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Evaluation and optimization of compatibility of spice powders and oleoresins as additives in cultured buttermilk

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Abstract

The utilization of whey in fermented dairy products offers nutritional benefits but requires careful formulation to maintain sensory acceptability. This study evaluated the compatibility and optimization of selected spices as additives in cultured buttermilk prepared by blending 50% dahi and 50% fermented whey using *Lactobacillus helveticus* MTCC 5463. The investigation was conducted in three phases: screening the compatibility of seven culinary spices (cumin, fennel, coriander, white pepper, ginger, mustard, and chilli) in both powder and oleoresin forms; optimizing the rate of addition; and evaluating combinations of compatible spices. Sensory evaluation on a 9-point hedonic scale revealed that spice powders of fennel, cumin, coriander, and mustard, and oleoresins of fennel, cumin, and ginger were the most compatible. Optimization studies indicated that increasing spice powder concentration to 1.5% significantly degraded color and texture scores, while oleoresin concentrations above 0.02% negatively impacted flavor. Consequently, 1.0% cumin powder and 0.02% cumin oleoresin were identified as ideal concentrations. Among various combinations tested, the formulation (CT3) containing 1% cumin powder and 0.02% cumin oleoresin achieved the highest sensory scores for flavor (8.25) and overall acceptability (8.28). The study concludes that specific concentrations of cumin powder and oleoresin are highly compatible with whey-based buttermilk, effectively masking potential whey flavors without compromising physicochemical stability.

Keywords: Cultured buttermilk, spice powders, oleoresins, sensory evaluation, optimization

Introduction

Cultured buttermilk is a popular fermented dairy beverage traditionally produced by the acidification of skim or partly skimmed milk. In recent years, the dairy industry has sought to valorize whey, a nutrient-rich byproduct of cheese and paneer manufacturing, by incorporating it into fermented beverages (Patel and Upadhyay, 2004) ^[16]. While whey offers excellent nutritional value, including soluble proteins and minerals, its acidic nature and distinct flavor profile can pose challenges to consumer acceptance when used as a base for buttermilk (Yalcin *et al.*, 1994; Horton, 1995) ^[19, 14].

To overcome these sensory challenges and potentially replace synthetic additives, natural spices and herbs are being explored. Spices not only enhance flavor but also contribute bioactive compounds such as antioxidants and antimicrobials. However, the compatibility of different spice forms (powders vs. oleoresins) and their optimal concentrations in a whey-based matrix remains a critical area of research. Improper dosing can lead to sedimentation, color defects, or overpowering flavors that render the product unacceptable (Sonali *et al.*, 2016) ^[18].

This study focuses on the systematic evaluation and optimization of common culinary spices to determine the most compatible additives for cultured buttermilk prepared with fermented paneer whey. The objective was to identify specific spice forms and concentrations that harmonize with the product's sensory profile while maintaining physicochemical stability.

Materials and Methods

Material

Raw Materials and Starter Culture

Double toned milk (1.5% fat / 9% SNF) was used for dahi preparation, and standardized pasteurized milk (4.5% fat / 8.5% SNF) was used to prepare paneer to obtain fresh whey.

The probiotic culture *Lactobacillus helveticus* MTCC 5463 was used as the starter culture.

Spices and Oleoresins

Seven spices and oleoresins were evaluated: white pepper (*Piper nigrum*), coriander (*Coriandrum sativum*), cumin (*Cuminum cyminum*), fennel (*Foeniculum vulgare*), ginger (*Zingiber officinale*), mustard (*Brassica juncea*), and red chilli (*Capsicum annuum*). These were tested in two forms: fine powder (ground and sieved through 36 mesh) and commercial oleoresins.

Chemicals

All the chemicals used in this study were of analytical grade. The citric acid used in present study was of food grade quality supplied by Dutt enterprise Anand.

Methods

Preparation of Cultured Buttermilk

Double toned milk (1.5% fat / 9% SNF) was used to prepare the dahi and standardized pasteurized milk (4.5% fat / 8.5% SNF) was used to prepare paneer to obtain the paneer whey. Fresh, sweet, good quality double toned milk was preheated to 90 °C for 5 min and filtered through muslin cloth, then cooled to temperature (37 °C) of inoculation. Paneer whey was prepared by the method given by (Bhattacharya *et al.*, 1971) [20]. Same heat treatment was given to the paneer whey as milk. Cultured buttermilk was prepared by blending dahi with fermented whey in 50:50 ratio (w/w). Starter cultures *Lactobacillus helveticus* MTCC 5463 were used as inoculum at the rate of 2%.

Evaluation of Compatibility of Spice Powders and Oleoresins as Additives in Cultured Buttermilk

Whole spice powder (0.5%), or their oleoresins (0.01%), was added to check the compatibility of spices as an additive in cultured buttermilk. The cultured buttermilk without any spice was kept as control. All the samples of buttermilk with added spices either in the form of powder or oleoresin were subjected to sensory analysis on a 9-point hedonic scale.

Optimization of Rate for Addition of Selected form of Spices in Cultured Buttermilk

Selected whole spice powders were added at the rate of 0.5, 1, 1.5, and 2% while selected oleoresins were incorporated at the rate of 0.01, 0.02 and 0.03%. The cultured buttermilk without any spice was kept as control. The samples of cultured buttermilk with acceptable sensory characteristics.

Sensory Evaluation

The product was subjected to the sensory evaluation by an expert trained panel of ten judges for colour and appearance, body and texture, flavour and overall acceptability criteria. Fresh product and the stored products were brought to 10 °C before giving for judging. A 9-point hedonic score card was used for sensory evaluation (Appendix-I) of buttermilk.

Analysis of Whey and Buttermilk

The TS, and protein content of Paneer whey and buttermilk as well as that of control candy samples were determined using the methods ISO 6731-2010. The fat content was analysed as per ISO 488:2008. Ash content was analyzed

following the procedure described in the BIS handbook (BIS, 1981). Determination of lactose content measured by Lane-Eynon method (BIS, 1981). Whey and Buttermilk were naturally coloured; an electrometric method was used to determine its acidity. The pH of Paneer whey and Buttermilk was determined by a digital pH meter (CH-8603, M/s. Mettler Toledo AG, Schwerzenbach). Titratable acidity was measured as per the ISO 6091:2010.

Statistical analysis

The data obtained during the present investigation were analyzed by completely randomized design (CRD) (Steel and Torrie, 1980) [21].

Results

Analysis of Paneer whey and Buttermilk

Double toned milk was used to prepare dahi. The fresh paneer whey was prepared using standardized pasteurized milk. The mean values of proximate chemical composition and chemical characteristics of double toned milk and paneer whey used in this study are presented in Table 1.

