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Firmness and instrumental consistency of Buffalo curd prepared with modified ratios of major milk constituents

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Abstract
Buffalo curd was prepared from buffalo milk with altered major milk constituents namely fat and Solids not fat ratio. In fresh buffalo curd after its incubation under 37ºC and 40ºC separately were analysed: Firmness and consistency of buffalo curd samples were analyzed using instrumental texture analyzer. Firmness, consistency attributes of buffalo curd samples, measured by texture analyser, showed a general increasing trend with increasing % Fat and % Solids not fat in milk. By laboratory analysis of instrumental textural profile of buffalo curd in detail it was found that there exhibits a positive correlation between with consistency and firmness of buffalo curd with the fat (F %) and Solids not fat (SNF) content of fresh buffalo curd. Firmness and consistency of buffalo curd were much better with increased fermentation temperature of 40ºC when compared to 37ºC of buffalo curd incubation. buffalo curd prepared at incubation temperature of 40˚C Firmness value probe revealed that increase of fat from 5% and SNF from 9% (Group 1) to Fat 8 %; SNF 14% (Group 7) at incubation temperature of 40˚C has increased the buffalo curd firmness value from 270.19 ±19.16 to 351. 23±13.66 and consistency value from 6484.12±112.34 to 6721.54 ±106.79 respectively.

Keywords: Buffalo curd, incubation temperature, firmness and consistency

Introduction
Buffalo curd has firm consistency, smooth texture, and pleasant aroma. Traditionally, it is prepared by boiling buffalo milk followed by cooling and culturing at ambient temperature using lactic culture and pouring into retail earthen cups and left undisturbed overnight for fermentation. After obtaining firm body curd has set, it is stored at a low temperature (4°C) and served chilled (Aneja *et al*. 2002; Singh 2007) [1, 19]. Various market survey reports on the quality of curd sold in different parts of the country revealed wide variations in the fat (1-12%) and solids not fat contents (6-25%) contents (Sarkar *et al*. 1996) [18]. Because of the pleasant sour taste cherished by all age groups and the availability of technology for the industrial manufacture (Ghosh and Rajorhia 1990b) [5], Various studies have reported that fat and solids not fat affects both the sensory and texture properties of cultured dairy products (Rash 1990; Lucey and Singh 1997; Tamime and Robinson 1999; Gayanjalee *et al*, 2024) [17, 9, 20, 4]. The growing awareness of impact of fermented foods on health among consumers may increase the marketing of curd in future. However, there is no elaborative study conducted on the extent to which fat and Solids not fat affecting its textural quality and acceptability. Hence, the present study was undertaken to see the effect of fat and solids not fat under different altered ratios in buffalo milk and how its impact on the Firmness and instrumental consistency of buffalo curd prepared under different incubation temperatures at 37 °C and also at 40 °C.

Materials and methods
Fresh buffalo milk is obtained from the farm. Using cream obtained from buffalo milk and skim milk powder, with the help of Pearson square method various fat and SNF combinations a

Textural analysis of buffalo curd
Textural attributes such as firmness and consistency of buffalo curd (M/s Scientific and

Digital Systems, Delhi) was analysed using Back extrusion method using a texture analyser. 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.

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 buffalo 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 in buffalo milk as given in table 1 and 2 were prepared using Pearson square method.

