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Physico-Functional Properties of *Jungle Jalebi* (*Pithecellobium dulce*) Fruit Powder

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ABSTRACT: *Jungle Jalebi* (*Pithecellobium dulce*) fruits have immense nutritional potential but have limited utilization. Drying of *Jungle Jalebi* fruits may enhance their utilization efficiency but can also change its physico-functional properties. Thus, the present study was planned to study physico-functional properties of developed *Jungle Jalebi* fruit powder (FP). The results revealed that the developed powder have high bulk density, swelling capacity, oil absorption, water solubility, water absorption & retention, foaming capacity and moderate least gelation concentration. Thus, it can be concluded that the *Jungle Jalebi* fruits powder can be effectively utilized as a functional ingredient in innovative food designing.

Keywords: *Jungle Jalebi, Pithecellobium dulce,* Functional properties, Fruit powder.

INTRODUCTION

Minor fruit plants have a vast array of nutraceuticals and bioactive compounds, which enhances their utilization as functional foods (Nasim *et al.,* 2022). These fruits are also an integral component of the Indian traditional food system, consumed by many rural and tribal communities (Harekrishna *et al.,* 2019). In Indian pharmacopeia, the therapeutic potential of minor fruits is very well known, and gaining popularity in the modern world as an alternative medicine (Tripathi, 2021). Despite being rich in phytonutrients and active pharmacological agents, there are many neglected and under utilised minor fruit plants which have limited cultivation, consumption, and trade in terms of both area and production (Saúco, 2013). Most of the underutilized minor fruits are confined mainly in natural wild, semi-wild and semidomesticated conditions, albeit with diverse genetic diversity. Focusing attention on such underutilised minor fruit plants may provide an efficient way to combat malnutrition with low agriculture input. Along with this, properly planned post-harvesting processing of these underutilized minor fruits may provide new dimensions in innovative food designing. Processing of minor fruits also have potential to generate additional income for tribal and rural communities who are mainly involved in their procurement (Nandal and Bhardwaj 2015; Das and Prakash 2011).

Similarly, in Indian traditional wisdom, one such known but under utilised minor fruit plant is *Jungle Jalebi* (*Pithecellobium dulce* which demands attention from both researchers and common people. The red and white aryls of *Jungle Jalebi* fruits are commonly consumed and known to have various therapeutic properties such as antidiabetic, gastroprotective, anti-inflammatory, hepatoprotective, cardioprotective, nephroprotective, antidiarrheal and antimicrobial activities (Sneha *et al*., 2020). These health promoting activities of *Jungle Jalebi* fruits are mainly due to the presence of several bioactive compounds such as anthocyanin, flavonoids, glycosides, saponins, polyphenols, phytosterols, and triterpenoids in *Jungle Jalebi* fruits (Raju and Jagdeeshwar 2014). However, the nutritional and therapeutic potential of *Jungle Jalebi* fruits are still under utilised due to multiple reasons like unawareness, seasonal availability (March-June) and localised cultivation within the forest areas. To enhance its all over availability and diversify its utilization, drying of *Jungle Jalebi* fruits may be performed. Drying of fruits provides an easy and cost-effective approach for their long-term preservation, but also alter various physical and chemical properties of its components (Santos *et al*., 2022). Physico-functional properties are the composite of all physical and chemical properties of food generated due to food composition, intra-action within (interactions between food constituents and morphological structure, molecular conformation) or interaction with the nature of environment in which these are associated and measured (Chandra *et al*., 2015). The study of physico-functional characteristics of fruit powders may help in understanding of their behaviour in specific food systems as well as possibility of their utilization in food processing industries (Lopez-Cordobaa and Goyanes 2017). Thus, this study was planned to assess various physico-functional properties of developed *Jungle Jalebi* fruit powder (FP), to understand its suitability for further food processing.

MATERIALS AND METHOD

A. Development of JJFP

The fresh fruits of *Jungle Jalebi* were procured form the local market of Udaipur, Rajasthan, India. After procurement, the fresh fruits of *Jungle Jalebi* were sun-dried and further processed to develop fruit powder (FP). Sun-drying was adopted as it was reported that sun-drying of *Jungle Jalebi* fruits have better nutrient and organoleptic properties retention as compared to oven and solar and oven drying (Shukla, 2018).

