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Effect of guar fiber on physicochemical, textural and sensory properties of sweetened strained yoghurt

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ABSTRACT
Naturally, milk & milk products are devoid of dietary fiber hence there is scope of dietary fiber fortification of dairy products. In the present study, sweetened strained yoghurt was fortified with dietary fiber using partially hydrolyzed guar gum (PHGG). PHGG is prepared by enzymatic hydrolysis of guar gum & exhibit low viscosity & molecular weight as compared to guar gum. PHGG was added to sweetened strained yoghurt at four levels i.e. 2.5%, 5.0%, 7.5% & 10% (w/w basis). Control & PHGG fortified sweetened strained yoghurt samples were subjected to textural (firmness, adhesiveness & cohesiveness) and sensory evaluation. Results revealed that PHGG can be utilized for fiber fortification of sweetened strained yoghurt. PHGG fortification in sweetened strained yoghurt decreased the firmness & adhesiveness whereas increased the cohesiveness. Sweetened strained yoghurt fortified with PHGG at 5% level showed overall sensory acceptability equivalent to control sweetened strained yoghurt.
Keywords:*Guar gum; dietary fiber; viscosity; sweetened strained yoghurt.*

1. INTRODUCTION

In last few decades, over rising demand for dairy products is observed for their taste and nutritive value. Among dairy products, fermented dairy products are getting more attention fromconsumers due to their nutritive as well as therapeutic value [1-7]. In India, seven percent of total milk production is utilized for the preparation of fermented dairy products such as curd, buttermilk and *Shrikhand*[8]. *Shrikhand* is a traditional Indian dairy product which is prepared by fermentation of whole milk by lactic acid bacteria followed by straining of curd (Chakka or strained dahi) and then mixing with powdered sugar and flavor. *Shrikhand* can also be referred to as sweetened strained yoghurt [9]. In Western India, *Shrikhand* is generally utilized as sweet dish during daily meals. *Shrikhand* is popularly consumed as a sweet in festive seasons in India. Sugar imparts sweetness to Shrikhand as a sweetening agent and enhances the taste. Dried fruits can also be used in Shrikhand making to improve flavour. *Shrikhand*contains nutritive wellness of fermented dairy products. It has a refreshing action similar to *Dahi*particularly during summer season. *Shrikhand* is popular among Indian people due to its specific characteristics such as palatability, taste, flavour and possible therapeutic value.

The different types of milk such as cow milk or buffalo milk used for Shrikhand making can influence its composition. Fermentation conditions and type of culture used can also influence some of its characteristics such as texture and acidity which ultimately affects the consumer liking. Whey removal during chakka preparation and sugar addition is considered to affect its moisture and total solid content. The method of manufacture of shrikhand includes traditional method and industrial method. For small-scale production of Shrikhand, traditional method is preferred. In traditional method, milk boiled, cooled and subjected to fermentation for preparation of dahi followed by straining with muslin cloth for whey removal. Strained dahi also is known as chakka is subjected to pressing and sugar and flavor addition. This traditional method for preparation of*shrikhand* is highly unorganized and leads to an effect on microbiological characteristics of *shrikhand*[10]. In industrial method, shrikhand is manufactured using different industrial equipments. In the industrial method, skim milk is pasteurized and inoculated with the culture and the curd or dahi is prepared. Then this curd is subjected to centrifugation for whey removal using a continuous quarg separator which produces chakka. Then the chakka thus obtained is mixed with cream, powdered sugar and desired flavours in a scraped surface heat exchanger for manufacture and pasteurization of the shrikhand. Superior quality with increased shelf life *shrikhand*is obtained if a post-processing heat treatment is given to the s*hrikhand*. Presently, there is an increase in demand forshrikhand containing some functional ingredient [11, 12].

Dietary fibers are the carbohydrate portions of food or food products thatare resistant to human digestive secretion and are considered having certain health benefits including cholesterol lowering, diabetes control and management of bowel function. In western countries, people are suffering from various diseases such as coronary heart disease, bowel disorders and type-2 diabetes due to their fiber deficient diet. Dietary fibers are basically of two types on the basis of their solubility- soluble and insoluble dietary fiber. Soluble dietary fiber is more beneficial than insoluble dietary fiber because of its certain health benefits. Partially hydrolyzed guar gum is extensively studied for its beneficial action as soluble dietary fiber [13]. Native guar gum is a high molecular weight galactomannan which exhibits very high viscosity when dissolved in aqueous solution. This property of guar gum makes it unfit for its use as soluble dietary fiber as it cannot be incorporated in food products at higher levels which are desired for physiological benefits. Hence native guar gum is

enzymatically hydrolyzed to prepare partially hydrolyzed guar gum having low molecular weight and low viscosity. As a result of which, it can be used as a source of soluble dietary fiber for fortification in various food products without influencing their sensory quality as it is tasteless, colorless, odorless and very less viscous in nature.

