

## IMPACT OF FAT LEVELS IN MILK ON THE COMPOSITION, SENSORY ATTRIBUTES AND FUNCTIONALITY OF BUFFALO MOZZARELLA CHEESE

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Four Mozzarella cheese samples (C<sub>1</sub>, C<sub>2</sub>, C<sub>3</sub> and C<sub>4</sub>) were prepared from buffalo milk standardized at four different fat levels (2.5, 2.0, 1.5 and 0.75 % respectively) and stored at 4°C ± 2 for two months. The outcome of fat variation in milk was investigated on cheese composition (moisture, fat, protein, pH, acidity, ash, salt, and calcium) and sensory attributes (texture, overall acceptance, flavour, and appearance) during storage. Cheeses were also evaluated for functionality (e.g. meltability and stretchability). Cheeses which contain the higher fat content (C<sub>1</sub> and C<sub>2</sub>) were also higher in moisture and lower in protein contents, calcium and salts. . Among the sensory attribute (appearance, flavour, texture, and overall acceptability) were more improved in high fat cheeses with the increased storage days. The cheeses with high fat level melt more but stretch less and vice versa.

**Keywords:** Chemical composition, fat, sensory evaluation, Mozzarella cheese, Pakistan.

### INTRODUCTION

Mozzarella is characterized as a pasta filata style; semi-hard Italian cheese. Increase in Mozzarella consumption is expected to grow due to the expansion of the pizza industry (IDF, 2001). Buffalo milk is preferred for Mozzarella due to high fat, vitamin A, protein and low cholesterol (Zicarelli, 2004). Differences in fat level and hence protein to fat ratio, that occur in milks have marked influences on composition, yield, rheology, flavour and sensory attributes of cheese (Guinee *et al.*, 2002). Key functional properties of mozzarella cheese, namely meltability, stretchability, free oil formation and browning are highly dependent on the underlying cheese structure and composition. Moisture content, fat percentage, salt, and mineral particularly calcium, pH and proteolysis dictate the resultant functionality of the cheese. These properties play heavily on consumer perceptions of cheese quality (Rowney *et al.*, 1998; McMahon and Oberg, 1998). Cheese making is a scientific craft worldwide but in Pakistan only few local industries (Adams, Nurpur, Deen's etc.) are supplying Mozzarella locally but none of these is of quality desired in pizza. Buffalo's milk is ranked second in the world after cow's milk being more than 12% of the world, milk production (Ahmed *et al.*, 2008). India and Pakistan are producing about 80% of the world's production (Ahmed *et al.*, 2008).

A lot of information is available in developed countries about this cheese but in Pakistan; no work has been done on mozzarella cheese. Radically there is a robust need of research exploration about dairy products specially Mozzarella cheese in modern era. There is also a dire need to introduce new techniques for the production and storage of cheeses with different fat

levels. So keeping in view the importance mozzarella cheese in Pakistan a little work is being initiated to establish cheese manufacturing units in dairy sector. The mozzarella cheese was prepared with four different fat levels to identify the important changes in composition and sensory attributes. Moreover the optimum formulation of mozzarella cheese was assessed by keeping in view its functional properties (e.g. stretchability, meltability etc.) under local conditions of Pakistan.

### MATERIALS AND METHODS

#### Cheese milk

Raw buffalo milk was obtained from Dairy Farm, Institute of Animal Nutrition and Feed Technology, University of Agriculture, Faisalabad, Pakistan and used in the preparation of cheese in Dairy Laboratory, National Institute of Food science and Technology.

