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Development of gluten-free *Faraali gulabjamun*

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Abstract
The present investigation was planned and conducted to develop a technology for the manufacture of gluten-free, *Faraali gulabjamun.* A combination of sago and potato starch was found suitable for use in *Faraali gulabjamun.* Addition of guar gum: xanthan gum @ 0.05: 0.15 % (w/w of *khoa*) resulted in the most desirable sensory attributes from amongst all the levels of hydrocolloids studied. *Khoa* (prepared from 4.5 % fat) was selected for preparation of *Faraali gulabjamun* because it had superior flavour, body and overall acceptability scores. From amongst different levels of sago and potato starch used, it was found that the overall acceptability scores sample containing 20 % potato starch and 1.0 % sago was significantly higher than all the other combination studied.

Keywords: *gulabjamun, khoa*, gluten-free, *faraali*, sago, potato starch

Introduction
Gulabjamun is a milk-based sweet popular in India. It is generally prepared from the cow or buffalo milk *khoa* by kneading with wheat flour (Maida) and baking powder to form smooth dough, portioning the dough, rolling them into balls of spherical shape, deep frying the balls in oil till they turn golden brown in colour and soaking them in the sugar syrup for overnight (Nalawade *et al.,* 2015) [28]. *Gulabjamun* is traditionally prepared from the *khoa* by kneading with wheat flour (Maida) as a binding material. The main function of binding material is to give the binding effect and helps to prevent the disintegration of *gulabjamun* balls during frying. Maida has good water binding properties because of starchy nature and its use in the *gulabjamun* mix provides the product with firmness. In *gulabjamun* ready mixes, maida content varies from 25-35%.

Consumption of wheat and wheat products including maida has been associated with celiac disease. Celiac disease is defined as a permanent intolerance to gluten (gliadins and the related prolamins from rye barley and oats) causing characteristic damage to the small bowel mucosa (Marsh, 1992) [24]. Gluten sensitivity is a condition that results in an adverse reaction to foods containing gluten, such as wheat, rye, and barley (Spaulding-Albright and Kupper, 2010) [34]. Some research workers have used alternative binding agents like maize flour, arrowroot powder, cassava flour, soy flour, moraiyo, wheat bran *etc*. However, in literature there is no work cited on use of potato starch as binder in *gulabjamun*. There is scanty information on use of sago and potato starch as binding agents in *gulabjamun*. Londhe (2000) [23] reported that sago containing *gulabjamun* had lower acceptability compared with that containing maida. Use of cassava flour prepared from fresh and soaked tubers at the rate of 15% in the *gulabjamun* preparation showed significant improvement in appearance, texture and overall acceptability of *gulabjamun* on organoleptic evaluation. It was also found that, flour prepared from soaked tubers could be used up to 20% in the *gulabjamun* preparation and found acceptable on organoleptic evaluation (Agarkar *et al*., 2004) [2]. Kale (1985) [18] prepared g*ulabjamun* by replacement of wheat flour defatted soybean flour. Singh *et al.* (2009) [33] used soya bean flour as a binder in preparation of *gulabjamun*. Chaudhary (2016) [7] determined the efficacy of addition of moraiyo flour in *gulabjamun* and its impact on the quality parameters. She reported that the highest overall acceptability score i.e. 8.10 was obtained in *gulabjamun* containing 30% moraiyo. Ghube *et al.* (2015) [14] used wheat bran for preparation of *gulabjamun.*

The effect of incorporating different binder flours including shingada (water chestnut), maida (wheat flour), and sago in *khoa* on the quality of the resulting *gulabjamun* produced was studied by Londhe *et al.* (2000) [23]. They reported that the overall acceptability of *gulabjamun* containing maida was superior compared with that containing sago and shingada flour. They found that *gulabjamun* containing maida (10%) was superior in terms of all sensory attributes considered, compared with the other flours.

The Sanskrit word for fast is 'upa-vaas', which means staying close to God. *Faraali food* is basically food that is permissible on fasting days (Sharma, 1971) [32]. Therefore, *Gulabjamun* which is prepared using maida as an ingredient is not suitable for people suffering from celiac disease for people who are fasting. In India sago, potato starch, dehydrated potato and amaranth are permitted during fasting. These ingredients are rich in starch and have good binding properties. Moreover, these ingredients are gluten free. Sago is a processed edible natural starch marketed in the form of small globules or pearls. There are several sources of sago especially the sago palm (*Metroxylon sagus* or *Metroxylon rumphii)* and palm fern (*Cycas circinalis*). Moreover, tapioca is reported as non-GMO and non-allergic (Kuntz, 2006) [21]. From processing standpoint it gives a more-stable end product with a uniform consistency and a better flavour profile. Potato (*Solanum tuberosum*) is one of the world's most important crop plants. Potato tubers are rich in starch and contain minerals and vitamins as well as essential amino acids. Potato starch is a very refined starch, containing minimal protein or fat. This gives the powder a clear white colour, and the cooked starch typical characteristics of neutral taste, good clarity, high binding strength, long texture and a minimal tendency to foaming or yellowing of the solution.