Naturally, milk & milk products are devoid of dietary fiber hence there is scope of dietary fiber fortification of dairy products. In present study, *Shrikhand* was fortified with partially hydrolyzed guar gum which is a source of soluble dietary fiber. PHGG was added to *Shrikhand* at four levels four levels i.e. 2.5%, 5.0%, 7.5% & 10% (w/w basis). Control & PHGG fortified *Shrikhand* samples were subjected to textural (firmness, adhesiveness & cohesiveness) and sensory evaluation.

2. MATERIALS AND METHODS

2.1. Raw materials and ingredients.

Pasteurized full cream milk with 6.0% fat and 9.0% solid-not-fat (SNF) was procured from the Dudhsagar Dairy (India) and milk samples were stored under refrigerated conditions until use. DVS culture (i.e. RST-744 & CHN-11) having mesophilic and thermophilic strains was procured from Chr. Hansen Inc. (Milwaukee, WI) and it was kept at −18°C temperature in a deep freeze until use. Guar gum sample was obtained from Hindustan Gum & Chemicals Ltd., India. Guar gum powder was sieved through 200# sieve to get gum powder with uniform fine particle size and was preserved in refrigerated condition followed by enzymatic hydrolysis of guar gum and analysis of partially hydrolyzed guar gum. Cellulase (USB Corporation, USA) and citric acid (LobaChemie, India) werealso used in study for enzymatic hydrolysis and pH maintenance, respectively. Rest chemicals were obtained from Sigma Chemicals.

2.2. Preparation of partially hydrolyzed guar gum.

Partially hydrolyzed guar gum was prepared via cellulase hydrolysis (0.19mg/g) at 50ºC & 5.6 pH for 4 hours [14]. For enzymatic hydrolysis of guar gum, pH of water was maintained 5.4 via citric acid addition. Enzyme at 0.19mg/g concentration was added to this acidified water. After this, fine guar gum powder was then dispersed and mixed in water. Enzymatic hydrolysis was carried out at these conditions until 4 hours in a BOD shaking incubator. After 4 hours of hydrolysis, low viscosity solution of partially hydrolyzed guar gum was collected. This enzyme treated low viscosity gum solution was then sterilized and subjected to filtration and freeze drying to evaporate moisture and to obtain solid partially hydrolyzed gum. The resultant dried gum was ground in pastel mortar to obtain powdered partially hydrolyzed guar gum.

2.3. Proximate analysis.

Proximate analysis parameters (such as moisture, protein, fat and ash content), total dietary fiber, insoluble dietary fiber and soluble dietary fiber content of native guar gum and partially hydrolyzed guar gum were determined via AOAC standard methods of analysis [15].

2.4. Viscosity of gum samples.

Spindle-type rotational viscometer (Brookfield, U.S.A.) was used for measuring viscosity of unhydrolyzed guar gum and partially hydrolyzed guar gum samples. Viscometer was fixed with specific spindle (i.e. S62 or S01) and then autozeroing was done in air before measuring the viscosity of the samples. Spindles were selected according to the maker's manual instructions. S62 spindle was used for measuring viscosity of unhydrolyzed guar gum solution whereas S01 spindle was used for partially hydrolyzed guar gum solution at 20 rpm. 1% (w/w) solution of both the gum samples was prepared by sprinkling gum sample in distilled water. After 2 hours of hydration, viscosity of aqueous gum solutions was measured at 20°C.

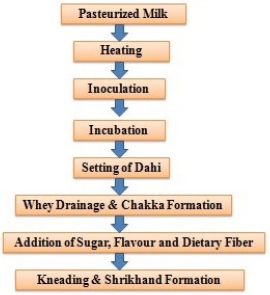

Figure 1. Flow chart for preparation of sweetened strained yoghurt.

