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Physio-chemical evaluation of skimmed and condensed milk of Buffalo

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ABSTRACT

The present study was conducted to evaluate the effect of skimming and condensation on composition and sensory quality of buffalo milk. Skimmed milk, and skimmed condensed milk of buffalo were examined for moisture, fat and ash contents; titrable acidity, specific gravity and sensory attributes like taste/flavor, body/texture and appearance against that of whole milk (control).Moisture content was remarkably higher in skimmed milk (88.90±0.15%) as compared to that of in skimmed condensed milk (75.80±0.55%) and in whole milk (84.18±0.34%). The increase in moisture content of skimmed milk was found to be related to the process of skimming where cream (fat rich portion of milk) was separated from whole milk. The condensation process had reduced the moisture content. Average fat content among the dry matter was found to be 41.40±0.69% and it reduced to 2.14±0.12% after skimming process. The condensation process improved the average fat content up to 2.42±0.19% in condensed skimmed milk, but differences were statistically non-significant (P > 0.05). Average ash content in whole buffalo milk was observed as 5.09±0.09%; dry matter basis (DMB), and it were increased to 7.45±0.09 %; DMB, when cream was separated. The remarkable increase in ash content i.e. from 7.45±0.09 to 8.69±0.21% was observed in condensed skimmed milk. The titrable acidity in term of lactic acid was comparatively higher in condensed milk (0.21±0.003%) followed by skimmed milk (0.19±0.002%) and whole buffalo milk (0.16±0.003%), but it relatively appeared under normal range. Average specific gravity of whole milk was observed as 1.031±0.003 and after separating cream from whole milk.It increased to 1.035±0.0002 in skimmed milk. The condensing of skimmed milk revealed the significantly (P <0.05) highest specific gravity(1.057±0.002) in the final product compared to that of skimmed milk and whole milk in present study. Sensory scores for flavor /taste in whole milk, skimmed milk and skimmed condensed milk were 18.23±0.32, 16.13±0.27 and 27.83±0.12, respectively from a total score of 30. Condensed milk (23.27±0.26)had shown better body/texture than that of whole milk (14.07±0.28) and skimmed milk (11.97±0.12)among score of 25. The appearance of skimmed condensed milk (8.83±0.14) exhibited the enhanced/better score in contrast to that of whole milk (6.13±0.19) and skimmed milk (4.84±0.14) among a total score of 10.

Key words: Physio-chemical, Skimmed, Condensed, Milk, Buffalo

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INTRODUCTION

Milk from domestic species has been universally recognized as an ideal food for human beings due to its great food value and palatability. It contains variety of chemical components with high nutritive value including body-building

protein, bone forming minerals, health giving vitamins and energy giving lactose and milk fat (1). Besides supplying certain essential fatty acids, it contains the above nutrients in an easily digestible form. In Pakistan major quantity of milk is produced from buffaloes, cattle, sheep, goat and camels, (2, 3). Though per capita milk availability is much higher than most of the developing countries, the common consumers in urban areas receive only 40% of the surplus milk from calves suckling, home consumption and indigenous home processing(4). While 15% of milk is being wasted due to the unsatisfactory and unhygienic conditions, under which the milk is collected, handled and distributed or due to improper cooling, storage and non-availability of processing facilities. However, the increasing demand for milk, especially in densely populated urban areas, needs consideration for improvement in above said attributes and quality characteristics to avoid wastage of milk and preservation for future utilization.

Naturally men have desired to assess the nutritive value of milk in terms of individual nutrients. An understanding of the chemical nature of food is essential if one is to achieve an understanding of the compositional quality of food and reactions which take place in food when conditions are changed, for example, heating, cooling, dehydration, drying, fermentation, radiation, addition of chemicals and condensation. In fact these treatments have been used to prepare different dairy products since prehistoric times. The dairy industry is fortunate to have a naturally wholesome food i.e. milk which can be processed easily and inexpensively into liquid milk products (skimmed milk, semi-skimmed milk, UHT milk, pasteurized milk, etc.), concentrated milk products (condensed milk, evaporated milk, Khoa, Mawa, Rabri etc.) or fermented/coagulated milk products (dahi/yoghurt, Kumiss, keifer, acidophilus milk, paneer/cheese, etc.) with superior nutritive qualities. No doubt, people prefer more healthy and delicious foods according to their food habits and consumed it in different forms like fresh, boiled and/or processed (5, 6). Among the various types / kinds of processed milk, skimmed milk is recognized as healthier dairy product with an extremely low fat percentage. It is produced by skimming process under which fat rich portion of milk is separated from whole milk. It could either be achieved through natural/gravity creaming or through centrifugal separation (7, 8). The milk is skimmed particularly to reduce the fat content and make the milk to use for every one of every age. For people who are concerned about the amount of fat in their diet, skimmed milk is an excellent alternative to whole milk. It is also an excellent option, if someone is looking for strong calcium enriched bones, vitalized body, active cells and ample amount of energy without any extra flab. Contrary to the myth that skimmed milk is less nutritious than that of whole milk, the skimmed milk has ample amount of nutrients and is completely equal to the normal milk from any other source. One thing to compromise is the flavor, where some individuals do not like it's very thin flavor. However, some people even appreciate this flavor.