According to American Diabetes Association (2012) [4] tapioca and potato are classified as gluten-free. Development of technology for manufacture of *gulabjamun* using gluten-free products such as amaranth, potato and tapioca will benefit persons who are fasting and gluten sensitive persons. Therefore, the present project is contemplated to evaluate the effect of selected binder's *viz*. sago and potato starch in the formulation of acceptable quality *gulabjamun* with a view to develop a gluten-free *gulabjamun* which would also be suitable as a fasting recipe.

Materials and Methods

Fresh, raw mixed (cow and buffalo) milk was used as the base material for manufacture of *khoa*. The average fat % of the milk was 5.3±0.2 and average MSNF content was 8.6±0.05 %. Sago and potato starch powder were procured from local market at Anand, Gujarat. The approximate composition of the sago was 11% moisture, 0.4% total ash, 0.10% acid insoluble ash, 98% starch, 0.30% protein, 0.20% crude fibre; by weight, 100 ppm sulphur dioxide and 4.5-7 pH of aqueous extract, and the approximate composition of potato starch was 18% moisture, 0.1% crude protein, 0.1% crude fat, 0.1% crude fibre, 0.3% crude ash, 78.3% starch and 81.5% carbohydrate; levels/kg. Guar gum and xanthan gum were obtained from HiMedia Laboratories Pvt Ltd., Mumbai. Good quality commercial grade cane sugar of 'Madhur' brand was used for preparing sugar syrup. Refined vegetable oil / Anand cottonseed oil (Anand Regional Co-operative oilseeds growers' Union Ltd., Ahmedabad) was used as frying medium in *faraali gulabjamun* preparation.

Caramel flavour was prepared in the laboratory by burning 300g sugar on direct flame in a clean and dry stainless steel vessel. After caramelization was completed (as indicated by a dark brown colour) heating was stopped and 100ml water was added and the ingredients were mixed thoroughly. The mixture was cooled and stored in a clean and dry glass bottle until use. Cardamom was procured from local market at Anand, Gujarat.

Preparation of *Khoa*

Standardized milk (4.5% milk fat and 8.5% MSNF). *Khoa* was prepared by heat desiccation in a steam jacketed stainless steel open pan operated at 0.75 kg/cm^2 steam pressure with continuous manual stirring and scrapping. The process of heating stirring was continued till the product acquired desired consistency (60-65% TS). At this stage caramel flavour was added @ 1 ml/100g *khoa* and blended thoroughly in the hot mass. The finished product was subsequently transferred to enamel trays, worked to pat form. The samples were kept at room temperature (25 to 30 °C) for 18-20 h and packaged in sanitized polyethylene pouches. The pouches were then stored at refrigerated temperature (4±2 °C) till use. The approximate composition of *khoa* was 32.00±0.53% moisture, 16.92±0.24% protein, 21.00±0.42% fat and 3.50±0.14% ash.

Process for manufacture of *Faraali gulabjamun*

The preliminary trials were conducted employing the tentative process for processing of binders *viz*. sago and potato starch and process of manufacturing of *Faraali gulabjamun* as depicted in Figure 1.

- **Preparation of Sago paste:** Sago beads were subjected to dry grinding in a mixer (sieving through 80 mesh size sieve) to obtain sago powder (10g). Addition of (4 X the weight of sago) water (45 °C). The paste was then soaked for one hour and Heating to 90 °C for 2-3 min to obtain sago paste.
- **Potato starch / hydrocolloid paste:** Potato starch powder (20g) was mixing with calculated amount of guar gum and xanthan gum and equal amount of water (45 °C) was added to form a paste. Heating to 70-75 °C for 3-4 min with continuous stirring to obtain potato starch paste.

Preparation of *Faraali gulabjamun*

Control(C) *gulabjamun* was prepared using the method reported by Aneja *et al*. (2002) [5] using maida (refined wheat flour) as a binding agent.

