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Research Article

Effect of Different Processing Conditions on the Physicochemical and Sensorial Characteristics of Cheddar Cheese Prepared from Different Milk Sources

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Abstract

Globally, the relationship between diet and human health convinces the customers to pay great attention to food and its composition. Milk is used widely to produce value-added goods. Milk formulation is an integral ingredient that is often used by Americans instead of influencing the consistency of the finished product. Pakistan is the 2nd largest buffalo milk producer, contributing about 67 percent, while cow milk accounts for about 31 percent of overall production. Cheese is a combination of a matrix of moisture, sugar, protein, salt, peptides, amino acids, lactose, minerals, and other small constituents. It is a biochemically dynamic product which, during ripening, undergoes important changes. Current investigation was done to see the effect of different processing conditions on the physicochemical and sensorial characteristics of cheddar cheese processed at lab scale. Three different levels of temperature were used 65, 70 and 75°C for processing of cheddar cheese, similarly three different levels of starter culture were used as $CaCl_2$% 0.07, 0.08, and 0.09. All the prepared cheese samples were then assessed for their moisture, protein, fat, acidity, pH and TS (total solids) contents. Highest moisture content was observed at 65°C Temperature and 0.07% Starter Culture (35.2 ± 0.0765). While the least moisture content was observed at 75°C Temperature and 0.09% Starter culture (34.515 ± 0.070.07). Lowest fat content was observed at 65°C Temperature and 0.07% Starter Culture (29.23 ± 0.0665). While the highest fat content was observed at 75°C Temperature and 0.09% Starter culture (29.46 ± 0.0565). Lowest protein content was observed at 65°C Temperature and 0.07% Starter Culture (28.12 ± 0.0465). While the highest protein content was observed at 75°C Temperature and 0.09% Starter culture (28.29 ± 0.0665). Lowest acidity content was observed at 65°C Temperature and 0.07% Starter Culture (0.82 ± 075). While the highest acidity content was observed at 75°C Temperature and 0.09% Starter culture (0.87 ± 0.0165). Highest pH content was observed at 65°C Temperature and 0.07% Starter Culture (5.26 ± 0.0165). While the least pH content was observed at 75°C Temperature and 0.09% Starter culture (5.15 ± 0.0175). Lowest TS content was observed at 65°C Temperature and 0.07% Starter Culture (5.15 ± 0.0175). While the highest TS content was observed at 75°C Temperature and 0.09% Starter culture (5.26 ± 0.0165). It was articulated in current study that temperature and amount of starter culture used readily effect the processing of cheddar cheese.

Keywords: Processing; Physicochemical; Cheese; Milk

Introduction

Globally, owing to the main relationship between diet and human wellbeing, consumers pay great attention to food and its composition [1]. Milk is used widely to produce value-added goods. Milk formulation is an integral ingredient that is often used by Americans instead of influencing the consistency of the finished product. The quantity and relative proportion of diriment components of milk, however, vary significantly between various dairy animals depend on their types, lactation stage, breeds, milking practices, feeding system climate, diet and season [2].

Pakistan is the 2nd largest producer of buffalo milk, contributing and producing 67.04 percent, while cow milk accounts for 31.56 percent of overall production [3]. Thanks to its unusual nutritional profile, buffalo milk is attracting rising scientific interest and investment in many countries [4]. It is enriched in fat, lactose, vitamins, protein and minerals, total solids and [5].

Cheese is a blend of lactose, moisture, peptides, salt, protein, sugar, amino acids, minerals and other small ingredients, wrapped in a matrix case [6]. Cheese is one of the biochemically dynamic products which, during ripening, undertakes important fluctuations. The ripening process of cheese is a very complicated micro-biological and bio-chemical mechanism involving enzymatic digestion of the components of the curd. It primarily entails the fermentation and oxidation of fats by lactose proteolysis. There are many biochemical functions in the body for the resulting ingredients and dynamic particles such as peptides, free fatty acids and others from cheeses that are ripened [7]. Cheddar cheese consistency is based on the starting cultures, processing technology and the composition of milk. Various forms of the non-bovine milk and their ultimate products are reported to possess special characteristics with respect to their nutritional profiling. In creating creative products with flexibility, flavor and accessibility, these under-utilized tools are of great value to milk farmers, processors and customers. Valuing non-bovine milk and their ultimate products also involves extensive research, in particular in the field of peptides and proteins. Bearing in mind the produce and composition of buffalo milk in Pakistan, current research work is carried out on the production of cheddar cheese. In addition, cheeses at several maturation stages are subjected to compositional profiling and proteolysis [8].

