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Effect of Whey Protein Isolate on the Properties of Freeze Dried *aloe vera* (*Aloe barbadensis* Mill) Powder

Ankit Dayal[1*], Anju Bhat[1], Rafia Rashid[1], Jagmohan Singh[1] and Sushil Sharma[2]

[1]Division of Food Science and Technology, [2]Division of Agricultural Engineering, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir, India

***Corresponding author*

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A B S T R A C T

The effect of whey protein isolate concentrations (10%, 15% and 20%) as carrier agent on the properties of freeze dried *aloe vera* powder was studied. Addition of whey protein isolate in *aloe vera* juice yielded powder with free flowable properties. The moisture content and water activity of the freeze dried powder decreased with incorporation of carrier agent. Colour properties observed on the basis of L*, a* and b* revealed that lightness (L*) of the powder increased with incorporation of whey protein while a* and b* decreased. Highest L* values (86.87) was observed at 20% of concentration. Water solubility, swelling capacity, dissolution time, tapped and bulk density increased whereas the water absorption index, hygroscopicity and cohesiveness measured in terms of Hausner ratio of the powder decreased with incorporation of whey protein. Powder recovery improved with addition and increasing concentration of whey protein. Carr index and Hausner ratio measured showed the better flow properties of the powder. Storage period significantly affected the physical and functional properties of the powder.

Introduction

Drying of fruits is one of the oldest techniques of food preservation known to man for example solar drying. One of the essential feature of drying is that the moisture content is reduced to a level (<5%) below which microorganisms can't grow. Freeze-drying, also known as lyophilization or cryodesiccation, has been proven as the best method for drying thermosensitive substances. This method minimizes thermal degradation reactions. It is comparatively costly method but the high value of nutraceutical extract and ability to encapsulate heat sensitive compounds could justify such costs (Lopez-Quiroga *et al.*, 2012).

Aloe vera (*Aloe barbadensis* Miller) originated in the warm, dry climates of Africa. *Aloe* is a member of liliaceae family and it resembles-cactus. *Aloe vera* is an important and traditional medicinal plant and has been used for its medicinal value for several thousand years. Its applications have been recorded in ancient cultures of India, Egypt, Greece, Rome and China. *Aloe vera* is known by several names, it is commonly known as ghrit kumari or gawarpatha in India. *Aloe vera* leaf contains two major liquid sources, yellow latex (exudate) and the clear gel (mucilage). The mucilaginous jelly from the parenchyma cells of the plant is referred to as *aloe vera* gel (Eshun and He, 2004).

Photochemistry of *aloe vera* gel has revealed the presence of vitamins, minerals, enzymes, sugars, polysaccharides, anthraquinones of phenolic compounds (Pugh *et al.,* 2001). *Aloe vera* has been utilized as a source of functional food, especially for the preparation of health food drinks and other beverages (Ramachandra and Rao, 2008).

Various carrier agents (maltodextrin, starch, modified starch and protein conjugates, gums, pectin, etc.) are available for the use in food. The ideal encapsulant should have film-forming properties, emulsifying properties, be biodegradable, be resistant to the gastrointestinal tract, have low viscosity at high solids contents, exhibit low hygroscopicity and have a low cost (Rocha-Parra *et al.,* 2016). Whey, major by-product from dairy industry, has good emulsifying properties and plays a protective role against thermal effects (Bernard, *et al.,* 2011). Whey protein form smooth and non- sticky films or shells much earlier than other drying aid resulting higher recovery of powders in a small amount of proteins being spray dried (Bhusari *et al.,* 2014).

Materials and Methods

Materials

Fresh and mature leaves of *aloe vera* and were whey protein isolate purchased from local market. Laboratory scale freeze dryer (Alpha 2-4 LDplus by Martin Christ) was employed for the freeze drying of *aloe vera* juice.

Methods

Processing of *aloe vera* juice

Aloe vera gel was extracted using using hand filleted technique and processed into juice. Leaves were dipped in 500 ppm potassium metabisulphite (KMS) solution for an hour and then washed thoroughly with tap water followed by cooling of leaves at 5°C for gel stabilization. Tapering tip and lower leaf base of *Aloe vera* leaves were trimmed off (1-2 inch) and the sharp spikes located along the leaf margins were also removed with the help of a sharp stainless steel knife. Thereafter, green rind portion (epidermis) was carefully separated from the parenchyma (inner fillet) by knife to avoid mixing of gel with yellow latex, located between the rind and the inner fillet. These fillets were then passed through the juicer to get the *aloe vera* juice. The *aloe vera* juice was filtered through sieve to remove coarse particle. The *aloe vera* juice obtained was mixed with whey protein isolate (WPI) at the concentrations of 10%, 15% and 20%. Then it was subjected to lyophilization (-61 to -65 °C for 72 hours). The *aloe vera* powder obtained after the lyophilization was coded as T_1, T_2 and T_3 for on the basis of carrier agent concentration i.e. 10%, 15% and 20% respectively. The powder was packed in laminated pouches and stored under room conditions.