2.5. Preparation of sweetened strained yoghurt (*shrikhand*).

Control shrikhand sample was prepared using pasteurized full cream milk of 6.0% fat and 9.0% solid-not-fat (SNF) content. Hot plate with magnetic stirrer was used to heat (42 °C) the milk. After heating, inoculation of milk was carried out with DVS culture with proper mixing followed by incubation at 42 °C for 7 hourrs. After the setting of dahi or Coagulum, the body of the coagulum was then broken and was tied and suspended in a muslin cloth for expulsion of whey for 8 hours. The semi-solid mass left after drainage of whey is called chakka, which is utilized as base material for preparation of shrikhand. Sugar and cardamom flavor was then added to the chakka or strained yoghurt followed by kneading in a dough mixer at very low speed for proper mixing of the ingredients. After kneading, shrikhand was ready and transferred to refrigerator for cooling and further analysis. For preparation of Fiber fortified *shrikhand*, PHGG as soluble dietary fiber source was added at 2.5%, 5.0%, 7.5% & 10% (w/w basis) level at the stage of sugar and flavor mixing in chakka. PHGG was mixed with the powdered sugar before adding to chakka. Rest of the unit operations was similar to the process for preparation of control shrikhand (Fig 1).

2.6.Titratable acidity and pH.

The titratable acidity of shrikhand samples was determined according to method reported by Srivastava and Kumar (1993) [16]. The titratable acidity values of shrikhand was determined using titration method. 10 g of shrikhand sample was mixed with 30 ml of hot distilled water. Phenolphthalein was used as an indicator. It was titrated against NaOH solution (0.1 N) using phenolphthalein indicator. Appearance of light pink color was considered as end point of the titration. pH of shrikhand samples was determined with pH meter..

2.7. Texture profile analysis.

Shrikhand samples were investigated for textural profile analysis (TPA) which includes hardness, cohesiveness, adhesiveness, gumminess and springiness. Texture Analyzer (TA-XT2i Model) from Stable Micro Systems,UK) was used to study TPA of shrikhand samples. The texture profile analysis was done by performing double compressions in a reciprocating motion using a flat end plunger (cylindrical) to obtain a plot of force versus time. The rest phase of 30 s was observed during two successive compressions. Pre-testing, testing and post-testing crosshead speeds were 4.0, 1.0 and 1.0 mm/s, respectively. 200 pps speed was selected for obtaining data during textural analysis. Five readings were taken for textural analysis. Values of Firmness, adhesiveness, cohesiveness were derived from manufacturer's software.

2.8. Sensory evaluation.

Sensory characteristics of shrikhand samples were evaluated via nine points Hedonic scale. On the ground of knowledge and past experience of sensory assessment of shrikhand, total twenty five sensory panel members were chosen. The sensory attributes assessed by sensory panel members were color, appearance, flavor, body, texture and overall acceptability. Shrikhand samples were taken out from refrigerator atleast 1 hour before the start of every evaluation session by the panelist. Shrikhand serving temperature during sensory evaluation was 10±2°C. Each shrikhand sample was presented in a plastic cup (50g capacity) with coded label. Samples were presented to the panelist in random order. Drinking water and spitting bowls were also panelist for mouth rinsing during samples evaluation.

3. RESULTS

3.1. Proximate analysis.

The results obtained from proximate analysis of hydrolyzed and unhydrolyzed gum samples are shown in Table 1.Moisture content of the partially hydrolyzed guar gum sample was lower in comparison to native guar gum sample which may be due to freeze drying of partially hydrolyzed guar gum sample which reduced its moisture. Similar to moisture, partially hydrolyzed guar gum also showed lower protein content as compared to native guar gum. This reduced level in protein is due to filtration operation after enzymatic hydrolysis which removes insoluble protein component from partially hydrolyzed guar gum. Ash content of the partially hydrolyzed guar gum was higher as compared to native guar gum. After enzymatic hydrolysis neutralization of acidic pH was carried out and the pH of gum solutions was brought to neutral. This alkali neutralization operation increases the ash content in partially hydrolyzed guar gum as compared to native guar gum. Due to the very high viscosity of unhydrolyzed guar gum sample, determination of dietary fiber content could not carry out in it. Results revealed that PHGG is a good source of total dietary fiber (TDF). It contains ample amount of soluble dietary fiber (SDF). Partially hydrolyzed guar gum contained 82.37 % of TDF and 79.52 % of SDF (Table 1). Proximate analysis results are in agreement with the reported results in the literature [17].

3.2. Viscosity.

Resistance to the flow of a liquid is known as its viscosity. It is a measure of frictional force between two adjacent layers of liquid. Food applications of native guar gum such as stabilization, thickening etc is due to its viscosity property hence it very important and desirable property for native guar gum. This viscosity property and gel forming action of native guar gum enable it for its use in numerous food products (such as ice cream, ketch, juice etc) as stabilizer and thickeners. Native guar gum showed viscosity of 5800 cps in 1% aqueous solution. Aqueous solution of partially hydrolyzed guar gum (1%) showed viscosity of 10 cps (Table 1). This reduction in viscosity of PHGG in comparison to native guar gum is due to reduction in chain length of galactomannan chain. PHGG with low viscosity is very much desirable so that it can be used at higher concentrations in various food products as a source of dietary fiber. The results obtained for viscosity of native and hydrolyzed guar gum are in agreement with the reported results in the literature [18].