For several years, cheese has formed a staple human diet part and references to its development can be found in early classical literature. In several old British texts, in particular in those concerned with farm practice in unique regions of England, Scotland and Wales, definition also occurs. Cheese, such as butter, serves as the milk industry's balancing wheel. Cheese making is a simple way to turn a large portion of milk nutrients into a food, i.e. less voluminous, well preserved, good nutritious content and palatable as well as readily digestible [9]. Cheese is produced by various processing methods from various forms of milk, including cows, sheep, goats, buffalo, etc. and ripened for various durations and conditions. In addition, the sensory profile varies; it differs in color, form, stiffness, odor and taste. Cheese is not safe at room temperature and thus requires special wrapping and cooling during all periods of manufacturing and selling [10].

The fresh acid curd types of cheese are formulated by acidification by the milk coagulation, whey or cream and those that are ready for ingesting until the processing is complete. In that coagulation happens near the iso-electric point of the caseins, they vary from variety of rennet curd cheese; a little volume of rennet can be used in the processing of cottage and quarg [11].

Materials and Methods

The investigation was performed in the Laboratory and Processing Unit of Malmo Foods (Pvt) Ltd. Lahore Pakistan. Target of current investigation was effect of different processing conditions on the physicochemical properties and sensorial characteristics of cheddar cheese.

Procurement of raw material

Mixed milk from Malmo Foods (Pvt.) Ltd. was obtained for the processing of cheese. In Chichawatni, Pakistan, there are collection centres. Starter cultures and rennet's of thermophilic (*Streptococcus thermophilus* and *Lactobacillus bulgaricus*) and mesophilic (*Lactococcus lactis* and *Lactococcus cremoris*) were obtained from Chr. Hansen Denmark Ltd.

Physicochemical analysis of milk

In order to verify its consistency for cheese making, the milk used for cheese processing was first tested for pH, acidity, protein, fat, solid-not-fat (SNF), total solids and moisture content.

pH determination

Milk pH was directly noted with the pH digital electronic meter (WTW 3110) after calibration with buffer solution of pH 4, 7 and 10. By blending 20g of chopped sample of cheese were prepared in a slurry form with 12 mL distilled water and then used to measure

the pH of cheese at 25°C with a pH meter fresh pH 4.0 and 7.0 standard buffers were used for calibration.

Acidity percentage

Milk acidity was estimated with AOAC (2016), method No. 947.05 by titration of milk sample 10mL with 0.1N NaOH yet light pink color appearance as an end point which persist for few min. Chopped sample of cheese (1g) were blended by mixing 10 mL hot water, filtered after strong shaking. Remaining liquid (filtrate) then titrated against NaOH (0.1N) with indicator (phenolphthalein).

The acidity (%) on the basis of lactic acid was calculated with given formula:

$$\text{Acidity (\%)} = \frac{\text{Volume used NaOH} \times 0.009}{\text{Volume of Milk}} \times 100$$

Protein content

The milk protein content was measured using the AOAC method (991.20) based on the Kjeldahl, Kjeltec Framework method (99120). (D-40599, made up by German, Behr Labor Technik GmbH). For digestion, 10 mL milk samples were taken in a (digestion) tube with the addition of two) digestion tablets (5g K_2SO_4 and 0.005g selenium) and 20 mL N-free H_2SO_4. Without sampling, digestion tablets and acid were applied to the blank tube. All the tubes were moved to the digestion block and first heated to control foaming at 230°C and then at 430°C. The digestion continued until the digestion became apparent. The digestion tube was attached to the distillation unit and distillation was carried out in the presence of 40% NaOH and the distillate was deposited (collected) in a conical flask with a boric acid solution (4 percent). Lastly, the conical flask contents were titrated against 0.1 N of N-free H_2SO_4 solution and the amount used was found when the pink colour emerged.

The nitrogen was calculated by the formula:

$$\text{Nitrogen (\%)} = \frac{\text{Volume (sample} - \text{blank) H2SO4} \times 0.0014}{\text{Weight of sample}} \times 100$$

$$\text{Protein (\%)} = \text{N(\%)} \times 6.38$$

Milk fat content

The content of milk fat was calculated using the Gerber technique. A 10 mL H_2SO_4 butyrometer was taken from the milk sample (10.94 mL). For improved fat isolation, the amyl alcohol was also applied slowly on top of the milk along the wall of the butyrometer. With the rubber cork, the butyrometer was closed and material mixed. Butyrometers were deposited for 10 minutes in a water bath at 66°C before full digestion. The Gerber system (Funke Gerber Supervision-N Germany) was subsequently used at 1100 rpm (5 min) for centrifugal butyrometers and permitted to stand in hot water (water bath) at 65°C for 5 minutes before directly reading the fat content from the neck of the butyrometer.

