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Effect of different Milk Solid Levels on pH, Acidity, Moisture Content and Lactose Percentage of Cheddar Cheese during Storage at 4°C

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Abstract: The research work was conducted at ASI (Animal Sciences Institute) laboratory, N.A.R.C, Islamabad. Buffalo milk was used in the preparation of the cheddar cheese. Three treatments, T_1, T_2 and T_3 (control) were made for the cheddar cheese from milk containing 12.5, 16 and 11.5% total solids, respectively. The total solid level of different milk samples was raised by adding skimmed milk powder. The cheddar cheese was stored in aluminum foils separate for each analysis, at 4°C for the period of 4 months and was examined physico-chemically for pH, acidity, moisture content and lactose percentage at the interval of 15 days. Cheese prepared from different solid levels of milk shows statistically significant results.

Key words: Cheddar cheese, pH, acidity, moisture content, lactose percentage

Introduction

Since times immemorial, milk is considered a complete food containing almost all the essential nutrients. Being a perishable commodity, it was never possible to store it as such for more than a few hours at ordinary temperature. With continuous efforts, it was found that conversion of milk into cheese would preserve nearly all the milk components for long period. Cheese making has been an art, handed over from generation to generation that was stressed in the late 18th century and afterwards the Cheese making became an art with science. Perusal of the literature concerning cheese reveals almost 2000 names applied to the cheese and it is mainly because of the movement of populations by free or enforced migration almost throughout the world. Remnants of material found in the tomb of Hories – Aha (3000 BC) proceed on examination to have been cheese. There is reference to cheese in Biblical times but written history is scarce until the periods of Roman and Greek Empires (Scott, 1986). Considerable amounts of free fatty acids were released throughout the storage period by the hydrolysis of fat contents. Lipase might have also contributed towards the increase in acidity of fat as reported by Bable and Hammer (1945).

Vanstone and Doughall (1960) reported the composition of Cheddar cheese manufactured from cow milk. Ranges from different constituents were: Moisture: 27.00 – 37.00%, Fat 28.00 – 37.00%, Protein: 23.00 – 33.00%, Ash: 3.60 – 4.70% and Acidity: 1.00- 2.00%.

Umeto and Sato (1975) found that increase in titratable acidity due to the lactic acid fermentation occurred in early stages of ripening. Broske and Shaver (1978) studied the relationship between rancidity and acid degree value. The cheese fat from five samples was hydrolyzed in alkaline medium and the free fatty acids were converted to their methyl esters. Acid degree value, pH and cheese scores were also determined. Two of the cheese samples with high initial acid degree values became rancid during storage. Only acid degree values correlated with rancidity. Klyuchyute *et al.* (1979) described the major technological characterization of manufacture of cheddar cheese. Experiment was carried out to investigate effect of three processing variable on quality of cheddar cheese made from mixture of fresh (85%) and partially ripened (15%) milk. Result showed that controlling moisture at 39-40% and pH at 5.33-5.41 of cheddar cheese was optimums for production of high quality cheese, whilst 39-40 was the best scalding temperature.

Dolezalek *et al.*, (1985) described the effect of pH and temperature on proteolytic activity of acetic acid bacteria. At pH 6.6, lactobacilli and thermophilic streptococci showed highest proteolysis in skim milk at 15°C and 45°C and mesophillic streptococcus exhibited only slight activity at all temperatures used (15- 50°C). Variations in pH (4.88, 5.2, 5.6 or 5.2) also had a strong influence on casein hydrolysis. To avoid development of bitter flavor in cheese, it is advisable to select starter culture on the basis of proteolytic activity and rate of lactic acid production over entire range of pH and temperature occurring during manufacturing and ripening of the cheese.

Joshi and Thakar (1993) conducted a research on 'Utilization of buffalo milk in manufacture of Cheddar cheese: changes during ripening'. Buffalo milk was standardized to a casein: fat ratio of 0.7, using skim milk and various proportions of sweet cream buttermilk and used to make Cheddar cheese. Incorporation of buttermilk in to the cheese significantly increased moisture, acidity and ripening index and decreased pH as compared to control cheeses.

Materials and Methods

Preparation of Cheddar Cheese: Milk for the preparation of the cheddar cheese was collected from ASI (Animal

Sciences Institute) dairy, N.A.R.C, Islamabad, Pakistan. The milk was divided into three lots and was analyzed for its quality and contents. One of the lots was kept as a control lot as it was not standardized and the rest of two lots of milk were standardized to 12.5 and 16% TS level and fat at 3.5% by adding a required amount of skimmed milk powder.