#### Cheese making

Four mozzarella cheese samples (C<sub>1</sub>, C<sub>2</sub>, C<sub>3</sub> and C<sub>4</sub>) were prepared from buffalo milk which were standardized at four different fat levels (2.5, 2.0, 1.5 and 0.75% respectively) and pasteurised by conventional method at 63°C for 30 min in a locally manufactured vat of 10 L capacity according to the procedure described by Tunick *et al.*, (2000). The cheese milk samples at 37°C were inoculated with freeze dried thermophilic starter culture (TCC-3 CHR HANSEN) @ 0.33g for 10 L of milk and ripened for 45 minutes. Then rennet @ 3.7 mL for 10 L of milk diluted to 40 mL was added and left for 35-40 minutes for coagulation. Curds were then cut in to 1cm cubes and healed for 10 minutes before stirring. The temperature of all vats was raised to 41°C with periodic gentle

stirring then the whey was drained at pH 6.2 and curds were cheddared at 41°C until the pH reached 5.2. Dry salting was carried out @ 1.5% of curd weight after cheddaring and milling. The curds were then stretched in hot water (80°C) until they were elastic and smooth. Then the curds were placed in moulds and stored at temperature of 4°C ± 2.

### Chemical analysis of milk and cheese

Standardized cheese milk samples were analysed for pH, fat (Gerber) and protein (Microkjeldahl) using their respective methods given by Kirk and Sawyer (1991). Moisture, casein, calcium, ash and salt contents of cheese samples were determined, using AOAC (1990) methods 920.124, 991.20, 927.03, 935.42, 991.25 respectively. The pH was measured by using pH meter (inoLab WTW series 720).

### Melt time

Melt time was measured as the time required for a fixed weight of shredded cheese to melt and fuse into a molten mass free of shred identity after every two week of storage (Guinee *et al.*, 2000).

### Stretchability

Shredded cheese was evenly distributed on the pizza base and then placed in an electric fan oven at 280°C for 4 minute before evaluation for stretchability according to Catherine *et al.*, (1998).

### Sensory evaluation of cheese

Sensory evaluation of cheese for various attributes was carried out by a panel of judges using the nine point hedonic scale (Land and Shepherd, 1988).

### Statistical analysis

The data obtained was analyzed through analysis of variance as described by Steel *et al.*, (1997).

## RESULTS AND DISCUSSION

### Cheese milk composition

Chemical composition of cheese milk is shown in Table 1. The fat content of cheese milks is ranged from 2.5 to 0.75%. Total protein content of the milks gradually decreased as the fat content in the milk increased.

**Table 1. Cheese milk composition**

Constituents	Cheese milk samples			
	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>
Protein (%)	3.02	3.09	3.10	3.12
Fat (%)	2.50	2.00	1.50	0.75
pH	6.66	6.66	6.67	6.65

### Cheese composition

Average chemical composition of cheese samples (Table 2) significantly varied from each other ( $p < 0.05$  and  $p < 0.01$ ). Samples showed gradual decrease in moisture content during successive days of storage (data not shown). However, among the cheese samples, highest moisture (53.07 %) and fat (19.63 %) was in C<sub>1</sub> while lowest moisture (49.84%) and fat (6.38 %) was found in C<sub>4</sub>. Fat facilitates the retention of moisture in cheese. High fat cheeses improved meltability, which may refer to the reason of their more moisture retention. There is no direct increase in moisture content of cheese with reducing the fat content, because the moisture content did not replace fat on an equal basis (Fife *et al.*, 1996).

Protein contents were significantly different in cheese samples ( $p < 0.05$ ). Contrarily to moisture contents, the protein contents increased with decreasing fat content of cheese (Table 2). Change in fat levels of cheese milk did not influence ( $p > 0.05$ ) the both acidity and pH of cheese. Sheehan and Guinee (2003) also found numerical, but non-significant increase in pH due to difference in fat content. Salt level in cheeses varied from 1.17 % (C<sub>1</sub>) to 1.45 % (C<sub>4</sub>). The differences among C<sub>1</sub>, C<sub>2</sub> and C<sub>3</sub> were nonsignificant. Calcium contents also significantly differed in cheese samples. It ranged from 611 mg 100g<sup>-1</sup> (C<sub>1</sub>) to 655 mg 100g<sup>-1</sup> (C<sub>4</sub>). A nonsignificant difference was noted in ash contents (3.56-3.50%) of C<sub>1</sub>, C<sub>2</sub> and C<sub>3</sub> while ash contents in C<sub>4</sub> were significant lower (3.46%).

