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EFFECT OF HEAT TREATMENT AND SALT CONCENTRATION ON ORGANOLEPTIC PROPERTIES OF SUDANESE BRAIDED (*MUDDAFFARA*) CHEESE MANUFACTURED WITH RAW OR PASTEURIZED MILK

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Abstract
Cheese is the most diverse group of dairy products that is widely produced and consumed worldwide. Of them, braided cheese locally known as Muddaffara is one of the most popular cheese types in Sudan. However, studies on the eating quality of Muddafara cheese is very limited. Therefore, the aim of the study was to investigate the effect of heat treatment and salt (0%, 5%, and 10%) on the sensory attributes of Sudanese braided cheese during ripening (3 months at 5±2°C). In this study, a factorial experiment in completely randomized design was used to evaluate the effects of these treatments on the sensory characteristics of braided cheese processed from raw (BCRM) and pasteurized (BCPM) milk and then ripened in salted whey for up to 3 months. The results indicated that the heat and salt concentration significantly ($P \leq 0.05$) affected the sensory attributes of braided cheese. Higher changes in texture had occurred in salted whey (SW) cheese during storage compared to that stored in 0% SW. Sensory characteristics of the cheese sample stored in 5% were significantly ($P \leq 0.05$) better when compared with those stored in 0 % and 10% SW. Organoleptically, BCRM and BCPM stored in 5% SW were superior to those stored in 0% and 10% salted whey. The obtained results suggest that pasteurization and ripening in low salted whey improved the acceptability and quality life of braided cheese. Further studies are needed to ascertain the microbiological quality and safety of BCRM.

Key words: Braided Cheese, BCRM, BCPM, Salt concentration, Sensory attributes

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1. INTRODUCTION

Cheese is the generic name for a group of fermented milk-based food products, produced in a wide range of flavours and forms throughout the world. Although the primary objective of cheese making is to conserve the principal constituents of milk, cheese has evolved to become a food with pleasure-seeking qualities as well as being highly nutritious (Fox and McSweeney 2004; Mohamed Ahmed *et al*., 2010). The nutritional and organoleptic quality of cheese is highly required to increase the consumer preference of this important food. However, these quality attributes are varied among different cheese types due to the variation in pre/post cheese-making practices. In particular, processing methods such as heat treatment of milk before cheese making beside the addition of salt to milk, cheese curd or in the brine solution during ripening could have significant impact on the quality attributes of cheese. Heat treatment of milk prior to cheese-making is known to have the potential to substantially increase cheese yield by incorporating the whey proteins in the cheese curd (Anema *et al*., 2007) and thus contribute to enhancing the nutritional quality of the final product. While, salt has a major effect on cheese composition, microbial growth, enzymatic activities and biochemical changes that occur during ripening such as glycolysis, proteolysis, lipolysis and para-casein hydration (Guinee 2004). Accordingly, salt could markedly affect the flavour and aroma, rheology and texture properties, cooking performance and, hence, the overall organoleptic quality of cheese (Guinee 2004). This substantial diversity in cheese making practice resulted in a wide

variety of cheeses each of which has complex sensory features (Delahunty and Drake 2004). The sensory attributes of cheeses such as appearance, flavour and texture, are properties that are perceived by the human senses, mainly during consumption (Delahunty and Drake 2004). Thus, sensory evaluation of cheese is unquestionably essential to determine the relative merits of cheese making processes, and the eating quality of cheese and its consumer acceptability.

In Sudan, cheese making is the main conservation method for excess milk in rural areas particularly during the rainy season when plenty of milk is available (El Owni and Hamid 2008) and accordingly many types of cheese are produced throughout the country. Of them, braided cheese locally known as Muddaffara is now being produced in Sudan. Muddaffara cheese is among the most popular cheese in Sudan and other Middle Eastern countries. It is estimated that about 7500 tons of Muddafara cheese is manufactured in Sudan each year and this cheese is sold in the local markets (FAO 2005). The last decade is witnessed with an increased demand for the production and consumption of Muddafara cheese in Sudan. However, research focusing on the sensory attributes of Muddafara cheese made from raw cow milk is very rare. Moreover, there is no study of the effect of pasteurizing cow milk and different level of salt on sensory quality of ripened Muddafara cheese. It is necessary to obtain best specifications and best organoleptic quality attributes and to extend the shelf life of Muddafara cheese. Therefore, the aim of this study was to investigate the effect of heat and salt concentration on sensory attributes of Muddafara cheese during storage periods.

