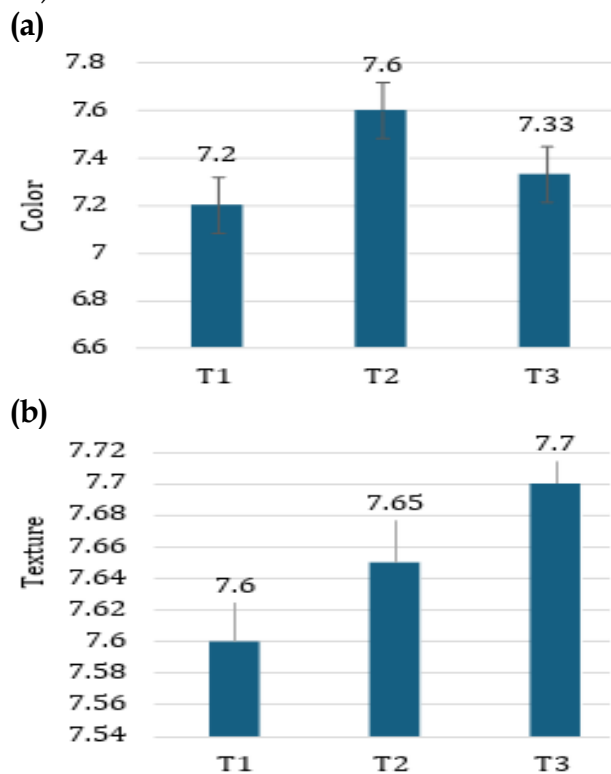


Fig. 4 (a-e). Sensory evaluation scores for color, aroma, taste, texture, and overall acceptability of *Moringa oleifera* leaf powder as affected by different grinding treatments.

Discussion

The significant differences observed across all measured parameters ($P < 0.05$) underscore the decisive influence of grinding intensity on the nutritional and technological quality of Moringa leaf

powder, with mechanical grinding consistently producing superior results.

Table1. Means (LSD values) of different variables along with standard errors.

Variables	Mean LSD (0.05)	S.E. (±SEM)
Yield (%)	0.5618	0.2436
Moisture (%)	0.2369	0.0968
Ash (%)	0.2066	0.0844
Protein (%)	0.1206	0.0493
Carbohydrates (%)	0.2717	0.111
pH	0.0762	0.0312
Weight loss after drying (g)	0.3631	0.1484
Water absorption capacity (g/g)	12.482	5.1009
Oil holding capacity (g/g)	11.795	4.8203
Particle size 20 µm (%)	0.1088	0.0472
Particle size 40 µm (%)	0.0968	0.2232
Particle size 60 µm (%)	0.1504	0.0652
Particle size 80 µm (%)	0.075	0.173
Particle size 120 µm (%)	0.0437	0.1008
Sensory Color	0.6666	0.2724
Sensory Aroma	0.0816	0.1883
Sensory Taste	0.0816	0.1883
Sensory Texture	0.6671	0.2726
Sensory Overall Acceptability	0.6663	0.2723

*SEM= standard error of the mean; Least Significant Difference (LSD) test was applied for the analysis of variance

The superior sensory scores for finely ground powder (T₃) across all attributes suggest that particle size reduction enhances not only physicochemical properties but also organoleptic acceptance, which is critical for commercial applications of Moringa leaf powder in functional foods. The reduced yield in T₂ and T₃ is attributed to physical losses during processing, including adhesion to equipment surfaces and particle loss due to finer grinding, which shows mechanisms and mitigation strategies. These observations are consistent with [Ali et al. \(2017\)](#) and [Zhang & Chen \(2021\)](#). They noted that high-speed mechanical

grinding reduces recovery due to mechanical inefficiencies, while post-harvest handling also influences overall yield ([Siddhuraju and Becker, 2003](#); [Xing et al., 2016](#)).

Moisture content declined with increasing grinding intensity, indicating that finer grinding accelerates moisture removal, improving storage stability. Ash content slightly increased with grinding, significant in T₁ and in T₃, suggesting enhanced mineral availability due to cell rupture, which aligns with [Nouman et al. \(2016\)](#), [Gopalakrishnan et al. \(2016\)](#), and [Al-Mamun & Hossain 2022](#). Protein content improved from lower in T₁ to higher in T₃, likely due to enhanced exposure of nitrogenous compounds. Similarly, carbohydrate content increased in T₁ and in T₃, which may be attributed to moisture loss and improved extractability of soluble carbohydrates. Minor reductions in pH were seen, significant in T₁ and in T₃, possibly reflecting the release of acidic phytochemicals during cell disruption. Weight loss after drying was higher in finely ground powders, with T₁ recording significantly higher than other treatments, indicating that finer grinding promotes moisture removal and affects final dry weight. Functional properties, including water absorption capacity (WAC) and oil holding capacity (OHC), improved with grinding intensity. WAC increased in T₁ and significantly decreased in T₃, while OHC was lower but significant. These improvements are attributed to increased exposure of hydrophilic and lipophilic binding sites due to particle size reduction, consistent with [Sultana \(2020\)](#) and [Armel et al. \(2021\)](#), highlighting the importance of fiber structure in hydration behavior.

Particle size distribution showed that

finer grinding (T_3) produced a higher proportion of very fine particles at smaller size was significant ($P < 0.05$), while coarser fractions at greater sizes were also more prevalent in T_3 due to significant high-speed grinding dynamics. Pestle grinding (T_1) significantly favored medium-sized particles, and blender treatment (T_2) produced a mixture with a significantly higher proportion at 60 μm . These trends align with previous findings by [Sakr et al. \(2024\)](#), [Zhang et al. \(2022\)](#), and [Huang et al. \(2020\)](#), demonstrating that particle size reduction enhances surface area, solubility, and flowability. Moreover, findings showed that the consistent improvement in functional properties with decreasing particle size can be attributed to the increased surface area-to-volume ratio, which facilitates greater interaction between powder particles and water or oil molecules during hydration and lipid-binding assays.

