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Influence of maltodextrin concentration on.physico-chemical characteristics of spray dried pumpkin (*Cucurbita moschata* L.) powder

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Abstract

Due to high water content, beverages are prone to microbial spoilage, enzymatic reactions, resulting in short shelf life and quality degradation. Converting into a powder form, makes it effortless to carry around, store, preserve, and use as an ingredient in product formulations. Decreased moisture as well as water activity lend to prolong powder's shelf life. Spray-drying is a quick, continuous, affordable, and reproducible dehydration technique for transforming liquids into powders by atomization using a hot drying medium, commonly air. Being a plentiful source of vitamins and minerals, pumpkin pulp is a viable option for converting to spray-dried powder thus extending its shelf life. In the current study, different spray-dried powder formulations were prepared with pumpkin pulp: carrier (maltodextrin) ratios as 70:30, 60:40 and 50:50 at 150°C drier inlet temperature and the influence of maltodextrin concentration on physico-chemical characteristics of spray dried pumpkin were analysed keeping outlet temperature, pressure and blower capacity constant at 65°C, 2kg/cm^2 and 50% respectively. A noteworthy curtailment in the nutritional parameters was discerned in spray dried pumpkin powder compared to the fresh pumpkin pulp. Assessment of physicochemical properties revealed a significant reduction in titratable acidity, ash, antioxidant activity, total polyphenols, ascorbic acid, β-carotene and moisture content of the powders and an increase in total soluble solids, water activity, sugars and bulk density with the increase in maltodextrin concentration. Crude fibre content was not detectable in spray dried powders.

Keywords: Carrier, Maltodextrin, Pumpkin powder, Spray drying

Introduction

Traditional beverage production entails diverse unit operations that elevate the risk of contamination. Due to the presence of high water content, beverages are prone to microbial spoilage and enzymatic reactions, resulting in short shelf life and quality degradation. Fruit juice powders are superior to their liquid counterparts in a number of ways, viz., enhanced shelf life; easier preservation, handling, transit, and storage; and reduced volume, weight, and packaging (Wu et al., 2006). Pumpkin, a widely cultivated and versatile vegetable, is an excellent source of antioxidants, β-carotene, polyphenols, carbohydrates and energy (Dini et al., 2013) and is suited for powder production. Drying and powdering will help reduce the moisture content, water activity and thus help in storage of powders for a longer period. There are several techniques to dry fruits and vegetables, which include freeze-drying, spray-drying, microwave drying, sun-drying, natural and forced convective drying. Different drying methods operate under different conditions and each and every drying technique has

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advantages and drawbacks of its own. The high sugar content causes it to become sticky during high-temperature drying by a mechanical drier, which renders it difficult to turn into powder. Spray-drying (S-D) is a quick dehydration process that transmutes liquid foods into powders (Tontul and Topuz, 2017). Higher yields, quicker drying time, cheaper production costs and improved moisture removal are a few advantages of spray drying (Nowshin et al., 2023). The three fundamental steps in spray drying are atomizing the liquid feed, combining tiny droplets with hot air to parch them and separating the parched particles from the air stream for assemblage.

Spray-dried pumpkin powder has important applications in the food sector. It serves as a valuable ingredient for food manufacturers as it can be utilized for the production of various products such as fortified foods, infant foods, nutritional supplements, Ready To Eat foods, bakery and confectioneries. The powdered form of the pulp possesses an inherent stickiness, given that the low molecular weight sugars exhibit a lower glass transition temperature, high hygroscopicity and low melting point, making it difficult to convert or store in the natural form. For these reasons, the addition of carrier agents or drying aids like maltodextrin (MD), gum arabica, etc. is recommended, which lowers the bulk density, hygroscopicity, moisture content, degree of caking and improves the rehydration capacity (Jiang et al., 2013).