2. MATERIALS AND METHODS

Materials

Fresh cow's milk was obtained from Khartoum University Farm, Khartoum, Sudan. Rennet, (Chr. Hansen's, Denmark), $CaCl_2$ was a product of Sigma Chemical Company (St Louis, MO, USA). Salt (NaCl) and Black cumin (*Nigella sativa*) were obtained from the local market, Khartoum, Sudan. All chemicals and reagents used were of technically recommended analytical grade.

Cheese Manufacture

Muddafara cheese was manufactured according to Altahir *et al*. (2014). Briefly, the obtained fresh cow milk (10 kg) was divided in two equal portions. One was used as raw milk without pasteurization and the other was pasteurized. Both milks were warmed to 40°C, and then starter culture with a combination of 1 : 1 *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (0.02%), rennet (0.5g/5kg milk) and CaCl2 were added to both milks. After complete coagulation (about 45 min), the curd was cut or broken to small parts and incubated until the required acidity (0.49- 0.67 lactic acid %) for kneading was reached. The curd was put on a wooden table, and left for (5 min) to drain off the remaining whey. The curd was then cooked in 500 mL of whey at 70-80°C for five minutes. A natural flavoring ingredient such as black cumin was added (0.5%) to the hot paste, then cut into small pieces and flattened-like a circle shape. The curds formed where then braided, divided into three equal portions, each packed in plastic container assigned randomly to one of the three salted whey (0%, 5%, and 10% salt) in a ratio of 1:1 (cheese: whey) and stored for up to 90 days at 5±2°C.

Organoleptic quality of cheese

The organoleptic qualities of Muddafara cheese were evaluated following the IDF standards (FIL-IDF 99B 1995). A panel of 10 semi-trained members, composed of adult male (5; age ranged from 24 to 32) and female (5, age ranged from 22 to 35), was assigned to determine the quality of the fresh and mature cheese (color, flavor, taste, texture and overall acceptability). Members were asked to score 1-5 hedonic scale (1 = poor, 2 = acceptable, 3= good, 4 =very good and 5 = excellent). The samples were randomized and presented using tag for each one. To determine the differences in judges' response, the mean scores were analyzed by Duncan's multiple range tests.

Statistical analysis

A factorial experiment in a completely randomized design (CRD) with three replications was used. Collected data were subjected to analysis of variance (ANOVA) and whenever appropriate ($P \leq 0.05$) Duncan multiple range test (Steel *et al.,* 1997) was employed to separate the treatments means using the SAS program (SAS 2007).

3. RESULTS AND DISCUSSION

Effect of heat treatment on the organoleptic properties of braided cheese

The change in the sensory attributes (color, flavor, taste, texture, saltiness and overall acceptability) of braided cheese is shown on Table 1. Heat treatment of milk (raw & pasteurized) had no effect ($P \geq 0.05$) on the color of braided cheeses. Organoleptically the two types of cheeses (BCRM & BCPM) had similar ($P \geq 0.05$) color score (3.61). With exception of saltiness, the rest of organoleptic parameters measured namely, flavor, taste, texture, and overall acceptability, BCRM outscored ($P \leq 0.05$) BCPM. On the other hand, the latter (BCPM) had significantly ($P \leq 0.05$) higher saltiness score (3.40) than BCRM (3.03). These results are in agreement with those of Nuser (2001) who found no significant change in color due to cooking of cheese. The taste and flavor were best in uncooked cheese and cheese cooked at 38ºC. However, low scalding improves the sensory properties of cheese (Salomoskiene 1998). Mohamed and Abdalla (2010) reported that except over all acceptability other parameters tested color, flavor, taste, body and saltiness did not significantly change of cooked and uncooked cheese. In addition, cheeses produced from pasteurized milk were found to be clearly different from those produced from unpasteurized milk, with the unpasteurized milk cheeses being more diverse in sensory character and more intensely flavored (Grappin and Beuvier 1997; Muir *et al.,* 1997; Murray and Delahunty 2000).