The effect of storage on fat and protein contents of Mozzarella cheese samples are presented in Fig 1 and 2, respectively. A declining trend ( $p < 0.01$ ) was observed during successive storage days both in fat and protein contents. Fox *et al* (2000) stated that during storage, there is proteolytic and lypolytic activity of culture microorganisms that break down protein and fat respectively. Minimum loss in protein was in C<sub>4</sub> with least fat content as showed in Fig 2. Cheeses with lower fat content and consequently lower moisture in non-fat-substance had slower rates of proteolysis (Dave *et al.*, 2003). Moreover, relatively high free moisture available in cheese during earlier storage period favors the hydration and hydrolysis of protein and fat (Lucy *et al* 2003).

Ripening is very important for quality cheese production. It is influenced by several factors, including plasmin, lipase, chymosin, proteinase and peptidases from the starter and non starter bacteria, pH and moisture levels of the curds, ripening time and temperature, salt content, salt-to-moisture ratio, and humidity. Enzymatic catabolism of aminoacid also

**Table 2. Average chemical composition of mozzarella cheese samples**

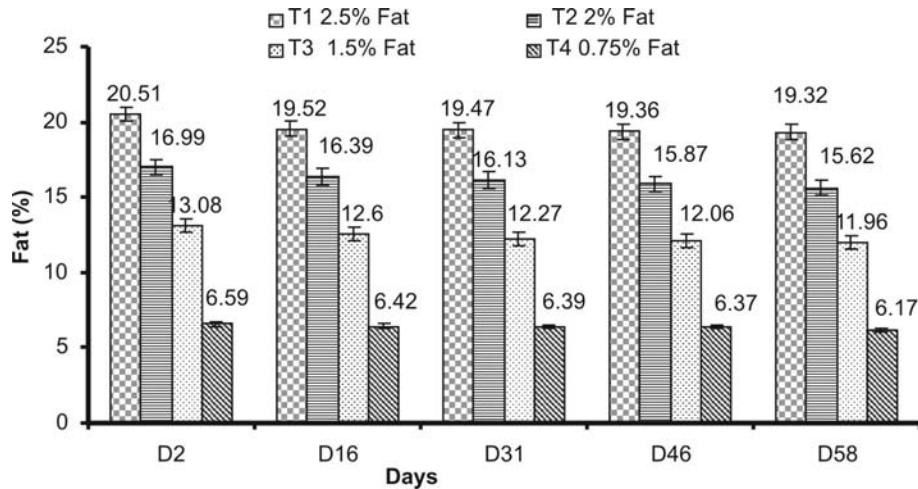
Cheese samples	Fat	Protein	Acidity	Salt	Ash	Moisture	Ca mg/100g	pH
	%							
C <sub>1</sub>	19.63a	24.49c	0.71 <sup>NS</sup>	1.17b	3.56a	53.07a	611d	5.06 <sup>NS</sup>
C <sub>2</sub>	16.19b	24.47c	0.70	1.22b	3.50a	52.60 ab	613c	5.11
C <sub>3</sub>	12.39c	25.41b	0.71	1.24b	3.50a	52.06 b	638b	5.12
C <sub>4</sub>	6.38d	26.78a	0.71	1.45a	3.46b	49.87 c	655a	5.12

\*Treatments with same letters within a column are not significantly different ( $p < 0.05$  or  $0.01$ )

