INFLUENCE OF PARTIALLY HYDROLYZED GUAR GUM AS SOLUBLE FIBER ON PHYSICOCHEMICAL, TEXTURAL AND SENSORY CHARACTERISTICS OF YOGHURT

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ABSTRACT

The effect of partially hydrolyzed guar gum fortification on physicochemical, textural and sensory characteristics of yoghurt was investigated. Fiber fortification was done at 1-5% levels to study the effect of soluble fiber fortification on the quality of yoghurt. Fiber addition significantly influenced the textural characteristics of yoghurt such as hardness, adhesiveness, cohesiveness, springiness and gumminess (p<0.05). Water holding capacity and viscosity was highest in yoghurt sample with 3% fiber while syneresis was lowest for the sample (p<0.05). The viscosity of the yoghurt samples increased with the fiber addition upto 3% level fortification, thereafter it decreased (p<0.05). Inclusion of soluble dietary fiber at 3% level in milk produced yoghurt with improved texture, physicochemical, higher nutritive value and desirable sensory characteristics.

Keywords: soluble fiber; syneresis; yoghurt; texture; sensory

INTRODUCTION

Yoghurt also known as Dahi in India is well known fermented dairy product in the Indian sub-continent and forms an important part in Indian diet. Yoghurt is known with different names in different countries such as Lebien (Iran), Jogurt (Turkey), Roba (Iraq), Shosim (Nepal) etc (Tamime and Robinson, 2007). Yoghurt is so popular in India that a meal is considered incomplete without consuming it towards the end of the meal. In southern parts of India, yoghurt is eaten with rice and is popularly known as curd rice and is used to prepare several dishes and is an important part in Indian diet. Yoghurt is a complete food. The beneficial role of dietary fiber in human nutrition has led to the growing demand for incorporation of novel fiber into foods (Mudgil and Barak, 2013). There is little information about fiber fortification in cultured dairy products. Various fibers like psyllium, guar gum, gum acacia, oat fiber and soy components can be used for fiber fortification in yoghurt. A lot of research work has been carried out on soluble fiber fortification of bakery products, processed foods, beverages etc, but research on fiber fortification in yoghurt is very limited. However, the effect of dietary fiber on Misti Dahi quality is reported in literature (Raju and Pal, 2014). Partially hydrolyzed guar gum is a low viscosity water soluble product which can be prepared by enzymatic hydrolysis of native guar gum (Mudgil et al., 2014). Partially hydrolyzed guar gum contains magnificent amount of soluble fiber (Mudgil et al., 2012a; Mudgil et al., 2012b). Native guar gum is generally used as stabilizer and thickener in various food products such as tomato ketchup, ice cream, beverages etc (Mudgil et al., 2011). Partially hydrolyzed guar gum is low molecular weight galactomannan having low viscosity, colorless, tasteless, odorless in nature and hence do not affect the product characteristics (Mudgil et al., 2016a; Mudgil et al., 2016b; Mudgil et al., 2016c; Mudgil et al., 2016d; Mudgil et al., 2018). In present study, partially hydrolyzed guar gum was selected for soluble fiber fortification of yoghurt and its effect on the physicochemical, textural and sensory characteristics of yoghurt.

MATERIALS AND METHODS

Raw materials and ingredients

Pasteurized standardized milk with 4.5% fat and 8.5% SNF was procured from Dudhsagar Dairy, Mehsana, India and stored in refrigerated conditions until use. A freeze-dried direct vat set (DVS) yoghurt culture (RST-744 & CHN-11) containing a mixed strain of thermophilic and mesophilic homofermentative bacterial culture was obtained from Chr. Hansen Inc. (Milwaukee, WI). The culture was stored at ~18°C until use. Partially hydrolyzed guar gum which is an enzymatically hydrolyzed guar gum with low viscosity was procured from Lucid Colloids Ltd., India.

