Texture profile analysis of low fat milk nuggets prepared with 2% fat corrected milk and skim milk coagulum and extended with optimum levels of barnyard millet flour and finger millet flour

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ABSTRACT
Texture profile analysis of any food product shows correlation with sensory and overall consumer acceptability of the developed milk products. Instrumental texture profile analysis was conducted on low fat milk nuggets prepared with 2% fat milk coagulum and skim milk coagulum and extended with optimum levels of barnyard millet flour and finger millet flour. The texture profile analysis results showed higher values for hardness, springiness, cohesiveness, gumminess and chewiness for the milk nuggets prepared with 2% fat milk coagulum as compared to the nuggets prepared with skim milk coagulum.

Key words: Barnyard millet flour (BMF), Finger millet flour (FMF), Low fat milk nuggets, Sensory acceptability, Texture profile.

INTRODUCTION
Millets, possess superior nutritional attributes and adaptability to drought and low-input conditions. They are rich in B vitamins, especially niacin, B6 and folic acid and minerals such as calcium, iron, potassium, magnesium and zinc. Use of millets in food formulations adds health value to the food products (Gopalan et al., 1999). It is gratifying that in recent years the Government of India has initiated programmes to promote millets as nutri-cereals. The National Academy of Agricultural Sciences (NAAS,2012), towards strengthening this initiative, organized a Brains Storming Session to analyze the current status of production, processing and utilization of millets in fortified foods, especially the blends with dairy products to promote functional foods. There is an increase demand of gluten free products from the developed countries of the world due to the rapidly increasing incidences of celiac disorders and intolerance to wheat based products. Millets are being looked as an important substitute of wheat. Other than being gluten free, millets also contain substantial levels of a wide range of phenolic compounds that impart desirable antioxidant characteristics (Hegde et al., 2004). The health promoting properties of millets, in particular their antioxidant activity may be used as nutraceutical as its utilization in functional foods has been well established (Dykes and Rooney, 2006).

Nuggets are small cube shaped convenience products. Various research studies have been conducted on meat nuggets. An attempt has been made by Jain (2003) and Mohapatra (2013) to prepare milk nuggets. Further, no information is available on preparation of milk nuggets using millet flours. The present research study was conducted for examining with an aim of instrumental texture profile of low fat milk nuggets prepared with 2% fat milk coagulum and skim milk coagulum and extended with optimum levels of barnyard millet flour and finger millet flour.

MATERIALS AND METHODS
Milk: Milk was procured from the Dairy Technology Section of Indian Veterinary Research Institute, Izzatnagar, Bareilly (U.P.). The mixed milk was pasteurized. Skim milk was prepared by separating the cream using a hand-driven centrifugal cream separator and fat content in required milk was standardized with skimmed milk using Pearson square method.

Chemicals and ingredients: Chemicals of analytical and food grade were purchased from standard firms (Hi-media, Qualigenes, Merck etc.). Other ingredients like barnyard millet, finger millet, refined wheat flour, sugar, spices, and condiments etc. were procured from the local market of Bareilly.

Experimental details: A basic formulation (control) was developed to prepare milk nuggets. This consisted of 91% skim milk coagulum and other ingredients like refined wheat flour, spice mix and salt. To prepare nuggets, the batter was...
prepared with proper mixing and steaming. The cooled product was cut to form nuggets.

**Preparation of milk coagulum:** The milk was heated to 90°C and cooled to 82°C and then coagulated with 2% citric acid solution by adding slowly with constant stirring. After coagulation, the curd was transferred to muslin cloth and the whey was drained off.

**Preparation of milk nuggets:** The coagulum was mixed properly in the mixer with salt for 2-3 min to prepare a fine paste. Then, other ingredients like refined wheat flour, millet flours, sugar, spice mix and condiments were added and mixing was done in mixer to get a batter of fine consistency. This batter was then filled firmly in moulds. The moulds containing the batter were cooked under steam for 20 min. The moulds were then taken out and cooled to room temperature. Then the loaves were separated from moulds and kept in refrigerator for 1 hour for proper setting of the batter to get a fine texture. Before packaging, loaves were brought to room temperature, weighed for calculating the yield and cut into the shape of cube shaped nuggets.

Texture profile analysis of milk nuggets was conducted by the procedure described by Bourne (1978) using a texture analyzer (TAHD plus Stable Micro system, UK). Chilled samples were tempered to bring to room temperature (27°C). Uniform sized pieces (1.5cm x 1.5cm x 1.5cm) of the products were used as the test samples. The samples were placed on a platform fixture and compressed twice to 80% of their original height by a compression probe (P75) at a cross head speed of 10 mm/s through two cycle sequence, using a 50 kg load cell. Three samples were analyzed under each product type and the readings were averaged.

The TPA values were obtained by graphing a curve using force and time plots. Values for hardness (peak force of the first compression cycle), adhesiveness (negative area under the baseline between the compression cycles), springiness (ratio of the time duration of the second compression to that of the first compression), cohesiveness (ratio of the positive force area during the second compression to that of the first compression), gumminess (breaking force multiplied by cohesiveness), and chewiness (Hardness multiplied by cohesiveness multiplied by springiness) were determined as described by Bourne (1978).

