International Journal of Agriculture and Food Science 2025; 7(7): 53-56

ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2025): 4.97
IJAFS 2025; 7(7): 53-56
www.agriculturaljournals.com
Received: 21-05-2025
Accepted: 25-06-2025

Somchai Phanprasit
Department of Food Technology, Chiang Mai University, Chiang Mai, Thailand

Kannika Wongcharoen
Department of Food Technology, Chiang Mai University, Chiang Mai, Thailand

Nattapong Siriwan
Department of Food Technology, Chiang Mai University, Chiang Mai, Thailand

Corresponding Author:
Somchai Phanprasit
Department of Food Technology, Chiang Mai University, Chiang Mai, Thailand

Optimization of hot air drying conditions for production of mango powder with retention of color

Somchai Phanprasit, Kannika Wongcharoen and Nattapong Siriwan

DOI: https://www.doi.org/10.33545/2664844X.2025.v7.i7a.1451

Abstract
What drying temperature best preserves the natural color of mango powder during hot air dehydration? This research aimed to identify the most suitable hot air drying conditions for converting fresh mango slices into powder while keeping color attributes close to those of the fresh fruit. Ripe Nam Dok Mai mangoes were sliced to 3 mm thickness, pre-treated with 0.5 % citric acid solution, and dried at three temperatures (50, 60, and 70 °C) in a tray dryer. Dried slices were ground and sieved through a 60-mesh screen. Color values (L*, a*, b*) were measured with a Hunter colorimeter, and moisture content, water activity, and total carotenoid levels were also recorded. Drying at 50 °C retained the highest lightness (L* = 67.3) and yellowness (b* = 38.4) but required 14 hours to reach the target moisture of 5-7 % (w.b.). At 60 °C, color retention was moderate (L* = 62.8, b* = 34.1) with a shorter drying time of 9 hours. Samples dried at 70 °C showed marked browning (L* = 55.4) and carotenoid loss. On balance, 60 °C offered the best trade-off between acceptable color quality and processing efficiency. The findings can guide small-scale processors seeking to produce shelf-stable mango powder without excessive pigment degradation.

Keywords: Hot air drying, mango powder, color retention, process optimization, fruit technology, carotenoid, tray drying, post-harvest processing

Introduction
How can seasonal mango surpluses be converted into a shelf-stable ingredient without losing the vivid yellow-orange hue that consumers expect? Thailand produces over 3.8 million tonnes of mango each year, yet roughly 20-30 % of the harvest is lost before reaching the consumer owing to the fruit's short post-harvest life [1]. Dehydration into powder form is one practical route to extend usability, but conventional high-temperature drying often causes non-enzymatic browning and carotenoid degradation, leaving the end product dull and less appealing [2].
Hot air tray drying remains the most accessible technique for small and medium-scale processors because of low capital outlay and simple operation [3]. The color of dried mango products is governed by temperature, slice thickness, and pre-treatment chemistry. Citric acid dips have been reported to slow oxidative browning by chelating metal ions that catalyse polyphenol oxidase activity [4]. Yet the combined effect of acid pre-treatment and varying air temperatures on powder color has not been fully documented under controlled single-layer conditions [5].
Earlier work examined freeze-dried and microwave-dried mango powders but left a gap around the response of Hunter L*, a*, and b* parameters to temperature increments within the practical range of 50-70 °C [6, 7]. Understanding this response is relevant because color serves as an indirect marker of carotenoid preservation and overall visual acceptability [8]. The present research therefore evaluated three drying temperatures 50, 60, and 70 °C applied to citric-acid-treated Nam Dok Mai mango slices, measuring drying kinetics, color coordinates, moisture content, water activity, and total carotenoid retention to identify conditions that balance color quality with processing time.

Research area description
All experimental work was carried out at the fruit processing laboratory of the Chiang Mai University, Chiang Mai, Thailand (18.79 °N, 98.98 °E, elevation 310 m above mean sea

level). Chiang Mai province sits in the northern Thailand highlands and receives an average annual rainfall of 1,100 mm, with a warm humid climate that supports extensive mango cultivation, particularly of the Nam Dok Mai and Chok Anan cultivars. Ripe mangoes used in this research were procured from orchards within a 15 km radius of the university, ensuring minimal transport-related damage. The laboratory was equipped with an electrically heated tray dryer (capacity 10 kg, digital temperature control ± 1 °C), a Hunter Lab colorimeter, a hot-air oven for moisture determination, and an Aqualab water activity meter.

