EFFECT OF GUAR GUM ON VISCOSITY OF ICE CREAM

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Received: 08-01-2014
Accepted: 14-08-2014

ABSTRACT

Guar gum was isolated and purified by wet processing method. Purified guar gum was utilized as a stabilizer in ice cream. Guar gum was used as a stabilizer in ice cream at level of 0.1, 0.2, 0.3 and 0.4 per cent. The effect of various concentration of guar gum on viscosity of ice cream was studied. The effect of different concentration and varying shear rate on viscosity of guar gum incorporated ice cream was investigated. Guar gum solution of various concentration and guar gum incorporated ice cream were evaluated for viscosity measurement by Roto-viscometer (RV-20) using MV-II spindle shear rate of 4.69 to 34.99 Sec.\(^{-1}\) at 37\(^\circ\)C temperature. It was observed that as the concentration of guar gum in ice cream was increased, viscosity of ice cream also got increased. Thus, the ice cream which was incorporated with 0.4 per cent of guar gum shows highest viscosity and viscosity of ice cream got decreased upon increase in shear rate.

Key words: Guar gum, Hydrocolloid, Ice cream, Stabilizer, Viscosity.

INTRODUCTION

Guar gum is a galactomannan polymer extracted from the seed of Cyanopsis tetragonolobus which has been cultivated for centuries by the farmers in semi-desert regions of northwest India. It has an approximate 1:2 ratio of D-galactose to D-mannose (Fox, 1997). Galactose side chains occur on the mannose backbone at every third mannose unit, on average. This relatively high degree of substitution increases solubility characteristics, making guar gum soluble in cold water. Guar gum solutions display stable viscosity over a pH range of 4 to 10. Viscosity and hydration rate of guar gum vary depending on the processing method used in the preparation of the gum.

Guar gum is one of the most extensively investigated polysaccharides; its rheological behaviour enables it to contribute to good sensory qualities, including mouth-feel and flavor release in ice cream. (Bhandari 2001) The only important solvent for galactomannans is water as they have tremendous affinity for water in its liquid state. When dispersed in water, hot or cold, galactomannans hydrate rapidly to form colloidal solutions of unusually high viscosity characteristics even at very low concentrations (Rao and Cooley, 1992). Ice cream provides these valuable proteins in a very palatable form. Ice-cream is a rich source of many essential vitamins, without which normal health and growth cannot be maintained. The digestibility and palatability of ice-cream is also very high (Varnam and Sutherland, 1994).

A rheological study of guar gum indicated a non-Newtonian, pseudo plastic behavior of its solutions. When the data was treated mathematically by the modified Newton’s law, \(F(N) = \eta G\), the exponential constant \(N\) was found to increase with increasing concentration of gum. The viscosity of the solutions remained fairly constant in the pH range from 1.5 to 10.5. (Tantry and Nagarsenker, 2001).

Hydrocolloids such as guar gum, can be added to increase the viscosity of the ice cream at lower total solids content. Consistency / viscosity of ice cream are an important attribute from the engineering and consumer viewpoint. Fat plays an important role in the stabilization of the ice cream structure, as partially coalesced fat is mainly responsible for stabilizing the air bubbles and the foam structure (Koxholt et al., 2001). As milk fat is substituted with fat replacers, both the texture and

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flavour profile of ice cream may change (Prindiville et al., 2000). In attempts to provide desirable flavour and texture characteristics of full fat ice cream, manufacturers substitute carbohydrates and protein based fat replacers for milk fat (Welty et al., 2001).

Ice cream is a frozen dessert made from dairy products. It is a complex colloidal system consisting of air cells, ice crystals and fat droplets dispersed into serum phase. The functionality of hydrocolloids in ice cream is related to cryoprotection – hindrance of the re-crystallization phenomena, enhancement of ice cream mixes viscosity, improvement of texture and mouth feel as well as shape retention (Marshall et al., 2003). The nutritive value of ice cream varies with its composition; however, all the constituents of milk are present in a concentrated form. Protein interacts at the oil water interface during homogenization to stabilize the fat emulsion and during freezing, proteins function to control destabilization of fat (Goff, 1997).

**MATERIALS AND METHODS**

Guar gum was obtained from guar seeds by simple wet processing method. The other materials used were milk, cream, skim milk powder, Sugar, Strawberry flavor, chemicals and glasswares.

**Standardization of extraction process for guar gum:** The isolation and purification of galactomannan from the guar seeds were achieved by simple wet processing method developed in this laboratory (Rodge et al., 2006a). In typical experiment, seeds (500 g) of guar were suspended in aqueous alkaline solution (1.5 per cent, w/v) containing urea (0.05 per cent, w/v) followed by vigorous boiling at 98°C for 5 min.

