Research Article • DOI: 10.1515/ijafr-2015-0008 IJAFR • 54(2) • 2015 • 73–78

Irish Journal of Agricultural and Food Research

Mixing sweet cream buttermilk with whole milk to produce cream cheese

Masoud Bahrami[1*], Dariush Ahmadi[1], Faranak Beigmohammadi[1], and Fakhrisadat Hosseini[2]

[1]Department of Food Science and Technology, College of Agriculture, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran.
[2]Standard Research Institute, Karaj, Iran.

Abstract

Buttermilk is an important by-product of the manufacture of butter. Sweet-cream buttermilk (SCBM) is similar in composition to skim milk, except for its high phospholipid and milk fat globular membrane protein content. The main objective of this investigation was to produce optimum quality cream cheese by replacing whole milk with different proportions of SCBM (5, 10, 15, 20, 25, 30, 35, 40, 45, and 50%). Statistical analysis showed that there were significant differences ($p < 0.05$) between the chemical and organoleptic properties of the samples. As the percentage of SCBM increased, the chemical composition of total solids, fat, protein, fat in dry matter (FDM) and ash of cheese milk decreased significantly, leading to a softer, moister curd. Samples prepared with more than 25% SCBM were not acceptable to the taste panel. The cream cheeses prepared using 25% and 30% SCBM had the highest yields. Total solids and FDM were strong predictors of cheese yield ($r^2 \approx 0.589$). The results also showed that the best range for replacement using SCBM is 20–25%.

Keywords

buttermilk • cream cheese • cheese yield • sensory properties

Introduction

Cheese is a generic term for a diverse group of milk-based food products. Hundreds of types of cheese are produced in a range of flavours, textures and forms (Barry and Tamime 2010). Cream cheese is one of the most popular cheeses and is normally produced using fresh whole milk (Jeon *et al*. 2012). Cream cheese is an acid coagulated, unripened, creamy-white cheese with a slightly acidic taste, a mildly diacetyl flavour, high moisture and high fat content (Kosikowski and Mistry 1997).

There is a wide variety of cream cheese types made with different amounts of dry matter and fat. Cream cheese is often spread on bread, bagels and crackers; used as a dip for potato chips and snacks; and in salads (Brighenti *et al*. 2008). Buttermilk is an important by-product of the manufacture of butter. It is a source of nutrients, such as lactose, protein, minerals and vitamins (Sodini *et al***.** 2006). The chemical composition of buttermilk varies substantially, depending on the production method, source of the milk and amount of water added during churning (Salhab 1998). Buttermilk is most similar in composition to skim milk, except for its high phospholipid and milk fat globule membrane fragment content (Pal and Garg 1989).

The use of buttermilk solids as a health food has been a focus of study. El-Sayed *et al*. (2006) reported that processed cheese spread containing 30% buttermilk concentrate significantly decreased ($p < 0.05$) total and low-density lipoprotein cholesterol content when fed to rats. Buttermilk solids have been demonstrated to possess antioxidant properties and have been suggested for use in stabilising food matrices against lipid peroxidation reactions (Wong and Kitts 2003).

Dairies, particularly in Iran, are confronted with the problem of disposing of manufacturing by-products. In Iran, buttermilk is only used in small quantities in the production of Doogh and in milk standardisation. Doogh is a savoury yogurt-based beverage popular in Iran, Afghanistan, Armenia, Iraq and Syria. It is sometimes carbonated and seasoned with mint.

Buttermilk is generally discharged as a waste product and is a major pollutant containing biological oxygen (Shodjaodini *et al*. 2000). One way to increase the demand for buttermilk is to find attractive uses for it as a cheese ingredient. Buttermilk has long been used as an ingredient in cheesemaking, and there is growing interest in the cheese industry for cheeses with specific functional/nutritional properties, and ways to cost-effectively increase yield (Govindasamy-Lucey *et al*. 2006).