Raw milk for the preparation of Cheddar cheese was found of good chemical quality, clean and fresh with an acidity of approximately 0.16% and then it was subjected to heat treatment that is considered suitable to be about 68-72°C for 15 seconds. The milk was pasteurized at 72°C for 16 seconds (HTST) high temperature for short time and then cooled to 30°-35°C. Cheddar cheese was produced by adding a "starter" (streptococcus lactis and leuconostoc citrovorus) to milk in order to produce acid and then fermented for 30 minutes at 40°C in a water bath. After 30 minutes, when acidity reached 0.2%, rennet @ 0.03 g/l was added and the lot was allowed to set approximately for 1 hr and simultaneously acidity was also kept under observation as the desired acidity at the time of curd formation was approximately 2%. The curd was held until the proper degree of firmness was acquired in a time of 6 to 8 hours and during this period a rapid increase in acidity occurs. The coagulated cheese was then cut into pieces or cubes with the help of curd knives. Then it was agitated to come out of whey, which was drained off. The pieces were heated for about 45 minutes at 38°C until desired pH of the whey was acquired. This heating of the curd is known as 'cooking'. The cubes were trenched to drain the whey and then matted for 15 minutes to form rubber slabs. This process of matting curd into cubes and handling is known as 'Cheddaring'. Then the cubes were piled to expel water or whey. Then those piles were kept for 2 hours until the percentage of acidity reached 0.5 to 1%. The blocks were cut into small pieces called 'milling' and salt was added at the rate of 2.5%, these slabs were hydraulically pressed at the rate of 20 psi for about 16-20 hours. After pressing, paraffin was applied on cheese blocks and then those blocks were wrapped in aluminum foils and were kept at 4°C and relative humidity was maintained at 60% for about 3-4 days. Then these were put in boxes and stored at 4°C and 60% relative humidity for shelf life studies.

Physico-Chemical Analysis

pH: pH of the cheese was determined by using pH meter as described by A.O.A.C. (1984).

Acidity Test: Acidity was determined as described by A.O.A.C. (1984).

Moisture Test: Moisture content was determined as described in A.O.A.C. (1984).

Lactose Test: Lactose was estimated as given in A.O.A.C. (1984).

Statistical Analysis: All the data regarding chemical analysis was statistically analyzed by using RCBD and the means were separated by applying LSD test as described by Steel and Toree (1980).

Results and Discussion

Buffalo milk subjected to chemical analysis prior to the preparation of cheddar cheese and after preparation of cheese whey was also subjected to chemical analysis as shown in (Table 1 and 2) respectively.

During storage cheese samples were analyzed physico-chemically for pH, acidity, moisture and lactose content (%).

pH: Cheese samples were analyzed for pH at interval of 15 days for a total storage period of 120 days. Initially the samples showed 5.5 pH that decreased to 4.62 at the end of stored period (Table 3). This decrease might be due to hydrolysis of fats, resulting fatty acids. High pH value was observed in cheddar cheese made from T_2 (16% TS) as compared to other samples T_1 (12.5% TS) and T_3 (control). When the data was analyzed it revealed that the storage intervals as well as the TS levels significantly ($P<0.05$) effects pH of cheddar cheese.

Acidity: Cheddar cheese when stored showed increase in the titratable acidity. As shown in the (Table 4), titratable acidity was 0.83% at initial reading and 1.80% at the end of 120 days. Rise in acidity was more pronounced after 90 days storage. When acidity was recorded at different solid levels higher acidity concentration was found in cheese prepared from control lot. Low percentage of acidity in 12.5% TS and 16% TS, 1.154 and 0.858 respectively, it might be due to the low fat contents. As fat on hydrolysis yields fatty acids and causes rise in acidity (Table 4).

These results are in agreement of the findings of Umeto and Sato (1975) and also with those of Bable and Hammer (1945). When data was subjected to statistical analysis it revealed that TS level had significant ($P<0.05$) effect on acidity percentage and storage intervals did not shown significant effect ($P<0.05$).

Moisture: Elimination of moisture is important because it is closely related to the firmness of the cheddar cheese, when the cheddar cheese was stored for a period of four months; the moisture content decline from 38.09% to

Table 1: Composition of buffalo milk before preparation of cheese

	Milk # 1	Milk # 2	Milk # 3
Fat %	3.5	3.5	7.5
TS	12.5	16.0	11.5
Protein	2.3	3.7	1.6
Lactose	2.01	3.2	1.4
Acidity	0.120	0.115	0.125
pH	6.8	6.9	6.8

Milk # 1 = Milk containing 12.5% solids
Milk # 2 = Milk containing 16% solids
Milk # 3 = Control milk

Table 2: Composition of whey after preparation of cheese

	Whey # 1	Whey# 2	Whey # 3
Fat	0.65	0.57	0.7
SNF	3.5	3.91	3.4
TS	4.15	4.48	4.1
Protein	0.21	0.29	0.33
Lactose	2.72	2.83	2.5
Acidity	0.73	0.79	0.7

whey # 1 = whey of cheese made from milk having 12.5 % solid
whey # 2 = whey of cheese made from milk having 16 % solid
whey # 3 = whey of cheese made from control milk

