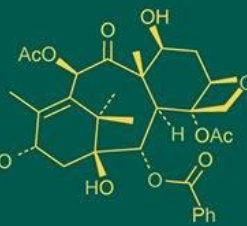
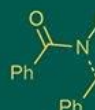
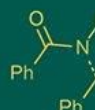
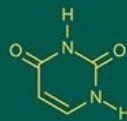
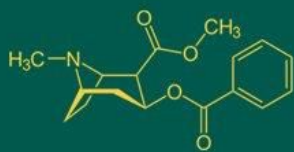


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Effect on quality of moringa leaves powder under different drying conditions

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Abstract

The present experiment entitled “Effect on quality of moringa leaves powder under different drying conditions” was conducted at Vegetable Science laboratory, College of Agriculture, IGKV, Raipur (C.G.) during 2023-24. The experiment was conducted to examine the quality assessment of moringa leaves powder under different drying conditions. The experiment was laid out in a Completely randomized design (CRD) replicated thrice, comprising of eight treatments viz. T₁: Natural drying (Sun drying) of moringa leaves (Control), T₂: Natural drying (Shade drying) of moringa leaves, T₃: Hot air oven drying of moringa leaves at 50 °C, T₄: Hot air oven drying of moringa leaves at 60 °C, T₅: Microwave oven drying of moringa leaves at 300W + 40 °C, T₆: Microwave oven drying of moringa leaves at 450W + 40 °C, T₇: Tray drying of moringa leaves at 50 °C and T₈: Tray drying of moringa leaves at 60 °C. Results revealed that effect of different drying methods on moringa leaves significantly lowest moisture content 6.43% was recorded in treatment T₈: Tray drying of moringa leaves at 60 °C. Treatment T₇: tray drying of moringa leaves at 50 °C recorded the significantly highest protein 26.11 g/100 g, fat 8.66g/100 g, fiber content 11.86g/100 g, energy content 331.84 Kcal, vitamin A content 6.20 mg/100 g and chlorophyll content 630.24 mg/100 g. Treatment T₂: natural drying (shade drying) of moringa leaves recorded significantly highest carbohydrate 43.03g/100 g, and ascorbic acid content 155.80 mg/100 g. Treatment T₈: tray drying of moringa leaves at 60 °C recorded significantly highest ash content 9.85g/100 g, iron content 28.35 mg/100 g and zinc content 3.93 mg/100 g.

Keywords: Moringa, drying, tray, microwave, protein, carbohydrate, iron, zinc

Introduction

Moringa (*Moringa oleifera*) belongs to the family 'Moringaceae' and is a multipurpose tree mostly grown in the tropics and subtropics of India. Moringa is native to India; however, it is a widely grown in Ethiopia, Pacific Islands, Florida, Sudan, Caribbean, Philippines, South Africa, Asia, and Latin America (Fahey JW 2005) [6]. Morphologically it is a fast-growing evergreen tree that usually grows up to 10-12 m in height along with wide canopy having enormous leaves (Arora *et al.*, 2013) [4]. Moringa leaves are one of the most useful multnutritive leafy vegetable harvested from moringa trees, it is rich source of minerals and vitamins and other essential nutrients. Moringa provides more than 90 nutrients and 46 types of antioxidants. In moringa leaves, minerals like potassium (397 mg/100 g), calcium (314 mg/100 g), magnesium (42 mg/100 g), iron (4.56 mg /100 g), zinc (0.72 mg/100 g), and vitamins such as β-carotene (6.78 mg/100 g), including, vitamin-C (220 mg/100 g) and carbohydrates (12.5 g/100 g), energy (62.88 Kcal), fiber (5.62 g/100 g), fat (1.64/100 g) and protein (6.41 g/100 g) are higher as compared to other leafy vegetables. Apart from nutritional enrichment, moringa leaves possess anti-cancerous, antimicrobial, anti-diabetic and neuroprotective compounds that help cure many serious diseases (Rajangam *et al.*, 2001) [10]. Drying is one of the most appropriate methods of moisture reduction and food preservation because it converts agricultural commodities into light weight and volume, easily transportable and storable products thereby minimising packaging, storage and transportation costs. Also, the drying of fresh agricultural commodities facilitates and promotes physio-chemical stability thereby enhancing its economic value by transforming its parent state (Silva *et al.* 2009) [13].