Several studies have examined the technological effects of buttermilk in the manufacture of dairy products such as Cheddar, feta, cottage, mozzarella and pizza cheeses and fermented milks (Joshi and Thakar 1993**;** Poduval and Mistry 1999; Gokhale *et al*. 1999; Shodjaodini *et al*. 2000**;**

*Corresponding author: Masoud Bahrami
E-mail: bahrami807@yahoo.com

DE GRUYTER OPEN

Govindasamy-Lucey *et al*. 2006; Kumar and Gupta 2012). The objectives of this study were, first, to investigate the impact of using different levels of SCBM on cream cheese manufacture including yield and chemical and sensory properties and, second, to demonstrate the effect of the addition of buttermilk as a functional ingredient in the production of cream cheese.

Materials and Methods

Milk and SCBM

Raw cow's milk and SCBM used in this study were obtained from a local dairy processor. The experimental treatments consisted of a control sample and different levels of whole milk were replaced by SCBM as follows:

T_0: whole milk 100%; T_1: whole milk 95% + SCBM 5%; T_2: whole milk 90% + SCBM 10%; T_3:whole milk 85% + SCBM 15%; T_4: whole milk 80% + SCBM 20%; T_5: whole milk 75% + SCBM 25%; T_6: whole milk 70% + SCBM 30%; T_7: whole milk 65% + SCBM 35%; T_8: whole milk 60% + SCBM 40%; T_9: whole milk 55% + SCBM 45%; and T_{10}: whole milk 50% + SCBM 50%.

Starter culture

Acidification is the basic process in the production of the majority of cheese varieties. Starter culture FRC-65, containing *Lactococus lactis* ssp. *cremoris* and *L. lactis* ssp. *lactis*, *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus* were supplied from Chr. Hansen Co. (Copenhagen, Denmark). These cultures are currently used by the dairy industry to produce cheese. The packages of starter culture were prepared according to the manufacturer's instructions. Animal rennet with trade mark Caglificio Clerici was purchased from Cadarago Co. (Italy) and was added to milk (0.245 g/kg).

Manufacture of cream cheese

Cream cheese was produced according to the method of Kosikowski and Mistry (1997). The cream cheese was produced from whole milk (control sample) by blending SCBM and whole milk. The samples were homogenised (12–14 MPa at 50–55ºC), pasteurised (65ºC for 30 min) and cooled to the incubation temperature of approximately 30°C. The mixture was then inoculated with 5% lactic culture and incubated for approximately 5 h. The mix is held at the specific temperature until it reached the desired pH of 4.5–4.8, and the rennet was added followed by incubation for 40–45 min for coagulation. The resulting coagulum was gently stirred and heated (for more effective whey separation) to 50–55ºC in a ripening tank for the batch method. The separated whey was drained and salt was added (1% of curd weight) with mixing for 5 min. The curd was then transferred into plastic moulds and pressed (2 kg/cm^2) for 2 h. The resulting cheese was then stored at 4ºC.

Determination of moisture content

Moisture content in cream cheese was determined by Method No. 926.08 of AOAC (1990). To determine the moisture content, porcelain dishes containing sand were dried in a hot air oven (Haraeus, VT 5042EK, Germany) at 103°C for 1 h, and after cooling, the weight (W_1) was measured, and later in each dish, 2 g sample (W_2) was mixed with the help of glass rod. The prepared samples were placed in hot air oven at 103 ± 5°C until a constant weight was obtained. Weight (W_3) of the dishes was recorded after samples were cooled in a desiccator. Moisture was calculated by using the following expression: moisture % = $(W_3 – W_1) \times 100/(W_2 – W_1)$.

Measurement of titratable acidity

The acidity was estimated by titration Method No. 920.124 of AOAC (1995). One gram of each cream cheese sample was mixed with warm water and the volume was made up to 10 ml in a 100 ml conical flask; each sample was shaken vigorously and filtered with Whatman paper No. 40. The filtrate was titrated with 0.1 N NaOH using phenolphthalein as indicator. Percent acidity was calculated by using the following expression: Titratable acidity % = 0.009 × volume of NaOH used × 100/weight of sample.

Estimation of pH

A sample (20 g) of cream cheese was blended with 12 ml water to prepare the cream cheese slurry and the pH was measured by a pH meter (Mettler Toledo MP220, Switzerland) after calibrating it with fresh standard buffer solutions of pH 4.0 and 7.0 (Ong *et al*. 2007).

Protein and fat determination

Protein in the cream cheese was determined by the Kjeldahl procedure (total percentage N × 6.35) according to Method No. 991.20 of AOAC (1995). Fat in the cream cheese was estimated by Method No. 991.20 of AOAC (1995).