The mean values for TS, fat, protein, lactose, ash, pH and acidity (% lactic acid) of double toned milk were 10.52, 1.60, 3.20, 4.98, 0.74, 6.65 and 0.13% respectively. This complies with standards given by FSSA (2011) for toned milk. The paneer whey contained on an average 6.08% TS, 0.31% fat, 0.59% protein, 4.68% lactose and 0.50% ash. The pH and acidity of whey was 5.60 and 0.19% lactic acid.

Goyal and Gandhi (2009) [7] in their study reported mean values of TS, fat, total protein and lactose of paneer whey as 5.8, 0.01, 0.41 and 4.5%, respectively.

Sonali *et al.* (2016) [18] in their study reported mean values for paneer whey and double toned milk as 5.96, 0.30, 0.56, 4.6 and 0.50%; and 10.5, 1.5, 3.3, 5.0 and 0.6%, respectively for TS, fat, total protein, lactose and ash.

Evaluation of Compatibility of Spice Powders and Oleoresins as Additives in Cultured Buttermilk

Spices were to be incorporated in cultured buttermilk for enhancing the shelf life. Therefore, compatibility of the added spices in cultured buttermilk necessitated some preliminary work for their selection. Seven different common culinary spices viz. cumin, fennel, coriander, white pepper, ginger, mustard, and chilli were selected for the study. The above spices in powder form and its oleoresin were added separately at the rate of 0.5% (w/w) and 0.01% into cultured buttermilk, respectively and the contents were thoroughly mixed. The resultant samples were subjected to sensory evaluation for acceptability along with the control sample. The cultured buttermilk without added spice served as control to check the compatibility of the spice for use in buttermilk. All the experimental samples were subjected to evaluation for their sensory attributes viz., flavour, colour and appearance, body and texture and overall acceptability using 9 points hedonic scale. Results along with their statistical analysis are presented in Table 2 and 3.

Effect on flavour

The most important criteria for evaluating the quality of any product is flavour, which in turn determines its acceptability. Sensory characteristics of the buttermilk samples as affected by addition of spices powder are shown

in Table 2. Examination of the data for flavour of cultured buttermilk indicated that the average scores for cultured buttermilk samples containing fennel, cumin, white pepper, coriander, mustard, ginger, chilli and control were 7.83, 8.08, 6.57, 7.80, 7.78, 6.80, 5.77 and 7.77 respectively. Among all the experimental samples, the one containing cumin powder had the highest score (8.08) but its difference in score from other cultured buttermilk samples containing fennel, coriander and mustard was non-significant ($p > 0.05$). The buttermilk samples containing white pepper and ginger scored comparatively less flavour scores. The least flavour score was for cultured buttermilk added with chilli powder due to its pungency and spicy taste given by the capsaicin compound present in chili.

The effect of addition of oleoresin on flavour score of cultured buttermilk is shown in Table 3. Examination of the data for flavour of cultured buttermilk indicated that the average scores for cultured buttermilk samples containing oleoresin of spices fennel, cumin, white pepper, coriander, mustard, ginger, chilli and control were 8.02, 8.20, 7.37, 7.40, 6.31, 8.03, 6.14 and 7.78, respectively. The highest flavour score was for cultured buttermilk added with cumin oleoresin followed by butter milk samples containing fennel and ginger oleoresin all scoring above 8.0 and the difference among them was statistically non-significant ($p > 0.05$). The sample cultured buttermilk containing oleoresin of white pepper and coriander scored less than those containing fennel, cumin and ginger but more than chilli. As in the case of chilli powder, cultured buttermilk sample containing chilli oleoresin also scored least score for flavour attribute. The buttermilk added with mustard oleoresin also scored less flavour score due its pungency.

Mahmoudi (2013) ^[15] evaluated organoleptic properties of bioyoghurt prepared from the milk containing cumin (*C. cyminum*) essential oil at different quantities, 50, 100 and 200 ppm. Among all samples, the most preferred one was the yoghurt which was prepared from the milk containing 50 ppm of essential oil combined with probiotic.

Ihemeje *et al.* (2015) ^[10] evaluated sensory quality of spiced (ginger and pepper) and plain yoghurt. Results showed that acceptability of the plain yoghurt can be significantly ($p < 0.05$) enhancement by the addition of spices. Organoleptically, the spiced and flavoured yoghurts were all acceptable by consumers but pepper fruit spiced yoghurt was the most preferred in terms of general acceptability. Amadou *et al.* (2017) ^[2] reported that sensory properties of ginger spiced yoghurt containing 0.5% of ginger was appreciated equally as that of sample without spices.

4.2.2 Effect on colour and appearance

Colour and appearance is another important parameter for sensory acceptability of any dairy product. This attribute is highly influenced by ingredients of the product. From the Table 2 it is very clear that the type of spice powder had great influence on colour and appearance.

The difference in the score for colour and appearance score of cultured buttermilk containing fennel, cumin, coriander mustard spice powder and control was non-significant. The least score for colour and appearance was for chilli powder due to the prominence of capsaicin pigment.

From the Table 4.3, it is evident that addition of oleoresin did not affect the colour and appearance of cultured

buttermilk except for chill oleoresin due to the appearance of red colour on the surface of buttermilk.

Food acceptance and preference are functions of product quality. Often colour is the first sensory characteristic perceived by the consumer and colour tends to modify other perceptions such as flavour and aroma. Fruits and spice added to the yogurt samples had a strong effect on the colour properties (Garcia-Perez *et al.*).

Effect on body and texture

The body and texture score of cultured buttermilk containing fennel, cumin, coriander, mustard and control were above 7.5 and the difference among these sample were non-significant ($p > 0.05$) (Table 2). The cultured buttermilk sample containing white pepper and ginger and chilli powder scored below 7.5 because there was problem of settling of spice powder in these samples, which influenced their aesthetic quality.

The addition of oleoresin did not affect the body and texture of cultured buttermilk except for chill oleoresin same as in the case of colour and appearance as shown in Table 3.

The body and texture of fermented milk is affected by the rate of acid production during the fermentation process, as well as the fat content and, milk solids. Also, the heating processes affect the texture of the fermented milk. Heating the mix denatures whey proteins, increases the water-holding capacity of milk protein, and increases the viscosity of fermented milk (Hekmat and Reid, 2006) ^[9].

Hamid (2014) ^[8] investigated the effect of different levels of cumin oil on sensory characteristics of white soft cheese and found that the effect on colour and texture of the cheese samples was not significant due to cumin oil concentrations.

