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Chemical Composition of Processed Cheese Using Sudanese White Cheese

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Abstract: Trails for production of the processed cheese from the Sudanese white cheese were done during this study. The processed cheese was made from Sudanese white cheese with different ripening time (15 days and 30 days) from milk with two level of fat present (2.2% and 4.4%). At time of processing, the processed cheese was packed into two types of containers (glass and plastic) and stored at 4º C for 3 months. The result revealed that the different fat percent showed significant differences ($P<0.05$) on the total solids, ash and fat contents. The acidity and protein contents showed non significant differences ($P>0.05$) with the different fat level of the milk from which the processed cheese was made. The acidity, ash, total solids and protein content showed significant differences ($P<0.05$) with different ripening time (15 days and 30 days). Also the storage periods showed significant differences ($P<0.05$) with the acidity, ash, total solids, protein and fat contents. The different types of packaging (plastic and glass) showed significant differences ($P<0.05$) for acidity, protein and fat contents. However, ash and total solids contents showed non-significant differences ($P<0.05$) with the different types of packaging of the processed cheese. Hence, the present study concluded that the Sudanese white cheese could be further reprocessed to obtain the processed Sudanese cheese with improved compositional content especially when fresh cheese was used.

Key words: Processed cheese, Sudanese white cheese, chemical composition, storage period, ripening time, fat level.

INTRODUCTION

Milk and dairy products have become a major part of the human diet in many countries over many years [16]. Approximately a third of the world's milk production is used in cheese manufacture and cheese is highly nutritious food, which is convenient and versatile and offers a diversity of flavours and textures [11]. Processed cheese may normally consider being stable products with a reasonable shelf life[19, 24].

Traditionally, processed cheese was made by heating and stirring mixture of natural cheese, chelating salts, fat and water at temperature between 70 and 95º C for short time about 5 to 10 minutes[30].

The majority of dairy proteins that play the important role of emulsifiers are caseins, the emulsification potential of which is improved by the use of chelating salts. This solubilized casein is able to interact with water and fat under agitation and heating and on cooling will form a gel structure[30]. Cheese can be considered as a paracasein network including fat and aqueous phases, changes in the composition of the aqueous phase reflect the enzymatic and physico-chemical phenomena that occur in cheese during ripening[5]. Processed cheese spreads are made by selecting suitable cheese according to age, flavour, body and texture, moreover proper selection of natural cheese is the most important for the successful production of processed cheese[6]. The processed cheese is often expected to be a stable product with a very long shelf life[28].

The total solids content of commercially available processed cheeses in Egypt ranged from 42.6 to 48.3% with an average of 45.4%, fat content showed wide variation among samples from 8.6 to 28.9% with an average of 16.1%, while the NaCl content of the cheeses was within the range of 2.7 to 3.5%[10]. The gross chemical composition (g 100 g^{-1} fat 12.3-22.8, protein 11.6-14.4 and carbohydrates 3.2-9.0) of the experimental samples were within the range typical of full- and low-fat commercial processed cheese spreads [20]. Different brands of processed cheese were stored at room temperature for 4 months, during storage moisture, fat, total and soluble protein and pH were slightly decreased[14]. Storage at room temperature for 4 months of market processes cheeses had a slight effect on its chemical composition; however the storage has a more pronounced effect on the quality and

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reheological properties of processed cheeses[14]. The sensory characteristics of flavour and texture of processed cheese decreased during storage at 37º C, but biochemical change in pH, soluble nitrogen and titratable acidity increased at the same storage temperature[31]. Also sensory evaluations of the processed cheese made from Sudanese white cheese showed decrease values during storage[25].

Pre-sterilized cans were used to pack processed cheese spread made from cheddar cheese prepared from buffalo milk[33]. Processed cheese is usually packed and wrapped in lacquered foil, tubes cups, cans cardboard or plastic, cartons and occasionally in glass jars[32].

Glass was recommended for packaging processed cheese due to it inertness and its availability in Egypt [21]. There are two main types of cheese in Sudan namely Sudanese white cheese (Gibna bayda) and braided semi hard cheese (Mudaffarra). Other types of cheese provided recently by Sudanese industries, are Mozzarella and Roome. However the processed cheese is rarely produced by the Sudanese industry, as cheese could be stored for longer periods and excess milk could be converted into processed cheese. Sudanese white cheese falls into the family of soft and semi-soft pickled cheese of east European countries, the East Mediterranean region and North Africa and is the most popular cheese in Sudan[1]. Hence the present study is a trial to produce processed cheese from Sudanese white cheese and to assess the different fat levels and different ripening periods on its composition. Also the shelf life and package materials for the processed cheese were evaluated.