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

Groups	Trials	Combinations of fat and SNF
Control	B1A11 (Control)	5 % fat and 9 % SNF
Group 1	B2A11	5 % fat and 10 % SNF
	B2A21	5 % fat and 11 % SNF
	B2A31	5 % fat and 12 % SNF
Group 2	B3A11	5.5 % fat and 8.5 % SNF
	B3A21	5.5 % fat and 9 % SNF
	B3A31	5.5 % fat and 10 % SNF
	B3A41	5.5 % fat and 11 % SNF
	B3A51	5.5 % fat and 12 % SNF
Group 3	B4A11	6 % fat and 8.5 % SNF
	B4A21	6 % fat and 9 % SNF
	B4A31	6 % fat and 10 % SNF
	B4A41	6 % fat and 11 % SNF
	B4A51	6 % fat and 12 % SNF
Group 4	B5A11	6.5 % fat and 8.5 % SNF
	B5A21	6.5 % fat and 9 % SNF
	B5A31	6.5 % fat and 10 % SNF
	B5A41	6.5 % fat and 11 % SNF
	B5A51	6.5 % fat and 12 % SNF
Group 5	B6A11	7 % fat and 8.5 % SNF
	B6A21	7 % fat and 9 % SNF
	B6A31	7 % fat and 10 % SNF
	B6A41	7 % fat and 11 % SNF
	B6A51	7 % fat and 12 % SNF
Group 6	B7A11	7.5 % fat and 8.5 % SNF
	B7A21	7.5 % fat and 9 % SNF
	B7A31	7.5 % fat and 10 % SNF
	B7A41	7.5 % fat and 11 % SNF
	B7A51	7.5 % fat and 12 % SNF
Group 7	B8A11	8 % fat and 8.5 % SNF
	B8A21	8 % fat and 9 % SNF
	B8A31	8 % fat and 10 % SNF
	B8A41	8 % fat and 11 % SNF
	B8A51	8 % fat and 12 % SNF

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

Groups	Trials	Combinations of fat and SNF
Control	B1A12 (Control)	5 % fat and 9 % SNF
Group 1	B2A12	5 % fat and 10 % SNF
	B2A22	5 % fat and 11 % SNF
	B2A32	5 % fat and 12 % SNF
Group 2	B3A12	5.5 % fat and 8.5 % SNF
	B3A22	5.5 % fat and 9 % SNF
	B3A32	5.5 % fat and 10 % SNF
	B3A42	5.5 % fat and 11 % SNF
	B3A52	5.5 % fat and 12 % SNF
Group 3	B4A12	6 % fat and 8.5 % SNF
	B4A22	6 % fat and 9 % SNF
	B4A32	6 % fat and 10 % SNF
	B4A42	6 % fat and 11 % SNF
	B4A52	6 % fat and 12 % SNF
Group 4	B5A12	6.5 % fat and 8.5 % SNF
	B5A22	6.5 % fat and 9 % SNF
	B5A32	6.5 % fat and 10 % SNF
	B5A42	6.5 % fat and 11 % SNF
	B5A52	6.5 % fat and 12 % SNF

Group 5	B6A12	7 % fat and 8.5 % SNF
	B6A22	7 % fat and 9 % SNF
	B6A32	7 % fat and 10 % SNF
	B6A42	7 % fat and 11 % SNF
	B6A52	7 % fat and 12 % SNF
Group 6	B7A12	7.5 % fat and 8.5 % SNF
	B7A22	7.5 % fat and 9 % SNF
	B7A32	7.5 % fat and 10 % SNF
	B7A42	7.5 % fat and 11 % SNF
	B7A52	7.5 % fat and 12 % SNF
Group 7	B8A12	8 % fat and 8.5 % SNF
	B8A22	8 % fat and 9 % SNF
	B8A32	8 % fat and 10 % SNF
	B8A42	8 % fat and 11 % SNF
	B8A52	8 % fat and 12 % SNF

