

Research Article

Effect of Milk Fat Level on Salt, Some Mineral Content and Sensory Characteristic of Sudanese White Cheese During Storage

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Abstract

Sudanese white cheese is a traditional pickled cheese to which 6-20% salt is added. Sudanese white cheese was made using three levels of milk fat: low fat (1%), partial skimmed (2%) and full fat (4%) milk. The produced cheese was packed into both glass and plastic containers and each were stored at room ($38\pm 2^{\circ}\text{C}$) and refrigerator ($5\pm 3^{\circ}\text{C}$) temperature. Salt, some minerals content and sensory evaluation were carried out every 2 weeks for a period of three months. The results revealed that Sudanese white cheese with the different fat levels were significantly ($P<0.05$) different in salt, sodium, calcium and phosphorous. Also the different types of packaging materials (glass and plastic) and storage duration showed significant ($P<0.05$) differences for salt content of the cheeses. The sensory evaluation was assayed for flavour, texture, appearance and the overall acceptability and showed significant ($P<0.05$) differences between the different types of cheeses. The cheese made using 2% milk fat kept in the glass containers and stored in refrigerator temperature gained the highest scores of organoleptic properties compared to other cheeses. The present study concluded that the cheese made with partially skimmed milk (2%) is better in its overall acceptability. This will suggest its introduction to the market and to convert the removed fat into other valuable dairy products (such as cream, butter and ghee). This will increase revenue for the producers and will give healthy images for the consumers who utilize such cheeses. The

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present study recommended further work in order to improve the acceptability of low fat cheese in Sudan.

Keywords: Low fat cheese; Macro minerals; Salt; Sensory evaluation; Sudanese white cheese

Introduction

Cheese is a rich source of essential nutrients; in particular, proteins, bioactive peptides, amino acids, fat, fatty acids, vitamins and minerals [1]. Cheese is the fresher ripened product obtained after coagulation and whey separation of milk, cream or partially skimmed milk, butter milk, or a mixture of these products [2].

The quality and composition of the cheese may vary considerably due to factors such as the quality and composition of the clotted milk, the method of manufacture, the time required to complete the whey drain, the quality of salt added and the method of handling of the finished cheese [3]. The different manufacturing methods and milk composition influence the chemical composition of the cheese [4]. Some factors that influence cheese quality of white cheese and therefore its nutritive value include composition of food materials, the natural of the compounds, the types of packaging system and the preservative used [5].

Low fat milk products, particularly low fat cheese represents a good choice for the development of new products with functional properties because the consumers are always looking forward to desirable and healthy products [6]. The higher present of fat on cheese is not required so the excess fat could be manufactured into the expensive products like butter, cream and ghee [7]. Low fat cheeses are usually characterized as having poor body, flavour, and functional properties because of high moisture and low salt. Procedures developed for manufacturing low fat cheeses include processing techniques, starter culture selection, and use of additives [8].

Homogenization of cream was found to improve the body and texture and functional properties of low fat cheeses, and increases yield when used for up to 50% reduction in fat. Stabilizers, fat-replacers, and sweet buttermilk have also been used to improve the quality of low fat cheeses [8]. The storage of cheese in glass containers elongates the cheese shelf life and that storage of soft cheese in cold temperature is better than room temperature [9].

Salt acts as preservative and flavour enhancer in cheese. In addition salt has a major role in the functional properties of the cheese [10]. Salt could markedly affect the flavour and aroma, rheology and texture properties, cooking performance and, hence, the overall organoleptic quality of cheese [11].

Salting has an effect on cheese yield, weight loss, chemical composition, microbiological and sensory characteristics of the Sudanese white cheese [12,13]. However the high salting preserves cheese from rapid deteriorating before ripening [14,15]. The way of salting is different among the producers of cheese [16,17].

The consumption of cheese is of great nutritional interest, due in particular to its composition of micronutrients especially minerals [18]. The cheese is the rich source of major and minor minerals, which include calcium, phosphorus, sodium, chloride, potassium and iron [19]. The mineral compounds participate in the coagulation; influence the draining of the whey and the texture of the curd and on the properties such as stability to heat and the capacity of coagulation depend [20]. On the other hand there are many reasons for the increased consumption of cheese including a positive dietary image, convenience and flexibility in use and the great diversity of flavour and texture [21]. Hence the present study was designed to assess the salt and the major minerals content of Sudanese white cheese as affected by milk fat level and to study the effect of storage conditions (packaging, storage temperature and duration) on the sensory properties of the cheeses.

Materials and Methods

Sources of materials, chemical and reagents

Fresh cow's milk was obtained from a dairy farm located at Soba (South Khartoum), Rennet (Chr. Hansen's, Denmark) and salt of commercial grade were obtained from the local market of Khartoum.

All chemicals and reagents used were of technically recommended grade from reputable sources

Preparation and storage of cheese

Three level of milk fat were used to process the Sudanese white cheese at the Faculty of Animal Production (Dairy Processing Lab), University of Khartoum as was described previously [9]. The milk fat standardization was performed using fat separator apparatus (Alfa Laval), to get 25% and 50% of the total fat content of the original milk. Then three samples of milk (full fat; 4%, 50% fat; 2% and 25% fat; 1%) were used for preparation of the cheese.