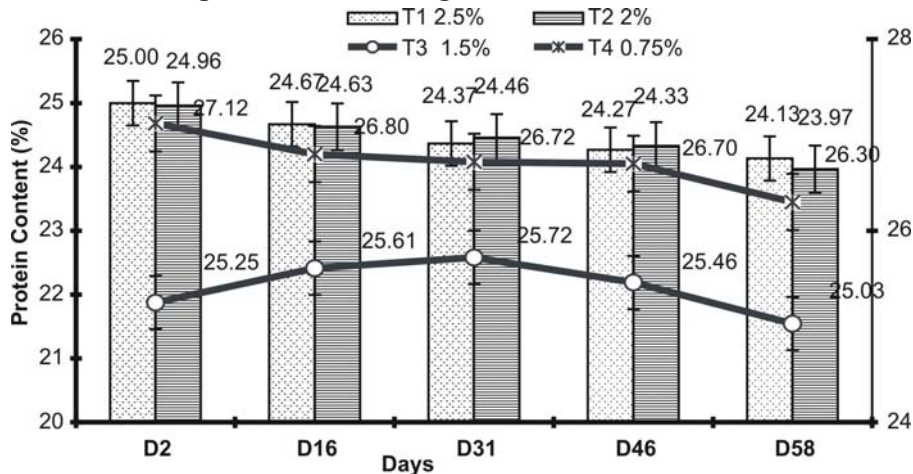
plays significant role in the improved quality cheese (Velo *et al.*, 2003). Cheese with high protein had improved appearance and texture due to more stability resulted by protein fat interlacing and calcium links to casein. During storage there was degradation of protein (casein)'s chemical structure, which in turn resulted in the loss of calcium and phosphorus with corresponding decrease in casein.

**Sensory evaluation**

The appearance of cheese has great value in its acceptability. There was no obvious trend of decrease or increase but at the mid of ripening time scores to all treatments were higher. The maximum scores (Fig 3) were awarded for C<sub>2</sub> (2% fat) and C<sub>3</sub> (1.5 % fat) as compare to C<sub>1</sub>. This indicated that high fat cheeses proved good in appearance while in case of low fat



**Fig. 1. Effect of storage on cheese fat content**



**Fig. 2. Effect of storage on cheese protein**

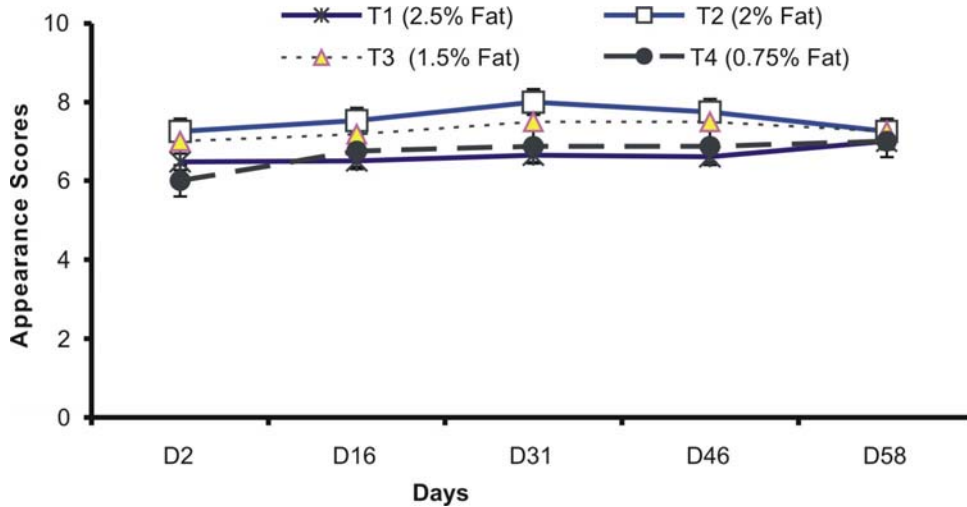


Fig. 3. Effect of storage on cheese appearance

cheeses, the appearance was poor, rough and lacking lust. Moreover low-fat Mozzarella cheese appeared to be harder, more brittle and less pliable (Zisu and Shah, 2004).