On the other hand, condensed milk contrast to fresh milk and/or skimmed milk is widely used as an ingredient in many desert recipes since 1900s due to its longer shelf life and lesser risk of spoilage. It is a very rich source of calories and is more nutritious than that of fresh milk. However, it may contain caramel flavor which is not acceptable for drinking purpose. It is prepared by evaporating a part of water from low fat whole milk and/or skimmed milk (8, 9) to improve the palatability of the product. Though, the product is processed through skimming and condensing, there may be a negative impact on some quality characteristics of the end product. Moreover, the quality of skimmed and/or condensed milk, has led to a need for more information on the physico-chemical and sensory attributes.

The production and marketing of skimmed and/or condensed milk has been started in Pakistan on commercial scale basis, but limited information regarding the physico-chemical characteristics and sensory qualities of these products is found in scientific literature. Considering the significance of milk in view of human health and its use in different forms, the present study has been proposed to evaluate the effect of skimming and condensation on compositional and sensory qualities of buffalo milk.

EXPERIMENTAL SECTION

A total of twenty batches of fresh whole buffalo milk were processed for skimming and condensation at the dairy processing laboratory, Department of Animal Products Technology, Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University Tandojam. Among each batch, whole milk (10 L) was filtered through muslin cloth to remove any remedy present in it, and sample (500ml) was taken in sample bottle for analysis purpose (Control). Further, the rest of milk (9.5 L) was skimmed and condensed according the method as illustrated in Figure 3.1. The pre-heated milk (40±2°C) was transferred to supply can of cream separator and skimmed through cream separator to obtain the skimmed milk. Similarly a sample of skimmed milk (500 ml) was transferred into sample bottle for analysis, and rest of skimmed milk was further heated to 90°C for 10 min. Then it was condensed

in Rising Film Evaporator by evaporating it under partial vacuum at 102°C. Finally the skimmed condensed milk was stored (5 °C) till analysis.

Chemical analysis of whole, skimmed and skimmed condensed milk

Moisture content

Moisture content was analyzed according to the method of Association of Official Analytical Chemists (AOAC, 2000). Milk sample (3g) was transferred in pre-weighed flat bottom aluminum dish, and transferred to hot air oven (101±1°C) for 4±1 h. Dried sample was then placed in desiccator (1h) having silica gel as desiccant. The weight of dish with dried sample was taken and calculation was made by applying the following formula:

$$\text{Moisture (\%)} = \frac{W_2\text{-}W_3}{W_2\text{-}W_1} \text{ X } 100$$

W_1 = weight of empty dish.
W_2 = weight of dish + sample.
W_3= weight of dish + dried sample

Fat content

Fat percentage was determined by Gerber method as reported by James (1995). Milk sample (11ml) was mixed with 90% sulfuric acid (10ml) and amyl alcohol (1ml) in butyrometer and closed with rubber cork. The mixture was mixed and placed in water bath at 65°C. Sample was centrifuged (1100 r.p.m.) in Gerber centrifuge machine for 5 min. and again placed in water bath at 65°C. The fat percentage was noted on the butyrometer scale.

Ash content

Ash percentage was determined by Gravimetric method as described by (20) using Muffle Furnace. The sample (5g) was taken in pre-weighed crucible, and transferred to Muffle Furnace (550°C) for 4±1 h. Ignited sample was transferred to desiccator having silica gel as desiccant. After 1h the dish was weighed and the ash content was calculated by following formula:

$$\text{Ash\%} = \frac{\text{weight of ignited sample}}{\text{weight of sample taken}} \text{ X } 100$$

Physical analysis of whole, skimmed and skimmed condensed milk

Tritrable Acidity

Titrable acidity was determined according to the method of AOAC (2000) (20). The sample (9ml) was titrated with NaOH (N/10) solution using titration kit, where phenolphthalein (4 drops) was used as an indicator. The volume of alkali was noted, and calculation was made by using following formula:

$$\text{Titrable acidity \%} = \frac{\text{Quantity of N/10 NaOH used X 0.009}}{\text{Volume of sample taken}} \text{ X } 100$$

Specific gravity

The specific gravity was determined according to the method of AOAC (2000) (20), by using pycnometer. The density of milk was measured against the density of standard (water). Firstly, pre-weighed pycnometer was filled with standard reference fluid (water) to some predetermined level at 20°C and weight was taken. Secondly, Milk sample was filled in similar pycnometer at similar level and temperature, and weighed. Specific gravity of milk was calculated by the following formula:

$$\text{Specific gravity} = \frac{\text{weight of milk sample}}{\text{weight of distilled water}}$$

Sensory evaluation

The sensory evaluation of milk samples (whole, skimmed and condensed) was performed by a panel consisting of 5 judges drawn from M.Sc. students of Department of Animal Products Technology. The vocabulary used for products description comprised of appearance/color, flavor/taste and body/texture with hedonic scale of 10, 30 and 25, respectively (10)