Analytical procedures

The salt and mineral content

The salt in cheese was determined according to a method described by Breen and Price [22]. Sodium, calcium, and phosphorus content were determined by the atomic absorption Spectrophotometer using the procedures [23].

Organoleptic evaluation

Ten untrained panelists, however they are familiar with Sudanese white cheese were asked to judge on the quality of the cheese for appearance, texture, flavour and overall acceptability of the cheese. Organoleptic evaluation of cheese samples was assessed according to the ranking method described by Ihekoronye and Ngoddy [24]. The sum of the ranking was assessed statistically at $P \leq 0.05$.

Statistical analysis

Data generated was subjected to Statistical Analysis System (SAS). Factorial randomized complete design was used; then the means and standard deviations were tested and separated using Duncan's Multiple Range Test [25].

Results

Salt content

Table 1 showed changes in salt content of Sudanese white cheese as affected by the level of milk fat (1%, 2% and 4%), type of packaging

and storage period. The level of the salt content decreased significantly ($P \leq 0.05$) during the storage period for the samples kept in the plastic containers and the glass containers (Table 1). The salt content decreased significantly ($P \leq 0.05$) as fat content increased. The salt content were found to be 14.16%, 11.90% and 11.05% in the cheese samples made from 1%, 2% and 4% fat, respectively for those samples kept in plastic containers at the end of storage period (90 days). However there was no significant ($P > 0.05$) differences between the salt content of cheese samples kept at room temperature and that stored in refrigerator.

Sodium content

The changes in the sodium content for Sudanese white soft cheese made of 1%, 2% and 4% milk fat as affected by the type of packing during the storage period were shown in table 2. The levels of the sodium content in all samples were increased significantly ($P \leq 0.05$) with the increase of the milk fat (Table 2). At 30 days of storage the sodium content for cheese samples kept in plastic containers were found to be 9.40, 6.23 and 8.20 mL/100g for the cheese made from 1%, 2% and 4% milk respectively, and 9.32, 7.77 and 7.23 mL/100g respectively, for samples kept in glass containers, respectively. Moreover the level of sodium content was significantly ($P \leq 0.05$) affected by the storage conditions, at room temperature; at the end of storage period; the sodium content for cheese made using 1%, 2% and 4% milk fat were 5.57, 3.01 and 4.76 mL/100g, respectively for the cheese kept in plastic containers and 5.17, 2.97 and 2.45 mL/100 g, respectively for the cheese kept in glass containers (Table 2). Generally the level of sodium content for those kept in the refrigerator were significantly ($P \leq 0.05$) lower than that at room temperature.

Calcium content

The level of calcium content was significantly ($P \leq 0.05$) affected by fat content. Also the calcium content in all samples of the cheese decreased significantly ($P \leq 0.05$) throughout the storage period, after 30 days of refrigerated storage, the calcium content of the cheese samples kept in plastic containers were 14.1, 14.19 and 14.53 mL/100 g in the Sudanese white cheese made from 1%, 2% and 4% milk fat, respectively and were 7.35, 8.53 and 8.01 mL/100 g, respectively for those kept in glass containers (Table 3). The highest value for calcium obtained (17.22 mL/100 g) at day 15 in full fat cheese stored at room temperature, while the lowest calcium values were obtained (7.35 mL/100 g) at the end of storage in low fat cheese kept at the refrigerator. However there were no significant ($P > 0.05$) differences between the calcium content of cheese samples kept at room temperature and those kept in refrigerator (Table 3).

Phosphors content

The level of phosphors was significantly ($P \leq 0.05$) affected by fat content and type of packaging. The maximum levels of the phosphors content (18.80 and 19.40 mL/100 g) of cheese samples were obtained in samples kept in plastic and glass containers, respectively at 15 days of the storage in the cheese samples made with 1% milk fat, while the minimum levels (4.54 and 4.00 mL/100 g) were obtained after 90 days of storage in cheese samples made using 4% milk fat that kept in plastic and glass containers, respectively (Table 4). Moreover there were significant ($P \leq 0.05$) differences in phosphorous content among all cheese samples during the storage of period (Table 4).