Materials and Methods

The experiment was conducted at Vegetable Science laboratory, College of Agriculture,

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Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during 2023-24. The experiment was laid out in a Completely randomized design (CRD) replicated thrice and the experiment comprising of eight treatments viz. T₁: Natural drying (Sun drying) of moringa leaves (Control), T₂: Natural drying (Shade drying) of moringa leaves, T₃: Hot air oven drying of moringa leaves at 50 °C, T₄: Hot air oven drying of moringa leaves at 60 °C, T₅: Microwave oven drying of moringa leaves at 300W + 40 °C, T₆: Microwave oven drying of moringa leaves at 450W + 40 °C, T₇: Tray drying of moringa leaves at 50 °C and T₈: Tray drying of moringa leaves at 60 °C. The fresh, mature, dark green and healthy leaves of moringa was collected from the KVK farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The samples were collected as per treatments and cleaned then dried with different drying methods such as (1) sun drying: A known quantity of fresh moringa leaves were spread out on a gunny bag sheet and kept outside for sun drying, the temperature during sun drying was ranged from 14 °C to 36.6 °C (Mid-January). The relative humidity during sun drying varied from minimum of 31% to maximum of 89%. The drying was completed in 2 days. (2) Shade drying: In this drying method the known quantity of fresh moringa leaves were spread on gunny bag sheet and kept in the room which was well ventilated. The drying was completed in 5 days. (3) Hot air oven drying: In a hot air oven dryer, the drying experiments were conducted at two different temperatures viz, 50 and 60 °C. The dryer was switched on 30 minutes before stabilize the drying temperature. Known quantity of samples were prepared in the set of three and spread as single layer aluminium tray. The aluminium trays loaded with fresh Moringa leaves were placed inside the drying chamber and left it for drying at 50 °C. Similarly, experimental procedure was repeated for 60 °C drying temperature. The drying was completed in 3 hour 40 minutes. (4) Microwave oven drying: A programmable domestic microwave (Samsung- CQ138S) with minimum 330W and maximum output 900W at 2450MHz was used for the drying experiments. The known amount of fresh moringa leaves were uniformly spread on the turntable glass plate inside the microwave cavity and drying was carried out at two different watts i.e. 300W+40 °C and 450W+40 °C constant hot air circulation. The drying was completed in 20 minutes. (5) Tray drying: In tray dryer, the drying experiments were conducted at two different temperatures viz, 50 and 60 °C. The dryer was switched on 30 minutes before stabilize the drying temperature. Known amount of samples were prepared in the set of three and spread as single layer aluminium tray. The aluminium trays loaded with fresh Moringa leaves were placed inside the drying chamber and left it for drying at 50 °C. Similarly, experimental procedure was repeated for 60 °C drying temperature. The drying was completed in 4 hours. The dried leaves material was ground to fine powder and analyzed for (i) Proximate composition (Moisture, protein, fat, fiber, carbohydrate, ash and energy). (ii) Vitamins (Vitamin A and vitamin C). (iii) Minerals (Iron and zinc) (iv) chlorophyll using the standard procedure of AOAC (2005)^[1].

Results and Discussions

Effect of different drying methods of moringa leaves on quality characteristics: The quality characteristics of moringa leaves significantly affected by the different drying

methods such as sun drying, shade drying, hot air oven drying, microwave oven drying, and tray drying, each have unique impacts on the quality characteristics of the moringa leaves.

Moisture content

The moisture content analyzed by different drying methods revealed that treatment T₈: Tray drying of moringa leaves at 60 °C recorded the significantly lowest moisture content 6.43% followed by 6.63% was recorded in treatment T₄: hot air oven drying at 60 °C and the highest moisture content 7.94% was recorded in treatment T₂: Natural drying (Shade drying) of moringa leaves and control treatment T₁: natural sun drying, recorded a moisture content of 7.34 %. The reduction in moisture content was due to the effect of the dehydration process. As the drying temperature and drying time increased, there was a reduction in moisture value. Similar result reported by Sahu (2020)^[11], Deepa (2019)^[5] and Ahmed *et al.* (2022)^[2].