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

Treatments (n=6)	**Buffalo milk curd samples based on the textural attributes of various fat and SNF combinations**					
Group 1*buffalo	**B1A11**	**B2A11**	**B2A21**	**B2A31**		
Firmness	270.19^{c}±19.16	270.43^{c}±18.67	272.35^{b}±22.45	280.02^{a}±26.31		
Consistency	6465.31^{d}±118.26	6488.11^{c}±125.63	6599.35^{b}±123.02	6618.21^{a}±131.41		
Group 2*	B1A11	B3A11	B3A21	B3A31	B3A41	B3A51
Firmness	270.19^{f} ±18.12	272.37^{e}±14.33	283.19^{d}±15.16	297.72^{c}±21.37	311.36^{b}±21.45	320.16^{a}±2372
Consistency	6465.31^{f}±118.26	6472.23±124.34	6486.34^{d}±112.52	6592.12^{c}±104.93	6618.01^{b}±120.86	6632.50±116.72
Group 3*	B1A11	B4A11	B4A21	B4A31	B4A41	B4A51
Firmness	270.19^{f}±19.16	310.02^{e}±18.06	316.42^{d}±20.20	320.21^{c}±17.08	326.67^{b}±20.51	335.84^{a}±20.43
Consistency	6465.31^{f}±118.26	6491.47^{e}±110.13	6591.33^{d}±112.21	6619.61^{c}±124.38	6633.37 ^{b}±121.24	6645.87 ^{a}±120.02
Group 4*	B1A11	B5A11	B5A21	B5A31	B5A41	B5A51
Firmness	270.19^{f}±19.16	316.44^{e}±17.23	474.86 ^{d}±0.78	316.34^{c}±0.83	328.72^{b}±0.92	335.23 ^{a}±20.43
Consistency	6465.31^{f}±118.26	6509.72 ^{e}±112.37	6572.70 ^{d}±135.35	6614.62^{c}±125.03	6639.92^{b}±127.06	6646.17 ^{a}±120.05
Group 5*	Control	B6A11	B6A21	B6A31	B6A41	B6A51
Firmness	270.19^{f}±19.16	319.23^{e}±17.16	319.23 ^{d}±0.64	320.27^{c}±0.83	336.52^{b}±0.96	339.77^{a}±22.43
Consistency	6465.31^{f}±118.26	6515.72^{e}±137.32	6619.70^{d}±121.31	6621.61^{c}±135.02	6654.68 ^{b}±154.02	6672.17 ^{a}±128.24
Group 6*	Control	B7A11	B7A21	B7A31	B7A41	B7A51
Firmness	272.19^{f}±19.16	324.26^{e}±18.12	324.21 ^{d}±0.64	326.27^{c}±0.83	341.56^{b}±0.96	346.72^{a}±22.43
Consistency	6466.31^{f}±118.26	6534.43 ^{e}±131.31	6638.70 ^{d}±151.28	6639.61^{c}±146.01	6673.88^{b}±153.66	6691.14 ^{a}±144.25
Group 7*	Control	B8A11	B8A21	B8A31	B8A41	B8A51
Firmness	270.19^{f}±1.16	328.23^{e}±18.17	329.62^{d} ±0.71	332.27^{c}±0.83	347.31^{b}±0.22	351. 23^{a}±13.66
Consistency	6465.31^{f}±118.26	6555.42^{e}±144.36	6656.59 ^{d}±138.71	6677.61 ^{c}±173.04	6698.55^{b}±162.13	6702.11 ^{a}±166.25

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

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

Treatments (n=6)	**Buffalo milk curd samples based on the textural score under various fat and SNF combinations**					
Group 1*buffalo	**B1A12**	**B2A12**	**B2A22**	**B2A32**		
Firmness	277.37^{b}±19.16	277.22^{b}±13.21	279.14^{b}±18.26	287.56^{a}±22.54		
Consistency	6484.12^{d}±112.34	6497.15 ^{c}±133.61	6518.41^{b}±119.34	6537.26^{a}±124.88		
Group 2*	B1A12	B3A12	B3A22	B3A32	B3A42	B3A52
Firmness	277.37^{c}±19.16	279.31^{e}±12.41	290.12^{d}±13.12	315.66^{c}±24.32	317.36^{b}±18.42	327.12^{a}±18.54
Consistency	6484.12^{d}±112.34	6491.45 ^{e}±128.31	6503.36^{d}±142.53	6609.44^{c}±123.93	6637.01^{b}±120.23	6651.56 ^{a}±125.69
Group 3*	B1A12	B4A12	B4A22	B4A32	B4A42	B4A52
Firmness	277.37^{c}±19.16	317.63^{e}±13.88	323.37^{d}±18.20	327.44^{c}±13.02	332.62^{b}±17.44	341.39^{a}±19.86
Consistency	6484.12^{d}±112.34	6509.22^{e}±119.44	6609.27^{d}±145.26	6627.55^{c}±136.31	6652.32 ^{b}±167.25	6664.82 ^{a}±135.39
Group 4*	B1A12	B5A12	B5A22	B5A32	B5A42	B5A52
Firmness	277.37^{c}±19.16	320.33^{e}±17.23	481.33 ^{d}±0.72	323.38^{c}±0.24	335.38^{b}±0.92	342.69 ^{a}±20.43
Consistency	6484.12^{d}±112.34	6518.68 ^{e}±109.46	6591.66 ^{d}±124.36	6614.62^{c}±119.45	6658.63^{b}±124.11	6665.89 ^{a}±142.72
Group 5*	Control	B6A12	B6A22	B6A32	B6A42	B6A52
Firmness	277.37^{c}±19.16	326.41^{e}±19.79	325.47 ^{d}±12.69	327.22^{c}±14.83	342.59^{b}±19.96	353.45^{a}±19.22
Consistency	6484.12^{d}±112.34	6534.79^{e}±156.48	6638.82^{d}±121.31	6640.64^{c}±148.56	6673.68 ^{b}±122.99	6691.17 ^{a}±128.24
Group 6*	Control	B7A12	B7A22	B7A32	B7A42	B7A52
Firmness	277.37^{c}±19.16	331.09^{e}±24.36	330.37 ^{d}±12.21	340.21^{c}±18.24.	361.68^{b}±19.41	367.34^{a}±16.34
Consistency	6484.12^{d}±112.34	6562.51 ^{e}±126.55	6695.41 ^{d}±132.66	6677.08^{c}±119.45	6692.88^{b}±153.66	6706.33 ^{a}±128.44
Group 7*	Control	B8A12	B8A22	B8A32	B8A41	B8A51
Firmness	277.37^{c}±19.16	335.66^{e}±21.34	335.44^{d} ±14.38	339.45^{c}±23.17	354.42^{b}±21.25	358. 26^{a}±19.22
Consistency	6484.12^{d}±112.34	6574.39^{e}±129.41	6675.43 ^{d}±143.66	6696.34±183.51	6717.41^{b}±148.45	6721.54 ^{a}±106.79

