Effect of variation of ginger juice on some physical and sensory properties of ice cream

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Abstract Frozen desserts like ice cream are valued for their pleasing flavour, cooling and refreshing effects. Ginger (Zingiber officinale) is valued for its medicinal and therapeutic properties. In present investigation, ginger - a natural herb, was used as a flavouring agent in ice cream. A basic ice cream mix having 12% fat, 11% solid not fat, 15% sucrose, 0.4% sodium alginate and 0.1% glycerol monostearate was prepared. Ginger juice was incorporated at levels of 0, 1, 2, 3, 4 and 5% w/w of ice cream mix. After experimentation, it was found that the gradual increase of ginger juice caused increase in freezing time with decrease in freezing point depression. The ginger juice also brought significant variations in overrun and melting characteristics. However, the variations were within a close range which ultimately did not impart adverse effect on sensory quality of ginger ice cream. The ice cream made with 4% ginger juice comprising of 11.53% fat and 3.89% protein with 43% overrun was found to be most acceptable.

Keywords: Ginger juice, ginger ice cream, overrun, melting characteristics, sensory quality

Introduction

Ice cream is a frozen dairy product made by suitable blending and processing of cream and other milk products, together with sugar and flavor, with or without stabilizer or colour and with incorporation of air during the freezing process. It was served for the first time some 3000 years ago to emperors of China in the form of frozen mixture of milk and rice (Soni, 2009). Ice cream contains 2 to 3 times as much fat and slightly more protein than milk. In addition, it may contain other food products such as fruits, nuts, eggs and sugar which enhance its food value. Ice cream is a product which is rich in calcium, phosphorus and other minerals of vital importance in building good bones and teeth. Being also rich in lactose, ice cream favours greater assimilation of the calcium content of the diet (Kansal, 1998). In India, ice cream is often served in weddings, in opening ceremonies and many other occasions (De, 2002). The ice-cream business in India was approximately Rs. 2000 Crore in the year 2013-14 (Trade Briefs, 2015). The per capita consumption of ice-cream in India is approximately 0.2 liter per annum while the average global per capita consumption is 2 liter (Anon, 2015). Ice cream in India is expected to see current retail value growth of 20%. The growing economy, along with increased disposable incomes ensures that the growth rate of ice cream to be high in near future (Euromonitor International, 2015).

Several investigations were carried out covering various aspects of ice cream preparation. Kumari et al. (2013) concluded that herbal ice cream is rich in medicinal and therapeutic properties. Several investigations were carried out covering various aspects of ice cream preparation. Kumari et al. (2013) assessed the physico-chemical characteristics for ice cream added with whey protein hydrolysates. Bisla et al. (2013) prepared nutritionally enhanced ice creams by the incorporation of soy milk, pumpkin seed, milk and pine apple pulp. Chavan et al. (2015) prepared ice cream with 3% sugar free natural (sucralose) and found it acceptable and advocated its use for diabetic, obese and vascular-cardiac patients.

The performance of a flavouring material in an ice cream depends not only on the quality of the added flavour but also on the quality of raw materials, composition consistency and processing. The ingredients used in the basic mix, type of sugar used and level of desired sweetness play important roles in determining quantity of the flavouring to be added. All of these together determine the ultimate quality of the perceived flavour (Lipsch, 1986). Guinard and Buchheim (1998) examined the human sensory system for ice cream which was found as a complex food stimulus. The intensity of flavour should be just strong enough to be easily recognized and delicately pleasing to taste (Arbuckle, 1986). Consumers assume higher degree of confidence in the wholesomeness and safety of natural foods and natural flavours. Kumar et al. (2013) concluded that herbal ice cream is gaining more popularity over synthetic products because of its functional, nutritional and pharmacological activities. A natural flavour exhibits variations in strength and quality, its ripeness at harvest and its subsequent handling. The industries...
must provide better quality novelty ice cream with natural flavour which gives medicinal benefits too.