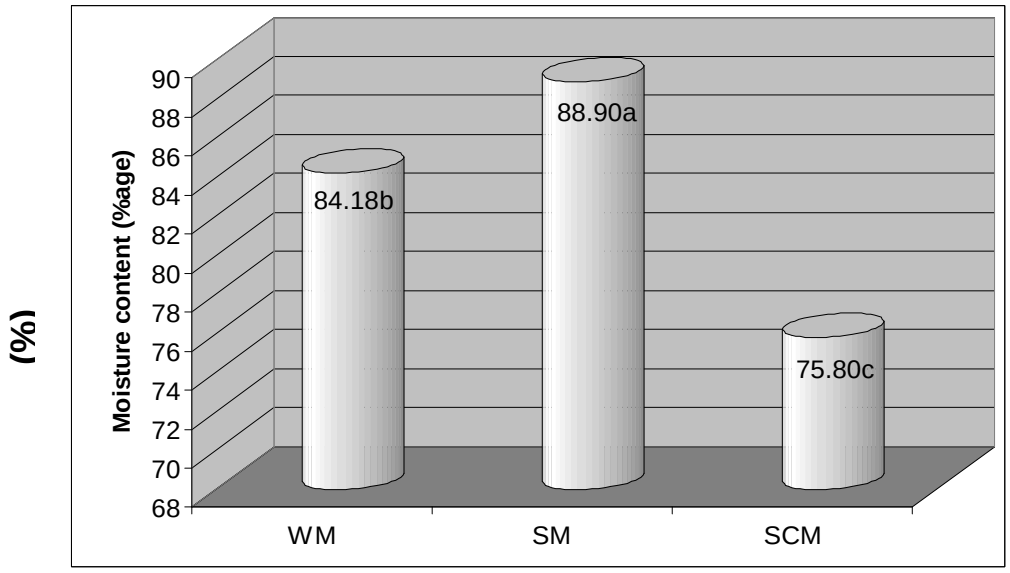
Statistical analysis

The obtained data was edited, tabulated and statistically analyzed by using computerized statistical package i.e. Student Edition of Statistics (SXW), version 8.1 (copyright 2005. Analytical Software, U.S.A).

RESULTS

Moisture content

Moisture content of buffalo whole milk, skimmed milk, and skimmed condensed milk was analyzed, and results are shown in Figure 4.1. It was observed that the moisture content in skimmed milk varied between 87.80 to 89.90%, in whole milk 81.80 to 86.70% and in skimmed condensed milk in between 72 to 80.20%. Moreover, the average moisture content was comparatively higher in skimmed milk (88.90±0.15%) than that of whole milk (84.18±0.34%) and skimmed condensed milk (75.80±0.55%). The analysis of variance (ANOVA) showed that the differences in moisture contents among whole milk, skimmed milk and skimmed condensed milk were statistically significant ($P < 0.05$). Whilst LSD (0.05) comparison of mean showed that the moisture content in different types of milk under present study was significantly ($P<0.05$) different from one another.



Data are the average of twenty batches each of WM, SM and SCM

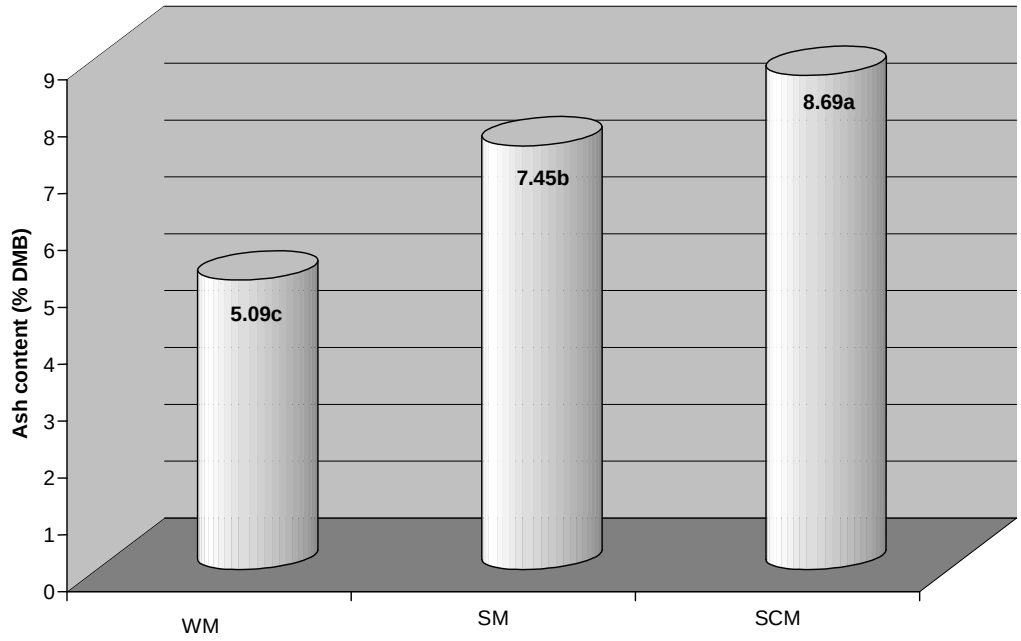
Figure 1: Moisture content (%) of whole milk (WM), skimmed milk (SM) and skimmed condensed milk (SCM)
LSD(0.05) = 1.08, SE ±= 0.54

