Standardization of the method for utilization of paneer whey in cultured buttermilk

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Abstract Whey is a liquid by-product obtained during manufacture of coagulated milk products like paneer, cheese etc. Its disposal as waste leads to heavy load in dairy effluent and loss of valuable milk solids. For efficient and economic utilization of whey, a method was standardized for the preparation of cultured butter milk using paneer whey as one of the ingredient. It involved fermentation of paneer whey and double toned milk separately using starter culture containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*. The paneer whey can be successfully incorporated up to 50 % by following the standardized method. The proximate chemical composition of cultured buttermilk was 8.31 % total solids, 2.26 % protein, 1.12 % fat, 4.42 % lactose and 0.56 % ash. The cultured buttermilk has acceptable sensory qualities and shelf life of 5 days under refrigerated condition.

Keywords Cultured butter milk · Paneer whey · Curd · Fermentation · Sensory qualities

Introduction

Buttermilk, a popular fermented beverage in India, (Mathur 1991) is not only refreshing, delicious and thirst quenching but also possess nutritional and therapeutic values. The available literature on buttermilk is scanty. Now a days, various types of buttermilk are available in the market like plain and spiced varieties. The quantum of scientific evidence demonstrated, based on clinical evidence has been overwhelming

and revealed many beneficial effects of fermented milks (Steinkraus 1994), thus carving a definite niche for these products as health foods. The nutritive value of fermented milk products is derived from the various metabolites produced by lactic acid bacteria during fermentation, besides nutrients available from the milk. Some of reported nutritional and physiological benefits of fermented milks are promotion of growth and digestion, implantation in gastro intestinal tract (GIT) thereby restoring the normal intestinal flora, improving bowel movement, ameliorating immunity and lowering blood cholesterol (Welch 1987; Yukuchi et al. 1992; Sanders 1994; Buttriss 1997). The anticholesterolaemic effect of fermented milk has been reported by many workers (Thakur and Jha 1981; Chawla and Kansal 1983). The therapeutic value of fermented milk has been clearly established by the researchers (Perdigon et al. 1986; Saavedra et al. 1994).

Generally, whey is of two types, i.e. Whey obtained during paneer (acid whey) or casein production (sweet whey). The type of whey produced will depend on the method used for precipitation. Whey is a good source of micronutrients. It contains whey proteins α -lactalbumin, β -lactoglobulin, immunoglobulin and serum albumin. It contains various vitamins (riboflavin, niacin, vitamin C, etc.), lactoferrin, lactoperoxidase and NPN compound. Research has been unequivocally established the excellent nutritional and functional properties of whey solids, especially the whey proteins (Jelen 2002 and Patel et al. 1992). The biological value (BV), protein efficiency ratio (PER) and net protein utilization (NPU) of egg and whey protein are 104, 3.6 and 92; and 100, 3.8 and 94 respectively (Renner 1986). Whey contains majority of the minerals such as calcium, phosphorous, potassium, magnesium, chloride, zinc, citrate, etc. Whey proteins are also a good source of sulfur-containing amino acids such as lysine, cysteine and methionine (Fox and McSweeney 1998).

Whey protein has potential as a functional food component to contribute to the regulation of body weight by providing satiety signals that affect both short-term and long-term food

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intake regulation (Khamrui and Rajorhia 1998). As whey is an inexpensive source of high nutritional quality protein, the utilization of whey as a physiologically functional food ingredient for weight management is of current interest.

Growing concern on the disposal of whey and related pollution control issues has compelled the dairy to find alternate ways for utilization of this by-product. At the same time recent investigations have established the potential nutritional value of the whey solids beyond dispute. In light of the global food shortage, the most logical use would be to return whey to the human food chain in a palatable form. Attempts to utilize the nutritive components of whey more completely in human food formulations with minimum of energy, material, labour and processing costs, are amongst the deciding factors in selecting the methods for utilization of whey.

Considering the nutritional value of whey, as well as its disposal problems and related issues of environment pollution, attempts to incorporate whey in buttermilk not only help in its utilization but also provide nutritional benefits.

