



# **Influence of Different Drying Methods on Proximate and Mineral Composition of Pea Pods**

**Anjali Kumari <sup>a</sup>, Monika Sood <sup>a\*</sup>, Julie D. Bandral <sup>a</sup>,  
Neeraj Gupta <sup>a</sup> and Ankita Choudhary <sup>a</sup>**

<sup>a</sup> *Division of Post Harvest Management, FoH&F, Sher-e-Kashmir University of Agricultural Science and Technology, Jammu-180 009, J&K, India.*

## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

## **Article Information**

DOI: <https://doi.org/10.9734/acri/2025/v25i41174>

## **Open Peer Review History:**

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://pr.sdiarticle5.com/review-history/134419>

**Original Research Article**

**Received: 11/02/2025**

**Accepted: 14/04/2025**

**Published: 17/04/2025**

## **ABSTRACT**

Pea pods, by-products of the pea processing industry, are a rich source of nutrients but are frequently disposed of incorrectly. In this study, pea pod powder (PPP) was developed by using different drying methods such as viz., sun, solar, tray, microwave, freeze and osmotic drying and was analyzed for its proximate and mineral composition. The results revealed that dried pea pod powder contained moisture, and the ash content of dried pea pods ranged from 8.95 to 5.10% and 7.74 to 5.87%, respectively. The highest crude protein, crude fat and crude fibre content of 15.02, 1.90 and 8.95 %, respectively, were recorded in freeze-dried (FD) pea pod powder. Further, FD PPP recorded the highest potassium, iron and magnesium content of 1832.37, 856.47 and 10.45 mg/100g, respectively, while the least potassium, iron and magnesium content of 1010.29, 718.56

\*Corresponding author: Email: [monikasoodfst@gmail.com](mailto:monikasoodfst@gmail.com);

and 5.84 mg/100g, respectively, were observed in the sun drying (SD) pea pod powder. According to the study, FD pea pod powder retained more of its proximate components, whereas sun-drying (SD) caused a larger loss of nutrients. When creating functional foods that offer health benefits, the best-dried pea pod powder can be utilized.

**Keywords:** *Nutrients; pea pods; freeze drying; proximate; osmotic dehydration; functional food.*

## 1. INTRODUCTION

Peas (*Pisum sativum* L.) are the second most widely planted legume in the world. Peas are consumed both in their green and dried forms all around the world. Around 5.7 million tonnes of peas were produced in India in the year 2020. Since peas are mostly processed into multiple food formats such as frozen, dried, and canned for, the outermost pod remains unused. This outer seed coat makes up 35–40% of the fresh weight of peas and if not properly utilized or disposed of can attract pathogens, posing a threat to human and animal life. These pea pods are rich reserves of fibre, carbohydrates, and crude proteins and may have numerous food applications. In addition, they are also rich in many macronutrients such as potassium, magnesium, iron and zinc and exhibit a low calorific value of 210 kcal/100 g, primarily because of their limited fat content (Nasir et al., 2022). Pea pods have also been reported to contain phenolic acids such as cinnamic acids and benzoic acids (e.g. gallic acid). Other polyphenols that occur in pea pods include flavonoids that consist of flavanones (naringenin and hesperidin), flavanols (epicatechin and catechin), flavanols (quercetin, quercetin 3-galattoside, and rutin), flavones (luteolin, diosmin, apigenin and kaempferol 3-glucoside) and isoflavones (genistein and myricetin) (Castaldo et al., 2021).

Drying is among the earliest and oldest techniques for maintaining crop quality (Xu et al., 2020). In the food industry, drying is a traditional and unmatched physical method of food preservation that is used for both direct product preparation and additional processing (Calín-Sánchez et al., 2020). Sun drying (SD) and solar drying (SoID) have drawbacks, such as temperature swings, unregulated humidity, and unsanitary circumstances that lead to subpar food items. One of the more cost-effective and regulated methods of drying is tray drying (TD); however, at higher temperatures, colour deterioration and heat-labile nutrients, such as vitamin C, may occur. Nowadays, microwave drying (MD) is also becoming more popular because of its even energy distribution and quick

drying time. However, it also has drawbacks, such as uneven heating and texture changes. By immersing food ingredients in aqueous solutions with high osmotic pressure, including sugar and salt then drying them conventionally, osmotic dehydration (OD) is used to partially remove water from the ingredients. Leaching of soluble components from food material into the steeping solution and prolonged drying durations are the primary drawbacks of osmotic drying. By using a low temperature and vacuum, the freeze-drying method, which is based on the sublimation principle, preserves food products' original flavour, texture, aroma, and maximal nutrients. As it reduces lipid oxidation and bioactive ingredients breakdown, freeze-drying is used on an industrial scale for long-term food storage (Bashir et al., 2020). This study attempts to determine the best drying technique that maintains product stability and safety while minimizing nutrient losses, especially with regard to protein, fibre, fat, ash, and vital minerals. Enhancing nutrient retention, improving food processing methods, and promoting the creation of premium dried food items are all possible outcomes of the research.