The changes of organoleptic properties of braided cheese in different salt level

The effect of whey salt concentration on the different organoleptic parameters (color, flavor, taste, texture, saltiness, and overall acceptability) of Sudanese braided cheese is shown on Table 2. Apparently salt concentration level had no effect ($P \geq 0.05$) on the color of braided cheese. Expectedly saltiness score of braided cheese increased significantly ($P \leq 0.05$) with the increase in the salt concentration of the whey in which the braided cheese was ripened. On the other hand, texture score decreased significantly ($P \leq 0.05$) with the increase in salt concentration. At 0% and 10 % salt concentration the braided cheese had lower flavor, taste, and overall acceptability scores than 5% salt concentration. These results are in agreement with El-Gazzar *et al*. (1983) who reported that low level of salt (5%) gave the best kashkaval cheese in shorter time of ripening. The mineral content plays an important role in establishing the characteristic structure, the texture of Cheddar cheese appears to be more dependent upon pH than on any other factor (Lawrence *et al*., 1987). Sodium chloride improves flavor, texture, and appearance of cheese as well as it suppresses the growth of spoilage organisms and reduces moisture content of cheese (Kosikowski 1985). However, Salama *et al*. (1982) reported that low level of salt (5%) gave the best characteristics of kashkaval cheese in shorter time of ripening.

Effect of the storage periods on organoleptic properties of braided cheese

The effect of storage periods on sensory characteristics of (color, flavor, taste, texture, saltiness and overall acceptability) Sudanese braided cheese is shown on Table 3.With exception of taste and saltiness properties, the rest of the sensory properties showed various degrees of change. The general trend of change was a decrease in the property with the increase in storage period. Saltiness score continued to increase ($P \leq 0.05$) with the increase in storage periods. It reached its peak (3.51) after 60 days of storage before it drops to 3.21 value at 90 days of storage, yet a value that was

significantly ($P \leq 0.05$) higher than the initial saltiness score. At 30 and 90 days of storage, braided cheese had similar ($P \geq 0.05$) saltiness score. It should be noted that such changes in saltiness score was not reflected on the taste of the braided cheese. Storage periods had no effect ($P \geq 0.05$) on the taste of braided cheese with the increase in storage period. Numerically, the lowest taste score (2.64) was found on the 60 days of storage. It should be noted that this correspond with the highest saltiness score (3.51). On the other hand, flavor showed mixed change as it decreased significantly ($P \leq 0.05$) on the 30 days of storage before it returned back to its initial value on day zero of storage. Texture showed insignificant ($P \geq 0.05$) decrease in score with the increase in storage periods till the 60 day thereafter on the 90 day of storage it showed a lower texture score ($P \leq 0.05$) than its initial score on day zero. These results were similar to those of Abdalla and Mohamed (2009) who reported that color of white cheese was not significantly changed as storage period increased while flavor and taste gradually improved throughout the storage period. The change can be caused by different factors such as the proteolysis of the cheese curd**.** These result disagreed with findings of Abd El-Hamid *et al*. (2001) and Sameen *et al*. (2008) who reported that the texture of Mozzarella cheese improved during storage period. Also these results disagreed with the findings of Saleem *et al*. (1978) and Tarakci and Kucukoner (2006) who reported increasing values for flavor and overall acceptability during ripening. Abdalla and Mohamed (2009) studied the effect of storage period on sensory characteristics of cheese. They found that color and body of cheese did not significantly ($P \geq 0.05$) changed during the storage period, whereas, the flavor, taste, saltiness, and overall acceptability gradually improved throughout the storage period.

Effect of heat treatment, salt concentration, and storage periods on the organoleptic characteristics of braided cheese

Table 4 presents the changes in the sensory attributes (color, flavor, taste, texture, saltiness and overall acceptability) of braided cheese as affected by the interaction of the factors of heat treatment, salt concentration and storage period. The interaction of three factors had no effect ($P \geq 0.05$) on the preference of the panelist to the color of braided cheese. None of the evaluated cheese samples had a color score of less than 3.13 out of 5 score. The flavor scores was significantly ($P \leq 0.05$) different in cheese samples during the ripening. The highest flavor score (4.63) was found on the 30 days of storage of the BCRM stored in 5% SW. On the other hand, the lowest flavor score (1.67) was in BCPM stored in 0% SW after 30 days of storage. These results are in agreement with those of El-Sheikh (1997) who found that the flavor of braided cheese made from different types of milk increased until day 30 and then slightly decreased. The taste scores of braided cheese types showed different changes during the ripening process. The highest taste score (4.67) was found with the BCRM stored in 5% SW on the day 30 of storage. On the other hand, the lowest taste score (1.43) was in BCPM stored in 0% SW after 30 and 90 days of storage, which may be attributed to proteolysis of the cheese due to prolonged storage period. Proteolysis is the most important process during cheese storage. It contributes to cheese off-flavor, off odor and abnormal texture through the breakdown of the released proteolysis products such as amino acids. Gouda (1986) reported that the degradation of casein fraction affected by sodium chloride caused reduction of pH and hence increased the rate of proteolysis.