Measurement of ash and total Solids

Ash samples were dried at 100°C for 4 h and then ashed at 550°C for 12 h, according to Method No. 935.42 of AOAC (1995). Total solids were estimated by Method No. 948.12 of AOAC (1995).

Measurement of cheese yield

Actual cheese yield was calculated for each vat of cheese as the weight of the cheese divided by the weight of the original

standardised milk multiplied by 100 (IDF, 1993, No. 9301). The moisture-adjusted cheese yields (Y_{MA}) were arithmetically calculated from actual yields (Y_A) based on the formula:
$Y_{MA} = Y_A \times (100 - \text{actual moisture})/(100 - \text{reference moisture})$ (McSweeney, 2007).

Sensory evaluation

The sensory quality of the cream cheese was determined by 12 trained panelists. The attributes determined were appearance (score 0.5–2), colour (score 0.5–1), body (score 0.5–2), texture (score 0.5–3), odour (score 0.5–2) and taste (score 0.5-10) and were evaluated according to the procedures of Sathya *et al*. (2012). The highest attainable total score was 20.

Statistical analysis

The experimental design was a completely randomised design with 11 treatments. All data were analysed using SPSS version 17.0.0. for Windows (SPSS Inc., USA) with a one-way analysis of variance (ANOVA). Differences between means were compared by Duncan's multiple range tests at a level of 0.05. Interaction between composition of cheese milk and yield was studied using multiple regressions. All compositional analyses for each sample were carried out in triplicate.

Results and Discussion

The chemical analysis of raw milk, SCBM and the treatments are shown in Table 1. As seen, the amount of total solids, fat, protein and ash of SCBM was lower than that for raw milk because they are released with the removal of buttermilk during the butter-making process.

The analysis of average variance of the chemical compounds of the primary mixtures shows that the amount of these compounds significantly decreased ($p < 0.05$) in all treatments. Buttermilk contains less total solids, fat, protein and SCBM ash than raw milk; increasing the proportion of SCBM in the primary mixture decreased the percentages of these components. Chemical analyses of cream cheese samples made from raw milk and made with different proportions of SCBM are shown in Table 2.

Total solids

A comparison of mean total solids for the treatments revealed significant differences ($p < 0.05$). As the proportion of SCBM increased, the percentage of total solids in the cream cheese fell, probably as a result of the decrease in total solids in the SCBM. Pal and Garg (1989) found that the percentage of total solids decreased because of the presence of lipoprotein compounds, particularly phospholipids and membrane proteins; these compounds increase the water retention capacity and, thus, increase the moisture content. Curds that had a larger proportion of SCBM at cutting time lost less whey; thus, the proportion of moisture in the cream cheese curds was greater and their total solids were lower.

Fat

The difference between the amount of fat in different treatments was significant ($p < 0.05$). Because the proportion of fat in SCBM was low, the percentage of cheese fat decreased as the proportion of SCBM in the mixture increased. The decreased level of fat is probably a result of the release of whey during curd cutting (Kosikowski and Mistry 1997).
Analysis of FDM data between treatments showed a significant difference ($p < 0.05$) in the amount of fat in the total solids of

Table 1. Chemical properties of whole milk, sweet cream buttermilk (SCBM) and mixtures of these products