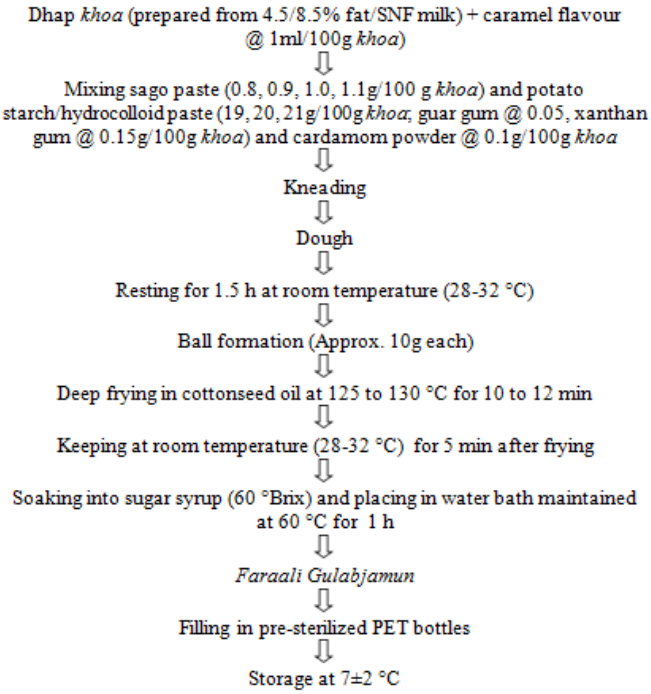

Fig 1: Tentative procedure for manufacturing of *Faraali gulabjamun*

Compositional analysis

Preparation of samples: *Faraali gulabjamun* soaked in sugar syrup were tempered at 40 °C for 20 min. They were then kept on a sieve of about one square centimeter mesh to allow the sugar syrup to drain for 10 min. The *faraali gulabjamun* were then cut into small pieces and mixed thoroughly to form a paste, which was then tested separately for different chemical constituents. Total nitrogen/protein content was determined by semi-microkjeldahl method AOAC (2002b) [6], using Kjel-plus digestion system (Model-KPS 006L, M/s.Pelican Instruments, Chennai) and Kjel-plus semi-automatic distillation system (Model- Distil M, M/s. Pelican Instruments, Chennai). Fat content of *Gulabjamun* was determined as per the procedure described in AOAC (2002b) [6]. Ash content was determined by procedure described in BIS (ISI: 1479-1961). The total solids content was determined by standard procedure using Mojonnier Milk Tester Model-D (Laboratory Manual, 1959) [22]. Total carbohydrate was derived by difference of sum total of the major constituents like moisture, protein, fat and ash from 100. The acidity of *faraali gulabjamun and sugar syrup* was determined by method described in BIS (IS: 1479-1962) for condensed milk. The pH of *gulabjamun* was measured using Systronic digital pH meter, Model 335. The method described by Franklin and Sharpe (1963) [12] for cheese was used. The homogenate prepared by diluting 20g sample in 20ml of glass distilled water was subjected to pH measurement. For the water activity measurement, the sample of *gulabjamun* tempered at 25 °C temperature, was measured using Rotronic Hygroskop Model: Hygrolab-3 (M/s. Rotronicag, Switzerland) connected to a sensing element (AW-DIO) with a measuring range of 0-100 % relative humidity (RH). The method prescribed by Deeth *et al*. (1975) [8] was used to estimate the FFA content of burfi. Peroxide value was determined by the method as described in Indian Standard: 1479 (Part II-1961). The soluble nitrogen content of gulabjamun sample was determined by the procedure outlined by Kosikowski (1982) [20] using three grams of sample.

For measuring the sugar syrup absorption, fried *gulabjamun* balls (two for each treatment) with known weight was transferred to 50ml beaker containing sugar syrup, and allowed to soak for overnight at room temperature. *Gulabjamun*, after removing from syrup was allowed to drain for 10 min. on wire gauge and then weighed. Increase in weight of two *gulabjamun* over initial weight was taken as the amount of sugar syrup absorbed by *gulabjamun* and represented as percentage absorption of sugar syrup.

Texture profile analysis: Five samples of each experimental *gulabjamun* were subjected to uniaxial compression to 50% of the initial sample height, using a Food Texture Analyzer of Lloyd Instruments LRX Plus material testing machine, England; fitted with 0-500 kg load cell. The force-distance curve obtained for a two-bite deformation cycle employing a Cross Head speed of 20 mm/min, Trigger 10 gf and 40% Compression of the samples to determine various textural attributes of *gulabjamun* held for 1 h at 23±1 °C and 55% RH.

Sensory evaluation: The sensory panel was composed of staff members and post graduate students working in the institution. Judges who were familiar with desirable attributes of *gulabjamun* were selected. The selection criterion was that subjects had to be regular consumer's of typical dairy sweets as well as their similar behavior between sensory evaluation sessions. The samples were subjected to sensory evaluation as described in using a 9-point hedonic scale scorecard as suggested by Stone and Sidel (2004) [36]. The judges were also requested to note down their observations/ comments for each attribute specified in the score card. The *faraali gulabjamun* were tempered to 35±2 ^{0}C for judging. Samples were served in odour free plastic cups covered with plastic lid. The samples were labeled with random three-digit code. The order of presentation of the samples was randomized across subjects.

Microbiological analysis: *Faraali gulabjamun* sample was analyzed for the standard Plate Count (SPC), Coliform count and Yeast and Mold count (YMC) by the methods as described in IS: 5550: 2005 [16] with slight modification.