Methods and materials

Double toned milk (1.5 % fat and 9 % Solids not fat (SNF); mixed milk marketed under ‘AMUL’ brand) obtained from *Vidya shoppe*, Anand was used for making Dahi. GM brand cumin was obtained from the local market of Anand. It was added after finely crushing in mixer at the rate of 0.4 % w/v of cultured buttermilk. Tata brand common salt was obtained from the local market of Anand. It was added at 0.5 % w/v of cultured buttermilk. ‘Sagar’ brand skim milk powder (SMP) was obtained from the *Vidya shoppe* Anand.

Preparation of cultured buttermilk

Double toned milk (1.5 % fat/9 % SNF) was used to prepare the Dahi and standardized pasteurized milk (mixed milk) was used to prepare the whey. The milk was preheated to 35–40 °C, and then filtered using muslin cloth. For standardization of SNF of final buttermilk, skimmed milk powder was used, wherever necessary. The milk was inoculated with starter culture at the rate of 2 % and incubated at 37±2 °C for 5 h. Paneer whey was prepared using the method given by (Sachdeva and Singh 1988). The flow diagram for preparation of cultured buttermilk is given in Fig. 1.

Dahi was stirred using a mechanical stirrer and cooled to less than 10 °C.

The paneer whey (30 %) was incorporated by any one of the following three modes. The control sample designated as ‘T₁’ contained water (30 %) in place of whey. All the samples of milk, paneer whey and mixture of milk with paneer whey were inoculated with (*Lactobacillus acidophilus*) culture at the rate of 2 % and incubated at 37 °C till the samples attained

desired acidity (0.5 % lactic acid). After setting of the curd, all the samples were cooled in the refrigerator. Four different types of cultured buttermilk were prepared by (a) addition of water at the rate of 30 % in curd, followed by mixing (‘T₁’ i.e. control), (b) addition of unfermented paneer whey at the rate of 30 % in to the curd, followed by mixing (‘T₂’), (c) addition of paneer whey at the rate of 30 % in to the milk followed by fermentation of the blend mixing (‘T₃’), (d) addition of fermented paneer whey at the rate of 30 % in to curd, followed by mixing (‘T₄’).

Selection of starter culture

Various cultures were tried for making Dahi, with a view to obtain cultured buttermilk with good consistency. *Lactobacillus delbrueckii* subsp. *bulgaricus* (Lb₂), *Streptococcus thermophilus* (MD₂), *Lactobacillus helveticus* MTCC 5463 (previously known as *Lactobacillus acidophilus*, V₃) and *Lactobacillus rhamnosus* MTCC 5462 (L₄) were subjected to screening in the phase of optimization of fermentation process. The cultures were added at the rate of 2 % and paneer whey was incorporated at the rate of 30 %. Samples were incubated in an incubator maintained at 37 °C. All the cultures were obtained from Department of Dairy Microbiology, SMC college of Dairy Science, Anand. The performance of these strains was evaluated by using them individually and in combination.

Physico-chemical analysis

The cultured buttermilk were analyzed for total solids (TS), protein, fat and ash as per methods advocated by Bureau of Indian standards (BIS 1981). The density was determined using specific gravity bottle at 27 °C. Viscosity of cultured buttermilk was determined by using ‘Brook field’ viscometer (DV II + Pro Viscometer, Model- LVDV- II + P, USA).

Soluble nitrogen content was estimated by the method outlined by Kosikowski (1970).

Sensory evaluation

The cultured buttermilk were analyzed for sensory characteristics by a panel of six judges using 9-point hedonic scale.

The cultured buttermilk were judged for flavor, colour and appearance, body and texture and overall acceptability. The maximum score for all characteristics were 9.

Statistical analysis

Statistical analysis of data was carried out by applying completely randomized design (CRD) (Steel and Torrie 1980). The data obtained during storage study of cultured buttermilk were subjected to statistical analysis using Factorial completely randomized design (FCRD).