The resultant dehusked seeds were thoroughly washed with tap water on a coarse sieve till the seeds were completely free from husk or hull. It was then subjected to sun drying or cabinet drying. The dried dehusked seeds were ground at low speed to achieve the separation of gum splits and germ meal, based on the principle of the nature of gum splits and germ meal fractions, respectively.

The gum splits obtained from the guar seeds were pulverized to 200 meshes and designated as ‘Crude Galactomannan Gum’. Further, partial purification of galactomannan was done by suspending it in distilled water followed by vigorous stirring to achieve viscogenic colloidal solution.

**Preferential fractionation of the galactomannan gum** was achieved by adding isopropanol or ethanol at different concentration levels (75 per cent, v/v). The resultant major gum fraction from the guar seeds was recovered quantitatively by centrifugation (5000 x g, 15 min). It was followed by drying in cabinet dryer.

The resultant purified galactomannan gum was further subjected to 60 per cent isopropanol (v/v) extraction at 70°C to remove phenyl glycosides, beany flavour, antinutritional factors etc. The purified galactomannan gum was colourless and odourless and designated as ‘Partially Purified Galactomannan’ of guar seed. The yield of the purified galactomannan was found to be 31.52 per cent, on whole seed basis.

**Different treatments prepared with incorporation of Guar gum at varying Concentrations:** Ice cream was prepared by incorporation of various four different concentration of guar gum. Carboxy methyl cellulose was used as the stabilizer in control sample of ice cream. Guar gum was incorporated in ice cream at level of 0.1, 0.2, 0.3 and 0.4 per cent is given in Table 1.

**Preparation of Ice cream with incorporation of guar gum:** There are various steps involved in the manufacture of ice cream. Knowing a mix specification, mix calculations are performed to determine the amounts of desired ingredients needed to formulate the mix. Mix processing begins with the assembly of the necessary ingredients in the desired amounts.

Generally this assembly requires weighing the ingredients or if liquid ingredients are used they are metered. Meters rely on knowing the density or the specific gravity of the ingredient and these values are highly temperature dependent. In most small scale

**TABLE 1:** Different treatments prepared with incorporation of Guar gum at varying Concentrations

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Guar gum Conc.(in %)</th>
<th>Ice Cream Mix Qty. in Litres</th>
</tr>
</thead>
<tbody>
<tr>
<td>C (Control)</td>
<td>Nil</td>
<td>1 Lit</td>
</tr>
<tr>
<td>T&lt;sub&gt;1&lt;/sub&gt;</td>
<td>0.1%</td>
<td>1 Lit</td>
</tr>
<tr>
<td>T&lt;sub&gt;2&lt;/sub&gt;</td>
<td>0.2%</td>
<td>1 Lit</td>
</tr>
<tr>
<td>T&lt;sub&gt;3&lt;/sub&gt;</td>
<td>0.3%</td>
<td>1 Lit</td>
</tr>
<tr>
<td>T&lt;sub&gt;4&lt;/sub&gt;</td>
<td>0.4%</td>
<td>1 Lit</td>
</tr>
</tbody>
</table>
operations weighing is the method of choice. Preparation of ice cream with incorporation of guar gum is given in figure 1. (Rodge et al., 2006b)

**Determination of viscosity of guar gum solutions prepared at different concentrations and viscosity of guar gum incorporated ice cream**

It was performed by using ‘Haake’s Roto Viscometer,’ RV-20 Model (Germany) calibrated at 37°C by using MV-II spindle shear rate. The dial reading was recorded as % T and calculations were made by using following equation.

\[ T = \% T \times A \]

Where, \( T \) = Shearing stress (Pas), \( \% T \) = Shear stress value of the display, \( A \) = Shear stress factor, \( D \) = \% D x M

The spindle constant A (1.78) and M (27.0) for particular spindle NV were obtained from the Manual of the instrument supplied by manufacturing company. The calculations for apparent viscosity were made by using following formula.

\[ N = \frac{T}{D}. \quad \text{(Pas)} \]

\[ N = \frac{T}{D} \times 1000 \quad \text{(cp)} \]

**RESULTS AND DISCUSSION**

**Apparent viscosity of different concentrations guar gum solution at different shear rate:** Guar gum being a hydrocolloid has property of improves viscosity of solution. The viscous behavior of guar gum varies with different shear rates and concentrations. In order to understand behavior of guar gum and its viscosity profile, the viscosity of guar gum at different levels were determined.

Guar gum has a straight chain of \( \beta \)-D-galactose and \( \alpha \)-D-mannoglycan with many single galactose branches. Therefore it combines properties of linear and branched polysaccharides and has a higher molecular weight than the other two hydrocolloids carrageenan and xanthan gum. This explains the higher viscosity imparted by guar gum. The maximum viscosity of guar gum is in 0.4 per cent the apparent viscosity is measured at the shear rate 4.69 s\(^{-1}\) (1663.3mPa.s). The minimum apparent viscosity is observed in case of 0.1 per cent concentration at the shear rate 34.99 s\(^{-1}\) (171.9mPa.s).

