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Development of dried *Salvadora persica* (Pilu) fruit powder: Its nutritional evaluation and storage stability

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Abstract

Salvadora persica (Pilu) is an underutilized fruit species naturally distributed in the arid and semi-arid regions of India and is valued for its nutritional composition, antioxidant potential, and medicinal properties. However, its utilization remains limited owing to its seasonal availability, highly perishable nature, and the lack of standardized processing techniques. Therefore, the present study was undertaken to develop dried *Salvadora persica* (Pilu) pulp powder and evaluate its nutritional characteristics.

Dried *Salvadora persica* (Pilu) fruits procured from Jodhpur, Rajasthan, were processed into pulp powder by subjecting them to cleaning, soaking, deseeding, hot-air oven drying, pulverization, and sieving. The prepared powder was thereafter evaluated for its proximate composition, mineral composition, vitamin C content, and antioxidant activity following standard analytical methods.

Nutritional characterization of the developed dried *Salvadora persica* (Pilu) pulp powder demonstrated appreciable levels of carbohydrates, calcium, vitamin C, and antioxidant constituents, highlighting its potential as a functional food ingredient. The developed powder exhibited favourable nutritional attributes and significant antioxidant activity, making it suitable for incorporation into value-added food products. Moreover, the processing technique enhanced the storage stability of the fruit while preserving its nutritional and functional qualities.

The present study indicates that dried *Salvadora persica* (Pilu) pulp powder is a promising functional food ingredient due to its desirable nutritional characteristics and antioxidant potential. Processing the fruit into pulp powder not only improves its shelf life and utilization but also enhances its commercial prospects, encouraging its sustainable exploitation and incorporation into value-added, health-promoting food products.

Keywords: *Salvadora persica*, Pilu fruit, pulp powder, nutritional characterization, antioxidant activity, functional food ingredient, hot-air drying

1. Introduction

Salvadora persica L. (Pilu), belonging to the Salvadoraceae family, is an underexploited fruit species commonly found in the arid and semi-arid regions of India, especially Rajasthan and Gujarat, as well as in various parts of Asia, Africa, and the Middle East. *S. persica* is a drought- and salt-resistant species naturally suited to harsh environments [8]. It has important ecological role and traditional significance in desert ecosystems [15]. While different parts of the plant have been traditionally used for food, fodder, oral care, and medicine, the edible fruits remain largely underused despite their notable nutritional and functional benefits [3].

Salvadora persica (Pilu) fruit is rich in various valuable nutrients and bioactive compounds such as carbohydrates, dietary Fiber, vitamin C, essential minerals, phenolic compounds, flavonoids, and other phytochemicals. The fruit is nutrient-dense and exhibits significant antioxidant activity [13]. It has been identified that multiple phenolic acids and flavonoids contribute to its potent antioxidant and anti-inflammatory effects [11]. Additionally, it's highlighted that these phytochemicals play key roles in the antimicrobial, antioxidant, anti-inflammatory, and other health benefits of *S. persica*, underscoring its promise as a functional food ingredient [1, 9].

Although *Salvadora persica* (Pilu) fruit has significant nutritional and therapeutic benefits, its use in processed foods is limited due to seasonal availability, high perishability, and a lack of standardized processing methods. It's reported that drying is an effective preservation technique that lowers moisture content, enhances storage stability, and helps maintain much

of the fruit's nutritional quality ^[10]. Moreover, fruit powders made from underutilized fruit pulp are valuable functional food ingredients because they concentrate nutrients and bioactive compounds ^[19]. It's also noted that turning underutilized fruits into powder extends shelf life, simplifies handling and storage, and makes them more suitable for use in diverse food products ^[16].

Fruit powders derived from underutilized crops are gaining popularity as they offer natural antioxidants, vitamins, minerals, and dietary Fiber while also extending the shelf life of products. Drying and powder production are effective value-adding methods that reduce post-harvest losses and boost the commercial use of underutilized fruits ^[18]. Similarly, its highlighted that processing these fruits into powders and other forms increases their economic value and supports food and nutritional security ^[14]. The dried fruit powders provide a practical solution to enhance the use of underexploited arid-zone fruits and expand their market potential ^[4].

