Utilization of wheat milling industry by-products for value added product development (Ice cream cone)

Manikanta M, Anjali Rana and Aashitosh A Inamdar

Abstract
The use of wheat milling industry by-products like wheat bran and resultant Atta in the value added product like ice cream improves its Physico-chemical and nutritional value. The replacement of refined wheat flour (Maida) with resultant Atta and wheat bran increases the dietary fiber & mineral content and decreases the carbohydrate content of the product. The reduced carbohydrate and increased dietary fiber improve the texture (crispiness) of the ice cream cone. The colour and appearance of the product developed during the baking process. The optimum proposition of wheat bran and resultant Atta in the blend makes light golden brown colour and sweetish roasted or baked aroma during baking process. Which is suitable for the combination of the different ice creams. The probiotic ice cream contains probiotic micro flora, which requires prebiotics for the growth. Ice cream cone contains prebiotics, these acts as the food for probiotics.

Keywords: Wheat bran, resultant Atta, ice cream cone, texture profile analyser, hunter colour meter, Amylograph, scanning electronic microscope

1. Introduction
The wheat kernel is composed of 2-3% germ, 80-85% starchy endosperm and 10-13% bran by weight (on dry basis) (Belderok, M. S. & Donner et al., 2000) [6]. The roller milling yields 75-80% products and 20-25% by-products based on different wheat varieties (Sakhare, A. D. & Inamdar, A. A. 2014) [22]. Resultant atta and wheat bran were major by-products of milling, 90% used as livestock feed while only 10% used in food industry as a source of dietary fiber. (Hossain et al., 2013) [9]. Wheat bran was a good source of nutrients such as dietary fiber (around 53%- xyans, fructans, cellulose, lignin, galactan, pentosans, pectin, mucilage), Vitamins (Vit-E and Vit-B), minerals(iron, zinc, manganese, magnesium and phosphorous) and bioactive compounds such as alkylresorcinols, ferulic acid, flavonoids, carotenoids, lignans and sterols.(Apprich et al., 2013) [8]. Developing a nutritious wafer cone (ice-cream cone) from the resultant atta and fine bran as a replacement to wheat flour (Maida). Which is good source of dietary fiber (soluble and insoluble), protein, minerals, vitamins and other bioactive compounds without added sugar and colours and lower starch content compared to normal wheat flour cones. Insoluble dietary fibres physiologically helps in improvement of gut peristalsis, with good water holding capacity. (Schneeman, 1999) [23]. Wafer term has two meanings; one is light, thin and crisp food product which is baked from batters and second is a crisp, often sweet, very thin, flat, light and dry biscuits. (Manley, 2011) [15]. Wafers are used as a carrier for another material as they are tasteless. Wafers are sold for culinary use such as serving with butter, cheese or ice cream (Tiefenbacher, 1998). Wafer cones are hollow, single- baked piece by piece for application with ice-cream. The basic recipes for a typical wafer batter consist of water, flour, oil, emulsifier and leavening agents (Manley, 2011) [15]. Wafer quality is affected by many parameters such as raw material quality, amount of water used in the recipe, parameters of batter mixing (mixing rate, mixing time, batter holding time) and baking parameters (temperature and time) and environmental conditions. Sheet weight, thickness, color, texture, moisture content, bending of sheet, stickiness to the plates; batter density and viscosity were studied in order to determine the quality of wafer sheets (Dogan, 2006).

2. Materials and methods
2.1 Raw material
Wheat procured from local market, Cleaned and conditioned. The roller milling process carried for milling operation. Wheat bran, germ and resultant Atta are the major by-products of...
wheat milling industry, these are stored at 4 °C (cold storage). Water, vegetable oil (sunflower refined oil), salt (sodium chloride) and baking soda.

2.2 Ice cream cone preparation
Ice cream cone (value added product) is prepared by various combinations of resultant Atta and bran as major ingredients. The formulations of RA: B as 100RA:0, 90RA:10B, 80RA:20B and 70RA:30B. The batter composed of 190% water, 0.35% salt, 5.35% vegetable oil and 0.35% baking soda on 100g flour basis with alteration 10%, 20% and 30% resultant atta replaced with fine bran. To prepare batter the sodium bicarbonate is dissolved in water at room temperature. These are mixed to make batter using mixer and kept for short period of time for resting. Batter is baked in baking instrument and cooled to room temperature.