Fat content

Fat content of buffalo whole milk, skimmed milk and skimmed condensed milk was analyzed, and results are shown in Table 4.1. The results reveal that fat content among the dry matter of whole buffalo milk varied between 36.70 to 46.11% (41.40±0.69%). After skimming process, it reduced to 0.75 and 3.11% (DMB) in skimmed milk. However, when skimmed milk was condensed, it was slightly increased to range in between 0.90 and 3.88% (DMB). Though, the average fat content in skimmed condensed milk seemed to be higher (2.42±0.49%, DMB) than that of skimmed milk (2.14±0.12%, DMB) but the differences were statistically non-significant ($P>0.05$).

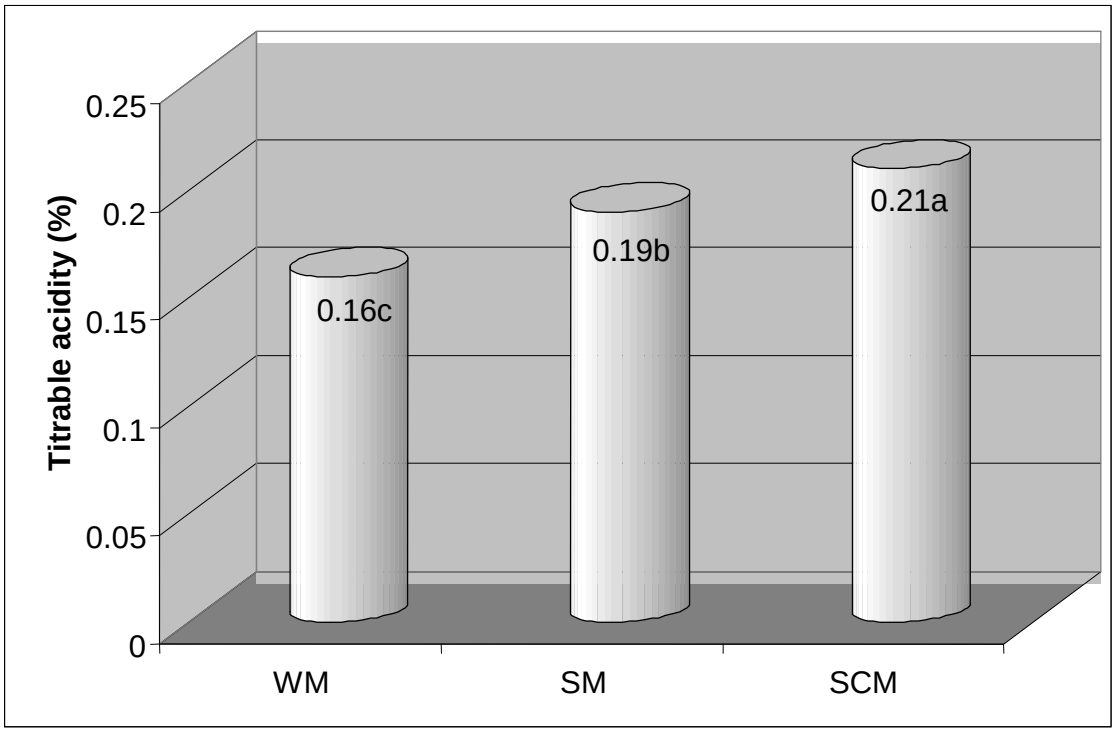
Ash content

Ash content of buffalo whole milk, skimmed milk and skimmed condensed milk was analyzed and results are shown in Figure 4.2. It was found that the ash content in skimmed condensed milk varied between 7.46 to 10.86%; DMB, in skimmed milk in a range between 6.89 to 8.04%; DMB and in whole milk in between 4.51 to 5.79%; DMB. However, average ash content in whole buffalo milk was found to the in concentration of 5.09±0.09%; DMB. It was remarkably increased to 7.45±0.9%; DMB in skimmed milk and 8.69±0.21%; DMB in skimmed condensed milk after applying skimming and condensation treatment to whole buffalo milk, respectively. Analysis of variance (ANOVA) showed that the differences among the ash contents of whole milk, skimmed milk and skimmed condensed milk were statistically significant ($P<0.05$). Whilst LSD (0.05) comparison of mean showed that all the means were significantly different ($P<0.05$) from one another.