While many studies have explored the phytochemical profile and medicinal benefits of *Salvadora persica*, there is limited scientific data on the development of dried Pilu pulp powder and its detailed nutritional assessment. This study aimed to create dried *Salvadora persica* (Pilu) pulp powder using a standardized process and to analyse its nutritional properties, including proximate composition, mineral levels, vitamin C content, antioxidant activity, and phytate content. The results are intended to provide scientific validation of the nutritional value of dried Pilu pulp powder and encourage its sustainable use and commercial application as a functional food ingredient.

2. Materials and Methods

2.1 Locale and procurement of raw material

The present investigation was carried out during 2025-2026 in the Foods and Nutrition Laboratories, Department of Food Science and Nutrition, College of Community and Applied Sciences (CCAS), Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur, Rajasthan, India. Microbiological analysis of the developed product was performed at the College of Dairy and Food Technology (CDFT), MPUAT, Udaipur. Dried *Salvadora persica* (Pilu) fruits used for the study were procured from Jodhpur, Rajasthan.

2.2 Preparation of Dried Pilu fruit powder

Dried *Salvadora persica* (Pilu) fruits were manually sorted and cleaned to remove dust, foreign materials, and other impurities. The cleaned fruits were soaked in potable water for approximately 15-20 min to facilitate seed removal, after which the seeds were separated manually. The resulting pulp was spread uniformly on stainless-steel trays and dried in a hot-air oven until a constant weight was achieved. After drying, the pulp was allowed to cool to room temperature and pulverized into a fine powder using an electric grinder. The powder was subsequently passed through a fine-mesh sieve to obtain a uniform particle size, packed in airtight polyethylene containers, and stored under ambient conditions until further nutritional evaluation.

2.3 Nutritional evaluation of dried Pilu pulp powder

The developed dried Pilu powder was analysed for its nutritional composition using standard analytical procedures.

2.3.1 Proximate composition

The proximate constituents, namely moisture, ash, crude protein, crude fat, and crude fibre, were analysed according to the standard methods ^[2].

2.3.2 Mineral analysis

The mineral composition of the developed dried *Salvadora persica* (Pilu) powder was determined using standard analytical procedures. Calcium content was estimated by the EDTA titrimetric method described by Cheng and Bray ^[6], iron content was analysed using Atomic Absorption Spectrophotometry (AAS) following the method of Bishnoi and Brar ^[5], and sodium content was determined using a flame photometer according to the procedure described by Chikhale and Chikhale ^[7].

2.3.3 Determination of vitamin C

The vitamin C content of the developed dried *Salvadora persica* (Pilu) pulp powder was determined using the 2, 6-dichlorophenol indophenol (DCPIP) dye titration method following the standard procedure ^[2]. The vitamin C content was expressed as milligrams of ascorbic acid per 100 g of sample.

2.3.4 Determination of antioxidant activity

The antioxidant activity of the developed dried *Salvadora persica* (Pilu) pulp powder was evaluated using the 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay. Methanolic extracts of the sample were prepared and allowed to react with the DPPH reagent, after which the absorbance was recorded using a UV-Visible spectrophotometer. The antioxidant activity was expressed as percentage DPPH radical scavenging activity.

2.4 Shelf-life assessment

The developed dried *Salvadora persica* (Pilu) pulp powder was packaged in airtight polyethylene pouches and stored under ambient conditions for a period of 30 days to assess its storage stability. Samples were withdrawn at 0, 10, 20, and 30 days for analysis. Changes in moisture content were monitored throughout the storage period using the standard hot-air oven method. The microbiological quality of the powder was evaluated by determining the total viable count (TVC) using the pour plate method on nutrient agar according to standard APHA procedures, and the results were expressed as colony-forming units per gram (CFU/g). The storage study was undertaken to determine the shelf stability and microbiological safety of the developed dried *Salvadora persica* (Pilu) pulp powder under ambient storage conditions.

2.5 Statistical analysis

All experiments were conducted in triplicate, and the data were presented as mean $\pm$ standard deviation (SD). Variations in moisture content and microbial load during the storage period were analysed using a Nested Completely Randomized Design (Nested CRD). Statistical significance was assessed at a probability level of $P \leq 0.05$.