WF: wheat flour, RA: Resultant atta, B: Wheat bran

2.3 Flour and batter Evaluation

2.3.1 Flour Analysis
The moisture, ash, fat and total protein are determined by AACC 2010 methods. The total dietary fiber is measured by AOAC 2010 method and colour value measured using Hunter Lab Colour Measuring System (Colour Measuring Labscan XE system, Reston, VA) according to the method described by Inamdar, A. A., & Prabhasankar, P. (2017) [10].

2.3.2 Water holding capacity
Water absorption capacities were determined as described by Sosulski et al. (1976) [24]. A gram of flour sample was mixed with 10 mL of distilled water or oil in a centrifuge tube and allowed to stand at 30 ± 2 °C for 1 h. Thereafter, it was centrifuged (200 g, 30 min). Water or oil absorption capacity was expressed as per cent water or oil absorbed by 1 g flour.

2.3.3 Pasting properties

2.3.4 Batter analysis
Viscosity of batter is measured by viscoanalyser, pH is measured using pH meter according to. Specific gravity and density described by Turabi, E., Sumnu, G., & Sahin, S. (2008) [29].

2.4 Product evaluation

2.4.1 Nutritional / Proximate analysis characteristics
The nutritional quality varies according to the proportion of the resultant atta and bran. Dietary fiber, fat, minerals, protein increases with bran carbohydrate decreases based on the trials. Determination of moisture, ash, total protein, fat (AACC 2010) [1] and dietary fiber (AOAC 2010) [4].

2.4.2 Texture analysis
The hardness or crispiness or breaking strength or load to break in N (newton) is measured using universal texture analyser (Lloyd Instruments Ltd, Fareham, Hampshire, U.K., Model LR-5K). Described by Morlan JW. Wood Janka Hardness Scale/Chart, by Common or Trade Name; (2009) [16].

2.4.3 Colour measurement
Ice-cream cones colour value were measured using the Hunter Lab Colour Measuring System (Colour Measuring Labscan XE system, Reston, VA) according to the method described by Inamdar et al. (2015) [11]. Colour reading were expressed by Hunter values for L*, a* and b*.

2.4.4 Scanning electronic microscopic (SEM) Studies
SEM studies were carried out according to the procedure followed by Bhargava et al. (2013) [7] using a Leo scanning electron microscope (Model 435 VP, Leo Electronic Systems, Cambridge, UK).

2.4.5 Sensory Evaluation
Sensory evaluation of ice-cream cones was carried out by 25 untrained panellists ranging from 25 to 55 years who are aware of the characteristics of ice-cream cone. Products were graded for important attributes: color (10) appearance (10), crispiness (15), mouth feel (15), taste (15). The cone samples in three replicates were evaluated by assigning scores as follows. Color (1 = very dark brown; 5 = golden brown), appearance (1 = rough surface, holes; 5 = smooth surface, no holes), crispiness (1=not crispy, hard to bite; 10=crispy, crunchy to bite), mouth feel (1= chewy, gritty, does not breakdown; 10= no grittiness, easy breakdown and clean mouth feel), taste (1= foreign, unpleasant; 10= typical and pleasant). The overall quality is the combined score of all the above attributes which is further categorized as follows: <30, unsatisfactory; 35–45, good; 46–55, very good; 56–65, excellent.

3. Results and Discussion

3.1 Proximate analysis
The proximate analysis of ice cream cone includes moisture, protein, fat, ash, acid insoluble ash and dietary fiber. As the bran content increases in the cone results in the slightly higher moisture compared with control. The dietary fiber including soluble and insoluble fiber increases water holding capacity of the cone. IC-C3 (3.21%) shows higher moisture content followed by IC-C2 (3.01%), IC-C1 (2.92%) and lower moisture content in IC-RA (2.89%). The moisture content of control (3.04%) samples shows in between IC-C2 and IC-C3. As the proportion of wheat bran increase in the cone results in slightly decrease in protein content. Higher the bran (RA: WF ratio) in ice cream cone indicates higher level of ash and acid insoluble ash. The bran contains high amount of dietary fiber (Soluble and Insoluble) and ash results in higher level of total dietary fiber, ash and AIA obtained in the ice cream cones having higher proportion of wheat bran. IC-C3 contains higher amount of dietary fiber and ash control sample, observed in Table.1.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control</th>
<th>IC-RA</th>
<th>IC-C1</th>
<th>IC-C2</th>
<th>IC-C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>3.04±0.05</td>
<td>2.89±0.12</td>
<td>2.92±0.07</td>
<td>3.01±0.08</td>
<td>3.24±0.11</td>
</tr>
<tr>
<td>Fat (%db)</td>
<td>4.38±0.09</td>
<td>5.55±0.12</td>
<td>5.72±0.14</td>
<td>5.84±0.15</td>
<td>5.98±0.17</td>
</tr>
<tr>
<td>Protein (%db)</td>
<td>10.12±0.13</td>
<td>10.16±0.15</td>
<td>10.03±0.18</td>
<td>9.87±0.17</td>
<td>9.76±0.19</td>
</tr>
</tbody>
</table>
3.2 Flour and Batter characteristics