Effect on overall acceptability

The overall acceptability score of cultured buttermilk containing different spice powders followed the same trend as that of flavour score for the experimental samples as evident from Table 2. The overall acceptability score was highest for cultured buttermilk sample containing cumin powder, followed by cultured buttermilk samples added spices fennel, coriander and mustard, respectively and the difference among these samples was non-significant ($p > 0.05$). Their scores were significantly higher compared to control sample. Therefore, spice powder namely fennel, cumin, coriander and mustard were selected for further study as they gave cultured buttermilk with most acceptable sensory characteristics.

In case of cultured buttermilk sample added with oleoresin, the experimental sample with cumin oleoresin scored highest score (8.16) for overall acceptability followed by the once with ginger oleoresin and cultured buttermilk with fennel oleoresin. But the difference in the score among these three experimental samples was non-significant ($p > 0.05$) but was significantly higher compared to control. Hence oleoresin of fennel, cumin and ginger were selected for further study as they gave cultured buttermilk with most acceptable sensory characteristics.

Ajala *et al.* (2013) ^[1] developed soy-corn milk from a blend of soybean milk and corn milk extract at a ratio of 3:1. The soy-corn milk type was spiced with ginger and garlic extract, respectively. The addition of ginger improved the

sensory quality of the soy-corn milk while taste panelist rated the garlic spiced corn milk very low.

Mahmoudi (2013) ^[15] evaluated organoleptic properties of bioyoghurt prepared from the milk containing cumin (*C. cyminum*) essential oil at different quantities, 50, 100 and 200 ppm. Among all samples, the most preferred one was the yoghurt, which was prepared from the milk containing 50 ppm of essential oil combined with probiotic.

Ihemeje *et al.* (2015) ^[10] evaluated sensory quality of spiced (ginger and pepper) and plain yoghurt. Results showed that acceptability of the plain yoghurt can be significantly ($p < 0.05$) enhanced by the addition of spices. Organoleptically, the spiced and flavoured yoghurts were all acceptable by consumers but pepper fruit spiced yoghurt was the most preferred in terms of general acceptability.

Amadou *et al.* (2017) ^[2] reported that sensory properties of ginger spiced yoghurt containing 0.5% of ginger was appreciated equally as that of sample without spices.

Effect on titratable acidity of cultured buttermilk

Lactose is largely removed in the whey during paneer making. Development of acid from lactose by culture is the first influencing factor in the manufacture of fermented dairy products. Therefore, titratable acidity is one of the most important points of concern for fermented dairy products. Result for analysis of titratable acidity of samples of cultured buttermilk prepared by addition of spice powders and oleoresins are presented in Table 4 and 5. The data shown in the Table 4 and 5 indicate that the titratable acidity of cultured buttermilk was not influenced by the type and form of spice added. The difference in the acidity among cultured buttermilk samples containing different spice powders were non-significant and the values ranged between 0.55 and 0.58% lactic acid. The difference in the acidity among cultured buttermilk samples containing different oleoresins were non-significant and the values ranged between 0.57 and 0.59% lactic acid.

Thus, based on sensory evaluation and titratable acidity data spice powders of fennel, cumin, coriander and mustard were selected for further study as they gave cultured buttermilk with most acceptable sensory characteristics.

In case of different oleoresins, oleoresin of fennel, cumin and ginger were selected for further study as they gave cultured buttermilk with most acceptable sensory characteristics.

Optimization of Rate of Addition of Selected Form of Spice (S) In Cultured Buttermilk

Selected spice powders and oleoresins were added at three different rates in cultured buttermilk. The experimental samples were subjected to sensory analysis. The selected spice powders fennel, cumin, coriander and mustard were added at three different rate namely 0.5, 1 and 1.5% in the cultured buttermilk and results of sensory evaluation are presents in Table 6. These rate of addition were selected based on preliminary trials. Selected oleoresins from first phase of the study namely fennel, cumin and ginger were added at three different rate namely 0.01, 0.02 and 0.03% in the cultured buttermilk and results of sensory evaluation are presents in Table 7. These rate of addition were selected based on preliminary trials.

Effect on flavour

The effect of different rate of addition of selected spice powders on the flavour characteristics of cultured buttermilk as shown in Table 4.6 revealed that cultured buttermilk, ST₅ (containing cumin at the rate of 1.0%) scored the highest value for flavour attributes followed by ST₄ (cumin, 0.5%), ST₁₀ (mustard, 0.5%), ST₇ (coriander, 0.5%) and ST₁ (fennel, 0.5%). But the difference among the experimental samples ST₅, ST₄, ST₁₀, ST₇ and ST₁ was non-significant ($p > 0.05$) and the flavour scores of these samples were significantly higher compared to control (ST₁₃). It is also very clear from the Table 6 that as a rate of addition of spice powders increased, the flavour score decreased correspondingly except for cumin. But even for cumin rate of addition at 1.5% level adversely affected the flavour scores.

The effect of different rates of addition of selected oleoresin on flavour score of cultured buttermilk is shown in Table 7. Examination of the data for flavour scores of cultured buttermilk indicated that the average score for OT₁, OT₂, OT₃, OT₄, OT₅, OT₆, OT₇, OT₈, OT₉ and OT₁₀ type of cultured buttermilk samples containing oleoresins was 7.63, 8.05, 6.57, 7.95, 8.23, 7.75, 7.81, 7.83 6.70 and 7.78 respectively. The highest flavour score was for OT₅ (0.02% of cumin oleoresin) followed by OT₂ (0.02% of fennel oleoresin).

The difference in the score among OT₂ and OT₅ was non-significant ($p > 0.05$) but differed significantly from control OT₁₀. All other experimental samples scored below 8.0 (which stand for like very much in 9 point hedonic scale). The samples OT₃ and OT₉ containing fennel and ginger at the rate of 0.03% respectively scored below 7.0 (which stand for like moderately in 9 point hedonic scale).

Effect on colour and appearance

As the rate of addition of spice powder increased, it had a major impact on colour and appearance score. Data from Table 6 indicated that 1.5% rate of addition of fennel (ST₆), coriander (ST₉) and mustard (ST₁₂) spice powder significantly reduced the colour and appearance of cultured buttermilk (the score dropped below 7.0). All other experimental samples including control scored above 7.0 (which stands for like moderately on 9 point hedonic scale) and difference among them were statistically non-significant ($p > 0.05$).

Contrary to the undesirable effect on colour and appearance characteristics of buttermilk caused by the increased rate of addition of spice powder; the rate of addition of oleoresin had negligible effect on the colour and appearance score of experimental sample as evident from Table 7. The difference in the score among the experimental samples were statistically non-significant ($p > 0.05$).

