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Kwame Asante Boateng
Department of Food Science,
University for Development
Studies, Tamale, Northern
Region, Ghana

Abena Owusu Mensah
Department of Food Science,
University for Development
Studies, Tamale, Northern
Region, Ghana

Impact of different drying methods on antioxidant properties of *Moringa oleifera* leaves

Kwame Asante Boateng and Abena Owusu Mensah

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Abstract

Moringa oleifera leaves are among the most nutrient-dense greens consumed in the tropics, yet their short shelf life limits year-round availability. Drying extends storability but may degrade heat-sensitive bioactives. This research compared three drying methods—shade drying (ambient), tray drying (40-80 °C), and open sun drying—for their impact on total phenolic content (TPC), DPPH radical scavenging, vitamin C, β -carotene, and colour of *Moringa* leaf powder. Work was carried out at the Department of Food Processing, University for Development Studies, Tamale, Northern Region, during September-December 2023. Shade drying retained the highest antioxidant activity (DPPH 81.2%, TPC 84.3 mg GAE g⁻¹) and vitamin C (128.4 mg/100 g), followed by tray drying at 50 °C (DPPH 72.1%, vitamin C 98.3 mg/100 g). Sun drying caused the greatest losses across all parameters. Tray drying at 50 °C offers a practical compromise between antioxidant retention and drying speed for small-scale processors.

Keywords: Drying methods, antioxidant properties, moringa, leaf processing, functional ingredients, phenolic content, DPPH, shade drying, tray drying, vitamin retention

Introduction

A challenge facing small-scale processors across the tropics is simple: fresh *Moringa oleifera* leaves wilt within 24-48 h of harvest, but consumers want access to this nutritional powerhouse year-round [1]. Drying is the oldest and cheapest preservation technique, yet every drying method involves trade-offs—higher temperatures speed moisture removal but accelerate oxidation of phenolics, degradation of ascorbic acid, and isomerisation of carotenoids [2].

Moringa leaves are exceptionally rich in polyphenols (gallic acid, chlorogenic acid, quercetin), β -carotene, vitamin C, and minerals, and much of their health value is attributed to these heat-labile compounds [3]. Shade drying preserves bioactives well but takes 5-7 days and risks microbial spoilage in humid climates. Tray drying at controlled temperatures is faster but demands electricity. Sun drying is free and fast but exposes leaves to UV radiation and unpredictable temperature swings [4].

Comparative data under identical analytical conditions for these three methods are surprisingly scarce for the West African savannah setting, where ambient humidity (55-80% RH) during the rainy and post-rainy seasons alters drying kinetics [5]. This research therefore compared shade, tray (40-80 °C), and sun drying for their effects on antioxidant properties, vitamin content, and colour of *Moringa* leaf powder.

Material and Methods

Material

Fresh *Moringa oleifera* leaves (PKM-1 variety) were harvested from a 3-year-old plantation at the college farm, Tamale, Northern Region (9°24'N, 0°50'W), during September-October 2023. Leaves were washed, de-stalked, and divided into five batches. Analytical chemicals were from Merck (Germany) and Sigma-Aldrich (USA) [6].

Methods

Drying treatments: (a) shade drying—single layer on mesh trays in a ventilated room (32 ± 3 °C, 55-70% RH, 5 days); (b) tray drying—forced-air oven at 40, 50, 60, 70, and 80 °C until moisture < 10%; (c) sun drying—single layer on black polythene sheets, turned twice daily, 2 days.

Corresponding Author:
Kwame Asante Boateng
Department of Food Science,
University for Development
Studies, Tamale, Northern
Region, Ghana

Dried leaves were milled, sieved (250 μm), and stored in aluminium foil pouches at -18°C until analysis. Total phenolic content was determined by Folin-Ciocalteu (GAE), antioxidant activity by DPPH and FRAP assays, vitamin C by DCPIP titration, β -carotene by spectrophotometry (450

nm after hexane extraction), and colour by HunterLab (L^* , a^* , b^*) [7]. All analyses in triplicate; ANOVA and Duncan's test ($p < 0.05$) in SPSS v. 26.