The flour (maida, resultant atta and blend of resultant atta with wheat bran) characteristics like water holding capacity and solubility index are measured, which results in the moisture content of final product. In different proportion of resultant atta and wheat bran results in increasing of water holding capacity and solubility index. Higher the bran proportion in resultant atta (70RA: 30B) shows higher WHC (1.89 g/g) compared with RA (1.7 g/g) and maida (1.69 g/g) observed in Table 2. The water holding capacity and solubility index majorly depends upon total dietary fibre content blends.

Batter pH is measured using MRC labs pH meter. The addition of leaving agent baking soda makes the batter neutral pH to alkaline pH. As proportion of wheat bran increases in the batter with replacement of resultant atta results in slightly increases the pH value, showed in Table 2. The viscosity of batter is measured at two different intervals of 30 seconds and 60 seconds. The wheat bran play significant role in increase in the viscosity of the batter due to the higher dietary fibre and reduced starch portion in the batter. The batter made with maida shows lower viscosity compared with batter made with 70RA: 30B. This higher optimum viscosity signifies in the spreading of better during pouring in to moulds for baking. Variations in viscosity at 30 seconds and 60 seconds resting intervals resulting in slight decrease in the viscosity observed in Table 2.

<table>
<thead>
<tr>
<th>Table 2: Flour and Batter characteristics</th>
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<tbody>
<tr>
<td>Flour and Batter characteristics</td>
</tr>
<tr>
<td>WHC (g/g)</td>
</tr>
<tr>
<td>Solubility Index (%)</td>
</tr>
<tr>
<td>pH of Batter</td>
</tr>
<tr>
<td>Viscosity of Batter (cP)</td>
</tr>
<tr>
<td>30 seconds</td>
</tr>
<tr>
<td>60 seconds</td>
</tr>
<tr>
<td>RA: Resultant atta B: Wheat Bran, WHC: Water Holding Capacity, g: Gram, %: percentage and cP: centipoise</td>
</tr>
</tbody>
</table>

3.3 Amylograph

The amylograph indicated the pasting properties of the flour. Gelatinization temperature is low for resultant atta and gradually increases as bran increases in the resultant atta from 60.3 to 62.3°C. As starch content decrease with increase in the bran results in the decrease of hot paste and cold paste viscosity observed in the Table 3. Set back viscosity increases and breakdown viscosity decreases with increases in bran due to the hydration and viscous properties of the dietary fibers. Amylograph characteristics of resultant atta and different proportion of resultant atta and bran showed in the Fig.1.
3.4 Texture analysis
The texture analyzer measures the force in newton required to break the ice cream cone (hardness) into two pieces. Higher the load or force required to break indicates the stiffness or less crispiness of cone. As bran content replaces the resultant atta, the force required to break cone decreases. IC-C3 (19.06 ± 0.23 N) shows the crispiness or force required to break is similar to control (17.41 ± 0.28 N). The hardness value or load (newton) decreases as decrease in the starch portion and with increase in bran content in ice cream cone. The crispiness of cone increases with increase in the dietary fiber which provides the crisp texture, the values are observed in Table 4.