B. Physico-Functional Properties of developed JJFP

Various physical and functional properties of the developed JJFP powder (in triplicates) were assessed by using following standard methods or their slight modifications:

(i) Bulk density. (International Standard Organization/International Dairy Federation [ISO/IDF], 2005b): Take 100g food sample in a measuring cylinder (250mL). After that, note the volume of measuring cylinder at 0 and 625 manual taps over a cushioned hard surface. Calculate, poured/true bulk density (0 taps), and tapped bulk density (625 taps) of the sample as per their recorded volumes (g/cm^3).

$$\text{Bulk density (g/cm}^3\text{)} = \frac{\text{Weight of Sample (g)}}{\text{Volume occupied the sample (cm}^3\text{)}}$$

Carr's index (compressibility/flowability index) and Hausner's ratio (cohesiveness index) is calculated from poured (loose) and tapped bulk density which represent flowability and cohesiveness of powders (Nandi *et al.*, 2020). A Carr's index ≥25 is an indicator of poor flowability, and ≤15, is of good flowability (Carr, 1965). A Hausner's ratio greater than 1.25 is an indicator of poor flowability (Hausner, 1967).

$$\text{Carr's Index} = \frac{\text{(Tapped bulk density - Poured bulk density)}}{\text{Tapped bulk density}} \times 100$$

$$\text{Hausner's ratio} = \frac{\text{Poured bulk density}}{\text{Tapped Bulk density}}$$

(ii) Swelling capacity (Bishnoi and Khetrapal 1993). Pour ten gram of food sample in a clean dry graduated measuring cylinder (100ml). Gentally level the sample and note down the occupied volume of sample. Add 100ml of distilled water into it and swirl the content by using glass rod. Keep it for one hour. After that, note down the change in occupied volume of sample. The swelling capacity (mL/g) is calculated as a change in volume (ml) of the sample due to one hour soaking.

$$\text{Swelling capacity (ml/g)} = \frac{\text{Volume after soaking (ml)} - \text{Volume before soaking (ml)}}{\text{Initial weight of sample (g)}}$$

(iii) Hydration capacity (Bishnoi and Khetrapal 1993). Take ten gram of food sample in a clean dry beaker. After taking the weight of beaker with sample, add 100mlof distil water into it. Stir the beaker gentally for even levelling. Cover with aluminium foil and keep it for overnight. After 24 hours, remove superfluous water with filter paper and again record the beaker weight. The hydration capacity (mL/g) was calculated as difference in volume due to soaking of the sample for 24 hours.

$$\text{Hydration capacity (ml/g)} = \frac{\text{Weight of beaker after soaking (g)} - \text{Weight of beaker before soaking (g)}}{\text{Weight of sample (g)}}$$

(iv) Water absorption capacity (WAC) and water solubility (WS) Anderson *et al.* (1969). Take one-gram sample into a pre-weighted centrifuge tube and add 10ml distil water into it. Keep the centrifuge tubes at ambient room temperature (30ºC) for 30 minutes with intermittent stirring by glass rod. After that centrifuge at 3000rpm for 20 minutes. After completion, decant the supernatants into a pre-weighted petri-dish and dry it in hot air oven (45ºC for 24 hours). Weight the dried sample, to calculate the amount of water-soluble solids of sample as WS(g/g). Take weight of the centrifuge tube with wet sediments of swollen sample to calculate WAC (ml/g).

$$\text{Water Absorption Capacity (mL/g)} = \frac{\text{Weight of wet sediment (g)}}{\text{Weight of sample (g)}}$$

Weight of wet sediment (g): Weight of centrifuge tube with wet sediment (g) -Weight of empty centrifuge tube (g)

$$\text{Water Solubility (g/g)} = \frac{\text{Weight of dry solid supernatant (g)}}{\text{Weight of sample (g)}}$$

Weight of dry solid supernatant (g): Weight of petridish with dry solid supernatant (g) - weight of petridish (g)

(v) Oil absorption capacity Eke and Akobundu (1993). Take one gram of sample in a pre-weighted centrifuge tube. Add 10ml of refined soyabean oil into it. Agitate the slurry on a vortex mixer for 2 min. Allow it to stand at ambient temperature for 30 min, then centrifuge at 300rpm for 25min. Measure the volume of free oil. The oil absorption capacity (mL/g) is expressed as the amount of oil (in ml) absorbed by a gram of flour sample.