MATERIAL AND METHODS

Sources of Milk Rennet and Salts: Fresh cow's milk (60 liters) was brought from Khartoum University farm, Rennet tablets were obtained from Chr- Hansen's Lab (Denmark), the salt was purchased from the local market and di-sodium phosphate was a product of Sigma Chemical Company.

Adjustment of Milk Fat and Cheese Preparation: The adjustment of milk fat and the preperation of cheese were done at the Department of Dairy Production, Faculty of Animal Production, University of Khartoum. The milk was adjusted to two different fat (4.4 and 2.2) using the cream separator (30 liters, each).

Preparation of Sudanese White Cheese: Sudanese white cheese was made following the method described previously [26] from the milk with two level of fat (30 liters, each). The method of production of the cheese was as follows: Milk was heated to 45° C then rennet (two tablets/ 100 Kg milk) was dissolved in little amount of water and added to the milk at 40º C. Salt (7% w/w) was added and the milk was stirred for 5 minutes then it left to develop a curd. The curd after coagulation was cut by stainless steel kitchen knife and kept for 5 minutes to separate the whey, which was collected and kept in room temperature. The curd was collected and transferred into clean wooden moulds lined with clean cloth then pressed with 1 kg weight over night. In the next day the curd was cut into cubes and weighted then transferred to plastic cans and the whey was added to the cheese. The cheeses that made from low and high fat content of milk were both stored at room temperature for ripening to15 and 30 days.

Preparation of the Processed Cheese: The cheese was cut into small pieces by using stainless steel kitchen knife. Then 3% of di-sodium phosphate (w/w) and 50% of distilled water were added. It was then mixed using a mixture at water bath steam (80º C for 5 minutes). Processed cheese were packed into two types of packaging (plastic pack and glass pack) and stored at 4º C.

Analysis of White and Processed Cheese: The fat content was determined by Gerber's method and the protein content was determined by Kjeldahl method[4]. Similarly total solids, ash and the titratable acidity were done according to AOAC[4].

Statistical Analysis: The data of the present study were analyzed using the complete randomized design. ANOVA test and Duncan Multiple Range test were used to determine the differences between means using SAS (1989) programs.

Results:

Acidity: Ripening time of Sudanese white cheese showed significant ($P<0.001$) variations on the level of acidity, which ranged from 0.63% to 0.92%. However the level of fat revealed non significant variations on the acidity of Sudanese white cheese (Table 1).

Generally significant ($P<0.001$) variations in the level of acidity of the processed cheese was observed when comparing the different storage periods and the different ripening time of Sudanese white cheese from which processed cheese was made (Table 2). However the different types of packaging showed significant variation after 30 days of storage. Similarly the interaction of the processed cheese made after different storage period and different types of packaging showed highly significant differences ($P<0.001$) for acidity of the processed cheese (Table 3). Moreover the interaction of different combination of processed cheese made from different fat percent of milk, ripening time

of Sudanese white cheese, different storage periods and different types of packaging showed highly significant differences (P<0.001) for acidity of the processed cheese as shown in Table 3.

Ash: The mean values of ash for the Sudanese white cheese were found to reduced significantly (P<0.001) with the ripening time (2.5 %, 2.3 % and 2.1 % for 0, 15 and 30 days, respectively as shown in Table 1.

Similarly significant (P<0.001) changes were reported in the ash levels (2.2 % and 2.4 %) for 2.2% and 4.4 % fat of the Sudanese white cheese. The ash level of the processed cheese was ranged from 1.75. % to 5.35 % and from 1.85 % to 5.40 % for 2.2% and 4.4 % fat level of Sudanese white cheese respectively as shown in Table 2. Moreover the different storage periods of the processed cheese and different ripening time of Sudanese white cheese from which the processed cheese was made showed highly significant differences (P<0.001) with ash content (Table 2). The interactions of different combinations of processed cheese made from different fat level of milk, ripening time of white cheese after which the processed cheese was made and the different storage periods and types of packaging of the processed cheese showed highly significant differences (P<0.001) for ash content (Table3).

Total Solids: Table 1 shows that the total solids content of the Sudanese white cheese were 41.58 % and 50.32 %, respectively for 2.2 % and 4.4 % fat of milk. Moreover highly significant variations (P<0.001) were reported due to the variation of fat content of cheese. The total solids contents of the Sudanese white cheese were also vary due to the different ripening time and were found to be 48.38 %, 45.60 % and 43.70 %, respectively during 0, 15 and 30 days of ripening (Table 1). The total solids showed highly significant differences (P<0.001) for the processed cheese made from different fat level of milk (25.50 % to 40.57 % and 28.55 % to 41.50 % for 2.2 % and 4.4 fat of the processed cheese, respectively). Similarly the ripening time of white cheese after which the processed cheese was made and the storage periods showed highly significant (P<0.001) variations (Table 2).

