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Effect of processing parameters on quality attributes of cow skim milk *Paneer*

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Abstract
Paneer is a very popular Traditional Indian Dairy Product. *Paneer* offers a profitable market for dairy industry. Viewing the urge of consumers for low fat products and at the same time the popularity of *paneer*, an attempt was taken to develop low fat *paneer* from cow skim milk with desirable quality attributes. Therefore the effects of some important processing parameters like milk coagulation temperature and brine concentration of dipping solution of *paneer* and the effect of addition of fat replacer-inulin into the cow skim milk on the sensorial quality of cow skim milk *paneer* were evaluated and compared with cow milk *paneer*. Based on sensorial appeal the amount of inulin to be added into the cow skim milk, coagulation temperature of milk and concentration of chilled brine solution for dipping of *paneer* were selected within the range of 1-2% of milk, 55-65 ˚C and 1-3%, respectively.

Keywords: Low fat *paneer*, cow skim milk, fat replacer-inulin, milk coagulation temperature, brine concentration, sensory evaluation

1. Introduction
India is the largest milk producer in the world with an annual production of 165.4 million tons having per capita availability of 355 g/day as per the NDDB statistics for the year 2016-2017. About 46% of milk produced is consumed as liquid milk and 50-55% is converted into Traditional Indian Dairy Products like *paneer* and *paneer* based products, *chhana* and *chhana* based products, *khoa* and *khoa* based sweets and desserts. *Paneer* one of the popular Traditional Indian Dairy Products, offers an enormous opportunity to dairy sector. In recent era owing to changing life style as well as increasing awareness about health, nutritional requirement consumers are focusing their interest on diversified food products with some functional roles. Development of low fat *paneer* is, therefore, gained a considerable attention. Production of low fat *paneer* from cow skim milk will not only serve the demand for fat conscious consumer, but also improve the economy in dairy sector by proper utilization of surplus skim milk and product diversification. Acceptability of low fat *paneer* is limited by its excessively firm, rubbery, chewy body and lack in flavour (Chawla *et al.*, 1985) [1]. A number of scientific approaches had already been applied to overcome the problems associated with low fat *paneer*. Still now there is a need for scientific study on these topics to get the desirable sensorial attributes as well as texture profile of the product which can be achieved by regulating the proportion and state of the major constituents such as water, protein and fat in the product through some modification in processing technique as well as addition of additives. The present study was, therefore, undertaken to evaluate the effect of different processing parameters and inulin- a fat replacer on the quality of low-fat *paneer* from cow skim milk.

2. Materials and Methods
The research work was carried out at Department of Dairy Technology, Faculty of Dairy Technology, W.B.U.A.F.S., West Bengal. Source of raw materials and the methodologies followed in technological and analytical aspects are delineated hereunder.

2.1. Raw Materials
Fresh, raw cow milk was collected from the Experimental Dairy Farm, W.B.U.A.F.S., West Bengal. Cow milk on an average contained 4.0 to 4.2% fat and 8.6 to 8.7% solids not fat. Edible common salt (M/S Nirma Ltd., Ahmadabad) was procured from the local market of Mohanpur, Nadia, West Bengal, India. Inulin (extracted from chicory root, Frutafit® HD, manufactured by Sensus, Netherlands) was procured from Premier Specialty Ingredients, Chennai, Tamil Nadu, India.

