International Journal of Food Science and Nutrition
www.foodsciencejournal.com
ISSN: 2455-4898
Received: 02-03-2025, Accepted: 28-03-2025, Published: 12-04-2025
Volume 10, Issue 2, 2025, Page No. 60-63

Comparative analysis of blanching on the biochemical attributes of *Moringa oleifera* Lam. leaves

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Abstract

The study investigated the effects of hot water, steam, and microwave blanching on the biochemical parameters of *Moringa oleifera* leaves to identify the optimal method for preserving nutritional quality and extending shelf life. Fresh leaves were subjected to blanching treatments, including control, hot water blanching (80°C for 1 min), steam blanching (1 min), and microwave blanching (800 W for 30 s), followed by shade drying and biochemical analysis. Results revealed that blanching significantly reduced moisture content, with microwave blanching showing the lowest (8.48%), while control leaves retained the highest (11.64%). Microwave blanching also yielded the highest crude fibre (13.50%) and carbohydrate content (42.0%), attributed to temperature-induced hydrolysis of polysaccharides, However, protein content declined after blanching, with hot water blanching recording the lowest (20.60%). Steam blanching retained higher ash (12.98%) and phenolic content (158.66 mg GAE/100 g), while microwave blanching preserved the most ascorbic acid (115.61 mg/100 g) and carotenoids (11.44 mg/100 g). Hot water blanching resulted in the greatest nutrient losses, particularly for ascorbic acid and phenols. Overall, microwave blanching emerged as the most effective method for retaining heat-sensitive nutrients and enhancing shelf stability, while steam blanching balanced nutrient retention and enzyme inactivation. These findings provide critical insights for optimizing blanching techniques to maximize the nutritional quality and shelf life of *Moringa oleifera* leaves, making them suitable for functional food applications and long-term storage.

Keywords: Biochemical parameters, blanching, drumstick, leaf powder, leafy vegetables, *Moringa oleifera* Lam., nutritional quality

Introduction

The growing global focus on achieving optimal health has highlighted the importance of a well-balanced lifestyle, with diet playing a fundamental role in disease prevention and overall well-being. Scientific research consistently highlights the pivotal role of nutrition in reducing the risk of chronic diseases, including diabetes, cancer, cardiovascular disorders, and malnutrition. Leafy vegetables, known for their affordability and sustainability, are a vital component of a healthy diet. They are abundant in essential vitamins, including ascorbic acid, β-carotene, riboflavin, and folic acid, as well as minerals like calcium, iron, potassium, and magnesium. Their high antioxidant activity and polyphenol content further enhance their nutritional profile, making them increasingly popular across diverse populations.

Drumstick (*Moringa oleifera* Lam.), a member of the *Moringa*ceae family, is a nutrient-rich perennial vegetable often referred to as the "miracle tree" or "tree of life." Indigenous to the sub-Himalayan regions of India, Pakistan, Bangladesh, and Afghanistan, it is extensively cultivated in southern India (Paliwal *et al.*, 2011) [17]. Every part of the *Moringa* tree *viz,* leaves, fruits, flowers, seeds, and bark serves as a valuable source of proteins, vitamins, and minerals, including potassium, calcium, phosphorus, iron, and β-carotene. The leaves, in particular, are exceptionally nutrient-dense, offering substantially higher levels of vitamin C, vitamin A, calcium, protein, potassium, and iron compared to common foods such as oranges, carrots, milk, and spinach. Additionally, *Moringa* leaves are renowned for their antioxidant, anti-inflammatory, anti-diabetic, and antimicrobial properties, positioning them as a potent functional food. (Gopalakrishnan *et al.*, 2016) [10].

Despite their nutritional benefits, fresh *Moringa* leaves have a high moisture content (approximately 73%), making them highly perishable and limiting their shelf life. This poses a challenge for their widespread use and availability. Effective post-harvest handling is crucial to preserving their nutritional quality and extending shelf life. To optimize the nutritional quality and shelf life of *Moringa oleifera* leaves, post-harvest processing techniques such as blanching are essential. Blanching, a thermal pretreatment, is widely used to inactivate enzymes, reduce microbial load, and preserve the nutritional and sensory qualities of leafy vegetables. However, the method of blanching significantly influences the retention of bioactive compounds and biochemical parameters such as moisture content, crude fibre, protein, vitamins, and antioxidants. Studies have shown that different blanching methods affect these parameters differently due to variations in heat transfer mechanisms, exposure time, and water contact. Hot water blanching has been shown to effectively inactivate enzymes like peroxidase but often results in significant losses of heat-sensitive nutrients such as ascorbic acid and chlorophyll (Ampofo-Asiama *et al*., 2021) [4]. Steam blanching; on the other hand, has demonstrated a protective effect on vitamin C retention, with blanched samples retaining higher levels of residual vitamin C compared to control (Nobosse *et al*., 2017) [16]. Microwave blanching has been reported to reduce antinutrients like tannic acid and phytic acid significantly, while oxalic acid levels remain largely unaffected (Mosha *et al*., 1995) [15]. These findings highlight the importance of selecting an appropriate blanching method to balance enzyme inactivation with nutrient retention. This study aims to evaluate the effects of different blanching methods—control, hot water blanching, steam blanching, and microwave blanching—on the biochemical parameters of *Moringa oleifera* leaves, with the goal of identifying the most effective method for preserving their nutritional quality and extending shelf life.

