Drying Methods Comparison of Carrot *(Daucus carota)* Using Vacuum and Oven Based on L*a*b Color and Total Carotene Content

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Abstract. This study was conducted to compare the effects of different drying methods on the L*a*b color and carotene content of carrot. The research method used a descriptive comparative approach. Carrots were obtained from the market and cleaned with running water, cut into thin slices approximately 2 mm, and blanched using 90°C water for 3 minutes, then transferred into ice-cold water to stop the cooking process. Carrots were then divided into two groups, one for each drying method. The first group was a vacuum dryer, and the second was an oven, both were at 60°C. Both methods were used until the sliced carrots became crisp and could be ground into powder. Carrot powder was then examined using CIELAB to determine the value of each color and extracted and analyzed using spectrophotometry for the carotene content. Obtained data, then analyzed using a t-test to determine the significance of drying methods on each color value. The results showed a significant difference in all color components between the drying methods. Oven drying produced lighter carrot powder (higher L* value), while vacuum drying resulted in stronger red–yellow tones (higher a* and b*) and higher total carotene content. This indicates that greater carotene retention is associated with deeper color intensity. The vacuum process likely reduced pigment oxidation, preserving carotenoids more effectively, whereas oven drying caused higher oxidation despite producing a brighter appearance.
Keywords: Carrot, drying method, carotene, preservation, vacuum drying

1 Introduction

Carrot is one of the most widely produced vegetables in Malang Raya, especially in Bumiaji, which has produced 8,890 tons of carrots, the highest amount produced by any vegetable among other kinds and other areas nearby in 2024 [1]. Carrots are often used by the food industry to be further processed into value-added products. Bigger industries and productions have led to a higher waste generation, including carrots that have not been processed and the byproducts that come from the industries. Although often discarded in large quantities,

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industrial carrot waste still has potential as a nutritious and sustainable ingredient for animal feed. Repurposing these by-products can reduce environmental impact while enhancing animal product quality, such as egg yolk color [2].

Carrots are not only valued for their culinary usage but also for their functional properties, particularly their high carotenoid content [3, 4]. In poultry production, dietary carotenoids are directly deposited into egg yolks, influencing both their coloration and nutritional profile. Enhanced egg yolk color is one of the poultry industry's goals because it increases consumer acceptance [2]. The addition of carotenoids into poultry feed has been shown to significantly change some yolk color parameters depending on the breed [5].

To preserve the carotenoid and quality of the carrots, post-harvest processing must be done correctly. Carrots are seasonal crops that need to be handled properly in order to increase their shelf life [2]. Drying is one of the steps that can be used to increase the stability and quality of bioactive compounds. The dehydration process can affect the components of a product such as β-carotene, anthocyanin, antioxidant as well as the color [6]. The drying process is tightly related to β-carotene since the higher temperature can increase the isomerization rate [7].

Lower moisture content in a product can result in a longer shelf time, which is beneficial when the carrots are stored for animal feed production [7]. This study was conducted to compare the effects of different drying methods on the L*a*b color and carotene content of carrot.

2 Materials and methods

This research was conducted in July-August 2025 at the Laboratory of Animal Nutrition in the Faculty of Animal Science, Universitas Brawijaya. The local variety carrot samples were rejected as a product because either oversized or undersized were obtained from Pasar Sayur Karangploso, East Java, Indonesia. The apparatus used included a 60-mesh sieve, vacuum dryer, oven, pan, grinder, and strainer. Initially, carrots were sliced into slices approximately 2-3 mm in thickness and blanched in 90°C water for 3-4 minutes [8]. Blanching was stopped by submerging the slices in ice-cold water, then rinsing and preparing them for drying. Two drying methods were applied in this research: vacuum drying (13 psi) and oven drying. The carrot slices were dried at 60°C using both methods until the moisture content was <10% (5-7 hours vacuum or 16-18 hours oven), then ground using a grinder and sieved to obtain a uniform particle. Powdered carrot samples were prepared in three replicates for each drying methods, then measured using CIELAB color space with a Minolta CR-10 colorimeter to determine their L*, a* and b* values. Samples were prepared in two replicates and analyzed for total carotene using a UV-Vis spectrophotometer in the Chemistry and Food Chemistry Laboratory. Statistical analysis was performed using the t-test to evaluate the significance of each drying method on the resulting color parameters [9].

3 Results and discussion

3.1 L*a*b Color

The results of L*a*b Color of dried carrots are shown in Table 1.

Table 1. L*a*b Color test result of carrots.

Treatment	Variable		
	L*	a*	b*
Oven Drying	63.43±0.50	14.87±0.50	22.83±0.50
Vacuum Drying	60.73±0.52	19.05±0.33	23.60±0.24

Color was measured in the CIELAB system to evaluate how drying method affects perceived brightness (L*) and hue (a* and b*). Different drying methods significantly affected the L* and a* ($p<0.0001$) and had less significant effect on the b* ($P<0,01$) . Oven-dried samples showed a greater L* (lightness) than the vacuum-dried samples, indicating a lighter, less saturated. In contrast, vacuum-dried carrots showed markedly higher a* (redness) and slightly higher b* (yellowness) values, reflecting enhanced preservation of the natural orange pigments derived from carotenoids. These results highlight an inverse relationship between lightness (L) and pigment concentration*, where higher carotenoid retention under vacuum conditions intensifies red and yellow tones but slightly darkens the product due to pigment density and reduced surface reflection. Similar trends have been reported in other vegetables such as pumpkin and sweet potato, where carotenoid degradation during hot air drying led to a reduction in a* values and overall color dullness [10]. By contrast, vacuum drying retained higher a* and slightly higher b* values, consistent with better preservation of carotenoid-derived orange pigments when exposure to heat and oxygen is minimized. The parallel changes in L*, a*, and b* support the interpretation that thermal and oxidative processes during oven drying alter both overall reflectance and chromaticity, and that a* in particular correlates with carotenoid concentration and thus serves as a useful rapid indicator of pigment retention. Comparison of a* value between vacuum and oven drying confirmed each method’s effect on pigment protection, higher a* value indicates more saturated red coloration and better visual retention [11].

3.2 Total Carotene

The result of the total carotene content of dried carrots are shown in Table 2.

Table 2. Carotene total test result of carrots.

Code	Average Total Carotene (µg/g)
Oven	703.83±6.85
Vacuum	767.84±4.20

Different drying methods had a significant effect (P<0,0001), with vacuum-dried carrots retaining more total carotene content (767.84 µg/g) than oven-dried samples (703.83 µg/g). The improved carotene preservation under vacuum conditions is attributed to minimal oxygen exposure and lower oxidative degradation during the drying process [11]. In contrast, continuous exposure to hot air during oven drying accelerates carotenoid oxidation and isomerization, leading to pigment loss and decreased redness (a* value).

The positive correlation between a* and total carotene content suggested that redness intensity can serve as a rapid visual indicator of carotenoid concentration, consistent with findings in dried tomato and papaya powders [12,13]. This relationship demonstrates that while oven drying enhances brightness (higher L*), it compromises pigment stability, whereas vacuum drying maintains stronger color saturation and higher total carotene content.

4 Conclusion

Different drying methods significantly influenced the color and carotene content of carrots. Oven drying produced lighter-colored powder with higher L* values, while vacuum drying resulted in deeper red–yellow tones (higher a* and b* values) and greater total carotene content. The positive relationship between a* value and carotene concentration indicates that color parameters can serve as a reliable indicator of pigment retention. Therefore, vacuum drying is the preferred method for preserving the visual appeal and the nutritional quality of carrots compared to conventional oven drying.

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