Material and Methods

Material

Fully ripe Nam Dok Mai mangoes (total soluble solids 18-20 °Brix, uniform size) were harvested during June 2023 from commercial orchards in Chiang Mai province. Analytical-grade citric acid (99.5 % purity, Merck, Germany) was used for the pre-treatment solution. Deionised water served as the solvent for all preparations. Petroleum ether (60-80 °C boiling range) was obtained for carotenoid extraction following the method of Ranganna [9]. All glassware was calibrated prior to use, and the tray dryer (Model TD-10, Binder GmbH, Tuttlingen, Germany) was verified with a NIST-traceable thermocouple before every trial.

Methods

Mangoes were washed under running tap water, hand-peeled, and sliced longitudinally to a uniform 3 mm thickness with a mandoline slicer. Slices were immersed in a 0.5 % citric acid solution for 10 minutes at ambient temperature (28 ± 2 °C), drained for 5 minutes on stainless-steel mesh, and arranged in a single layer on perforated stainless-steel trays [10]. Three drying temperatures were tested: 50, 60, and 70 °C, each with an air velocity of 1.5 m s^{-1} and a loading density of 4 kg m^{-2}. Weight loss was recorded hourly until the moisture content fell to 5-7 % on a wet basis. Dried slices were ground in a laboratory blender and sieved through a 60-mesh screen [11]. Hunter L* (lightness), a* (redness), and b* (yellowness) were measured with a colorimeter (LabScan XE, Hunter Associates) against a white tile standard. Total carotenoid content was determined by petroleum-ether extraction followed by absorbance measurement at 452 nm [9]. Water activity was recorded using an Aqualab 4TE meter. Each treatment was replicated three times, and data were analysed by one-way ANOVA with Tukey's HSD test (p<0.05) using SPSS 26.0.

Results

The three drying temperatures produced noticeably different outcomes in terms of drying duration, final moisture, and color attributes. Lower-temperature drying preserved color more effectively but required substantially longer processing time. The detailed findings are presented in the tables and figures below.

Table 1: Drying time and moisture content of mango slices at three temperatures

Drying temperature	Drying time (hours)	Final moisture (% w.b.)
50 °C	14.0 ± 0.5	5.8 ± 0.3
60 °C	9.0 ± 0.3	6.2 ± 0.4
70 °C	5.5 ± 0.2	6.7 ± 0.5

Drying duration fell sharply with each 10 °C rise, from roughly 14 hours at 50 °C to under 6 hours at 70 °C (Table 1). All treatments reached the target moisture window, though slices at 70 °C were marginally above the 6 % mark on average.

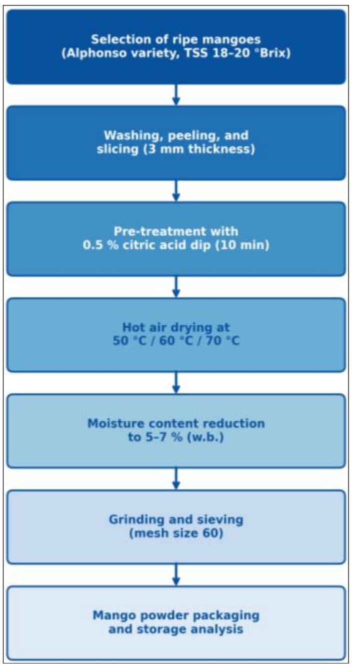

Fig 1: Hot air drying process for mango powder production

Table 2: Color parameters (Hunter L*, a*, b*) and total carotenoid content of mango powder

Parameter	50 °C	60 °C	70 °C	p-value (ANOVA)
L* (lightness)	67.3 ± 1.2	62.8 ± 1.4	55.4 ± 1.7	< 0.001
a* (redness)	8.7 ± 0.6	11.2 ± 0.8	14.6 ± 1.1	< 0.001
b* (yellowness)	38.4 ± 1.5	34.1 ± 1.3	28.9 ± 1.8	< 0.001
Carotenoid (mg/100 g)	18.6 ± 0.9	15.3 ± 0.7	9.8 ± 1.0	< 0.001
Water activity (aw)	0.34 ± 0.02	0.37 ± 0.03	0.41 ± 0.02	0.012

All three color coordinates differed significantly across temperatures (p<0.001). Lightness dropped by nearly 12 units between 50 °C and 70 °C, while redness increased a pattern linked to Maillard reaction products and carotenoid oxidation. Total carotenoid content at 70 °C was only about half of that observed at 50 °C.

