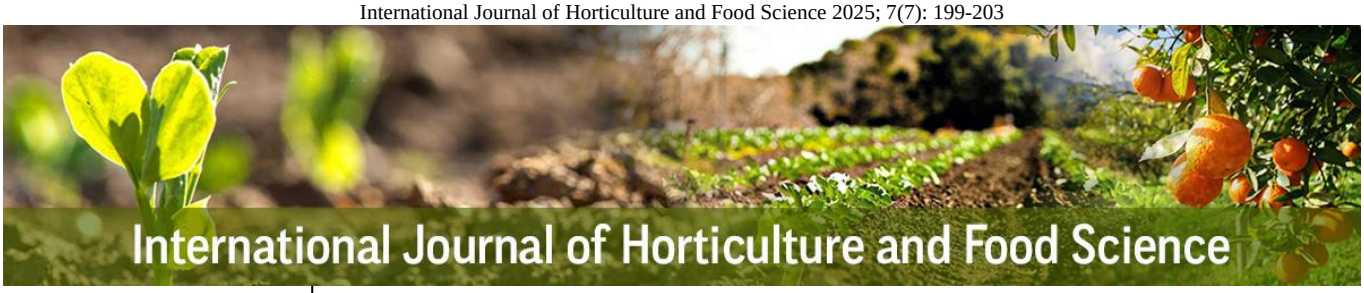

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Microbial lactic starter communities, buffalo milk curd prepared at moderately higher incubation temperatures: A comprehensive sensory analysis

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Abstract
The various starter cultures and their combinations were used to prepare buffalo milk curd samples with buffalo milk standardized to 5 per cent fat and 9 per cent Solids Not Fat combination. The sensory scores of buffalo milk curd samples prepared with various combinations of starter cultures by incubating at 40°C and stored at refrigeration temperature.
Dairy starter cultures were obtained from NDRI, Karnal. The curd samples were evaluated for sensory attributes on a nine-point hedonic scale by a panel of judges. The sensory scores for curd samples prepared using buffalo milk curd prepared by combination of starter cultures *Lactococcus lactis* subsp. *lactis* + *Lactococcus lactis* subsp. *cremoris* + *Lactococcus lactis* subsp. *lactis biovar diacetylactis* inoculation and incubated at 40°C were higher than the control and other treatments interms of flavour, body and texture, colour and appearance, overall acceptability (8.82 ±0.01, 8.70 ±0.01, 8.83 ±0.01, 8.81 ±0.01) on day 0 and lowest flavour, body and texture, colour and appearance, overall acceptability scores (7.46 ±0.01, 7.08 ±0.01, 8.03 ±0.01, 7.47 ±0.01) were observed for buffalo milk curd sample prepared using buffalo milk curd prepared by *Lactococcus lactis* subsp. *cremoris* inoculation and incubated at 40°C starter culture on day 0.

Keywords: Buffalo milk curd-pH- refrigeration-starter cultures-Incubation temperature

1. Introduction
Traditional Indian fermented milk product, Buffalo milk curd, is preferably made using lactic starter cultures, popularly through the back-slopping method. This method often leads to inconsistencies in curd. Commercially available curd in the market may also lack the desirable flavour attributes preferred by Indian consumers. Hence, the study aims to developbuffalo milk curd prepared at moderately higher incubation temperature. There are variety of starter culture blends for curd production. The development of fermented foods and beverages requires a high level of sensory acceptability. The use of organic substrates by starter cultures can result in the production of various metabolites, such as organic acids, esters, and carbonyl compounds, which impart flavor and aroma to fermented products. It is important to consider employing suitable microbial strains that do not negatively impact sensory characteristics.
Permanent role for sensory evaluation in business have been made with numerous efforts to develop a more and specifically in the moretypical, technical environment. Examination of the technical reports suggests that progress in the development of sensory evaluation an acceleration in the trend over the pastdecade. Much of the impetus for the recent growth in sensory evaluation appearsto have come from food based sectors of the economy.
This research work aims at identifying suitable starter culture for buffalo milk curd prepared at moderately higher incubation temperatures at 40ºC. This could offer an effective solution for dairy manufacturers to produce high-quality and consumer preferred buffalo curd.