Table 1. Proximate analysis of native and partially hydrolyzed guar gum.

Parameters	Guar Gum	Partially Hydrolyzed Guar Gum
Moisture (%)	11.12±0.17	8.56±0.19
Ash (%)	0.8±0.02	2.41±0.12
Protein (%)	4.51±0.05	2.09±0.36
Fat (%)	0.35±0.04	1.16±0.32
TDF (%)	-	82.37±1.45
IDF (%)	-	2.85±0.39
SDF (%)	-	79.52±1.05
Viscosity	5800±100cps	10±1 cps

Note: The values are mean ± S.D. of determinations made in triplicates

3.3.Titratable acidity and pH of Shrikhand.

Titratable acidity of shrikhand samples were observed between 0.989-0.994 (% l.a.) (Table 2). Titratable acidity of control shrikhand was 0.989 % (as % lactic acid) which is in accordance with the results reported in literature [19-21]. Results revealed that titratable acidity of shrikhand increased slightly with increasing fiber level in shrikhand. pH of control and fiber fortified shrikhand ranged from 4.77 to 4.81.The results revealed that there waslittle difference in the titratable acidity and pH of control and fiber fortified shrikhand samples. This little increase in acidity and reduction of pH of fiber fortified shrikhand sample in comparison to control shrikhand sample is attributed to increased levels of lactic acid formed in the shrikhand samples. Similar results were reported in literature for yoghurt fortified with date fiber [22].

Table 2. Titratable acidity and pH of control and fiber fortified sweetened strained yoghurt.

Sample	Titratable Acidity	pH
Control	0.989±0.002	4.81±0.04
2.5% Fiber	0.991±0.002	4.80±0.02
5.0% Fiber	0.991±0.004	4.80±0.03
7.5% Fiber	0.992±0.003	4.79±0.03
10.0% Fiber	0.994±0.004	4.77±0.04

Note: The values are mean ± S.D. of determinations made in triplicates.

3.4. Textural properties.

Texture analyzer is used for performing texture profile analysis (TPA) test for samples. In this test, the food sample is compressed twice which imitates the chewing condition of food sample in human mouth and describes the textural properties of that food sample [23]. Results obsereved for firmness, adhesiveness and cohesiveness are depicted in Table 3. Values obtained for textural parameters of shrikhand showed that the addition of soluble fiber improved the textural characteristics of shrikhand which further improved on increasing the concentration of soluble dietary fiber level in shrikhand. Firmness of food is a

measure of maximum force used by the food sample for the first compression to the desired level.

Table 3. Textural properties of sweetened strained yoghurt.

Sample	Firmness (g)	Adhesiveness (g/s)	Cohesiveness	Gumminess (g)
Control (S1)	32.2±0.21	90.4±0.52	0.58±0.02	18.67±0.02
2.5% Fiber (S2)	31.1±0.42	88.9±0.30	0.61±0.01	18.97±0.04
5.0% Fiber (S3)	29.7±0.31	86.3±0.24	0.63±0.02	18.71±0.03
7.5% Fiber (S4)	25.6±0.50	84.7±0.23	0.66±0.01	16.89±0.05
10.0% Fiber (S5)	24.3±0.32	82.9±0.31	0.67±0.02	16.28±0.04

Note: The values are mean ± S.D. of determinations made in triplicates.