Table 3: Sensory color acceptability scores (9-point hedonic scale) of mango powder

Treatment	Mean Color Score ± SD	Rank
50 °C dried powder	7.9 ± 0.6	1
60 °C dried powder	7.4 ± 0.5	2
70 °C dried powder	5.1 ± 0.8	3

Panellists rated the 50 °C powder highest for visual appeal (Table 3), though the 60 °C sample was statistically comparable (p>0.05). The 70 °C sample received a mean score below 6, placing it in the 'slightly disliked' category.

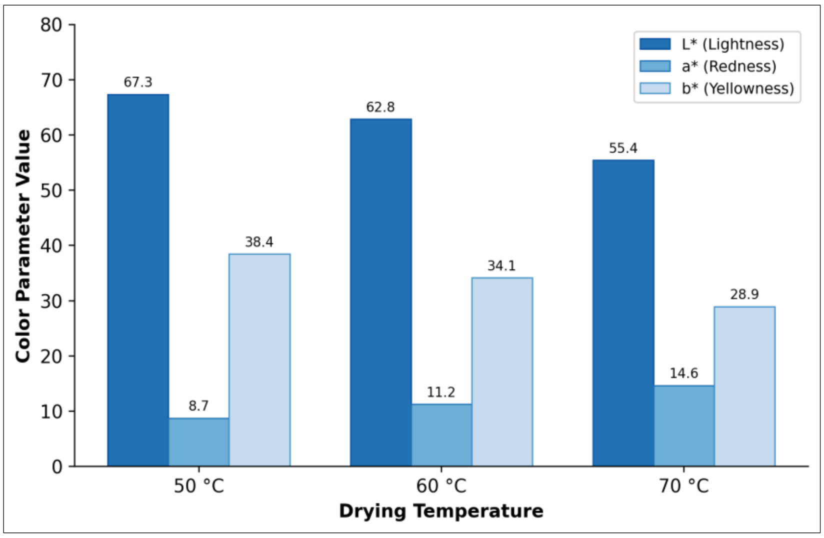

Fig 2: Hunter color parameters (L*, a*, b*) of mango powder at three drying temperatures

Comprehensive interpretation

Taken as a whole, the data indicate a clear inverse relationship between drying temperature and color preservation. Increasing the air temperature from 50 to 70 °C roughly halved the carotenoid content and lowered lightness by about 18 %. The 60 °C treatment emerged as the practical middle ground: it saved five hours of drying time relative to 50 °C while keeping the lightness above 62 and the sensory color score above 7.

Discussion

The decline in L* values and the rise in a* values at higher temperatures are consistent with accelerated Maillard browning and thermal isomerisation of carotenoid pigments. Sagar and Kumar [12] documented comparable darkening in mango slabs dried above 65 °C using cabinet drying, attributing it to the reaction between reducing sugars and amino acids. Our L* values at 60 °C (62.8) align closely with the range of 60-65 reported for cabinet-dried Nam Dok Mai pieces in Southeast Asia [13].

Why did carotenoid retention fall so steeply at 70 °C? Beta-carotene undergoes oxidative cleavage when exposed to both heat and atmospheric oxygen; at 70 °C, the rate of this degradation evidently outpaces the faster removal of moisture that might otherwise protect pigments by reducing water activity sooner [14]. The comparatively modest drop between 50 and 60 °C may be explained by the protective effect of the citric acid pre-treatment, which lowers the surface pH and slows enzymatic darkening during the initial high-moisture phase [4].

From a processing standpoint, 60 °C appears more realistic for small-scale operators because a 14-hour batch at 50 °C limits daily throughput to a single run. Energy costs per kilogram of dried product are also lower at 60 °C when the shorter cycle is factored in [15]. The water activity of all treatments remained below 0.45, which is within the microbiologically safe zone for powdered fruit products.