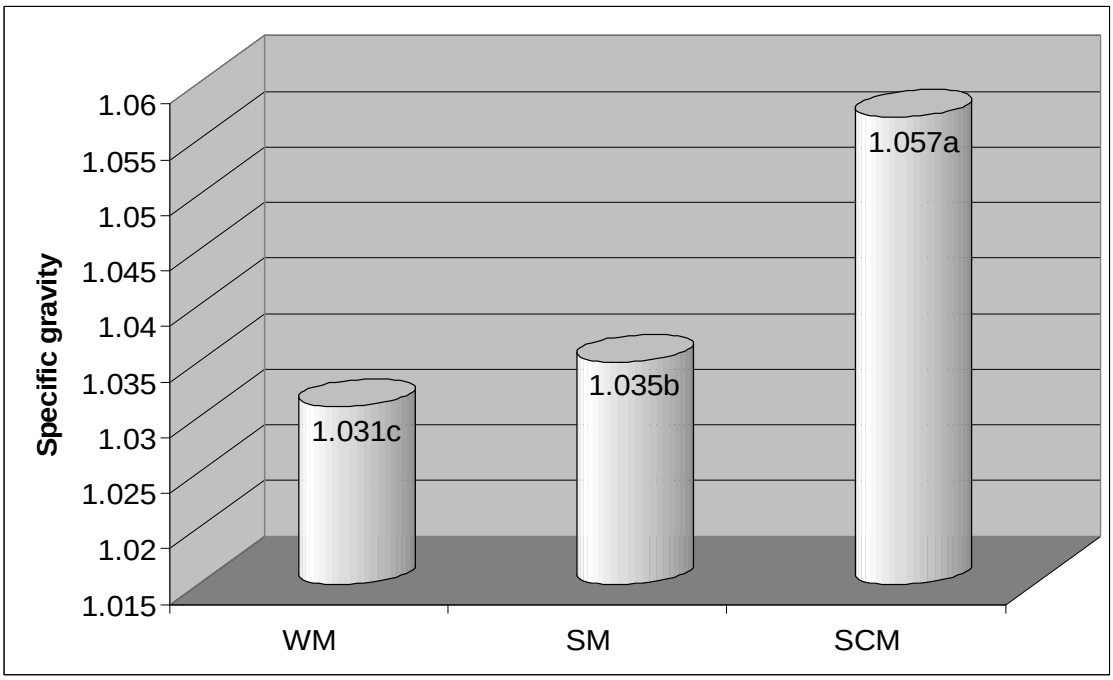
Data are the average of twenty batches each of WM, SM and SCM

Figure 2:Ash content (%; DMB) of whole milk (WM), skimmed milk (SM) and skimmed condensed milk (SCM), LSD(0.05) = 0.02, SE± = 0.12



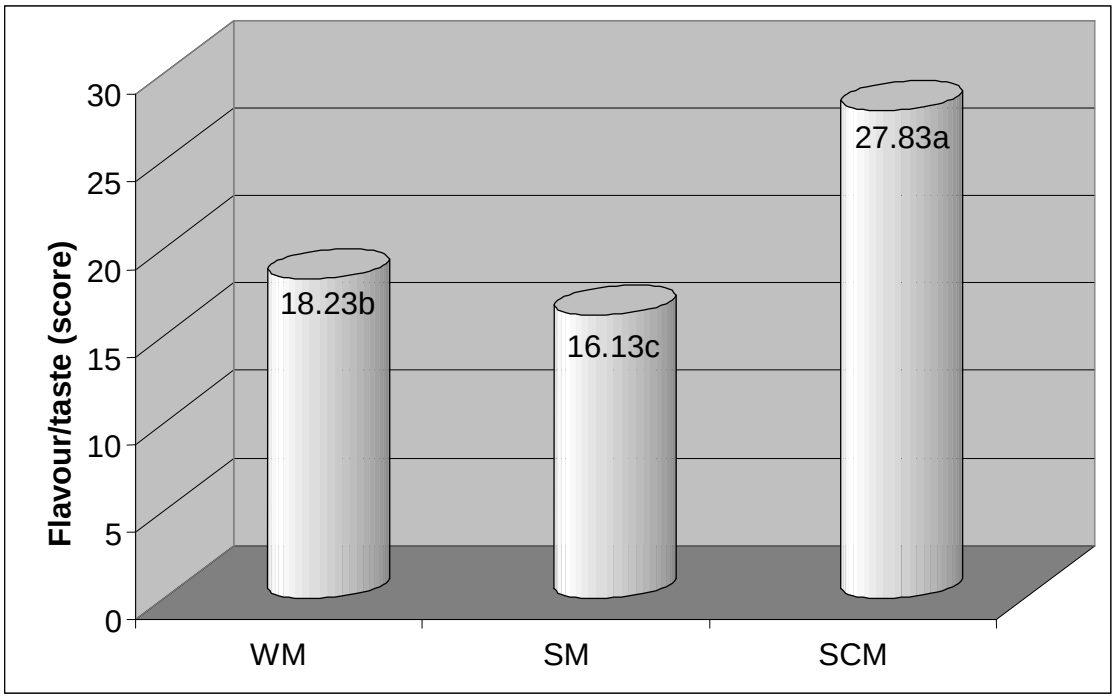
Data are the average of twenty batches each of WM, SM and SCM

Figure 3:Titrable acidity (%) of whole milk (WM), skimmed milk (SM) and skimmed condensed milk (SCM) LSD (0.05)= 0.009, SE ±= 0.004