**Texture profile parameters were interpreted as follows:**
- Hardness (Ns/cm² or g/mm²) = Maximum force required to compress the samples.
- Adhesiveness (Ns) = works necessary to pull the compression plunger away from samples.
- Springiness (cm/mm) = ability of samples to recover its original shape after a deforming force was removed.
- Cohesiveness (ratio) = extent to which sample could be deformed prior to rupture (A₁/A₂), A₁ being the total energy required for first compression and A₂ the total energy required for the second compression.
- Gumminess (Ns/cm² or g/mm²) = force required to disintegrate a semisolid sample for swallowing.
- Chewiness (Ns/cm or g/mm) = work required to masticate the samples for swallowing.

**Statistical analysis:** Data generated from various trials under each experiment were pooled and compiled and analyzed as per the standard statistical methods (Snedecor and Cochrans, 1995) and interpreted. Means and standard error were computed for each parameter. The data were subjected to analysis of variance.

**RESULTS AND DISCUSSION**

The texture profiles scores of milk nuggets prepared from 2% fat milk coagulum with optimum level incorporation of BMF and FMF separately and skim milk coagulum with optimum level incorporation of BMF and FMF separately are presented in Table 1. ANOVA revealed that incorporation of BMF and FMF had significant (p<0.01) effect on the texture profile of milk nuggets.

Values for hardness (N/cm²) ranged from 100.17±10.80 in product with 2% fat milk coagulum and optimum level of BMF to 48.18±3.84 in nuggets prepared with skim milk coagulum and optimum level of FMF. In both, 2% fat milk coagulum product and skim milk coagulum to that of the first compression), gumminess (breaking force multiplied by cohesiveness), and chewiness (Hardness multiplied by cohesiveness multiplied by springiness) were determined as described by Bourne (1978).

**Table 1:** Texture profile of low fat milk nuggets prepared with 2% fat milk coagulum and skim milk coagulum and extended with optimum levels of barnyard millet flour and finger millet flour (Mean± S.E.)*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness (N/cm²)</td>
<td>100.17±10.80*</td>
<td>72.15±2.71*</td>
<td>81.92±1.21*</td>
<td>48.18±3.84*</td>
</tr>
<tr>
<td>Adhesiveness (Ns)</td>
<td>-0.34±0.07*</td>
<td>-0.42±0.06*</td>
<td>-0.13±0.05*</td>
<td>-0.14±0.17*</td>
</tr>
<tr>
<td>Springiness (cm)</td>
<td>0.19±0.01*</td>
<td>0.24±0.01*</td>
<td>0.15±0.01*</td>
<td>0.14±0.00*</td>
</tr>
<tr>
<td>Cohesiveness (ratio)</td>
<td>0.39±0.03*</td>
<td>0.36±0.02*</td>
<td>0.26±0.02*</td>
<td>0.40±0.02*</td>
</tr>
<tr>
<td>Gumminess (N/cm²)</td>
<td>38.02±1.73*</td>
<td>26.25±2.70*</td>
<td>20.35±0.80*</td>
<td>18.51±0.4*</td>
</tr>
<tr>
<td>Chewiness (Ncm)</td>
<td>7.40±0.68*</td>
<td>6.29±0.53*</td>
<td>3.12±0.25*</td>
<td>2.72±0.00*</td>
</tr>
</tbody>
</table>

*Mean±S.E. with different superscripts in a row differ significantly (p<0.05)

T1-2% fat milk coagulum with 15% BMF
T2-2% fat milk coagulum with 7% FMF
T3-skim milk coagulum with 15% BMF
T4 - skim milk coagulum with 7% FMF
product, hardness was significantly ($p<0.05$) higher in BMF incorporated product than FMF incorporated product. This might be due to the higher starch contents as Mounsey and O’Riordan (2001) reported that the addition of high amount of starches in imitation cheese increased cheese hardness, which they attributed to hydrogen bonding of amylose leached from the starch particles during the cheese cooking. Further, in 2% fat milk coagulum products, hardness was higher than skim milk coagulum products. This might be due to their higher fat contents. Noronha et al. (2008) has reported similar results in imitation cheeses showing higher hardness values for cheese containing 13% fat than that containing 2% fat.

Values for adhesiveness (Ns) were significantly ($p<0.05$) higher in 2% fat milk coagulum products in both, BMF and FMF incorporated nuggets as compared to their counterparts prepared from skim milk coagulum. Further, there was no significant difference between BMF and FMF incorporated products in case of both types of coagulum based nuggets separately. Springiness is the ability of the sample to recover its original form after a deforming force is removed. Springiness was significantly ($p<0.05$) higher in 2% fat milk coagulum products than skim milk coagulum products.

Cohesiveness (in ratio) describes the amount a product can be misshaped before it breaches. Cohesiveness values ranged from 0.26±0.02 in skim milk coagulum nuggets with BMF to 0.40±0.02 in skim milk coagulum nuggets with FMF. Further, the values were comparable among T1, T2 and T4 and these were significantly higher ($p<0.05$) than T3.

Gumminess (N) and chewiness (Ncm) values for 2% fat milk coagulum nuggets were significantly ($p<0.05$) higher than skim milk coagulum products. Further, there was no significant ($p>0.05$) difference between BMF and FMF incorporated products in case of both types of coagulum based nuggets separately.

CONCLUSION
The texture profile analysis showed higher values for hardness, springiness, cohesiveness, gumminess and chewiness for the milk nuggets prepared with 2% fat milk coagulum as compared to the nuggets prepared with skim milk coagulum.

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