Protein content

Significantly highest protein content 26.11 g/100 g was recorded in treatment T₇ which involved tray drying at 50 °C followed by 25.05 g/100 g was recorded in treatment T₃: Hot air oven drying of moringa leaves at 50 °C. While the lowest protein content 22.12 g/100 g was recorded in treatment T₂ which involved natural drying (Shade drying) of moringa leaves. The control treatment T₁: natural sun drying recorded a protein content of 23.05 g/100 g. The results on drying methods significantly affects the protein content of moringa leaves, with tray drying at 50 °C being the most effective method for retaining protein content. It is might be due to the drying process increased the protein content at specific temperature due to moisture loss then after at higher temperature protein starts degrading due to thermal denaturation of proteins to free amino acids and nucleotides and might be the probable reason for the decrease in protein content with increase in drying temperatures. In the present study the increase in protein content of dried moringa leaves compared to fresh leaves as a result of moisture loss might influenced dry matter content (Oulai *et al.*, 2016)^[9] and drying process increased the protein content due to moisture loss (Osum *et al.*, 2013)^[8]. The findings were in agreement with the work of Deepa (2019)^[5] and Ahmed *et al.* (2022)^[2].

Carbohydrates

Highest carbohydrate content 43.03 g/100 g was recorded in treatment T₂ which involved natural drying (Shade drying) of moringa leaves followed by 41.48 g/100 g was recorded in treatment T₁: natural drying (Sun drying) of moringa leaves (Control) recorded carbohydrate content. While the lowest carbohydrate content 36.93 g/100 g was recorded in treatment T₆ which involved Microwave oven drying of moringa leaves at 450W + 40 °C. The results on drying methods significantly affects the carbohydrate content of moringa leaves, with natural drying (Shade drying) of moringa leaves being the most effective method for retaining carbohydrate content. It might be due to during heating starch was turned to dextrin which drove off the water, while the sugar caramelised quickly and then burnt carbohydrates, which lost during heating Satwase (2013)^[12]. Similar result was observed by Deepa (2019)^[5].

Fat content

The highest fat content 8.66 g/100 g was recorded in treatment T₇, which involved tray drying of moringa leaves at 50 °C followed by 8.30 g/100 g was recorded in treatment T₃: Hot air oven drying of moringa leaves at 50 °C. While the lowest fat content 7.90 g/100 g was recorded in treatment T₂ which involved natural shade drying. The control treatment T₁ with natural sun drying recorded a fat content of 8.08 g/100 g. The results revealed that drying methods significantly affects the fat content of moringa leaves, with tray drying at 50 °C being the most effective method for retaining fat content. It might be due to the reduction of moisture content leads to an increase in the concentration of fat. Similar result was found by Sahu (2020)^[11], Deepa (2019)^[5].

Fiber content

Significantly the highest fiber content 11.86 g/100 g was recorded in treatment T₇: tray drying of moringa leaves at 50 °C which was statistically at par with treatment T₃ (11.79 g/100 g) followed by 11.50 g/100 g recorded in treatment T₈: Tray drying of moringa leaves at 60 °C. While the lowest fiber content 10.51 g/100 g was recorded in treatment T₂: natural drying (Shade drying) of moringa leaves. The treatment T₁ (control) natural sun drying, recorded a fiber content of 10.98 g/100 g. The results revealed that drying methods significantly affects the fiber content of moringa leaves, with tray drying of moringa leaves at 50 °C being the most effective method for retaining fiber content. It might be due to the nutritional composition increased as leaves were subjected to drying, this could be as result of the concentration of fiber content recorded higher in tray dryer. Similar result observed by Umar *et al.* (2015)^[14], Satwase *et al.* (2013)^[12] and Deepa (2019)^[5].

Energy content: The highest energy content 331.84 Kcal was recorded in treatment T₇: Tray drying at 50 °C of moringa leaves which was statistically at par with T₅ (331.00 Kcal), T₆ (330.87 Kcal) and T₈ (331.70 Kcal) whereas the lowest energy content 328.70 Kcal was recorded in treatment T₃, which involved hot air oven drying of moringa leaves at 50 °C. The treatment T₁ (control) natural sun drying, recorded an energy content of 330.10 Kcal. It might be due to the concentration effect by the removal of the moisture content in moringa leaves. Similar result observed by Sahu (2020)^[11].