3. Results and Discussion

3.2.1 Proximate Composition

The proximate composition of the developed dried *Salvadora persica* (Pilu) fruit powder is presented in Table 1. The developed powder exhibited low moisture content

($8.32 \pm 0.37\%$), ash content of $8.53 \pm 0.15\%$, crude protein of $1.43 \pm 0.05\%$, crude fat of $1.93 \pm 0.81\%$, crude fibre of $1.55 \pm 0.19\%$, carbohydrate content of $86.25 \pm 0.82\%$, and an energy value of 368.15 ± 3.86 kcal/100 g. The low moisture content together with the high carbohydrate and appreciable mineral contents indicates that the developed powder possesses desirable nutritional quality and improved storage stability.

Comparable findings were reported by Kumari *et al.* [17], who observed $8.12 \pm 0.35\%$ moisture, $10.44 \pm 1.93\%$ crude fibre, and reported that *Salvadora persica* fruit contained appreciable amounts of carbohydrates and minerals. Likewise, Khursheed *et al.* [12] reported $9.37 \pm 0.31\%$ ash, $11.45 \pm 0.36\%$ crude fat, $5.92 \pm 0.21\%$ crude protein, $73.66 \pm 1.34\%$ carbohydrates, and an estimated energy value of approximately 413 kcal/100 g in dried *Salvadora persica* fruit. The variations observed between the present study and previous reports may be attributed to differences in cultivar, geographical origin, maturity stage, drying conditions, and processing methods, which are known to influence the proximate composition of dried fruit powders.

Overall, the developed dried *Salvadora persica* (Pilu) fruit powder exhibited a favourable nutritional profile characterized by low moisture content, high carbohydrate concentration, appreciable mineral content, and moderate levels of protein, fat, and dietary fibre. These findings highlight its potential as a functional food ingredient and support its utilization in the development of nutritionally enriched value-added food products.

Table 1: Proximate composition of Pilu powder (100 grams)

S. No.	Nutrients	Pilu powder
1.	Moisture (g)	0.32 ± 0.03
2.	Ash (g)	8.53 ± 0.15
3.	Fat (g)	1.93 ± 0.81
4.	Crude protein (g)	1.43 ± 0.05
5.	Crude Fiber (g)	1.55 ± 0.19
6.	Carbohydrate (g)	86.25 ± 0.82
7.	Energy (kcal)	368.15 ± 3.86

All values are Mean $\pm$ SD of 3 observations

3.2.2 Minerals Composition and Vitamin C content

The mineral composition and vitamin C content of the developed dried *Salvadora persica* (Pilu) fruit powder are presented in Table 2 and 3. The analysis revealed that the powder contained 1012.66 ± 0.57 mg/100 g calcium, 0.138 ± 0.004 mg/100 g iron, 30.43 ± 0.25 mg/100 g sodium, and 66.01 ± 0.65 mg/100 g vitamin C. These findings indicate that the developed powder is a valuable source of essential minerals, particularly calcium, along with an appreciable amount of vitamin C, thereby enhancing its nutritional quality and supporting its potential use as a functional food ingredient.

Comparable observations were reported by Kumari *et al.* [13] who demonstrated that *Salvadora persica* fruit is a good source of calcium, iron, vitamin C, and other essential nutrients, emphasizing its nutritional importance as an underutilized fruit crop. Likewise, Farag *et al.* [9] described *S. persica* as a nutrient-rich plant containing considerable amounts of calcium, sodium, potassium, magnesium, iron, and vitamin C, all of which contribute to its nutritional as well as therapeutic properties. The differences between the present findings and those reported in earlier studies may be attributed to variations in cultivar, agro-climatic conditions,

soil characteristics, stage of fruit maturity, and processing techniques, all of which are known to influence the nutrient composition of plant materials.

Overall, the developed dried *Salvadora persica* (Pilu) fruit powder exhibited a favourable nutrient profile, characterized by a high calcium content together with an appreciable amount of vitamin C. These results highlight its nutritional significance and support its utilization as a promising functional ingredient for the development of value-added food products.