Materials and Methods
The buffalo milk curd standardized to 5% fat and 9% SNF samples prepared with various combinations of starter cultures (Table 1) by incubating at 40 °C and stored at refrigeration temperature 5.00 ± 0.5 ºC.

The sensory evaluation of experimental buffalo milk curd samples was conducted by a group of twelve trained judges, who assessed their color, appearance, flavor, body, texture, and overall acceptability on a 9-point hedonic scale. The panel of judges assessed the coded buffalo milk samples at random, according to the methodology described by Indian standards (IS, 1971). A panel conducted sensory evaluation of samples. The panelists were knowledgeable about sensory evaluation of dairy products and had previously been involved in such evaluations. Before testing, the cured samples in the plastic containers were conditioned at room temperature for 15 minutes.

In the sensory evaluation room under appropriate fluorescent lighting, sensory evaluation of the samples was carried out. Each panelist was instructed to taste the samples and rate them on a 9-point hedonic scale. Color and appearance, body and texture, flavor, and overall acceptability were all tested during the acceptance test according to the 9-point structured hedonic scale. The 9-point scale was used to establish that the highest value indicates the highest degree of preference for all sensory attributes. The panelists were tasked with providing scores on a sensory evaluation scorecard. Water was given to panelists to rinse their palates before and after tasting the sample. The numerical score given by judges for individual attribute was computed to obtain mean and these means were subjected to statistical analysis.

Results and Discussion

The sensory scores for buffalo milk curd samples prepared using B2Ll+Lc+Ld combination of starter cultures incubated at 40ºC were higher than the control (8.82 ±0.01, 8.70 ±0.01, 8.83 ±0.01, 8.81 ±0.01) and other treatments in terms of flavour, body and texture, colour and appearance, overall acceptability on day 0 and lowest flavour, body and texture, colour and appearance, overall acceptability scores (7.46 ±0.01, 7.08 ±0.01, 8.03 ±0.01, 7.47 ±0.01) were observed for buffalo milk curd sample prepared using B2Lc starter culture on day 0. (Table 2-4).

The flavour, body and texture, colour and appearance, overall acceptability scores (6.86 ±0.01, 6.62 ±0.01, 7.05 ±0.01, 7.01 ±0.01) were higher than the control and other treatments for the buffalo milk curd samples prepared using B2Ll+Lc+Ld (Table 2-5) starter culture combinations and incubated at 40ºC on day 6 of storage at 5.00 ± 0.5ºC and whereas flavour, body and texture, colour and appearance, overall acceptability scores were lower than the control and other treatments for the buffalo milk curd sample prepared using B2St starter culture (3.83 ±0.01, 3.60 ±0.01, 6.16 ±0.01, 4.02 ±0.01) on day 6 of storage at 5.00 ± 0.5 ºC.

The maximum sensory score was given by the sensory panel to the curd samples prepared using combined cultures (B2Ll+Lc+Ld) on both 0 and 6 of storage at refrigeration temperature. (Fig 1- 4)

Curd sample containing combined starter cultures (B2Ll+Lc+Ld) with significantly high sensory scores was selected for further studies.

The lower sensory scores for some starter culture is explained by Ghosh and Rajorhia (1990) [3] recorded that the heterofermentative nature of the bacterial culture, which produces small amounts of formic acid and CO2, causes certain dahi samples to have low flavor ratings due to its ability to impart a sharp taste to the product.

Table 1: List of treatments for the buffalo milk curd prepared with various starter culture combinations incubated at 40 °C are as follows