Fig. 1 Generalized flow diagram for preparation of cultured buttermilk. * Optional, added for studies using additives (as discussed under Table 6 and further)

Results and Discussion

Selection of mode of addition of whey

Cultured buttermilk obtained by three possible modes viz., (a) mixing unfermented whey with curd ('T₂'), (b) mixing the unfermented whey in milk and fermenting this blend ('T₃'), and (c) fermentation of whey and mixing the fermented whey with curd ('T₄'), were analyzed for their sensory characteristics and their titratable acidity values (Table 1). The cultured buttermilk obtained by fermenting whey and milk separately, followed by addition of the fermented whey to the curd ('T₄') scored highest for overall acceptability and titratable acidity amongst all the samples. The sample 'T₄' had optimum viscosity desired for butter milk as well clean pleasing flavour. Whereas other samples viz., 'T₂', ('T₄' and ('T₄')The

overall acceptability score of cultured buttermilk prepared by addition of unfermented whey to curd ('T₂') was lowest amongst all the samples. Thus, direct incorporation of unfermented whey significantly decreased the overall acceptability. Therefore, in preparation cultured buttermilk, fermenting whey separately and subsequent addition of the fermented whey in to the curd was selected as the mode of addition of the whey.

Thus, it had become evident that the direct incorporation of unfermented paneer whey significantly decreased the flavour score of the cultured buttermilk, when compared with flavour score of the cultured buttermilk, wherein paneer whey was fermented in combination with milk. This may be attributed lack of typical taste and aroma of the unfermented paneer whey, since paneer whey without fermentation has watery and salty taste and bland aroma. Fermentation had eliminated

Table 1 Effect of mode of addition of whey on sensory profile and titratable acidity of cultured buttermilk

Mode of addition of paneer whey	Sensory score *				Titratable acidity* (% lactic acid)
	Flavour	Colour and appearance	Body and texture	Overall acceptability	
Control (T ₁)	7.09 ^a	7.54	7.20	7.21 ^a	0.55 ^a
Unfermented paneer whey in curd (T ₂)	6.38 ^b	7.66	7.41	6.44 ^b	0.57 ^a
Paneer whey in milk, followed by fermentation (T ₃)	7.21 ^a	7.64	7.48	7.21 ^a	0.58 ^a
Fermented paneer whey in curd (T ₄)	8.15 ^c	7.84	7.59	8.12 ^c	0.61 ^b
SEM	0.181	0.064	0.116	0.163	0.163
CD	0.544	NS	NS	0.489	0.048

*Values with same superscript in each column do not differ significantly ($P < 0.05$), $n = 5$

the adverse of effect of paneer whey on flavour of cultured buttermilk, with concomitant improvement in product. The beneficial effect of fermenting paneer whey of flavour score of cultured buttermilk may be aroused from formation of typical compounds from components of paneer whey by fermentation, which contributed to aroma and taste of the product. The significant better flavour score obtained in case of fermentation of paneer whey alone might be attributed to possible elimination of interference from components of fat, casein, etc. or their degradation products in fermentation process. Van der Schaft (1995) found that fermentation of paneer whey using *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* produces a more intense yogurt flavor compared with that obtained when skim milk is fermented.

Therefore, better performance of fermenting paneer whey alone followed by its addition in curd compared to fermenting paneer whey along with milk for preparation of buttermilk is in general agreement with results reported in the literature for differences in flavour development through fermentation of paneer whey and that of the milk. In lactic acid bacteria citrate is transported to cell and metabolized to pyruvate, which is further converted in to various aroma compounds like formate, acetate, acetaldehyde, diacetyl, acetoin, etc. Thus, one of the reasons attributed for better flavour score of cultured buttermilk prepared with fermented paneer whey to presence of citrate in the paneer whey and its utilization of formation flavour compounds. Therefore, results obtained in present study for effect of mode of addition of paneer whey on flavour of cultured buttermilk are in general accordance with those reported in the literature.

The paneer whey contained about 6.5 % total solid. Therefore, incorporation of paneer whey into cultured buttermilk in place of water contributes to total solids content of the resultant cultured buttermilk, which in turn improved the colour and appearance score of the product. Colour and appearance score of cultured buttermilk obtained from addition of unfermented paneer whey and the cultured buttermilk obtained from fermenting blend of milk and paneer whey was almost similar. Use of fermented in preparation of cultured buttermilk improved the colour and appearance score of resultant product. Therefore, cultured buttermilk obtained from addition of fermented paneer whey in curd had the highest colour and appearance score. The slight improvement in colour and appearance of cultured buttermilk due to fermentation of paneer whey may be attributed physicochemical changes taking place in components of paneer whey by process of fermentation.