Storage effected ( $p < 0.01$ ) the texture of mozzarella cheese, as cheese matures a decrease in firmness (or softening) of the body was observed. The result showed two phases of texture development during storage. Phase one occurred within the first 7-14 days when the rubbery texture of the young cheese was converted into more smooth characteristic texture of the specific variety (Jhong 1976; McMahon and Oberg, 1998). Among the cheese samples, high fat cheeses especially C<sub>1</sub> and C<sub>2</sub> showed to have better texture which further improved with storage than C<sub>3</sub> and C<sub>4</sub>. After 31 days their textural scores decreased but texture of C<sub>3</sub> improved up to 46 days (Fig. 4).

The graphical presentation (Fig 5) of cheese with different fat content and storage periods indicate significant effect on cheese overall acceptability. The acceptability of C<sub>2</sub> was superior followed by C<sub>3</sub>, C<sub>1</sub> and C<sub>4</sub> during whole storage period.

Flavour of cheese is one more important sensory property. Cheese ripening has a significant effect on cheese flavour development. Lower flavour scores were awarded on the day 2<sup>nd</sup> of storage to all cheese samples, which rose during storage as the flavour characteristics developed up to one month. After this, due to some unknown and undesirable enzymatic and chemical reactions, the flavour scores drop off. Overall, highest scores for flavour were awarded to C<sub>2</sub> (2.0 % fat) followed by C<sub>1</sub>, C<sub>3</sub> and C<sub>4</sub> which exhibited minimum score for flavour as compare to all other cheese samples (Fig. 6).

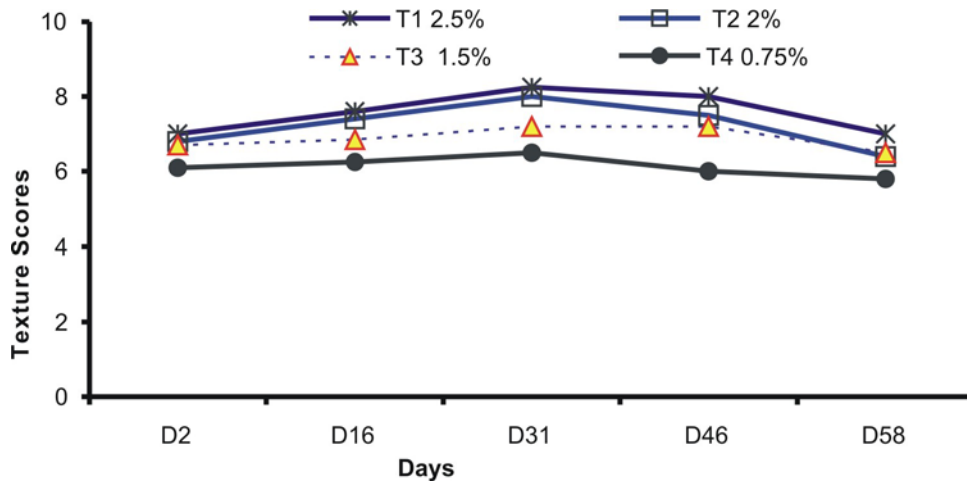
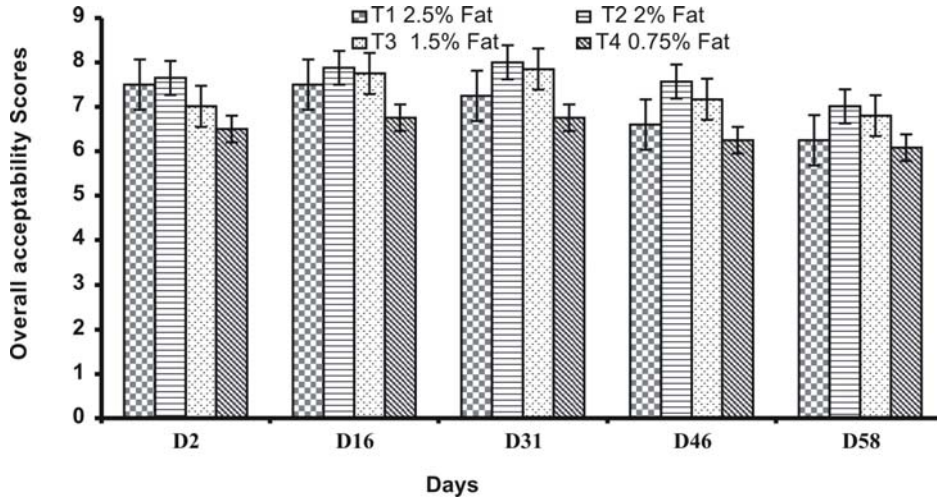
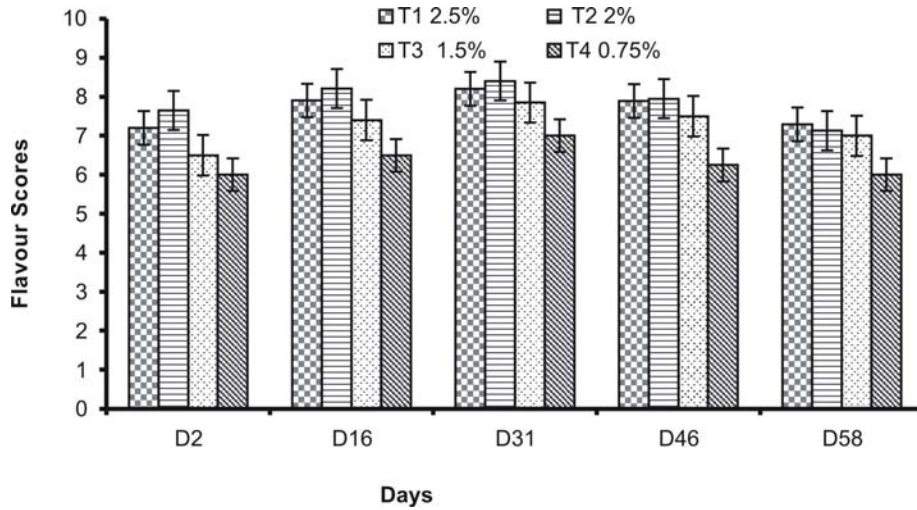


