Physical and sensory characteristics of low fat dairy dessert (Rasogolla) fortified with natural source of β-carotene

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Rasogolla (a white color ping pong like juicy ball prepared by boiling mashed fresh cheese or cottage cheese ball in concentrated sugar syrup) fortified with carrot paste (10%, 20%, 30%, 40% and 50% levels named as sample CRA, CRB, CRC, CRD and CRE respectively), were developed and then compared to conventional Rasogolla taken as control by both sensory and instrumental analysis. All 5-type carrot Rasogolla were similar to control in respect of moisture, sucrose and ash but differed in fat and protein content. Textures of carrot Rasogolla were similar to control in terms of elasticity and cohesiveness. A trained panel found that carrot Rasogolla (CRA, CRB, and CRC) was more acceptable than CRD, CRE or control Rasogolla. Carrot Rasogolla CRC possesses highest β-carotene level. Rasogolla fortified with carrot could be a valuable addition to indigenous dairy products.

Keywords: β-Carotene, Carrot, Rasogolla, Sensory evaluation, Sugar syrup

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Introduction

Vitamin A deficiency1-3 (VAD), leading cause of nutritional blindness and mild xerophthalmia in children, is the most common dietary deficiency in the world. Daily pro-vitamin A intake recommended by the FAO is 250-400 retinol equivalent (RE) for children, 575-725 RE for adolescent, and 750 RE for adults. Theoretically, β-carotene possesses 100% vitamin A activity while α-carotene possesses almost half activity (50-53%)4,5. About 80% of vitamin A value as RE is provided by β-carotene6. The β-carotene demand has increased due to its anticancer activity, activity as a free radical quencher and antioxidant, besides protection against cardiovascular diseases, cataract formation, immune responses and neural defects6.

Carrots1,4,5,7-9 have the highest content of carotene (6.9-15.8 mg carotenoids per 100 g of carrot) compared to several raw fruits and vegetables as follows: β-carotene, 60-80; α-carotene, 10-40; lutein, 1-5; and other minor carotenoids, 0.1-1%. Heinonen6 observed that α-carotene (1200-2300 µg/100g carrots) is sufficient to satisfy the human daily vitamin requirement.

Milk is a good item for fortification of natural source of β-carotene. India is the largest single milk producing country in the world (96.1 million tonnes in 2005)10. Rasogolla, one of the most popular and delicious sweet of India is prepared from chhana (a heat and acid coagulated milk protein mass, analogous to cottage cheese). Thus Rasogolla can be a most important food item for fortification of natural source of β-carotene.

Considerable research work has been done on Rasogolla manufacturing process of Rasagolla11,12. This study investigates physical and sensory characteristics of fortified Rasogolla, formulated with five levels of carrot and compares results with conventional Rasogolla.

Materials and Methods

Materials

Fresh cow milk (3.5-4.0 % fat, 8.3-8.7 % solid not fat) was collected from local dairy plant. Fat of milk was determined by Rose-Gottlieb method13. pH of milk was determined by a digital pH meter (Model L1-120, Elico Private Ltd., Hyderabad, India). Total solids and titrable acidity of milk were also measured13. Sugar, wheat flour, arrowroot and dark orange color fresh carrots (Daucus carota L. var chantenay) were purchased from local super market in Jadavpur, Kolkata, India. Lactic
acid was obtained from Loba Chemie (Loba Chemie Pvt Ltd, Mumbai, India). The β-carotene (95% pure) was purchased from Sigma Chemical Co. (St. Louis, Mo., USA). Solvents (diethyl ether, petroleum ether, potassium hydroxide) used for extraction of pigments, were purchased from Qualigens (Qualigens Fine Chemicals, Mumbai, India), methanol from SRL (Sisco Research Laboratories Pvt. Ltd., Mumbai, India) and anhydrous sodium sulfate from Merck (Merck Ltd., Mumbai, India). All chemicals used were of analytical grade.

Preparation of Samples

Samples include preparation of carrot paste, chhana & carrot fortified chhana balls, sugar syrup and Rasogolla (Table 1).

**Carrot Paste**

Carrots were cleaned properly and cut into thin round slices (1-2 cm thickness) along with skin. Carrot slices were then blanched for 2 min in boiling water (100°C). Blanched carrot slices were ground in a Kitchen Aid Mixer (Forbes, Eureka Forbes Ltd., Bangalore, India) at 8000 rpm for 10 min to get a fine orange colored paste.