Preparation of yoghurt

Control yoghurt sample was prepared using pasteurized standardized milk of 4.5 % fat and 8.5% SNF. The milk was heated to 42 °C on a bench-top stirring hot plate (Nova Instruments Pvt. Ltd.). Milk was inoculated with RST-744 (0.1 unit/litre) & CHN-11 (0.01 unit/litre) culture blend and mixed thoroughly in the milk. The milk was transferred to 50 ml, 100 ml & 250 ml cups with lids (Fig. 1). The samples were incubated at 42 °C in incubator (Patel Instruments Ltd, India) for 7 hrs. For fiber fortified yoghurt, soluble dietary fiber was added to the standardised milk at 1-5% levels. To allow good dispersion of the fiber in milk,
the fiber was sprinkled in vortex of milk using laboratory stirrer at 800 rpm. The milk was processed further similarly as control yoghurt. After incubation, yoghurts were immediately cooled in an ice water bath and stored at 10°C for 16 h. All the yoghurts were prepared in triplicate and the results were expressed as mean.

![Figure 1 Process for preparation of yoghurt](Image)

**Titratable acidity and pH**

The titratable acidity values of yoghurt samples were determined after mixing 10 g of yoghurt sample with 10 ml of hot distilled water (90°C). Phenolphthalein was used as an indicator. The mixture was then titrated with 0.1 N NaOH to an end point of just appearance of faint pink color. pH of yoghurt samples were measured using glass electrode digital pH meter. All the measurements were made in triplicate and the results were expressed as mean.

**Synerysis**

Synerysis in yoghurt samples was determined using drainage method as described by Chawla and Balachandran (1994) with slight modifications. In present study, after about 16 h of storage under refrigeration, the set yoghurt cups were taken out and tempered at 25°C for 2 h. The contents of the yoghurt cups were loosened with the help of a spatula from the sides and directly emptied into a glass funnel with a Whatman No.1 filter paper. The funnel was placed on a graduated glass cylinder (17.5-25 cm) of 50 ml capacity. The funnel with cylinder was kept in a room maintained at 25°C. The quantity of whey collected in graduated glass cylinder after 2 h of drainage was measured and considered as synerysis, expressed as percent whey separated.

**Viscosity**

Apparent viscosity (expressed in cPs) of yoghurt samples were measured using viscometer (Brookfield, USA). Viscometer was auto zeroed in the air after fixing the spindle (ASTM Disk Spindle S-62 at room temperature). Yoghurt samples were tempered to 25°C and stirred gently 20 times in clockwise and anticlockwise direction using a spatula and filled into a beaker for measuring the viscosity. The spindle S-62 was selected for viscosity measurement of yoghurt based on the instructions described in supplier’s instruction manual. The viscosity of stirred yoghurt samples was measured at 5 rpm, after starting rotation and results were expressed in cPs. Apparent viscosity reading was recorded after 60 seconds rotation of the spindle. Viscosity was measured for each sample in triplicate and the results were expressed as mean.

**Water holding capacity**

The water holding capacity of yoghurt samples was determined using a modified method as reported by Bodini et al. (2004). Ten grams of yoghurt samples were taken in centrifuge tubes and then centrifuged at 1,250 × g for 10 min at 5°C in a refrigerated high-speed centrifuge (Remi Centrifuge, Mumbai). The amount of whey expelled (g) during centrifugation (W) was weighed, and WHC calculated as follows: WHC (%) = (10 – W)/10 × 100. The measurement was carried out in triplicate and the results were expressed as mean.

**Texture profile analysis of yoghurt**

Yoghurts were analyzed for textural characteristics such as hardness, adhesiveness, cohesiveness, springiness and gumminess. Texture Profile Analysis (TPA) was carried out using Texture Analyzer, TA-XT2i (Stable Micro Systems, Surrey, UK). The texture profile analysis was analyzed by performing two sequential compressions using a flat-end cylindrical plunger (25-mm probe) separated by a rest phase of 30 s that generated plot of force versus time. Samples were compressed up to 70% of their original length. Crosshead speeds of 4.0, 1.0 and 1.0 mm/s were maintained for pretest, test and post test settings, respectively. The speed of obtaining the data was 200 pps. Five independent observations were made. Hardness, adhesiveness, cohesiveness, springiness and gumminess values were calculated from the obtained profiles using the software provided by Stable Microsystems.