The interaction of the three factors had similar effect ($P \geq 0.05$) on the preference of the panelist to the texture of braided cheese. The highest score (4.47) of texture was found with the BCRM stored in 5% SW on the day 30 of storage. On the other hand, the lowest score (1.17) was found with BCPM cheese stored in 10% SW (1.17) after 90 days of storage. El-Gazzar *et al*. (1983) reported that higher level of salt produced a hard, rubbery and crumbly kashkaval cheese due to the relatively low moisture content, which retarded maturity. The saltiness score in both BCRM and BCPM

increased ($P \leq 0.05$) with the increase in salt concentration of each types of braided cheese and had similar ($P \geq 0.05$) score during prolonged storage. The lowest saltiness score (1.10) at the end of storage of BCRM stored in 0% SW and highest score (4.87) appeared with BCRM stored in 10% SW after 30 days. With exception of the BCRM stored in 5% SW, the acceptability score was similar ($P \geq 0.05$) for the cheese samples during storage increase. The highest acceptability score (4.87) appeared with BCRM in 5% SW, and the lowest score (1.20) was found, with BCPM in 10% SW at the end of storage. Zaugg (1995) reported that the high salt concentration used in cheese ripening usually makes cheese unpalatable. Some of these results were similar with Sameen *et al*. (2008) who concluded that the sensory attributes of Mozzarella cheese appearance, texture and overall acceptability were improved during storage period. Moreover, Abd El-Rafee *et al*. (2004) observed that the flavor and appearance and flavor scores of Mozzarella cheese improved during storage while body and texture score decreased. Low salt treatment remained superior in all critical properties of overall acceptability, taste, texture, and saltiness. It seems that low salt cheese always gain better acceptability as reported by Prokopek *et al*. (1992). Also the acceptability of cheese depends mostly on the flavor formed during the ripening process. Fatty acids and volatile sulfur compounds are believed to be the most important compounds that contribute to the flavor and free fatty acids are of particular importance in this regard (Chow, 2007). Hamid *et al*. (2008) studied the effect of salt concentration on sensory characteristics of Sudanese white cheese and concluded that the cheese with 6% salt was significantly ($P \leq 0.05$) better when compared with cheese made with 4% salt. This could be due to the effect of salt on the proteolytic enzymes and moisture content of cheese (Fox, 1993).

Table 1. The organoleptic properties of braided cheese processed from raw and pasteurized milk

Sensory attributes	BCRM	BCPM
Color	3.61[a]	3.61[a]
Flavor	3.40[a]	2.63[b]
Taste	3.15[a]	2.44[b]
Texture	3.17[a]	2.58[b]
Saltiness	3.03[b]	3.40[a]
Acceptability	2.75[a]	2.13[b]

"a-b" Mean values followed by different superscripts letters in each row are significantly different ($P \leq 0.05$).
BCRM=braided cheese processed from raw milk, BCPM=braided cheese processed from pasteurized milk.

Table 2. The changes of organoleptic properties of braided cheese in different salt level.

	Salt concentration (%)		
Sensory attributes	**0**	**5**	**10**
Color	3.66[a]	3.64[a]	3.53[a]
Flavor	2.70[c]	3.38[a]	2.97[b]
Taste	2.06[c]	3.74[a]	2.59[b]
Texture	3.52[a]	2.96[b]	2.14[c]
Saltiness	1.37[c]	3.83[b]	4.45[a]
Acceptability	2.07[b]	3.16[a]	2.10[b]

"a-c" Mean values followed by different superscripts letters in each row are significantly different ($P \leq 0.05$).

Table 3. Effect of the storage periods on organoleptic properties of braided cheese.

Sensory attributes	Storage periods (days)			
	0	**30**	**60**	**90**
Color	3.96 [a]	3.45 [b]	3.59 [b]	3.43 [b]
Flavor	3.17 [a]	2.76 [b]	3.16 [a]	2.98[ab]
Taste	2.85 [a]	2.88 [a]	2.64 [a]	2.81 [a]
Texture	3.16 [a]	2.94 [a]	2.79[ab]	2.61 [b]
Saltiness	2.88 [c]	3.27 [b]	3.51 [a]	3.21 [b]
Acceptability	3.29 [a]	2.44 [b]	2.18 [c]	1.84 [d]

"a-d" Mean values followed by different superscripts letters in each row are significantly different ($P \leq 0.05$).