In case of cultured buttermilk from unfermented paneer whey physicochemical changes occurring in protein of paneer whey used were lacking. Lack of such changes in protein of paneer whey used may be responsible for low sensory score of resultant cultured buttermilk. This addition of water diluted the total content of the curd and gave watery appearance to the product, which intern caused lowering of body and texture

score of the product. The paneer whey contained about 6.5 % total solid. Therefore, incorporation of paneer whey into cultured buttermilk in place of water contributes about to total solids content of the resultant cultured buttermilk and improved the body and texture score of the product. Body and texture score of cultured buttermilk obtained from addition of unfermented paneer whey and the cultured buttermilk obtained from fermenting blend of milk and paneer whey was almost similar. Use of fermented in preparation of cultured buttermilk improved the body and texture score of resultant product. Therefore, cultured buttermilk obtained from addition of fermented paneer whey in curd had the highest body and texture score. The slight improvement in body and texture of cultured buttermilk due to fermentation of paneer whey may be attributed physicochemical changes taking place in components of paneer whey by process of fermentation.

The direct incorporation of unfermented paneer whey significantly decreased the overall acceptability score of the cultured buttermilk, when compared with overall acceptability score of conventional cultured buttermilk. This may be attributed lack of typical flavour in unfermented paneer whey and other associated changes constituents paneer whey. Thus, incorporation of paneer whey into milk before fermentation eliminates the adverse of effect of paneer whey on overall acceptability of cultured buttermilk. This effect may be attributed to changes taking place in component of paneer whey during fermentation.

Selection of starter culture

The primary role of starter culture in fermented dairy products is production of lactic acid from lactose by fermentation. However, in addition to the production of acid it also plays several other important functions. Selection of starters is based on the rate of acid production, flavour production, proteolysis, lipolysis, bacteriocin production, tolerance to adverse conditions, etc. (Deka et al. 1984; Sodini et al. 2002).

Cultured buttermilks prepared by the addition of fermented paneer whey in the curd i.e. mode selected in the previous phase ('T₃') by following the method illustrated in Fig. 1, were judged for sensory characteristics and were analyzed for titratable acidity (Table 2).

The data shows that there was no significant difference in the sensory attributes of the cultured buttermilk prepared using the individual starter cultures but they do differ significantly in values for acidity.

Since none of the individual starter culture tried for preparation of cultured butter milk by 'T₄' mode gave products with satisfactory acceptability (above 7.5), four different combinations of the above referred three starter cultures i.e. 'SC₁' (*Streptococcus thermophilus*, *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Lactobacillus helveticus*), 'SC₂' (*Streptococcus thermophilus* and *Lactobacillus helveticus*), 'SC₃'

Table 2 Effect of individual starter culture on sensory profile and titratable acidity of cultured buttermilk

Starter culture	Sensory score*				Titratable acidity* (% lactic acid)
	Flavour	Colour and appearance	Body and texture	Overall acceptability	
<i>Streptococcus thermophilus</i>	6.68	7.38	7.31	6.71	0.63
<i>Lactobacillus helveticus</i>	7.01	7.40	7.37	7.09	0.58 ^a
<i>Lactobacillus delbrueckii</i> subsp. <i>bulgaricus</i>	6.59	7.70	7.21	6.89	0.60 ^a
<i>Lactobacillus rhamnosus</i>	6.56	7.31	7.18	6.54	0.52
SEM	0.268	0.136	0.158	0.261	0.007
CD	NS	NS	NS	NS	0.022

*Values with same superscript in each column do not differ significantly ($P < 0.05$), $n = 5$

(*Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*) and ‘SC₄’ (*Lactobacillus delbrueckii* subsp. *bulgaricus* and *Lactobacillus helveticus*) were screened.

Different types of interactions can occur in strain mixtures and affect culture performance (Hugenholtz 1986). This could lead to desirable changes in acidification and modification of texture and organoleptic properties of cultured dairy products (Pescumaa et al. 2008).

It is evident from the data that the selection of starter combination has a significant effect on overall acceptability of the cultured buttermilk. In case of ‘SC₃’ combination shows highest scores as compared to other culture combinations used. This may be attributed to its ability to produce flavour producing volatile compound by fermentation of the product. It was appeared from the overall acceptability of the scores of cultured buttermilk prepared by fermentation using ‘SC₂’ combination shows slightly lower score than that of ‘SC₃’ combination. This may be attributed to its efficiency of utilization of various metabolic product is lower. It was observed from the overall acceptability score of the cultured buttermilk prepared by fermentation using ‘SC₁’ combination shows slightly lower scores than that of ‘SC₂’ combination. The data suggested that the use of ‘SC₄’ combination during preparation of cultured buttermilk, gave cultured buttermilk lowest overall acceptability score which may be due to its ability to inability of the cultures to grow symbiotically.