2.2. Manufacturing procedure of cow milk *paneer* and cow skim milk *paneer*

A control sample of cow milk *paneer* (CCP) was prepared following the method prescribed by Sachdeva and Singh (1988) [6] and Sanyal and Yadav (2000) [7]. Experimental sample of cow skim milk *paneer* (CSP) was manufactured following the method prescribed by Sachdeva and Singh (1988) [6] and Sanyal and Yadav (2000) [7] with some modification where inulin was added into the milk at different level and, coagulation temperature and salt concentration of brine solution were varied. To prepare CSP, first fresh cow milk was standardized to 0.5% fat. The standardized milk was then heated to 90 °C. During heating when the temperature reached to 45-50 °C, inulin was added into the milk in different concentration (0, 1, 2 and 3% of skim milk). The milk was cooled to a temperature of 70 °C and calcium chloride ($CaCl_2$) was added @ 0.05% of milk. Citric acid was added at different coagulation temperatures (50, 55, 60, 65, 70 and 80 °C). The coagulum was allowed to remain in whey for 5 min without agitation and strained through a clean fine muslin cloth to remove whey. The curd mass was pressed for 20 min in a muslin cloth-lined rectangular wooden hoop (internal dimension: 16 x 12 x 12 cm) having small holes on all the sides and bottom, by placing a weight of 10 kg on top of the hoop. The pressed curd was removed from the hoop, weighed and immersed in chilled (4 – 6 °C) brine solution of different salt concentration (1, 2, 3 and 4%) for 2 h. The ICSP was removed from chilled water, kept on a stainless-steel table top for 5 min to drain off the loose water, reweighed, cut into pieces of uniform size (200 g, approx.), packaged in 3 ply laminated (PE/Al foil/PE) pouch and stored in a refrigerator at 8±2 °C. In case of CCP the milk fat percentage was standardized to 4.5%, milk was coagulated at 80 °C and concentration of brine for dipping solution was maintained as 4%.

2.3. Sensory evaluation

The *paneer* samples were evaluated by a panel of 7 trained judges selected from the Faculty of Dairy Technology, W.B.U.A.F.S., West Bengal for sensory characteristics through a descriptive test that includes a 100 point sensory Score Card supplemented with scoring guide. The sensory attributes included flavour (maximum score 50), body and texture (maximum score 35) and colour and appearance (maximum score 15).

2.4. Statistical analysis

The significant change among different processing conditions was assessed by analysis of variance (ANOVA) using Prism 5 software package. The significant difference among means was compared using Tuckey Post Hoc test.

3. Results and Discussion

3.1. Evaluation of effects of processing parameters on cow skim milk *paneer*

3.1.1. Effect of coagulation temperature on sensory attributes of cow skim milk *paneer*

A study was carried out to evaluate the effect of coagulation temperature of 50 ˚C, 55 ˚C, 60 ˚C, 65 ˚C, 70 ˚C and 80 ˚C. Augmentation of milk coagulation temperature from 50 ˚C to 60 ˚C increased flavour score. Further increase of temperature decreased the flavour score of low fat *paneer*. Chawla *et al.* (1985) [1] also observed an inverse relationship between coagulation temperature and flavour score of low fat *paneer*. The flavour score of control *paneer* prepared by coagulating milk at 80 ˚C differed non significantly (p>0.05) with the low fat *paneer* prepared by coagulated cow skim milk at 60 ˚C. In the present study (Table 1) an increase in body and texture score was noticed with increase in milk coagulation temperature upto 60 ˚C. The body and texture scores for cow skim milk *paneer* samples which were prepared by coagulating milk at 50, 55 and 60 ˚C, respectively differed non significantly (p>0.05) with control sample of *paneer*. The body and texture score of low fat *paneer* decreased significantly (p<0.05) when milk coagulation temperature was increased to 70 °C. Chawla *et al.* (1985) [1] observed that coagulation temperature of 75 °C resulted in harder *paneer* which as a consequence lowered the body and texture score, while coagulation at 65 °C produced slightly softer *paneer* with higher body and texture score. Raghavendra (2010) [4] reviewed the study of Sachdeva (1983) [5] who reported that higher temperature of coagulation caused lower moisture retention and as a consequence contributed to hardness, responsible for lower body and texture score.A positive correlation of milk coagulation temperature with colour and appearance of *paneer* was noticed in the present study (Table 1).

Table 1: Effect of milk coagulation temperature (˚C) on sensory attributes of *paneer*

Fat (%)	Coagulation temperature (˚C)	Flavour	B & T	C & A
0.5	50	42.00 ± 0.29^{c}	31.17 ± 0.73^{b}	13.67 ± 0.60
0.5	55	44.00 ± 0.50^{bc}	33.33 ± 0.33^{a}	13.83 ± 0.17
0.5	60	45.17 ± 0.44^{ab}	33.83 ± 0.17^{a}	14.00 ± 0.29
0.5	65	43.67 ± 0.17^{bc}	32.50 ± 0.29^{ab}	14.00 ± 0.00
0.5	70	39.17 ± 0.73^{d}	27.83 ± 0.60^{c}	14.17 ± 0.17
0.5	80	35.83 ± 0.60^{e}	23.00 ± 0.29^{d}	14.17 ± 0.17
4.5	80	47.17 ± 0.44^{a}	34.33 ± 0.17^{a}	14.33 ± 0.17

a,b,c,d: means ± SE with different superscripts within a column differ significantly (p<0.05)