Spray drying is a rapid, inexpensive, and continuous process that transforms a solution into dried powder efficiently while **c**onvective drying, on the other hand, is a slower process that results in lower porosity in the dried powders, affecting rehydration capacity. S-D powders have a short dissolution time in water, while convectively dried powders do not completely dissolve, indicating differences in rehydration properties (Barbosa et al., 2015). According to Mudalip et al. (2021), Spray drying and freeze drying are commonly used techniques for encapsulating bioactive compounds from food and herbal plant sources. Spray drying is preferred for its low operating cost and flexibility, making it a better economic option compared to freeze drying. Both techniques can produce good quality products based on the types of wall materials and process conditions used.

The low glass transition (*Tg*) temperature in the pumpkin pulp causes stickiness due to increased sugar and organic acid content. Therefore, the addition of wall materials with low *Tg*, like maltodextrin, is added. Maltodextrin forms a compatible matrix with the solid materials in the pulp to increase the overall glass transition temperature of the powders, aiding in overcoming stickiness and caking during spray drying (Fang and Bhandari, 2012; Caliskan and Dirim, 2013).

Fruit powder's physical and chemical traits vary depending on the drying technique adopted and characteristics of the S-D powder are profoundly impacted by the type of feed and the drying environment during spray drying. Hence, an experiment was undertaken at the Department of Postharvest Management, College of Agriculture, Vellayani, during 2023-24 to study the influence of MD concentration on the physicochemical characteristics of S-D pumpkin (*Cucurbita moschata* L.) powder.

Materials and methods

Fruit pieces of pumpkin (*Cucurbita moschata*) variety Ambili, discarded as waste in the vegetable seed production unit of College of Agriculture, Vellayani was utilized for the study. The pieces were washed, peel removed, cut into small pieces using a vegetable cutter, ground using a mixer grinder and strained to get pulp. The pulp was mixed with carrier material, maltodextrin (DE 20) in three different ratios viz., 70:30, 50:50 and 60:40 to prepare the feed and was fed into the spray drying machine (lab spray dryer LS-D-48 by JISL) at 150°C inlet temperature for preparation of spray-dried pumpkin powders (Plate 1.). The feed mixes with the hot air in the drying chamber and is converted to powder

Plate I. Spay dried pumpkin powders at different maltodextrin concentration

form during atomisation, which was collected from the cyclone separator. The outlet temperature, atomization pressure and blower capacity were maintained constant at 65°C, 2 kg/cm^2 and 50%, respectively. The experiment was accomplished in CRD with three treatments replicated five times using the statistical web application GRAPES developed by Gopinath et al. (2021).

Biochemical and nutritional quality parameters of the prepared powder were assessed using standard procedures. Total Soluble Solids (TSS) (°B) of the juice powder was discerned using a hand refractometer (ERMA). Titratable acidity, ash, moisture content, reducing and total sugar (titrimetric method of Lane and Eynon, 1923), ascorbic acid, β carotene and total polyphenol content of the pumpkin powder were determined (Ranganna, 1986). Crude fibre content was appraised using the method depicted by Sadasivam and Manickam (1996). The total antioxidant activity was discerned using a 2, 2- diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay depicted by Sharma and Bhat (2009).

Physical properties viz., water activity was discerned using Novasina LabSwift-aw water activity meter (M/s. Novasina AG, Neuheimstrasse 12, CH-8853 Lachen, Switzerland); bulk density by tapping method (Bhandari et al., 1992) and the static angle of repose was measured to characterize the flowability of spray dried powder through fixed funnel method.

Nutritional parameters viz., crude fibre, ascorbic acid, total polyphenols and antioxidant activity of fresh pumpkin pulp used for powder preparation were assessed to compare the difference in nutritional parameters between pulp and powders.