Amongst all the combinations of starter cultures, the combination ‘SC₃’ (*Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*) gave cultured buttermilk with the highest acceptability and acidity value (Table 3). And hence, starter culture comprising of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* (1:1) was selected.

Optimization of whey incorporated in cultured buttermilk

After deciding the mode of addition of whey (‘T₃’) and selecting starter culture (SC₃) for use in preparation of culture buttermilk, further work was carried out to find amount of whey to be incorporated in to the cultured buttermilk to obtain product with best sensory qualities. The result of sensory analysis and acidity of whey incorporated at different rates i.e. 30, 40, 50 and 60 % is shown in Table 4.

The flavor of cultured buttermilk was maximum for the sample containing fermented paneer whey at the rate of 50 %. From the data it can be seen that initially flavour score of the cultured buttermilk improved with increase in amount of paneer whey added, reached to a maximum level of 8.58 and then declined on further increase in rate of paneer whey addition. On increase in rate of paneer whey addition from 30 to 40 %, flavour score of the cultured buttermilk increased significantly. On further increase in rate of paneer whey addition

Table 3 Effect of combination of starter culture on sensory profile and titratable acidity of cultured buttermilk

Starter culture (in combination)	Sensory score*				Titratable acidity* (% lactic acid)
	Flavour	Colour and appearance	Body and texture	Overall acceptability	
SC ₁	7.49 ^a	7.95	7.85	7.44 ^a	0.61
SC ₂	7.63 ^a	7.96	8.00	7.66 ^a	0.59
SC ₃	8.24 ^b	8.11	8.01	8.21 ^b	0.62
SC ₄	6.81 ^c	7.78	7.63	6.81 ^c	0.61
SEM	0.187	0.117	0.129	0.161	0.013
CD	0.563	NS	NS	0.484	NS

*Values with same superscript in each column do not differ significantly ($P < 0.05$), $n = 5$

Table 4 Effect of level of whey addition on sensory profile and titratable acidity of cultured buttermilk

Paneer whey (%)	Sensory score*				Titratable acidity* (% lactic acid)
	Flavour	Colour and appearance	Body and texture	Overall acceptability	
30	7.38 ^a	8.07 ^a	7.99 ^a	7.38	0.60 ^a
40	8.11 ^b	8.14 ^a	8.03 ^a	8.06 ^a	0.60 ^a
50	8.58 ^b	8.07 ^a	8.11 ^a	8.59 ^a	0.61 ^{ab}
60	7.03 ^a	7.21 ^b	6.96 ^b	6.99 ^b	0.64 ^b
SEM	0.154	0.076	0.101	0.122	0.009
CD	0.462	0.228	0.303	0.368	0.028

*Values with same superscript in each column do not differ significantly ($P < 0.05$), $n = 5$

form 40 to 50 %, flavour score of the cultured buttermilk increased further, however this increase in the score was statistically non-significantly. Finally on increase in rate of paneer whey addition form 50 to 60 %, flavour score of the cultured buttermilk decreased significantly. The maximum flavour score of the cultured buttermilk was obtained on addition of paneer whey at the rate of 50 %. The minimum flavour score of the cultured buttermilk was obtained on addition of paneer whey at the rate of 60 %.

From the data it can be seen that initially colour and appearance score of the cultured buttermilk slightly improved with increase in amount of paneer whey added, reached to a maximum level of 8.14 and then declined on further increase in rate of paneer whey addition. On increase in rate of paneer whey addition from 30 to 40 %, colour and appearance score of the cultured buttermilk increased, however this increase in the score was only marginal and statistically non-significantly. On further increase in rate of paneer whey addition form 40 to 50 %, colour and appearance score of the cultured buttermilk decreased further, however this decrease in the score was statistically non-significantly. Finally on increase in rate of paneer whey addition form 50 to 60 %, colour and appearance score of the cultured buttermilk decreased significantly.