$$\text{Oil absorption capacity (ml/g)} = \frac{\text{Volume of oil before centrifugation (ml)} - \text{Volume of oil after centrifugation (ml)}}{\text{Weight of sample (g)}}$$

(vi) Foaming capacity and stability (Narayana & Rao 1982): Take one gram of sample in a measuring cylinder at ambient room temperature. Add 50mL distil water into it and note the occupied volume of suspension. Mix the suspension with glass rod and tightly seal it with cork or aluminium foil. Shake/whip it for 5 minutes. Record the foam volume after 30seconds (foam capacity, mL/g) and after one hour (foam stability, mL/g).

$$\text{Foam capacity (ml/g)} \frac{\text{Volume of foam after whipping(ml) – Volume of foam before whipping (ml)}}{\text{Weight of sample (g)}}$$

$$\text{Foam stability (mL/g)} = \frac{\text{Volume of foam after one hour of whipping whipping(ml) - Volume of foam before whipping (ml)}}{\text{Weight of sample (g)}}$$

(vii) Least gelatinization concentration (Coffman and Garciaj 1977). Prepare 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 30% of sample dispersions by using distil water. Heat all the dispersions at 90°C in water bath for one hour. Cool the contents under the tap water and keep it for two hours at room temperature. Determine the least gelation concentration(g) as that concentration when the sample from inverted beaker did not slip down.

(viii) Titratable acidity (Food Safety and Standard Authority of India [FSSAI], 2015): For test solution, take one gram of food sample and make the volume up to 100mL with distil water. Keep it at room temperature for 30 minutes. After that, filter the solution and take 10ml of the filtrate. Add three drops of phenolphthalein indicator into it. Titrate it with pre-standardised 0.1N NaOH solution (against 0.1N oxalic acid) till the end point (light pink colour persisting for 30 seconds). Also run a blank (distil water) along with test sample. Calculate the titratable acidity (%) as citric acid equivalents (equivalent weight=70g) based on the used amount of 0.1N NaOH for the titration of one gram sample.

$$\text{Titratable Acidity (\%)} = \frac{\text{EW} \times \text{N} \times \text{T}}{\text{Weight of sample (g)} \times \text{V}} \times 100$$

Where, EW=Equivalent weight of acid of consideration, N= Normality of NaOH solution, T=Total prepared volume of sample, and V= Volume of sample used for titration

C. Statistical analysis

The assessed physico-functional properties of developed *Jungle Jalebi* fruits powder (FP) were statistically analysed by using mean and standard deviation.

RESULTS AND DISCUSSION

The physico-functional properties of developed powder from *Jungle Jalebi* fruits are presented in Table 1.

A. Bulk density

Bulk density (g/cm^3) refers to the weight of a unit volume of powder (Fitzpatrick *et al*., 2013). It represents occupied volume of sample due to pouring along with the interparticle space and intraparticle voids which creates a relatively loose structure. Tapped/true bulk density indicates maximum bulk density, achieved after compression from an external force without causing any deformation to the particles (Lopez-Cordobaa and Goyanes 2017). Carr's index (compressibility index) and Hausner's ratio (flowability index) is calculated from poured and tapped bulk density which represent flowability and cohesiveness of powders (Caliskan and Diri, 2016). A compressibility index ≤15 indicates good flowability and ≥25 indicates poor flowability. A Hausner's ratio ≥1.25 is an indicator of poor flowability and cohesiveness of flours (Goyal *et al*., 2016). Thus, the bulk density is a useful criterion for characterizing, handling, and processing of powder system in the food and pharmaceutical industries (Micha, 2011).

In present study, the developed FP showed high poured and tapped bulk density as 0.64±0.00g/cm^3 and 0.81±0.00g/cm^3 respectively. The calculated Carr's index and Hausner's index of developed FP are 20.99±0.00 and 1.27±0.00 respectively. The high bulk density of FP indicates its dense nature and suggests various attributes such as large particle size, coarse/granular structure, high particle density, less porous, cohesive (particle weight is less than the interparticle attractive forces), fair flowability, high compressibility, and easy dispersibility with need of sustainable packaging which contributes to high transport and storage cost (Agunbiade and Sanni 2001; Amanidikwa *et al*., 2015). The calculated Carr's and Hausner's index indicate fair flowability and high cohesiveness of the developed FP (Nandi *et al*., 2020; Sahni and Shere 2017).