Moreover the interaction of the processed cheese made from different fat level of milk, ripening time of Sudanese white cheese and different storage periods showed significant differences (P<0.05) for total solids content of the processed cheese (Table 3). Moreover the interaction of the different combinations of the processed cheese made from different fat level of milk, ripening time of Sudanese white cheese after which the processed cheese was made, the different storage periods and the types of packaging showed highly significant differences (P<0.001) for total solids content of the processed cheese (Table 3).

Protein: The protein contents of the Sudanese white cheese were found to be 19.76 % and 20.12 % for 2.2 % fat, 4.4 % fat respectively, which were not significantly different (Table 1). Table 2 shows that the ranges for protein content of the processed cheese were 8.90 % to 14.90 % and 6.23 % to 14.30 % for 2.2 % and 4.4 % fat of milk, respectively. The different fat level of milk, ripening time of Sudanese white cheese, the different storage periods and the types of packaging showed in most of the cases highly significant differences (P<0.001) for protein content of the processed cheese (Table 2). Moreover the differences of interactions of the processed cheese made from different fat level of milk, ripening time of Sudanese white cheese and different storage periods and types of packaging showed highly significant differences (P<0.001) with protein content of the processed cheese (Table 3).

Fat: Table 1 shows that the fat content of the Sudanese white cheese were found to be 15.4 % and 23.4 % for cheeses made with 2.2 % and 4.4 % fat of milk respectively, which was highly significantly (P<0.001) different. Similarly the ripening time showed significant (P<0.001) variations in the level of fat of the Sudanese white cheese (Table 1). Table 2 show the range values for fat content of the processed cheese was 6.5 % to 12 % for the processed cheese made from 2.2 % However the processed cheese with 4.4 % fat of milk revealed 16.0 % to 22.50 % fat which were highly significantly different (P<0.001) as shown in Table 2. Similarly the ripening time of Sudanese white cheese, the different types of packaging and storage periods showed highly significant differences (P<0.001) of fat content of the processed cheese (Table 2). The interaction of the different combination of the processed cheese made from different fat level of milk, ripening time of Sudanese white cheese after which the processed cheese was made, the different storage periods and the types of packaging showed highly significant differences (P<0.001) with fat content of the processed cheese (Table 3).

Discussion: In the previous study comparison between the processed cheese and white Sudanese cheese on the yield showed that the processed cheese yielded more quantities [25]. This is might be due to the addition of distilled water during the processing of the processed cheese. However the fat level did not affect significantly (P> 0.05) the yield of the processed cheese, which support the previous report that fat was found to have non significant effect on the rheological

behaviour of processed cheese[8]. Similarly the change in the viscosity profile during cooking occurred in processed cheese might indicated that the 'creaming reaction' is primarily a protein-based interaction, which takes places with or without the presence of fat[19].

Acidity was found to decrease at time of processing and that might be due to the heat treatment during processing of the processed cheese. However, the Sudanese white cheese showed increase in acidity (Table 1) and that might be due to the storage temperature, which activated the natural microflora of raw milk to develop acidity as the result of lactose fermentation[15]. Moreover, whether at the room temperature or in the refrigerator about 45–80 % of increase in the acidity was mainly due to lactic acid formed by the usually predominating lactic acid bacteria[23]. Similarly the present results showed increase of the acidity in the processed cheese made from Sudanese white cheese after 15 days ripening and 30 days ripening (Table 2). The increase of acidity observed during storage might suggest survival of lactic acid bacteria[29,31]. This might be due to the survival of some microorganisms in the raw milk that was not pasteurized before manufacturing of cheese. It was reported that when milk was heated to prepare Domiati cheese the acidity values decreased[9].

The Sudanese white cheese showed slightly decrease in ash content. The ash content decrease and then remind constant through out the storage period of Sudanese white cheese[1,2]. However increase in ash content due to the decrease in moisture content and/or absorption of salt by the crud was shown[3]. Ash content revealed increased levels in the processed cheese (Table 2) and that might be due to the addition of emulsifier salts at time of processing (3% disodium phosphate). Significantly higher concentration of ash and phosphorus in bitter cheese samples were noticed in the respective batches of processed cheese slices had been produced apparently using an over doses of specific emulsifying agent[20]. The ash content showed slight decrease in both types of the processed cheese during storage period (Table 2) might be due to the decrease of the total solids during storage period. It was also found that the ash content of Sudanese white cheese decrease and remained constant through out the storage period[2].