The body and texture score of the cultured buttermilk improved with increase in amount of paneer whey added,

reached to a maximum level of 8.11 and then declined on further increase in rate of paneer whey addition. On increase in rate of paneer whey addition from 30 to 40 %, body and texture score of the cultured buttermilk increased marginally and the increase in score was statistically non-significant. Again on further increase in rate of paneer whey addition form 40 to 60 %, body and texture score of the cultured buttermilk increased marginally and the increase in score was statistically non-significant. Finally on increase in rate of paneer whey addition form 50 to 60 %, body and texture score of the cultured buttermilk decreased significantly.

The body and texture, and overall acceptability of cultured buttermilk improved with increase in the rate of addition of fermented paneer whey up to 50 % and then decreased to a minimum at 60 %. The use of different amount of paneer whey in the preparation of cultured butter milk had significant effect on titratable acidity of the resultant cultured butter milk. It can be concluded that fermented paneer whey added to curd (fermented milk) at the rate of 50 % resulted in cultured buttermilk with highly acceptable sensory profile and satisfactory acid development (Table 4).

Addition of SMP

The effect of addition of SMP on the sensory characteristics of cultured butter milk was studied. Milk was first preheated to 40 °C, divided in to four equal parts and SMP was at the rate

Table 5 Effect of addition of SMP on sensory profile and titratable acidity of cultured buttermilk

SMP (%)	Sensory score*				Titratable acidity* (% lactic acid)
	Flavour	Colour and appearance	Body and texture	Overall acceptability	
0	8.30 ^c	7.76	7.50	8.31 ^b	0.61 ^{ab}
0.5	8.00 ^{bc}	7.93	7.96	8.03 ^b	0.63 ^b
1.0	7.40 ^{ab}	8.11	8.22	7.43 ^a	0.63 ^b
1.5	7.21 ^a	7.84	7.51	7.29 ^a	0.59 ^a
SEM	0.187	0.122	0.184	0.185	0.006
CD	0.561	NS	NS	0.556	0.018

*Values with same superscript in each column do not differ significantly ($P < 0.05$), $n = 5$

Table 6 Comparison of sensory profile and titratable acidity of different types of cultured buttermilk

Types of cultured buttermilk	Sensory score*				Titratable acidity* (% lactic acid)
	Flavour	Colour and appearance	Body and texture	Overall acceptability	
MS ₁	7.08 ^a	7.68 ^a	7.25 ^a	7.20 ^a	0.71 ^b
MS ₂	7.20 ^a	7.87 ^b	7.37 ^a	7.64 ^a	0.67 ^c
T ₂ [#]	7.21 ^a	7.50 ^a	7.64 ^b	7.27 ^a	0.56 ^d
T ₄ [#]	8.66 ^b	8.00 ^b	8.29 ^c	8.69 ^b	0.62 ^a
T ₅ [#]	7.87 ^c	8.04 ^b	7.85 ^d	7.81 ^c	0.64 ^a
SEM	0.098	0.102	0.075	0.219	0.008
CD	0.296	0.308	0.228	0.662	0.022

*Values with same superscript in each column do not differ significantly ($P < 0.05$), $n = 5$

containing salt and spice

‘T₂’ stands for cultured buttermilk prepared by adding paneer whey to curd

‘T₄’ stands for cultured buttermilk prepared by adding fermented paneer whey to curd

‘T₅’ stands for cultured buttermilk prepared by adding fermented paneer whey to curd containing SMP

MS₁ and MS₂ stands for market samples 1 & 2 respectively

of 0, 0.5, 1.0 and 1.5 % of the final product. The samples of milk were further heated to 90 °C for 5 min, filtered and cooled to 37 °C. Then cultured buttermilk was prepared from the samples of milk along with fermented paneer whey by following the method as described in Fig. 1.

From the work carried out to evaluate the effect of addition of SMP on sensory attributes and titratable acidity of cultured buttermilk prepared with use of fermented paneer whey, it was revealed that the addition of SMP resulted in to decrease in flavour score and overall acceptability of the product even at the lowest rate (0.5 %) of addition (Table 5). It improved the colour and appearance of the product, however, this improvement was not statistically significant. The addition of the SMP did not make any profound influence on the titratable acidity of resultant cultured buttermilk. (Table 6)

Comparison of different types of cultured buttermilk

It is reported that cultured buttermilk is a lightly salted fermented milk product that is manufactured from low fat milk using mesophilic cultures and flavor-producing organisms (Mistry 2001). In market also salted cultured buttermilk with spice is also available. Therefore, in present study also samples of salted cultured buttermilk with spice comparable to the market samples were prepared. For this cultured buttermilks were prepared by employing methods standardized in the laboratory. However, in preparation of these samples salt and cumin powder were added at the rate of 0.5 and 0.4 % respectively (Fig. 1).

