PRODUCTION AND EVALUATION OF LOW FAT CHEDDAR CHEESE USING BUFFALO MILK

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ABSTRACT

Low fat cheeses often suffer from undesirable texture and, flavor and test. The present study was conducted to assess the yield, texture, flavor and quality of low fat Cheddar cheese and full fat Cheddar cheese using buffalo milk during ripening. The proximate attributes such as moisture, ash, protein and fat and physical attributes such as pH, colour, flavour, taste, texture, hardness and overall acceptability properties of both cheeses were studied at day one and during ripening. Nine points hedonic scale ranking method was used to evaluate organoleptic characters. The average yield of low fat Cheddar cheese and full fat Cheddar cheese were obtained from fresh buffalo milk (720 ± 10 per 5 Lit of milk) and 215 ± 50 per 5 Lit of milk, respectively. Moisture, protein and fat contents were significantly ($P < 0.05$) changed at day one and during the ripening period. Fat content of the full fat cheese and low fat cheese was increased throughout ripening period. Moisture and protein contents were slightly decreased with ripening period. As whole, Fat and protein contents were significantly ($P < 0.05$) higher in the full fat cheese than the low fat cheese while the moisture content was significantly ($P < 0.05$) higher in low fat cheese compared to full fat cheese. In general, the sensory quality such as colour, flavour , taste intensity and texture was higher in cheeses obtained by full fat than those made by low fat cheese in the ripening period. Hardness of cheese was higher in the low fat cheese than the full cream cheese throughout the ripening period. Finally, majority of panelist preferred full fat cheddar cheese and few of panelists accepted low fat Cheddar cheese.

Key Words: Low fat Cheddar cheese, color, flavor, sensory evaluation, ripening

Introduction

During the past few decades over consumption of dietary fat is associated with various illnesses (Fenelon and Guinee, 2000). This has made awareness to increase in the demand for low-fat foods consumption, including cheese (Nouira et. al., 2011). However, the consumption of low/reduced-fat cheese is still insufficient (Morsi, 2014). In the dairy industry, manufactures are developing different varieties of reduced fat, low fat and fat - free milk products. In fact, fat reduction presents a challenging problem because fat is important for texture and flavor of dairy products such as cheese (Jameson, 1990). Fat reduction in hard and semi-hard cheeses results in undesirable rubbery texture, lack of flavor, and/or presence of off-flavors (Olson and Johnson, 1990). Reduced-fat and low-fat cheeses which possess the characteristics of traditional full-fat cheeses have been in demand (Nouira et al., 2011).

Cheese is the most diverse group of dairy products and is arguably, the most academically involves a wide range of disciplines, especially analytical, physical chemistry, biochemistry, microbiology, rheology, and sensory science (Fox and McSweeney, 2004). Cheese is a concentrated dairy product formed by acid or rennet coagulation followed by cooking of curd, draining off the whey and pressing the curd (Fox et al., 2000). When producing low fat Cheddar cheeses, processing parameters must be altered substantially in order to produce an acceptable test color, texture and flavor. Different strategies were described to overcome both texture and flavor defects, which include the retention of higher moisture in the curd, which can partially replace fat and improve texture through cutting into larger cubes, lowering the cooking temperature, draining and milling at a higher pH.

Low fat cheeses are usually characterized by poor flavor and functional properties due to high moisture and low salt (Punidadas et al., 2000; Mistry, 2001). Fat removed in manufacturing low fat cheese is largely replaced with moisture and the ratio of moisture in fat - free substance of cheese is similar to that of a full cream cheese (Mistry, 2001). The dietary guidelines and desire for consumption of low-fat products have affected inclinations in the market place (Solheim and Lawless, 1996). With an increasing trend for health and wellness-related food products and the nutritionists‟ and medical professionals‟ constant pressure to reduce the consumption of animal fat, there is a segment of consumers nowadays who wants to buy low-fat cheeses but expect no compromise in quality. Dairy processors have a great opportunity to stay on top of the health and wellness trend, and significantly increase cheese sales through the development of consumer acceptable low fat cheese. However, reducing fat in Cheddar negatively impacts flavor and texture. Therefore, our study has designed to investigate the physical and chemical properties of Cheddar cheese using low fat buffalo milk.