Materials and methods

The common fruiting type of *Moringa* was selected for the experiments from farmers' field in Ollukkara, Thrissur district, Kerala. The experiment followed a completely randomized design with five replications. Fresh *Moringa oleifera* Lam. leaves were collected, destalked, and washed before undergoing blanching treatments.

The different blanching treatments were

T_1: Control (without blanching)

T_2: Hot water blanching (80°C for 1 min)

T_3: Steam blanching (1 min)

T_4: Microwave blanching (800 W for 30 s)

For hot water blanching, samples were wrapped in muslin cloth and immersed in water maintained at 80°C for one minute. Steam blanching was conducted using a steam cooker for 1 min, while microwave blanching was performed in a microwave-safe container with minimal water to prevent excessive moisture loss. The samples were blanched at 800 watts for 30 seconds. After blanching, the samples were immediately cooled to halt the process. Following pre-treatment, the leaves were shade-dried, powdered, and subjected to biochemical analysis. Flow chart of whole process of blanching is depicted in *Figure 1*

Moisture Content: Moisture content was determined using the A.O.A.C. (1980) method. Five grams of the sample were dried in a hot air oven at 60–70°C until a constant weight was achieved. The moisture content was calculated as:

$$\text{Moisture content} = \frac{W_2 - W_1}{\text{Initial weight}} \times 100$$

Crude Fibre: Crude fibre was analysed following Sadasivam and Manickam (1996) [22]. The sample was boiled with sulphuric acid and sodium hydroxide, filtered, and ignited. The crude fibre content was calculated as:

$$\text{Crude fibre (\%)} = \frac{\text{Loss in weight on ignition } (W_2\text{-}W_1) - (W_3\text{-}W_1)}{\text{Weight of the sample}} \times 100$$

Crude Fat: Fat content was estimated using the Soxhlet apparatus with petroleum ether as the solvent (A.O.A.C., 2012). The fat content was calculated as:

$$\text{Fat (\%)} = \frac{\text{Final weight of the beaker} - \text{initial weight of the beaker}}{\text{Weight of the sample taken}} \times 100$$

Total Protein: Protein content was determined using the Lowry *et al*. (1951) [14] method. Absorbance was measured at 660 nm using a spectrophotometer, and protein content was calculated from a standard curve.

Total Ash: Ash content was determined by igniting the sample in a muffle furnace at 650°C. The ash content was calculated as:

$$\text{Ash content (\%)} = \frac{\text{Weight of crucible after ashing - weight of empty crucible}}{\text{Weight of the sample taken}} \times 100$$

Total Carbohydrates: Total carbohydrates were estimated using the anthrone reagent method (Sadasivam and Manickam, 1996) [22]. Absorbance was measured at 630 nm, and carbohydrate content was calculated from a standard curve.

Ascorbic Acid: Ascorbic acid content was determined by titrating the sample extract against 2,6-dichlorophenol indophenol dye (A.O.A.C., 1955).

Total Chlorophyll: Chlorophyll content was estimated using 80% acetone, and absorbance was measured at 645 nm and 663 nm (Ranganna, 1977) [20].

Total Carotenoids: Carotenoid content was determined by measuring the absorbance of the petroleum ether extract at 450 nm (Ranganna, 1986) [21].

Total Phenols: Phenol content was estimated using the Folin-Ciocalteau reagent, and absorbance was measured at 650 nm (Sadasivam and Manickam, 1992).

Statistical Analysis: The experiment was conducted using a completely randomized design with four treatments and five replications. The data obtained were statistically analysed using one-way ANOVA in WASP-Web Agri Stat Package 2.0 (Jangam and Thali, 2004) [11] developed by ICAR Research Complex for Goa, India. The significance of differences among treatments was assessed at a 5% significance level."