Ginger (Zingiber officinale) is one such natural herb which is valued for its medicinal and therapeutic properties since time immemorial. Ginger is a perennial rhizome resembling shape of an irregular palm having circular scars all along their length. Ginger has been found helpful in preventing cough and colds (Buchman, 1980). Ginger is employed as a treatment for asthma, breathlessness, vomiting in many Asian countries. Ginger is a relatively, new flavour used in dairy products. Gavhane et al. (2014) concluded that ginger powder can be very well utilized for preparation of nutritious, palatable and low cost peda by blending at the rate of 2% with 95% khoa (buffalo milk) on weight basis. Pinto et al. (2004), Pinto et al. (2006) and Pinto et al. (2010) used ginger in both form i.e. as juice and shreds for preparation of ice cream. The present investigation involved quantification of physical and sensory parameters due to variation in ginger juice in ice cream.

Materials and Methods

The milk fat, milk solids not fat, sugar with or without other sweeteners and stabilizers (the traditional ingredients or components of ice cream) impart certain intrinsic properties to the taste and mouth feel that cannot be easily duplicated by substitution with other ingredients (Flores et al., 1993). In the present investigation, the ginger ice cream was made with following ingredient and procedure.

Dairy ingredients

The dairy ingredients used in the manufacture of ginger ice cream were milk, butter and skim milk powder as the source of fat and SNF. Pasteurized homogenized whole milk, marketed by M/s Dinshaw’s Dairy Food Ltd, Nagpur along with skim milk powder of “Amulya” brand (ISI certified) were used in preparation of ice cream mix. Fresh cow milk butter having 80 per cent fat was used in the present investigation.

Non-dairy ingredients

The non dairy ingredients used for preparation ice cream were cane sugar, stabilizer, emulsifier and fresh ginger. Alginate S4 of S. Square and Co., Gwalior was used as a stabilizer. Glycerol Mono Stearate (GMS) of Brion Fine Chem., Bombay was used as emulsifier. Commercial grade sugar and fresh ginger were procured from the local market of Raipur city.

Preparation of ginger juice

Ginger juice was prepared by passing the freshly peeled ginger through a clean and sanitized fruit and vegetable mixi (M/s Sumeet Machines Ltd., Nasik). The ginger paste was collected and then strained through a fine muslin cloth to remove its fibers.

Preparation of ice cream mix

The quantity of milk, unsalted butter, skim milk powder, sucrose, alginate and glycerol monostearate required for a batch (i.e. 1 kg of ice cream mix) was calculated by serum point method (Marshall and Arbuckle, 1994). The composition of basic mix was kept constant with 12% fat, 11% SNF, 15% sucrose, 0.4% sodium alginate and 0.1% glycerol monostearate. The required quantities of various ingredients for each treatment were weighed, mixed and blended thoroughly. Skim milk powder was mixed with 1/3 part of sugar and then added. The calculated amount of stabilizer and emulsifier were mixed with remaining 2/3 parts of sugar and added only when the temperature of the ice cream mix reached 70°C in steam jacketed kettle. The mixes were then further heated to 75°C, homogenized in a clean and sanitized homogenizer at I stage 2500 N/m² and II stage 500 N/m² pressure and pasteurized by holding the mix at 70°C for 30 min. (Arbuckle, 1986). The pasteurized mix batches were then immediately cooled to about 5°C and aged at 5 ± 2°C for 24 h. The flavouring ingredient (ginger juice) was added just before freezing. Six batches of ice cream mixes were prepared for feeding in a batch freezer. Ginger juice was incorporated at level 0 (control), 1, 2, 3, 4 and 5% w/w of ice cream mix.

Preparation of ice cream

The mix was frozen in a semi automatic ‘King Star’ home freezer (M/s Systronic Ltd., Ahmedabad) at -2.5°C having capacity of 1 kg of mix. The metallic cylindrical vessel of the freezer and the beater cum scraper assembly were cleaned and sanitized with a cleaning solution (Teepol) having 10 g per liter of water. Then the prepared mix was poured inside the cylinder till about half of its height. The surrounding passage was filled with ice pieces and coarse salt (25 to 30% of ice). After assembling the freezer, the freezing started and it stopped after 27-32 min till the mix froze to the desired consistency. The scraper assembly was removed from the cylinder then for hardening, cylinder was kept in deep freezer at -15 ± 2°C for 60 min. The laboratory made ginger ice cream was then subjected for physical and sensory evaluation.