Shelf life studies: *Faraali gulabjamun,* which was prepared using a combination of binders (*viz.* sago and potato starch), was packed in composite polyethylene terephthalate PET bottles (sterilized using a solution of 150 ppm available chlorine solution for 10 min at 35 °C). The experimental samples were studied for the storage related changes. The samples packed in PET bottles were kept at refrigerated temperature (7±2 °C). The compositional, physico-chemical, rheological, sensory and microbial properties of fresh and stored samples of *faraali gulabjamun* were monitored at predetermined time interval after every 7th d. Stored *faraali gulabjamun* was rejected on basis of sensory evaluation as well as visible yeast and mold growth on the surface.

Statistical analysis: Statistical analysis of data was carried out as per Steel and Torrie (1980) [35] using completely randomized design.

Result and Discussion

Five types of binders were screened for their suitability for incorporation into *faraali gulabjamun viz*. sago, potato starch, amaranth flour, shingada flour and makhana. *Gulabjamun* was prepared using the method reported by Aneja *et al*. (2002) [5] using different binders at different levels *viz*. 5.0, 7.5, 10.0, 12.5, 15.0, 17.5 and 20.0% (w/w of *khoa*). When sago was used as a binding agent it was observed that, at low levels *viz*. 5.0, 7.5 and 10.0%, dough not cohesive enough was resulting in disintegration of *gulabjamun* during frying. At higher levels i.e. levels higher than 10% very soft, fragile, body resulting in breakage in handling.

When potato starch was used as a binding agent, it was observed that at lower levels of addition i.e. <10%, dough not cohesive enough resulting in disintegration of *gulabjamun* during frying at all the levels of addition. Whereas, at higher levels it resulted in thick and hard crust resulting in a hard centre core and a heavy bodied product. Moreover, pronounced soapy flavour of dough, lacks desired sweetness Addition of amaranth resulted in a typical off taste associated with the amaranth was also carried forward to the *gulabjamun.* At lower levels i.e. less than 5.0%, soft and fragile body and irregular body whereas, at higher levels i.e. levels higher than 10.0% disintegration of *gulabjamun* balls during frying. Addition of shingada and makhana flour resulted in product with very soft and fragile body at all the levels tried. All the binders (except maida) were not suitable as binding agents in *gulabjamun* when used singly. Hence it was decided to use a combination of binders *viz.* In order to select the most suitable combination of binders, trials were conducted using selected binders *viz.* sago: potato starch added @ 1g: 20g per 100 g *khoa* (SP), sago: amaranth flour

@ 1g: 5g per 100g *khoa* (SA), sago: shingada flour @ 1g: 10g per 100g *khoa* (SS) and sago: makhana @ 1g: 10g per 100g *khoa* (SM) in combinations as shown in Table 1. These levels were selected based on preliminary trials. The average sensory scores of *faraali gulabjamun* incorporated with different types of binding agents is presented in Table 1.

Table 1: Average sensory scores of *gulabjamun* incorporated with different types of binding agents

Type of binder	Sensory scores (1-9)			
	Flavour	Body and Texture	Colour and appearance	Overall acceptability
Control (C)	8.16^{a} ±0.15	8.06^{a} ±0.06	8.40^{a} ±0.10	8.06^{a} ±0.06
Sago + Potato starch (SP)	6.80^{b} ±0.10	6.10^{b} ±0.10	6.03^{b} ±0.06	6.60^{b} ±0.10
Sago + Amaranth (SA)	6.20^{c} ±0.10	5.93^{b} ±0.25	6.10^{b} ±0.10	5.96^{c} ±0.12
Sago + Shingada (SS)	5.90^{d} ±0.10	5.30^{c} ±0.20	5.76^{c} ±0.12	5.66^{d} ±0.06
Sago + Makhana (SM)	4.16^{e} ±0.06	5.13^{c} ±0.15	5.43^{d} ±0.06	4.10^{e} ±0.10
S.Em.	0.06	0.10	0.05	0.05
C.D. (0.05)	0.19	0.30	0.16	0.16
C.V. (%)	1.70	2.74	1.41	1.47

Each observation is mean ± SD of 3 replicate experiments (n=3)

^{a,b,c,d,e}:Superscript letters following numbers in the same column denote significant difference (P<0.05)

It can be seen from Table 1 that *gulabjamun* containing blend of sago and potato starch i.e. sample SP was superior in respect to body and texture compared to the rest of the samples. The decrease in body and texture scores of experimental samples SA (5.93), SS (5.30) and SM (5.13) was attributed to their very soft and fragile body and the decrease in body and texture scores of SP (6.10) to its thick and hard crust resulting in a hard center core and a heavy bodied product. The overall acceptability score of control (C) was significantly (P<0.05) higher than all the other samples. From amongst the experimental samples, only SP was in the acceptable range i.e. greater than 6.0. Based on the results, a combination of sago and potato starch was found suitable for use in *faraali gulabjamun* and was selected and used in this study.