Ash content

Treatment T₈: tray drying of moringa leaves at 60 °C recorded significantly highest ash content 9.85g/100 g which was statistically at par with T₄ (9.80 g/100 g) and T₇ (9.69 g/100 g) while the lowest ash content 8.50 g/100 g was recorded in treatment T₂: natural drying (shade drying) of moringa leaves. The control treatment T₁: natural sun drying recorded an ash content of 9.07 g/100 g. The results revealed that drying method significantly affects the ash content of moringa leaves, with tray drying of moringa leaves at 60 °C being the most effective method for retaining ash content. It might be due to dense dry matter concentrated on loss of moisture content. Similar result was observed by Umar *et al.* (2015)^[14] and Deepa (2019)^[5].

Vitamin-A: The highest Vitamin A content 6.20 mg/100 g was recorded in treatment T₇: which involved tray drying at

50 °C followed by 5.75 mg/100 g was recorded in treatment T₂: Natural drying (Shade drying) of moringa leaves. While the lowest Vitamin A content 5.20 mg/100 g was recorded in treatment T₁ which involved natural drying (sun drying). The results revealed that drying method significantly affects the Vitamin A content of moringa leaves, with Tray drying at 50 °C being the most effective method for retaining Vitamin A content. Vitamin-A is a fat soluble and sensitive to light therefore the more vitamin A retention in tray drying. Similar result found by Joshi and Mehta (2010)^[7] and Ahmed *et al.* (2022)^[2].

Ascorbic Acid

Ascorbic acid content 155.80 mg/100 g was recorded significantly highest in treatment T₂: natural drying (shade drying) followed by 126.18 mg/100 g was recorded in treatment T₁: natural drying (sun drying) and the lowest ascorbic acid content 104.32 mg/100 g was recorded in treatment T₆: microwave oven drying of moringa leaves at 450W+40 °C. The results revealed that drying method significantly affects the ascorbic acid content of moringa leaves, with natural shade drying being the most effective method for retaining ascorbic acid content. It is highly water soluble and heat labile vitamin and it is only nutrient, which reduced after dehydration as it is oxidized rapidly on exposure to heat and air. Similar result was observed by Sahu (2020)^[11] and Ahmed *et al.* (2022)^[2].

Iron content

Significantly the highest iron content 28.05 mg/100 g was recorded in treatment T₈: tray drying of moringa leaves at 60 °C which was statistically at par with T₃ (27.88 mg/100 g), T₄ (27.90 mg/100 g) and T₇ (28.03 mg/100 g). While the lowest iron content 27.18 mg/100 g was recorded in treatment T₂, which involved natural drying (Shade drying) of moringa leaves. The control treatment T₁ with natural sun drying, recorded an iron content of 27.21 mg/100 g. The results revealed that drying method significantly affects the iron content of moringa leaves, with tray drying of moringa leaves at 60 °C being the most effective method for retaining iron content. It is might be due to the iron is a mineral and is much more stable to heat and light, it does not deplete or break down during the different drying process. Similar result was recorded by Deepa (2019)^[5] and Sahu (2020)^[11].

Zinc content

Treatment T₈: tray drying of moringa leaves at 60 °C recorded significantly highest zinc content 3.81 mg/100 g which was statistically at par with T₃ (3.77 mg/100 g), T₄ (3.80 mg/100 g), T₅ (3.59 mg/100 g), T₆ (3.62 mg/100 g) and T₇ (3.80 mg/100 g) whereas the lowest zinc content 3.44 mg/100 g was recorded in treatment T₂: natural drying (shade drying) of moringa leaves. The control treatment T₁ with natural sun drying, recorded a zinc content of 3.48 mg/100 g. The results indicate that drying method significantly affects the zinc content of moringa leaves, with tray drying of moringa leaves at 60 °C being the most effective method for retaining zinc content. It might be due to zinc is a mineral and is very stable during drying, zinc does not deplete or break down during the drying process. Therefore, the actual amount of zinc remains relatively constant on different drying methods, but it becomes more concentrated as water is removed. Similar result observed by Deepa (2019)^[5], Anuja and Ramkumar (2017)^[3]