## 2. MATERIALS AND METHODS

### 2.1 Raw Material

The pea pods were purchased from a local vegetable vendor's shelling-shelled peas in Jammu and sent to the food processing and training centre of the Division of Post Harvest Management, SKUAST-Jammu. 10% salt solution was prepared by mixing NaCl (1 g) purchased from Jammu with distilled water (9 mL). The hot water blanching procedure was used to sift, clean, and blanch the pods. To blanch, pea pods were submerged in 80°C hot water for two minutes, and then they were immediately submerged in cold running water for three minutes. The blanched pods' parchment coating was carefully removed. The pods were then divided into six lots and subjected to different drying methods at different temperatures such as T<sub>1</sub>-Sun drying (28°C for 4-5 days), T<sub>2</sub>-Solar drying (28°C for 3-4 days), T<sub>3</sub>-Tray drying (60°C

until the moisture content below 10%), T<sub>4</sub>-Microwave drying (900W until the moisture content below 10 %), T<sub>5</sub>- Freeze drying (-60°C for 10 hours), T<sub>6</sub>-Osmotic dehydration (brining) with 10% salt solution (60°C until the moisture content below 12%).

## 2.2 Analysis of Proximate and Mineral Composition

The moisture, crude fat, crude fibre and ash content of dried pea pod was determined according to AOAC (Association of Official Analytical Chemists [AOAC], 2012). The crude protein was determined by the micro Kjeldahl method (Sadasivam & Manickam, 2008). Following the ash determination, the mineral contents (potassium, magnesium and iron) were ascertained in accordance with the AOAC (2005) protocol. Every formulation ash residue was broken down using a solution of perchloric acid and nitric acid (1:4). After allowing the samples to cool, their contents were filtered using Whatman filter paper 42. Distilled water was added to each sample solution until the final amount reached 25 ml. Using an Atomic Absorption Spectrophotometer (Spectra AA 220, USA Varian), the aliquot was utilized independently to measure the mineral contents of potassium, magnesium, and iron.

## 2.3 Statistical Analysis

The data were statistically examined using analysis of variance (ANOVA) and completely randomized design (CRD). A 5% probability level was used to calculate the importance of the treatments.

# 3. RESULTS AND DISCUSSION

## 3.1 Proximate Components

The water activity of FD pea pod powder showed low water activity (0.42) due to the high removal of moisture content as a result of sublimation. The moisture content of the pea pod drastically decreased as a result of all the drying techniques. The highest moisture of 8.95 % was found in the SD sample, followed by SolD, representing 8.12% (Table 1). This could be a result of SD's variable temperature and relative humidity as opposed to TD, which uses a constant temperature to effectively remove moisture (Muyanja et al., 2012). The lower moisture content was found in freeze drying because, in contrast to conventional drying techniques, the sublimation of frozen moisture to

direct vapours causes a larger loss of water, which agrees with the findings of (Hsu et al., 2003). The crude protein concentration of PPP was significantly impacted by the various drying methods. The (FD) PPP had higher crude protein content (15.02%) followed by TD (14.79%). (Table 1).

Pea pods have a naturally low lipid content, which contributes to the low-fat level of PPP. Pea pods have a comparatively modest amount of lipids, with linoleic acid being the main fatty acid. Nonetheless, in comparison to other components, the total fat content is still quite low. The low-fat level of PPP is due to its composition makes it appropriate for uses where a lower fat intake is preferred (Mateos-Aparicio et al., 2010). The data shown in Table 1 reported the effect of different drying methods on the crude fat content of pea pods. In comparison to other drying techniques, the freeze-drying process preserved a larger level of crude fat content (1.90%) due to low-temperature and reduced exposure to damaging conditions, better preserving the lipids and yielding a higher fat content in the final powder, which is consistent with findings by (Oni et al., 2015) that showed freeze-dried edible botanicals retain more crude fat than those that are sun- or oven-dried.