B2C Dahi culture incubated at 40°C (Control cow curd)
B2Ll *Lactococcus lactis* subsp. *lactis* inoculation
B2Lc *Lactococcus lactis* subsp. *cremoris* inoculation
B2Ld *Lactococcus lactis* subsp. *lactis biovar diacetylactis* inoculation
B2Ll+Ld *Lactococcus lactis* subsp. *lactis and* + *Lactococcus lactis* subsp. *lactis biovar diacetylactis*
B2Lc+Ld *Lactococcus lactis* subsp. *cremoris* + *Lactococcus lactis* subsp. *lactis biovar diacetylactis* inoculation
B2Ll+Lc+Ld *Lactococcus lactis* subsp. *lactis* + *Lactococcus lactis* subsp. *cremoris* + *Lactococcus lactis* subsp. *lactis biovar diacetylactis* inoculation
B2Lnl *Leuconostoc lactis* inoculation
B2Lnm *Ln.mesenteroides* subsp. *cremoris* inoculation
B2Lnl+Lnm *Leuconostoc lactis and Ln.mesenteroides* subsp. *cremoris* inoculation
B2Lp *Lactobacillus plantarum* inoculation
B2Lpp *Lactobacillus paraplantarum* inoculation
B2St *Streptococcus salivarius* subsp. *thermophilus* inoculation

Table 2: Flavour scores of buffalo milk curd with various starter cultures incubated at 40°C during refrigerated storage

Storage period in days	Starter cultures							
	B2C	B2Ll	B2Lc*	B2Ld	B2Ll+Ld	B2Lc+Ld	B2Ll+Lc+Ld	B2St
0	8.71^{bA}±0.10	8.70^{bA}±0.10	7.46^{dA}±0.10	8.71^{bA}±0.10	8.82^{aA}±0.10	7.51^{cA}±0.10	8.82^{aA}±0.10	7.51^{dA}±0.10
2	7.99^{dB} ±0.10	7.98^{dB}±0.10	7.01^{eA}±0.10	8.32^{bA}±0.10	8.22^{cB}±0.10	7.01^{eB}±0.10	8.40^{aA}±0.10	7.01^{eB}±0.10
4	6.49^{cC}±0.10	5.99^{dC}±0.10	6.01^{dB}±0.10	7.02^{bB}±0.10	7.03^{bC}±0.10	6.02^{dC}±0.10	7.52^{aB}±0.10	6.51^{cC}±0.10
6	4.91^{bD}±0.10	4.90^{cD}±0.10	4.92^{cC}±0.10	4.91^{cC}±0.10	4.90^{cD}±0.10	4.92^{cD}±0.10	6.86^{aC}±0.10	3.83^{dD}±0.10
8	3.80^{bE}±0.10	3.81^{bE}±0.10	3.80^{bD}±0.13	3.81^{bD}±0.10	3.87^{bE}±0.13	3.88^{bE}±0.13	5.05^{aD}±0.13	2.84^{cE}±0.10
10	2.82^{dF}±0.10	2.88^{aF}±0.10	2.83^{cE}±0.10	2.84^{bE}±0.10	2.88^{aF}±0.10	2.82^{cF}±0.10	2.88^{aE}±0.10	2.83^{cE}±0.10

Mean ± Standard error values from six trials.

Mean values bearing different superscripts in a column differed significantly ($P < 0.01$)

Table 3: Body and texture scores of buffalo milk curd with various starter cultures incubated at 40°C during refrigerated storage

Storage period in days	Starter cultures							
	B2C	B2Ll	B2Lc*	B2Ld	B2Ll+Ld	B2Lc+Ld	B2Ll+Lc+Ld	B2St
0	8.65^{bA}±0.10	8.24^{dA}±0.10	7.08^{eA}±0.10	8.30^{cA}±0.10	8.41^{cA}±0.10	7.10^{eA}±0.10	8.70^{aA}±0.10	7.10^{eA}±0.10
2	7.57^{dB} ±0.10	7.58^{dB}±0.10	6.59^{eB}±0.10	7.91^{bB}±0.10	7.80^{cB}±0.10	6.60^{eB}±0.10	8.30^{aA}±0.10	6.60^{eB}±0.10
4	6.07^{cC}±0.10	5.49^{dC}±0.10	5.50^{dC}±0.10	6.61^{bC}±0.10	6.62^{bC}±0.10	5.62^{dC}±0.10	7.11^{aB}±0.10	6.10^{cB}±0.10
6	4.48^{cD}±0.10	4.58^{bD}±0.10	4.60^{bD}±0.10	4.61^{bD}±0.10	4.60^{bD}±0.10	4.61^{bD}±0.10	6.62^{aC}±0.10	3.60^{dC}±0.10
8	3.58^{bE}±0.10	3.58^{bE}±0.10	3.60^{bE}±0.13	3.60^{bE}±0.10	3.61^{bE}±0.13	3.61^{bE}±0.13	4.81^{aD}±0.13	2.81^{cD}±0.10
10	2.99^{bF}±0.10	2.63^{cF}±0.10	2.59^{cF}±0.10	2.60^{cF}±0.10	2.62^{cF}±0.10	2.60^{cF}±0.10	3.65^{aE}±0.10	2.62^{cD}±0.10