3.1.2. Effect of inulin content on sensory attributes of cow skim milk *paneer*

Milk fat is one of the principal components, influencing flavour and texture of *paneer*. Inulin was used as fat replacer in low fat *paneer* to give mouthfeel. Inulin content had positive correlation with flavour score. The flavour score for low fat *paneer* improved significantly (p<0.05) after addition of inulin. Table 2 shows that flavour score of low fat *paneer* was increased with increase in inulin level upto 2%. Thereafter, a decrease in flavour score was observed with increase of inulin level. A non significant difference between flavour score of control *paneer* and low fat *paneer* with 2% added inulin was observed. Similar to flavour score, an increase in body and texture score for low fat *paneer* with increase in inulin level upto 2% was observed and afterward a decrease in body and texture score was observed with

increase of inulin level (Table 2). Yahyavi *et al.* (2014) [8] studied the effect of inulin on low fat feta cheese and reported that inulin improved the water retention property. The moisture retention ability of inulin might be the reason for lowering of the hardness of *paneer* as well as increased body and texture score as compared to cow skim milk *paneer* without inuln. The colour and appearance scores of low fat *paneer* with 0, 1, 2 and 3% added inulin, and control *paneer* differed non significantly (p>0.05) with each other.

Table 2: Effect of inulin content on sensorial property of *paneer*

Fat (%)	Inulin (% of milk)	Flavour	B & T	C & A
0.5%	0%	40.83 ± 0.17^{d}	30.83 ± 0.17^{b}	14.00 ± 0.29
0.5%	1%	45.00 ± 0.29^{bc}	33.83 ± 0.44^{a}	14.17 ± 0.17
0.5%	2%	46.17 ± 0.44^{ab}	34.00 ± 0.29^{a}	13.83 ± 0.17
0.5	3%	43.67 ± 0.17^{c}	33.67 ± 0.17^{a}	13.83 ± 0.17
4.5	0%	47.17 ± 0.44^{a}	34.33 ± 0.17^{a}	14.33 ± 0.17

a,b,c,d: means ± SE with different superscripts within a column differ significantly (p<0.05)

3.1.3. Effect of brine concentration on sensory attributes of cow skim milk *paneer*

Table 3 represents a non significant difference of flavour as well as body and texture score of cow skim milk *paneer* samples dipped in brine solution of 3 and 4% strength with control *paneer* samples. In low fat *paneer* samples the increase in brine concentration from 1% to 3% decrease the flavour and body and texture score but non significantly (p>0.05). Kaur *et al.* (2003) [2] reported that dipping of paneer in brine solution decreased the moisture content and water activity of *paneer*. The decrease of moisture content in cow skim milk *paneer* might be the reason for lowered score of body and texture with increase in brine concentration.

Table 3: Effect of strength of brine solution on sensory attributes of *paneer*

Fat (%)	Brine solution strength	Flavour	B & T	C & A
0.5	1	46.17 ± 0.44^{ab}	33.17 ± 0.44^{ab}	13.83 ± 0.17
0.5	2	45.87 ± 0.13^{ab}	32.87 ± 0.13^{ab}	14.00 ± 0.29
0.5	3	43.17 ± 1.48^{bc}	30.17 ± 1.48^{b}	14.17 ± 0.17
0.5	4	41.00 ± 0.50^{c}	28.00 ± 0.50^{c}	14.17 ± 0.17
4.5	4	47.17 ± 0.17^{a}	34.17 ± 0.17^{a}	14.33 ± 0.17

a,b,c,d: means ± SE with different superscripts within a column differ significantly (p<0.05)

4. Conclusion

The findings of the present study revealed that low fat *paneer* from cow skim milk can be prepared with the acceptable sensorial quality by using fat replacer-inulin and some process modification. Based on sensorial appeal the amount of inulin to be added into the cow skim milk, coagulation temperature of milk and concentration of chilled brine solution for dipping of *paneer* were selected within the range of 1-2% of milk, 55-65 ˚C and 1-3%, respectively for further optimization of processing conditions of cow skim milk *paneer*.

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