Results and discussion

The biochemical parameters of *Moringa oleifera* leaves were significantly influenced by blanching treatments and the results are presented in *Table 1*. A visual comparison of *Moringa oleifera* leaf powders subjected to different blanching methods is presented in *Figure 2*. Unblanched leaves exhibited the highest moisture content (11.64%). Blanching reduced moisture levels, with microwave blanching showing the lowest (8.48%). This reduction is attributed to tissue softening during blanching, enhancing moisture removal, as supported by Raja *et al*. (2019) [19]. Microwave blanching, in particular, produced more porous structures, facilitating faster drying (Abano *et al*., 2020) [1]. %). The moisture content of leaves, subjected to hot water blanching (9.46%) was on par with steam blanched samples (9.12%).

Blanching increased crude fibre content, with microwave blanching yielding significantly highest content (13.50%) compared to the control (6.92%). This rise may result from temperature-induced hydrolysis of polysaccharides, enhancing fibre solubility (Acho *et al*., 2015) [2]. Crude fat content slightly increased after blanching, with steam blanching recording the highest (7.80%), though differences among treatments were statistically on par. Total ash content decreased by 5-14% following blanching, with hot water blanching exhibiting the lowest ash content (11.66%). This reduction is primarily due to the leaching of minerals into the blanching water, as reported by Pavani and Aduri (2018) [18]. Steam and microwave blanching retained higher ash content, likely due to limited water exposure (Champaneri *et al*., 2020) [8].

Protein content of the leaves declined after blanching, with the unblanched leaves having the highest protein content (28.16%) and hot water blanching recording the lowest (20.60%). This reduction in protein content is linked to the loss of water-soluble nitrogenous compounds (Kshirsagar *et al*., 2017) [12]. Conversely, blanching increased total carbohydrate content by 12-35%, with microwave blanching yielding the highest (42.0%) carbohydrate content. This rise may result from the breakdown of ketogenic amino acids into glucose (Fadupin *et al*., 2015) [9].

Blanching significantly reduced ascorbic acid levels, with the leaves without blanching showed the highest (125.61 mg100g^{-1}) and leaves subjected to hot water blanching showed the lowest (89.50 mg100g^{-1}) ascorbic acid. Microwave blanching retained the most ascorbic acid (115.61 mg100g^{-1}), likely due to shorter processing times (Gupta *et al*., 2008). Total chlorophyll content was recorded highest in the control (433.0 mg100g^{-1}), with microwave blanching retaining the most among treated samples (299.8 mg100g^{-1}). Blanching deactivates chlorophyllase but disrupts chloroplasts, leading to chlorophyll degradation (Le *et al*., 2021).

Carotenoid content increased after blanching, with microwave blanching showing the highest (11.44 mg100g^{-1}). This rise is attributed to reduced moisture content and the breakdown of protein-carotenoid complexes during heating (Ahmed & Langthasa, 2022) [3]. Total phenolic content was highest in the control (210.00 mg GAE/100 g), with steam and microwave blanching retaining relatively higher levels (158.66 and 152.66 mg GAE/100 g, respectively). Hot water blanching resulted in the lowest phenol (139.00 mg GAE/100 g), likely due to leaching of phenolic compounds into the blanching medium (Wickramasinghe *et al*., 2020) [23].

