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Relating instrumental texture of cow curd with major milk constituents

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Abstract
The relationship among fat, Solids not fat of cow curd with firmness and consistency attributes of textural parameters of curd was investigated at different degrees of its incubation and reported here. The fat (F%) and Solids not fat (SNF) content of fresh cow milk was adjusted to 9, 12, 15, 18, 21 and 24% using spray dried-skim milk powder. Cow curd was prepared from these milks with adjusted TS and were chilled to 5 °C.
Firmness, consistency attributes of cow curd samples, measured by texture analyser, showed a general increasing trend with increasing % Fat and % Solids not fat in milk. Sensory scores were the highest at 15% TS. The % Fat and % Solids not fat content, Firmness, consistency attributes of texture were interdependent and instrumental texture parameters highly influenced the major milk constituents.
By laboratory analysis of instrumental textural profile of cow curd in detail it was found that there exhibits a positive correlation between with consistency and firmness of cow curd with the fat (F %) and Solids not fat (SNF) content of fresh cow curd. Relationships were much better with increased fermentation temperature of 40ºC when compared to 37ºC of curd incubation.

Keywords: Fat (F%) and Solids not fat (SNF) content -cow curd- Texture analyser-firmness and consistency-fermentation temperature

Introduction
Firmness and consistency of cow curd samples of altered major milk constituents *viz* % fat and % Solids not fat were studied. Curd manufacture in India needs improvements in the existing methods of production and marketing so as to ensure a uniformly high standard in the quality of curd. The formulation of any step for improving the production of curd should however be based on a proper appreciation of the factors which go to determine the quality of curd, such as the types of organisms associated with curd produced in different parts of the country and their characteristics, influence of climatic and seasonal variations, quality of milk used and method of manufacture, about which there is very little information available.
Texture is a collective term and comprises physical properties of the product, such as hardness, adhesiveness, viscosity, and springiness. They are all derived from the structural elements and can be perceptible by human senses. Consequently, texture is one of the basic quality determinator of fermented dairy products. Instrumental texture analysis, coming from penetrometric methods, is one of the main methods for texture determination of set-yoghurts. (Escher F, 1993; Benezech, 1994) [4, 1] This research enlightens about the relationship between percent of fat content and percent of total solids in milk, incubation temperature for curd with its firmness and consistency attributes of cow curd texture.

Materials and methods
Fresh cow milk was obtained from farm and skim milk powder with 5 percent moisture and 95 percent solubility were used in this study. Major milk constituents was adjusted to contain the desired fat and SNF levels using the Pearson square method.

Table 1: List of treatments for the cow milk curd with various fat and SNF Combinations incubated at 37 °C

Groups	Trials	Combinations of fat and SNF
Control	C1A11 (Control)	3.2 % fat and 8.3 % SNF
Group 1	C2A11	3.5 % fat and 8.5 % SNF
	C2A21	3.5 % fat and 9 % SNF
	C2A31	3.5 % fat and 10 % SNF
	C2A41	3.5 % fat and 11 % SNF
	C2A51	3.5 % fat and 12 % SNF
Group 2	C3A11	4 % fat and 8.5 % SNF
	C3A21	4 % fat and 9 % SNF
	C3A31	4 % fat and 10 % SNF
	C3A41	4 % fat and 11 % SNF
	C3A51	4 % fat and 12 % SNF
Group 3	C4A11	4.5 % fat and 8.5 % SNF
	C4A21	4.5 % fat and 9 % SNF
	C4A31	4.5 % fat and 10 % SNF
	C4A41	4.5 % fat and 11 % SNF
	C4A51	4.5 % fat and 12 % SNF
Group 4	C5A11	5 % fat and 8.5 % SNF
	C5A21	5 % fat and 9 % SNF
	C5A31	5 % fat and 10 % SNF
	C5A41	5 % fat and 11 % SNF
	C5A51	5 % fat and 12 % SNF
Group 5	C6A11	5.5 % fat and 8.5 % SNF
	C6A21	5.5 % fat and 9 % SNF
	C6A31	5.5 % fat and 10 % SNF
	C6A41	5.5 % fat and 11 % SNF
	C6A51	5.5 % fat and 12 % SNF
Group 6	C7A11	6 % fat and 8.5 % SNF
	C7A21	6 % fat and 9 % SNF
	C7A31	6 % fat and 10 % SNF
	C7A41	6 % fat and 11 % SNF
	C7A51	6 % fat and 12 % SNF

Table 2: List of treatments for the cow milk curd with various fat and SNF Combinations incubated at 40 °C