Effect on body and texture

The rate of addition of spice powder also influenced the body and texture score. The experimental sample ST₄ (cumin 0.5 percent) and ST₁₃ (control) scored highest for body and texture followed by ST₅ (cumin 1%), ST₁₀ (mustard 0.5%), ST₁ (fennel 0.5%) and ST₇ (coriander 0.5%) but the difference among these samples was statistically non-significant ($p > 0.05$). On increasing the rate of addition

of spice powder to 1.5% the body and texture score reduced drastically below 7.0 irrespective of the type of spice. The difference in scores among the samples OT₁, OT₂, OT₃, OT₄, OT₅, OT₆, OT₇, OT₈, OT₉ and OT₁₀ containing different rate and type of oleoresins was non-significant. The scores of the all samples were above 8.0 (which stand for like very much in 9 point hedonic scale). This was in accordance with the data for colour and appearance endorsing that finding that rate of addition oleoresins did not influence the body and texture as well as colour and appearance.

Effect on overall acceptability

Among all experimental samples added with different rates of selected spice powders, the cultured buttermilk ST₅ containing 1% of cumin powder had the highest (8.15) score for overall acceptability followed by ST₄ (8.09), ST₁₀ (7.99), ST₁ (7.94) and ST₇ (7.89) and the difference in the score among these samples was non-significant ($p > 0.05$). The data from Table 4.6 also revealed that irrespective of the type of spice powder, the overall acceptability score decreased significantly at 1.5 per cent rate of addition.

Thus, based on sensory evaluation it was resolved that the cultured buttermilk samples ST₁ (fennel 0.5%), ST₄ (cumin 0.5%), ST₅ (cumin 1.0%), ST₇ (coriander 0.5%), and ST₁₀ (mustard 0.5%) were the best among all the experimental samples.

The cultured buttermilk samples OT₅ and OT₂ containing cumin and fennel oleoresins at 0.02% rate scored highest among all experimental samples and the difference among them was non-significant. Same as in the case of spice powders, the cultured buttermilk samples containing oleoresins at 0.03% had significantly lower score compared to its counterparts. Therefore, based on the sensory evaluation cultured buttermilk OT₅ and OT₂ containing i.e. fennel and cumin oleoresin at 0.02% were adjudged as the best.

Effect on titratable acidity of cultured buttermilk

Total titratable acidity is the total amount of hydrogen ions present in the fermented milk sample with the exception of those bound to alkaline ions. The determination of total titratable acid is more relevant in the evaluation of fermentation capacity of microbes (Geidam *et al.*, 2007)^[6]. Variations in titratable acidity that occur in milk can thus be associated to differential microbial population during fermentation (Eissa *et al.*, 2010)^[4].

Results for analysis of titratable acidity of samples of cultured buttermilk prepared by addition of different rates of spice powders and oleoresins are presented in Table 8 and 9. The data shown in the Table 8 and 9 indicate that the titratable acidity of cultured buttermilk was not influenced by the different rate of addition of spices.

The difference in the acidity among cultured buttermilk samples ST₁, ST₂, ST₃, ST₄, ST₅, ST₆, ST₇, ST₈, ST₉, ST₁₀, ST₁₁ and ST₁₂ containing different spice powders and control, ST₁₃ were non-significant and the values ranged between 0.56 and 0.58% lactic acid.

The acidity of cultured buttermilk OT₁, OT₂, OT₃, OT₄, OT₅, OT₆, OT₇, OT₈ and OT₉ containing different oleoresins and control, OT₁₀ ranged between 0.58 and 0.60 per cent lactic

acid and the difference in the acidity among these samples were non-significant.

Thus, based on sensory evaluation and titratable acidity, among different rate of spice powders studied, fennel, cumin, coriander and mustard at 0.5% rate and cumin at 1.0% were selected for further study as they gave cultured buttermilk with most acceptable sensory characteristics.

In case of cultured buttermilk sample added with different oleoresins, oleoresin of fennel and cumin at 0.02% were selected for further study as they gave cultured buttermilk with most acceptable sensory characteristics and titratable acidity.

Evaluation of Compatibility of Combination of Different Forms of Selected Spices

Various combinations of selected rates of spice powders and oleoresins were added to cultured buttermilk to check their compatibility. The combination was made using compatible spices based on preliminary trials. The result of analysis are presented in the Table 10.

Effect on flavour

The experimental samples CT₂ (0.5% fennel powder+ 0.5% coriander powder), CT₃ (1% cumin powder + 0.02% cumin oleoresin) and CT₄ (0.5% cumin powder + 0.5% coriander powder) scored above 8.0 and the difference in the score among these samples was statistically non-significant ($p > 0.05$). The control sample CT₁ scored less than 8.0 and it differed significantly from CT₂, CT₃ and CT₄. The experimental samples CT₉ (0.5% mustard powder + 0.5% fennel powder + 0.02% fennel oleoresin) and CT₁₃ (1% cumin powder + 0.5% mustard powder + 0.02% cumin oleoresin) scored below 7.0 (which stands for like moderately on 9 point hedonic scale).

Effect on colour and appearance

The colour and appearance scores of cultured buttermilk samples CT₁ (control), CT₂ (0.5% fennel powder+ 0.5% coriander powder), CT₃ (1% cumin powder + 0.02% cumin oleoresin), CT₄ (0.5% cumin powder + 0.5% coriander powder), CT₅ (0.5% fennel powder + 0.5% coriander +0.02% fennel oleoresin) and CT₁₄ (0.5% fennel powder + 0.02% fennel oleoresin) were above 8.0 and the difference among them was non- significant. The lowest score for colour and appearance was for samples CT₉ (0.5% mustard powder + 0.5% fennel powder + 0.02% fennel oleoresin) followed by CT₁₂ (1% cumin powder + 0.5% mustard powder) and CT₁₃ (1% cumin powder + 0.5% mustard powder + 0.02% cumin oleoresin). These data revealed that when spice powder addition increased above 1% it significantly affected the colour and appearance score of cultured buttermilk.

Effect on body and texture

Data from Table 4.10 showed that the body and texture scores of cultured buttermilk samples CT₁ (control), CT₂ (0.5% fennel powder+ 0.5% coriander powder), CT₃ (1% cumin powder + 0.02% cumin oleoresin), CT₄ (0.5% cumin powder + 0.5% coriander powder), CT₅ (0.5% fennel powder + 0.5% coriander +0.02% fennel oleoresin) and CT₁₄ (0.5% fennel powder + 0.02% fennel oleoresin) were above 8.0 and the difference among them was non-significant. The

lowest score for colour and appearance was for samples CT₉ (0.5% mustard powder + 0.5% fennel powder + 0.02% fennel oleoresin), CT₁₂ (1% cumin powder + 0.5% mustard powder) and CT₁₃ (1% cumin powder + 0.5% mustard powder + 0.02% cumin oleoresin). These data revealed that as in the case of colour and appearance, when spice powder concentration in the buttermilk increased above 1%, it significantly affected the body and texture of the product.