Duration (Days)	Samples/ types											
	1				2				3			
	Storage											
	F		R		F		R		F		R	
	Package											
	P	G	P	G	P	G	P	G	P	G	P	G
0	18.50 ^a ±1.09	18.50 ^a ±1.09	18.50 ^a ±1.09	18.50 ^a ±1.09	18.20 ^{ab} ±0.09	18.20 ^{ab} ±0.09	18.20 ^{ab} ±0.09	18.20 ^{ab} ±0.09	18.10 ^{ab} ±0.74	18.10 ^{ab} ±0.74	18.10 ^{ab} ±0.74	18.10 ^{ab} ±0.74
15	18.50 ^a ±0.12	17.50 ^b ±1.02	18.20 ^{ab} ±0.47	16.80 ^{bc} ±0.74	18.00 ^{abc} ±0.71	15.50 ^{bcd} ±0.94	16.10 ^{bc} ±0.52	15.35 ^{bcd} ±0.79	16.70 ^{bc} ±0.77	16.32 ^{bc} ±0.63	15.67 ^{bcd} ±0.69	15.38 ^{bcd} ±0.32
30	17.20 ^b ±0.96	16.10 ^{bc} ±1.14	18.10 ^a ±0.63	16.50 ^{bc} ±0.61	17.55 ^b ±0.88	14.60 ^c ±0.63	14.16 ^c ±0.55	14.00 ^c ±0.81	16.10 ^{bc} ±0.67	14.10 ^c ±0.62	13.90 ^{bcd} ±0.74	13.52 ^{cd} ±0.56
45	16.10 ^{bc} ±0.97	15.80 ^{bcd} ±0.97	16.80 ^{bc} ±0.47	15.00 ^{bcd} ±0.66	15.15 ^{bcd} ±0.91	14.00 ^c ±0.46	13.64 ^{cd} ±0.58	13.24 ^{cd} ±0.58	14.45 ^c ±0.75	12.12 ^{cde} ±0.69	12.42 ^{cde} ±0.46	12.09 ^{cde} ±0.44
60	15.10 ^{bcd} ±1.00	15.00 ^{bcd} ±0.85	16.00 ^{bc} ±0.64	14.90 ^c ±0.67	12.10 ^{cde} ±0.93	13.35 ^{cd} ±0.58	12.71 ^{cde} ±0.51	12.35 ^{cde} ±0.45	12.80 ^{cde} ±0.69	12.00 ^{cde} ±0.69	11.67 ^c ±0.59	11.25 ^c ±0.49
75	15.00 ^{bcd} ±1.01	14.80 ^c ±0.86	14.50 ^c ±0.87	14.00 ^c ±0.59	12.04 ^{cde} ±0.41	12.47 ^{cde} ±0.76	12.50 ^{cde} ±0.56	11.56 ^c ±0.64	11.50 ^c ±0.71	11.36 ^c ±0.71	11.29 ^c ±0.61	11.00 ^c ±0.35
90	14.16 ^c ±0.98	12.14 ^c ±0.94	12.00 ^{cde} ±0.96	12.00 ^{cde} ±0.56	11.90 ^c ±0.46	11.19 ^c ±0.88	10.02 ^{ef} ±0.70	11.07 ^c ±0.64	11.05 ^c ±0.91	11.00 ^c ±0.66	10.20 ^{ef} ±0.72	10.01 ^{ef} ±0.51
Lsd _{0.05}	0.0531*											
SE±	0.0049											

Table 1: Effect of milk fat, types of packaging and storage temperature on salt content (%) of Sudanese white cheese during storage period.

Each value is an average of two independent samples expressed on dry weight basis.

Mean ± SD value (s) bearing different superscript letter(s) within columns and rows are significantly different (P 0.05).

Duration (Days)	Samples/ types											
	1				2				3			
	Storage											
	F		R		F		R		F		R	
	Package											
	P	G	P	G	P	G	P	G	P	G	P	G
0	12.10 ^a ±1.45	12.10 ^a ±1.45	12.10 ^a ±1.45	12.10 ^a ±1.45	11.67 ^{ab} ±0.99	11.67 ^{ab} ±0.99	11.67 ^{ab} ±0.99	11.67 ^{ab} ±0.99	11.18 ^{ab} ±0.67	11.18 ^{ab} ±0.67	11.18 ^{ab} ±0.67	11.18 ^{ab} ±0.67
15	11.06 ^{ab} ±1.45	10.86 ^{abc} ±1.18	10.29 ^{abc} ±1.05	10.13 ^{abc} ±1.11	9.58 ^{abcd} ±0.84	8.68 ^{ab} ±0.73	7.96 ^{bc} ±0.69	7.05 ^{bc} ±0.71	10.39 ^{abc} ±0.91	10.10 ^{abc} ±0.83	9.67 ^{abcd} ±0.61	8.91 ^b ±0.72
30	9.40 ^{abc} ±1.09	9.32 ^{abc} ±1.19	9.69 ^{abcd} ±1.97	9.44 ^{abcd} ±1.14	6.23 ^b ±1.11	7.77 ^{bc} ±1.23	6.43 ^{bcd} ±1.06	6.11 ^{bcd} ±1.69	8.20 ^{abcd} ±2.06	7.23 ^{bcd} ±1.96	8.41 ^b ±1.46	6.06 ^{bcd} ±0.72
45	9.54 ^{abcd} ±1.03	9.14 ^{abcd} ±1.47	8.42 ^b ±2.03	8.67 ^{ab} ±1.46	7.52 ^b ±1.47	6.15 ^{bcd} ±1.27	5.72 ^c ±1.09	5.44 ^c ±1.77	8.14 ^b ±2.08	8.01 ^b ±1.88	7.29 ^{bc} ±1.67	5.42 ^c ±1.36
60	8.09 ^b ±1.05	7.38 ^{bc} ±1.96	7.67 ^{bc} ±1.77	7.43 ^{bc} ±1.74	6.83 ^{bcd} ±1.64	5.61 ^c ±1.64	4.55 ^{cd} ±1.84	4.09 ^{cd} ±1.71	7.71 ^{bc} ±2.11	7.29 ^{bc} ±1.67	6.41 ^{bcd} ±1.67	4.14 ^{cd} ±1.74
75	7.61 ^{bc} ±1.09	6.84 ^{bcd} ±1.88	7.36 ^{bc} ±1.76	6.05 ^{bcd} ±2.00	5.17 ^k ±1.69	4.18 ^{cd} ±1.74	3.13 ^{ef} ±1.67	3.01 ^{cde} ±1.74	6.77 ^{bcd} ±2.29	6.45 ^{bcd} ±1.74	5.44 ^c ±1.36	3.22 ^{cde} ±1.26
90	6.52 ^{bcd} ±1.07	6.12 ^{bcd} ±1.79	5.57 ^c ±2.01	5.17 ^c ±2.04	4.32 ^{cd} ±1.74	3.29 ^{cde} ±1.19	3.01 ^{cde} ±1.64	2.97 ^{cdef} ±1.69	5.90 ^c ±2.01	5.14 ^c ±1.76	4.76 ^c ±1.56	2.45 ^{cdef} ±1.64
Lsd _{0.05}	0.9157**											
SE±	0.0068											

Table 2: Effect of milk fat, types of packaging and storage temperature on sodium (mL/100 g) of Sudanese white cheese during storage period.