The superior sensory scores for finely ground powder (T_3) across all attributes suggest that particle size reduction enhances not only physicochemical properties but also organoleptic acceptance, which is critical for commercial applications of Moringa leaf powder in functional foods, indicating that finer, uniform powders improve flavor release, mouthfeel, and visual appeal. Blender-ground powder (T_2) presented significant sensory improvements, while manual grinding (T_1) scored slightly lower, reflecting the uneven particle size and lower uniformity. These results corroborate findings by [Handayani et al. \(2022\)](#), [Kannangara et al. \(2018\)](#), and [Sharma et al. \(2012\)](#), confirming that fine grinding enhances dispersibility, texture, and consumer preference.

Moreover, another study is aligned with the findings of our study, in which the

Effects of superfine grinding on physicochemical, thermal, and structural properties of Moringa Oleifera leaf (MOL) powders were examined, where five samples with diverse particle sizes were obtained by superfine grinding and shear maceration methods. Superfine grinding could produce smaller MOL particles with broader particle size distribution and superior surface area. Insoluble dietary fiber and protein contents were reduced just after the superfine grinding process. As the particle size reduced, bulk density, tap density, water and oil holding capacities were also reduced, but angles of repose and slide exhibited the opposite tendency. Differential scanning calorimetry curves showed that peak temperature and enthalpy change decreased with decreasing particle size. No new chemical functional groups were observed in Fourier transform infrared spectroscopy in all samples, and the microscopic images revealed that superfine grinding changed the particle shape, and the surface roughness decreased with the lessening particle size of *M. oleifera* leaf powders ([Huang et al., 2020](#)). The enhanced WAC and OHC observed in finely ground powders may be attributed to increased exposure of hydrophilic polysaccharides and lipid-binding sites following structural disruption of plant tissues during intensive grinding.

Conclusions

It is concluded from the study that the particle size distribution of Moringa oleifera leaf powder was significantly influenced by grinding methods. The particle size of moringa leaf powder resulted in significant differences in physicochemical and functional properties. The particle sizes of moringa leaf powder obtained were 20 μm , 40 μm , 60 μm , 80 μm , and 120 μm . exhibited

moisture, protein, ash, carbohydrates, pH, WAC, OHC, and sensory attributes. The results suggest that moringa leaf powder with a particle size around 60 μm exhibited superior overall quality characteristics. It is also concluded that the functional properties of moringa leaf powder obtained with the particle size at 60 μm treatment T₃ showed good sensory properties of treatment. Grinding-machine treatment significantly improved the physicochemical, functional, and sensory characteristics of moringa leaf powder, suggesting that fine particle-size reduction may enhance its suitability for functional food and nutraceutical applications.

Conflict of interest

The authors declare that they have no competing interests.

Data Availability Statement

The data used to support the findings of this study are available from the corresponding author upon request.

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Authors Contributions

All the authors equally contributed to the manuscript

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Annexure (A)

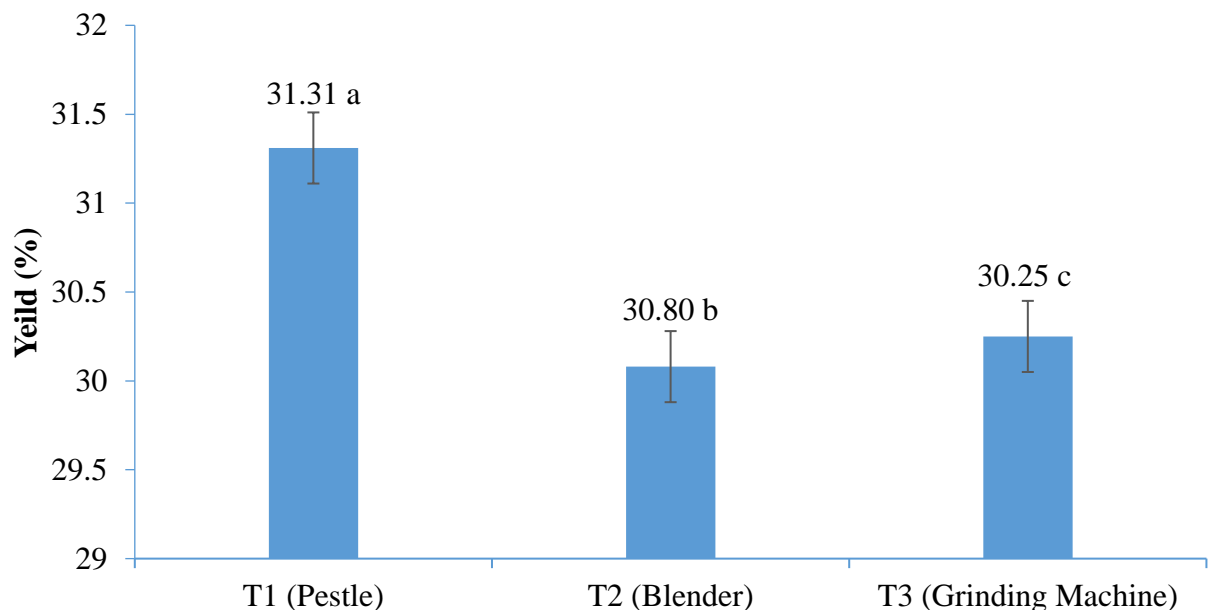


Fig. 1 Effect of different grinding treatments on yield of moringa leaf powder.