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

Results

Firmness and consistency values for buffalo milk curd with various fat and SNF combinations

The firmness and consistency attributes of the buffalo milk curd made by incubating the sample 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 buffalo curd samples. Modifications were made in the major milk constituents of buffalo curd milk ie, Fat and solids not fat and analysis were related with texture profile of the best combination of fat and SNF for buffalo milk curd was carried out based on the textural properties. Firmness value, i.e., the peak force obtained during penetration of the probe revealed that increase of fat from 5%to 8% and Solids Not Fat from 9 to 12% (Group 7) at incubation temperature of 37˚C has increased the buffalo curd firmness value from 270.19 ±19.16 to 358. 26±19.22 and consistency value from 6465.31 ± 118.26 to 6702.11 ±166.25 respectively.

Similarly buffalo curd prepared at incubation temperature of 40˚C Firmness value probe revealed that increase of fat from 5% and SNF from 9% (Group 1) to Fat 8 %; SNF 14% (Group 7) at incubation temperature of 40˚C has increased the buffalo curd firmness value from 270.19 ±19.16 to 351. 23±13.66 and consistency value from 6484.12±112.34 to 6721.54 ±106.79 respectively.

The textural qualities of the buffalo 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 buffalo 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 buffalo curd.

Discussion

Firmness and consistency values for buffalo milk curd with various fat and SNF combinations

The laboratory analysis pertaining to the textural scores of the buffalo 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. (Khalifa, 2019) [8].

Such differences could be attributable to the varying content of total solids and total fat in buffalo milk, and also to depends on the incubation temperature used for manufacture of buffalo curd. These findings are in agreement with Nahar *et al.* (2007) [11] who found that fat and SNF improved the quality attributes of curd. The results also correlates well with the findings of Anema (2008) [2], Emirmustafaoğlu *et al* (2019) [3] that buffalo milk curd fermented at a higher temperature or left in storage is more susceptible to whey separation, more sensitive to the external force indicated by the flow behavior index and less able to recover to the original structure after fermentation, whereas buffalo milk curd fermented at the lower temperatures of 37 or 40°C was more consistent and these temperatures are recommended to improve the microstructure and syneresis of buffalo milk curd.

The experimental results are also found in concurrence with findings of Hussain *et al*., (2016) who stated that lowering of body and texture scores upon increase of solids not fat beyond certain level. This could be ascribed to the faster growth of lactic acid bacteria resulted in higher acid production leading to oozing out of water from the protein matrix in curd.

Conclusion

Based on the detailed investigation on various samples of buffalo curd, firmness and instrumental consistency of Buffalo curd prepared with altered ratio of major milk constituents found to increase with increase in the ratio of fat and solids not fat.

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