Each value is an average of two independent samples expressed on dry weight basis.

Mean ±SD value (s) bearing different superscript letter(s) within columns and rows are significantly different (P 0.05).

Duration (Days)	Samples/type											
	1				2				3			
	Storage											
	F		R		F		R		F		R	
	Package											
P	G	P	G	P	G	P	G	P	G	P	G	
0	18.50 ^{ab} ±1.03	18.50 ^{ab} ±1.03	18.50 ^{ab} ±1.03	18.50 ^{ab} ±1.03	19.16 ^a ±1.96	19.16 ^a ±1.96	19.16 ^a ±1.96	19.16 ^a ±1.96	18.65 ^{ab} ±1.11	18.65 ^{ab} ±1.11	18.65 ^{ab} ±1.11	18.65 ^{ab} ±1.11
15	16.17 ^{abcd} ±0.99	17.18 ^{abc} ±0.87	16.00 ^{abcd} ±0.97	14.33 ^{bc} ±0.94	16.50 ^{abcd} ±0.97	15.13 ^b ±0.91	16.24 ^{abcd} ±0.99	15.80 ^b ±0.68	15.24 ^b ±0.71	16.80 ^{abcd} ±0.81	16.57 ^{abcd} ±0.81	17.22 ^{abc} ±0.91
30	14.01 ^{bc} ±0.91	15.40 ^b ±0.91	14.76 ^{bc} ±0.96	12.14 ^c ±0.91	14.19 ^{bc} ±0.89	13.88 ^{bcd} ±0.87	15.25 ^b ±0.90	14.43 ^{bc} ±0.65	14.53 ^{bc} ±0.73	15.14 ^b ±0.85	15.43 ^b ±0.85	15.15 ^b ±0.95
45	12.50 ^c ±0.95	13.15 ^{bcd} ±0.95	13.43 ^{bcd} ±0.95	11.22 ^{cd} ±0.95	12.02 ^d ±0.91	11.60 ^{cd} ±0.90	14.02 ^{bc} ±0.95	13.71 ^{bcd} ±0.84	13.15 ^{bcd} ±0.72	14.00 ^{bc} ±0.86	14.25 ^{bc} ±0.86	13.01 ^{bcd} ±0.94
60	10.59 ^{cd} ±0.96	11.93 ^{cd} ±0.93	12.59 ^{cd} ±0.94	9.72 ^{cd} ±0.94	10.72 ^{cde} ±0.74	9.65 ^{cd} ±0.89	12.95 ^c ±0.91	10.49 ^{cde} ±0.77	11.36 ^{cd} ±0.85	12.22 ^c ±0.84	12.49 ^c ±0.77	11.42 ^{cd} ±0.92
75	9.59 ^{def} ±0.87	9.83 ^{def} ±0.91	10.59 ^{cde} ±0.96	8.92 ^d ±0.94	9.52 ^{def} ±0.81	8.72 ^d ±0.94	10.92 ^{cde} ±0.94	8.03 ^d ±0.71	10.42 ^{cde} ±0.81	10.65 ^{cde} ±0.83	8.03 ^{mmo} ±0.95	10.36 ^{cde} ±0.64
90	7.35 ^{de} ±0.91	8.33 ^d ±0.90	9.32 ^{def} ±0.94	7.39 ^{de} ±0.90	8.53 ^d ±0.86	7.52 ^{de} ±0.95	8.29 ^d ±0.93	7.50 ^{de} ±0.69	8.01 ^d ±0.84	8.48 ^d ±0.81	8.74 ^d ±0.91	8.56 ^d ±0.69
Lsd _{0.05}	0.1989**											
SE±	0.07071											

Table 3: Effect of milk fat, types of packaging and storage temperature on calcium (mL/100 g) of Sudanese white cheese during storage period.

Each value is an average of two independent samples expressed on dry weight basis.

Mean± SD value (s) bearing different superscript letter (s) within columns and rows are significantly different (P0.05).