Chemical analysis of ice cream

The fat, protein, total solids, pH and acidity of ice cream samples were estimated using standard procedure mentioned in BIS SP: 18 Part XI (1981).

Evaluation of physical properties

The ice cream was examined for its physical characters i.e. freezing time, freezing point depression, overrun and melting
characteristics.

Freezing time

The following formula was used for estimating freezing time. This formula is applied for fluids with high moisture levels over a wide range of freezing conditions. It combines Plank’s equation and modifications for the effect of various object shapes (Cleland and Valentas, 1997 and Hossain et al., 1992).

\[
    t_f = \frac{1}{E} \left[ \frac{\Delta H_1}{\Delta T_1} + \frac{\Delta H_2}{\Delta T_2} \right] \left[ \frac{R}{h} + \frac{R^2}{2k_f} \right] 
\]

Where,

- \( t_f \) = freezing time of ice cream (s)
- \( E \) = shape factor 2 (because an infinitely long cylinder has two fully contributing dimensions)
- \( \Delta H_1 \) = quantity of heat removed from normal to freezing temperature (J)
- \( \Delta H_2 \) = quantity of heat removed from freezing to final temperature of ice cream (J)
- \( \Delta T_1 \) = average of initial temperature of ice cream mix and mean freezing temperature (°C)
- \( \Delta T_2 \) = average of mean freezing temperature of ice cream mix and temperature of cooling medium (°C)
- \( R \) = radius of the cylinder of ice cream (m)
- \( h \) = convective heat transfer coefficient (W/m²K)
- \( k_f \) = thermal conductivity of ice cream (W/m°C)

Freezing point depression

At standard conditions the water must freeze at 0°C but the salts tend to freeze water at somewhat lower temperature. The same is true with ice cream mix also. In the ice cream mix, the constituents or addition of ingredients reduces the freezing point. The difference between 0°C and actual freezing temperature is called freezing point depression. This was estimated on the basis of following equation. This equation ensures more accuracy as it includes the mass fractions of all constituents of mix to be converted into ice cream.

\[
    \frac{\lambda}{R_k} \left[ \frac{1}{T_0} - \frac{1}{T_f} \right] = \ln \left[ \frac{(X_w - X_f - X_b)M_w}{(X_w - X_f - X_b)M_w + (X_s + X_r)M_E} \right] 
\]

Where,

- \( \lambda \) = molar latent heat of fusion (J/mol)
- \( R_k \) = universal gas constant (J/kg mol K)
- \( T_0 = 0°C \) (i.e. 273K) temperature
- \( T_f \) = absolute temperature of freezing of ice cream mix (K)
- \( X_w \) = mass fraction of total water (liquid water + ice + bound water)
- \( X_f \) = mass fraction of fat
- \( X_b \) = mass fraction of bound water
- \( X_s \) = mass fraction of solids not fat
- \( M_w \) = effective molecular weight of solids (atomic mass unit, amu)
- \( M_s \) = molecular weight of total water (atomic mass unit, amu)

Overrun

A known volume of ice cream mix was weighed accurately and then the same volume of ice cream was weighed and the overrun was determined as

\[
    \text{Percent overrun} = \frac{W_1 - W_2}{W_2} \times 100 
\]

Where,

- \( W_1 \) = Weight of ice cream mix (kg)
- \( W_2 \) = Weight of same volume of ice cream (kg)

Melting characteristic

The procedure (Upadhyay et al., 1978) to determine melting characteristic of ice cream was followed in the present set of experiment. A chunk of 1 liter ice cream was taken and a slice weighing about 100 g was cut in duplicate. The slices were separately placed over a 250 wire mesh and then placed over a long stem glass funnel of 15 cm diameter. The funnel with wire mesh containing ice cream slice was placed over a 100 ml glass cylinder. It was then kept in an incubator maintained at 37.5°C for 40 min. The volume and weight of melted ice cream was noted down. In this way the melting characteristic was determined as percentage weight of total ice cream melted in 40 min at 37.5°C.