Compared to present study, Chandra *et al.* (2015) reported bulk density (g/cm^3) of wheat flour (0.76), rice flour (0.91) green gram flour (0.78) and potato flour (0.72) which have similarity with the bulk density of developed FP and exhibits possibility of its easy handling. Sahni and Shere (2017) also reported similar range of bulk density ((g/cm^3), Carr's index and Hausner' s index for apple (0.557, 19.64 & 1.24), carrot (0.515, 21.56 & 1.275) and beetroot pomace powder (0.631, 23.07 & 1.30) respectively. Saifullah *et al*. (2016) also reported similar findings for pitaya, pineapple, mango and guava fruit powders in terms of bulk density (0.59-0.65g/cm^3), true density (1.34-1.38g/cm^3) Carr's index (20.73-23.51) and Husaner's index (1.26-1.31). Thus, the bulk density of FP is quite similar with cereal/pulse flours and other fruit powders which indicates its easy handling for further processing.

Table 1: Physico-Functional Properties of *Jungle Jalebi* fruit powder (FP).

Sr. No.	Physico-Functional Properties	JJFP (on dry weight basis)	Suggested Characteristics
1.	Bulk density (g/cm^3)	0.64±0.00	Large particle size, coarse nature, granular structure, high particle density, less porous, cohesive
2.	True/ tapped bulk density	0.81±0.00	
3.	Carr's index	20.99±0.00	High compressibility and fair flowability
4.	Hausner's index	1.27±0.00	
5.	Swelling capacity (mL/g)	4.80±0.10	Large surface area, presence of hydrophilic constituents in composition
6.	Water solubility (g/ml)	0.46±0.14	High amount of water-soluble compounds, easy digestibility
7.	Water absorption capacity (mL/g)	3.93±0.08	Highly fibrous, hygroscopic and tend to sticky
8.	Hydration capacity (mL/g)	3.83±0.25	
9.	Oil absorption capacity (mL/g)	3.00±0.00	High oil absorption
10.	Foaming capacity (mL/g)	12.00±0.00	High foaming capacity with low stability
11.	Foaming stability (%)	4.00±0.00	
12.	Least gelation concentration (%)	10±0.00	Moderate gelling ability
13.	Titratable acidity (% as citric acid equivalents)	3.5±0.00	High sugar acid ratio

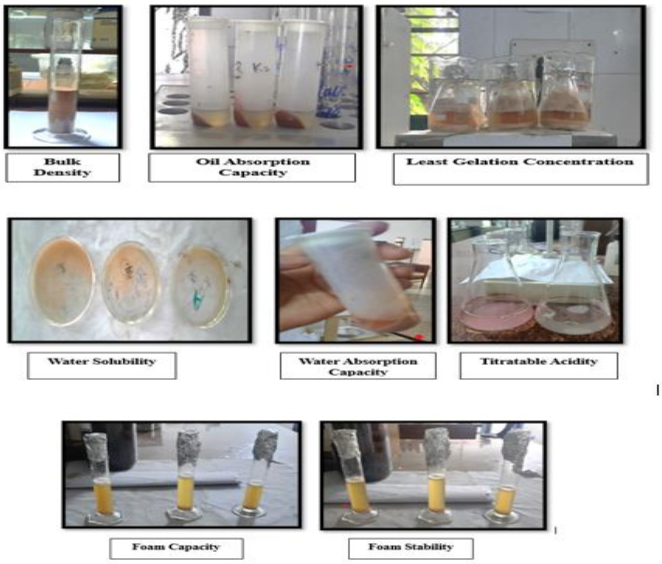

Fig. 1. Analysis of physico-functional properties of *Jungle Jalebi* Fruit Powder (FP).

B. Swelling capacity

Swelling capacity (ml/g) indicates the change in particle size due to hydration. It is the ability of polysaccharides (starch/fibre) to imbibe water and swell (Moorthy & Ramanujam 1986). When powder/flour is heated with excess water, hydrogen bonds which stabilizes the structure of molecules are disrupted due to heat and embrace themselves with water which further leading to swelling of the granule (Tester & Karkalas 1996). Along with the polysaccharides content, the swelling capacity of powders also depends on its particle size, variety and processing (Iwe *et al*., 2015).