Factor	SCBM	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
Total solid (%)	10.25^{f}	12.33^{a}	12.27^{a}	12.12^{ab}	12.06^{ab}	11.95^{b}	11.79^{bd}	11.75^{bd}	11.6^{d}	11.51^{de}	11.41^{e}	11.32^{e}
Fat (%)	1.33^{f}	3.58^{a}	3.51^{a}	3.39^{b}	3.26^{bc}	3.14^{c}	3.03^{c}	2.95^{cd}	2.77^{cd}	2.67^{d}	2.61^{d}	2.44^{e}
Protein (%)	3.05^{e}	3.54^{a}	3.52^{a}	3.48^{a}	3.46^{ab}	3.43^{b}	3.41^{bc}	3.4^{c}	3.36^{c}	3.34^{cd}	3.31^{d}	3.29^{d}
PFR*	2.29^{a}	0.98^{f}	1.00^{f}	1.02^{f}	1.06^{e}	1.09^{e}	1.12^{d}	1.15^{d}	1.21^{c}	1.25^{c}	1.26^{c}	1.34^{b}
Ash (%)	0.681^{d}	0.72^{a}	0.719^{a}	0.717^{a}	0.715^{a}	0.713^{ab}	0.709^{abc}	0.710^{abc}	0.703^{abc}	0.695^{bcd}	0.692^{cd}	$.0.690^{cd}$
pH	6.63^{a}	6.6^{a}	6.61^{a}	6.62^{a}	6.63^{a}	6.63^{a}	6.63^{a}	6.62^{a}	6.62^{a}	6.64^{a}	6.6^{a}	6.64^{a}
Acidity (%)	0.141^{c}	0.145^{a}	0.143^{abc}	0.144^{ab}	0.143^{abc}	0.144^{ab}	0.144^{ab}	0.143^{abc}	0.142^{bc}	0143^{abc}	0.142^{bc}	0.142^{bc}

Within the same row, the values with the different letter are significantly different ($p < 0.05$).
****PFR, protein-to-fat ratio; T_0: whole milk 100%., T_1: whole milk 95% + SCBM 5%, T_2: whole milk 90% + SCBM 10%, T_3:whole milk 85% + SCBM 15%, T_4: whole milk 80% + SCBM 20%, T_5: whole milk 75% + SCBM 25%, T_6: whole milk 70% + SCBM 30%, T_7: whole milk 65% + SCBM 35%, T_8: whole milk 60% + SCBM 40%, T_9: whole milk 55% + SCBM 45% and T_{10}: whole milk 50% + SCBM 50%***

Table 2. Chemical properties of cream cheese made of whole milk and with mixtures of sweet cream buttermilk (SCBM)

Treatment	Total solid (%)	Fat (%)	Protein (%)	FDM (%)	Ash (%)	pH	Acidity (%)	Y_A (%)	Y_{MA} (%)	PFR
T_0	37.68^{a}	10.48^{a}	15.53^{a}	28.41^{a}	1.34^{a}	4.43^{b}	0.43^{a}	18.16^{bc}	17.11^{a}	1.48^{g}
T_1	37.52^{a}	10.39^{a}	15.37^{b}	28.39^{a}	1.32^{a}	4.43^{b}	0.42^{a}	17.95^{d}	16.84^{b}	1.47^{g}
T_2	37.16^{ab}	9.48^{b}	15.24^{bc}	27.43^{b}	1.25^{ab}	4.44^{b}	0.40^{b}	17.51^{ef}	16.27^{cd}	1.60^{f}
T_3	36.74^{b}	8.71^{c}	15.05^{c}	26.48^{bc}	1.18^{b}	4.44^{b}	0.39^{bc}	17.35^{f}	15.94^{d}	1.72^{e}
T_4	36.23^{c}	8.42^{c}	14.41^{d}	26.1^{c}	1.15^{b}	4.45^{ab}	0.38^{cd}	18.26^{b}	16.54^{bc}	1.72^{e}
T_5	35.01^{d}	7.15^{d}	13.78^{de}	22.68^{d}	1.12^{b}	4.45^{ab}	0.38^{cd}	19.73^{a}	17.03^{a}	1.92^{d}
T_6	32.95^{e}	7.05^{d}	13.62^{e}	22.46^{d}	1.1^{bc}	4.46^{ab}	0.37^{d}	19.85^{a}	16.35^{c}	1.93^{d}
T_7	31.04^{e}	6.41^{e}	13.17^{ef}	21.05^{e}	1.06^{c}	4.46^{ab}	0.37^{d}	18.15^{c}	14.08^{d}	2.05^{c}
T_8	30.15^{ef}	6.13^{e}	12.94^{f}	20.45^{ef}	1.05^{c}	4.47^{a}	0.36^{e}	17.66^{e}	13.31^{f}	2.11^{b}
T_9	28.0^{f}	5.51^{ef}	12.55^{g}	19.21^{f}	1^{cd}	4.47^{a}	0.35^{ef}	17.32^{f}	12.12^{g}	2.27^{b}
T_{10}	27.01^{g}	5.18^{f}	12.07^{h}	19.08^{g}	0.93^{d}	4.47^{a}	0.34^{f}	17.12^{g}	11.56^{h}	2.33^{a}