Table 3: Effect of TS levels and storage interval on the pH of the cheddar cheese stored at 4°C

	Storage intervals (days)									
Treat.	0	15	30	45	60	75	90	105	120	Means
T_1	5.6	5.5	5.4	4.97	4.76	4.56	4.23	4.12	4.12	4.81 B
T_2	5.5	5.4	5.4	5.3	5.2	5.1	5.1	5	5	5.23 A
T_3	5.4	5.3	4.95	4.9	4.85	4.8	4.75	4.75	4.75	4.49 B
Means	5.50A	5.40B	5.25C	5.05D	4.93DE	4.82EF	4.69F	4.62G	4.62G	

Each value is the mean of three readings.
Figs. bearing same letters are statistically not different from one another ($P < 0.05$).

Table 4: Effect of TS levels and storage interval on the % acidity of cheddar cheese stored at 4°C

	Storage Intervals (days)									
Treat.	0	15	30	45	60	75	90	105	120	Means
T_1	0.85	0.87	0.91	1.1	1.19	1.27	1.33	1.42	1.42	1.154 B
T_2	0.71	0.75	0.8	0.85	0.89	0.91	0.92	0.91	0.89	0.858 B
T_3	0.91	0.97	1.3	1	2.51	2.11	3.01	3.09	3.09	1.999 A
Means	0.83E	0.87DE	1.01D	0.99D	1.53B	1.43C	1.76AB	1.81A	1.80 A	

Each value is the mean of three readings.
Figures bearing same letters are statistically not different from one another ($P < 0.05$)

Table 5: Effect of TS levels and storage interval on the moisture content (%) of the cheddar cheese stored at 4°C

	Storage Intervals (days)									
Treat.	0	15	30	45	60	75	90	105	120	Means
T_1	37.16	37.00	36.03	34.87	33.7	33.41	32.83	32.97	32.01	34.42 B
T_2	34.87	34.31	33.62	32.98	32.48	32.13	31.92	31.38	31.36	32.78 B
T_3	40.24	38.78	37.7	36.9	35.8	35.1	35.5	34.5	34.01	36.34 A
Mean	38.09A	37.07AB	35.78B	34.92BC	33.99C	33.55CD	33.08D	32.49DE	32.44E	

Each value is the mean of three readings.
Figures bearing same letters are statistically not different from one another ($P<0.05$)

Table 6: Effect of TS levels and storage interval on the lactose percentage of cheddar cheese stored at 4°C

Treat.	Storage Intervals (days) 0	15	30	45	60	75	90	105	120	Means
T_1	5.71	5.46	5.33	5.07	4.9	4.85	4.75	4.75	4.75	5.07 B
T_2	6.8	6.75	6.7	6.63	6.59	6.56	6.54	6.52	6.47	6.62 A
T_3	5.1	4.46	3.71	2.97	2.19	1.77	1.33	1.01	1	2.62 C
Means	5.87A	5.56AB	5.25B	4.89BC	4.56BC	4.40C	4.21CD	4.10D	4.08D	

Each value is the mean of three readings
Figures bearing same letters are statistically not different from one another ($P < 0.05$)

32.44% (Table 5), as the product was sealed in aluminum foils and the analysis of moisture was carried out immediately on opening the foil at all the intervals specified for testing. Reasons for decrease in moisture were possibly due to other factors also. It has been observed that hydrolysis of fat and protein took place on storage as ripening process continued unabated. Similar results have been also reported by Ralston (1948), Wanston and Dougball (1960), Dixon *et al.* (1969) and Johnson and Peterson (1974).
When the data was subjected to statistical analysis significant effect ($P<0.05$) of different total solid levels as well as storage interval were observed. High moisture content (36.34%) was found in cheese sample prepared from T_3 (control). Minimum level of moisture was observed in cheese made at 16% total solid level.

Lactose Percentage: Effect of TS and storage on lactose contents was noted during this research work . Maximum lactose content (6.62%) were found in T_2 and minimum lactose level was observed in the sample T_3 (2.616 %). A general observation was that the lactose content of cheese increased with the increase in TS levels and decrease during storage period as it was 5.87 % at initial reading and was later found to be decreased up to 4.08 % by the end of the experiment. The statistical analysis indicates that TS level have highly significant ($P<0.05$) effect on the lactose content of the cheddar cheese while storage intervals also showed significant ($P<0.05$) effect.

Conclusion

From this research work it is concluded that; Cheddar cheese made with high level of total solids gave low acidity and moisture, while gave high pH and lactose content. Total solids and storage significantly affects the physic-chemical properties of cheddar cheese made at different solid level. Further research should be conducted by making cheese with solids more then 16% and with solids less then 12.5%.

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