Table 2: Mineral content of dried pilu powder (g per 100 g)

S. No.	Nutrients	Pilu powder
1.	Sodium (mg)	30.43 ± 0.25
2.	Calcium (mg)	1012.66 ± 0.57
3.	Iron (mg)	0.138 ± 0.004

All values are Mean $\pm$ SD of 3 observations

Table 3: Vitamin C content of dried Pilu powder (per 100 g)

Parameter	Pilu powder
Vitamin C	66.01 ± 0.65

All values are Mean $\pm$ SD of 3 observations

3.2.3 Antioxidant Activity

The antioxidant activity of the developed dried *Salvadora persica* (Pilu) fruit powder is presented in Table 4. The developed powder exhibited a DPPH radical scavenging activity of $67.20 \pm 0.43\%$, indicating its high antioxidant potential. The antioxidant activity may be attributed to the presence of phenolic compounds, flavonoids, vitamin C, and other bioactive constituents in *S. persica*.

Comparable findings were reported by Khanam *et al.* [11] who observed significant antioxidant activity in *Salvadora persica* fruit due to its high phenolic and flavonoid content. Similarly, Farag *et al.* [9] highlighted that the antioxidant properties of *S. persica* are associated with its diverse phytochemicals, including phenolics and flavonoids. Minor variations between the present study and previous reports may be attributed to differences in fruit maturity, processing conditions, and analytical methods.

Overall, the developed dried *Salvadora persica* (Pilu) fruit powder exhibits considerable antioxidant activity, supporting its potential as a functional food ingredient and a natural source of antioxidants.

Table 4: Antioxidant activity of dried Pilu powder (per 100 g)

Parameters	Pilu Powder
DPPH percent Inhibition	67.2 ± 0.43

All values are Mean $\pm$ SD of 3 observations

3.3 Shelf-life assessment of the dried Pilu Pulp Powder

3.3.1 Effect of storage on Moisture content

The moisture content of the developed dried *Salvadora persica* (Pilu) fruit powder increased significantly ($p < 0.05$) during the 30-day storage period, as presented in Table 5. The gradual increase in moisture content may be attributed to the hygroscopic nature of the dried fruit powder, which tends to absorb moisture from the surrounding environment despite being packed in airtight polyethylene pouches. Similar observations were reported by Pui *et al.* [17] who found that fruit powders readily absorb moisture during storage because of their hygroscopic properties, resulting in changes in physicochemical characteristics. The authors further emphasized that appropriate packaging and

controlled storage conditions are essential for minimizing moisture uptake and maintaining the quality and shelf life of dried fruit powders.

Table 5: Effect of storage on Moisture content of dried Pilu Pulp Powder

S.NO.	Product	Day 0	Day 10	Day 20	Day 30
4.	Pilu powder	0.32 ± 0.03	0.45 ± 0.04	0.58 ± 0.05	0.71 ± 0.06
	SE		0.012		
	CD		0.78**		

All observations are Mean ± SD of 3 observations **Significant at 5% level of significance

3.3.2 Microbial analysis

The total viable count of the developed dried *Salvadora persica* (Pilu) fruit powder showed a significant ($p < 0.05$) increase over the 30-day storage period, as presented in Table 6. This gradual rise in microbial population may be attributed to the extended storage duration under ambient conditions, which can permit limited microbial proliferation even when the product is stored in airtight polyethylene pouches. Nevertheless, the microbial counts remained within the acceptable permissible limits throughout the storage period, demonstrating the microbiological stability of the developed dried Pilu fruit powder and confirming its suitability for safe storage under ambient conditions for up to 30 days.

Table 6: Total Plate Count in dried Pilu Pulp Powder

Days	Cfu/ml in 10^{-3} dilutions	Cfu/ml in 10^{-4} dilutions
0	Nil	Nil
10	Nil	Nil
20	5×10^3	Nil
30	14×10^3	2×10^4

4. Conclusion

The present study successfully developed dried *Salvadora persica* (Pilu) fruit powder and demonstrated its potential as a nutritionally valuable functional ingredient. The developed powder was characterized by a desirable nutritional composition, including appreciable levels of essential minerals, vitamin C, and antioxidant activity, highlighting its nutritional and functional significance. During the 30-day storage period under ambient conditions, only slight increases in moisture content and microbial load were observed, while both parameters remained within acceptable limits, indicating good storage stability and microbiological safety. Overall, the findings indicate that processing *Salvadora persica* fruits into dried powder is a practical strategy for extending shelf life, enhancing the utilization of this underutilized fruit, and supporting its incorporation into functional food formulations as well as its sustainable commercialization.