Within the same column, the values with the different letter are significantly different ($p < 0.05$).
Y_A = actual yield, Y_{AM} = moisture-adjusted yield.
T_0: whole milk 100%, T_1: whole milk 95% + SCBM 5%, T_2: whole milk 90% + SCBM 10%, T_3:whole milk 85% + SCBM 15%, T_4: whole milk 80% + SCBM 20%, T_5: whole milk 75% + SCBM 25%, T_6: whole milk 70% + SCBM 30%, T_7: whole milk 65% + SCBM 35%, T_8: whole milk 60% + SCBM 40%, T_9: whole milk 55% + SCBM 45% and T_{10}: whole milk 50% + SCBM 50%.

the samples, but the degree of difference was less than that for the percentage of fat. The decrease in fat may result from an increase in moisture in the curd (Pal and Garg 1989).

The fat and protein content are major constituents in milk and have an influence on the yield and quality of cheese. The protein content of milk is relatively stable compared to fat content, which is altered by various factors (McSweeney 2007).

Protein

A comparison of the mean protein content showed that increasing SCBM in a mixture significantly decreased the amount of protein ($p < 0.05$). As the percentage of SCBM increased, coagulation time increased and clots that were soft and delicate in texture were formed. The formation of such curds probably resulted from a decrease in the protein content in the mixture. The presence of lipoprotein compounds in the SCBM with the increased water retention of these compounds decreased the permeability of the curd in proportion to the amount of whey, forming softer curds with a high moisture content (Pal and Garg 1989). The protein-to-fat ratio (PFR) of cheese milk has marked effects on cheese composition, component recoveries and cheese yield (Guinee *et al*. 2007). According to the results of this study, a range 1.05–1.15 for PFR is recommended for cheese milk.

Ash

The average ash content of the cheese samples was 1.13%, ranging from 0.93% to 1.34% (Table 2). There was a significant difference in the ash content between the treatment samples ($p < 0.05$). As the percentage of buttermilk increased, the percentage of ash in the cheese decreased probably because of the decreased amount of buttermilk ash. The release of minerals could also decrease the percentage of ash (Shodjaodini *et al*. 2000).

Cheese yield

A comparison of the means for cheese yield showed a significant difference between samples ($p < 0.05$). Table 2 shows that as the percentage SCBM increased to 30%, the yield increased and then decreased. The moisture level of the cheese increased in the presence of lipoprotein compounds (phospholipids) and fat globule membranes. The ability of these compounds to retain and absorb whey probably resulted in better yields (Shodjaodini *et al*. 2000). The curd prepared by incorporating SCBM into whole milk was soft bodied, which probably resulted from the change in the electric charge on the casein during churning, the presence of phospholipids and the other milk fat globule membrane materials and free fat in the buttermilk (Shreshtha and Gupta 1979).

Calculation of the determination coefficient for the effect of chemical compound modification on yield showed that pH and ash contributed to only 2% of the change in yield. Total solids and FDM contributed to 58.9% of the change; all chemical compounds contributed to 81% of the change.

As the percentage of SCBM increased in the primary mixture, yield first increased, then decreased and then again increased. It was observed that delicate curds were generated when more than 30% SCBM was added to the mixture, which made separation of whey during curd cutting more difficult, thus the amount of time for curd cutting increased. A comparison of means for moisture-adjusted yield showed a significant difference between samples ($p < 0.05$). The degree of difference between the moisture-adjusted yield was more than actual yield, it ranged from 11.56% to 17.11%. Variation in cheese yield because of differences in moisture content of the cheese can be minimised if the actual cheese yield is adjusted to the standard moisture content for the cheese (Emmons *et al*. 1990).

Sensory evaluation

Sensory evaluation revealed significant differences between the samples ($p < 0.05$). As can be observed from Table 3, as the percentage of SCBM increased, the evaluator ratings for texture and flavour decreased. Overall, using SCBM as a cheese ingredient at high levels of about 25% could adversely affect cheese sensory properties, so that samples containing 30% or more of SCBM were considered unacceptable. As unripened cheeses, including cream cheese, are not aged, taste is more important than aroma. The fats and lipoproteins (e.g. phospholipids) have a major influence on flavour (Perveen *et al*. 2011).