Physico-chemical properties

The moisture content was determined by using an electronic moisture analyzer (MB 54, Citizen). The water activity was determined using water activity meter (Aqua Lab, Decagon devices, USA). For hygroscopicity, 1.5 g of the powder was placed in an airtight container containing saturated solution of sodium carbonate. Sample was weighed after 1 week and hygroscopicity was expressed (Cai and Corke, 2000). For dissolution test, 50 mg of powder sample was taken in a test tube. 1 ml of distilled water was added and was mixed by vortexing. The time (s) to fully reconstitute the powders was recorded (Quek *et al.*, 2007). The colour parameters of the encapsulated powder were determined using Hunter lab colorimeter (Patras *et al.*, 2011).

Functional properties

2.5 g powder was suspended in 50 ml tared centrifuge tubes containing 30 ml of distilled water. The sample was stirred intermittently over a period of 30 minutes and centrifuged at 3000 rpm for 10 min. The supernatant obtained was poured carefully into a tared evaporating dish for further calculation (eqn. 2) of water solubility index (Anderson *et al.*, 1969). The remaining gel was weighed and the water absorption index was calculated (eqn 1). Swelling capacity was determined using the equation 3 (Lai and Cheng, 2004). Two grams of powder was loaded into a 10 ml graduated cylinder and the volume occupied was recorded to calculate the bulk density (eqn 4) (Sansone *et al.*, 2011). Tapped density by placing two grams of powder in a 10 ml graduated cylinder and calculating the volume after the sample was smoothly dropped 120 times on top of a rubber mat from a height of 15 cm (Ozdikicierler *et al.*, 2014). The flowability and cohesiveness (Table 1) of the powder, expressed as Carr index (CI %) and Hausner ratio (HR) respectively and was calculated from tapped (ρT) and bulk density (ρB) (eqn 5 and 6) (Jinapong *et al.*, 2008).

$$\text{Water absorption index} = \frac{\text{weight of gel} - \text{weight of ground dry sample}}{\text{weight of ground dry sample}} \qquad \text{(eqn 1)}$$

$$\text{Water solubility index (\%)} = \frac{\text{weight of dry solids from the supernatant}}{\text{weight of ground dry sample}} \text{x100} \qquad \text{(eqn 2)}$$

$$\text{Swelling capacity} = \frac{\text{Dry weight}_{\text{supernatent}}}{\text{Dry weight}_{\text{sample}} \text{ x } (1 - \frac{\text{WS\%}}{100})} \qquad \text{(eqn 3)}$$

$$\text{Bulk density} = \frac{\text{Mass of powder}}{\text{volume}} \qquad \textbf{(eqn 4)}$$

$$\text{CI (\%)} = \frac{\rho T - \rho B}{\rho T} \qquad \textbf{(eqn 5)}$$

$$\text{HR} = \frac{\rho T}{\rho B} \qquad \textbf{(eqn 6)}$$

Powder recovery/yield

Powder recovery/yield, was evaluated by determination of the product recovery given by the percentage ratio between the total mass of product recovery and the mass of extract, fed in the system (Fazaeli *et al.*, 2012).

Statistical analysis

Three replications of the samples for each test were performed and the data recorded was calculated by factorial-CRD (completely randomized design).

Results and Discussion

Moisture content

Moisture content of *aloe vera* powder differed significantly in all the treatments. The highest moisture content (3.74 %) was observed in T_1 and the lowest (3.40%) in T_3. Incorporation and increased concentration of WPI increased the total solids in juice to be dried which in turn reduced the total water available for evaporation, thus decreased the moisture content. Moisture content decreases with incorporation and increasing concentration of WPI (Bhusari *et al.*, 2014).