Table 4. Effect of heat treatment, salt concentration, and storage periods on the Sensory evaluation of braided cheese.

Heat treatment	Salt concentration (%)	Storage period (days)	Sensory attributes					
			Color	flavor	taste	texture	saltiness	acceptability
BCRM	0	0	3.87[a]	2.43 [d]	2.10 [c]	3.50 [b]	1.37 [c]	2.80[bc]
		30	3.43 [a]	3.13 [c]	3.43 [b]	4.47 [a]	1.13 [c]	1.57 [c]
		60	3.57 [a]	2.97 [c]	2.00 [c]	3.57 [b]	1.13 [c]	1.33 [c]
		90	3.13 [b]	3.13 [c]	2.23 [c]	3.37 [b]	1.17 [c]	1.27 [c]
	5	0	4.00 [a]	3.67[bc]	3.27 [b]	2.97[b]	3.50 [b]	3.80 [b]
		30	3.53[ab]	4.63 [a]	4.67 [a]	3.53 [b]	3.37 [b]	4.87 [a]
		60	3.57 [a]	3.87 [b]	4.37 [a]	3.47 [b]	3.87 [b]	4.20 [b]
		90	3.50[ab]	3.97 [b]	4.43 [a]	3.53 [b]	3.37 [b]	3.77 [b]
	10	0	3.97 [a]	3.33 [c]	2.93 [c]	2.70 [c]	3.27 [b]	3.37 [b]
		30	3.63 [b]	3.03 [c]	2.57 [c]	2.20 [c]	4.87 [a]	2.13 [c]
		60	3.67 [a]	3.50 [c]	2.47 [c]	2.87 [b]	4.77 [a]	2.20 [c]
		90	3.43 [a]	3.13 [c]	3.33 [b]	1.87 [c]	4.53 [a]	1.70[c]
BCPM	0	0	4.00 [a]	2.83[cd]	1.87 [c]	2.97 [b]	1.77 [c]	3.07 [b]
		30	3.40 [a]	1.67 [f]	1.43 [c]	3.40 [b]	1.33 [c]	2.43 [c]
		60	3.83 [a]	2.97 [c]	2.00 [c]	3.47 [b]	1.93 [c]	2.70 [c]
		90	4.03 [a]	2.43 [d]	1.43 [c]	3.43 [b]	1.10 [c]	1.37 [c]
	5	0	4.17 [a]	3.27 [c]	3.30 [b]	3.50 [b]	3.27 [b]	3.17 [b]
		30	3.57[ab]	1.93 [f]	3.67 [b]	2.40[c]	4.30 [a]	2.23 [c]
		60	3.47 [a]	2.80[cd]	2.93 [b]	1.97[c]	4.67 [a]	1.47 [c]
		90	3.33 [b]	2.90 [c]	3.27 [b]	2.30[c]	4.33 [a]	1.77 [c]
	10	0	3.77 [a]	3.47 [c]	3.63 [b]	3.30 [b]	4.10 [a]	3.57 [b]
		30	3.13 [b]	2.17 [d]	1.53 [c]	1.63 [c]	4.63 [a]	1.43 [c]
		60	3.47[a]	2.83[cd]	2.07 [c]	1.40 [c]	4.67 [a]	1.20 [c]
		90	3.20 [b]	2.30 [d]	2.17 [c]	1.17 [c]	4.73 [a]	1.20 [c]
			3.61	2.63	2.44	2.58	3.40	2.13

"a-f" Means followed by different superscripts letters in each column are significantly different ($P \leq 0.05$).
BCRM=braided cheese processed from raw milk. BCPM= braided cheese processed from pasteurized milk.

4. CONCLUSION

Almost all the sensory characteristics of braided cheese samples made from raw and pasteurized milk and stored in 5% SW were superior to those stored in 0 % and 10% SW. Additionally, pasteurization and ripening in low SW improved the acceptability and quality life of braided cheese. Although braided cheese made from raw milk had good sensory quality, further studies are needed to ascertain the microbiological quality and safety of raw milk braided cheese under low salt ripening conditions.

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