**Sensory evaluation**

Sensory evaluation of control yoghurt and fiber fortified yoghurt was done using 9-point Hedonic scale. 25 panelists were selected on the basis of their previous experience and knowledge of sensory evaluation of dairy and dairy-associated products. Color and appearance, body & texture, flavor and overall acceptability were evaluated by panel. All samples were removed from the refrigerator 1 h before the beginning of every evaluation session. Serving temperature range for samples was 10 to 12°C. Each yoghurt was presented in a 100-g plastic cup fitted with lid and labelled with a 3-digit code. Order of presentation of samples was randomized. Water and expectoration cups were also presented to each panelist to rinse their mouths between samples. Evaluation was divided into three sections: visual, texture, and flavor evaluations. For visual attributes, the surface of each yoghurt was examined in terms of free whey. After that, texture and flavor evaluations were conducted.

**Statistical analysis**

The experimental data collected was analyzed for significant differences with the help of analysis of variance (ANOVA) conducted using SPSS 16.0 software.

**RESULTS AND DISCUSSION**

**Titratable acidity and pH**

Titratable acidity of control and fiber fortified yoghurt ranged between 0.76-0.78 (% lactic acid) as presented in Table 1. Titratable acidity of yoghurt showed an increasing trend with increase in level of fiber fortification. pH of yoghurt samples ranged from 4.40 to 4.43. The results of titratable acidity and pH showed no significant changes in control yoghurt and fiber fortified yoghurts. However, slight increase in the titratable acidity and lower pH values could be attributed to enhanced levels of lactic acid development in yoghurt samples. The results were in concordance with the study reported in literature (Hashim et al., 2009).

**Table 1 Physicochemical properties of control and fiber fortified yoghurt**

<table>
<thead>
<tr>
<th>Dahi</th>
<th>Titratable Acidity (%)</th>
<th>pH</th>
<th>WHC (%)</th>
<th>Synerysis (ml/50 g)</th>
<th>Viscosity (S-62, 5 rpm, 20°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.76±0.02</td>
<td>4.43±0.04</td>
<td>43.07±0.03</td>
<td>26±0.5</td>
<td>982±3.3</td>
</tr>
<tr>
<td>Y1</td>
<td>0.76±0.02</td>
<td>4.43±0.02</td>
<td>44.54±0.06</td>
<td>22±0.3</td>
<td>159±6.25</td>
</tr>
<tr>
<td>Y2</td>
<td>0.76±0.03</td>
<td>4.42±0.05</td>
<td>45.02±0.04</td>
<td>20±0.3</td>
<td>187±2.20</td>
</tr>
<tr>
<td>Y3</td>
<td>0.76±0.02</td>
<td>4.41±0.04</td>
<td>53.73±0.05</td>
<td>18±0.5</td>
<td>219±13.35</td>
</tr>
<tr>
<td>Y4</td>
<td>0.77±0.04</td>
<td>4.41±0.03</td>
<td>48.10±0.03</td>
<td>20±0.4</td>
<td>155±5.25</td>
</tr>
<tr>
<td>Y5</td>
<td>0.78±0.03</td>
<td>4.40±0.05</td>
<td>39.90±0.04</td>
<td>31±0.2</td>
<td>123±8.40</td>
</tr>
</tbody>
</table>

Values are mean ± S.D. of determinations made in triplicate. The values followed by different superscripts are significantly different at P< 0.05. Y1=1% fiber, Y2=2% fiber, Y3=3% fiber, Y4=4% fiber, Y5=5% fiber