Water activity (a_w)

Water activity (a_w) was maximum (0.169) in treatment T_1 and the lowest (0.142) in T_3. Water activity of the powders decreased with incorporation of carrier agent and increase in their concentrations. This might be due to the increased total solids like in case of moisture content. Drying aids reduced the water activity in ginger powder (Phoungchandang and Sertwasana, 2010). Water activity decreased with increased concentration of carrier agents (Bhusari *et al.,* 2014).

Water absorption index

The data (Table 2) revealed that different concentrations of carrier agent and storage period significantly affected the water absorption index of freeze dried aloe vera powder. Highest water absorption index (3.36 g/g) was recorded in T_1 and the lowest (2.99 g/g) was in T_3. With the increase in concentration of carrier agents, water absorption index of the powder decreased. Carrier agents decreased the water absorption index in *Satureja montana* powders (Vidovic *et al.,* 2014). These effects of carrier agents may be attributed to the inverse relationship between the carrier agent's concentration and the mean particle size (Adhikari *et al.,* 2003). Carrier agents decreased the water absorption index in encapsulated bioactive components of purple sweet potato (Ahmed *et al.,* 2010).

Water solubility index / solubility index

Maximum water solubility index (87.23 %) was recorded in T_3 and the lowest (84.01 %) in T_1. The addition of carrier agents seemed to improve the solubility of the powder which might be attributed to the fact that carrier agent had superior water solubility (Goula and Adampoulos, 2008). Similar results were observed in freeze dried anthocyanin powder (laokuldilok and Kanha, 2015).

Swelling capacity

From the data (Table 2), it is evident that the highest swelling capacity (2.98 ml/g) was recorded in T_3 and the lowest (2.62 ml/g) in T_1. The swelling capacity of the powders increased with WPI, this might be due to the starch-water interactions (Ahmed *et al.,* 2010; Gunaratne and Hoover, 2002). Amylopectin fraction of starch is believed to be primarily responsible for swelling (Vanzo *et al.,* 2009).

Hygroscopicity

Hygroscopicity is a measurement of the capacity of the food to contain occluded moisture and is an important property, to be considered during the storage of the product (Rodríguez-Hernández *et al.,* 2005). Higher hygroscopicity (7.96 g/100g) was in T_1 and the lowest (6.02 g/100g) was in T_3. With the increase in concentration, hygroscopicity decreased which might be due to the low moisture content. Increased concentration of carrier agent decreased the hygroscopicity of the tamarind pulp powder and beetroot juice concentrate respectively (Bazaria *et al.,* 2016; Bhusari *et al.,* 2014).

Dissolution

Dissolution test is the measurement of the reconstitution speed of dried powder into water. It is expressed as the time taken by the powder to fully reconstitute in water by vortexing (Quek *et al.,* 2007). Increase in dissolution time with increase in concentration was recorded.

Highest (21.67 s) dissolution time was recorded in T_3 and the lowest (15.67 s) in T_1, this might be due to increase in total solids in the powder. Increased concentration of carrier agent increased the dissolution time in freeze dried watermelon powder (Oberoi and Sogi, 2015).

Colour (L*, a* and b*)

Colour is a very important quality characteristic of fruit and vegetable products which influences the consumer acceptability.

