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Textural property and cost of economics of developed synbiotic cottage cheese using *Lactobacillus acidophilus* (La-5) and *Lactobacillus casei* (Ncdc-298) with pectin

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Abstract
The present study was undertaken to develop a synbiotic cottage cheese using *Lactobacillus acidophilus* (*LA-5*) and *Lactobacillus casei* (*NCDC-298*) with pectin and to study its textural parameters hardness and brittleness and the cost of economics. Cottage cheese was prepared by starter culture method by using commercial cheese starters and probiotic cultures individually and a combination of both in the ratio 1:1. The hardness of all the treatments of synbiotic cottage cheese was observed to increase with the storage period whereas the brittleness was inversely correlated. The cost of production for synbiotic cottage cheese was calculated to be Rs. 471.89/kg, and that for the control cottage cheese was Rs. 156.90/kg. The high cost of pectin contributed to an increase in the production cost of the pectin added treatments.

Keywords: Probiotic cheese, pectin, hardness, brittleness, economics

1. Introduction

According to the PFA Rules (1976) [1], cheese is the product obtained by draining, after the coagulation of milk with a harmless milk coagulating agent, under the influence of harmless bacterial cultures. Cheese is valued for its portability, shelf life, and high content of protein, calcium and phosphorous. Cottage cheese is a soft and unripened cheese made from skim milk. It has a mildly acidic flavour. It consists of small curd flakes that have a meaty consistency (De S, 1980) [2].

Probiotics as defined by (FAO/WHO, 2002) [3] are 'live microorganisms which, when administered in adequate amounts, confer a health benefit on the host'. The addition of probiotic microorganisms to various foods to enhance their nutritive value and potential health benefits is currently of great interest. Among the most used organisms are those belonging to the genera of *Lactobacilli*, which are believed to have beneficial effects on human health.

Pectin is a structural heteropolysaccharide contained in the primary cell walls of terrestrial plants. It is an acidic polysaccharide abundant in fruit and vegetables processing residues. Typically, the highest quality pectin in foods comes from fruits such as apple, lemon, grapefruit and orange.

Hussein and Shalaby, (2014) [4] studied Kareish cheese made with starter and rennet and had the lowest hardness, gumminess and chewiness values, but the highest cohesiveness and springiness values. It was revealed that the hardness and gumminess are negatively correlated to cohesiveness and springiness.

Lee and Marshall, (1981) [5] studied the textural characteristics of process cheese with Instron Food Testing System, where they observed that the hardness of cheese was lowered, but cohesiveness was increased by adding soy protein to process cheese. The cohesiveness of milk curd was lowered by native soy protein and even more by boiled soy protein. Also hardness and springiness were lowered by boiled soy protein. Glibowski and Bochynska (2006) [6] reported higher hardness of inulin-whey protein gels probably due to interaction inulin-whey proteins.

The cost of production and net returns per kg of Chhana-murki in 500 g polypropylene pouches was estimated as Rs. 253.23 and 96.77, respectively (Shalini *et al.*, 2019) [7].

In the present-day scenario, the young generation is interested in healthy foods having good palatability, low-fat content and high health benefits. The development of functional food with the addition of prebiotic and probiotics with good textural properties and affordable cost is an emerging need of the hour.

2. Material and Method
Fresh whole milk was received from Livestock Farm Complex, Veterinary College and Research Institute, Namakkal. The skim milk was obtained from whole milk by centrifugation method after separation of cream.
This study utilised the cheese starter culture from National Collection of Dairy cultures, NDRI, Karnal. Probiotic cultures *Lactobacillus acidophilus* (*LA-5*) and *Lactobacillus casei* (*NCDC-298*) from National Collection of Dairy cultures, NDRI, Karnal were propagated and maintained in skim milk media and MRS broth for preparation of cottage cheese. Neotea pectin powder was purchased from Neoteric DCBA Ideas and was preserved in the moisture-proof pack for incorporation. Commercially available good quality calcium chloride was used in this study. Commercially available good quality microbial rennet was used in this study.