**Chhana and Chhana Balls**

Chhana was prepared by reported method\(^1\) with slight modification. The milk was heated to boiling point for 2-3 min and then cooled to 70-75°C. Freshly prepared 1% hot lactic acid solution (70°C) was added slowly to the milk with gentle stirring till the entire mass of milk coagulated, showing a greenish yellow tinge in the whey. The contents were left undisturbed for 5-10 min. Coagulated chhana mass was collected in a stainless steel strainer and washed in running tap water (25°C) for 1-2 min. Chhana was separated from water in a press filter (Reliance Enterprise, Kolkata, India). About 80-90 g of chhana was obtained from 500 ml milk.

Chhana was kneaded in a vertical dough mixer (Khare & Associates, Delhi, India) to obtain smooth dough. Chhana additives such as wheat flour (25 g/kg of chhana) and arrowroot starch (15 g/kg of chhana) were added during kneading. In case of carrot Rasogolla, carrot paste (10, 20, 30, 40, and 50% on the basis of chhana) was added to chhana along with the additives during kneading. Chhana dough as well as chhana-carrot dough was then cut into small pieces (each of about 10 g), which were molded into round balls by revolving in a gyratory ball-making machine (Reliance Enterprise, Kolkata, India) at a speed of 200 rpm.

**Sugar Syrup**

Cooking syrup 55-60°Brix and soaking syrup 35-40°Brix were prepared separately for cooking and soaking of Rasogolla respectively. The sugar solutions were clarified by boiling with milk (5ml/l of sugar solution) for 2-3 min.

**Rasogolla**

Freshly clarified 55-60°Brix sugar syrup (2-3 l) was boiled on a gas oven. Chhana balls as well as carrot fortified chhana balls were dropped into the boiling syrup separately. After a few seconds, foam was formed which covered the floating balls. After every 2 min, hot water (20-30 ml) was added to boiling syrup to compensate for the evaporated water. The balls were kept in boiling solution for 15 min. At the end of cooking, Rasogolla balls were transferred to the warm sugar syrup (35-40°Brix, temp 60-70°C) and kept for 8-10 h for better soaking. After cooling to room temperature, Rasogolla samples were used for experiment.

**Proximate Analysis and β-carotene Content of Rasogolla**

Moisture, fat, protein, sucrose and ash contents of Rasogolla were determined\(^5\). Rasogolla samples were measured for β-carotene content using reported method\(^1\)
with slight modifications. To measure β-carotene, Rasogolla sample (50 g) for each treatment was taken in a homogenizer (Remi, Kolkata, India). For saponification, homogenized sample (10 g) was taken for each replication under each treatment in a flask along with methanol (75 ml) and 50% KOH solution (25 ml). Unsaponifiable materials were then extracted with diethyl ether 2 times (40 ml, 20 ml) and ether extract was washed with distilled water 2 times (50 ml each time). Extract was dried over anhydrous sodium sulphate. Diethyl ether was evaporated to 25 ml on steam bath and residual part was evaporated in a rotary vacuum evaporator (Eyela, NE, Rikakikai co. Ltd., Tokyo, Japan). Dried sample was then diluted in petroleum ether (20 ml). Yellow to orange color of petroleum ether was measured at 450 nm with a U-2000 spectrophotometer (Hitachi, Japan). Carrot paste was also measured for β-carotene in the same way in order to compare retention level of β-carotene in Rasogolla sample. Retention level of β-carotene (%) was calculated on the basis of mass of carotene present in carrot added to chhana for fortification, mass of mixture of chhana and carrot, and mass of carotene present in the respective Rasogolla samples.

Color
A Hunter lab color measurement system, ColourFlex 45/0, D65, 10° observer (Hunter Associates Laboratory Inc., Reston, VA, USA) was used to measure color intensity in Rasogolla samples. Three replications were taken for each treatment. Each sample (30 g), homogenized in Kitchen Aid Mixer, was evenly spread on the bottom of colorimeter sample cup at a depth of 15 mm. Color was measured after cooling the samples. Four readings were obtained per sample by rotating the cup a quarter of a turn each time. Results were expressed in ‘L’ (0= black, 100= white), ‘a’ (- = green, + = red) and ‘b’ (- = blue, + = yellow) values.

Compression Test
Compression force was evaluated on Rasogolla samples from each of the three replications using an Instron Universal Testing Machine (Model 4301, Instron Ltd., High Wycombe, Bucks, UK) with a 100N load cell. After keeping overnight at room temperature, a 20 mm cube was cut from the center of Rasogolla from each treatment. Each sample was compressed axially in two consecutive compression cycle by a 40 mm diam flat plate attached to moving crosshead. The testing conditions were: compression ratio of deformation from the initial height of the sample, 50%; cross head speed (pre and post test speed), 20 mm/min; and chart speed, 20 mm/min. Force-distance curve obtained was used to derive texture profile parameters.

