Original Research Article

Optimization and Characterization of Freeze-Dried Pumpkin Powders: Powder Quality and Nutrient Stability

ABSTRACT

Being a good source of nutrients, viz., ascorbic acid, β-carotene, phenols, and antioxidants, pumpkin pulp (*Cucurbita moschata*) can be utilised as a functional ingredient in many food products by converting them into a more stable product like pumpkin powder. Hence the present study is focused on the production of freeze-dried pumpkin powder by two different methods (drying in petri plates with 5mm sample thickness and in 250 ml flask). The moisture content and water activity were reduced by 92.50% and 74.73%, respectively, compared to the fresh pumpkin pulp, indicating safe storage limits. Freeze-dried pumpkin powders exhibited a decrease of 25% ascorbic acid, 21.58% β-carotene, 39.39% reduction in total polyphenols and 89.58% in antioxidant content. The powder properties of the developed freeze-dried powders exhibited water activity of $0.4a_w$ to $0.35a_w$ bulk density of 0.15 to 0.12 g cm^{-3}, and flowability of 18.39° to 22.74°.

Keywords: Pumpkin, freeze-drying, nutritional properties, powder quality

1. INTRODUCTION

Cucurbita moschata, commonly known as winter squash or pumpkin, is a highly nutritious crop rich in carotenoids, vitamins, dietary fibre, minerals, phenolic compounds, and bioactive substances [1]. The fruit pulp is a rich source of beta-carotene, vitamin A, tocopherol, and dietary fibre. It aids in regulating insulin, lowering blood sugar, improving glucose tolerance, and offers anti-obesity, anti-diabetic, antibacterial, and anticancer effects Incorporating [1] [2]. This versatile crop not only offers a wide array of essential nutrients but also shows promising medicinal value, highlighting its significance in enhancing overall health and nutrition.

Conventional drying methods for pumpkin pulp are hindered by several challenges, like depletion of nutrients and the lengthy drying process. Even though drying process enhances specific nutrients like β-carotene and protein, it also results in decreased levels of zinc, iron, calcium, and energy due to oxidation [3]. Moreover, traditional techniques may not adequately conserve the nutritional quality and visual appeal of pumpkins, giving rise to issues such as nutrient loss, machine sticking, and saccharification during the manufacturing process [4]. These limitations underscore the significance of exploring novel drying methodologies, such as freeze drying, to effectively uphold the nutritional value and excellence of pumpkin powder.

Freeze-drying plays a crucial role in the preservation of pumpkin pulp, as it aids in the retention of its nutritional composition and prolongs its shelf life. Studies have demonstrated that the freeze-drying process of pumpkin pulp leads to superior preservation of essential nutrients such as total carotenoids, proteins, and total phenolic compounds when compared to alternative drying methods [5][6]. Moreover, freeze-drying plays a pivotal role in upholding the intrinsic characteristics of the pumpkin powder, including moisture content, particle size, and density, thereby ensuring the secure storage of the final product [7]. Additionally, the efficacy of freeze-drying in maintaining bioactive compounds and antioxidant properties in fruits like carnauba underscores its potential to safeguard the nutritional attributes of pumpkin pulp over an extended period[8]. In conclusion, freeze-drying is a valuable method for the preservation of pumpkin pulp, safeguarding its nutritional integrity, and augmenting its shelf stability.

2. MATERIAL AND METHODS

The present study was carried out in the Department of Postharvest Management, College of Agriculture, Vellayani. Fruits of pumpkin (*Cucurbita moschata*) variety 'Ambili', which were discarded as waste at the vegetable seed production unit of the College of Agriculture, Vellayani, were employed for the research. The pumpkin pieces were washed, peeled, cut into small pieces with a vegetable cutter, ground using a mixer grinder, and strained to extract the pulp. The pulp was then pre-feezed at -20°C for 4-5 hrs. and freeze-dried under vacuum at -48 ± 2 °C condenser temperature. The frozen pulp thus obtained was freeze-dried in both petri plates and in a 250ml flask. The temperature of the heating plate was maintained constant throughout the process of drying. The dried pulp was converted into powder using a blender. The experiment was done in CRD with two treatments replicated ten times using the statistical web application 'GRAPES' [9]

Biochemical and nutritional quality parameters of the freeze-dried powder were assessed. Moisture content[10], ascorbic acid, β carotene, total polyphenol content [11], crude fibre [12] and total antioxidant activity [13] were analysed.