In present study, the swelling capacity of FP is 4.80±0.10ml/g. Similar to present study, high swelling capacity in black current fruit powder as 4.99mg/g was reported by Jureviciute *et al*. (2022). Although Sahni and Shere (2017) reported very high swelling capacity (ml/g) in apple, carrot and beetroot powder as 7, 11.25 and 7.8 respectively. Comparison with the findings of Chandra *et al*. (2015) who reported swelling capacity of wheat flour (17.6%) rice flour (15.20%), green gram flour (19.80%) and potato flour (42.90%), the developed FP showed very high swelling capacity (480%). In cereal and pulse flours, the swelling capacity is mainly due to starch and their high amylose/amylopectin ratio (Sasaki and Matsuk 1995), but in fruit powders, it is more due to fibre content (Tan *et al*., 2016). The *Pithecellobium dulce* fruits were found to have less starch content (≤0.1%) and high dietary fibre as 5.83-6.82g/100g (Pio leon *et al*., 2013). Thus, the high swelling capacity of FP may be due to its high fibre content, large particle size (surface area) and presence of more hydrophilic compounds in its composition.

C. Water solubility, water absorption and hydration capacity

The interaction of food materials with water is reflected in terms of solubility of food constituents in water (water solubility) absorption of water by food constituents and their holding in internal tissues (water absorption/holding capacity) and saturation of food constituents with excess amount of water (hydration/water retention capacity).

Water solubility (g/ml) refers to the ability of the flour/powder to dissolve in water. It determines the amount of polysaccharides or polysaccharide release from the granule on the addition of excess water (Yusuf *et al.*, 2017). Water absorption/binding/holding capacity (mL/g) reflects amount of water that can be absorbed and bound to per gram of powder without any external force and application. While water retention capacity or hydration capacity (g/g) indicates quantity of water that remains bounded to the hydrated powder with application of an external force (Aryee *et al*., 2018). Water absorption and hydration capacity is predominantly dependent on the proteins at room temperature and to a lesser extent on starch and cellulose (Otegbayo *et al*., 2013).

In present study, the water solubility of FP is 0.46g/ml which indicates high amount of water-soluble compounds in its composition. Compared to present study, Sabhadinde (2014) reported high water solubility index (WSI) in spray dried *kinnow* juice powder as 85.2-98.8% due to addition of maltodextrin (10-50%) in it. Sadowska *et al*. (2022) reported that fibre preparations of chokeberry, apple and cocoa have low WSI as 30.1, 27.4 and 16.7% respectively and comprises mostly pectin, hemicelluloses, gums, plant mucilage etc. Similarly, hydroalcoholic extract of the Pithecellobium dulce fruits also showed presence of several water-soluble bioactive compounds such as polyphenols, flavonoids, triterpenes anthocyanins, polar amino acids and water-soluble polysaccharides etc. (Saral & Preeti 2021; Dhanisha *et al.*, 2021). The high-water solubility of food also indicates high digestibility due to ease of enzyme action on it (Awechi *et al.*, 2019).

In present study, the water absorption and retention capacity of FP are 3.93±0.08mL/g and 3.83±0.25mL/g. High water absorption and retention may be attributed to presence of several hydrophilic components in foods such as polysaccharides, polar amino acids, and dietary fibre (Sreerama *et al*., 2012). Compared to present study, Sahni and Shere (2017) reported similar range of water holding capacity for apple, carrot and beetroot powder as 4.45, 5.425 and 5.04mL/g and water retention capacity as 3.046, 4.109 and 4.338mL/g respectively. Preethi & Mary Saral (2014) reported that potato have 243.2% water binding capacity. Thus, it is quite clear that developed FP shows high water solubility, absorption, and hydration capacity.

The high level of interaction of developed FP with water also indicates its hygroscopic and sticky nature. The hygroscopicity of fruit powders may be due tothe presence of high sugar content and their amorphous state (Foster *et al*., 2006). Due to amorphous sugar and low water activity (due to drying), fruit powders absorbs more water from the environment (hygroscopicity), and leads to several physical and chemical changes (Roos, 1995). The development of stickiness in fruit powders is mainly due to the glass transition of sugars. Glass transition is a process in which amorphous materials (sugars) changes from glassy to rubbery states due to increase in temperature. Once the ambient temperature becomes higher than the glass transition temperature, fruit powders absorb more moisture and transit from glassy to rubbery state and become sticky (Jaya & Das 2007). High water absorption is undesirable for longer storage and make the product more susceptible for microbial attack (Oikonomou & Krokida 2012).