Results and discussion

The effect of MD concentration or pulp carrier ratio on the chemical quality parameters of S-D powder at 150°C is depicted in Table I. Maltodextrin is a polysaccharide, a water-soluble white starchy powder with a neutral taste, that is used principally in foods and beverages as a thickener, sweetener, and/or stabilizer aaaand is available as a white,

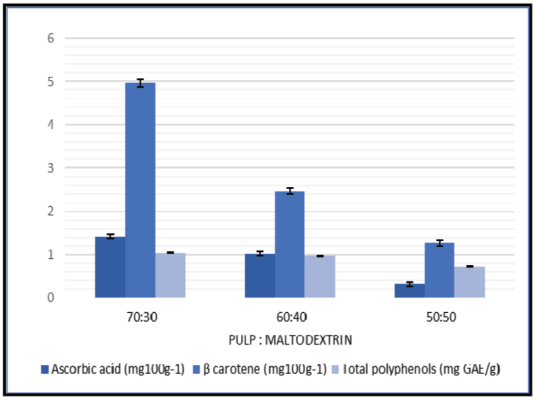
Table I: Effect of maltodextrin concentration on chemical quality parameters of spray dried powder

Pulp: Carrier ratio	TSS (°Brix)	Total Sugars (%)	Reducing sugar (%)	Titratable acidity (%)	Ash (%)
70:30	47.60	47.10	10.30	0.65	0.94
60:40	52.90	51.33	14.86	0.52	0.35
50:50	56.60	62.48	16.43	0.37	0.30
SE±(m)	0.781	0.639	0.354	0.010	0.008
CD (0.05)	2.407	1.97	1.09	0.032	0.024

hygroscopic, spray-dried powder that is practically flavourless and has a dextrose equivalency less than 20, indicating that it contains long carbohydrate chains along with 2-3% glucose and 5-7% maltosewith low fat and low calorie . In water, it is easily soluble and dispersible, whereas in alcohol, it is soluble to nearly insoluble. It can be advantageous to eat maltodextrin with other foods that include fibre, protein, and healthy fats in order to lessen the effect of the ingredient on blood glucose levels. These elements may contribute to a more gradual rise in blood glucose levels by slowing the breakdown and absorption of carbs (Chronakis, 1998; Parikh et al., 2014).

The Total Soluble Solids of the spray-dried pumpkin powder was established to be within 47.6 to 56.6°B. TSS increased with increase in MD concentration from 30 to 40 % as observed in case of pineapple and watermelon powders (Abadio et al., 2004; Quek et al., 2007). But TSS of the powder was not statistically changed when maltodextrin concentration was increased from 40 to 50 %. Total and reducing sugars increased with the increase in TSS content. Total sugar content of developed pumpkin powders ranged from 47.1 to 62.48% and reducing sugar content from 10.3 to 16.43%. Sugar content amplified with increase in MD concentration in the spray-dried powders. When it comes to low molecular weight sugars like fructose and sucrose, maltodextrin acts as a very good encapsulant. Oberoi and Sogi (2015) observed similar results in spray dried watermelon powder. Ash content of the S-D pumpkin powders was reckoned to be within the range of 0.30% to 0.94% and acidity within 0.37% to 0.65%. An increase in maltodextrin content reduced the ash content and titratable acidity of the powdered product, as maltodextrin does not contain any ash and acidity. The results were harmonized with the findings of Caliskan and Dirim (2013). Crude fibre content in pumpkin samples were analysed and there were no traces of fibre in spray-dried pumpkin powders.

Fig. I and II shows the upshot of MD concentration on the nutritional quality parameters of S-D powders. Ascorbic acid or vitamin C is an essential nutrient which plays an imperative role in the development of human health. Because of its low consistency during heat treatments, ascorbic acid is considered as one of the indicators in food processing quality (Podsêdek, 2007). Ascorbic acid content of pumpkin powders ranged between 0.32mg100g^{-1} to 1.42mg100g^{-1} and spray-dried pumpkin powders had a β-carotene content of 1.26 to 4.96 mg100g^{-1}. Ascorbic acid and β carotene content of the developed S-D pumpkin powders slimmed down with an increase in maltodextrin concentration. The results are coordinated with the findings of Grabowski et al. (2008). In other words, ascorbic acid and β -carotene increased with an increase in pulp concentrations. The