Traditionally *gulabjamun* is prepared using maida (refined wheat flour) as a binding agent. Gluten is the protein present in wheat that holds the dough together and makes the flour pliable and thick and gives it the ability to be kneaded and to accept injected air. Whereas, in the experimental product, gluten-free binders *viz.* sago and potato starch were used, therefore the dough obtained did not have the desired pliability which is obtained when maida is used as binder. The absence of gluten in sago/ potato starch based dough entails a lower ability to provide desirable body and texture to the product, so to obtain dough with optimum properties, an agent that will give the formulation the required consistency needs to be added. Use of hydrocolloids such as xanthan gum and methylcellulose gave good results in products in which wheat flour was replaced with other cereals such as rice flour (Mukprasirt *et al.*, 2000 and 2001; Amboon *et al.*, 2010) [26, 27, 3]. A mixture of hydrocolloids viz. guar gum: xanthan gum @ 0.05: 0.15 % (w/w of *khoa*) was added to the dough to further improve the body and textural properties of the product.

Effect of addition of different levels of potato starch and sago on compositional attributes of *Faraali Gulabjamun*

In order to optimize the level of sago and potato starch, Potato starch and sago were incorporated in *gulabjamun* at selected levels. Potato starch and sago were added at the rate of (19, 20 and 21% w/w of *khoa*) and (0.8, 0.9, 1.0 and 1.1% w/w of *khoa*), respectively. Incorporation of both, potato starch and sago showed significant (P<0.05) effect on protein content of *faraali gulabjamun*. The interaction effect between potato starch and sago was found to non-significantly (P>0.05) affect the protein content of *faraali gulabjamun*. The values obtained for protein content in *gulabjamun* in this study is far lower than those reported in literature. The protein content of *faarali gulabjamun* in this study was found to range from 4.74 to 4.94%. Ghosh *et al*. (1986) [13] reported that the protein content of *gulabjamun* ranged from 6.0 to 7.6%. Prajapati *et al.* (1991) [31] reported protein of *gulabjamun* made from unconcentrated and concentrated milk was 7.6 and 9.5%, respectively. Chaudhary (2016) [7] prepared *gulabjamun* using moraiyo (little millet) as a binder which is used in fasting and reported that the protein content varied from 7.19 to 8.92%. The wide differences obtained in literature in protein content of *gulabjamun* could also be attributed to difference in sugar syrup absorption and type and quantity of binders used. The lower level of protein obtained in this study might be due to almost insignificant levels of protein (<0.3%) in both the binders used in this study compared to protein content of maida which is commonly used for manufacture of *gulabjamun* whereas, maida has a protein content of about 12%.

The range of mean values of fat of different *faraali gulabjamun* under study were 10.99 (P3S4) to 11.25(P1S1). Incorporation of potato starch and sago showed significant (P<0.05) effect on fat content of *faraali gulabjamun*. The higher levels of addition of potato starch showed progressive and significantly (P<0.05) decrease contents of fat. The higher levels of addition of sago also showed progressive and significantly (P<0.05) lower contents of fat. This difference in fat content of *faraali gulabjamun* could be ascribed to the differences in the surface characteristics of the crust. It has been reported that the microstructure of the crust region formed during the first moments of frying and the moving boundary at the crust/core interface determine the texture, oil-uptake, colour and crispiness of the food (Pinthus *et al.*, 1993; Farid and Chen, 1998; Farkas *et al.*, 1996; Moreira *et al*., 1999) [19, 10, 11, 25]. The relevant data on this aspect for comparison are lacking in literature. However, these results are in agreement with those of Chaudhary (2016) [7] who reported that the *gulabjamun* prepared using moraiyo as binding agent had 11.09 to 12.32% when moraiyo was added @ 20 to 40% by wt. of *khoa* respectively. The fat content in present study are also in corroboration with those obtained by Kant and Broadwayb (2017) [19] who reported a fat content of 13.81 to 13.97% in *gulabjamun* prepared from soy fortified milk.

Addition of sago as well as potato starch at different levels studied did not have any significant (P>0.05) effect on total solids content of *gulabjamun*. The interaction between sago and potato starch was found to be statistically non-significant

(P>0.05). Chaudhary (2016) [7] who obtained total solids values in range of 67.56 to 71.39% in *gulabjamun* containing moraiyo as a binding agent. However, the values of total solids in this study are lower than those reported by Prajapati *et al.* (1992) [31], Deshmuskh *et al.* (1993) [9], Adhikari *et al.* (1994) [1] and Thakar *et al.* (1994) [37] who reported values 71.07 to 72.49, 68.0 to 75.30, 74.40 to 80.32 and 72.0 to 72.80% respectively. The variations in total solids of *faraali gulabjamun* could be attributed to differences in binding agents used in this study resulting in differences in sugar absorption ratio in experimental samples. In view of complete lack of information available in the literature on the parameters studied in the present experimentation, it is difficult to make comparison.