Duration (Days)	Samples/type											
	1				2				3			
	Storage											
	F		R		F		R		F		R	
	Package											
P	G	P	G	P	G	P	G	P	G	P	G	
0	22.70 ^a ±0.97	22.70 ^a ±0.97	22.70 ^a ±0.97	22.70 ^a ±0.97	20.50 ^b ±0.84	20.50 ^b ±0.84	20.50 ^b ±0.84	20.50 ^b ±0.84	18.20 ^b ±0.77	18.20 ^b ±0.77	18.20 ^b ±0.77	18.20 ^b ±0.77
15	18.80 ^b ±0.81	19.40 ^b ±0.89	18.30 ^b ±0.76	17.20 ^{bc} ±0.81	19.05 ^b ±0.70	19.00 ^b ±0.83	18.40 ^b ±0.79	17.20 ^{bc} ±0.66	15.80 ^{cd} ±0.32	13.70 ^d ±0.81	12.20 ^{de} ±0.78	11.40 ^{def} ±0.00
30	16.00 ^c ±0.85	17.60 ^{bc} ±0.91	17.00 ^{bc} ±0.77	16.40 ^c ±0.85	16.20 ^c ±0.75	15.60 ^{cd} ±0.85	13.00 ^d ±0.81	12.20 ^{de} ±0.69	10.60 ^f ±0.46	9.40 ^{fg} ±0.76	8.70 ^{gh} ±0.77	7.85 ^g ±0.00
45	14.10 ^{bcd} ±0.84	16.80 ^c ±0.93	16.80 ^c ±0.81	15.40 ^{cd} ±0.77	15.10 ^{cd} ±0.71	14.75 ^{cde} ±0.74	12.20 ^{de} ±0.80	11.11 ^{def} ±0.49	9.80 ^{fg} ±0.41	8.60 ^{gh} ±0.75	7.40 ^g ±0.70	6.58 ^{gh} ±0.00
60	12.60 ^{de} ±0.79	15.91 ^{cd} ±0.74	15.80 ^{cd} ±0.86	14.60 ^{cde} ±0.74	14.30 ^{cde} ±0.67	13.70 ^d ±0.61	11.40 ^{cde} ±0.84	10.50 ^f ±0.46	8.40 ^{gh} ±0.39	7.80 ^g ±0.76	6.70 ^{gh} ±0.68	6.30 ^{gh} ±0.00
75	11.40 ^{def} ±0.81	15.40 ^{cd} ±0.76	13.60 ^d ±0.87	12.20 ^{de} ±0.72	13.60 ^d ±0.66	12.50 ^{de} ±0.64	10.35 ^f ±0.86	9.60 ^{fg} ±0.71	7.50 ^g ±0.41	7.50 ^g ±0.41	5.20 ^{ghi} ±0.49	5.12 ^{ghi} ±0.00
90	10.80 ^f ±0.85	14.60 ^{cde} ±0.76	12.00 ^{de} ±0.36	11.10 ^{def} ±0.68	12.40 ^{de} ±0.42	10.25 ^f ±0.58	9.90 ^{fg} ±0.69	8.00 ^{gh} ±0.64	6.60 ^{gh} ±0.32	6.60 ^{gh} ±0.77	4.54 ^{ghij} ±0.56	4.00 ^{ghij} ±0.00
Lsd _{0.05}	0.4623**											
SE±	0.057											

Table 4: Effect of milk fat, types of packaging and storage temperature on phosphorous (mL/100 g) of Sudanese white cheese during storage period.

Each value is an average of two independent samples expressed on dry weight basis.

Mean± SD value (s) bearing different superscript letter(s) within columns and rows are significantly different (P0.05).

Organoleptic properties of Sudanese white soft cheese as affected by fat content

Tables 5-8 showed the organolyptic properties of Sudanese soft cheese as affected by fat content during the storage. After 15 days

of storage, the appearance of the cheese samples were found to be affected significantly ($P \leq 0.05$) by the level of milk fat (Table 5). The cheese samples made using 2% milk fat revealed the highest scores followed by the cheese made using 4% milk fat, whereas the cheese made from 1% milk fat obtained the lowest scores.

Duration (Days)	Samples/type											
	1				2				3			
	Storage											
	F		R		F		R		F		R	
	Package											
P	G	P	G	P	G	P	G	P	G	P	G	
0	3.4± 0.06 ^h	3.5± 0.02 ^s	3.3± 0.01 ⁱ	3.4± 0.02 ^h	3.6± 0.04 ^f	3.6± 0.04 ^f	3.5± 0.07 ^e	3.5± 0.04 ^e	3.4± 0.03 ^b	3.5± 0.04 ^e	3.6± 0.02 ^f	3.5± 0.07 ^e
15	3.60±0.06 ^f	3.20±0.01 ^l	3.60±0.06 ^f	3.60±0.05 ^f	3.80±0.04 ^d	3.70±0.05 ^e	3.60±0.07 ^f	3.80±0.03 ^d	3.60±0.04 ^f	3.60±0.03 ^f	3.80±0.04 ^d	3.60±0.03 ^f
30	3.50±0.06 ^e	3.30±0.02 ^l	3.40±0.07 ^h	3.60±0.06 ^f	4.50±0.02 ^a	3.80± 0.05 ^d	3.90± 0.02 ^e	4.00±0.02 ^b	3.80±0.05 ^d	3.60±0.05 ^f	3.70± 0.02 ^e	3.80±0.04 ^d
60	3.20±0.06 ^l	3.10±0.04 ^k	3.20±0.05 ^l	3.30±0.03 ^l	3.60±0.03 ^f	3.10±0.06 ^k	3.00±0.03 ^l	3.80±0.04 ^d	3.20±0.03 ^l	3.00±0.02 ^l	3.20±0.04 ^l	3.20±0.05 ^l
90	3.00± 0.06 ^l	2.90±0.07 ^m	3.00± 0.03 ^l	3.10±0.04 ^k	3.50± 0.03 ^e	3.00± 0.02 ^l	3.00± 0.01 ^l	3.50± 0.01 ^e	3.00± 0.02 ^l	2.80±0.04 ⁿ	3.20± 0.05 ^l	3.00± 0.03 ^l
Lsd _{0.05}	0.9125*											
SE±	0.0378											

Table 5: Effect of milk fat, types of packaging and storage temperature on appearance of Sudanese white cheese during storage period.