Irrespective of type of buttermilk, the addition of salt and spice (cumin) improved the sensory scores. For the results for titratable acidity of cultured buttermilk revealed that the market sample ‘MS₁’ the spiced and salted cultured buttermilk had

the highest acidity value followed by ‘MS₂’ which were higher and significantly different than the samples prepared by standardized method (by mode ‘T₄’ and culture ‘SC₃’). However ‘T₂’, ‘T₄’ and ‘T₅’, very superior to the market samples of the product with respect to sensory quality. No data about the comparison of cultured buttermilk of any type is available in the literature. The lowest scores of market samples of cultured buttermilk in sensory evaluation may be attributed to their bland flavour, watery consistency, thin body and low acidity compared to the samples prepared by the method standardized in the laboratory using fermented paneer whey. The main reason for relatively lower performance of the market sample was its low total solids content of the market samples. The

Table 7 Chemical composition of cultured buttermilk

Types of cultured buttermilk	Constituents (%)				
	Total solid	fat	protein	Lactose	ash
MS ₁	6.61 ^a	1.05 ^a	2.12 ^a	2.35 ^a	0.52 ^a
T ₂	8.27 ^b	1.05 ^a	2.16 ^a	4.55 ^b	0.56 ^{abc}
T ₄	8.31 ^b	1.12 ^b	2.26 ^a	4.42 ^c	0.56 ^{abc}
T ₅	8.92 ^c	1.15 ^b	2.45 ^b	4.68 ^d	0.63 ^{bc}
SEM	0.026	0.018	0.050	0.019	0.025
CD	0.082	0.057	0.171	0.058	0.077

*Values with same superscript in each column do not differ significantly ($P < 0.05$), $n = 5$

‘T₂’ stands for cultured buttermilk prepared by adding paneer whey to curd, ‘T₄’ stands for cultured buttermilk prepared by adding fermented paneer whey to curd, ‘T₅’ stands for cultured buttermilk prepared by adding fermented paneer whey to curd containing SMP, MS₁ stands for market sample 1

Table 8 Selected characteristics of cultured buttermilk

Types of cultured buttermilk	Characteristics		
	Titrateable acidity (lactic acid %)	Soluble nitrogen (%)	Density (g/ml)
T ₂	0.60 ^a	0.25 ^a	1.035 ^a
T ₄	0.62 ^a	0.40 ^b	1.033 ^a
T ₅	0.65 ^b	0.40 ^b	1.032 ^a
SEM	0.010	0.019	0.003
CD	0.019	0.058	0.010

*Values with same superscript in each column do not differ significantly ($P < 0.05$), $n = 5$

‘T₂’ stands for cultured buttermilk prepared by adding paneer whey to curd, ‘T₄’ stands for cultured buttermilk prepared by adding fermented paneer whey to curd, ‘T₅’ stands for cultured buttermilk prepared by adding fermented paneer whey to curd containing SMP

market samples also tend to form separate paneer whey like layer on standing.

Composition of cultured buttermilk

The fresh samples of cultured buttermilk (also samples of cultured buttermilk contained salt and spice) were analyzed for their TS, protein, fat, lactose and ash content. The data

obtained for chemical composition of fresh samples of cultured buttermilk is presented in Table 7.

Selected characteristics of cultured buttermilk

For satisfactory quality cultured buttermilk (also samples of cultured buttermilk contained salt and spice) other than its composition, its certain physicochemical characteristics are also important. Various parameters of cultured buttermilk viz., density, titrateable acidity, viscosity and soluble nitrogen content were evaluated. Results of the study are depicted in the Table 8. Viscosity of ‘T₂’, ‘T₄’ and ‘T₅’ were 72, 78 and 81 cp respectively at 7 °C.