Groups	Trials	Combinations of fat and SNF
Control	C1A12 (Control)	3.2 % fat and 8.3 % SNF
Group 1	C2A12	3.5 % fat and 8.5 % SNF
	C2A22	3.5 % fat and 9 % SNF
	C2A32	3.5 % fat and 10 % SNF
	C2A42	3.5 % fat and 11 % SNF
	C2A52	3.5 % fat and 12 % SNF
Group 2	C3A12	4 % fat and 8.5 % SNF
	C3A22	4 % fat and 9 % SNF
	C3A32	4 % fat and 10 % SNF
	C3A42	4 % fat and 11 % SNF
	C3A52	4 % fat and 12 % SNF
Group 3	C4A12	4.5 % fat and 8.5 % SNF
	C4A22	4.5 % fat and 9 % SNF
	C4A32	4.5 % fat and 10 % SNF
	C4A42	4.5 % fat and 11 % SNF
	C4A52	4.5 % fat and 12 % SNF
Group 4	C5A12	5 % fat and 8.5 % SNF
	C5A22	5 % fat and 9 % SNF
	C5A32	5 % fat and 10 % SNF
	C5A42	5 % fat and 11 % SNF
	C5A52	5 % fat and 12 % SNF
Group 5	C6A12	5.5 % fat and 8.5 % SNF
	C6A22	5.5 % fat and 9 % SNF
	C6A32	5.5 % fat and 10 % SNF
	C6A42	5.5 % fat and 11 % SNF
	C6A52	5.5 % fat and 12 % SNF
Group 6	C7A12	6 % fat and 8.5 % SNF
	C7A22	6 % fat and 9 % SNF
	C7A32	6 % fat and 10 % SNF
	C7A42	6 % fat and 11 % SNF
	C7A52	6 % fat and 12 % SNF

Textural analysis of cow curd

Back extrusion method using a texture analyser was used to find the textural attributes such as firmness and stickiness (M/s Scientific and Digital Systems, Delhi). For determining the textural attributes, the pasteurized and cooled curd was filled up to 5 cm in a sterilized glass beaker (10 cm height and 6 cm diameter) and tempered at 25 °C for 2 h prior to analysis. The probe was penetrated up to 10 mm (20 percent compression) into the curd at a crosshead speed of 1.0 mm/s. The probe displaced the material by compression followed by back extrusion so that the fluid flow upward through the concentric annular space. From the resulting force-time curves, firmness, i.e., the force for compression, stickiness, i.e., the negative peak force during withdrawal, work of shear and work of adhesion were calculated using the Texture Exponent System software supplied by the manufacturer along with the instrument. All measurements were done in quadruplicate per sample.

Distance (10 mm) during which it senses a resistance force that is directly proportional to the firmness of the set curd.

The resistance offered by the curd samples to the probe during the penetration was measured as the firmness (g) of the curd. The area under the positive peak of the curve was measured as the consistency (g-sec) of the curd and the area under the negative peak was measured as the viscosity index (g-sec) of the curd. The viscosity index i.e. the area of the negative peak is the reflection of the total work done by the probe during its withdrawal from the curd during the test (Sfakianakis and Tzia, 2014; Bourne, 2002) [11, 2].

Texture Measurement Textural attributes such as firmness and consistency were determined by back extrusion method using a texture analyser. For determining the textural attributes, the pasteurized and cooled curd mix was filled (~125 mL) up to 5 cm in a pre-sterilized glass beaker (10 cm height and 6 cm diameter) and incubation was carried out at different temperature. The beakers were tempered at 25 °C for 2 h prior to analysis. The probe (A/BE 35) was penetrated up to 10 mm (20% compression) into the set cow curd at a crosshead speed of 1.0 mm/s. The probe displaced the material by compression followed by back extrusion, so that the fluid flowed upward through the concentric annular space. From the resulting force-time curves, firmness, i.e., the force for compression, consistency, i.e., the negative peak force during withdrawal, work of shear and work of adhesion were calculated using the Texture Expert Exceed software (version 2.55) supplied by the manufacturer along with the instrument. All measurements were done in quadruplicate per sample.

Effect of major milk components Fat and Solids Not fat under altered combinations as given in table 1 and 2 were prepared using Pearson square method.

Mistry and Hassan (1992) [7] reported that the firmness (as determined by a penetrometer) of non-fat yoghurt fortified with either non-fat dry milk (NDM) or high milk protein powder (HMPP) increased as compared with the unfortified one. Similar pattern was observed with the consistency, i.e., the negative peak force obtained during the withdrawal of the probe, among the three treatments. The increased consistency could be due to increased lactose content resulted from increased mean solids not fat (MSNF) content.