Sensory quality

Ginger ice cream samples were subjected to sensory evaluation using a score card suggested by Arbuckle (1986). Usually consumers judge the quality of ice cream on the basis of its flavour, body and textural characteristics. The sensory quality of ginger ice cream samples was adjudged by a panel of 5 judges selected on the basis of their consistency in scoring of various ice cream samples. Out of total 100 marks, marks awarded for sensory attributes of ‘flavour’ and ‘body & texture’ were 45 and 30 marks respectively. Other parameters were allowed as perfect by default so as to focus more on ‘flavour’ and ‘body & texture’. The fresh samples of ice cream, after 1 h of hardening at -15 ± 2°C in deep freezer, were evaluated for organoleptic characteristic by a panel of trained judges.
Table 1: Composition of ginger ice cream

<table>
<thead>
<tr>
<th>No.</th>
<th>Treatments</th>
<th>Level of ginger juice (%)</th>
<th>Fat %</th>
<th>Protein %</th>
<th>TS %</th>
<th>pH</th>
<th>Acidity %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>T₀</td>
<td>0% (Control)</td>
<td>11.94</td>
<td>3.99</td>
<td>38.31</td>
<td>6.35</td>
<td>0.196</td>
</tr>
<tr>
<td>2.</td>
<td>T₁</td>
<td>1</td>
<td>11.86</td>
<td>3.98</td>
<td>38.11</td>
<td>6.33</td>
<td>0.197</td>
</tr>
<tr>
<td>3.</td>
<td>T₂</td>
<td>2</td>
<td>11.78</td>
<td>3.96</td>
<td>37.93</td>
<td>6.33</td>
<td>0.185</td>
</tr>
<tr>
<td>4.</td>
<td>T₃</td>
<td>3</td>
<td>11.71</td>
<td>3.93</td>
<td>37.61</td>
<td>6.32</td>
<td>0.200</td>
</tr>
<tr>
<td>5.</td>
<td>T₄</td>
<td>4</td>
<td>11.53</td>
<td>3.89</td>
<td>37.46</td>
<td>6.31</td>
<td>0.204</td>
</tr>
<tr>
<td>6.</td>
<td>T₅</td>
<td>5</td>
<td>11.32</td>
<td>3.86</td>
<td>37.23</td>
<td>6.31</td>
<td>0.206</td>
</tr>
</tbody>
</table>

Table 2: Effect of ginger juice on physical properties of ice cream

<table>
<thead>
<tr>
<th>No.</th>
<th>Treatment</th>
<th>Treatment (Ginger juice %)</th>
<th>Freezing time (min.)</th>
<th>Freezing point depression (°C)</th>
<th>Overrun (%)</th>
<th>Grams meltdown down in 40 min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>T₀</td>
<td>0 % Control</td>
<td>15.83</td>
<td>3.278</td>
<td>51.13</td>
<td>45.23</td>
</tr>
<tr>
<td>2.</td>
<td>T₁</td>
<td>1 %</td>
<td>15.95</td>
<td>3.264</td>
<td>49.05</td>
<td>42.2</td>
</tr>
<tr>
<td>3.</td>
<td>T₂</td>
<td>2 %</td>
<td>16.12</td>
<td>3.242</td>
<td>46.88</td>
<td>39.5</td>
</tr>
<tr>
<td>4.</td>
<td>T₃</td>
<td>3 %</td>
<td>16.31</td>
<td>3.221</td>
<td>44.35</td>
<td>36.75</td>
</tr>
<tr>
<td>5.</td>
<td>T₄</td>
<td>4 %</td>
<td>16.48</td>
<td>3.199</td>
<td>42.53</td>
<td>33.43</td>
</tr>
<tr>
<td>6.</td>
<td>T₅</td>
<td>5 %</td>
<td>16.62</td>
<td>3.182</td>
<td>38.97</td>
<td>28.75</td>
</tr>
</tbody>
</table>

Note: Superscripts at 5% level of significance indicate they are significantly different from each other at 5% level of significance.