Table 2: Influence of varied levels of potato starch and sago on composition of *Faraali gulabjamun*

Potato starch (P)	Sago (S)				Average For Potato starch
	0.8	0.9	1.0	1.1	
	Protein (%)				
19	4.94±0.03	4.91±0.02	4.91±0.03	4.89±0.04	4.91
20	4.85±0.02	4.83±0.03	4.82±0.02	4.82±0.02	4.83
21	4.79±0.05	4.77±0.02	4.74±0.04	4.74±0.03	4.76
Average For Sago	4.86	4.84	4.82	4.81	
	CD (0.05) P= 0.024; S= 0.028; PxS = NS				
	Fat (%)				
19	11.25±0.05	11.23±0.32	11.20±0.14	11.18±0.05	11.29
20	11.14±0.08	11.12±0.08	11.10±0.12	11.09±0.08	11.11
21	11.05±0.07	11.03±0.07	11.01±0.25	10.99±0.18	10.97
Average For Sago	11.14	11.24	11.07	11.04	
	CD (0.05) P= 0.123; S= 0.143; PxS= NS				
	Total solids (%)				
19	66.97±0.09	67.36±0.33	66.87±0.39	67.02±0.09	67.05
20	67.02±0.14	67.02±0.12	67.06±0.26	67.01±0.24	67.03
21	67.07±0.26	67.06±0.31	67.02±0.43	67.02±0.38	67.04
Average For Sago	67.02	67.15	66.98	67.02	
	CD (0.05) P= NS; S= NS; PxS= NS				

* Each observation is mean ±SD of 3 replications. P = Potato starch, S = Sago

Effect of Addition of Different Levels of Potato Starch and Sago on Physico-Chemical Properties of *Faraali Gulabjamun*

The ranges of mean values for acidity of sugar syrup of different *faraali gulabjamun* under study were 0.32 to 0.44ml 0.1 N NaOH required to neutralize 100ml sugar syrup. Addition of potato starch at different levels studied did not have any significant (P>0.05) effect on total acidity content of *gulabjamun*. Addition of sago at different levels studied have any significant (P<0.05) effect on acidity content of *gulabjamun*. The interaction between sago and potato starch was found to be statistically significant (P<0.05).

Addition of potato starch and sago at different levels studied did not have any significant (P>0.05) effect on water activity of *gulabjamun*. The interaction between sago and potato starch was also found to be statistically non-significant (P>0.05). Chaudhary (2016) [7] obtained water activity values in range of 0.902 to 0.909 in *gulabjamun* containing moraiyo as a binding agent. Vaja (2012) [38] reported water activity values in range of 0.903 and 0.883 in *gulabjamun* containing sweet cream buttermilk: whey and whey powder: maida as a binding agent respectively. Thus, the results obtained in the present investigation corroborates with reported literature.

Sugar syrup absorption is defined as the increase in weight of *gulabjamun* balls over the initial weight of fried *gulabjamun* balls and is expressed as percentage. The values of sugar syrup absorption ranged from 93.37 to 123.17 g/100g. The effect of level of sago on sugar syrup absorption was found to be significant (P<0.05). The effect of interactions between potato starch and sago on sugar syrup absorption was found to be statistically significant (P<0.05). Sugar syrup absorption of experimental *gulabjamun* increased significantly (P<0.05) with increase in rate of addition of sago. At higher level of potato starch addition, the sugar syrup absorption decreased due to formation of hard crust outside the *gulabjamun* balls and at higher level of sago addition, the sugar syrup absorption increased due to softer body of the *gulabjamun.* The rate of addition of potato starch had significant (P<0.05) effect on sugar syrup absorption. Chaudhary (2016) [7] obtained sugar syrup absorption in range of 113.67 to 109.89 g/100g in *gulabjamun* containing moraiyo as a binding agent. Vaja (2012) [38] reported sugar syrup absorption 97.58 and 114.54%. in *gulabjamun* containing sweet cream buttermilk: whey and whey powder: maida as a binding agent respectively. Thus, the results observed in the present study corroborates with those reported in literature.

Table 3: Influence of varied levels of potato starch and sago on Physico-Chemical properties of *Faraali gulabjamun*

Potato starch (P)					Average For Potato starch
	Sago (S)				
	0.8	0.9	1.0	1.1	
	Acidity (%LA)				
19	0.32±0.02	0.38±0.01	0.36±0.02	0.44±0.03	0.38
20	0.35±0.01	0.33±0.01	0.38±0.01	0.43±0.02	0.37
21	0.35±0.01	0.37±0.01	0.38±0.01	0.43±0.02	0.38
Average For Sago	0.34	0.36	0.37	0.43	
	CD (0.05) P= NS; S= 0.016; PxS= 0.028				
	Water activity				