Water holding capacity, water retention capacity and swelling capacity of fruit powders, indicates hydration capacity of fibre and give insights regarding its behaviour during gut transit and food processing (Dhingra *et al*., 2012). The water solubility, absorption and retention capacity are important functional properties that determine behaviour of food during processing especially in dough handling (Iwe *et al*., 2016), bulking and consistency (Sujita and Kumar 2017) and formulation of therapeutic food products. As the water absorption capacity reflects optimum amount of water required to be added before it becomes excessively loose/sticky to process. Very low or excessive water absorption can negatively affect the quality of food products (Awuchi *et al*., 2019). Thus, the high-water absorption and retention properties of FP powder may assert many health benefits if utilised directly as a functional ingredient or food (Dhingra *et al*., 2016) but may negatively affect the texture of the food products during processing (Sahni and Shere 2016). Thus, judicious decision making is required while incorporation of JJFP as a functional ingredient, in any food preparation and processing.

D. Oil absorption capacity

Oil absorption (ml/g) capacity refers to the amount of oil absorbed by per gram of food. The oil is absorbed due to complex interactions between non-polar amino acids and lipid molecules of foods that also develop mouthfeel and flavour retention properties of food products (Sindhu & Khatkar 2016). The oil and water binding capacity of food, mainly depends on protein structure, amino acid composition, and presence of polar and hydrophobic groups. The oil absorption capacity of flours/powders is an important functional application to be kept in mind while preparing any food formulations (Chandra and Samsher 2013).

In present study, the oil absorption capacity of developed FP is 3.00±0.00ml/g. The oil absorption capacity of developed FP is very high from wheat (141.56%), rice (118.36%) and gram flour (154.43%) as reported by Kakar *et al*. (2022) but comparable to refined wheat flour i.e., 3.40ml/g (Sahoo & Divakar 2016). Sahni and Shere (2017) reported oil absorption capacity of apple, carrot and beetroot powder in the range of 2.206 to 2.442ml/g. The high oil binding capacity of developed FP may be attributed to its high bulk density, particle size and presence of fibre (Cadden, 2006; Jiang *et al*., 2022). The oil absorption capacity of JJFP suggests its limited functional utility in food processing but its judicious utilization as a functional ingredient to reduce oil absorption during the process of human digestion (Daou & Zhang 2014).

E. Foaming capacity and stability

Foam are the colloids of liquid and air in which liquid, trap air bubbles in the thin films due to physical disturbance or mechanical stress of the liquid. The foaming capacity is the amount of interfacial area created by whipping of aqueous solution. Foam stability indicates the time required to lose either 50% of the liquid or foam or after one hour of foam formation (Mauer *et al*., 2003). Foaming capacity and stability are the major outcome of protein which create continuous cohesive film around the air bubbles of foam (Kaushal *et al.*, 2012). Foaming stability depends on relative electrostatic forces among the polypeptides and protein molecules. Non polar residues in protein increases the foam stability while polar residues decrease it (Alleoni, 2006).

In present study, the foam capacity of developed FP is 12.00±0.00mL/g and foam stability after one hour is 25% corresponding to 4.00±0.00ml/g). It indicates that the developed FP have high foam capacity with low foam stability. The similar trend was also observed by Thakur *et al*. (2020), who reported that without any treatment, the dried guava flash has 0.96g/cm^3 foam density, 7.34% foam expansion and no foam stability. Chandra *et al.* (2015) also reported similar foam capacity and foam stability in wheat flour as 12.92 and 1.94% respectively. An inverse relationship between foam capacity and foam stability may be due to the fact that flours with high foaming ability form large air bubbles, surrounded by thin but less flexible protein film. These air bubbles may collapse with time and subsequently lowers the foam stability (Jitngarmkusol *et al*., 2008). Thus, the findings of present study indicates that the developed JJFP may have good application in bakery and confectionary industries due to high foaming capacity.

F. Least gelation temperature

The least gelation concentration represents the minimum concentration of powder at which it can form gel. The gelling ability of food may be due to thermal degradation of starch, or/and denaturation of protein. Heating in aqueous medium causes swelling of starch and proteins, which stabilizes gel at particular concentration (Alleoni, 2006). Flours/powders with high protein and starch content have competition between protein gelation and starch gelatinization (Kaushal *et al*., 2012). Foods with low value of least gelation concentration have high ability of gel formation and suitable for food preparations in which gelling properties are needed (Nawaz *et al*., 2015).