**Synerysis**

Whey separation or synerysis is considered as a defect on the surface of yoghurt, set yoghurt and other set-style fermented dairy products and is defined as the expulsion of whey from the network which then becomes visible as surface whey and negatively affects consumer perception. The synerysis value of control yoghurt sample (Y1) was 26 ml while it was 31 ml for yoghurt sample (Y1) with 5% soluble fiber. In the present study, the synerysis in yoghurt samples decreased with increase in level of fiber fortification up to 3% (Y3) then showed a sharp increase. The fortification of partially hydrolysed guar gum (PHGG) as soluble fiber significantly decreased whey separation in all yoghurt samples. This effect could be attributed to the gelling capacity of the PHGG soluble fiber and its high ability to interact with the milk constituents (mainly proteins), and stabilize the protein network, preventing free movement of water. Functionality of hydrocolloids in yoghurt is demonstrated by their ability to bind water. However, at higher concentration of partially hydrolysed guar gum soluble fiber, there is higher tendency of whey separation or synerysis because it affects the network and textural properties.

**Viscosity**

Viscosity is resistance to flow of a fluid. It is a desirable characteristics in yoghurt as it contributes to mouthfeel and physical properties such synerysis, whey separation and water holding capacity. Yoghurts fortified with soluble fiber had the higher viscosity values as compared to control yoghurt, which showed the lowest viscosity. Viscosity values of yoghurt samples recorded were ranges between 982-2191 cPs. Fiber fortification up to 3% level in yoghurt samples increased the viscosity values whereas above this concentration there was an observed a decrease in viscosity of yoghurt samples. While lower concentration of soluble fiber supported the network formation and contributed to high viscosity in yoghurt samples.
Water holding capacity

Water holding capacity of yoghurt is considered as an indicator of its ability to retain serum in the gel structure. The ability of yoghurt to exhibit minimal whey separation is an important factor with respect to consumer perception (Lee and Lucey, 2010). Water holding capacity of yoghurt fortified with fiber increased to 53.73 % as compared to 43.07 % of control yoghurt sample. This increase in water holding capacity of yoghurt is due to higher water holding capacity of soluble fiber which also provided strength to yoghurt coagulum network and aids in more water retention. At 5% fiber concentration, the water holding capacity of yoghurt reduced to 39.9% which is even lesser than control curd sample. The lower water holding capacity at higher percentage of fiber was partially due to the unstable gel network of yoghurt, in which the weak colloidal linkage of protein micelles could not entrap water within its three dimensional network (Donkor et al., 2007).

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Texture profile analysis of control and fiber fortified yoghurt</th>
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<tbody>
<tr>
<td>Sample</td>
<td>Hardness (g)</td>
</tr>
<tr>
<td>---------</td>
<td>--------------</td>
</tr>
<tr>
<td>Control</td>
<td>45.5±0.27a</td>
</tr>
<tr>
<td>Y1</td>
<td>53.9±0.32c</td>
</tr>
<tr>
<td>Y2</td>
<td>54.2±0.24b</td>
</tr>
<tr>
<td>Y3</td>
<td>49.9±0.22a</td>
</tr>
<tr>
<td>Y4</td>
<td>47.4±0.18bc</td>
</tr>
<tr>
<td>Y5</td>
<td>38.5±0.20d</td>
</tr>
</tbody>
</table>

Values are mean ± S.D. of determinations made in triplicate. The values followed by different superscripts are significantly different at P < 0.05. Y1 = 1% fiber, Y2 = 2% fiber, Y3 = 3% fiber, Y4 = 4% fiber, Y5 = 5% fiber