Solid-not-fat content

Solid not fat (SNF) will be estimated by method using Lactometer. The Lactometer reading (LR) was noted from the meter and SNF were calculated as follows:

SNF% = (Fat% x 0.22) + (Lactometer Reading/4) + 0.72

Total solids

Total solids (TS) were estimated with the AOAC 925.23 method. The weighed quantity of samples was put in crucible and put in hot air oven for drying (105 ± 3°C). The weight of the dried sample was noted and used to calculate the total solids as follows:

$$\text{Total Solids (\%)} = \frac{\text{Weight of dried sample (g)}}{\text{Weight of Sample (g)}} \times 100$$

Moisture content

Contents of moisture in milk of cheese samples were evaluated using hot air oven for drying samples at 104 ± 4°C up till persistent wt of samples was obtained by using AOAC, (2012) Method (926.08). A small quantity of sand was filled in the drying crucible for protection to avoid lose of samples at the bottom. Then, the crucibles were applied high temperature (104°C for 1h) in oven. Desiccators were used to cool the samples after removal from the oven. The drying crucible was weighed as w1. After that, ~ 3 - 4g of chopped cheese samples were weighed and denoted as w2 and carefully mixed sand and samples with glass rod and put back in oven at 104°C for 5h. Again, cool in the desiccator when given time was completed in the oven and recorded the weight as w3 and calculated the moisture by using following equation:

$$\text{Moisture (\%)} = \frac{\text{Wt of wet sample} - \text{Wt of dried sample}}{\text{Wt of sample}} \times 100$$

Sensory evaluation

Variant sensory parameters (color, texture, flavor, taste and general acceptability) were tested for the cheese. Cheese samples (sensory parameters) were tested at 7 intermediate days during ageing by a panel of qualified assessors. Using a (9-point) hedonic scale, voluntary panelists were chosen (9 = like highly, 8 = like very much, 7 = like moderately 6 = Like Mildly, 5 = neither like nor hate, 4 = slightly dislike, 3 = moderately dislike and 2 = very much dislike, and 1 = extremely dislike).

Data analysis procedure

Statistical analysis was performed using Mini Tab 18.1. Analysis of Variance and Fisher LSD tests were performed to fetch the level of significance.

Results and Discussion

Analysis of Standardized Milk

Following table shows the composition of components of milk used for production of cheese. It can be seen from the table that the milk used for the processing of cheese had a pH of pH (6.75 ± 0.09), Acidity (0.12 ± 0.01), Protein (3.9 ± 0.04), Fat (3 ± 0.05), SNF (7.35 ± 0.11), TS (10.35 ± 0.14).

Components	Result
pH	6.75 ± 0.09
Acidity	0.12 ± 0.01
Protein	3.9 ± 0.04
Fat	3 ± 0.05
SNF	7.35 ± 0.11
TS	10.35 ± 0.14

Table 1

Physico-chemical analysis of cheddar cheese

All the samples of cheddar cheese were analyzed for their physico-chemical parameters including, Moisture, Fat, Protein, Acidity, pH, and TS.

Table 2 shows the Fisher Least Significant Difference Test results for the physico-chemical parameters of various cheese samples processed at different conditions.

Moisture

Highest moisture content was observed at 65°C Temperature and 0.07% Starter Culture (35.2 ± 0.0765). While the least moisture content was observed at 75°C Temperature and 0.09% Starter culture (34.515 ± 0.070.07). It can also be seen that with the increase of Temperature °C the moisture content was articulated to decrease and similarly with the increase of starter culture the moisture content also articulated to decrease. So, this can be said that processing the cheese at higher temperature deceases the moisture content while processing the cheese with more amount of starter culture also decreases the moisture content.

Fat

Lowest fat content was observed at 65°C Temperature and 0.07% Starter Culture (29.23 ± 0.0665). While the highest fat content was observed at 75°C Temperature and 0.09% Starter culture (29.46 ± 0.0565). It can also be seen that with the increase of Temperature °C the fat content was articulated to increase and similarly with the increase of starter culture the fat content also articulated to increase. Although the increase in fat with respect to Temperature and Starter culture is non-significant, the reason behind this could be the decrease in moisture content with the increase of temperature and starter culture.