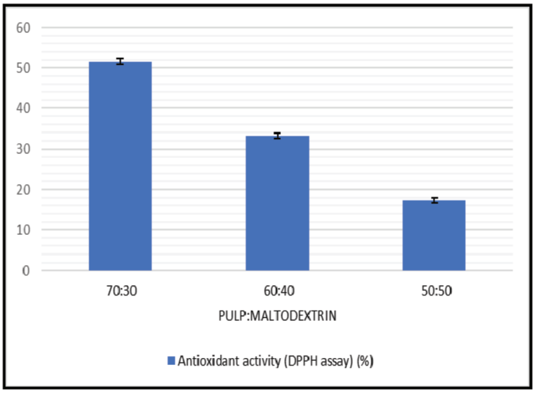


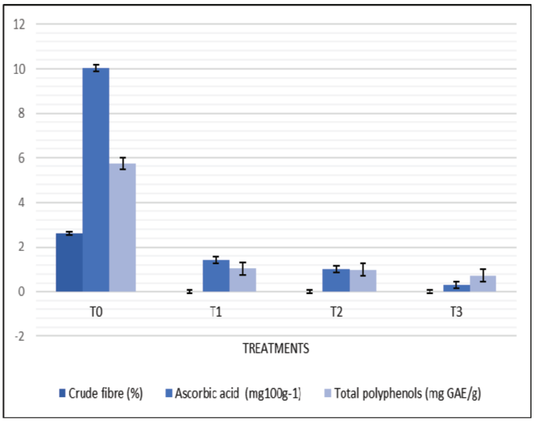
Figure I & II: Effect of maltodextrin concentration in nutritional quality parameters of spray dried powder

Table 2: Effect of maltodextrin concentration on physical properties of spray dried powder

Pulp: Carrier ratio	Moisture content (%)	Water activity (aw)	Bulk density (g/ml)	Flowability (Angle of repose)(degree)
70:30	2.91	0.36	0.50	9.02
60:40	1.16	0.37	0.45	12.41
50:50	1.11	0.38	0.35	16.08
SE±(m)	0.041	0.001	0.007	1.008
CD (0.05)	0.126	0.003	0.023	3.107

phenolic content of the developed S-D pumpkin powders covered between 0.73 to 1.04 mg GAE/g pumpkin powder. Maltodextrin content had a blowback on the phenolic content of the spray-dried pumpkin powders owing to its concentration effects. The antioxidant activity of the developed pumpkin powders decreased with an increase in MD concentration (51.57 to 17.25%). As maltodextrin does not possess any free radical scavenging activity, increased maltodextrin concentration led to decreased antioxidant activity in pumpkin powders. Similar results were obtained for spray-dried amla powder (Mishra et al., 2014).

A good food powder should have low moisture content, water activity, smaller particle size, bulk density, increased flowability, better reconstitution and convenience in transport and storage (Intipunya and Bhandari, 2010). The effect of MD concentration on the physical properties of S-D powder is exhibited in Table II. The moisture content of the spray-dried pumpkin powders decreased with an increase in MD concentration, and it ranged between 1.11 to 2.91%. The water activity of pumpkin powders increased with increase in maltodextrin concentration (0.36-0.38 aw). Increased bulk density is linked wih the sticky nature of the powder (Shrestha et al., 2007; Goula and Adamopoulos, 2008). The particles that adhere together leave lesser space among them and caused reduced bulk density. Bulk density of S-D pumpkin powder decreased with increased maltodextrin concentration. This was in agreement with the verdicts of Krishnaiah et al. (2014). According to Caliskan and Dirim (2013), the flowability of a powder is the measure of its free-flowing nature. For the purposes of packaging, handling, measuring, shipping, filling and emptying bags, storage, dosing purpose and choosing settings for conditioning and mixing, the manufacturer and the final user must ensure proper powder flow. Addition of maltodextrin reduces hygroscopicity, preventing stickiness observed during spray drying by averting sugar crystallisation and, ultimately, improving the flowability of powder. The flowability of powders augmented with increase in MD concentration.