Table 3: Mean (±SE) firmness and consistency values for cow milk curd with various fat and SNF combinations incubated at 37 °C

Treatments	Cow milk curd samples based on the textural score under various fat and SNF combinations					
Group 1*	**Control**	**C2A11**	**C2A21**	**C2A31**	**C2A41**	**C2A51**
Firmness	232.53^{d} ±20.78	236.01^{c}±20.36	234.87^{bc}±20.80	239.36^{b}±0.71	254.77^{a}±20.98	258.37^{a}±20.94
Consistency	6319.26^{e}±100.53	6340.93^{d}±100.86	6357.54^{cd}±120.90	6413.44^{c}±120.67	6432.83^{b}±120.40	6446.56^{a}±120.27
Group 2*	Control	C3A11	C3A21	C3A31	C3A41	C3A51
Firmness	232.53^{d}±20.78	255.13^{c}±0.06	258.04^{c}±0.51	260.55^{ab}±0.77	261.59^{ab}±0.24	265.98^{a}±4.23
Consistency	6319.26^{c}±100.53	6376.34^{b}±121.62	6395.37^{b}±121.69	6415.42^{b}±131.66	6436.18^{a}±135.60	6466.52^{a}±125.72
Group 3*	Control	C4A11	C4A21	C4A31	C4A41	C4A51
Firmness	232.53^{d}±20.78	255.13^{c}±18.06	258.04^{c}±21.51	260.55^{ab}±25.77	260.51^{ab}±2124	278.48^{a}±24.23
Consistency	6319.26 ^{c}±100.53	6407.86±110.84	6432.77 ^{b}±120.82	6458.67±121.79	6483.98±130.90	6510.16^{a} 125.92
Group 4*	Control	C5A11	C5A21	C5A31	C5A41	C5A51
Firmness	232.53^{d}±20.78	264.90^{c}±17.45	269.92^{ab}±20.76	269.30^{ab}±19.81	271.88^{ab}±24.81	279.02^{a}±26.31
Consistency	6319.26 ^{a}±100.53	6444.09^{b}±110.54	6463.78^{b}±121.84	6486.11±125.63	6598.35^{c}±1.02	6615.66^{c}±141.41
Group 5*	Control	C6A11	C6A21	C6A31	C6A41	C6A51
Firmness	232.53^{a}±20.78	271.91^{b}±18.46	282.06^{b}±19.47	296.77 ^{b}±22.38	309.89 ^{c}±23.85	319.60 ^{c}±24.79
Consistency	6319.26 ^{e}±100.53	6470.15^{d}±120.86	6485.34^{d}±110.57	6590.14^{c}±100.92	6617.01^{b}±118.85	6630.50^{a}±114.73
Group 6*	Control	C7A11	C7A21	C7A31	C7A41	C7A51
Firmness	232.53c±20.78	309.03^{b}±18.09	315.41^{b}±20.20	319.21^{b}±17.08	325.12^{a}±20.51	334.86^{a}±20.43
Consistency	6319.26 ^{e}±100.53	6490.41±110.20	6590.52^{c}±117.76	6618.63^{ab}±118.31	6632.50^{a}±121.24	6644.13^{a}±120.05

*Means bearing superscript within the treatments differ significantly (P<0.01) (n=6)

Table 4: Mean (±SE) firmness and consistency values for cow milk curd with various fat and SNF combinations incubated at 40 °C

Treatments (n=6)	Cow milk curd samples based on the textural score under various fat and SNF combinations					
Group 1*	**Control**	**C2A12**	**C2A22**	**C2A32**	**C2A42**	**C2A52**
Firmness	239.21^{d}±21.13	243.62^{c}±22.41	241.35^{c}±20.35	246.91^{bc}±20.75	261.63^{b} ±20.32	265.22^{a}±21.24
Consistency	6338.26^{e}±103.21	6359.93^{de}±104.22	6376.54^{d}±122.08	6432.44^{c}±124.32	6451.83 ^{b}±121.28	6465.56 ^{a}±123.24
Group 2*	Control	C3A12	C3A22	C3A32	C3A42	C3A52
Firmness	239.05^{f}±22.07	262.17^{d}±20.32	265.32^{d}±21.22	267.12^{bc}±20.41	268.02^{b}±20.16	272.16^{a}±22.08
Consistency	6357.08^{d}±103.79	6395.34 ^{d}±123.36	6410.25^{c}±122.45	6434.01^{c}±129.41	6455.23^{b}±126.33	6485.33^{a}±129.84
Group 3*	Control	C4A12	C4A22	C4A32	C4A42	C4A52
Firmness	239.21^{e}±21.13	242.13^{d}±18.06	265.04^{c}±21.51	267.55^{bc}±25.77	267.51^{b}±2124	285.48^{a}±24.23
Consistency	6338.26^{e}±103.21	6426.66^{d} ± 112.71	6451.35^{d} ±123.34	6487.41^{c} ^{b}±123.66	6502.32^{b} ^{c}±131.34	6529.14^{a}±122.68
Group 4*	Control	C5A12	C5A22	C5A32	C5A42	C5A52
Firmness	239.21^{e}±21.13	271.62^{d}±17.45	276.26^{bc}±20.76	275.81^{c}±19.81	278.46^{b}±24.81	285.39^{a}±26.31
Consistency	6338.26^{d}±114.73	6463.23^{c}±109.28	6482.28^{c}±117.24	6504.34^{b}±129.77	6617.64^{a}±118.52	6634.21^{a}±134.26
Group 5*	Control	C6A12	C6A22	C6A32	C6A42	C6A52
Firmness	239.21^{e}±21.13	278.24^{d}±18.46	289.32^{d}±19.47	302.26^{c}±22.38	316.42^{b}±23.85	326.37^{a}±24.79
Consistency	6338.26^{e}±121.68	6489.39^{d}±119.43	6504.61^{c}±116.33	6609.28^{b}±106.58	6636.44 ^{a}±114.37	6649.27 ^{a}±115.62
Group 6*	Control	C7A12	C7A22	C7A32	C7A42	C7A52
Firmness	239.21^{f}±24.06	316.44^{e}±17.23	322.63^{d}±18.95	326.37^{c}±19.32	332.43^{b}±21.26	341.24^{a}±21.82
Consistency	6357.25^{e}±110.62	6509.72^{d}±112.37	6609.41^{c}±119.26	6637.41^{b}±116.44	6651.39^{a}±119.68	6663.72^{a}±119.47