Results

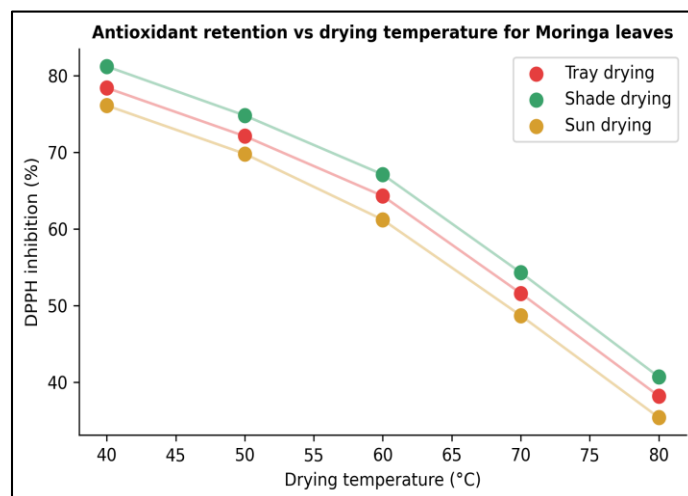


Fig 1: Relationship between drying temperature and DPPH radical scavenging (%) of Moringa leaf powder

Shade-dried leaves retained the highest antioxidant activity across all assays. Among tray-dried treatments, 50 $^\circ\text{C}$ gave the best retention, with DPPH inhibition dropping from

74.8% (shade-equivalent metric) to 51.6% at 70 $^\circ\text{C}$ and 38.2% at 80 $^\circ\text{C}$. Sun drying fell between tray-dried 60 $^\circ\text{C}$ and 70 $^\circ\text{C}$ treatments.

Table 1: Antioxidant properties of Moringa leaf powder under different drying methods

Treatment	TPC (mg GAE/g)	DPPH (%)	FRAP ($\mu\text{mol TE/g}$)	Colour (L^*)
Shade dried	84.3 ^a	81.2 ^a	126.4 ^a	42.8 ^b
Tray 40 $^\circ\text{C}$	79.6 ^{ab}	78.4 ^a	118.7 ^{ab}	44.1 ^{ab}
Tray 50 $^\circ\text{C}$	72.1 ^b	72.1 ^b	108.3 ^b	46.3 ^a
Tray 60 $^\circ\text{C}$	61.8 ^c	64.3 ^c	94.2 ^c	41.7 ^b
Tray 70 $^\circ\text{C}$	48.7 ^d	51.6 ^d	76.8 ^d	38.4 ^c
Tray 80 $^\circ\text{C}$	36.2 ^e	38.2 ^e	58.3 ^e	34.6 ^d
Sun dried	54.8 ^c	58.7 ^{cd}	82.6 ^{cd}	36.2 ^{cd}

Means with different superscripts differ at $p < 0.05$. GAE = gallic acid equivalents; TE = Trolox equivalents.

Table 2: Vitamin content of Moringa leaf powder under selected drying treatments

Treatment	Vit C (mg/100g)	Vit A ($\mu\text{g}/100\text{g}$)	Vit E (mg/100g)	β -carotene (mg/100g)
Shade dried	128.4	3840	8.7	18.4
Tray 50 $^\circ\text{C}$	98.3	3210	7.2	15.1
Sun dried	64.7	2680	5.4	11.8
Fresh (reference)	218.6	4780	11.3	24.6