As shown in the Table 2, all the gum solutions were susceptible to shear thinning, a characteristic of pseudoplastic foods, and therefore the apparent viscosities decreased with increasing shear rate.

**Apparent viscosity of ice cream:** Apparent viscosity of ice cream samples containing different

**TABLE 2:** Apparent viscosity of different concentrations guar gum solution at different shear rate

<table>
<thead>
<tr>
<th>Shear rate (S(^{-1}))</th>
<th>Viscosity of guar gum at varying concentrations (mPa.s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1%</td>
<td>4.699 391.5 838.7 1243.2 1663.3</td>
</tr>
<tr>
<td>0.2%</td>
<td>7.689 283.8 712.3 893.6 1241.8</td>
</tr>
<tr>
<td>0.3%</td>
<td>12.71 212.6 659.4 776.1 915.5</td>
</tr>
<tr>
<td>0.4%</td>
<td>21.06 185.2 595.1 698.7 867.2</td>
</tr>
<tr>
<td>0.5%</td>
<td>34.99 171.9 527.8 613.3 786.9</td>
</tr>
<tr>
<td>S.E.</td>
<td>92.37 118.85 141.76 169.94</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>272.08 341.76 412.58 501.21</td>
</tr>
</tbody>
</table>

*Each value represents average of three determinations

**FIG 1:** Preparation of ice cream with incorporation of guar gum.

Selection of ingredients

Figuring the mix

Making the mix (Incorporation of Guar Gum)

Pasteurizing the mix

Boiling for 10 minutes

Cooling to room temperature

Homogenization

Aging the mix (0 to 4°C)

Freezing of mix (-4 to -5°C)

(Ice cream machine)

Packaging of Ice cream

Hardening

Frozen storage
concentrations guar gum at different shear rate is shown in Table 3.

The maximum viscosity of guar gum is in 0.4 percent, the apparent viscosity is measured at the shear rate 4.69 s⁻¹ (9981.9 mPa.s). The minimum apparent viscosity is observed in case of 0.1 percent concentration at the shear rate 34.99 s⁻¹ (6227.5 mPa.s).

**CONCLUSION**

The guar gum solutions are prepared by blending gum with mild hot water for studying of viscosity properties of guar gum. Then the gum extracted was purified and utilized as a stabilizer in ice cream at four different concentrations. The effect of different concentration and varying shear rate on viscosity of guar gum incorporated ice cream was investigated. The concentration of guar gum utilized were 0.1, 0.2, 0.3 and 0.4 per cent w/v. Guar gum solution of various concentration and guar gum incorporated ice cream were evaluated for viscosity measurement by Roto-viscometer (RV-20) using MV-II spindle shear rate of 4.69 to 34.99 Sec.⁻¹ at 37°C temperature. The result obtained on viscosity were showed increased trends as concentration of guar gum solution increased. When shear rate was increased, viscosity of guar gum solutions was decreased.

**REFERENCES**


**TABLE 3:** Apparent viscosity of ice cream samples containing different concentrations guar gum at different shear rate

<table>
<thead>
<tr>
<th>Shear rate (s⁻¹)</th>
<th>C</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
<th>T₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.699</td>
<td>8240.1</td>
<td>8634.3</td>
<td>9221.4</td>
<td>9653.2</td>
<td>9981.9</td>
</tr>
<tr>
<td>7.689</td>
<td>7665.4</td>
<td>7915.8</td>
<td>8633.7</td>
<td>9072.5</td>
<td>9467.4</td>
</tr>
<tr>
<td>12.71</td>
<td>7115.7</td>
<td>7347.9</td>
<td>7928.3</td>
<td>8471.6</td>
<td>8710.8</td>
</tr>
<tr>
<td>21.06</td>
<td>6763.2</td>
<td>7119.4</td>
<td>7410.1</td>
<td>7882.9</td>
<td>8207.7</td>
</tr>
<tr>
<td>34.99</td>
<td>6227.5</td>
<td>6559.1</td>
<td>6985.2</td>
<td>7397.8</td>
<td>7781.2</td>
</tr>
<tr>
<td>S.E.</td>
<td>383.57</td>
<td>436.65</td>
<td>485.13</td>
<td>543.26</td>
<td>597.44</td>
</tr>
<tr>
<td>C.D at 5%</td>
<td>1129.80</td>
<td>1224.43</td>
<td>1395.81</td>
<td>1585.18</td>
<td>1741.67</td>
</tr>
</tbody>
</table>

*AEach value represents average of three determinations*