Protein

Lowest protein content was observed at 65°C Temperature and 0.07% Starter Culture (28.12 ± 0.0465). While the highest protein content was observed at 75°C Temperature and 0.09% Starter culture (28.29 ± 0.0665). It can also be seen that with the increase of Temperature °C the protein content was articulated to increase and similarly with the increase of starter culture the protein content also articulated to increase. Although the increase in protein with respect to Temperature and Starter culture is non-significant, the reason behind this could be the decrease in moisture content with the increase of temperature and starter culture.

Acidity

Lowest acidity content was observed at 65°C Temperature and 0.07% Starter Culture (0.82 ± 075). While the highest acidity content was observed at 75°C Temperature and 0.09% Starter culture (0.87 ± 0.0165). It can also be seen that with the increase of Temperature °C the acidity content was articulated to increase and similarly with the increase of starter culture the acidity content also articulated to increase. Although the change in acidity along with increase in temperature and acidity is non-significant, but it could possibly because of the reason that starter culture used is of acidic nature and with the increase in temperature increases the molecular vibrations and ultimately increase the acidity.

pH

Highest pH content was observed at 65°C Temperature and 0.07% Starter Culture (5.26 ± 0.0165). While the least pH content was observed at 75°C Temperature and 0.09% Starter culture (5.15 ± 0.0175). It can also be seen that with the increase of Temperature °C the pH content was articulated to decrease and similarly with the increase of starter culture the pH content also articulated to decrease. Although the change in pH along with increase in temperature and acidity is non-significant, but it could possibly because of the reason that starter culture used is of acidic nature and with the increase in temperature increases the molecular vibrations and ultimately increase the acidity and ultimately a lower pH.

TS

Lowest TS content was observed at 65°C Temperature and 0.07% Starter Culture (5.15 ± 0.0175). While the highest TS content was observed at 75°C Temperature and 0.09% Starter culture (5.26 ± 0.0165). It can also be seen that with the increase of Temperature °C the TS content was articulated to decrease and similarly with the increase of starter culture the TS content also articulated to decrease. Although the decrease in TS with respect to Temperature and Starter culture is non-significant, the reason behind this could be the decrease in moisture content with the increase of temperature and starter culture.

Temp °C	$CaCl_2$%	Moisture	Fat	Protein	Acidity	pH	TS
65	0.07	35.2 ± 0.0765	29.23 ± 0.0665	28.12 ± 0.0465	0.82 ± 0.075	5.26 ± 0.0165	5.26 ± 0.0165
	0.08	35.03 ± 0.0665	29.26 ± 0.0565	28.2 ± 0.0765	0.83 ± 0.070	5.245 ± 0.0265	5.245 ± 0.0265
	0.09	34.9 ± 0.0465	29.31 ± 0.0665	28.25 ± 0.0865	0.845 ± 0.0165	5.23 ± 0.0265	5.23 ± 0.0265
70	0.07	34.975 ± 0.0665	29.28 ± 0.0665	28.16 ± 0.0565	0.83 ± 0.070	5.235 ± 0.0165	5.235 ± 0.0165
	0.08	34.84 ± 0.0570	29.36 ± 0.0565	28.215 ± 0.0665	0.845 ± 0.0165	5.225 ± 0.0265	5.225 ± 0.0265
	0.09	34.725 ± 0.0570	29.43 ± 0.0665	28.265 ± 0.0765	0.86 ± 0.0165	5.19 ± 0.0165	5.19 ± 0.0165
75	0.07	34.795 ± 0.0870	29.32 ± 0.0665	28.195 ± 0.0565	0.835 ± 0.0170	5.22 ± 0.0265	5.22 ± 0.0265
	0.08	34.625 ± 0.0575	29.39 ± 0.0465	28.24 ± 0.0565	0.855 ± 0.0165	5.18 ± 0.0170	5.18 ± 0.0170
	0.09	34.515 ± 0.070.07	29.46 ± 0.0565	28.29 ± 0.0665	0.87 ± 0.0165	5.15 ± 0.0175	5.15 ± 0.0175

Table 2

Sensorial parameters

Color

Lowest Color scores was observed at 65°C Temperature and 0.07% Starter Culture (6.44 ± 0.93B). While the highest Color scores was observed at 70°C Temperature and 0.08% Starter culture (7.37 ± 0.06AB). Moreover, it can be seen from the table that all the treatments of the cheese formulated at either conditions were accepted by all the panel of judges.