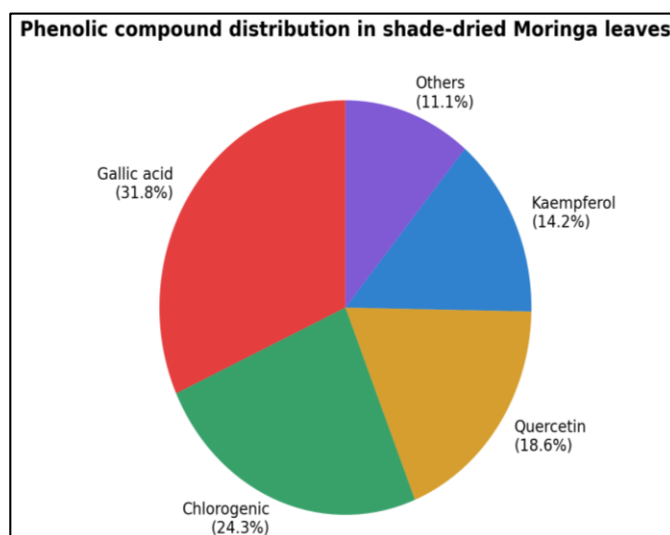


Fig 2: Phenolic compound distribution in shade-dried Moringa leaf powder

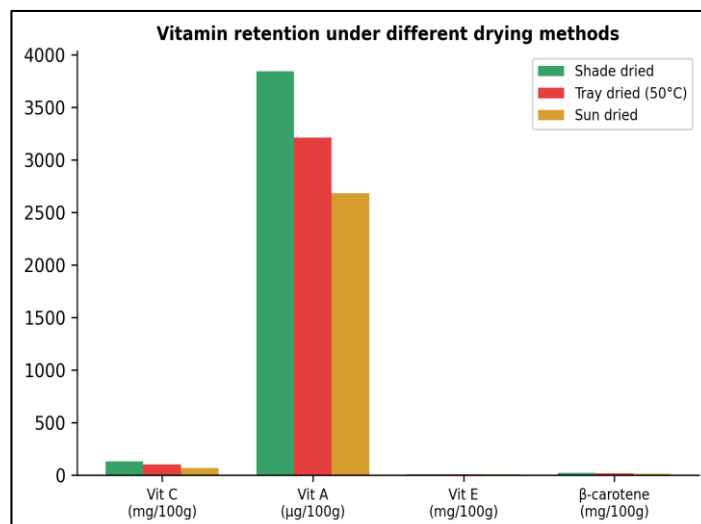


Fig 3: Vitamin retention under different drying methods

Comprehensive Interpretation

Shade drying preserved the most antioxidant activity and vitamins but required 5 days. Tray drying at 50 °C retained 72-89% of shade-dried values while completing in 6-8 h, making it the most practical choice for small processors. Temperatures above 60 °C caused steep losses in all bioactives. Sun drying was fast but suffered from UV-induced oxidation and uncontrolled temperature spikes.

Discussion

Shade drying's superiority is consistent with earlier findings by Satwase *et al.* [4], who reported 15-25% greater TPC retention in shade-dried vs sun-dried Moringa from Maharashtra. The present research extends this comparison to tray drying at five temperatures, filling a gap in the literature for humid eastern Ghana. The steep decline above 60 °C aligns with the thermal degradation kinetics of chlorogenic acid and quercetin reported by Sultana *et al.* [8], who identified 55-60 °C as the critical threshold for polyphenol stability in leafy vegetables.

Vitamin C was the most sensitive marker: sun drying destroyed 70.4% of the fresh-leaf value, whereas shade drying retained 58.7%. This mirrors the oxidation-driven degradation pathway of ascorbic acid, which is accelerated by UV exposure and metal-catalysed reactions on sun-drying surfaces [9].

The practical implication is clear: where electricity is available, tray drying at 50 °C should replace sun drying. Where it is not, shade drying under improved airflow (mesh trays, ventilated sheds) remains the best option, provided drying time can be tolerated [10].

Conclusion

This research set out to identify the drying method that best preserves the antioxidant and vitamin profile of Moringa oleifera leaves for use as a functional food ingredient. Shade drying retained the highest bioactive levels (DPPH 81.2%, vitamin C 128.4 mg/100 g), followed by tray drying at 50 °C (72.1%, 98.3 mg/100 g). Sun drying and high-temperature tray drying (70-80 °C) caused severe losses. For small-scale processors in humid regions, tray drying at 50 °C offers the best trade-off between quality and processing time. Open questions include the long-term storage stability of powders from each method, the effect of blanching pre-

treatment on colour and nutrient retention, and the consumer acceptability of Moringa powder in fortified food products.

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