Mean± SD value (s) bearing different superscript letter(s) within columns and rows are significantly different (P0.05).

Duration (Days)	Samples/type											
	1				2				4			
	Storage											
	F		R		F		R		F		R	
	Package											
P	G	P	G	P	G	P	G	P	G	P	G	
0	3.2± 0.01 ^l	3.1± 0.05 ^k	3.2± 0.04 ^l	3.1±0.06 ^k	3.2± 0.04 ^l	3.1± 0.07 ^k	3.1± 0.07 ^b	3.2± 0.07 ^l	3.2± 0.06 ^l	3.3± 0.05 ^l	3.1± 0.02 ^k	3.4± 0.04 ^h
15	3.40± 0.03 ^h	3.20± 0.06 ^l	3.30± 0.05 ^l	3.30± 0.05 ^l	3.80± 0.05 ^d	3.50± 0.04 ^e	3.60± 0.05 ^f	3.70± 0.05 ^e	3.30± 0.04 ^l	3.40± 0.03 ^h	3.30± 0.04 ^l	3.60± 0.05 ^f
30	3.60± 0.04 ^f	3.30± 0.04 ^l	3.50± 0.07 ^s	3.40± 0.08 ^h	4.20± 0.06 ^a	4.10± 0.05 ^b	3.80± 0.06 ^d	3.90± 0.08 ^e	3.60± 0.07 ^f	3.70± 0.05 ^e	3.50± 0.05 ^e	3.60± 0.06 ^f
60	2.80± 0.05 ^m	2.60± 0.08 ^e	2.90± 0.08 ^l	2.70± 0.04 ⁿ	3.70± 0.05 ^c	3.80± 0.07 ^d	3.40± 0.07 ^b	3.50± 0.04 ^e	3.40± 0.04 ^h	3.50± 0.07 ^e	3.40± 0.03 ^h	3.40± 0.05 ^h
90	2.20± 0.04 ^q	2.40± 0.05 ^p	2.20± 0.06 ^q	2.10± 0.06 ^r	3.50± 0.04 ^b	3.50± 0.04 ^b	3.20± 0.08 ^l	3.20± 0.05 ^q	3.10± 0.07 ^k	3.20± 0.04 ^q	3.30± 0.05 ^l	3.20± 0.01 ^l
Lsd _{0.05}	0.9684*											
SE±	0.0375											

Table 6: Effect of milk fat, types of packaging and storage temperature on texture of Sudanese white cheese during storage period.

Mean± SD value (s) bearing different superscript letter(s) within columns and rows are significantly different (P0.05).

Duration (Days)	Samples/type											
	1				2				3			
	Storage											
	F		R		F		R		F		R	
	Package											
P	G	P	G	P	G	P	G	P	G	P	G	
0	3.2± 0.08 ^k	3.0± 0.05 ^m	3.31± 0.04 ^j	3.0± 0.04 ^m	3.5± 0.05 ^h	3.8± 0.04 ^e	3.6± 0.03 ^s	3.7± 0.05 ^f	3.4± 0.06 ^t	3.3± 0.04 ^j	3.5± 0.03 ^h	3.64± 0.04 ^s
15	3.40± 0.05 ⁱ	3.20± 0.04 ^k	3.40± 0.05 ⁱ	3.20± 0.05 ^k	3.80± 0.04 ^e	3.60± 0.05 ^s	3.80± 0.02 ^e	3.90± 0.04 ^d	3.60± 0.05 ^s	3.50± 0.05 ^h	3.70± 0.04 ^f	3.80± 0.08 ^e
30	3.60± 0.07 ^e	3.50± 0.05 ^h	3.60± 0.07 ^e	3.40± 0.05 ⁱ	4.50± 0.07 ^a	4.00± 0.08 ^c	4.00± 0.07 ^c	4.00± 0.05 ^b	3.90± 0.04 ^d	3.80± 0.02 ^e	3.90± 0.05 ^d	3.80± 0.07 ^e
60	3.40± 0.03 ⁱ	3.30± 0.05 ^j	3.40± 0.08 ⁱ	3.00± 0.07 ^m	3.80± 0.085 ^e	4.20± 0.03 ^b	3.40± 0.06 ^f	3.60± 0.06 ^d	3.20± 0.07 ^k	3.40± 0.04 ^j	3.50± 0.06 ^h	3.50± 0.03 ^h
90	3.00± 0.05 ^m	3.10± 0.07 ^l	2.20± 0.04 ⁿ	2.10± 0.06 ^o	3.60± 0.07 ^s	3.50± 0.06 ^h	3.00± 0.08 ^m	3.20± 0.07 ^k	3.00± 0.06 ^m	3.20± 0.08 ^k	3.20± 0.06 ^k	3.30± 0.04 ^j
Lsd _{0.05}	0.9118*											
SE±	0.0235											

Table 7: Effect of milk fat, types of packaging and storage temperature on flavour of Sudanese white cheese during storage period.