Fig.1 Bulk and tapped density of the freeze dried aloe vera powder

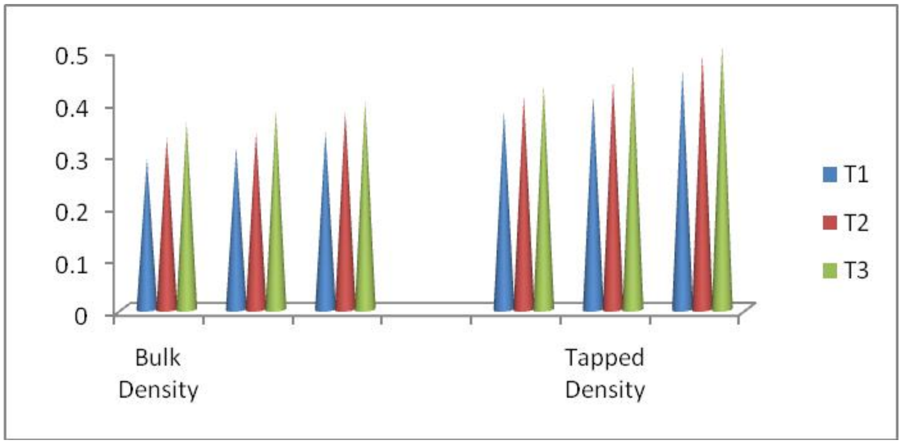

Fig.2 Cohesiveness (Hausner ratio) of freeze dried *aloe vera* powder

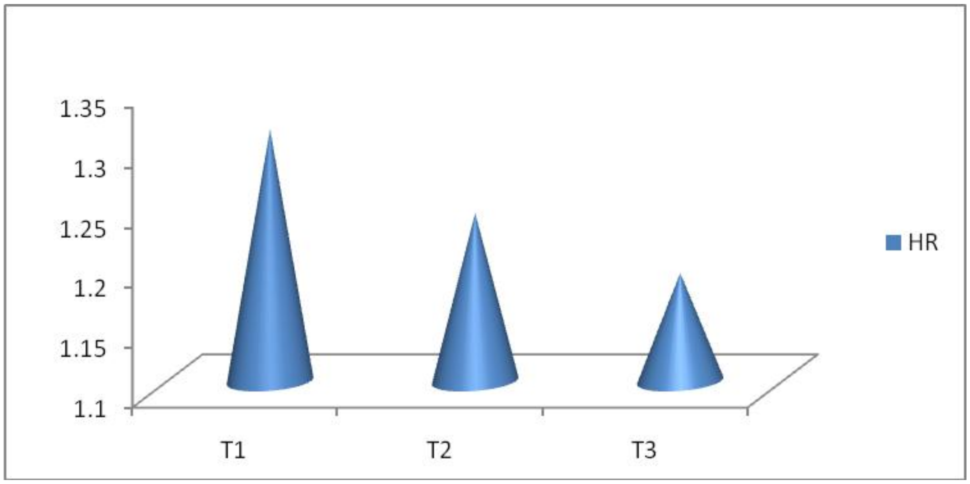

Fig.3 Carr index (CI%) of freeze dried *aloe vera* powder

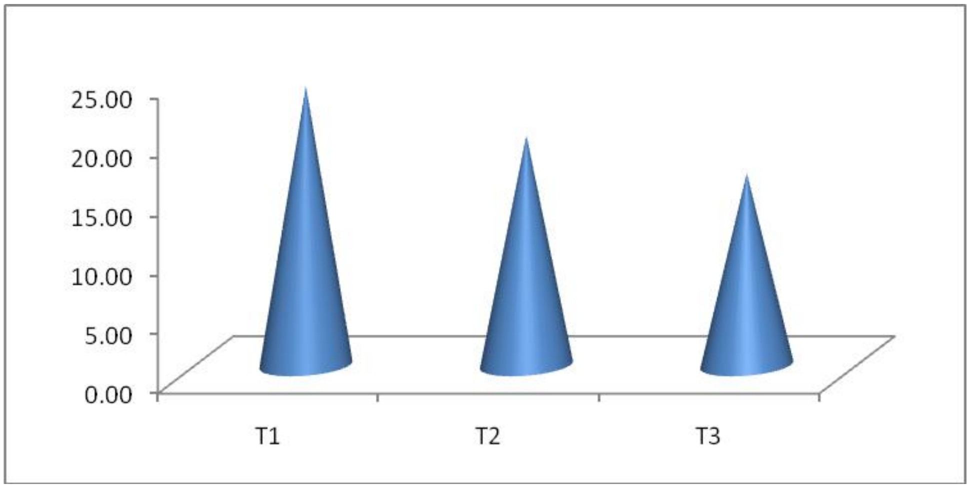

Fig.4 Yield (%) of freeze dried *aloe vera* powder

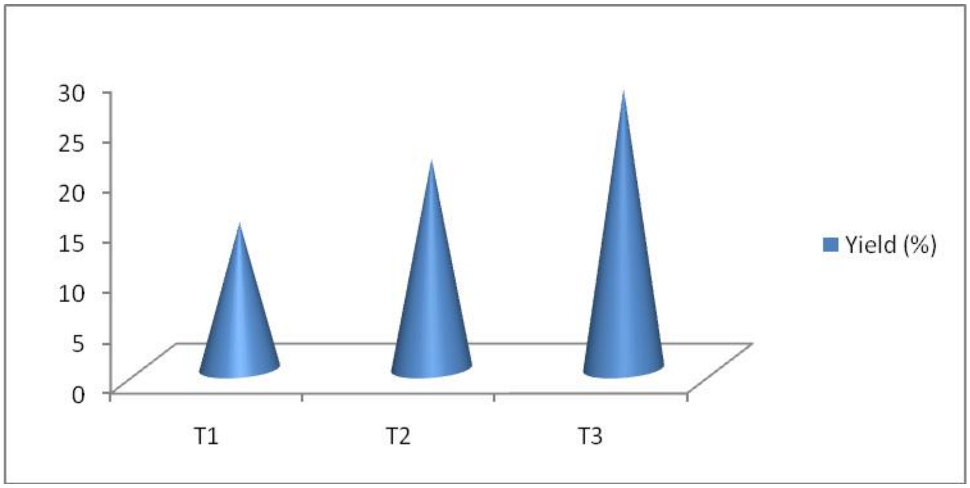

Table.1 Standard values for measuring flowability and cohesiveness of the powder

CI (%)	Flowability		HR	Cohesiveness
<15	Very good		<1.2	Low
15–20	Good		1.2–1.4	Intermediate
20–35	Fair		>1.4	High
35–45	Bad			
>45	Very bad			

Table.2 Physio-chemical and functional properties of freeze dried *aloe vera* powder

Parameter	WPI concentration		
	10% (T1)	15% (T2)	20% (T3)
Moisture Content	3.87	3.63	3.51
Water activity	0.171	0.159	0.148
Water absorbtion index (g/g)	3.36	3.16	2.99
Water solubility index (%)	84.01	84.99	87.23
Swelling capacity (%)	2.62	2.77	2.98
Hygroscopicity (g/100g)	7.96	6.88	6.02
Dissolution (s)	21.67	22.91	25.72
L* [whiteness (+) /darkness (-)]	80.68	81.33	81.66
a* [redness (+) /greenness (-)]	1.39	1.33	1.29
b* [yellowness (+) /blueness (-)]	21.35	21.02	20.74

*T_1 (*Aloe vera* : WPI :: 90 : 10); T_2 (*Aloe vera* : WPI :: 85 : 15); T_3 (*Aloe vera* : WPI :: 80 : 20)

It was observed that with addition and increase in concentration of carrier agent, L* value increased. Highest L* value (81.66) was observed in T_3 and the lowest (80.68) was observed in T_1. a* and b* values decreased with the addition of WPI. Maximum a* value (1.39) and b* value (21.35) was observed in T_1 and the minimum (1.29 and 20.74) was observed in T_3 respectively (Table 2). Idham *et al.,* (2012) reported the similar decreasing trend for (a* and b*) in anthocyanins from *Hibiscus sabdariffa L*. with increased concentration of carrier agent.

Bulk density and tapped density

Highest bulk and tapped density (0.36 and 0.43 g/ml) was recorded in T_3 and the lowest (0.29 and 0.38 g/ml) in T_1 respectively. Increased concentration of whey protein increased the bulk and tapped density. Bulk density of powders is affected by chemical composition, particle size and moisture content as well as by processing and storage conditions (Beristain *et al.,* 2001).