Mean ± Standard error values from six trials.
Mean values bearing different superscripts in a column differed significantly ($P < 0.01$)

Table 4: Colour and appearance scores of buffalo milk curd with various starter cultures incubated at 40°C during refrigerated storage

Storage period in days	Starter cultures							
	B2C	B2Ll	B2Lc*	B2Ld	B2Ll+Ld	B2Lc+Ld	B2Ll+Lc+Ld	B2St
0	8.75^{bA}±0.10	8.72^{cA}±0.10	8.03^{dA}±0.10	8.72^{cA}±0.10	8.83^{aA}±0.10	8.14^{dA}±0.10	8.83^{aA}±0.10	8.07^{dA}±0.10
2	8.48^{dA} ±0.10	8.68^{dA}±0.10	7.99^{eA}±0.10	8.66^{bA}±0.10	8.77^{cB}±0.10	8.08^{eA}±0.10	8.77^{aA}±0.10	8.02^{eA}±0.10
4	7.52^{cB}±0.10	7.02^{dB}±0.10	7.05^{dB}±0.10	7.03^{bB}±0.10	7.04^{bC}±0.10	7.03^{dB}±0.10	7.53^{aB}±0.10	7.22^{cB}±0.10
6	6.87^{bC}±0.10	5.74^{cC}±0.10	5.81^{cC}±0.10	5.80^{cC}±0.10	5.79^{cD}±0.10	5.85^{cC}±0.10	7.05^{aB}±0.10	6.16^{dC}±0.10
8	5.28^{cD}±0.10	5.25^{cC}±0.10	5.31^{cC}±0.13	5.24^{cD}±0.10	5.26^{cE}±0.13	5.25^{cD}±0.13	6.84^{aC}±0.13	5.83^{bD}±0.10
10	5.14^{dD}±0.10	3.17^{dD}±0.10	5.21^{cC}±0.10	5.15^{dD}±0.10	5.08^{dE}±0.10	5.11^{dD}±0.10	6.06^{aD}±0.10	5.54^{bD}±0.10

Mean ± Standard error values from six trials.
Mean values bearing different superscripts in a column differed significantly ($P < 0.01$)

Table 5: Overall acceptability scores of buffalo milk curd with various starter cultures incubated at 40°C during refrigerated storage

Storage period in Days	Starter cultures							
	B2C	B2Ll	B2Lc*	B2Ld	B2Ll+Ld	B2Lc+Ld	B2Ll+Lc+Ld	B2St
0	8.70^{bA}±0.10	8.76^{bA}±0.10	7.47^{cA}±0.10	8.69^{bA}±0.10	8.81^{aA}±0.10	7.49^{cA}±0.10	8.81^{aA}±0.10	7.48^{cA}±0.10
2	8.00^{dB} ±0.13	8.20^{cB}±0.13	6.96^{dB}±0.10	8.31^{bA}±0.13	8.21^{cB}±0.13	7.01^{eA}±0.13	8.41^{aA}±0.10	6.94^{feB}±0.13
4	6.49^{cC}±0.13	6.01^{dC}±0.13	5.96^{dC}±0.10	7.01^{bB}±0.13	7.03^{bC}±0.13	6.01^{dB}±0.13	7.52^{aB}±0.10	6.52^{cC}±0.10
6	6.02^{bD}±0.10	5.01^{cD}±0.10	5.02^{cD}±0.10	5.00^{cC}±0.10	5.01^{cD}±0.10	5.02^{cC}±0.10	7.01^{aC}±0.10	4.02^{dD}±0.13
8	4.00^{bE}±0.10	4.01^{bE}±0.10	4.01^{bE}±0.13	4.01^{bD}±0.10	4.01^{bE}±0.13	4.01^{bD}±0.13	5.22^{aD}±0.13	3.82^{cD}±0.10
10	3.01^{bF}±0.10	3.04^{bF}±0.10	3.01^{bF}±0.10	3.01^{bE}±0.10	3.03^{aF}±0.10	3.01^{bE}±0.10	4.06^{aE}±0.10	3.03^{bE}±0.10