Conclusions

Cream cheese is a soft, fresh, acid-coagulated cheese product. It is one of the most popular soft cheese products in the world and is often used as a food ingredient in many applications. Although there has been quite extensive study on cream cheese, very little work has been published, and most of the information is kept exclusively within certain food companies. The present study shows that the by-product SCBM can be effectively used in the production of cream cheese. The addition of more than 25% buttermilk is neither recommended nor is it cost-effective to add less than 20% buttermilk. The best percentage of SCBM is 20–25%. In this range, the cream cheese has high yield and an acceptable quality. The use of SCBM decreases environmental pollution from discarding the by-product, decreases production costs and increases profits.

Table 3. Sensory properties of cream cheese made of whole milk and with mixture of sweet cream buttermilk (SCBM)

Factor	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
Appearance	1.87^{a}	1.81^{a}	1.81^{ab}	1.78^{ab}	1.72^{b}	1.71^{b}	1.68^{bc}	1.65^{bc}	1.62^{bc}	1.53^{c}	1.51^{c}
Colour	0.86^{a}	0.84^{a}	0.81^{a}	0.8^{a}	0.76^{b}	0.75^{b}	0.74^{b}	0.73^{b}	0.72^{b}	0.71^{b}	0.7^{b}
Body	1.75^{a}	1.68^{a}	1.60^{b}	1.54^{b}	1.32^{c}	1.32^{c}	1.15^{d}	1.06^{d}	1.05^{d}	0.87^{e}	0.77^{e}
Texture	2.8^{a}	2.64^{ab}	2.53^{b}	2.25^{c}	2.13^{cd}	2.11^{d}	2.03^{de}	1.97^{e}	1.95^{e}	1.36^{f}	1.31^{f}
Odour	1.85^{a}	1.83^{a}	1.75^{b}	1.72^{b}	1.72^{b}	1.71^{bc}	$1.7b^{c}$	1.7^{bc}	1.69^{bc}	1.68^{c}	1.65^{c}
Taste	9.2^{a}	8.87^{a}	8.33^{ab}	8.08^{b}	7.18^{b}	6.72^{b}	5.8^{c}	4.9^{d}	4.8^{d}	4.75^{d}	4.3^{e}
Total Score	18.33^{a}	17.67^{ab}	16.83^{ab}	16.17^{b}	14.83^{c}	14.32^{c}	13.17^{d}	12.05^{d}	11.83^{de}	10.9^{e}	10.14^{e}

Within the same row, the values with the different letter are significantly different ($p < 0.05$).
T_0: whole milk 100%., T_1: whole milk 95% + SCBM 5%, T_2: whole milk 90% + SCBM 10%, T_3:whole milk 85% + SCBM 15%, T_4: whole milk 80% + SCBM 20%, T_5: whole milk 75% + SCBM 25% T_6: whole milk 70% + SCBM 30%, T_7: whole milk 65% + SCBM 35%, T_8: whole milk 60% + SCBM 40%, T_9: whole milk 55% + SCBM 45% and T_{10}: whole milk 50% + SCBM 50%.

References

AOAC. 1990. Official Methods of Analysis, 15th Ed. Association of Official Analytical Chemists, Washington, DC, USA.

AOAC. 1995. Official Methods of Analysis, 16th Ed. Association of Official Analytical Chemists, Washington, DC, USA.

Barry, A. Law. and Tamime, A. Y. 2010. Technology of Cheesemaking. Second Edition. Wiley Blackwell Publishing, New Jersey: 41-45.

Brighenti, M., Govindasamy-Lucey, S., Lim, K., Nelson, K. and Lucey, J. A. 2008. Characterization of the rheological, textural, and sensory properties of samples of commercial US cream cheese with different fat contents. *Journal of Dairy Science* **91**: 4501-4517.

Emmons, D. B., Ernstrom, C. A., Lacroix, C. and Verret, P. 1990. Predictive formulae for yield of cheese from composition of milk: a review. *Journal of Dairy Science* **73**: 1365-1394.

El-Sayed, M. S., Samah, M. E. S., Hamed, I. M., Asker, A. A., Hamzawi, L. F. and El-Sayed, M. M. 2006. Plasma lipid profile of rats fed on processed cheese spread enriched with buttermilk concentrate. *Egyptian Journal of Dairy Science* **34**: 169-174.