Table 3: Statistical analysis of Physical parameters of ginger ice cream

<table>
<thead>
<tr>
<th>No.</th>
<th>Particular</th>
<th>F_{crit}</th>
<th>CD at 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Overrun</td>
<td>368.24</td>
<td>0.79</td>
</tr>
<tr>
<td>2.</td>
<td>Melting characteristics</td>
<td>315.19</td>
<td>1.14</td>
</tr>
<tr>
<td>3.</td>
<td>Freezing time</td>
<td>128.83</td>
<td>0.092</td>
</tr>
<tr>
<td>4.</td>
<td>Freezing point depression</td>
<td>127.26</td>
<td>0.011</td>
</tr>
</tbody>
</table>

F_{crit} 5% = 2.77

Table 4: Effect of ginger juice on sensory quality of ice cream

<table>
<thead>
<tr>
<th>No.</th>
<th>Treatment number</th>
<th>Treatment (Ginger juice %)</th>
<th>Flavour</th>
<th>Body and texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>T₀</td>
<td>0 % Control</td>
<td>35</td>
<td>24</td>
</tr>
<tr>
<td>2.</td>
<td>T₁</td>
<td>1 %</td>
<td>36</td>
<td>24</td>
</tr>
<tr>
<td>3.</td>
<td>T₂</td>
<td>2 %</td>
<td>37</td>
<td>25</td>
</tr>
<tr>
<td>4.</td>
<td>T₃</td>
<td>3 %</td>
<td>38</td>
<td>25</td>
</tr>
<tr>
<td>5.</td>
<td>T₄</td>
<td>4 %</td>
<td>39</td>
<td>26</td>
</tr>
<tr>
<td>6.</td>
<td>T₅</td>
<td>5 %</td>
<td>34</td>
<td>23</td>
</tr>
</tbody>
</table>
Statistical analysis

The whole experiment was based on 4 replications (i.e. 24 lots) of preparation of ice cream. The significance was tested by employing Complete Randomize Design and comparison between means was made by using least significant difference (critical difference) value at 5% level of significance.

Results and Discussion

Composition of ice cream

The variation in amount of ginger juice caused considerable changes in composition of ice cream which is given in Table 1. The variation of fat was found decreasing from 11.94 to 11.32% while protein decreased from 3.99 to 3.86%. Kumar et al. (2013) also reported decrease in the fat, protein, reducing sugar, non-reducing sugar and total solids with increasing levels of tulsi extract at 2, 3 and 4%. Similar trends of reduction in fat and protein were also reported by Pinto et al. (2010) when ginger shreds percentage increased from 0 to 8%.

A. Physical properties of ice cream

(i) Effect on ginger juice on freezing time

For any product which is to be frozen; prediction of freezing time is most difficult as it involves various physical (density, porosity etc.) and thermal characteristics (convective heat transfer coefficient, enthalpy, specific heat etc.) (Cleland and Valentas 1997). From Table 2, freezing time was found increasing from 15.83 min to 16.62 min with increase in ginger juice from 0 to 5%. Higher juice percentage has imparted higher moisture in ice cream. Therefore, required freezing time was more as it had to freeze higher amount of water. Thereby, extra amount of latent heat is to be extracted from ice cream mix causing delay in freezing.

(ii) Effect of ginger juice on freezing point depression

The addition of ingredient lowers the freezing point of ice cream. The freezing point depression was calculated as per eqn. (2). Table 2 presents the variation of freezing point depression (°C) of ginger ice cream. The perusal of data indicates that treatment T1 (3.278), T2 (3.264), T3 (3.242), T4 (3.221), T5 (3.199) and T6 (3.182) are significantly different with each other. The lowest freezing point depression (3.182°C) was observed in treatment T5 and highest (3.278) in T1. Moreover, Table 3 shows that the effect of the ginger juice on freezing point depression of ice cream which is significant from the F-test (F_{cal} = 127.26 > F_{tab} = 2.77).

(iii) Effect of ginger juice on over run of ice cream

The equation (3) was used to calculate the per cent overrun of ice cream. The data in Table 2 presents the per cent overrun of ginger ice cream. The highest overrun was observed (51.13) in treatment T1 and lowest (38.97) in treatment T5. The gradual increase of ginger juice in the treatment resulted insignificant decrease in overrun of ice cream. The data also indicated that treatment T1 (51.13), T2 (49.05), T3 (46.88), T4 (44.35), T5 (42.53) and T6 (38.97) are significantly different with each other. The low overrun % is acceptable because high overrun (>80%) often go together with a somewhat foamy dry consistency and relatively slow melting behavior and flavour release (Lipsch, 1986). As evident by analysis of variance from Table 3, ginger concentration was found to be highly significant because value of F_{cal} is much higher (368.24) than the value of F_{tab} (2.77). This revealed that the variation in amount of ginger juice has caused appreciable effect on the overrun value.