In present study, the least gelation concentration for the developed FP is 10.00±0.00%. The least gelation concentration of FP is comparable to the findings of Chandra *et al*. (2015) who reported similar least gelation concentration in range of 8-10%for wheat and composite flours (substitution of wheat in ratio of 15, 30 and 45% with rice, green gram and potato flours). Arinola and Akingbala (2018) also reported 12% least gelation concentration in breadfruit flour and recommended it as a gel forming agent or an additive to other gel forming materials in food products.

G. Titratable acidity

Acidity in fruits is mainly due to the presence of organic acids (mainly malic and citric acid) in most ripe fruits (Etienne *et al*., 2013). Titratable acidity (%) indicates quantity of organic acids present in fruits. Organic acids of fruits affect not only flavour, colour and stability of food, but also prevent lipid oxidation and microorganism growth (Tyl & Sadlar 2017).

In present study, the titratable acidity for the developed FP is 3.5±0.00% as citric acid equivalents. Comparison with other studies, developed FP have lower titratable acidity as compared to lemon juice (5.65% as reported by Sindhu and Khatkar (2018) and tamarind (18.65% as reported by Hamacek *et al*. (2013). The findings of present study are similar to th findings of Rao *et al*. (2011), who reported that titratable acidity of white and red pink aryl powders of *Pithecellobium dulce* fruits as 2.4-4.5% as citric acid equivalents. Saha *et al.* (2021) also reported that raw and ripe pre-treated *Pithecellobium dulce* fruits have titratable acidity as 4.66 and 4.2% respectively. They also explained that fruits have low sugar-acid ratio at raw stage which can be related to its sour and slight astringent aftertaste. During ripening process, degradation of fruit acids and increase in fruit sugars, improves sugar-acid ratio which impart slightly sweet taste and fruit flavour.

Similar to present study, Preethi & Mary-Saral (2016) also studied physico-chemical studies properties of soluble polysaccharides fractions of *Pithecellobium dulce* fruits. They reported that polysaccharides of *Pithecellobium dulce* fruits have bulk density (0.69-0.71g/cm^3), tapped density (0.77-0.86g/cm^3), Carr's index (15.47-22.7), Hausner's index (1.2-1.29), swelling capacity (1.65-3.1%) and water binding capacity (198.6-252.2%) with presence of bounded polyphenols and tannins. They suggested that polysaccharides extracted from the *Pithecellobium dulce* fruits may act as a novel ingredient in the pharmaceutical formulations.

Comparative to present study, they reported lesser values as bulk density (0.504 g/cm^3), compressibility index (2.451) and Hausner's ratio (1.025), water solubility (0.12g/mL), oil absorption capacity (110%), foam capacity (2.127%) and least gelation capacity (8%), water absorption capacity (186%) and high hydration capacity (5.016 g/g). The difference in physico-chemical properties of developed FP may be due to difference in pre-treatments and used drying method. They endorsed its successful incorporation of 10% *Pithecellobium dulce* powder in multigrain pasta and reported that it enhanced its nutritive value in term of ash, crude fibre and protein. Similarly, Shukla (2018) found that incorporation of *Pithecellobium dulce* fruit powder (40%) in muffin cake, biscuits and in some Indian traditional preparations such as *shakkarpara* and *chikki* were highly acceptable and improved vitamin C, antioxidants and polyphenols contents as compared to their respective control. They also recommended use of *Pithecellobium dulce* fruit powder in ready to eat and therapeutic food products to enhance their nutritive and functional value.

CONCLUSIONS

Thus, from the study of physico-chemical properties of developed FP powder it is clear that it has high bulk density with passable flow ability. The smooth interaction of FP with water is reflected by high swelling capacity, solubility, water absorption and retention with moderate least gelation concentration. High foaming capacity with low foaming stability suggests its suitability for bakery and confectionary products. The high oil absorption capacity limits its optimum utilization in food products.

FUTURE SCOPE

Thus, on the basis of physico-chemical properties it may be suggested that the developed *Jungle Jalebi* fruit powder (FP) can be judiciously utilized as a functional ingredient/ food which can be used for value addition of food products

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