Sensory Evaluation
Recruitment, selection and training of panelists (18 from among students, staff and faculty at Jadavpur University, Kolkata, India) were performed following standard sensory evaluation procedures. Panelists (12) were selected and trained for 3 h in a focus group setting to become familiar with 1-9 grading scale as well as colour, flavour, stickiness, softness, elasticity, chewiness etc. references that were formulated in the laboratory for training purposes. Samples representing extremely high or low levels of color, flavor, stickiness, softness, chewiness were presented to familiarize panelists with upper and lower limits of the scale. Colour was evaluated as the increase in the intensity of orange colour in the sample. Flavour of the sample was judged according to the presence of acrid smell. Softness was identified as to what extent of effort was required to swallow the sample. Stickiness was defined as the adherence of the sample to mouth. Elasticity was determined as to what extent a deformed material returned to original position after the withdrawal of deforming forces. Chewiness was defined as the force needed to bite and work inside mouth to make it easier to swallow.

Samples of each treatment were placed in a glass petri plate and covered with aluminum foil. Samples were coded with 3 digit random codes. One petri plate from each of the six treatments and one reference sample were offered to the panelists. The panelists were seated in partitioned booths and were provided with unsalted cracker and water for rinsing between samples. Sensory characteristics were scored on a 9 point scale, where 5 = no difference from the standard; 1 = large, superior to standard; 9 = large, inferior to standard. Each panelist assessed three samples. The entire experiment was repeated thrice.

Statistical Analysis
The studies were replicated three times and mean results are reported. Analysis of variance of proximate analysis, β-carotene content, color, compression test and sensory panel data were done with the help of Analysis ToolPak program under Microsoft Excel 2000. A complete randomized block design was used to determine the main effects of treatments. Means were compared by Fisher’s Least Significant Difference Test at a significance level of p ≤ 0.05.
Results and Discussion

Proximate Analysis and \( \beta \)-carotene Determination

Fat and protein content of Rasogolla gradually decrease with increasing carrot percentage (Table 2). Control Rasogolla had highest fat and protein level than all type of carrot Rasogolla. This is because as the proportion of carrot increased, the amount of chhana, which is a rich source of protein (casein), decreased. Thus fat and protein content in the Rasogolla sample decreased with increase in percentage of carrot. During cooking of chhana balls, fat was lost in the sugar syrup\(^{11}\). Leaching of fat into the syrup may be enhanced by carrot Rasogolla due to their more porous structure. Moisture, sucrose and ash content of Rasogolla samples did not differ significantly (\( p > 0.05 \)). Chhana does not contain any sucrose. Carrot contains a little amount of sucrose. But during cooking, high concentration of sugar syrup initiate osmosis in the Rasogolla samples and maintain sugar level at more or less the same level.

The \( \beta \)-carotene levels in different Rasogolla samples differed significantly (\( p \leq 0.05 \)) between samples because of difference in the proportion of carrot used for preparation of samples (Table 2). Presence of \( \beta \)-carotene in control Rasogolla is because milk contains little \( \beta \)-carotene\(^{19} \). CRC sample showed highest \( \beta \)-carotene content, followed by CRD and CRE. Retention of \( \beta \)-carotene (Fig. 1) was highest in CRC (30.01\%). But in CRD and CRE, there was a drastic reduction in the retention level of \( \beta \)-carotene. A significant amount of \( \beta \)-carotene was lost during cooking as the samples came in direct contact with heat and oxygen. Thermal processing resulted in a heavy loss of \( \beta \)-carotene concentration in the processed food sample\(^{20} \), which might be the cause of lower retention level of \( \beta \)-carotene in all samples. During canning, some carotenoids\(^{20} \) migrate into the brine as they are released from carotene binding proteins or that \( \beta \)-carotene protein complex is slightly water-soluble. During boiling of Rasogolla, higher porosity of CRD and CRE samples enhanced the loss of carotene-protein complex in sugar syrup. However, consumption of carrot Rasogolla can contribute to a part of total daily requirement of \( \beta \)-carotene.