Effect on overall acceptability

The experimental samples CT₂ (0.5% fennel powder + 0.5% coriander powder), CT₃ (1% cumin powder + 0.02% cumin oleoresin) and CT₄ (0.5% cumin powder + 0.5% coriander powder) scored above 8.0 (which stand for like very much in 9 point hedonic scale) and the difference in the scores among these samples was statistically non-significant ($p > 0.05$) as shown in Table 4.10. The control sample, CT₁ scored less than 8.0 and it differed significantly from CT₂, CT₃ and CT₄. The experimental samples CT₉ (0.5% mustard powder + 0.5% fennel powder + 0.02% fennel oleoresin) and CT₁₃ (1% cumin powder + 0.5% mustard powder + 0.02% cumin oleoresin) scored below 7.0 (which stands for like moderately on 9 point hedonic scale).

Thus, based on the data from sensory analysis it was established that combination of spices namely 0.5% fennel powder and 0.5% coriander powder; 1% cumin powder and 0.02% cumin oleoresin; and 0.5% cumin powder and 0.5% coriander powder gave most acceptable cultured buttermilk.

Effect on titratable acidity of cultured buttermilk

Results for analysis of titratable acidity of samples of cultured buttermilk prepared by different combination of selected spices powder and oleoresins are presented in Table 11. The acidity of cultured buttermilk samples CT₁, CT₂, CT₃, CT₄, CT₅, CT₆, CT₇, CT₈, CT₉, CT₁₀, CT₁₁, CT₁₂ and CT₁₃ containing different combination of spices and control sample CT₁₄ ranged from 0.56 to 0.58% lactic acid and the difference among them was statistically non-significant ($p > 0.05$) as shown in Table 11.

Thus, based on sensory evaluation and titratable acidity, among different combinations of selected spices, the combinations of spices namely 0.5% fennel powder and 0.5% coriander powder; 1% cumin powder and 0.02% cumin oleoresin; and 0.5% cumin powder and 0.5% coriander powder gave most acceptable cultured buttermilk.

Discussion

This research focused on optimization of spices in addition of cultured buttermilk with utilization of Paneer whey. As a nutrient-dense dairy byproduct rich in lactose, proteins, and minerals, whey offers substantial value when transformed into functional frozen confectionery, enhancing both nutrition and economic utilization.

Spices in addition to contributing taste and aroma to foods, also contain variety of bioactive substances including antioxidants. The phenolic contents in spices act as antioxidant due to their redox properties, allowing them to act as reducing agents, hydrogen donors, free radical quenchers and metal chelators (Madsen and Bertelsen, 1995; Pokorny and Korczak, 1997)^[14, 17].

The superior performance of cumin, fennel, coriander, and mustard powders (scores >7.75) aligns with their traditional

usage in Indian cuisine. Cumin, in particular, is a staple in savory buttermilk ("Chhaach") and lassi. The poor performance of chilli powder (score 5.77) was attributed to its high pungency and the leaching of red capsacin pigments, which created visual defects described as "red separation." White pepper and ginger powders were penalized for sedimentation, which negatively impacted the "Body and Texture" scores (7.62 and 7.80, respectively). This sedimentation is a common challenge with fibrous spice powders in low-viscosity beverages.

Oleoresins, being concentrated extracts, offered different sensory profiles. Cumin oleoresin maintained its superiority (Score: 8.16), suggesting that the essential volatile compounds responsible for cumin's characteristic aroma are well-preserved and compatible with the dairy matrix. However, mustard oleoresin failed (Score: 7.47) despite the success of mustard powder. This discrepancy is likely due to the concentration of allyl isothiocyanate in the oleoresin, which produces an intensely sharp, pungent sensation that is unpleasant in a beverage format without the buffering capacity of the fibrous powder matrix. Similarly, chilli oleoresin was rejected due to "excessive heat" and color defects.

Comparing the two forms, powders generally contributed to "Body and Texture" positively (when not settling), likely due to water absorption by fiber content. Oleoresins had negligible impact on texture but carried a higher risk of flavor overpowering (as seen with mustard and chilli). This necessitated the optimization of addition rates.

At 1.5% concentration, sensory scores for fennel, coriander, and mustard plummeted below 7.0 (the "like moderately" threshold). The primary defects cited were "overpowering flavor," "gritty mouthfeel," and "sedimentation." Cumin was the exception; it maintained a high score (8.15) even at 1.0%, indicating a higher consumer tolerance for this specific flavor profile in buttermilk. This resilience of cumin allows for higher fortification levels, which may be beneficial for delivering bioactive compounds without compromising taste.

For oleoresins, the window of optimal acceptance was narrow. While 0.02% concentrations of cumin and fennel scored excellent (>8.00), increasing the level to only 0.03% resulted in scores dropping to ~6.6. This sharp decline highlights the potency of oleoresins; a minute increase can shift the sensory profile from "pleasant" to "chemical" or "medicinal." The optimal rate of 0.02% aligns with findings by Otaibi and Demerdash (2008)^[22], who noted that lower concentrations of essential oils often yield better sensory results in dairy products like Labneh.

Crucially, neither the type of spice nor the rate of addition significantly altered the titratable acidity of the fresh product (values remained ~0.56-0.60%). This suggests that the spices do not possess sufficient buffering capacity or inherent acidity to immediately shift the pH of the buttermilk system. This stability is vital for processing, as it means spice addition does not require formulation adjustments to maintain the target acidity.

Evaluation of combinations revealed that blending spice forms can enhance sensory quality beyond single-spice formulations.

The combination of 1.0% Cumin Powder + 0.02% Cumin Oleoresin () achieved the highest scores across all phases of

the study (Flavor: 8.25, Overall: 8.28). This synergy can be explained by the complementary nature of the two forms

- 1. Powder:** Provides "body," mouthfeel, and a sustained background flavor.
- 2. Oleoresin:** Provides immediate, intense aromatic "top notes" that hit the palate first. Together, they create a full-bodied, complex flavor profile that effectively

masks the acidic or salty off-notes potentially contributed by the fermented whey.