Total chlorophyll: The highest total chlorophyll content 630.24 mg/100 g was recorded in treatment T₇: Tray drying of moringa leaves at 50 °C which was statistically at par with T₃ (629.65 mg/100 g). While the lowest total chlorophyll content 500.45 mg/100 g was recorded in treatment T₁: Natural drying (Sun drying) of moringa leaves. The results indicate that drying method significantly

affects the total chlorophyll content of moringa leaves, with tray drying of moringa leaves at 50 °C being the most effective method for retaining total chlorophyll content. It might be due the lower drying temperatures are more effective in preserving chlorophyll, which degraded at higher temperatures. Similar trend observed by Sahu (2020) [11].

Table 1: Effect of different drying methods of moringa leaves on proximate composition.

Tr. No.	Treatment details	Moisture (%)	Protein (g/100 g)	Carbohydrates (g/100 g)	Fat (g/100 g)	Fiber (g/100 g)	Energy (Kcal)	Ash (g/100 g)
T ₁	Natural drying (Sun drying) of moringa leaves (Control)	7.34	23.05	41.48	8.08	10.98	330.10	9.07
T ₂	Natural drying (Shade drying) of moringa leaves	7.94	22.12	43.03	7.90	10.51	330.13	8.50
T ₃	Hot air oven drying of moringa leaves at 50 °C	6.80	25.05	40.94	8.30	11.79	328.70	9.61
T ₄	Hot air oven drying of moringa leaves at 60 °C	6.63	24.71	39.19	8.22	11.45	329.58	9.80
T ₅	Microwave oven drying of moringa leaves at 300W + 40 °C	7.01	24.14	38.45	8.20	11.19	331.00	9.30
T ₆	Microwave oven drying of moringa leaves at 450W + 40 °C	6.82	23.44	36.93	8.15	11.10	330.87	9.55
T ₇	Tray drying of moringa leaves at 50 °C	6.75	26.11	40.16	8.66	11.86	331.84	9.69
T ₈	Tray drying of moringa leaves at 60 °C	6.43	24.80	39.17	8.25	11.50	331.70	9.85
	SE (m)	0.06	0.09	0.17	0.06	0.06	0.48	0.06
	CD @ 5%	0.17	0.28	0.50	0.18	0.19	1.43	0.17
	C.V.	1.38	0.66	0.73	1.24	0.98	0.25	1.02

Table 2: Effect of different drying methods of moringa leaves on vitamins, minerals and chlorophyll content.

Tr. No.	Treatment details	Vitamin-A (mg/100 g)	Ascorbic Acid (mg/100 g)	Iron (mg/100 g)	Zinc (mg/100 g)	Total chlorophyll (mg/100 g)
T ₁	Natural drying (Sun drying) of moringa leaves (Control)	5.20	126.18	27.21	3.48	500.45
T ₂	Natural drying (Shade drying) of moringa leaves	5.75	155.80	27.18	3.44	550.46
T ₃	Hot air oven drying of moringa leaves at 50 °C	5.59	115.38	27.88	3.77	629.65
T ₄	Hot air oven drying of moringa leaves at 60 °C	5.39	110.77	27.90	3.80	615.78
T ₅	Microwave oven drying of moringa leaves at 300W + 40 °C	5.70	106.12	27.56	3.59	605.46
T ₆	Microwave oven drying of moringa leaves at 450W + 40 °C	5.58	104.32	27.57	3.62	580.27
T ₇	Tray drying of moringa leaves at 50 °C	6.20	112.45	28.03	3.80	630.24
T ₈	Tray drying of moringa leaves at 60 °C	5.55	109.78	28.05	3.81	620.61
	SE (m)	0.07	0.74	0.10	0.08	2.13
	CD @ 5%	0.21	2.22	0.30	0.24	6.38
	C.V.	2.17	1.09	0.63	3.77	0.62

Conclusion

It can be concluded from the investigation entitled “Effect on quality of moringa leaves powder under different drying conditions” that maximum quality parameters were recorded significantly highest value in T₇: Tray drying of moringa leaves at 50 °C. Hence the treatment T₇: Tray drying of moringa leaves at 50 °C can be considered as the most effective for retaining the quality parameters.

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