19	0.92±0.01	0.90±0.01	0.90±0.03	0.91±0.02	0.91
20	0.91±0.01	0.92±0.01	0.91±0.02	0.92±0.01	0.91
21	0.91±0.02	0.91±0.04	0.91±0.03	0.91±0.01	0.91
Average For Sago	0.91	0.91	0.91	0.91	
	CD (0.05) P= NS; S= NS; PxS= NS				
	Sugar syrup absorption (g/100 g)				
19	96.40±0.68	96.52±0.56	110.47±0.64	116.30±0.35	104.93
20	96.49±0.23	103.16±0.31	116.37±0.18	123.17±0.70	109.80
21	93.37±0.41	96.14±0.50	110.32±0.31	116.72±0.33	104.14
Average For Sago	95.42	98.61	112.39	118.73	
	CD (0.05) P= 0.39; S= 0.45; PxS= 0.78				

* Each observation is mean ±SD of 3 replications. P = Potato starch, S = Sago

Effect of addition of different levels of potato starch and sago on sensory attributes of *Faraali Gulabjamun*

The data presented in Table 4 are the average values for sensory scores of *faraali gulabjamun* made with different treatment combinations. Potato starch at all the levels of addition significantly (P<0.05) affected the flavour scores *faraali gulabjamun*. Similarly level of sago was found to be significantly (P<0.05) effect the flavour scores of *faraali gulabjamun*. The effect of interactions between potato starch and sago were found to be statistically significant (P<0.05) for flavour scores. The flavour score of P2S3 was the highest i.e. 20% potato starch and 1% sago. This combination was found to be significantly (P<0.05) higher than all the other treatments studied. At higher rate of addition of potato starch can give persistence of its flavour which affects the overall flavour scores of *faraali gulabjamun*. Moreover, addition of sago can markedly improve the flavour scores of *faraali gulabjamun* due to its characteristics bland taste. Thus, improvement in flavour of *faraali gulabjamun* by incorporating a combination of sago and potato starch is clearly established form the present investigation. The average values for body and texture for different samples of *faraali gulabjamun* were found to vary from7.63 (P3S1 and P3S2) to 8.10 (P2S3). The data show that potato starch at all the levels of addition significantly (P<0.05) affected the body and texture scores *faraali gulabjamun*. Addition of potato starch up to 20 % levels resulted in improvement in body and texture scores of *faraali gulabjamun*, whereas higher levels (i.e. levels greater than 20%) of addition of potato starch had detrimental effect on body and texture score of *gulabjamun*. It was found that *faraali gulabjamun* containing higher levels of potato starch i.e. greater than 20% resulted in deterioration in the quality of *faraali gulabjamun.* At higher levels of addition of potato starch it imparted a peculiar decrease body and texture scores of *faraali gulabjamun*. Similarly, the data presented in Table 4 reveal that level of sago was found to be significantly (P<0.05) effect the body and texture scores of *faraali gulabjamun*. The effect of interactions between potato starch and sago were found to be statistically non-significant (P>0.05) for body and texture scores. At higher rate of addition of potato starch (i.e.>20) can give persistence of its body and texture which affects the overall acceptability scores of *faraali gulabjamun*. Moreover, addition of sago can markedly improve the body and texture scores of *faraali gulabjamun* due to its characteristics softness.

The data presented in Table 4 show that potato starch at all the levels of addition significantly (P<0.05) affected the colour and appearance scores *faraali gulabjamun*. The effect of interactions between potato starch and sago were found to be statistically non-significant (P>0.05) for colour and appearance scores. The data show that potato starch at all the levels of addition significantly (P<0.05) affected the overall acceptability scores *faraali gulabjamun*. Addition of potato starch up to 20 % levels resulted in improvement in overall acceptability scores of *faraali gulabjamun*, whereas higher levels (i.e. levels greater than 20%) of addition of potato starch had detrimental effect on overall acceptability score of *gulabjamun*. It was found that *faraali gulabjamun* containing higher levels of potato starch i.e. greater than 20% resulted in deterioration in the quality of *faraali gulabjamun.* Similarly, the level of sago was found to be significantly (P<0.05) effect the overall acceptability scores of *faraali gulabjamun*. There was a progressive increase in overall acceptability scores of *faraali gulabjamun* up to 1% level of addition of sago. Thereafter, higher levels (i.e. 1.1%) of addition of sago resulted in decrease in overall acceptability score. The effect of interactions between potato starch and sago were found to be statistically significant (P<0.05) for overall acceptability scores. The overall acceptability score of P2S3 was the highest i.e. 20% potato starch and 1% sago. This combination was found to be significantly (P<0.05) higher than all the other treatments studied. Moreover, addition of sago can markedly improve the overall acceptability scores of *faraali gulabjamun* due to its characteristics bland taste.

Thus, improvement in overall acceptability of *faraali gulabjamun* by incorporating a combination of sago and potato starch is clearly established form the present investigation. No published data on overall acceptability scores of *faraali gulabjamun* as affected by addition of sago and potato starch are available for comparison. It can be seen that potato starch and sago are binders that are used at a fraction of percentage, and yet, they produce dramatic flavour, body and texture and colour and appearance effects in *faraali gulabjamun* resulting in improved overall acceptability. The overall acceptability scores of P2S3 (i.e. sample containing 20% potato starch and 1.0% sago) was significantly higher than all the other combination studied.