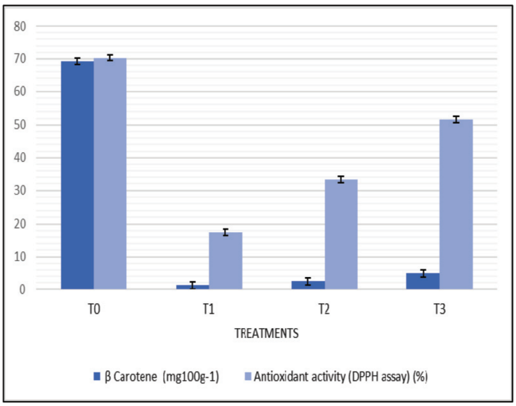


Figure III&IV: Nutritional parameters in fresh pumpkin pulp and spray dried pumpkin powder

The nutritional traits of the developed S-D powders were analogised with fresh pumpkin pulp and is depicted in Fig. III and IV. Pumpkin pulp had 69.3 mg $100g^{-1}$ β-carotene which was in line with the findings of Mala and Kurian (2016). Spray drying causes a momentous decrease in the amount of β-carotene in the powders due to the isomerisation of the molecules. During the process of dehydration, oxidative degradation of molecules occurs due to exposure to oxygen (von Elbe and Schwartz,1996). Fresh pumpkin pulp had a phenolic content of 5.76 GAE/10g. Similar value (4.726 GAE/10g) was obtained by Dini et al. (2013). Fresh pumpkin pulp had 10.03 $mg100g^{-1}$ ascorbic acid and 70.31% antioxidant activity. A significant decrease in ascorbic acid, total polyphenols and antioxidant activity were detected in the S-D powders compared to the fresh pulp. Also, the crude fibre present in the fresh pulp was practically nil upon the spray drying process. As pumpkin fruit is pulpy, it was quite difficult to convert into powder by spray drying technique. The pulp had to be clarified, eliminating a sizable portion of the coarse particles and pulp, which are abundant in fibre and phenolic chemicals, in order to allow the atomizer to operate properly. Given the nature of the transitioning phase at the glass transition temperature (*Tg*), amorphous materials usually have a connection with stickiness. Significant concentrations of carriers must be added to alter the amorphous state by raising the *Tg*. (Osorio et al., 2011). However, through the inclusion of bulky elements, this addition boosts the solid content, which negatively impacts the nutritious qualities. Even though spray-drying of pumpkin pulp into powder significantly reduces the nutrient content, factors like easy handling and transportation, storage stability, reduced volume, better packaging and increased shelf life promotes the production of spray-dried powders. Among copius drying techniques used to concoct fruit powders, S-D is considered as the most expedient and most extensively used in industry (Adiba et al. 2011).

Raja et al., (1989) stated that MD with a dextrose equivalent DE) of 10–20 is ideal for wall materials in S-D powder form because of higher concentrations' reduced turbidity. As a result, drying at low temperatures and low pressure by means of less MD might be the ideal approach for making pumpkin fruit powder. Incorporating carrier agents with high *Tg* in the combination, viz., maltodextrins with a low DE to the feed can also be tried to improve powder quality (Verma & Singh, 2015).

Conclusions

In the present study, the out-turn of maltodextrin on the physicochemical characteristics of S-D pumpkin powder was analysed. The incorporation of maltodextrin in spray-dried pumpkin powder abated the moisture content. Though the carriers are essential for the purpose of spray drying, increasing their concentration above a particular limit will negatively affect the quality of spray dried powders. Total soluble solids increased with maltodextrin concentration, affecting sugars, ash, and acidity. Nutritional parameters like ascorbic acid, β-carotene, phenolic content, and antioxidant activity decreased with higher maltodextrin levels. Physicochemical and nutritional trade-offs highlight the complexity of optimizing spray-dried pumpkin powder quality.

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