Flavor

Lowest Flavor scores was observed at 75°C Temperature and 0.09% Starter Culture (6.44 ± 0.07D). While the highest Flavor scores was observed at 70°C Temperature and 0.07% Starter culture (7.51 ± 0.12A). Moreover, it can be seen from the table that all the treatments of the cheese formulated at either conditions were accepted by all the panel of judges.

Texture

Lowest Texture scores was observed at 75°C Temperature and 0.09% Starter Culture (6.37 ± 0.04F). While the highest Texture scores was observed at 70°C Temperature and 0.07% Starter culture (7.74 ± 0.07A). Moreover, it can be seen from the table that all the treatments of the cheese formulated at either condition were accepted by all the panel of judges.

Taste

Lowest Taste scores was observed at 75°C Temperature and 0.09% Starter Culture (6.68 ± 0.05E). While the highest Taste scores was observed at 70°C Temperature and 0.07% Starter culture (7.61 ± 0.05A). Moreover, it can be seen from the table that all the treatments of the cheese formulated at either condition were accepted by all the panel of judges.

Overall acceptability

Lowest Overall Acceptability scores was observed at 75°C Temperature and 0.09% Starter Culture (6.64 ± 0.07C). While the highest Overall Acceptability scores was observed at 70°C Temperature and 0.07% Starter culture (7.75 ± 0.07A). Moreover, it can be seen from the table that all the treatments of the cheese formulated at either condition were accepted by all the panel of judges.

Conclusion

The current study was done to see if the temperature and starter culture affect different quality attribute of cheddar cheese. The results from the study are summarized as; The study concludes that cheddar cheese is affected by processing at different condition of temperature and amount of starter culture used. It was articulated in current study that processing the cheese at higher temperature

Temp °C	$CaCl_2$%	Color Score	Flavor Score	Texture Score	Taste Score	Overall Acceptability Score
65	0.07	6.44 ± 0.93B	7.42 ± 0.06A	7.51 ± 0.08B	7.4 ± 0.07AB	7.53 ± 0.06AB
	0.08	7.27 ± 0.06AB	7.27 ± 0.06AB	7.43 ± 0.06B	7.26 ± 0.07BC	7.37 ± 0.04B
	0.09	6.99 ± 0.13AB	7.11 ± 0.11B	7.14 ± 0.07CD	7.44 ± 0.07AB	7.33 ± 0.06B
70	0.07	7.8 ± 0.1A	7.51 ± 0.12A	7.74 ± 0.07A	7.61 ± 0.05A	7.75 ± 0.07A
	0.08	7.37 ± 0.06AB	7.41 ± 0.08A	7.39 ± 0.06B	7.43 ± 0.07AB	7.59 ± 0.21AB
	0.09	7.11 ± 0.08AB	7.11 ± 0.07B	7.33 ± 0.06BC	7.15 ± 0.08C	7.3 ± 0.07B
75	0.07	7.3 ± 0.09AB	7.3 ± 0.11AB	7.06 ± 0.09D	7.35 ± 0.08BC	7.31 ± 0.08B
	0.08	6.86 ± 0.09AB	6.8 ± 0.09C	6.81 ± 0.08E	6.91 ± 0.08D	6.88 ± 0.06C
	0.09	6.63 ± 0.08B	6.44 ± 0.07D	6.37 ± 0.04F	6.68 ± 0.05E	6.64 ± 0.07C

Table 3

deceases the moisture content while processing the cheese with more amount of starter culture also decreases the moisture content. Although the increase in fat with respect to Temperature and Starter culture is non-significant, the reason behind this could be the decrease in moisture content with the increase of temperature and starter culture. Similarly, the increase in protein with respect to Temperature and Starter culture is non-significant; the reason behind this could be the decrease in moisture content with the increase of temperature and starter culture.

Although the change in acidity along with increase in temperature and acidity is non-significant, but it could possibly because of the reason that starter culture used is of acidic nature and with the increase in temperature increases the molecular vibrations and ultimately increase the acidity. Similarly, the change in pH along with increase in temperature and acidity is non-significant, but it could possibly because of the reason that starter culture used is of acidic nature and with the increase in temperature increases the molecular vibrations and ultimately increase the acidity and ultimately a lower pH. The decrease in TS with respect to Temperature and Starter culture is non-significant; the reason behind this could be the decrease in moisture content with the increase of temperature and starter culture.

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Volume 5 Issue 6 June 2021