In principle, density increases as volume decreases at a given constant mass. In the present study, bulk densities of powders, increased gradually as the ratio of carrier agents increased (Fig. 1).

Bulk density increased with increased concentration of carrier agent in dried pink guava and avocado oil (Shishir *et al.,* 2014; Bae and Lee, 2008). Tapped density corresponds to the real solid density and does not consider the spaces between the particles, in contrast to the bulk density, which takes into account all these spaces (Cynthia *et al.,* 2015). Tapped density increased with increase in carrier agent (Fig. 1) due to increase in weight of end product in ber powder (Singh *et al.,* 2014).

Cohesiveness (Hausner ratio) and Carr index (CI%)

With the increase in concentration of carrier agents, the mean Hausner ratio (Fig. 2) and Carr index (Fig. 3) of freeze dried powder decreased significantly. Highest Hausner ratio and Carr index was recorded in T_1 and the lowest Hausner ratio and Carr index in T_3.

Powder recovery/yield

Highest yield (27.32 %) of freeze dried powder was recorded in T_3 and the lowest (14.53%) in T_1. Significant increase in the yield percentage was observed with increase in concentration of whey protein isolate (Fig. 4).

Aloe vera powder was produced using freeze drying technique at three whey protein concentration. Whey protein isolate was an effective drying aid helped in reducing stickiness and altered the physicochemical properties of the *aloe vera* powder. With increase in concentration of WPI, the moisture content of the freeze dried powder decreased, whereas time for reconstitution increased. Solubility and lightness (L*) of the powder was increased with increasing concentration of WPI. Storage also had significant effect on the properties of the freeze dried powder. Moisture content, water activity, dissolution time bulk and tapped density increased with time while solubility and lightness of the product decreased.

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