Fig. 4. Effect of storage on cheese texture

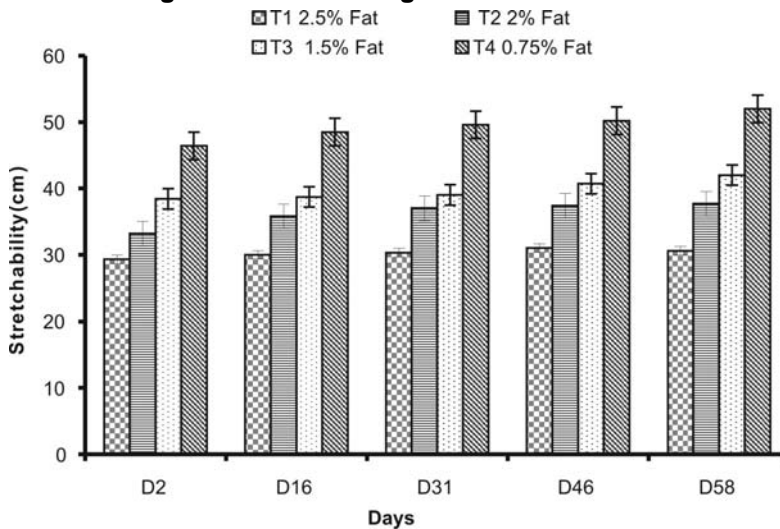
*Impact of fat levels in milk of buffalo mozzarella cheese*