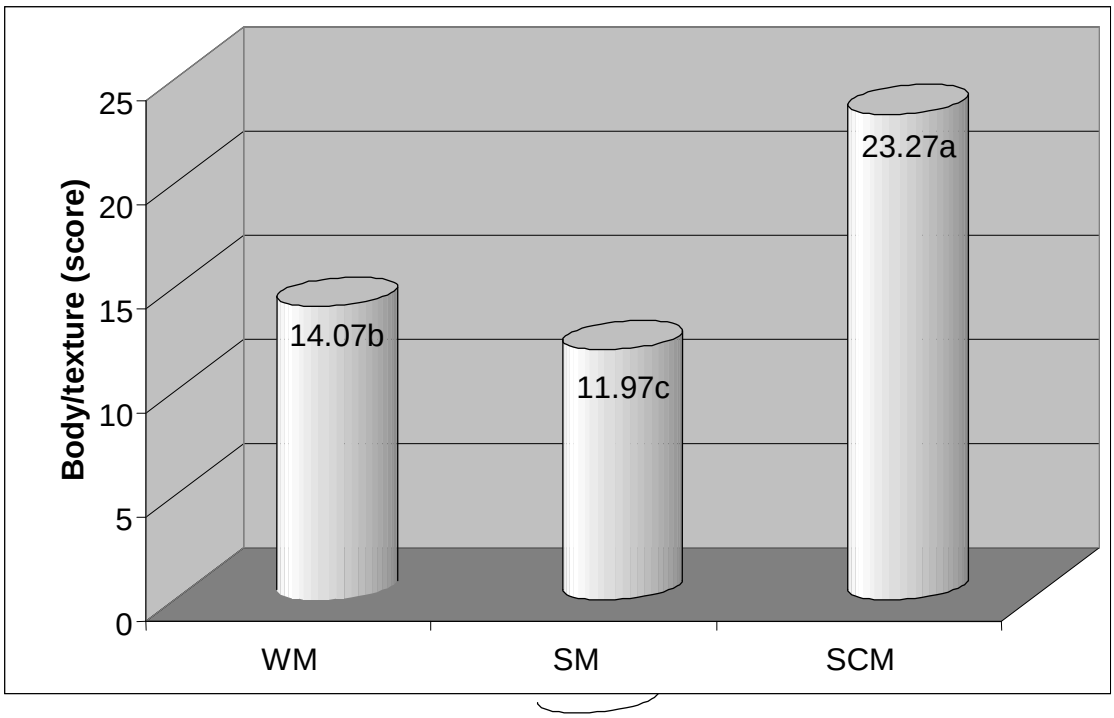
Data are the average of twenty batches each of WM, SM and SCM

Figure 4: Specific gravity of whole milk (WM), skimmed milk (SM) and skimmed condensed milk (SCM)
LSD (0.05)= 0.003, SE ±= 0.001



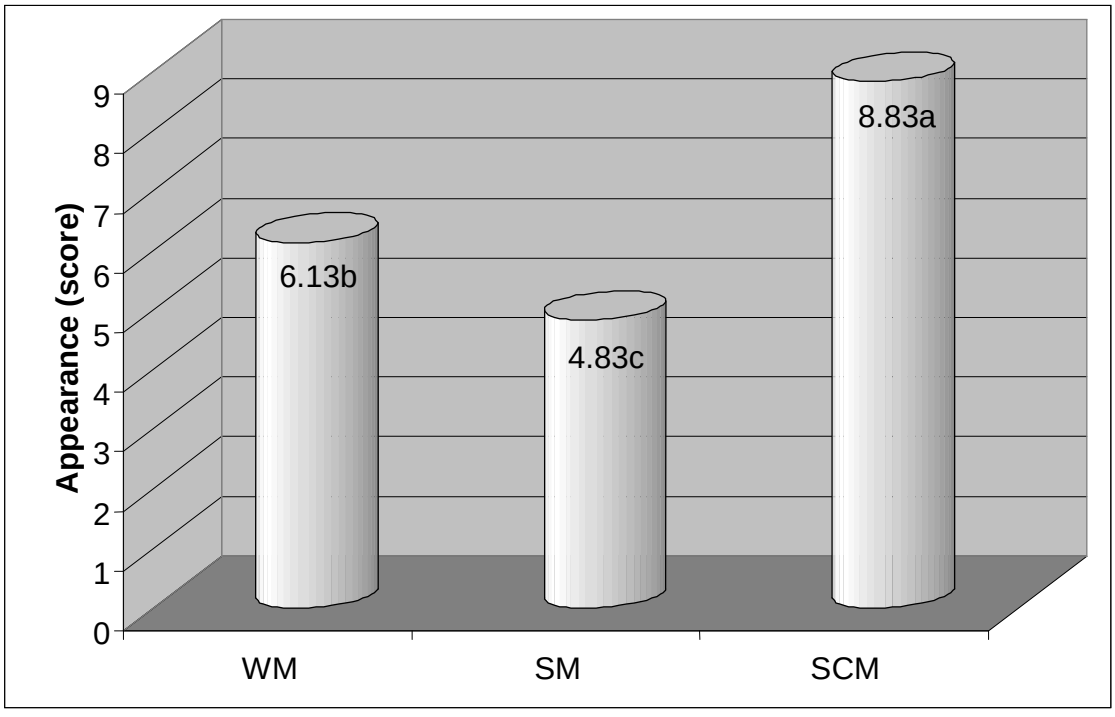
Data are the average of twenty batches each of WM, SM and SCM