Mean ± Standard error values from six trials.
Mean values bearing different superscripts in a column differed significantly ($p < 0.01$)

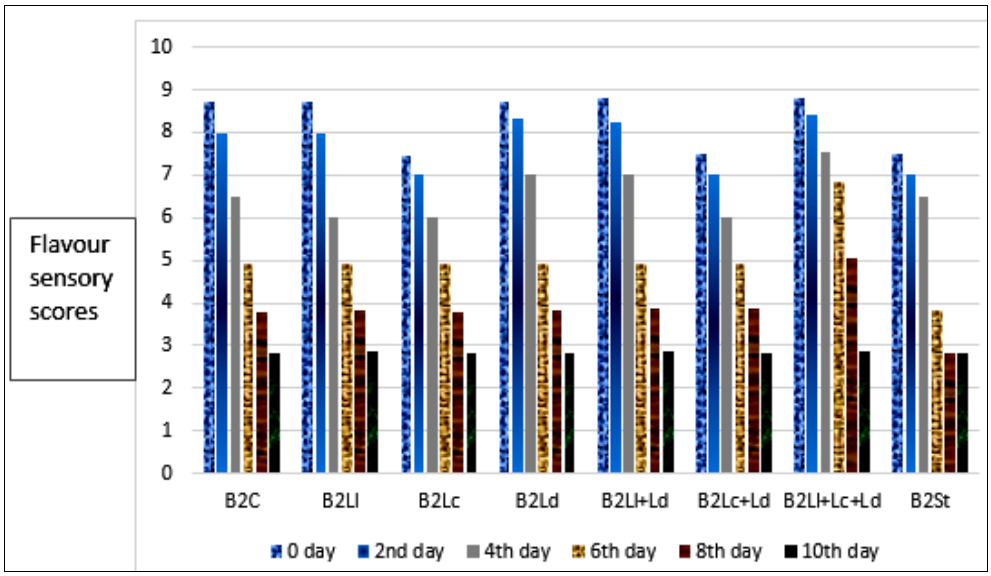

Fig 1: Flavour scores of buffalo milk curd with various starter cultures incubated at 40 °C during refrigerated storage

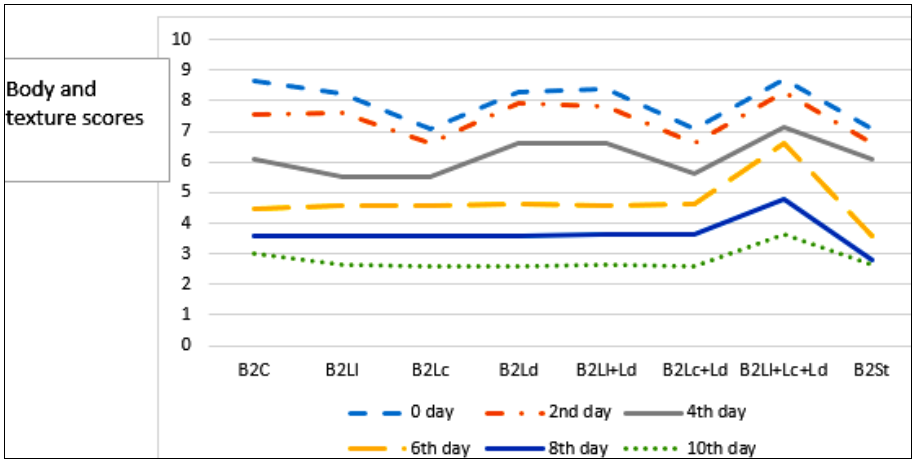

Fig 2: Body and texture scores of buffalo milk curd with various starter cultures incubated at 40°Cduring refrigerated storage