MATERIALS AND METHODS

PREPARATION OF FULL CREAM AND LOW FAT CHEDDAR CHEESE

Fresh milk obtained from milk collecting centre and the fat was removed by cream separator up to 2.5%. Cheddar cheeses were made from 2.5 % low fat and 6.0% full fat, pasteurized (63 oC for 30 minute and cooled to 31oC). Cheese milk assigned to cheese vats. Each vat was filled with pasteurized milk and stabilizer the temperature at 31oC, a starter culture was directly added at a rate of rate of 4.5 g / 5.0 L of milk into the vats and mixed thoroughly for 4-5 min. After 60 minutes coagulants were added

into the each vat and the milk mixed thoroughly for 1 to 2 minutes. After settled the coagulum, the coagulated milk were cut by using 15 mm knife. The curd was allowed to stand for 15 min and stirred gently with a spoon for 5 min. The temperature was gradually increased from 31 to 40 oC over 30 min and held at this temperature for about 1 hr. The whey was then drained and curds were underwent for cheddaring process . During this process, the cud was turned, piled and replied. Then the curd blocks were milled into small pieces and stirred for 15 min. Dry salt was added (2.5 % w/w of curd) and the curd was mixed thoroughly for 15 mim. Then the curd was molded and pressed over night at 40 psi. Finally the curd was stored for 3 months at 7-8oC in the vacuumed packed. The samples were taken for analysis at day one, 2nd week, 4th week, 6th week, 8th week and 10th week of ripening.

PROXIMATE ATTRIBUTES (NUTRIENTS) ANALYSIS

Full fat cheese and low fat cheese samples were subjected to nutritional analysis to determine the nutritional composition of cheese parameter which were considered to the analysis; such as cheese fat, cheese protein, total dry matter, ash content and moisture. These cheese samples were analyzed in triplicate for moisture by oven drying at 102oC to get constant weight according to IDF method (AOAC, 1990) and percentage of moisture was calculated as moisture (%) =100 - total solid (%). Total protein content of cheese samples was determined by measuring total nitrogen using the Kjeldahl method and converting it to protein content multiplying by 6.38 (AOAC, 1990). The fat content of cheese was determined by the Gerber method (Anon, 1972)

MEASUREMENT OF PH:

The pH of cheese paste by preparing by blending 5 g grated cheese with 5 mL of deionizer water (Patel et al., 1993). The pH was measured on a digital pH meter (model -Delta 320 pH meter) after calibration with fresh pH 4.0 and 7.0 stranded buffer.

SENSORY EVALUATION

In sensory evaluation, the samples were subjected to nine-point hedonic scale test and the acceptability of samples was judged by 15 untrained members to determine consumer preference. The sensory characteristics such as colour, flavour, taste, texture, hardnesss and overall acceptability of the full cream cheese and low fat cheese were judged by the panelists at day one, 2nd week, 4th week, 6th week, 8th week and 10th week of storage period.

STATISTICAL ANALYSIS

Data obtained in chemical analysis were subjected to Analysis of Variance (ANOVA) and mean separation was done with Duncan's Multiple Range Test (DMRT). Descriptive statistics was done on sensory attributes and the means were compared using the Tukey's test ($P < 0.05$).

RESULTS AND DISCUSSION

YIELD AND pH

The result show that Cheddar cheese produced using low fat milk (2.5%) and full fat milk (6.0%) in Table 1. The yield of full fat cheese was significantly ($P < 0.05$) higher in cheese produced from full fat milk than cheese produced from low fat milk. There was no significant ($P > 0.05$) change in pH of both fresh cheeses at the time of production while pH of whey was also not changed in both fresh cheeses because the considerable bio chemical and microbial changes were not occurred in fresh cheese. This study agreed with the finding report of Muir et al., (1996) which reported at day one that average pH value of low fat and full fat cheeses were 5.68 and 5.00, respectively. Fox et al. (2000) reported that during the low fat cheese production, fat level was adjusted through standardization process reduce the yield of cheese. It could be the reason for the variation yield cheese.