- 3. Other Successful Blends:** The blend of Fennel + Coriander (CT2) and Cumin + Coriander (CT4) also performed well (scores >8.0), confirming that these traditional spice pairings are chemically and sensorially compatible with the whey-buttermilk matrix

Table 1: Proximate composition and chemical characteristics of paneer whey and toned milk

Proximate composition (%)		
	Paneer Whey	Double toned milk
Constituents	Mean $\pm$ SD	Mean $\pm$ SD
Total solids	6.08 $\pm$ 0.02	10.52 $\pm$ 0.05
Fat	0.31 $\pm$ 0.02	1.60 $\pm$ 0.02
Protein	0.59 $\pm$ 0.03	3.20 $\pm$ 0.04
Lactose	4.68 $\pm$ 0.06	4.98 $\pm$ 0.02
Ash	0.50 $\pm$ 0.02	0.74 $\pm$ 0.02
Chemical characteristics		
Characteristics	Value	
pH	5.60 $\pm$ 0.09	6.65 $\pm$ 0.04
Acidity (% lactic acid)	0.19 $\pm$ 0.02	0.13 $\pm$ 0.02

Table 2: Effect of spice powders on sensory characteristics of cultured buttermilk

Types of spice powder*	Sensory score**			
	Flavour	Colour and appearance	Body and texture	Overall acceptability
Fennel	7.83 ^{ab}	8.01 ^a	8.10 ^a	7.81 ^{ab}
Cumin	8.08 ^a	8.18 ^a	8.15 ^a	8.10 ^a
White pepper	6.57 ^c	7.07	7.62 ^c	6.58 ^c
Coriander	7.80 ^{ac}	7.83 ^{ab}	8.03 ^{ab}	7.77 ^{ab}
Mustard	7.78 ^{ab}	7.93 ^a	7.92 ^{ab}	7.94 ^{ab}
Ginger	6.80 ^c	7.52 ^b	7.80 ^{bc}	6.74 ^c
Chilli	5.77	6.07	6.95	5.87
Control	7.77 ^b	8.02 ^a	8.06 ^{ab}	7.75 ^b
SEm	0.10	0.11	0.09	0.12
CD (0.05)	0.31	0.35	0.29	0.34
CV%	2.28	2.45	1.98	2.74

*All spice powders were added at the rate of 0.5%.
Control= cultured buttermilk without any spice.

**The values are means of three replications and the values within columns (treatments) with same superscript did not differ significantly ($p > 0.05$) from each other.

Table 3: Effect of oleoresins on sensory characteristics of cultured buttermilk

Types of oleoresin*	Sensory score			
	Flavour	Colour and appearance	Body and texture	Overall acceptability
Fennel	8.02 ^a	8.10 ^a	8.01 ^a	7.98 ^{ab}
Cumin	8.20 ^a	8.15 ^a	8.03 ^a	8.16 ^a
White pepper	7.37 ^b	8.14 ^a	7.89 ^a	7.40 ^c
Coriander	7.40 ^b	8.12 ^a	7.93 ^a	7.31 ^c
Mustard	6.31 ^c	8.08 ^a	7.92 ^a	7.47 ^c
Ginger	8.03 ^a	8.03 ^a	8.04 ^a	8.00 ^{ab}
Chilli	6.14 ^c	7.71	7.72	6.50
Control	7.78	8.02 ^a	8.06 ^a	7.85 ^b
SEm	0.06	0.07	0.06	0.07
CD (0.05)	0.19	0.21	0.17	0.21
CV%	1.38	1.41	1.18	1.53

*All oleoresins were added at the rate of 0.01%.
Control= Cultured buttermilk without any oleoresin

**The values are means of three replications and values within columns (treatments) with same superscript did not differ significantly ($p > 0.05$) from each other.

Table 4: Effect of spice powders on titratable acidity of cultured buttermilk

Types of spice powder*	Titratable acidity (%lactic acid)
Fennel	0.56
Cumin	0.57
White pepper	0.57
Coriander	0.56
Mustard	0.57
Ginger	0.58
Chilli	0.57
Control	0.55
SEm	0.03
CD	NS
CV%	6.56
*All spice powders were added at the rate of 0.5%. Control= cultured buttermilk without any spice. The values are means of three replications.	

Table 5: Effect of oleoresins on titratable acidity of cultured buttermilk

Types of oleoresin*	Titratable acidity (%lactic acid)
Fennel	0.58
Cumin	0.59
White pepper	0.58
Coriander	0.59
Mustard	0.57
Ginger	0.58
Chilli	0.59
Control	0.57
1	
SEm	0.02
CD	NS
CV%	4.90
*All spice powders were at the rate of 0.01% Control= cultured buttermilk without any oleoresin. The values are means of three replications.	

Table 6: Effect of rate of addition of spice powders on sensory characteristics of cultured buttermilk

Rate of addition of spice powders	Sensory score			
	Flavour	Colour and appearance	Body and texture	Overall acceptability
ST ₁ (0.5% Fennel)	7.92 ^{ab}	8.09 ^{abc}	7.90 ^{abc}	7.94 ^{ab}
ST ₂ (1.0% Fennel)	7.40 ^c	7.71 ^{abc}	7.63 ^{bcd}	7.73 ^b
ST ₃ (1.5% Fennel)	6.25 ^f	6.74 ^{de}	6.80 ^e	6.49 ^e
ST ₄ (0.5% Cumin)	8.12 ^a	8.14 ^a	8.06 ^a	8.09 ^a
ST ₅ (1.0% Cumin)	8.20 ^a	8.12 ^{ab}	8.02 ^a	8.15 ^a
ST ₆ (1.5% Cumin)	6.76 ^{de}	7.12 ^d	7.62 ^{cd}	6.80 ^{cd}
ST ₇ (0.5% Coriander)	7.95 ^{ab}	7.94 ^{abc}	7.90 ^{abc}	7.89 ^{ab}
ST ₈ (1.0% Coriander)	7.35 ^c	7.66 ^{bc}	7.60 ^{cd}	7.42
ST ₉ (1.5% Coriander)	6.51 ^{ef}	6.64 ^e	6.64 ^e	6.64 ^{de}
ST ₁₀ (0.5% Mustard)	8.05 ^{ab}	7.99 ^{abc}	7.99 ^{ab}	7.99 ^{ab}
ST ₁₁ (1.0% Mustard)	6.94 ^d	7.63 ^c	7.46 ^d	7.10 ^c
ST ₁₂ (1.5% Mustard)	5.85	6.58 ^e	6.33	6.02
ST ₁₃ (Control*)	7.77 ^b	8.02 ^{abc}	8.06 ^a	7.75 ^b
SEm	0.09	0.16	0.12	0.09
CD (0.05)	0.28	0.46	0.36	0.27
CV%	2.18	3.61	2.73	2.06
The values are means of three replications. * ST ₁₃ = Control, the cultured buttermilk without any spice. Values within columns (treatments) with same superscript did not differ significantly ($p > 0.05$) from each other.				