2.1 Preparation of synbiotic cottage cheese
Cottage cheese was prepared by starter culture method by using commercial cheese starter, probiotic cultures *Lactobacillus acidophilus* (*LA-5*) and *Lactobacillus casei* (*NCDC-298*), and a combination of both in the ratio 1:1, and the treatments were designated as, C, T1, T2, T3 and T4 respectively.
Cottage cheese was prepared as per Blanchette *et al.* (1996) [8], with some new modifications. The prebiotic pectin was added at 0.3 per cent and the probiotics were added at a 5 per cent level. In each treatment, fresh whole milk was preheated to 40 °C and the cream was separated to obtain skimmed milk. Pectin was added to the skimmed milk and it was pasteurized at 80 °C for 10 minutes then cooled to 32 °C. Calcium chloride was added at 0.02 per cent level and stirred well and kept for 10 minutes. Cheese culture or the probiotics were added at the rate of 5 % and incubated at 37-40 °C for 40 minutes to 1 hour for the development of acidity. After the development of acidity, rennet was added at 0.1-0.2 g per litre of milk and was incubated at 37 °C until a firm coagulum was formed. The coagulum was then cut into small cubes and cooked up to 53-56 °C for 90 minutes. The whey released during the cooking process was drained using a muslin cloth and the curd cubes were washed to remove excess acidity. The excess water was drained off and the obtained cottage cheese was salted at 0.6 %. It was packed in polystyrene cups and stored at 4° C.
The developed synbiotic cottage cheese was subjected to textural studies on 0, 3, 7 and 14 days of storage.

2.2 Texture analysis of cottage cheese
The hardness and brittleness of synbiotic cottage cheese were characterized using the Instron Texture Analyser (Model: TAXT Plus, Stable Microsystems) and Texture Expert Software. Six measurements for each sample were recorded using a 5 mm diameter stainless steel probe attached to a 5 kg load cell. The penetration depth at the geometrical centre of the samples was 10 mm and the penetration speed was set at 10.0 mm/s. The hardness of the samples was determined as the peak compression force during penetration. All determinations were carried out at 15 °C. A Fracture Wedge Set (A/WEG) was used to measure the hardness of cottage cheese and the brittleness of cottage cheese.

2.3 Economic viability of synbiotic cottage cheese
Cost of production for control and various treatments of cottage cheese were calculated using the data on the prevailing market price of the raw materials, cost of processing and cost of packaging materials etc.

2.4 Statistical analysis
The data obtained in all the experiments were analyzed statistically by applying two-way ANOVA by approved statistical methods of SPSS (version 20.0).

3. Results and Discussion
3.1 Hardness of synbiotic cottage cheese during storage at 4 °C
The mean (n=6) values for the hardness of synbiotic cottage cheese for different treatments during the storage are presented in Table 1. The results showed a significant (P<0.05) increase in the hardness values from day 0 to 14 of storage. The lowest value (131.32 ± 20.93) was obtained for C on day 0 of storage which increased up to (342.64 ± 33.66) on day 14 of storage. Further, the highest hardness value was noticed for T4 (226.33 ± 8.15) on day 0 of storage, which increased up to 333.37 ± 17.82 on day 14 of storage. A significant difference (P<0.05) in hardness was observed between different treatments.
The hardness values for synbiotic cottage cheese were significantly (P<0.05) increased with advancing storage period for all the treatments, which ranged from 129.20 to 357.54 g force. This may be attributed to the loss of moisture content during the storage period. The results are in close proximity with Georgia *et al.*, (2017) [9], where the hardness of white soft cheese ranged from 91.9 to 106.0 g force. The results observed are similar to Mohammad *et al.*, (2019) [10] where the firmness of the cheese sample stored at 4±1 °C significantly (P<0.05) increased from 8 to 22 days of storage.
Kaminarides *et al.*, (2015) [11], obtained similar results where the Halloumi cheese curds exhibited higher values of hardness because of cooking compared to the uncooked cheese curd due to their lower moisture contents. Hagar *et al.*, (2016) [12], observed an increase in hardness for probiotic cheeses and a drop for synbiotic cheeses after 4 weeks of storage. However, Hussein and Shalaby, 2014 [4] reported the lowest hardness in Kareish cheese made with starter and rennet.

3.2 Brittleness of synbiotic cottage cheese during storage at 4 °C
The mean (n=6) values for brittleness of synbiotic cottage cheese for different treatments during the storage are presented in Table 2. The results showed a significant decrease (P<0.05) in the brittleness values from day 0 to 14 of storage. The highest value (7.37± 0.28) was obtained for C on day 0 of storage that decreased up to 1.21 ± 0.18 on day 14 of storage. Further, the lowest brittleness value was detected for T4 (5.91 ± 0.34) on day 0 of storage that decreased up to 1.09 ± 0.19 on day 14 of storage.
The mean brittleness values of the synbiotic cottage cheese were observed to decrease significantly (P<0.05) during the storage period. Further, it was observed that the brittleness values are inversely proportionate to the hardness. However, Birhanu (2018) [13] observed that cow milk soft cheese made using culture R-707 gave significantly (P<0.01) higher firm and brittle than cow milk soft cheese made using cultures STI-12, XPL-2 and CHN-22.