**Fig. 5. Effect of storage on cheese overall acceptability**



**Fig. 6. Effect of storage on cheese flavour**



**Fig. 7. Effect of storage on cheese stretchability**



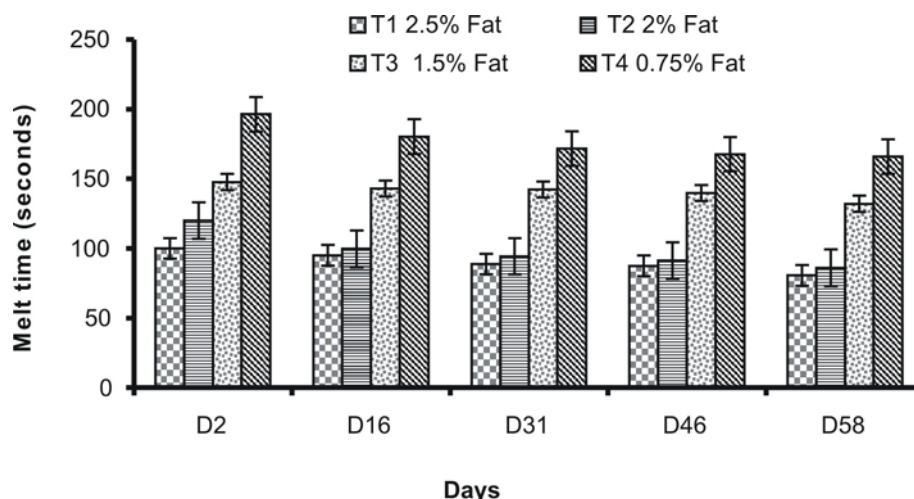


Fig. 8. Effect of storage on cheese meltability

### Stretchability

Stretchability is the tendency of an object to form elongated fibrous strands that do not break when pulled (Kindstedt, 1993). The results showed that there was significant effect of fat contents and storage days on the stretchability of cheese (Fig. 7). The cheeses with high fat had less stretch ( $C_1$ ) as compared to low fat cheeses that have more stretch ( $C_3$ ). In all the cheese samples, stretchability increased with the successive days of storage this is in agreement with previous studies on Mozzarella and other varieties (Guinee *et al.*, 2002; Kindstedt, 1995).

### Melt time

Melt time is defined as the time required for shredded cheese, loaded at a rate of  $0.173 \text{ g cm}^{-2}$  onto a polished stainless steel tray, to melt into a uniform mass free of shred identity (Guinee *et al.*, 1998). Meltability is strongly bonded with fat content of cheese. Cheese took more time to melt at start of ripening but with the time of cheese maturation the time decreased these results are in agreement with the previous studies of (Guinee *et al.*, 2002; Kindstedt, 1995). The results showed that fat content and storage days had significant effect on melt time (Fig. 8). Cheese at lowest fat level generally showed poor meltability because meltability is directly related with fat content of cheese as the fat decrease the melt time increases, although fat in relation to protein also has some effect on meltability (McMahon and Oberg, 1998). The increase in melt is also attributed due to increase in proteolysis, fat coalescence and water binding capacity of casein matrix, which promotes heat induced displacement of adjoining layers of the casein matrix on heating (Guinee, 2003). When protein

hydrolyses it improves the meltability by favouring in rheological characteristics of cheese (Rowney *et al.*, 1998). Due to proteolysis, weakening of the cheese structure occurs. This weakening increases the melt of cheese and can also alter the viscoelastic behavior of Mozzarella cheese (Dave *et al* 2002).

### CONCLUSION

Fat content in cheese affect the moisture, protein and calcium which ultimately influence the sensory and functionality characteristics of Mozzarella cheese. Cheeses with higher fat were higher in moisture retention and lower in proteins content. Overall acceptability and meltability of cheese containing 2.0% was higher than the other samples followed by the  $C_1$  (2.5% fat),  $C_3$  (1.5% fat) and  $C_4$  (0.75% fat). While the cheese containing 0.75% fat was found to have more stretchability which is the main characteristic of Mozzarella cheese.

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