These results are more or less corroborating the findings of Pinto et al. (2010) in which they found that with addition of treated ginger shreds from 0 to 8%, the over run of ice cream reduced from 45.47 to 31.08 %. Pinto et al. (2004) also reported that decrease in overrun from 50.27 to 39.29 when addition of ginger juice increased from 0 to 5%. Pawar et al. (2014) reported 32.85% overrun during preparation of low fat custard apple ice-cream.

(iv) Effect of ginger juice on melting characteristics

The analysis of variance values on melting characteristics was done (Table 2). It revealed that the effect of variation in ginger juice on melting characteristics of ice cream is pronouncedly significant from the F-test (F_{cal} = 315.19 > F_{tab} = 2.77). The gradual increase of ginger juice in the treatments resulted in a significant decrease in the melting characteristics of ice cream (at 1% ginger juice = 42.2g and at 5% = 28.75g).

B. Effect of ginger juice on sensory attributes of ice cream

It has been reported that milk fat plays an important role in the quality of ice cream by imparting richness, suitable flavour and smoothness (Chavan et al. 2015). In the present investigation, the fat and other constitutes are kept same. This means that variation in textural quality was due to only variation in ginger juice. The success of any food product has always rested on the acceptance of the product by the consumers. The results of sensory analysis are presented in Table 4. It clearly represents influence of addition of ginger juice on the organoleptic attributes of ice cream.

(i) Flavour

Among all the samples T4 was found to be the best. It could be seen that use of ginger juice in ice cream increased its flavour preference, when added up to 4% only. Addition of the juice at
5% level led to decrease in flavour score, which was lower than that of samples T1, T2, T3, T4 and even T0 (control). The aroma of ginger is mainly due to its volatile essential oil. The pungency of ginger is attributed to its non-volatile constituents like gingerols, shogoal, paradol etc. (Narayana, 1988). These might be responsible for the desired flavour of ice cream containing ginger. The intensity of aroma and pungency of ice cream is optimally balanced at 4% level of ginger juice addition.

Kumar et al. (2013) found that in tulsi ice cream, flavour increased up to 3% level. They reported that 4% level led to decrease in score due to intense flavour. Pinto et al. (2004) reported flavour preference for ginger juice when added at the rate of 4, 3, 2 and 1% in ice cream when judged against vanilla as control. In another study, Pinto et al. (2010) reported increase in flavour when treated ginger shreds were added upto 6%. On the basis of flavour and total score Trivedi et al. (2014) recommended the ice cream containing basil juice at the rate of 6% and freeze dried basil at the rate of 1% by weight of mix.

(ii) Body and texture

The score of body and texture is also presented in Table 4 which indicates superiority of T4 ice cream over all other samples. These values also indicate that the ice cream containing ginger juice was preferred with respect to its body and texture characteristics as compared to control. Raising the level of the juice to 5% (T5) caused a very slight decrease in score of the ice cream in comparison to the T0 (control).

For preparation of ice cream, with the incorporation of ginger juice at 4% rate (Pinto et al., 2004, Pinto et al., 2006) and the incorporation of ginger shreds at 6% rate (Pinto et al., 2010) found superior flavour characteristics over vanilla ice cream. David (2014) reported that the scores for body and texture of ice cream did not differ significantly when ginger juice is incorporated at the rate of 2, 4 and 6%.

Conclusions

The gradual increase of ginger juice increased freezing time but decreased freezing point depression. It decreased both physical characteristics i.e. overrun and melting characteristics. Small increase of ginger juice level appreciably decreased the percent overrun. All the experimental samples had significantly lower meltdown than control sample which indicated lower or delayed meltdown of ginger ice cream. The ice cream made with 4% ginger juice was found most acceptable. On sensory analysis, it was found that the variations in flavour and ‘body and texture’ were within a close range which had shown that ginger juice had not imparted any adverse effect on sensory quality of ice cream.

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