Gokhale, A. J., Pandya, A. J. and Upadhyay K. G. 1999. Effect of substitution of water with sweet buttermilk on quality of processed cheese spread. *Indian Journal of Dairy Science* **52**: 256-261.

Govindasamy-Lucey, S., Lin, T., Jaeggi, J. J., Johnson, M. E. and Lucey, J. A. 2006. Influence of condensed sweet cream buttermilk on the manufacture, yield and functionality of pizza cheese. *Journal of Dairy Science* **89**: 456-467.

Guinee, T. P., Mulholland, E. O., Kelly. J. and Callaghan, D. J. 2007. Effect of protein-to-fat ratio of milk on the composition, manufacturing efficiency, and yield of Cheddar cheese. *Journal of Dairy Science* **90**(1): 110-123.

International Dairy Federation .1993. Factors affecting the yield of cheese. *International Dairy Federation*. Special Issue No. 9301. Int. Dairy. Fed. Brussels. Belgium.

Jeon, S. S., Ganesan, P., Lee, Y.S., Yoo, S. H. and Kwak, H. S. 2012. Texture and sensory properties of cream cheese and cholesterol-removed cream cheese made from whole milk powder. *Korean Journal for Food Science of Animal Resources* **32**: 49-53.

Joshi, N. J. and Thakar, P. N. 1993. Utilization of buttermilk in manufacture of buffalo milk cheddar cheese: Changes during ripening. *Journal of Food Science Technology* **30**:172–175.

Kosikowski, F. V. and Mistry, V. V. 1997. Procedures and analyses In: Cheese and fermented milk foods, Kosikowski, F. V. (ed), Westport, CT, 43-49.

Kumar, J. and Gupta, V. K. 2012. The influence of admixing sweet cream buttermilk to buffalo milk on quality of chhana production. *Milchwissenschaft* **67**: 57-60.

McSweeney, P. L. H. 2007. Cheese problems solved. Woodhead Publishing Limited, Abington Hall, Abington, Cambridge CB21 6AH, England: 102-104.

Ong, L., Henriksson, A. and Shah, N. P. 2007. Proteolytic pattern and organic acid profiles of probiotic products. *International Dairy Journal* **5**: 877-903.

Pal, D. and Garg, F. C. 1989. Studies on the utilization of sweet-cream buttermilk in manufacturing of paneer. *Journal of Food Science Technology*. **26**: 259-564.

Perveen, K., Alabdulkarim, B. and Arzoo, S. 2011. Effect of temperature on shelf life, chemical and microbial properties of cream cheese. *African Journal of Biotechnology*. **10**: 16929-16936.

Poduval, V.S. and Mistry, V.V. 1999. Manufacture of reduced fat mozzarella cheese using ultrafiltered sweet buttermilk and homogenized cream. *Journal of Dairy Science*. 82:1–9.

Salhab, H. 1998. The application ultrafiltration in the manufacture of cream cheese. M.Sc. thesis, Alberta Univ., Edmonton, Canada.

Sathya, R., Pradeep, F. S., Angayarkanni, J. and Palaniswamy, M. 2012. Influence of microbial rennet on the production of cheddar cheese made using cow milk. *Asian Pacific Journal of Tropical Biomedicine*. 4: 1-7.

Shodjaodini, E. S., Mortazavi, A. and Shahidi F. 2000. Study of cottage cheese production from sweet buttermilk. *Journal of Agricultural Science and Technology.* **14**: 61-70.

Shreshtha, R. G. and Gupta, S. K. 1979. Dahi from sweet cream buttermilk. *Indian Dairyman*. **31**, 657-60.

Sodini, I., Morin, P., Olabi, A. and Jimenez-Flores, R. 2006. Compositional and functional properties of buttermilk: a comparison between sweet, sour, and whey buttermilk. *Journal of Dairy Science*. **89**: 525-36.

SPSS. 2008. SPSS for Windows, Release 17.0.0., SPSS, Inc., Chicago, USA.

Wong, P. Y. Y. and Kitts, D .D. 2003. Chemistry of buttermilk solid antioxidant activity. *Journal of Dairy Science.* **86**: 1541-1547.