Color

Color of Rasogolla samples (Table 3) became darker in the order of (\( p \leq 0.05 \)) control, CRA, CRB, CRC, CRD and CRE. Redness ‘a’ value of samples differ significantly (\( p \leq 0.05 \)) between the treatments except CRD and CRE, which were similar (\( p > 0.05 \)). The \( \beta \)-carotene, which was responsible for redness in the sample, is a fat-soluble color. During cooking fat is generally lost from the samples into sugar syrup\(^{11} \). This phenomenon thus could result in loss of red color to the syrup. This loss is further enhanced by the porous structure of Rasogolla samples. In CRE, higher percentage of carrot gave more porous structure of Rasogolla than CRD and this enhanced the loss of red color. This may be the cause of similar redness value in CRD and CRE. Negative reading of ‘a’ value of control

<table>
<thead>
<tr>
<th>Properties</th>
<th>Control</th>
<th>CRA</th>
<th>CRB</th>
<th>CRC</th>
<th>CRD</th>
<th>CRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture, %</td>
<td>54.35±0.63</td>
<td>54.48±1.92</td>
<td>54.48±2.36</td>
<td>54.45±0.85</td>
<td>54.59±2.0</td>
<td>54.58±1.85</td>
</tr>
<tr>
<td>Fat, %</td>
<td>5.4±0.08(^{a})</td>
<td>4.9±0.06(^{b})</td>
<td>4.7±0.05(^{b})</td>
<td>4.3±0.09(^{c})</td>
<td>3.1±0.06(^{d})</td>
<td>2.4±0.06(^{e})</td>
</tr>
<tr>
<td>Protein, %</td>
<td>5.23±0.05(^{a})</td>
<td>4.84±0.07(^{b})</td>
<td>4.5±0.07(^{c})</td>
<td>3.99±0.09(^{d})</td>
<td>3.46±0.06(^{e})</td>
<td>3.03±0.07(^{f})</td>
</tr>
<tr>
<td>Sucrose, %</td>
<td>39.97±1.88</td>
<td>38.8±0.56</td>
<td>38.93±2.55</td>
<td>39.27±1.79</td>
<td>40.67±1.55</td>
<td>40.23±3.17</td>
</tr>
<tr>
<td>Ash, %</td>
<td>1.57±0.05</td>
<td>1.60±0.03</td>
<td>1.61±0.02</td>
<td>1.63±0.05</td>
<td>1.64±0.04</td>
<td>1.65±0.04</td>
</tr>
<tr>
<td>( \beta )-carotene, µg/ 100 g</td>
<td>74.33±8.62(^{e})</td>
<td>279.72±4.05(^{c})</td>
<td>482.36±7.78(^{d})</td>
<td>858.09±6.08(^{a})</td>
<td>784.07±7.38(^{b})</td>
<td>723.11±6.26(^{c})</td>
</tr>
</tbody>
</table>

Data represents means of three samples analyses (n=3) ± s.d. Means with the same superscript within the same row are not significantly different (\( p > 0.05 \)).

Control: Rasogolla without fortification of carrot; Rasogolla fortified with: 10 % carrot, CRA; 20 % carrot, CRB; 30 % carrot, CRC; 40 % carrot, CRD; and 50 % carrot, CRE.
Table 3—Hunter color values of Rasogolla samples

<table>
<thead>
<tr>
<th>Treatment</th>
<th>L</th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>71.77 ± 0.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.80 ± 0.04&lt;sup&gt;c&lt;/sup&gt;</td>
<td>12.27 ± 0.13&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRA</td>
<td>61.45 ± 0.11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.02 ± 0.12&lt;sup&gt;d&lt;/sup&gt;</td>
<td>18.54 ± 0.06&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRB</td>
<td>57.35 ± 0.12&lt;sup&gt;c&lt;/sup&gt;</td>
<td>10.12 ± 0.10&lt;sup&gt;c&lt;/sup&gt;</td>
<td>20.65 ± 0.09&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRC</td>
<td>56.06 ± 0.16&lt;sup&gt;d&lt;/sup&gt;</td>
<td>12.39 ± 0.12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>21.31 ± 0.04&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRD</td>
<td>54.58 ± 0.11&lt;sup&gt;e&lt;/sup&gt;</td>
<td>13.15 ± 0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23.53 ± 0.06&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRE</td>
<td>52.59 ± 0.12&lt;sup&gt;f&lt;/sup&gt;</td>
<td>13.22 ± 0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>25.15 ± 0.04&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Data represents means of three samples analyses (n=3) ± s.d.