Physical quality parameters such as water activity were discerned using the NovasinaLabSwift-aw water activity meter (M/s. Novasina..AG, Neuheimstrasse 12, CH-8853 Lachen, Switzerland); bulk density by tapping method [14] and the angle of repose was measured to characterize the flowability of freeze-dried powders through fixed funnel method.

3. RESULTS AND DISCUSSION

3.1 Biochemical and nutritional quality parameters

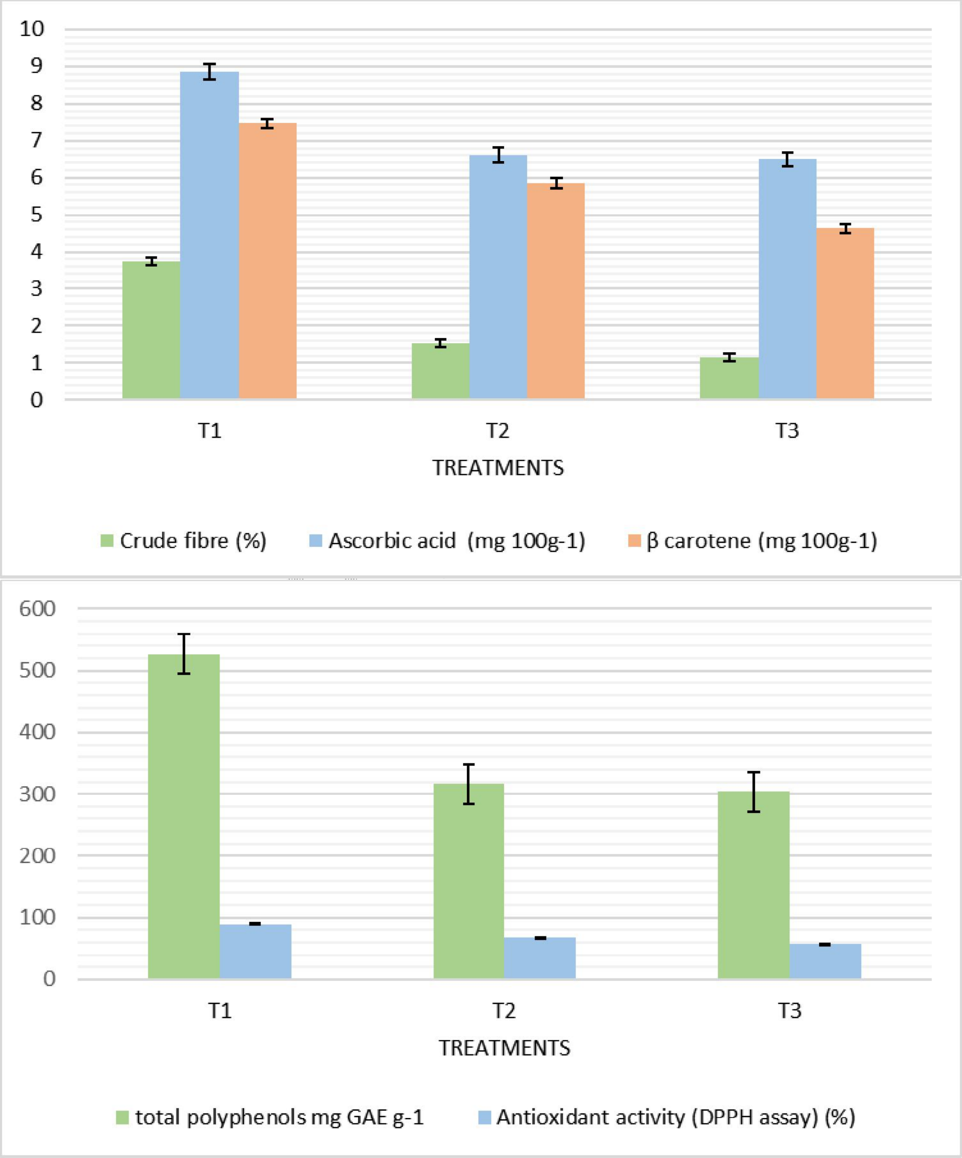
The biochemical and nutritional quality parameters of the fresh pumpkin pulp and developed freeze-dried powders are depicted in Figure 1.