The crude fibre content in dried pea pods powder was in the range of 8.95 to 7.52% (Table 1). The crude fibre is higher in FD pea pod powder because of the concentration effect and structural integrity of fibre components during drying (Siriwattananon & Maneerate, 2016). The crude fibre content followed the order of FD pea pod powder > MV dried pea pod powder > TD pea pod powder > OD dried pea pod powder > SD pea pod powder. These results are in line with the findings of (Morais et al., 2017) reporting higher crude fibre in peels of oven dried avocado and melons than the samples subjected to freeze drying. When comparing the impact of various drying techniques on the amount of ash, the highest ash content was revealed in FD pea pod powder as compared to other methods. The reason for this could be that the low temperatures and vacuum used during the freeze-drying process improved mineral retention, leading to greater ash values (116). According to (Hsu et al., 2003), higher ash content was reported in freeze-dried yam flour in comparison to oven-dried samples compatible with our findings. While comparing the sun and solar drying methods of pea pod powder, the sun and solar drying methods showed lower ash

**Table 1. Effect of drying methods on proximate composition of pea pods**

<b>Drying methods</b>	<b>Water activity (a<sub>w</sub>)</b>	<b>Moisture(%)</b>	<b>Crude protein (%)</b>	<b>Crude fat (%)</b>	<b>Crude fibre (%)</b>	<b>Ash (%)</b>	<b>Carbohydrate (%)</b>	<b>Energy (Kcal/100g)</b>
T <sub>1</sub>	0.67	8.95	12.44	1.10	7.52	5.87	62.12	308.14
T <sub>2</sub>	0.64	8.12	13.04	1.23	7.84	6.04	63.73	318.15
T <sub>3</sub>	0.57	7.98	14.79	1.79	8.01	6.81	60.31	316.51
T <sub>4</sub>	0.53	7.56	14.20	1.45	8.32	6.45	61.39	315.41
T <sub>5</sub>	0.42	5.10	15.02	1.90	8.95	7.74	62.23	326.10
T <sub>6</sub>	0.48	7.15	13.97	1.67	7.11	7.55	62.07	321.71
<b>Mean</b>	<b>0.55</b>	<b>7.47</b>	<b>13.91</b>	<b>1.52</b>	<b>7.62</b>	<b>6.74</b>	<b>61.97</b>	<b>317.67</b>
<b>CD(p≤0.05)</b>	<b>0.05</b>	<b>0.06</b>	<b>0.20</b>	<b>0.31</b>	<b>0.24</b>	<b>0.08</b>	<b>0.38</b>	<b>2.51</b>

**Table 2. Effects of drying methods on mineral composition of pea pod**

<b>Drying methods</b>	<b>Potassium(mg/100g)</b>	<b>Magnesium(mg/100g)</b>	<b>Iron(mg/100g)</b>
T <sub>1</sub>	1010.29	718.56	5.84
T <sub>2</sub>	1163.55	795.02	5.95
T <sub>3</sub>	1324.32	921.22	8.82
T <sub>4</sub>	1297.74	874.68	8.27
T <sub>5</sub>	1832.65	987.54	10.45
T <sub>6</sub>	1182.37	856.47	6.69
<b>Mean</b>	<b>1301.82</b>	<b>858.91</b>	<b>7.67</b>
<b>CD (p≤0.05)</b>	<b>4.36</b>	<b>3.69</b>	<b>0.04</b>

content (Table 1). This is because longer air exposure combined with temperature and humidity variations causes more mineral loss (Bashir et al., 2020).

### 3.2 Mineral Components

The data in Table 2 shows the effect of drying on the mineral composition of pea pods. It was observed that higher mineral content (potassium, magnesium and iron) of 1832.65, 987.54 and 10.45 mg/100g, respectively were observed in FD pea pods. The lower temperature and vacuum used in FD pea pods may have contributed to the higher mineral retention by reducing the microbial and metabolic processes that drive mineral losses. Similar results were found by (Tyagi & Pal, 2015) in freeze-dried amla fruit. Due to the greater temperature, lower humidity, and quicker drying time during solar drying as opposed to SD pea pods, the SolD sample was found to have a higher mineral content than the SD sample (Table 2). According to (Ukegbu & Okereke, 2013) observed a similar pattern in the mineral content of amaranth leaves that were subjected to solar drying and the sun.

### 4. CONCLUSION

Drying is a traditional food preservation technique. Nutrient losses vary in magnitude depending on the operating circumstances of various drying techniques. Freeze drying is highly recommended for pea pods due to its ability to retain essential nutrients, including proteins, fibre, and minerals. Unlike other drying methods, freeze drying minimizes thermal degradation, thereby preserving the structural and functional integrity of nutrients. Freeze drying uses low temperatures and vacuum, which reduces nutrient loss, whereas sun drying causes more loss due to changing ambient conditions. The dried pea pods can be used as a functional ingredient in a number of products with additional value.

### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

### REFERENCES

- Association of Official Analytical Chemists (AOAC). (2005). *Official methods of analysis* (17th ed.). Association of Official Analytical Chemists.
- Bashir, N., Sood, M., & Bandral, J. D. (2020). Impact of different drying methods on proximate and mineral composition of oyster mushroom (*Pleurotus florida*). *Indian Journal of Traditional Knowledge*.
- Calín-Sánchez, Á., Lipan, L., Cano-Lamadrid, M., Kharaghani, A., Mastalerz, K., Carbonell-Barrachina, Á. A., & Figiel, A. (2020). Comparison of traditional and novel drying techniques and its effect on quality of fruits, vegetables and aromatic herbs. *Foods*, 9, 1261. <https://doi.org/10.3390/foods9091261>
- Castaldo, L., Izzo, L., Gaspari, A., Lombardi, S., Rodríguez-Carrasco, Y., Narváez, A., Grosso, M., & Ritieni, A. (2021). Chemical composition of green pea (*Pisum sativum* L.) pods extracts and their potential exploitation as ingredients in nutraceutical formulations. *Antioxidants*, 11(1), 105. <https://doi.org/10.3390/antiox11010105>
- Hsu, C., Chen, W., Weng, Y., & Tseng, C. (2003). Chemical composition, physical properties and antioxidant activities of yam flours as affected by different drying methods. *Food Chemistry*, 83(1), 85–92.
- Mateos-Aparicio, I., Cuenca, A. R., & Suárez, M. V. J. (2010). Pea pod, broad bean pod and okara, potential sources of functional compounds. *LWT*, 43(9), 1467–1470.
- Morais, D. R., Rotta, E. M., Bonafe, E. G., Suzuki, R. M., Souza, N. E., & Matsushita, Visentainer, J. V. (2017). Proximate composition, mineral contents and fatty acid composition of the different parts and dried peels of tropical fruits cultivated in Brazil. *Journal of the Brazilian Chemical Society*, 28(2), 308–318.
- Muyanja, C., Kyambadde, D., & Namugumya, B. (2012). Effect of pretreatments and drying methods on chemical composition and sensory evaluation of oyster mushroom (*Pleurotus ostreatus*) powder and soup. *Journal of Food Processing and Preservation*, 38(1), 457–465.
- Nasir, G., Zaidi, S., & Tabassum, N. (2022). A review on nutritional composition, health benefits and potential applications of by-products from pea processing. *Biomass Conversion and Biorefinery*.

- <https://doi.org/10.1007/s13399-022-03324-0>
- Oni, M. O., Ogungbite, O. C., & Akindele, A. K. (2015). The effect of different drying methods on some common Nigerian edible botanicals. *International Journal of Advanced Research in Botany*, 1(1), 15–22.
- Sadasivam, S., & Manickam, A. (2008). Anti-nutritional factor. In *Biochemical methods for agricultural science* (pp. 215–216). New International Publication Limited.
- Siriwattananon, L., & Maneerate, J. (2016). Effects of drying methods on dietary fiber content in fruit and vegetable from non-toxic agricultural field. *International Journal of Geomate*, 11(6), 2896–2900.
- Tyagi, A., & Pal, A. (2015). Physico-chemical properties of chakiya variety of amla (*Emblca officinalis*) and effect of different dehydration methods on quality of powder. *World Journal of Pharmaceutical Research*, 4(6), 1042–1048.
- Ukegbu, P. O., & Okereke, C. J. (2013). Effect of solar and sun drying methods on the nutrient composition and microbial load in selected vegetables, African spinach (*Amaranthus hybridus*), fluted pumpkin (*Telferia occidentalis*) and okra (*Hibiscus esculentus*). *Journal of Food Science and Technology*, 2(5), 35–40.
- Xu, Y., Xiao, Y., Li, D., Liu, C., Jiang, N., Song, J., & Zhang, M. (2020). A comparative evaluation of nutritional properties, antioxidant capacity and physical characteristics of cabbage (*Brassica oleracea* var. *capitata* var. L.) subjected to different drying methods. *Food Chemistry*, 309, 124935. <https://doi.org/10.1016/j.foodchem.2019.06.002>

**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of the publisher and/or the editor(s). This publisher and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

© Copyright (2025): Author(s). The licensee is the journal publisher. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:  
The peer review history for this paper can be accessed here:  
<https://pr.sdiarticle5.com/review-history/134419>