Firmness is generally recognized as an important criterion thatis used for the assessment of textural evaluation of food products. The values obtained for the firmness of shrikhand samples were ranged between 24.3 to 32.2 g. The lowest value for the firmness was observed for shrikhand sample (S5) containing 10% dietary fiber however the highest value for firmness was observed in control sample not fortified with dietary fiber. In general, it was observed that the firmness of the shrikhand decreases with an increase in the level of fortification of dietary fiber. Shrikhand samples fortified with fibers were prepared via replacement of specific levels of chakka with partially hydrolyzed guar gum. This reduction in shrikhand firmness is due to the very low viscosity of PHGGas compared to chakka which ultimately leads to softer texture in fiber fortified shrikhand. Internal structure of shrikhand is responsible for its textural and rheological properties. Compact internal structure leads to firm texture in shrikhand sample. Microstructure of shrikhand consists of assembled network of casein micelles structure which provides strength and delicate gel-like structure to shrikhand and makes it highly non-Newtonian in behavior [24]. In double compression, adhesiveness of the food samples is generally estimated by the area of negative peak. Similar to firmness data, adhesiveness values for shrikhand samples reduced with addition of dietary fiber. Control shrikhand without added dietary fiber was the most adhesive sample. The lowest value for adhesiveness was observed for shrikhand sample (S5) fortified with 10% dietary fiber. The values obtained for adhesiveness of shrikhand samples were ranged 82.9 to 90.4 (g/s). The lower adhesiveness values for fiber fortified shrikhand samples indicates that during eating, less force is required to remove the fiber fortified shrikhand sample as compared to control shrikhand sample. In other words, fiber fortification leads to production of less adhesive shrikhand which is desirable attribute from sensory point of view. This reduction in adhesiveness of shrikhand is due to partially hydrolyzed guar gum addition which enhances the cohesion between sugar molecules and casein micelles of chakka. The values obtained for cohesiveness of shrikhand samples were ranged from 0.58 to 0.67. Control shrikhand (S1) was least cohesive whereas shrikhand sample (S5) fortified with 10% dietary fiber was the most cohesive sample. This increase in cohesiveness of shrikhand is due to the increased binding and more compact structure of shrikhand caused by partially hydrolyzed guar gum which strengthen the bonding between sugar and casein molecule and resulted in cohesive structure. Gumminess of a food sample is generally obtained via multiplying hardness and cohesiveness values. Gumminess of shrikhand samples increased slightly and then decreased due to reduced firmness and increased cohesiveness values of shrikhand samples with increased level of fiber fortification.

3.5. Sensory evaluation.

Sensory characteristics are the most significant criteria for the development of functional food products. The success of any food product including new products or functional food products in market very much depends on its sensory properties from consumer point of view. Sensory evaluation of control shrikhand and fiber fortified shrikhand is presented in Table 4. Sensory characteristics of fiber fortified shrikhand showed a marked decrease in comparison to control shrikhand as evidenced bythe values of overall acceptability values. However, shrikhand fortified with 5% fiber level showed a comparable overall acceptability score with control shrikhand sample.

Table 4. Sensory evaluation of sweetened strained yoghurt.

Sample	Color& Appearance	Flavor	Body & Texture	Overall Acceptability
Control (S1)	8.1±0.17	7.6±0.11	7.3±0.07	8.1±0.16
2.5% Fiber (S2)	8.0±0.20	7.7±0.10	7.5±0.10	7.9±0.12
5.0% Fiber (S3)	7.9±0.21	7.5±0.16	8.2±0.12	8.0±0.10
7.5% Fiber (S4)	8.1±0.19	7.6±0.12	7.5±0.09	7.0±0.11
10.0% Fiber (S5)	8.1±0.15	7.5±0.15	7.2±0.18	6.8±0.23

Note: The values are mean ± S.D. of determinations

Color and appearance and flavor characteristics of fiber fortified shrikhand samples were comparable without any symbolic change as compared to control shrikhand sample. Sensory scores of body and texture characteristics of shrikhand samples showed that shrikhand fortified with 2.5-7.5 % fiber resulted insensory score higher than control shrikhand score. However, shrikhand fortified with 10% fiber resulted insomewhat lower score of body and texture characteristics as compared to control shrikhand. On the basis of sensory scores obtained it was observed that partially hydrolyzed guar gum can be incorporated as dietary fiber in shrikhandupto the level of 5% with some improved sensory characteristics in shrikhand which is in accordance with the results reported in literature for partially hydrolyzed guar gum fortified in yoghurt [25].

4. CONCLUSIONS

Naturally, milk and milk products do not contain dietary fiber. Partially hydrolyzed guar gum obtained after enzymic hydrolysis of guar gum can be utilized as a rich source of soluble dietary fiber as it contains around 80 % soluble dietary fiber. Incorporation of PHGG in sweetened strained yoghurt, not only fortify dietary fiber but also retained its sensory characteristics and improve textural characteristics. Sweetened strained yoghurt fortified with 5% level of partially hydrolyzed guar gum showed equivalent sensory characteristics as compared to control sweetened strained yoghurt sample.It is concluded that sweetened strained yoghurt fortified with partially hydrolyzed guar gum produce soft and more cohesive sweetened strained yoghurt as compared to control sample.

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6. ACKNOWLEDGEMENTS

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