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References

- Aljarbou AN, Alshammari MA, Alnasser SM, Alotaibi NH, Alnasser MA. *Salvadora persica*: A review of its phytochemistry, pharmacological properties, and therapeutic potential. *Journal of Ethnopharmacology*. 2022;289:115036.
- AOAC International. Official methods of analysis of AOAC International. 17th ed. Gaithersburg (MD): AOAC International; 2000.
- Aumeeruddy MZ, Zengin G, Mahomoodally MF. A review of the traditional and modern uses of *Salvadora persica* L. (Miswak): Toothbrush tree of Prophet Muhammad. *Journal of Ethnopharmacology*. 2018;213:409-444.
- Bairwa SK, Gupta NK, Gupta S, Singh J, Bairwa LN. Economically important underutilized fruits suitable for arid eco-system: A review. *Indian Journal of Arid Horticulture*. 2023;4(1-2):41-46.
- Bishnoi RR, Brar SPS. A handbook of soil testing. Ludhiana: Punjab Agricultural University; 1988.
- Cheng KL, Bray RH. Determination of calcium and magnesium in soil and plant material. *Soil Science*. 1951;72(6):449-458.
- Chikhale HU, Chikhale PU. Flame photometric estimation of sodium and potassium ion present in water sample of Darna and Godavari River. *International Journal of Scientific and Engineering Research*. 2017;8(1):131-135.
- Dhakad A, Chouhan T, Meena SK, Khan S, Neha. Production technology of Pilu (*Salvadora persica* L.). In: *Modern Production Technology of Underutilized Fruit Crops*. Jaipur: Yash Publication; 2024. p. 331-343.
- Farag MA, Abdel-Mageed WM, El Gamal AA, Basudan OA. *Salvadora persica* L.: Toothbrush tree with health benefits and industrial applications-A review. *Saudi Pharmaceutical Journal*. 2021;29(7):751-760.
- Khanal S, Ojha P, Karki R. Effect of drying methods on nutritional, physicochemical and functional properties of bael (*Aegle marmelos*) fruit powder. *Journal of Food Processing and Preservation*. 2023;47(6):e17302.
- Khanam A, Ahmad A, Iftikhar N, Ali Q, Qureshi MI. Variation in phenolic profile, antioxidant, and anti-inflammatory activities of *Salvadora oleoides* Decne. and *Salvadora persica* L. fruits and aerial part extracts. *Life*. 2022;12(9):1446.
- Khurshid N, Abdel-Maksoud MA, Alrokayan S, Afzal K, Zubairi MN, Sultan MT, et al. *Salvadora persica* fruit methanolic extract, nutritional profiling, therapeutic potential in high-fat diet-induced hyperlipidemic rats: *in vivo*, *in vitro*, and *in silico* approaches. *Food Science & Nutrition*. 2026;14(3):e71595.
- Kumari S, Yadav A, Kumar S. Nutritional composition, antioxidant activity and mineral profile of *Salvadora persica* fruit. *International Journal of Current Microbiology and Applied Sciences*. 2017;6(9):1705-1712.
- Meena VS, Gora JS, Singh A, Ram C, Meena NK, Pratibha, et al. Underutilized fruit crops of Indian arid

- and semi-arid regions: Importance, conservation and utilization strategies. *Horticulturae*. 2022;8(2):171.
15. Mekhemar M, Geib M, Kumar M, Radha, Hassan Y, Dörfer C. *Salvadora persica*: Nature's gift for periodontal health. *Antioxidants*. 2021;10(5):712.
 16. Poonia G, Kumar S. Exploring bioactive compounds in underutilized fruit crops of arid and semi-arid regions: A comprehensive review. *Journal of Scientific Research and Reports*. 2024;30(7):728-742.
 17. Pui L, Saleena L, Ghazali H. Storage stability and anti-caking agents in spray-dried fruit powders: A review. *Foods and Raw Materials*. 2024;12(2):229-239.
 18. Rawat S, Das KK. Value addition of underutilized fruits of arid region: A review. *International Journal of Chemical Studies*. 2020;8(4):1655-1659.
 19. Tak SK, Sharma A, Sharma S. Underutilized fruits: A potential source of bioactive compounds and functional food ingredients. *Journal of Food Measurement and Characterization*. 2024;18:1-15.