Texture profile analysis

Texture profile analysis of food sample in a texture analyzer imitates the conditions in the mouth by compressing a product twice (Bourne, 1978). Results for texture profile analysis parameters such as hardness, cohesiveness, adhesiveness, springiness and gumminess are presented in Table 2. Results of texture profile analysis revealed that textural properties of yoghurt significantly improved on addition of soluble fiber. Hardness is used to estimate the maximum force of the first compression and is considered as a critical parameter for evaluation of textural characteristics of food. The highest hardness was measured in Y2 yoghurt sample (54.2 g), while the lowest one was observed in Y5 and control yoghurt sample (38.5 g & 42.5 g, respectively). Textural and rheological characteristics of coagulated yoghurt are generally determined by their internal structure. Tight and rigid internal molecular structure results in a firm protein gel. The microstructure of yoghurt consists of a three-dimensional network of casein particles containing spherical molecules of different sizes (Fiszman et al., 1999). Results suggest that fiber fortification in yoghurt upto 4% level give strength to network architecture. Adhesiveness is commonly calculated as the area of a peak. Adhesiveness value was highest for control yoghurt sample (43.8) and lowest for Y5 sample (42.1) which demonstrates that less force was required to remove the material adhered to the mouth during eating yoghurt samples fortified with fiber as compared to control yoghurt sample. Fiber fortification leads to decrease in adhesiveness of yoghurt samples. This may be due to the gummy nature of partially hydrolyzed guar gum which reduces the adhesiveness characteristic in yoghurt. Cohesiveness of yoghurt samples were increased with increased level of fiber fortification which indicates that fiber fortification supports and enhances the strength of internal bonds of all samples. Gummyness is the multiplication of hardness and cohesiveness. With the increased values of cohesiveness and variable values of hardness, gumminess of yoghurt samples first increased and then decreased. Springiness of control and fiber fortified yoghurt samples showed an increasing trend with respect to fiber fortification levels. The springiness of Y3 (0.92) and Y5 (0.91) yoghurt samples were higher than of the other samples indicating that yoghurt samples fortified with fiber returned more easily to its original shape after the deforming force was removed.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Sensory characteristics of control and fiber fortified yoghurt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
<td>Color &amp; Appearance</td>
</tr>
<tr>
<td>---------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Control</td>
<td>7.0±0.45a</td>
</tr>
<tr>
<td>Y1</td>
<td>6.9±0.30b</td>
</tr>
<tr>
<td>Y2</td>
<td>7.1±0.25bc</td>
</tr>
<tr>
<td>Y3</td>
<td>8.5±0.30b</td>
</tr>
<tr>
<td>Y4</td>
<td>7.5±0.22b</td>
</tr>
<tr>
<td>Y5</td>
<td>6.0±0.14a</td>
</tr>
</tbody>
</table>

Values are mean ± S.D. of determinations made in triplicate. The values followed by different superscripts are significantly different at P < 0.05. Y1 = 1% fiber, Y2 = 2% fiber, Y3 = 3% fiber, Y4 = 4% fiber, Y5 = 5% fiber

Sensory evaluation

Sensory evaluation of control and fiber fortified yoghurt is presented in Table 3. Compared to control yoghurt sample, the sensory characteristics of yoghurt fortified with fiber markedly improved except in case of Y5 sample in which fiber concentration was highest i.e.5%. Lower values for sensory characteristics of Y5 sample can also be co-related with pH, acidity, water holding capacity, syneresis and viscosity of curd. Sensory evaluation as well as overall acceptability results of the yoghurt samples showed that Y3 yoghurt sample (3% fiber level) was the most acceptable sample by judging panel members. Y5 sample scored highest among all samples with respect to color and appearance, body and texture, flavor and overall acceptability.

CONCLUSION

Partially hydrolyzed guar gum as soluble fiber can be used as yoghurt improver as it improved textural, physicochemohical and desirable sensory characteristics. Fiber fortification of yoghurt enhances the viscosity and water holding capacity of yoghurt samples. Moreover, it reduced the syneresis of yoghurt which can be an additional advantage to the yoghurt manufacturers. Fiber fortified yoghurt samples showed non-significant increase in acidity as compared to control sample but at acceptable level. Sensory evaluation results revealed that Y3 and Y5 yoghurt sample fortified with 3% soluble fiber was having highest acceptability. It is concluded that fortified yoghurt with 3% soluble fiber produced an acceptable product with improved characteristics.

REFERENCES