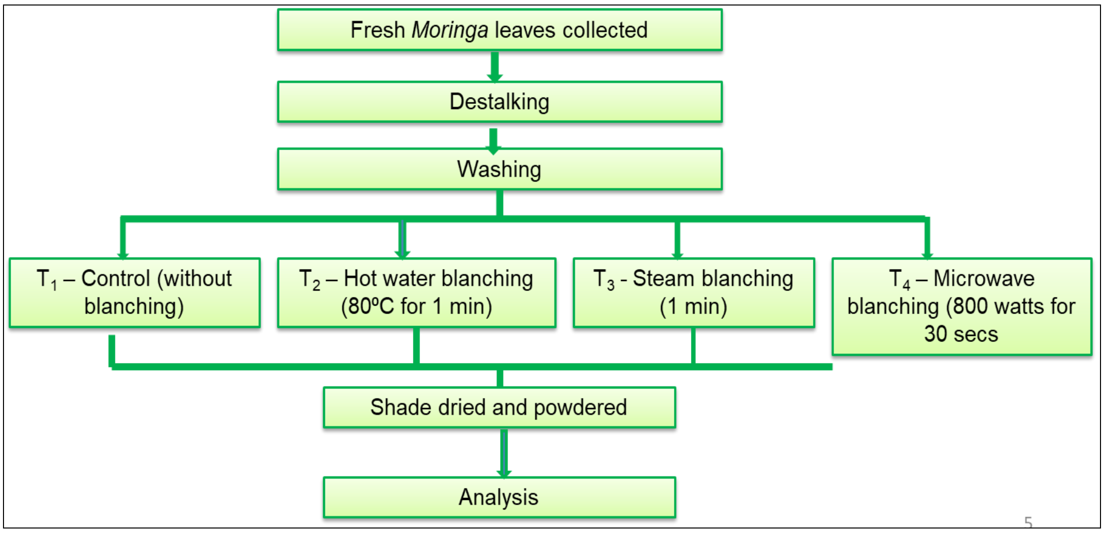
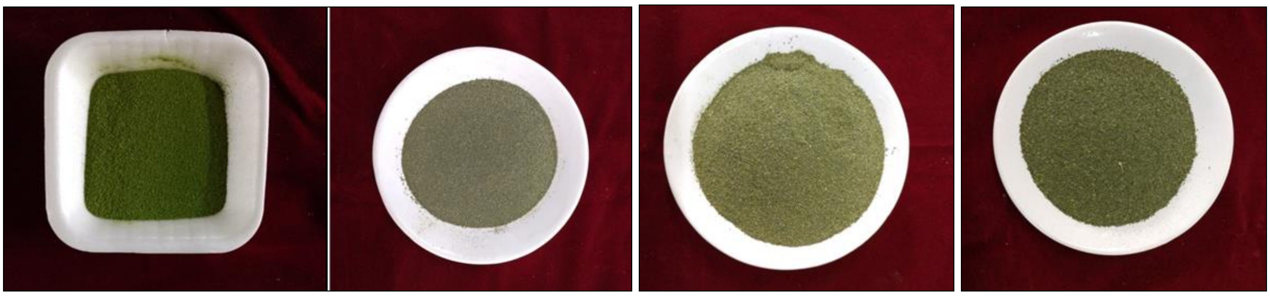


Fig 1: Process flow chart of blanching treatments in Moringa oleifera leaves



(a) **(b)** **(c)** **(d)**

Fig 2: Visual comparison of *Moringa* leaf powder blanched using different blanching methods. *a)* T_1 (Control) *b)* T_2 (Hot water blanching) *c)* T_3 (Steam blanching) *d)* T_4 (Microwave blanching)

Table 1: Effect of blanching treatments on physical and biochemical parameters of *Moringa* leaves (T_1 – Control (without blanching), T_2 – Hot water blanching, T_3 – Steam blanching, T_4- Microwave blanching, CD (5%)- Critical difference at 5%)

Treatments	Moisture content (%)	Crude fibre (%)	Crude fat (%)	Total ash (%)	Total protein (%)	Total carbohydrate (%)	Ascorbic acid (mg100g^{-1})	Total chlorophyll (mg100g^{-1})	Total carotenoid (mg100g^{-1})	Total phenols (mg GAE100g^{-1})
T1	11.64^{c}	6.92^{d}	6.63^{b}	13.67^{a}	28.16^{a}	31.00^{d}	125.61^{a}	433.00^{a}	6.40^{d}	
T2	9.46^{b}	11.00^{b}	7.60^{a}	11.66^{c}	20.60^{d}	34.75^{c}	89.50^{c}	267.00^{b}	9.26^{b}	
T3	9.12^{b}	9.65^{c}	7.80^{a}	12.98^{b}	22.18^{c}	37.65^{b}	98.23^{c}	284.50^{b}	7.93^{c}	
T4	8.48^{a}	13.50^{a}	7.53^{a}	12.38^{b}	24.23^{b}	42.00^{a}	115.61^{b}	299.80^{b}	11.44^{a}	
CD (5%)	0.638	0.383	0.689	0.679	0.728	1.948	7.404	83.5	0.853	9.304

Conclusion

In conclusion, blanching treatments significantly altered the biochemical composition of *Moringa oleifera* leaves, reducing moisture content and enhancing crude fibre and carbohydrate levels, while decreasing protein, ascorbic acid, and phenolic content due to leaching and thermal degradation. Microwave blanching was most effective in retaining nutrients like ascorbic acid and carotenoids, whereas steam blanching preserved higher ash and phenolic content. Hot water blanching caused the greatest nutrient losses. Despite some nutrient reductions, blanching improved shelf stability and enhanced specific nutritional attributes, with microwave blanching emerging as a promising method for minimizing degradation. These findings provide valuable insights for optimizing blanching techniques to preserve the nutritional quality of *Moringa* leaves for functional food applications and long-term storage.

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