3.3 Economics of synbiotic cottage cheese production
The cost of production for synbiotic cottage cheese with different treatments is presented in Table 3. There was a

significant difference in cost of production between the control and various treatments. The highest cost of production was observed for T2 and T3 at Rs. 471.89 followed by Rs. 465.79, 452.90 and 156.9 for T4, T1 and C, respectively.
The cost of production for control cottage cheese was Rs. 156.90/kg, which was lower than the synbiotic cottage cheese (Rs. 471.89/kg). The high cost of pectin (prebiotic) incorporated in all other treatments lead to an increase in the cost of production. The results of this study are in close proximity with the findings of Kaushal and John (2017) [14], who reported a production cost of Rs.262.16 for control cottage cheese and Rs.325.42 for the experimental cottage cheese.

Table 1: Mean (± SE) hardness (g force) of synbiotic cottage cheese during storage at 4 °C

Treatments	Storage period (days)			
	0	3	7	14
C	131.32 ± 20.93^{Abc}	287.81 ± 26.14^{ABbc}	301.64 ± 18.51^{ABbc}	342.64 ± 33.66^{Cbc}
T1	202.06 ± 17.17^{Ab}	245.45 ± 37.58^{ABb}	265.19 ± 27.56^{ABb}	289.49 ± 17.50^{Cb}
T2	129.20 ± 15.83^{Aa}	160.90 ± 10.29^{ABa}	174.22 ± 10.89^{ABa}	213.45 ± 6.34^{Ca}
T3	217.51 ± 16.35^{Ac}	273.33 ± 11.40^{ABc}	308.04 ± 14.76^{ABc}	357.54 ± 15.66^{Cc}
T4	226.33 ± 8.15^{Abc}	251.88 ± 5.16^{ABbc}	277.38 ± 12.58^{ABbc}	333.37 ± 17.82^{Cbc}

Mean (n=6) bearing different uppercase superscripts between columns differ significantly ($P<0.05$)
Mean (n=6) bearing different lowercase superscripts between rows differ significantly ($P<0.05$)

Table 2: Mean (± SE) brittleness (mm) of synbiotic cottage cheese during storage at 4 °C

Treatments	Storage period (days)			
	0	3	7	14
C	7.37 ± 0.28^{Db}	4.53 ± 0.15^{Cb}	2.95 ± 0.19^{Bb}	1.21 ± 0.18^{Ab}
T1	6.27 ± 0.14^{Dc}	5.01 ± 0.16^{Cc}	3.87 ± 0.25^{Bc}	2.44 ± 0.06^{Ac}
T2	6.63 ± 0.45^{Dd}	5.52 ± 0.23^{Cd}	4.57 ± 0.15^{Bd}	2.91 ± 0.27^{Ad}
T3	6.16 ± 0.12^{Da}	4.47 ± 0.40^{Ca}	3.02 ± 0.20^{Ba}	0.69 ± 0.15^{Aa}
T4	5.91 ± 0.34^{Dab}	4.82 ± 0.21^{Cab}	3.18 ± 0.41^{Bab}	1.09 ± 0.19^{Aab}

Mean (n=6) bearing different uppercase superscripts between columns differ significantly ($P<0.05$)
Mean (n=6) bearing different lowercase superscripts between rows differ significantly ($P<0.05$)

Table 3: Economics of synbiotic cottage cheese

Treatment	Cost of ingredient						Cost of labour/ packaging/ electricity etc., (Rs.)	Cost of production of 1 kg of symbiotic cottage cheese (Rs.)
	Skim milk (Rs.)	Pectin (Rs.)	Calcium chloride (Rs.)	Starter culture (Rs.)	Rennet (Rs.)	Salt (Rs.)		
Control	105.6	0.0	0.1	0.5	0.6	0.1	50	156.90
T1	105.6	296	0.1	0.5	0.6	0.1	50	452.90
T2	110.4	310.293	0.1	0.4	0.6	0.1	50	471.893
T3	110.4	310.293	0.1	0.4	0.6	0.1	50	471.893
T4	108.8	305.796	0.1	0.4	0.6	0.1	50	465.796

4. Conclusion
The present study showed that the hardness and brittleness of the developed synbiotic cottage cheese were inversely correlated. The combined treatment of *Lactobacillus acidophilus* (*LA-5*) and *Lactobacillus casei* (*NCDC-298*) in the ratio 1:1 was observed to be better in comparison to the other treatments in textural parameters. Also, the cost of the combined treatment T4 was comparatively lower than treatments with individual probiotic cultures. Therefore, we can suggest that synbiotic cottage cheese can be developed using *Lactobacillus acidophilus* (*LA-5*) and *Lactobacillus casei* (*NCDC-298*) with good textural parameters and affordable cost and also turn out to be a profit source for entrepreneurs.

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