*Means bearing superscript within the treatments differ significantly (P<0.01) (n=6)

Results

Alterations were made in the major milk constituents of cow curd milk ie, Fat and solids not fat and analysis were related with texture profile of the best combination of fat and SNF for cow milk curd was carried out based on the sensory and textural properties. Firmness value, i.e., the peak force obtained during penetration of the probe revealed that increase of fat from 3-2% and SNF from 8.3 (Group 1) to Fat 6%; SNF 12% (Group 6) at incubation temperature of 37˚C has increased the cow curd firmness value from 232.53 ±20.78 to 334.86 ±20.43 and cohesiveness value from 6319.26±100.53 to 6644.13±120.05 respectively.

Similarly cow curd prepared at incubation temperature of 40˚C Firmness value probe revealed that increase of fat from 3-2% and SNF from 8.3 (Group 1) to Fat 6%; SNF 12% (Group 6) at incubation temperature of 40˚C has increased the cow curd firmness value from 239.21 ±21.13 to 341.24±21.82 and cohesiveness value from 6338.26±103.21 to 6663.72±119.47 respectively.

The textural qualities of the cow milk curd samples incubated at 37ºC and 40ºC are presented in Tables 3 and 4. As the fat and SNF contents of the milk increased, there was a corresponding increase in the firmness and consistency of the curd samples. Hence, based on the textural qualities the clear-cut conclusion about the fact that increase in fat and SNF will positively increase the firmness and consistency of cow.

Discussion

The data pertaining to the textural scores of the cow milk curd samples prepared with various combinations of fat and SNF and with incubation temperature of 37ºC and 40ºC is presented in Table 3 and 4. The values of all measured texture parameters, namely firmness, and consistency were significantly different and increased in the following order of increase in fat and Solids not fat content.

Such differences could be attributable to the varying content of total solids and total fat in cow milk, and also to the incubation temperature underwent. Moreover, further differences were found by Vlahopoulou *et al*. (1994) [12] for yoghurt gels. A looser consistency has been ascribed to the gel from cow milk curd with lower total solids, despite the

lower total protein content in the milk.

In this study, cow curd samples samples were incubated at 37 **°C** and 40C under different trails. These observations are similar to observations of Lee and Lucey (2004) [5], they observed that the lower fermentation temperature allows more interaction and cross-links within proteins in the gel leading to the formation of a network that is homogenous in structure.

In this experiment, the Curd samples incubated at 40 °C a higher textural scores than the other curd samples incubated at 37 °C. This observation correlates with the observation of Lee and Lucey (2004) [5] who had analyzed that yogurt gels incubated at 40 °C exhibited more obviously branched and homogeneous interconnected protein networks, and the gels networks underwent less obvious structural changes during fermentation, compared with yogurt gels made at 45.7 °C. Our findings also correlated with the findings of Nguyen *et al*., (2014) [8] who had stated that yoghurt produced from a faster fermentation at 43 °C was firmer with a more porous microstructure that exhibited a higher degree of syneresis.

Conclusion

Cow milk curd is a popular fermented dairy product of India having moderate to high fat and high total solids content. Firmness and consistency increases with increase in the content of Fat and SNF of cow milk. Relationship between cow curd Firmness and consistency with increase in ratio of major milk constituents were much better with increased fermentation temperature of 40ºC when compared to 37ºC of curd incubation.

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