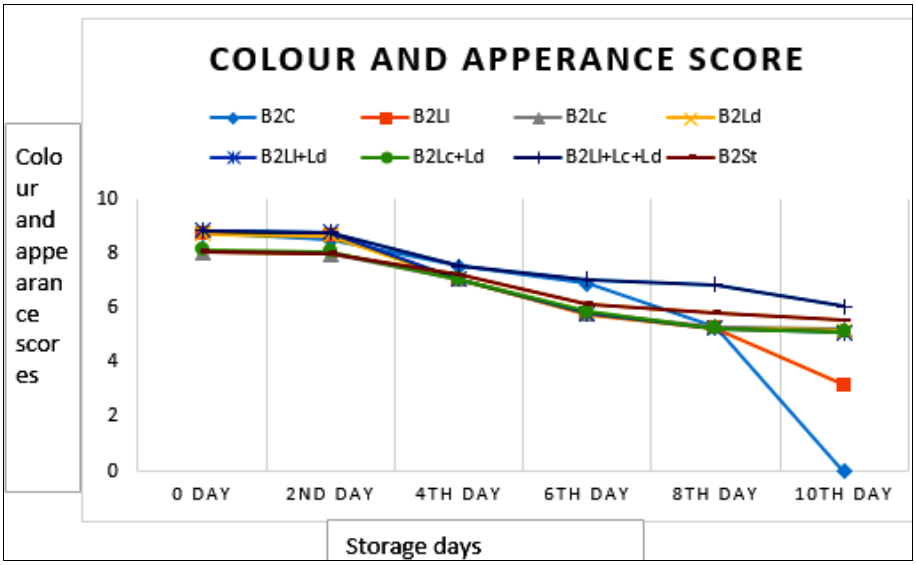

Fig 3: Colour and appearance scores of Buffalo milk curd with various starter cultures incubated at 40°C during refrigerated storage

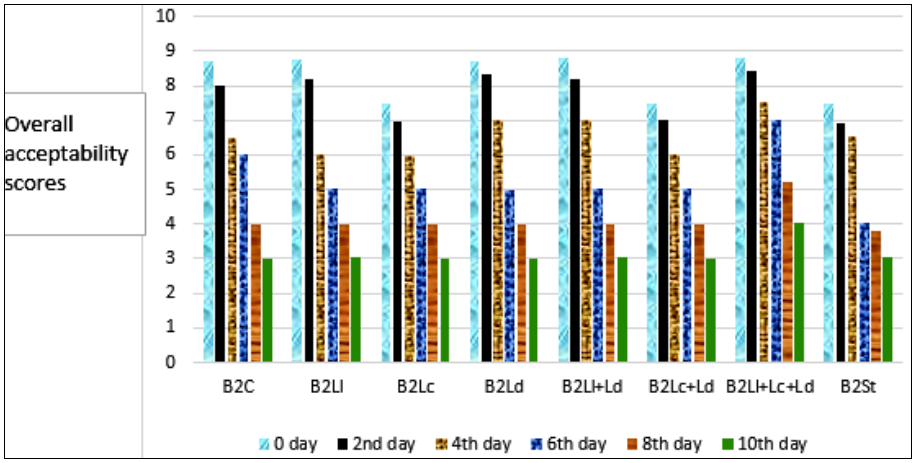

Fig 4: Overall acceptability scores of Buffalo milk curd with various starter cultures incubated at 40°C during refrigerated storage

Conclusion

Utilizing a variety of starter cultures, mixed culture, it was found that higher score under sensory evaluation is the buffalo milk curd prepared by using combined starter cultures of *Lactococcus* species at moderately higher incubation temperature stored at low refrigeration temperature for up to 6 days scored higher in sensory evaluation. Sensory evaluation linked microbial diversity to attributes such as creamy texture, fruity aroma, and sour taste, furthermore *Lactococcus lactis* along with its subspecies was also positively correlated with desirable traits. Hedonic score indices highlighted the correlation between microbial diversity and sensory attributes while scoring buffalo milk curd microbial uniqueness, emphasizing its organoleptic properties.

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