Table 1: Yield components of low fat and full fat cheese.

Yield Parameters	Treatments	
	Full fat cheese	**Low fat cheese**
Yield (g)/ **5 Lit of milk**	720 ± 10^{a}	215 ± 50^{b}
Whey pH	4.88 ± 0.08^{a}	4.86 ± 0.04^{a}

Means followed by same letters in each row do not differ significant based on DMRT at ($P < 0.05$).

PROXIMATE ATTRIBUTES (NUTRIENTS) OF FULL FAT AND LOW FAT CHEESE AT DAY ONE

The result of nutritional composition of full fat and low fat cheese sample at day one show that there was no significant ($P > 0.05$) change in ash content among two types of cheeses due to considerable bio chemical and microbial changes were not occurred at day one of cheeses (Table 2). Moisture, protein and fat content were significantly ($P < 0.05$) changed in the two types of cheese. The variations were due to the adjustment in the fat level in low fat cheese milk by the standardization process. As a result, it revealed that decreasing the fat content of cheese milk resulted in an increase in cheese moisture and a decrease in cheese yield.

Table 2: Proximate attributes (nutrients) of full and low fat cheese at day one

Attributes	Full cream cheese	Low fat cheese
Ash (%)	4.40 ± 0.40[a]	3.84 ± 0.10[a]
Moisture (%)	38.65 ± 0.05[a]	55.61 ± 0.01[b]
Protein (%)	20.50 ± 0.10[a]	16.62 ± 0.05[b]
Fat (%)	32.45 ± 0.25[a]	19.88 ± 0.05[b]

Means followed by same letters in each row do not differ significant based on DMRT at ($P < 0.05$).

These observations are in agreement with the data reported by Morsi, (2014). The variations were due to the adjustment in the fat level in low fat cheese milk by the standardization process. Dabour et al., (2006) reported that Cheddar cheese with low fat retained higher moisture level (36% - 48%) compared to full fat cheese.

CHANGE OF PROXIMATE (NUTRIENTS) COMPOSITION AND PH DURING RIPENING PERIOD

The mean values of moisture content of full fat cheese and low fat cheese were significantly ($P < 0.05$) varied during the ripening period (Table 3). The moisture content was higher in low fat cheese than full fat cheese. Overall the moisture content of cheese was decreased in both cheeses during ripening this may lead to the salting that took place during this period and increased proteolysis during ripening (Lane et al., 1997). (Patel et al., 1993; Pino et al., 2009) and . Muir et al., (1996) stated that low fat cheeses had higher moisture content than compared to full fat cheese and he also reported that average moisture content value of reduced with ripening period at 100C. Ash contents did not show any significant ($P > 0.05$) changers in two types of cheese. Moreover, it was observed that the ash content of full cream cheese was slightly higher than the low fat cheese.

Protein contents was significantly ($P < 0.05$) changed in both cheeses during ripening period. The results revealed that the protein content of full fat cheese was higher than the low fat cheese. Howver, protein content of both cheeses was deceased during the ripening period. Meyer and Spahni (1998) also reported that protein reduction could be proteolysis of thermophic starter cultures in the cheese during ripening. Bachmann et al., (1999) reported that the protein content was 21.4% months after ripening period in full fat cheese.

A fat content of cheese was significant ($P < 0.05$) higher in full fat cheese than the low fat cheese. Even though, fat content of both cheeses was increased during the whole ripening period. According to Muir et al., (1996) average fat content value of reduced fat cheese was 21.27% and full cream average fat in dry matter value ranged from 49.9% to 55.3% at 12 months of ripening at 100C.

Table 3: Variations in proximate composition of full fat and low fat cheese during ripening.