Figure 5: Flavour/taste of whole milk (WM), skimmed milk (SM) and skimmed condensed milk (SCM)
LSD (0.05)= 0.71, SE ±= 0.36



Data are the average of twenty batches each of WM, SM and SCM

Figure 6: Body/texture (score) of whole milk (WM), skimmed milk (SM) and skimmed condensed milk (SCM)
LSD (0.05)= 0.65, SE ±= 0.33



Data are the average of twenty batches each of WM, SM and SCM

Figure 7:Appearance/colour (score) of whole milk (WM), skimmed milk (SM) and skimmed condensed milk (SCM
LSD (0.05)= 0.45, SE ±= 0.22

Effect of skimming and condensation on physical characteristics of buffalo milk

Titrable acidity

Titrable acidity of buffalo whole milk, skimmed milk and skimmed condensed milk was analyzed, and results are illustrated in Figure 3. It was found that the titrable acidity of whole buffalo milk was in a range between 0.14 and 0.19%. After skimming, it varied between 0.18 to 0.2% in skimmed milk. However, acidity in skimmed condensed milk ranged between 0.19 to 0.24%. It was further observed that the average titrable acidity was found to be higher in skimmed condensed milk (0.21±0.003%) compared to that of in skimmed milk (0.19± 0.002%) and/or in whole milk (0.16±0.003%). Statistical analysis (ANOVA) showed significant differences among whole milk, skimmed milk and skimmed condensed milk ($P< 0.05$).

Specific gravity

Specific gravity of whole buffalo milk, skimmed milk and skimmed condensed milk was determined, and results are depicted in Figure 4.4. It was found that the specific gravity of whole buffalo milk was in range between 1.029 to 1.033, while in skimmed milk it varied between 1.034 to 1.037 and in skimmed condensed milk between 1.048 to 1.070. The specific gravity was comparatively higher in skimmed condensed milk (1.057±0.002%) than that of skimmed milk (1.035±0.0002%) and whole milk (1.031±0.0003%). The analysis of variance (ANOVA) showed that the differences in specific gravity among whole milk, skimmed milk and skimmed condensed milk were statistically significant ($P < 0.05$).

Effect of skimming and condensation on the sensory attributes of buffalo milk

Flavor/taste

The flavor/taste scores of whole milk, skimmed milk and skimmed condensed milk was evaluated and results are depicted in Figure 4.5. The flavor/taste score rated for whole milk was in a range, between 15 to22 and in skimmed milk it varied between 14 to 18, whilst skimmed condensed milk perceived the score in between 27 and 29. The average flavor/taste score was found to be 18.23±0.32 and it was reduced to the score of 16.13±0.27 when whole milk was skimmed. However, taste/flavor was improved after applying condensation treatment to skimmed milk and the condensed product perceived the highest score i.e. 27.83±0.12 among the total score of 30. Moreover ANOVA showed that the differences among flavor/taste score for whole milk, skimmed milk and skimmed condensed milk was statistically significant ($P<0.05$). Further LSD (0.05) comparison of means showed that all the means were different from one another ($P<0.05$).

Body/texture

The body/texture score of buffalo whole milk, skimmed milk and skimmed condensed milk was evaluated, and results are depicted in Figure 4.6. Body/texture score perceived for whole milk varied between 11 to 17 and it ranged 10 to 13 in skimmed milk. Whilst score rated for skimmed condensed milk was in a range between 21 and 24 among a total score of 25. However, score rated for whole milk was 14.07±0.28 and it reduced to average score of 11.97±0.12 in skimmed milk. Moreover, body/texture was improved when skimmed milk was treated for condensation and perceived the highest average score of 23.27±0.26 among the total score of 25. Whilst LSD (0.05) comparison of mean showed that the mean score rated for different forms of milk was statistically significant ($P<0.05$).

Appearance/color

The appearance/color score rated for buffalo whole milk, skimmed milk and skimmed condensed milk was evaluated, and results are shown in Figure 4.7. It was found that the appearance score rated for whole milk varied between 4 to 8 and for skimmed milk it was in a range between 4 to 6. However, skimmed condensed milk perceived the score in between 8 to 9 among total score of 10. Average appearance score assigned to skimmed condensed milk (8.83±0.14) was comparatively higher than that of perceived by whole milk (6.13±0.19) and skimmed milk (4.83±0.14). However, the analysis of variance (ANOVA) showed that the differences in appearance score of buffalo whole milk, skimmed milk and skimmed condensed milk were statistically significant ($P < 0.05$). While computing the LSD (0.05), the result showed that all the means were significantly different ($P<0.05$) from one another.