Mean± SD value (s) bearing different superscript letter(s) within columns and rows are significantly different (P0.05).

Duration (Days)	Samples/type											
	1				2				3			
	Storage											
	F		R		F		R		F		R	
	Package											
P	G	P	G	P	G	P	G	P	G	P	G	
0	3.4± 0.04 ⁱ	3.6± 0.05 ^e	3.3± 0.04 ^j	3.2± 0.05 ^k	3.6± 0.07 ^s	3.4± 0.05 ⁱ	3.5± 0.04 ^h	3.4± 0.03 ⁱ	3.4± 0.03 ⁱ	3.2± 0.05 ^k	3.5± 0.05 ^h	3.3± 0.05 ^j
15	3.60± 0.06 ^e	3.80± 0.07 ^e	3.50± 0.05 ^h	3.40± 0.04 ^j	4.20± 0.04 ^e	3.90± 0.03 ^d	4.20± 0.05 ^e	3.80± 0.05 ^e	3.60± 0.03 ^s	3.40± 0.05 ⁱ	3.60± 0.04 ^f	3.50± 0.04 ^h
30	3.80± 0.07 ^e	3.80± 0.02 ^e	3.70± 0.07 ^f	3.70± 0.07 ^f	4.50± 0.05 ^b	4.20± 0.04 ^e	4.70± 0.06 ^e	4.20± 0.06 ^e	3.80± 0.04 ^e	3.70± 0.07 ^f	3.40± 0.06 ^f	3.60± 0.07 ^e
60	3.20± 0.03 ^k	3.30± 0.04 ^j	3.00± 0.02 ^m	2.80± 0.03 ^m	4.20± 0.04 ^e	3.80± 0.04 ^e	4.20± 0.05 ^e	3.80± 0.06 ^e	3.40± 0.05 ⁱ	3.50± 0.04 ^h	3.20± 0.03 ^k	3.40± 0.08 ⁱ
90	2.80± 0.04 ⁿ	2.80± 0.05 ⁿ	2.50± 0.04 ⁿ	2.60± 0.06 ^o	3.90± 0.03 ^d	3.80± 0.04 ^e	3.80± 0.03 ^e	3.60± 0.04 ^e	3.00± 0.06 ^m	3.10± 0.05	3.00± 0.07 ^m	3.20± 0.04 ^k
Lsd _{0.05}	0.9643*											
SE±	0.0299											

Table 8: Effect of milk fat, types of packaging and storage temperature on overall acceptability of Sudanese white cheese during storage period

Mean± SD value (s) bearing different superscript letter(s) within columns and rows are significantly different (P0.05).

After 30 days of storage (Tables 5-8), the appearance, texture, flavour and overall acceptability of cheese sample made using 2% milk fat were still superior compared to the other samples, while those made from 1% milk fat showed the poorest ranks. After 60 days of storage, the appearance, texture, flavour and overall acceptability of cheese samples made from 2% milk fat obtained the highest ranks. Moreover the data were significantly ($P \leq 0.05$) different in comparison to that made from 1% and 4% milk fat. Also the same results were obtained after 90 days of storage (Tables 5-8), the cheese samples

made using 1% milk fat were the poorest in appearance, flavour, taste, texture and overall acceptability.

Discussion

The salt content of Sudanese white cheese obtained in the present result (10.01-18.50 mL /100 g) were lower than those reported by Abdalla et al. who found about 27% for Sudanese white cheese [26]. The average of salt was 7.57% and 4.06% for traditionally produced cheese samples and that produced by modern industry [27].

The amount of salt used by the producers varied from 7-10% [13,17]. The way of salting differs among the producers of cheese [16,17]. However the values of salt content in all cheese samples in the present study were higher than those reported previously [16,28-30] who reported values of 5.03-12%, 2.27-8.77%, 7.24-8.43% and 8.69-9.36%, respectively. The Sudanese white cheese is unique in containing high concentrations of salt, which is added to the milk before processing [31]; in order to preserve cheese from rapid deterioration before it ripens [15]. This because salt controls microbial growth, enzyme activity, biochemical changes during ripening and development of flavour and aroma of cheese [11]. Salt is usually added to control the growth of lactic acid bacteria and to prevent undesirable microbial growth by killing or limiting the growth of food borne pathogens and spoilage microorganisms [10]. All of these factors make it difficult to reduce the salt content in cheese without substantially adversely affecting the quality [32].

The salt content of white soft cheese samples was affected significantly ($P \leq 0.05$) by fat level and the storage period (Table 1). However non-significant variations were obtained between the cheeses kept in the different packaging materials. Similarly it was reported that the lower values of salt content in the cheeses that kept in plastic and gallon packages might be due to high proteolytic activity and decrease in soluble constituents of cheese that results from partial degradation of protein and their subsequent solubility in whey solution [33].

Sodium content of Sudanese white cheese ranges from 2.45 to 12.10 mg/100 g and was generally higher in the cheese kept in plastic containers compared to those kept in the glass containers (Table 2). The total sodium content in cheeses has a broad range which varies from about 40 to 800 mg sodium/100 g of most types of natural cheese, where salt is the only source of sodium [34]. Moreover the samples stored at room showed higher values compared to those stored in the refrigerator. The levels of the milk fat revealed significant ($P \leq 0.05$) variation in the sodium content of Sudanese white cheese (Table 2). Similar decrease in sodium content of Sudanese white cheese was reported during storage [33,35]. Sulieman et al., reported a decrease in sodium in mozzarella cheese. However increase of sodium chloride during storage of the cheese was also reported [36].