Attributes	Full fat cheese					
	Day 01	Week 02	Week 04	Week 06	Week 08	Week 10
Moisture (%)	38.65 ± 0.05^{e}	37.75 ± 0.75^{ef}	36.80 ± 0.10^{fg}	36.64 ± 0.03^{fg}	36.24 ± 0.34^{gh}	35.04 ± 0.52^{h}
Ash (%)	4.40 ± 0.40^{a}	4.45 ± 0.05 ^{a}	4.45 ± 0.20 ^{a}	4.40 ± 0.01^{a}	4.45 ± 0.05^{a}	4.40 ± 0.00^{a}
Protein (%)	20.50 ± 0.10^{a}	20.67 ± 0.00 ^{a}	19.62 ± 0.0.05^{b}	19.71 ± 0.04 ^{b}	18.95 ± 0.03 ^{c}	18.66 ± 0.10 ^{d}
Fat (%)	32.45 ± 0.25^{a}	32.52 ± 0.79^{a}	32.57 ± 1.96 ^{a}	32.72 ± 0.06^{a}	32.77 ± 0.26^{a}	32.80 ± 0.42^{a}
pH	4.76 ± 0.03^{c}	4.75 ± 0.03^{c}	4.76 ± 0.01^{c}	4.81 ± 0.01^{bc}	4.83 ± 0.00^{b}	4.89 ± 0.01^{a}
Attributes	**Low fat cheese**					
	Day 01	**Week 02**	**Week 04**	**Week 06**	**Week 08**	**Week 10**
Moisture (%)	55.61 ± 0.01^{a}	55.36 ± 0.04^{a}	54.79 ± 0.01^{b}	53.73 ± 0.17^{c}	52.08 ± 0.08 ^{d}	51.98 ± 0.01^{d}
Ash (%)	3.84 ± 0.04^{b}	3.85 ± 0.05^{b}	3.85 ± 0.05^{b}	3.90 ± 0.10^{b}	3.80 ± 0.00^{b}	3.85 ± 0.05^{b}
Protein (%)	16.62 ± 0.05^{f}	15.83 ± 0.03^{f}	16.05 ± 0.05^{g}	15.85 ± 0.12^{g}	15.60 ± 0.15 ^{h}	15.30 ± 0.02^{i}
Fat (%)	14.88 ± 0.05^{b}	14.88 ± 0.125^{b}	14.91 ± 0.01^{b}	14.91 ± 0.39^{b}	14.92 ± 0.42^{b}	14.95 ± 0.08^{b}
pH	4.80 ± 0.01^{bc}	4.81 ± 0.04^{bc}	4.80 ± 0.00^{bc}	4.85 ± 0.01^{b}	4.88 ± 0.00^{a}	4.90 ± 0.02^{a}

Means followed by same letters in each row do not differ significantly based on DMRT at ($P < 0.05$).

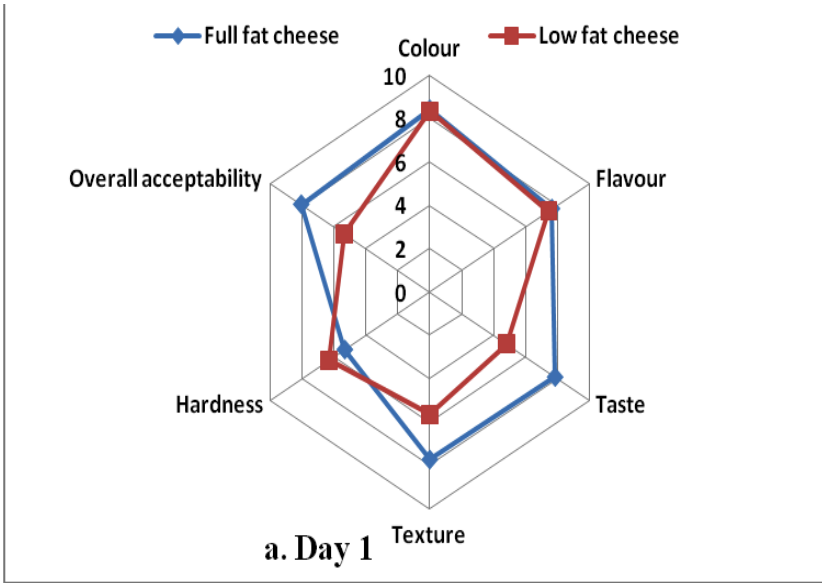
pH:

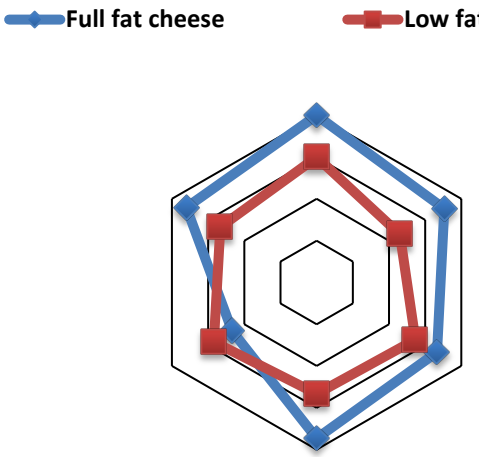
Initially, the pH of cheese made from full fat (4.76 ± 0.03) was slightly lower than the cheese made from low fat (4.80 ± 0.01). The pH was slightly reduced in the early stage, Four weeks after, it significantly ($p<0.5$) increased consistently throughout ripening. Galán et al. (2008) observed a similar response for cheese produced from plant and animal types of coagulant. It is reported that increasing pH during ripening of cheese attributed to the utilization of lactic acid from lactate, the formation of non-acidic decomposition products, and liberation of dissociated amino acids and alkaline products of protein decomposition (McSweeney et al., 1993). Muir et al., (1996) also reported that average pH value of reduced fat cheese was 5.68 and full cream average pH value ranged from 5.00 to 5.56 during 3 to 12 months of storage at 100C. Dabour et al., (2006) revealed that the ripening pH reached 6.5 at maximum level at 3-12 months ripening. In this study, the results were coincided with his study.

SENSORY QUALITIES

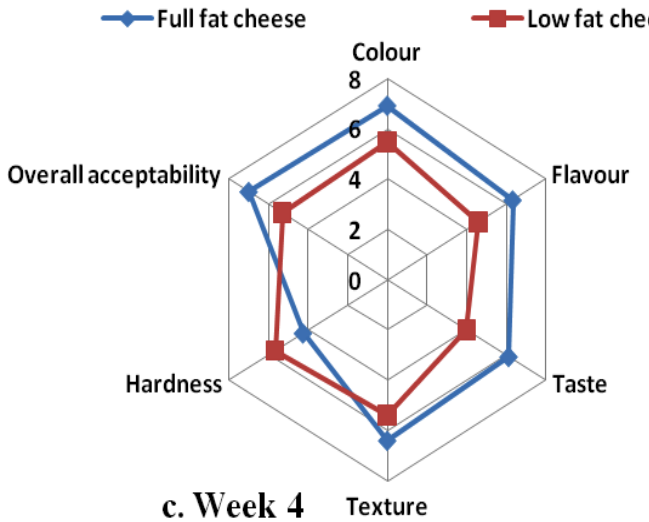
Figure 1 (a-f) has shown that the cheeses had a pronounced opaqueness with a matt surface appearance that is typical of Cheddar cheese. But it did not significantly ($P > 0.05$) changed in colour in two types of cheese at day one due to considerable bio chemical and microbial changes were not occurred in the fresh cheeses (Fox et al., 2000). Color intensities of these cheeses varied significantly ($p < 0.05$) in both

Figure 1: Sensory attributes of cheese samples during storage period presented by a "spider web (a-f)