Fresh pumpkin pulp exhibited a moisture content of 92.5% which was reduced to 1.98% for FDPP and 2.81% for FDPF. The moisture content of FDPF was greater than FDPP. Similar results were obtained for the moisture content of freeze-dried mango (4%), guava (5%) and strawberry slices (9%) [15]. Freeze-dried powders exhibit a very low moisture content which aids in their storage for a longer period of time [16]. The ascorbic acid content of the developed freeze-dried powders was lower compared to that of the fresh pumpkin pulp (8.85 mg $100g^{-1}$). An ascorbic acid content of 6.6 mg $100g^{-1}$ was exhibited by FDPP and 6.49mg $100g^{-1}$ by FDPF. A loss of about 25% of ascorbic acid was observed. Similarly, a loss in ascorbic acid content was observed in freeze-dried tomatoes (8.2% loss), guava (37%), mango (26.92%) and pineapple (24.20%) [15] [17].

β-carotene content of the fresh pumpkin pulp was found to be 7.46mg $100g^{-1}$. This was reduced to 5.85 mg 100 g^{-1} for FDPP and 4.63 mg 100 g^{-1} for FDPF. A reduction of about 21.58 % was observed for the β-carotene content. Freeze-drying retains more β-carotene content compared to other drying methods [18]. A reduction in β-carotene content of 15.75 % in carambola, 8.6% in papaya, 43.1% in watermelon, and 26.19% in freeze-drying were observed [19].

The total polyphenol content of the fresh pumpkin pulp was 526.81 mg GAE g^{-1}. The developed FDPP exhibited 316.62 mg GAE g^{-1}, and FDPF exhibited 303.80 mg GAE g-1, accounting for a loss of about 39.39%. Retention of the majority of the phenolic compounds in freeze-dried strawberry and white zapote were also reported [20] [21]. A crude fibre content of 3.74% was recorded for the fresh pumpkin pulp. FDPP showed a crude fibre content of 1.52% and FDPF showed a crude fibre content of 1.15%. Similar retention in crude fibre content in free-dried watermelon rind was observed [22]. 89.58% of antioxidant activity was observed for fresh pumpkin pulp, 67.90% for FDPP and 57.11% for FDPF. Antioxidant activity was reduced to only 24.20% after the freeze-drying process. A similar result was observed for Chilean guava, where the antioxidant content was reduced to 33.30% of the fresh fruit [23].

Figure I & II: Nutritional parameters in fresh pumpkin pulp and freeze-dried pumpkin powder



T1- Fresh pumpkin pulp
T2 -Freeze-dried pumpkin powder in petri plate

T3- Freeze-dried pumpkin p[owder in flask

3.2 Physical quality parameters

The physical quality parameters of the developed freeze-dried powders are depicted in Table 1.

The water activity of the fresh pumpkin pulp was recorded as 0.95 a_w. FDPP exhibited a water activity of $0.24a_w$ and FDPF, $0.35a_{w.}$ A reduction of about 74.73% in water activity of the freeze-dried powders were observed. Water activity values between 0.20 and 0.40 are found to be stable during storage as it reduces the chances of browning and oxidation. Water activity of 0.2 was observed for freeze-dried acerola powder and 0.26 for freeze-dried sour cherry powder [24] [25].

Bulk density is an important parameter in powder production for packaging, storage, and transport. Freeze-dried pumpkin powders exhibited a bulk density of 0.15g cm^{-3} for FDPP and 0.12 g cm^{-3} for FDPF. A similar bulk density of 0.13 g cm^{-3} was observed for freeze-dried pumpkin powder in another study [6]. Flowability (angle of repose) of the developed freeze-dried pumpkin powders done using fixed funnel method recorded a value of 18.39° for FDPP and 22.74° for FDPF. A similar result was reported in freeze-dried jamun powder which recorded an angle of repose of 29° [26].

Table 1: Physical properties of freeze-dried powder

4. CONCLUSION

In the present study, freeze-drying of pumpkin pulp was done in petri plates and in 250 ml flasks and their physicochemical characteristics were analysed. Freeze-drying of the pumpkin pulp in petri plates exhibited higher nutrient retention and physical quality parameters compared to the freeze-dried pulp in 250 ml bulb. Physical quality parameter values represented excellent powder quality characteristics for the developed freeze-dried powders.

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Treatments	Moisture content (%)	Water activity (aw)	Bulk density(g/ml)	Flowability(Angle of repose)(degree)
T1 (Petri plate)	1.98	0.24	0.15	18.39
T2 (flask)	2.81	0.35	0.12	22.74
SE(± m)	0.041	0.002		1.171
CD (0.05)	0.123	0.006	NS	3.479

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

FDPP: Freeze-Dried Powder in Petriplate
FDPF: Freeze-Dried Powder in Flask