Table 3: Amylograph characteristics of the flour

<table>
<thead>
<tr>
<th>Amylograph characteristics</th>
<th>Maida</th>
<th>RA</th>
<th>90RA:10B</th>
<th>80RA:20B</th>
<th>70RA:30B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginning of gelatinization (°C)</td>
<td>60.8</td>
<td>60.3</td>
<td>60.7</td>
<td>61.2</td>
<td>62.3</td>
</tr>
<tr>
<td>Hot paste viscosity (BU)</td>
<td>650</td>
<td>656</td>
<td>622</td>
<td>509</td>
<td>454</td>
</tr>
<tr>
<td>Cold paste viscosity (BU)</td>
<td>1192</td>
<td>1179</td>
<td>1062</td>
<td>1023</td>
<td>1000</td>
</tr>
<tr>
<td>Break down (BU)</td>
<td>390</td>
<td>298</td>
<td>266</td>
<td>198</td>
<td>175</td>
</tr>
<tr>
<td>Set back (BU)</td>
<td>542</td>
<td>523</td>
<td>530</td>
<td>553</td>
<td>546</td>
</tr>
</tbody>
</table>

RA: Resultant Atta B: Wheat Bran, BU: Barbender Unit.

3.4 Color values
The hunter color value (L value) measure the lightness to darkness of the product. L value ranges from 0 to 100. Higher the L-value indicates towards lightness of the product. Market ice cream cone (made from maida) shower higher L-value compared with ice cream cone made with resultant atta and blend of resultant atta and wheat bran. IC-C3 shows slightly dark colour (61.59) compared IC-RA (66.3) and control (66.56). The bran content and colour developed (golden dark) during baking process results in the decrease in L value compared to control. As the wheat bran content increases in the cone the L-Value decreases observed in Table 4.

Table 4: Texture and physical characteristics of the cone

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Control</th>
<th>IC-RA</th>
<th>IC-C1</th>
<th>IC-C2</th>
<th>IC-C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Texture: Load (N)</td>
<td>17.41±0.28</td>
<td>51.64±0.31</td>
<td>34.68±0.29</td>
<td>22.12±0.21</td>
<td>19.06±0.23</td>
</tr>
<tr>
<td>b. Colour value: L-value</td>
<td>66.56±0.34</td>
<td>66.3±0.38</td>
<td>65.01±0.39</td>
<td>63.11±0.31</td>
<td>61.59±0.35</td>
</tr>
<tr>
<td>c. Weight (g)</td>
<td>3.870±0.032</td>
<td>6.68±0.022</td>
<td>4.831±0.093</td>
<td>4.610±0.120</td>
<td>4.54±0.130</td>
</tr>
</tbody>
</table>

RA: Resultant atta, Control: Commercial market ice cream cone sample, IC- Ice cream cone, C1: 90RA:10B, C2:80RA:20B, C3: 70RA:30B, N -newton and g- grams

3.5 Scanning Electronic Microscopic (SEM) studies
The ice-cream cones are analysed for the SEM for the structural studies. The distribution of starch, protein and air cells were observed. Vacuoles or air packets distribution, the crispiness is differentiated. As the bran content increase or decrease in starch portion in the ice cream cone results in porous structure. The dietary fibre of bran and leavening agent creates more porous structure (Fig 2.a). Higher the starch or endosperm portion makes structure more compact (Fig 2.b). The outer layer of cone is more baked and it hard or compact sheet is formed compared to centre and inside layers in the cone observed in Fig 2. The cross-sectional view of ice-cream cones at 100X was observed.

Fig 2: Scanning Electronic Microscopic cross-sectional view of ice cream cones at 100X

3.5 Sensory
Sensory evaluation of ice-cream cones was carried out based on different characteristics like colour & appearance, texture (crispy or hard to bite or crunchy to bite), mouth feel (chewy or gritty or easy to break or clean mouth feel) and taste (foreign or unpleasant or pleasant). The IC-C3 (60) samples shows higher score in sensory attributes compared to control sample (43). The colour and appearance of the IC-C3 as high score compared with other cones (IC-RA, IC-C1 and IC-C2) including control. The overall sensory quality IC-C3 of colour & appearance, texture (easy to bite and crispiness), clean mouth feel, pleasant taste is superior compare to control sample. The combined score 60, 52, 45, 39 and 43 of all the sensory attributes of different samples IC-C3, IC-C2, IC-C1,
IC-RA and Control respectively. The overall sensory attributes of IC-C3 (Excellent) is better than Control (Good).

4. Conclusion
Use of wheat milling by-products like wheat bran and resultant atta in the value added product (ice cream cone) makes more economical and improved in the textural and sensory characteristics compared with product made with wheat flour. The product prepared 70RA:30B ratio shows better nutritional value (dietary fiber, minerals and reduced carbohydrates) and also improved sensory and texture attributes compared with the control (product prepared using refined wheat flour). The overall aspects of process, production, sensory and nutritional value of IC-C3 is better than Control.

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References