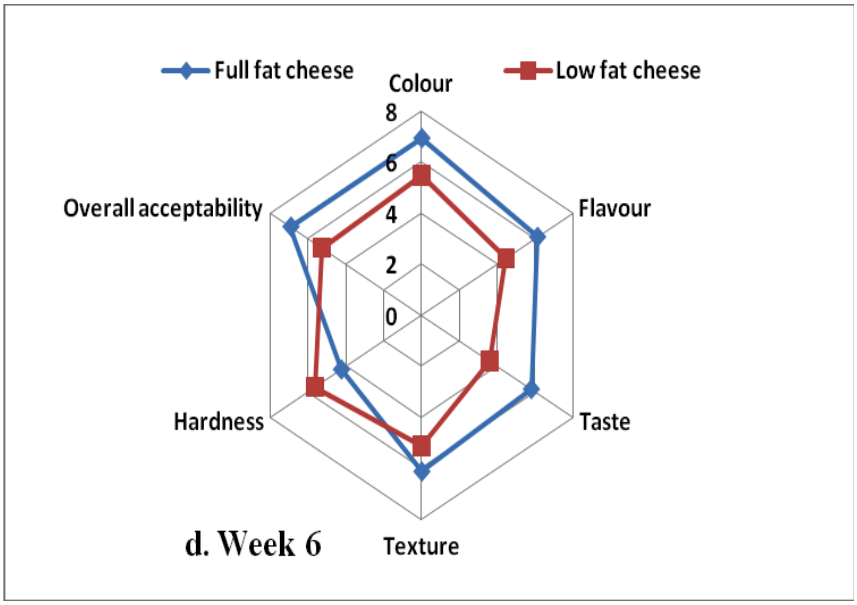




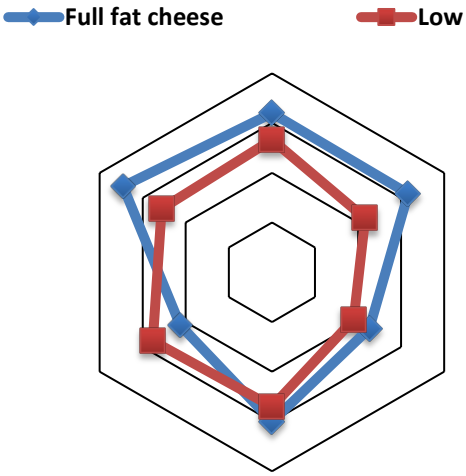
b. Week 2



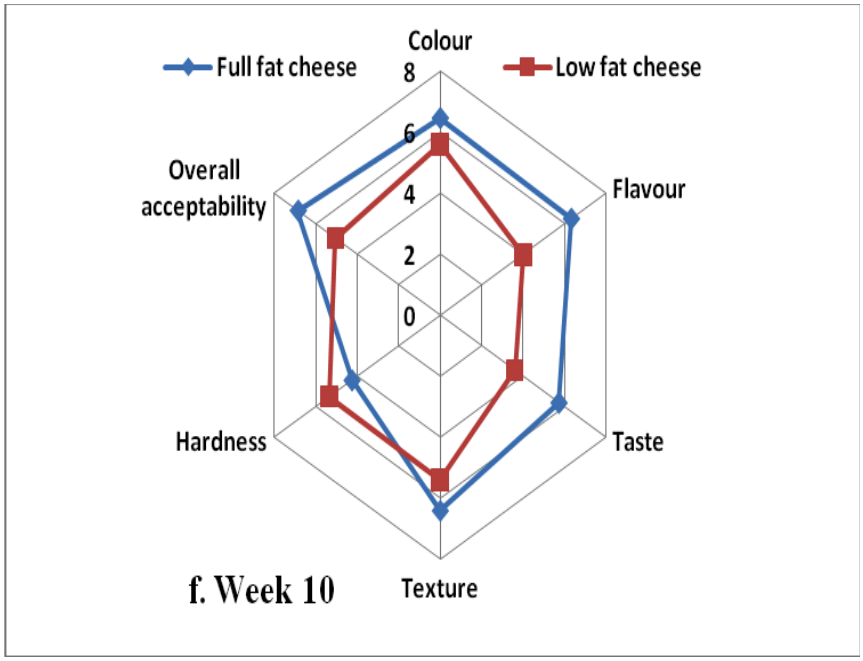
c. Week 4



d. Week 6



e. Week 8



cheeses during ripening. Colour was lowered in both cheeses during ripening period. Ultimately, colour change was ($p<0.05$) higher in low fat cheese than full fat cheese.

There was no significant ($P > 0.05$) change in flavour between low fat and full fat cheese at day one, it leads to considerable bio chemical and microbial changes were not occurred in day one fresh cheeses (Fox et al., 2000). At beginning, the flavour intensity was decreased in both cheeses due to the less active of bio chemical changes and microbial changes occurred. Then after flavour gradually increase during the end of storage period but full fat cheese had a higher flavour preference than the low fat cheese (Paul and Mcsweeney, 2004). Secondary reactions lead to the production of volatile flavour compounds from the metabolism of free fatty acids and free amino acids during ripening (McSweeney et al., 1993).