Means with the same superscript within the same column are not significantly different (p > 0.05)

L = Lightness to darkness value (100 = white, 0 = black); a = red to green value (+ = redness, - = greenness); b = yellow to blue value (+ = yellowness, - = blueness).

Control: Rasogolla without fortification of carrot; Rasogolla fortified with: 10 % carrot, CRA; 20 % carrot, CRB; 30 % carrot, CRC; 40 % carrot, CRD; and 50 % carrot, CRE.

Rasogolla exhibited presence of some greenish tinge in the sample. Yellowness ‘b’ value of Rasogolla samples differs significantly (p ≤ 0.05) between all the treatments. CRE showed highest ‘b’ value due to highest proportion of carrot in the sample.

**Compression Test**

Hardness of CRA (Table 4) although differed significantly (p ≤ 0.05) from other treatments but was similar with CRB (p > 0.05). Similarly, difference in hardness of CRB, CRC and CRD did not reach the significance level (p > 0.05). CRE had the lowest hardness value compared to all treatments. As the carrot proportion increased in the sample, proportion of chhana decreased, thus there was a reduction in the percentage of fat in total sample. This reduced the hardness of carrot Rasogolla. Higher fat content in chhana improved texture of Rasogolla<sup>11</sup>. Cohesiveness and springiness of Rasogolla samples although differed but did not reach significance level (p > 0.05). Control Rasogolla had the
highest cohesiveness and springiness value. There was a reduction in cohesiveness and springiness value with increase in the proportion of carrot in the sample. Gumminess and chewiness are the derived factors of hardness, cohesiveness and springiness. As the proportion of carrot increased in the sample, both gumminess and chewiness decreased significantly ($p \leq 0.05$). It is again seen that control Rasogolla had the highest gumminess and chewiness value.

**Sensory Evaluation**

Sensory evaluation indicates that color acceptance level of control Rasogolla was similar ($p > 0.05$) with CRA and CRB (Table 5). Orange color of CRC, CRD and CRE were highly accepted by panelists and acceptance level significantly varies ($p \leq 0.05$) with control Rasogolla and CRA. Use of higher proportion of carrot in CRC, CRD and CRE was the factor responsible for creating such differences in acceptance level. Regarding flavor, acceptance level gradually decreased with increase in the proportion of carrot. An explanation for the decreasing score in flavor acceptance may be that higher proportion of carrot in the sample induced acrid smell in the product. However, panelists found no significant difference ($p > 0.05$) in flavor of all treatments.

CRC, CRD and CRE were the most soft followed by CRB, CRA and finally the control Rasogolla (Table 5). This is possibly because higher proportion of carrot in CRC, CRD and CRE gave more porous structure and reduced firmness. Control Rasogolla had the least stickiness, which was more acceptable. With the increase in proportion of carrot in carrot Rasogolla, there was an increase of stickiness. This is possibly due to the decreasing fat level in carrot Rasogolla (Table 2). Fat contributes to making the food more oily but less sticky.
CRD and CRE scored significantly lower (p ≤ 0.05) elasticity; suggesting that Rasogolla formulations with carrot at these levels were more acceptable by the panelists. Fat content is associated with elasticity of any food. Higher percentage of fat (Table 2) in control Rasogolla may be the cause of its higher elastic nature. Panelists indicated that all samples were less chewy than reference sample (Table 5). Among the treatments, control Rasogolla had highest chewiness. Thus chewiness of Rasogolla decreased with increase in the proportion of carrot.

There was no significant difference (p > 0.05) in overall acceptability between the treatments although carrot Rasogolla (CRA, CRB and CRC) scored slightly higher than the control Rasogolla. Overall acceptability value was same for control Rasogolla and CRD sample. Lower acceptability of CRE was due to the broken, uneven surface as well as acrid smell of carrot in the sample. According to overall acceptability, panelists prefer carrot Rasogolla CRC (up to 30% fortification) than control Rasogolla.

Conclusions

Indigenous dairy product, Rasogolla (a most delicious dessert) was prepared in a modified way incorporating carrot (10, 20, 30, 40 and 50% of the total weight). Significant differences existed in fat and protein content, color, instrumental texture, β-carotene retention and sensory profile among fortified Rasogolla samples. Control Rasogolla was an acceptable product. Panelists found that CRA, CRB and CRC were more acceptable than control Rasogolla. CRD and CRE were less acceptable to panelists, perhaps due to the slight acrid flavor and stickiness due to higher proportion of carrot. It is seen that the main advantage of using carrot paste in Rasogolla is that it provides natural β-carotene in the food as well as provide a low-fat value added product.

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References