Table 4: Influence of varied levels of potato starch and sago on Sensory Attributes of *faraali gulabjamun*

Potato starch (P)	**Sago (S)**				**Average For Potato starch**
	0.8	**0.9**	**1.0**	**1.1**	
	Flavour (1-9)				
19	7.50±0.10	7.73±0.06	7.83±0.12	7.63±0.06	7.68
20	7.53±0.12	7.70±0.10	8.20±0.10	7.90±0.00	7.83
21	7.47±0.06	7.57±0.06	7.73±0.12	7.60±0.10	7.59
Average For Sago	7.50	7.67	7.92	7.71	

	CD (0.05) P= 0.074; S= 0.085; PxS= 0.149				
	Body and Texture (1-9)				
19	7.70±0.10	7.63±0.38	7.90±0.10	7.70±0.10	7.73
20	7.87±0.06	7.97±0.12	8.10±0.10	7.90±0.10	7.96
21	7.63±0.06	7.80±0.10	7.83±0.06	7.70±0.10	7.74
Average For Sago	7.73	7.80	7.94	7.77	
	CD (0.05) P= 0.118; S= 0.137; PxS= NS				
	Colour and Appearance (1-9)				
19	8.00±0.10	8.10±0.10	8.20±0.10	8.10±0.10	8.10
20	8.10±0.10	8.20±0.10	8.47±0.06	8.27±0.06	8.26
21	8.13±0.06	8.17±0.06	8.37±0.06	8.13±0.06	8.20
Average For Sago	8.08	8.16	8.34	8.17	
	CD (0.05) P= 0.069; S= 0.079; PxS= NS				
	Overall Acceptability (1-9)				
19	7.57±0.06	7.73±0.06	7.93±0.06	7.63±0.06	7.72
20	7.60±0.10	7.77±0.06	8.17±0.06	7.90±0.00	7.86
21	7.50±0.10	7.60±0.10	7.83±0.06	7.63±0.06	7.64
Average For Sago	7.56	7.70	7.98	7.72	
	CD (0.05) P= 0.058; S= 0.067; PxS= 0.116				

* Each observation is mean ±SD of 3 replications. P = Potato starch, S = Sago

Based on the results obtained in this study, a final standardized recipe was developed which is presented in Table 5.

Table 5: Final standardized recipe of *faraali gulabjamun*

Sr. No.	Ingredient	Quantity
1.	*Khoa* (33-35% moisture)	100 g
2.	Sago	1 g
3.	Potato starch	20 g
4.	Guar gum	0.05 g
5.	Xanthan gum	0.15 g
6.	Cardamom powder	0.1 g
7.	Caramel flavour	1 g
Total		122.3 g

The approximate composition, physico-chemical properties, rheological characteristics, sensory attributes and microbiological quality of the optimized product are detailed below in Table 6. Sensory terms related to desirable and undesirable attributes for *Faraali gulabjamun* is presented in Table 6.

Table 6: Compositional, physico-chemical, rheological and sensory attributes of *Faraali gulabjamun*

Sr. No.	Attributes	Values
Compositional Attributes		
1.	Protein (%)	4.82 ± 0.02
2.	Fat (%)	11.10 ± 0.12
3.	Ash (%)	1.21 ± 0.03
4.	Acidity of sugar syrup (% LA)	0.38 ± 0.01
5.	Total solids (%)	67.06 ± 0.26
6.	Total carbohydrate (%)	49.83 ± 0.19
Physico-chemical properties		
1.	Sugar syrup absorption (g/100 g)	116.37 ± 0.18
2.	Acidity of *gulabjamun* (% LA)	0.174 ± 0.01
3.	Water activity (aw)	0.91 ± 0.02
4.	pH	6.21 ± 0.09
Rheological/Textural properties		
1.	Hardness (N)	3.90 ±1.14
2.	Springiness (mm)	8.0 ± 0.13
3.	Gumminess (N)	1.41 ± 0.09
4.	Cohesiveness	0.25 ± 0.03
5.	Adhesiveness (Nmm)	0.16 ± 0.05
6.	Chewiness (Nmm)	7.73±0.10

*****Each observation is mean ± SD of three replications (n=3)

Conclusion

Thus, it can be concluded on the basis of this study that a combination of sago and potato starch was most suitable for manufacture of gluten-fee, *faraali gulabjamun*. Addition of guar gum: xanthan gum @ 0.05: 0.15% resulted in the improvement in body and texture properties of *faraali gulabjamun*. A combination of 20 g potato starch and 1.0 g sago (per 100 g *khoa*) gave significantly higher acceptability compared to all the other combination studied.

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