The calcium content of the cheese ranged between 19.16 and 7.35 mg/100 g as shown in table 3. The calcium content was reported as 608-1107 mg/100 g [37]. Calcium enhances the cheese making process by reducing the coagulation time and the gel firmness [38]. Moreover the milk salts, calcium and phosphate have an important role in the rennet coagulation of milk and in the structure and buffering of cheese [39].

The level of calcium content was significantly ($P \leq 0.05$) affected by fat content and it decrease significantly during the storage period, while there were no significant ($P \leq 0.05$) differences between the calcium content of cheese samples kept at room temperature and those kept in refrigerator. A previous finding also reported a decrease in phosphorus content of Sudanese white cheese during storage [40]. Similarly it was reported that the calcium and sodium content decreased significantly ($P \leq 0.05$) throughout the storage period [33]. The decrease of calcium contents could be explained by the dissolution of calcium into the pickling solution or absorption of why by curd [41]. The solubility of calcium and phosphorus salts in the acidic medium

lead to the loss of both of them [42]. Significantly lower values for calcium were obtained for cheese samples kept in the glass containers compared to those kept in plastic containers (Table 3). Whereas non-significant differences were found between the cheese samples kept in lined and non-lined metal tin packages. The significantly lower calcium content in glass containers was correlated well with their higher acidity [33].

The highest phosphorus level (19.40 mg/100 g) was obtained for the cheese kept in the glass at the beginning of storage and the lower value (4.00 mg/100 g) was reported after 90 days of storage. Phosphorus in cheese revealed 444-695 mg/100 g [37]. The significant ($P \leq 0.05$) variations of level of phosphorus in Sudanese white cheese using milk with different fat content might be due to the concentration of phosphorus level of the milk used. The reduction of phosphorus levels during the storage was reported previously for Sudanese white cheese during storage [40]. Similarly it was found significant decreased during ripening for potassium, calcium, phosphorus and sodium [34]. Moreover the phosphorus concentration was highest for cheeses manufactured in May compared to those made during February [43].

The levels of calcium and phosphorus obtained during this study (Table 3 and 4) were similar to those reported by Prieto et al. who reported a ratio of about 1.2 [44]. Lower ratio of Ca: P was given as 2.15 [45]. However the equilibrium between calcium and phosphorus is important for successful coagulation of curd during cheese making [46]. Moreover the mineral content of cheese depends on the origin of the milk (cow, ewe and goat) and it's ripening [47].

Sudanese white cheese made during the present study using 2% milk fat revealed significantly higher score for appearance, texture, flavour and overall acceptability. However the cheese made using 1% fat showed the lowest scores for estimated sensory attributes. Moreover the data showed superiority of the cheese made using milk with 2% fat. It was reported that in cheese, the removal or reduction of fat adversely affect the flavour and texture [48]. However the overall acceptability showed that the processed cheese made from white Sudanese cheese after 15 days ripening from partially skimmed milk (2.2 %) was better than that made with full milk fat (4.4%) [7]. Also it was reported that the full-fat Edam cheese had more intensive colour, tender consistency and better taste than the reduced-fat cheese [49]. Moreover the texture, flavour and physico-chemical properties of cheese are greatly governed by the milk fat [50].

All cheeses made during this study received higher scores for the flavour and overall acceptability. This might be due to the higher level of salt used (Table 1). A high salt content of ~1.8% in low fat cheddar cheese was necessary to show the desired flavour [32]. The addition of high salt to cheeses showed the highest desirability due to the high cheddar intensity flavour and lack of an unpleasant aftertaste [51].

The salty taste is highly appreciated by many consumers and saltiness is regarded as one of the basic flavours in food due to the sodium, giving the desired characteristic taste to cheese products. Finally, salt interacts with major components in the cheese and thereby affecting the functional characteristics [52]. Moreover salt has an essential function in the protein hydration and the modification of the water binding capacity of casein within the cheese matrix and viscosity, which affects the stability and textural properties [10].

Slightly higher sensory scores were reported in some of the cheese samples kept at room temperature and packed into plastic container. The processed cheese packed into glass received more acceptability than the plastic container [7]. On the other hand, hundreds types of cheeses are produced in the world, their styles, textures and flavours depend on the origin of milk, animal's diet, butterfat content, bacteria and mold, the processing, and aging conditions [53].

Deterioration of the cheese samples after 90 days of storage could be due to the reduction of its salt. Reducing NaCl resulted in unpleasant aftertaste and bitterness and at salt levels below 1.5% compared to higher levels of 1.8 to 3%, an increase in the growth of undesired non-starter bacteria occurred that caused bitter flavours due to excessive proteolyses [51].

Conclusion

The present study concluded that the level of fat content affected the Sudanese cheese acceptability and properties. Although the cheese made from milk with 1% fat gained the higher content of sodium, calcium and phosphorus content. However the cheese made from milk with 2% fat showed the superior scores and the cheese made from milk with 1% fat had the poorest ranks of overall acceptability texture flavour and taste.

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