Storage studies

Stability of cultured buttermilk, during storage is of vital importance and crucial for commercial success of the product. Cultured buttermilk especially being a fermented product containing viable microorganisms, various issues may be expected during storage. Therefore, different types of cultured buttermilk prepared in the laboratory were studied for their storage stability. The different types of cultured buttermilk i.e. cultured buttermilk prepared by (a) adding paneer whey to curd (‘T₂’), (b) adding fermented paneer whey to curd (‘T₄’) and (c) adding fermented paneer whey to curd containing

Table 9 Effect of storage on sensory characteristics of cultured buttermilk

		1	2	3	4	5
		Flavour				
	T ₂	7.08	6.77	6.5	6.19	4.77
	T ₄	8.60	8.25	8.02	7.49	6.01
	T ₅	7.58	7.41	7.05	6.41	4.69
	CD(0.05)	T=0.316, P=0.341, TxP=NS, CV%=7.142				
		Colour and appearance				
‘T ₂ ’ stands for cultured buttermilk prepared by adding paneer whey to curd	T ₂	7.83	7.61	7.44	7.41	7.32
	T ₄	7.91	7.91	7.66	7.55	7.41
	T ₅	7.85	7.83	7.58	7.46	7.35
‘T ₄ ’ stands for cultured buttermilk prepared by adding fermented paneer whey to curd	CD(0.05)	T=NS, P=0.211, TxP=NS, CV%=4.146				
		Body and texture				
‘T ₅ ’ stands for cultured buttermilk prepared by adding fermented paneer whey to curd containing SMP	T ₂	7.58	7.47	7.38	6.94	5.97
	T ₄	8.13	7.88	7.83	7.44	6.36
	T ₅	8.05	7.71	7.52	7.27	5.60
‘T’ stands for differences due to treatments i.e. ‘T ₂ , T ₄ ’, and T ₅ ’	CD(0.05)	T=0.221, P=0.239, TxP=NS, CV%=4.813				
		Overall acceptability				
‘P’ stands for differences due to storage period (days)	T ₂	7.02	6.8	6.41	6.19	4.74
	T ₄	8.60	8.19	7.96	7.41	6.50
‘TxP’ for difference due to interaction between treatment and period	T ₅	7.74	7.32	6.95	6.30	4.52
	CD(0.05)	T=0.126, P=0.136, TxP=0.333, CV%=2.938				

‘T₂’ stands for cultured buttermilk prepared by adding paneer whey to curd

‘T₄’ stands for cultured buttermilk prepared by adding fermented paneer whey to curd

‘T₅’ stands for cultured buttermilk prepared by adding fermented paneer whey to curd containing SMP

‘T’ stands for differences due to treatments i.e. ‘T₂’, ‘T₄’, and ‘T₅’

‘P’ stands for differences due to storage period (days)

‘TxP’ for difference due to interaction between treatment and period

SMP('T₅') were stored at 7±1 °C in sealed glass bottles. The samples were monitored for changes in sensory attributes and acidity. The evaluation was continued till the product remained acceptable in sensory analysis. The results obtained for sensory evaluation of fresh and stored cultured buttermilk are presented in the Table 9.

From the work carried out for storage study of the cultured buttermilk it is evident that the all sensory attributes of cultured buttermilk prepared with fermented paneer whey ('T₄') remained above the acceptable level for 5 days (Table 9). Coliform count in all samples were zero. Thus, the keeping quality of the cultured buttermilk prepared with fermented paneer whey was five days, which was in general agreement with the data reported in the literature. Some variation in keeping quality of the cultured buttermilk may be attributed to variation in composition of the product, rate of addition of starter culture and temperature of the storage.

Conclusion

It can be concluded that a good quality cultured buttermilk can be prepared by the method standardized in the laboratory i.e. by employing culture containing *Streptococcus thermophilus* and *Lactobacillus delbrückii* subsp. *bulgaricus* in 1: 1 ratio, followed by incubation at 37 °C for 5 h. The fermented whey can be successfully incorporated to the extent of 50 % of curd. The resultant cultured butter milk was of acceptable sensory qualities. Salt (0.5 %) and spice (0.4 %) can be incorporated in to the cultured buttermilk to improve the sensory attributes of the product. The overall acceptability score of cultured buttermilk went below acceptable level on 5th day of storage when the sample was stored in glass bottles at 7±2 °C. Salt (0.5 %) and spice (0.4 %) can be incorporated in to the cultured buttermilk to improve the sensory attributes of the product.

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