Table 1: Effect of skimming and condensation on fat content (%) of whole milk (WM), skimmed milk (SM) and skimmed condensed milk (SCM)

Descriptive measures	Fat content (%); DMB		
	WM	SM	SCM
Minimum	36.70	0.75	0.90
Maximum	46.11	3.11	3.88
Mean	41.40	2.14	2.42
SE Mean	0.69	0.12	0.19

Data are the average of twenty batches each of WM, SM and SCM

DISCUSSION

In the present study, moisture content was remarkably higher in skimmed milk (88.90±0.15%) as compared to that of in skimmed condensed milk (75.80±0.55%) and/or in whole milk (84.18±0.34%). It could be noted that this increase in moisture content of skimmed milk was found to be related to the process of skimming where cream (fat rich portion of milk) was separated from whole milk. It is well known that moisture content is inversely correlated with fat content of milk and removing of fat content from milk may result the increase in moisture content. However, condensation process had reduced the moisture content and consequently improved the consistency of the product. Moreover, the results of the moisture content in the present study was comparatively higher than that of reported by different workers (11) i.e. 81.56% for whole milk and 74% for skimmed condensed milk respectively, whilst lower than that of reported by (12) .It was further observed that the moisture content varied greatly in milk under present study and keeping this view in mind, the data was calculated on dry matter basis to observe the statistical differences between the constituents of different products.

Average fat content among the dry matter was found to be 41.40±0.69% and it reduced to 2.14±0.12% after skimming process. It has been stated that milk after extraction of milk fat by mechanical or other process shall contain less than 3% fat (13). Moreover, condensation process improved the average fat content up to 2.42±0.19% in condensed skimmed milk. Regardless fat content in condensed milk was higher compared to that of in skimmed milk, but differences were statistically non-significant ($P > 0.05$). Fat content in the present study was remarkably higher than that of reported concentration of skimmed milk (<0.1%) (14).

Average ash content in whole buffalo milk was observed as 5.09±0.09%; DMB, and it were increased to 7.45±0.09 %; DMB, when cream was separated from it. Further it is of interest to note that remarkable increase in ash content i.e. from 7.45±0.09 to 8.69±0.21% was observed in a consequence of a skimmed milk condensation. Moreover, the result of ash content after condensing of skimmed milk was relatively consistent with that of observed by different workers (15) i.e. 8.6 and 8.5%; DMB, respectively. Whilst it was not agreed with the result of (16)and(17), who observed the comparatively lower results i.e. 5.8 and 3.6%; DMB, respectively.

In the present study, the titrable acidity in term of lactic acid was comparatively higher in condensed milk (0.21±0.003%) followed by skimmed milk (0.19±0.002%) and whole buffalo milk (0.16±0.003%). It could be argued that titrable acidity tends to increase when the process of condensation applied to milk (Rosenthal, 1991). Regardless the acidity in condensed milk and/or skimmed milk which seems to be significantly higher than that found in whole milk, it relatively appears to be under normal range of sweetened condensed milk (i.e. .013 – 0.18%) (18).

Average specific gravity of whole milk was observed as 1.031±0.003, whereas after separating cream from whole milk, it increased to 1.035±0.0002 in skimmed milk. However, condensing of skimmed milk revealed the significantly ($P<0.05$) highest specific gravity(1.057±0.002) in the final product compared to that of other products in present study. The results of present study was not in line with that of (19).

Sensory score rated for flavor/taste in whole milk, skimmed milk and skimmed condensed milk were 18.23±0.32, 16.13±0.27 and 27.83±0.12, respectively from a total score of 30. Likewise score for body/texture were 14.07±0.28 (whole milk), 11.97±0.12 (skimmed milk) and 23.27±0.26 (skimmed condensed milk) among score of 25. It is of interest to note that condensed milk does have better body/texture than that of whole and/or skimmed milk. Consequently, the appearance of skimmed condensed milk (8.83±0.14) exhibited the enhanced/better score contrast to that of whole milk (6.13±0.19) and/or skimmed milk (4.84±0.14) among a total score of 10.

It could be argued that the flavor attribute of whole milk differed considerably from that of skimmed milk, and was rich in flavor. This could be attributed with the presence of fat globules which are largely responsible for the richness of flavor. Although fat free milk (skimmed milk) perceived the lowest score, the high dry matter content obtained through condensation process had enhanced the richness of flavor. It is often assumed that compounds from fat globules membrane contribute to rich flavor, but other small spherical particles after condensation may also enhance the richness(13).

CONCLUSION

It has been concluded from the present study that: Skimming process had significant influences on chemical and sensory qualities of milk. A remarkable increase was observed in moisture and ash content and in titrable acidity, specific gravity of skimmed milk compared to that of control (whole milk). The fat, appearance/color, taste/flavor and body/texture were comparatively reduced from that of control. Since the density of skimmed milk appeared thinner than that of control, the product perceived the lower score on appearance/colour, taste/flavour and body/texture. The condensation process had significantly decrease the moisture content, and enhanced the titrable acidity, specific gravity, appearance/colour, taste/flavor and body/texture of condensed milk compared to that of skimmed milk as well as control.

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