Table 7: Effect of rate of addition of oleoresins on sensory characteristics of cultured buttermilk

Rate of addition of oleoresins	Sensory score			
	Flavour	Colour and appearance	Body and texture	Overall acceptability
OT ₁ (0.01% Fennel)	7.63 ^d	8.58	8.11	7.67 ^{cd}
OT ₂ (0.02% Fennel)	8.05 ^{ab}	8.55	8.33	8.00 ^{ab}
OT ₃ (0.03% Fennel)	6.57 ^e	8.51	8.14	6.61 ^e
OT ₄ (0.01% Cumin)	7.95 ^{bc}	8.61	8.12	7.85 ^{bc}
OT ₅ (0.02% Cumin)	8.23 ^a	8.60	8.27	8.20 ^a
OT ₆ (0.03% Cumin)	7.75 ^{cd}	8.62	8.08	7.55 ^d
OT ₇ (0.01% Ginger)	7.81 ^{cd}	8.47	8.19	7.79 ^{bc}
OT ₈ (0.02% Ginger)	7.83 ^{bcd}	8.52	8.19	7.85 ^{bc}
OT ₉ (0.03% Ginger)	6.70 ^e	8.57	8.13	6.62 ^e
OT ₁₀ (Control*)	7.78 ^{cd}	8.34	8.18	7.82 ^{bc}
SEm	0.08	0.05	0.06	0.07
CD (0.05)	0.23	NS	NS	0.22
CV%	2.01	1.01	1.24	1.60

The values are means of three replications.
 * OT₁₀ = Control, the cultured buttermilk without any spice.
 Values within columns (treatments) with same superscript did not differ significantly ($p > 0.05$) from each other.

Table 8: Effect of rate of addition of spices powders on titratable acidity of cultured buttermilk

Rate of addition of spice powders	Titratable acidity (%lactic acid)
ST ₁ (0.5% Fennel)	0.56
ST ₂ (1.0% Fennel)	0.57
ST ₃ (1.5% Fennel)	0.58
ST ₄ (0.5% Cumin)	0.56
ST ₅ (1.0% Cumin)	0.57
ST ₆ (1.5% Cumin)	0.58
ST ₇ (0.5% Coriander)	0.56
ST ₈ (1.0% Coriander)	0.57
ST ₉ (1.5% Coriander)	0.58
ST ₁₀ (0.5% Mustard)	0.56
ST ₁₁ (1.0% Mustard)	0.57
ST ₁₂ (1.5% Mustard)	0.58
ST ₁₃ (Control*)	0.56
SEm	0.01
CD	NS
CV%	4.34

The values are means of three replications.
 * ST₁₃ = Control, the cultured buttermilk without any spice.
 Values within columns (treatments) with same superscript did not differ significantly ($p > 0.05$) from each other.

Table 9: Effect of rate of addition of oleoresins on titratable acidity of cultured buttermilk

Rate of addition of oleoresins	Titratable acidity (%lactic acid)
OT ₁ (0.01% Fennel)	0.58
OT ₂ (0.02% Fennel)	0.59
OT ₃ (0.03% Fennel)	0.60
OT ₄ (0.01% Cumin)	0.58
OT ₅ (0.02% Cumin)	0.59
OT ₆ (0.03% Cumin)	0.60
OT ₇ (0.01% Ginger)	0.58
OT ₈ (0.02% Ginger)	0.59
OT ₉ (0.03% Ginger)	0.60
OT ₁₀ (Control*)	0.58
SEm	0.01
CD	NS
CV%	3.72

The values are means of three replications.
 * OT₁₀ = Control, the cultured buttermilk without any spice.
 Values within columns (treatments) with same superscript did not differ significantly ($P > 0.05$) from each other.

Table 10: Effect of combination of spices on sensory characteristics of cultured buttermilk

Treatment	Sensory score			
	Flavour	Colour and appearance	Body and texture	Overall acceptability
CT ₁	7.73 ^b	8.08 ^a	8.14 ^{abc}	7.82 ^{bc}
CT ₂	8.10 ^a	8.25 ^a	8.22 ^a	8.08 ^{ab}
CT ₃	8.25 ^a	8.18 ^a	8.28 ^a	8.28 ^a
CT ₄	8.05 ^a	8.25 ^a	8.27 ^a	8.07 ^{ab}
CT ₅	7.27 ^{cd}	8.10 ^a	8.17 ^{ab}	7.22 ^f
CT ₆	7.49 ^{bc}	7.42 ^b	7.80 ^{bcd}	7.51 ^{de}
CT ₇	7.64 ^b	7.47 ^b	7.74 ^d	7.59 ^{cd}
CT ₈	7.55 ^b	7.48 ^b	7.71 ^d	7.60 ^{cd}
CT ₉	6.67 ^e	6.45 ^c	7.07 ^e	6.90
CT ₁₀	7.61 ^b	7.62 ^b	7.82 ^{bcd}	7.57 ^{cd}
CT ₁₁	7.66 ^b	7.63 ^b	7.78 ^{cd}	7.61 ^{cd}
CT ₁₂	7.27 ^{cd}	6.36 ^c	6.93 ^e	7.20 ^f
CT ₁₃	6.59 ^e	6.55 ^c	6.96 ^e	6.55
CT ₁₄	7.23 ^d	8.06 ^a	8.15 ^{abc}	7.26 ^{ef}
SEm	0.09	0.07	0.06	0.10
CD (0.05)	0.25	0.21	0.18	0.27
CV%	1.96	1.56	1.38	2.18

CT₁=Control without any spice
 CT₂= 0.5% fennel powder + 0.5% coriander powder
 CT₃=1% cumin powder + 0.02% cumin oleoresin
 CT₄=0.5% cumin powder + 0.5% coriander powder
 CT₅= 0.5% fennel powder + 0.5% coriander +0.02% fennel oleoresin
 CT₆=1% cumin powder + 0.5% fennel powder
 CT₇=1% cumin powder + 0.5% fennel powder + 0.02% cumin oleoresin
 CT₈=1% cumin powder + 0.5% fennel powder + 0.02% fennel oleoresin
 CT₉=0.5% mustard powder + 0.5% fennel powder + 0.02% fennel oleoresin
 CT₁₀=1% cumin powder + 0.5% coriander powder
 CT₁₁=1% cumin powder + 0.5% coriander powder +0.02% cumin oleoresin
 CT₁₂=1% cumin powder + 0.5% mustard powder
 CT₁₃=1% cumin powder + 0.5% mustard powder + 0.02% cumin oleoresin
 CT₁₄=0.5% fennel powder + 0.02% fennel oleoresin
 The values are means of three replications.
 Values within columns (treatments) with same superscript did not differ significantly ($p > 0.05$) from each other

Table 11: Effect of combination of spices on titratable acidity of cultured buttermilk