Taste of cheese was significantly ($P < 0.05$) changed during storage period among full fat cheese and low fat cheese. There were no significant ($P > 0.05$) changes in low fat cheese and full fat cheese individually during the whole ripening period. Even though, taste preference was decreased from day one to end of the ripening period. As a whole, full cream cheese had a greater preference compared to low fat cheese in early stages of ripening and the preference of taste declined with ripening period in both cheeses. Law, (2001) reported that the lack in taste in cheese due to mixture of small peptides and amino acids directly influences the taste and mouth feel of cheese during ripening.

TEXTURE:

The changes in hardness values during cheese ripening were studied. Reduction of fat increased the hardness in low fat cheeses. In this study, hardness was significantly ($P < 0.05$) lower in full fat cheese than low fat cheese from day one to end of the ripening. Morsi (2014) reported that these observations are comparable to previous findings. Early part of storage period (2-4 weeks) non rubbery texture was identified in both cheeses and end of storage the texture was drastically decreased. It might be the αS1-1 casein molecules present in early of ripening period which reduces the rubbery texture (Dabour et al., 2006). Further, modifications of the conventional method of cheese making protocol could decrease in hardness that can be attributed to the increase in the moisture level of the cheese. During the first early months of ripening, hardness was decrease in all types of cheese and followed by an increase hardness in the latter part of ripening, this may be due to the breakdown of the casein and the increase of protein-protein interactions (Morsi, 2014)

As a whole, results revealed that the texture was significantly ($P < 0.05$) changed in both cheeses from day one to end of ripening. Further, texture preference decreased from day one to end of ripening period. Full fat cheese got a higher degree of texture preference than low fat cheese. The result of the present study agreed with the findings of Upadhyay et al., (2004) who reported that Proteolysis contributes to the softening of cheese texture during ripening due to hydrolysis of the casein matrix of the curd and through a decrease in the water activity of the curd due to changes in water binding by the new carboxylic acid and amino groups formed on hydrolysis. McSweeney et al., (1993) stated that the rate and extent of acidification influence the initial texture of the curd by controlling the rate of demineralization during ripening. Many reports have also shown that when the fat content of cheese is progressively reduced, the cheese develops an undesirable firm, weak, rubbery texture Numerous strategies have been applied to improve the texture of low fat cheese, which has been reviewed in several occasions. However, it still remains a challenge to reduce fat and maintain the texture of a comparable full fat cheese.

OVERALL ACCEPTABILITY:

The overall acceptability revealed that in both cheeses, full fat cheese obtained the highest scores for color, flavour, taste and texture. The lowest scores for both texture and flavor were obtained in the case of low fat cheese. Overall acceptability is the most complex organoleptic property of foodstuffs. This is a combination of all other sensory qualities and judgment of this property is difficult and varies between individuals to a higher extent than the other characteristic. Majority of panelist prefer full fat cheese and few of panelist accepted low fat cheese. Low fat cheese is good for health. Hence most panelists were not preferred low fat cheese. Most of consumers prefer full fat cheese in terms of right colour, rich pleasing flavour, smooth texture, rich taste of cheese.

CONCLUSIONS

The study show that quality attributes of full cream and low fat cheese during the ripening process. Proximate attributes such as moisture, fat, protein and pH were significantly ($P < 0.05$) affected during the ripening period. The findings of this study revealed that both sensory quality and acceptability of cheeses with different fat level composition were significantly affected ($P < 0.05$) in both types of the cheeses. Full cream cheese had higher in all the sensory attributes namely colour, flavour, taste, texture and hardness. The low fat cheese had higher hardness compared to full cream cheese. The results have also revealed that full cream cheese was more overall acceptable than the low fat cheese. It is concluded that the different fat level composition milk used in cheese making significantly affected sensory quality and acceptability. Further, the results of this study showed that consumer might have preference for variation in cheese consistencies, pleasant flavour and colour, rich taste and had significance influence on overall acceptability of the product. Hence, cheese manufacturers need to improve on sensory properties in particular flavour and taste for better consumer acceptability of low fat cheese.

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