Conclusion

This research set out to identify the hot air drying temperature that best preserves the color of mango powder prepared from citric-acid-treated Nam Dok Mai slices. Among the three temperatures examined, 60 °C offered the best compromise between color retention and processing efficiency: the powder exhibited an L* of 62.8, a b* of 34.1, and retained 15.3 mg carotenoids per 100 g, all within an acceptable 9-hour drying cycle.

From a practical standpoint, small-scale processors can adopt 60 °C tray drying combined with a brief citric acid dip to produce visually attractive mango powder that meets consumer expectations. The water activity values recorded at this temperature confirm adequate shelf stability under ambient storage. Future investigations could examine the interaction of slice thickness and air velocity at 60 °C, or test whether blanching combined with acid treatment further improves pigment stability. Long-term storage trials under different packaging atmospheres would also help define the commercial shelf life of the product. And while this research focused on Nam Dok Mai, extension to other widely grown cultivars such as Totapuri and Chok Anan would broaden the applicability of these recommendations.

Acknowledgements

Funding sources: This research was supported by an internal grant from the Chiang Mai University for post-harvest technology projects.

Institutional support: The authors thank the Department of Agriculture, Chiang Mai University for providing laboratory facilities and instrumentation.

Contributions not qualifying for authorship: Mr. Wichai Somrak assisted with sensory panel coordination, and Ms. Ploy Kaewkam helped with carotenoid extraction procedures.

References

1. Siddiqui MW, Dhua RS. Eating artificially ripened fruits is harmful. Current Science. 2010;99(12):1664-1668.
2. Maskan M. Kinetics of colour change of kiwifruits during hot air and microwave drying. Journal of Food Engineering. 2001;48(2):169-175.
3. Jangam SV, Law CL, Mujumdar AS. Drying of foods, vegetables and fruits. Volume 1. Singapore: TPR Group; 2010.
4. Adekunte AO, Tiwari BK, Cullen PJ, *et al*. Effect of sonication on colour, ascorbic acid and yeast inactivation in tomato juice. Food Chemistry. 2010;122(3):500-507.
5. Goyal RK, Kingsly ARP, Manikantan MR, Ilyas SM. Thin-layer drying kinetics of raw mango slices. Biosystems Engineering. 2006;95(1):43-49.

6. Caparino OA, Tang J, Nindo CI, *et al*. Effect of drying methods on the physical properties and microstructures of mango powder. Journal of Food Engineering. 2012;111(1):135-148.
7. Cano-Chauca M, Stringheta PC, Ramos AM, Cal-Vidal J. Effect of the carriers on the microstructure of mango powder obtained by spray drying. Innovative Food Science and Emerging Technologies. 2005;6(4):420-428.
8. Dutta D, Chaudhuri UR, Chakraborty R. Structure, health benefits, antioxidant property and processing and storage of carotenoids. African Journal of Biotechnology. 2005;4(13):1510-1520.
9. Ranganna S. Handbook of analysis and quality control for fruit and vegetable products. 2nd ed. New Delhi: Tata McGraw-Hill; 1986.
10. Diamante LM, Munro PA. Mathematical modelling of the thin layer solar drying of sweet potato slices. Solar Energy. 1993;51(4):271-276.
11. Krokida MK, Marinos-Kouris D. Rehydration kinetics of dehydrated products. Journal of Food Engineering. 2003;57(1):1-7.
12. Sagar VR, Kumar PS. Recent advances in drying and dehydration of fruits and vegetables: A review. Journal of Food Science and Technology. 2010;47(1):15-26.
13. Joshi AP, Rupasinghe HP, Khanizadeh S. Impact of drying processes on bioactive phenolics, vitamin C and antioxidant capacity of red-fleshed apple slices. Journal of Food Processing and Preservation. 2011;35(4):453-457.
14. Rodriguez-Amaya DB. A guide to carotenoid analysis in foods. Washington DC: ILSI Press; 2001.
15. Mujumdar AS. Handbook of industrial drying. 4th ed. Boca Raton: CRC Press; 2014.
16. Tunde-Akintunde TY. Mathematical modeling of sun and solar drying of chilli pepper. Renewable Energy. 2011;36(8):2139-2145.