Treatment	Titratable acidity (% lactic acid)
CT ₁ (Control without spice and oleoresin)	0.56
CT ₂ (0.5% fennel powder+ 0.5% coriander powder)	0.56
CT ₃ (1% cumin powder + 0.02% cumin oleoresin)	0.58
CT ₄ (0.5% cumin powder + 0.5% coriander powder)	0.57
CT ₅ (0.5% fennel powder + 0.5% coriander +0.02% fennel oleoresin)	0.56
CT ₆ (1% cumin powder+ 0.5% fennel powder)	0.56
CT ₇ (1% cumin powder + 0.5% fennel powder + 0.02% cumin oleoresin)	0.57
CT ₈ (1% cumin powder + 0.5% fennel powder + 0.02% fennel oleoresin)	0.56
CT ₉ (0.5% mustard powder + 0.5% fennel powder + 0.02% fennel oleoresin)	0.56
CT ₁₀ (1% cumin powder + 0.5% coriander powder)	0.56
CT ₁₁ (1% cumin powder + 0.5% coriander powder +0.02% cumin oleoresin)	0.57
CT ₁₂ (1% cumin powder + 0.5% mustard powder)	0.57
CT ₁₃ (1% cumin powder + 0.5% mustard powder + 0.02% cumin oleoresin)	0.58
CT ₁₄ (0.5% fennel powder + 0.02% fennel oleoresin)	0.57
SEm	0.01
CD	NS
CV %	3.72

The values are means of three replications

Conclusion

The evaluation and optimization process conclusively demonstrated that cumin is the most versatile and compatible spice for whey-based cultured buttermilk. The optimal formulation strategy involves a dual-approach: using 1.0% cumin powder for body and 0.02% cumin oleoresin for aroma. This formulation (CT₃) not only masks the inherent tartness of the whey but also provides a superior sensory experience compared to the control and other spice

variations. The study confirms that careful selection of spice form and concentration is critical to preventing textural defects and flavor imbalances in value-added dairy beverages.

Conflict of Interest

There are no conflicts of interest associated with this publication.

Data availability

The datasets generated and analyzed during this study are available from the corresponding author upon reasonable request.

Authors' contribution: RH

The research concept and experimental work were carried out; by Nishit Chaudhari & Bhoomika S Desai under the SB: supervision of Dr. Smitha Balakrishnan.; Dr. Smitha Balakrishnan and Dr. A.M Patel SB, AMP: contributed to the analysis and interpretation of the research findings provided a critical review of the draft manuscript and assisted with data interpretation and contributed to the final revisions of the manuscript.

Ethical Approval

Use of artificial intelligence tools-

Reference

1. Ajala L, Ologunde MO, Adetuyi FO. Physicochemical and sensory qualities of spiced soy-corn milk. *Afr J Biotechnol.* 2013;12(17):2262-2265.
2. Amadou NM, Richard EA, Waingeh NC, Hélène I, Ndombow YK, Jules-Roger K. Physicochemical and sensory properties of ginger spiced yoghurt. *J Nutr. Ther.* 2017;6(3):68-74.
3. Bureau of Indian Standards. Handbook of food analysis: dairy products. BIS Part XI. New Delhi: Indian Standards Institution; 1981.
4. Eissa EA, Ahmed IM, Yagoub AEA, Babiker EE. Physicochemical, microbiological and sensory characteristics of yoghurt produced from goat milk. *Livest Res Rural Dev.* 2010;22(8):281-286.
5. García-Pérez FJ, Lario Y, Fernández-López J, Sayas E, Pérez-Alvarez JA, Sendra E. Effect of orange fiber addition on yogurt color during fermentation and cold storage. *Color Res Appl.* 2005;30(6):457-463.
6. Geidam YA, Ambali AG, Onyeyili PA. Phytochemical screening and antibacterial properties of organic solvent fractions of *Psidium guajava* aqueous leaf extracts. *Int. J Pharmacol.* 2007;3(1):68-73.
7. Goyal N, Gandhi DN. Comparative analysis of Indian paneer and cheese whey for electrolyte whey drink. *World J Dairy Food Sci.* 2009;4:70-72.
8. Hamid OIA. Effect of cumin oil concentrations on chemical composition and sensory characteristics of Sudanese white cheese during ripening. *Int. J Curr. Microbiol Appl Sci.* 2014;3(4):961-968.
9. Hekmat S, Reid G. Sensory properties of probiotic yogurt compared to standard yogurt. *Nutr Res.* 2006;26(4):163-166.
10. IHEMEJE A, Nwachukwu CN, Ekwe CC. Production and quality evaluation of flavoured yoghurts using carrot, pineapple, and spiced yoghurts using ginger and pepper fruit. *Afr J Food Sci.* 2015;9(3):163-169.
11. International Organization for Standardization. Milk Determination of fat content Gerber butyrometers. ISO 488. Geneva: ISO; 2008.
12. International Organization for Standardization. Dried milk—Determination of titratable acidity. ISO 6091. Geneva: ISO; 2010.
13. International Organization for Standardization. Milk, cream and evaporated milk Determination of total solids content. ISO 6731. Geneva: ISO; 2010.
14. Madsen HL, Bertelsen G. Spices as antioxidants. *Trends Food Sci Technol.* 1995;6(8):271-277.
15. Mahmoudi R. Improvement of hygienic quality and organoleptic properties of bioyoghurt using *Cuminum cyminum* L. essential oil. *J Agroalimnt Proc Technol.* 2013;19(4):405-412.
16. Patel HG, Upadhyay KG. Substitution of milk solids by sweet cream buttermilk solids in manufacture of basundi. *Indian J Dairy Sci.* 2004;57(4):272-275.
17. Pokorný J, Nguyen HTT, Korczak J. Antioxidant activities of rosemary and sage extracts in sunflower oil. *Food Nahrung.* 1997;41(3):176-177.
18. Sonali PL, Smitha B, Aparnathi KD. Sensory attributes and physicochemical characteristics of cultured buttermilk prepared by partial substitution of milk with paneer whey. *Int. J Curr Microbiol Appl Sci.* 2016;5(12):333-348.
19. Yalcin S, Wade VN, Hassan N. Utilisation of channa whey for the manufacture of soft drinks. *GIDA Teknolojisi Dernegi.* 1994;19:351-355.
20. Bhattacharya KR, Sowbhagya CM, Swamy YI. Some physical properties of paddy and rice and their interrelations. *Journal of the Science of Food and Agriculture.* 1971 Feb;23(2):171-86.
21. Hogendoorn H, Vismans MM. Controlled propagation of the African catfish, *Clarias lazera* (C. & V.): II. Artificial reproduction. *Aquaculture.* 1980 Sep 1;21(1):39-53.
22. Otaibi MA, Demerdash HE. Improvement of the quality and shelf life of concentrated yoghurt (labneh) by the addition of some essential oils. *African Journal of Microbiology Research.* 2008 Jul 1;2(7):156-61.