The addition of distilled water (50%) was reducing the total solids content of the processed cheese compared to Sudanese white cheese as shown in Table 1 and Table 2. Moreover the decrease in total solids of cheese curd could be explained by the degradation of total protein, dissolution of salt and fat into the picking solution or absorption of why by curd[7]. However, the processed cheese from Sudanese white cheese after 15 days ripening revealed higher scores than the processed cheese from Sudanese white cheese after 30 days ripening. This was reasonable result and it might be due to decrease in fat content and protein content during storage period as reported previously[12,14,28].

Protein content of the processed cheese was decreased (Table 2) and that might be due to the addition of distilled water (50%), which result in reducing the total solids. Moreover, the Sudanese white cheese showed decrease of protein content and that might be due to protein, which decreased considerably due to its degradation and loss in the whey[3,17].

Moreover the protein content for both types of the processed cheese made during the present study showed some decrease during storage. This because protein of the processed cheese decreased by storage time, which might be due to the limited degradation or assimilation of protein in cheese[14]. Similarly it might be due to reduction in amino acid contents of the processed cheese could be caused by the streacker amino acid degradation and the maillard reaction[28].

Moreover the amino acid would continue to decrease during storage of the processed cheese depending on the storage duration and temperature[12].

The Sudanese white cheese showed slight decrease of fat content (Table 1). This was agreed with the previous reports[1,23]. Moreover some fat must have leaked from curd into the brine solution, which partially might explain the decrease in fat content in curd during storage[1]. In this study the processed cheese showed decrease in the fat content during storage periods (Table 2). However, the processed cheese made from Sudanese white cheese after 15 days of ripening showed slight decrease compared with that made after 30 days or ripening (Table 2). This might be due to the fat content of the processed cheese, which decrease during storage[14]. However, non significant changes in the fat content of the processed cheese during storage were reported[29].

The different fat levels showed highly significant differences in the levels of fat, protein and total solids of the processed cheeses. This might be due to the decrease in the fat content resulted in significant ($P< 0.05$) decreases in contents of moisture in non-fat substance and pH 4.6 soluble N and increases in the contents of moisture, protein, intact casein and free amino acids [13]. Similarly the reduction observed due to the ripening time is due to maturation of cheese, since some of the constituent are lost in the whey as some fat must have leaked from curd into the brine solution, which partially might explain the decrease in fat content in curd during the storage period[1]. The protein decreased considerably due to degeneration of protein and loss in whey[17].

The present study concluded that there is possibility of using the Sudanese white cheese as a raw

material for preparation of the processed cheese.

Moreover the shorter ripening time is better than the longer as long as pasteurization is not practiced, in order to obtain good quality products with maximum shelf duration. As it was noticed that the processed cheese made during the preset study showed lower shelf life (3 months or less) compared with those reported by Hamed [14]) who found that market processes cheeses stored at room temperature showed a shelf life of 4 months. From the results of the present study we encourage preparing the processed cheese in Sudan from the Sudanese white cheese.

Further work is needed and recommended on the role of emulsifiers in the processed cheese from Sudanese white cheese and to understand in more details the optimum conditions for it's manufacturing.

Table 1: Effect of different fat level and ripening time on composition of Sudanese white cheese

Items	Fat% level		S.L	Ripening time (days)			S.L
	2.2%	4.4%		0	15	30	
Acidity %	0.768^{a}	0.768^{a}	N.S	0.63^{c}	0.74^{b}	0.92^{a}	0.001***
Ash %	2.2^{b}	2.42^{a}	0.001***	2.5^{a}	2.3^{b}	2.1^{c}	0.001***
Total solid %	41.58^{b}	50.32^{a}	0.001***	48.375^{a}	45.6^{b}	43.7^{c}	0.001***
Protein%	19.76^{a}	20.12^{a}	N.S	21.85^{a}	21.0^{a}	18.2^{a}	NS
Fat%	15.4^{b}	23.4^{a}	0.001***	19.6^{b}	24.5^{a}	24.25^{a}	0.001***

In this and the following tables:
S.L = significant level
N.S = non significant (P>0.05)
* = (P<0.05), ** = (P<0.01), *** = (P<0.001)
The same superscript letter in rows indicated significant differences (P< 0.05)

Table 2: Variation of the composition of the processed cheese with different fat level, packaging and ripening time of the raw cheese during storage.

Item	Packaging	Storage periods	4.4% Fat				2.2% Fat			
			0 day	30 days	60 days	90 days	0 day	30 days	60 days	90 days
Acidity %	Glass	15 days	0.62^{a}	0.80^{b}	1.14^{c}	1.42^{d}	0.62^{a}	0.84^{b}	1.10^{c}	1.38^{d}
		30 days	0.80^{b}	1.02^{c}	1.26^{c}	NE	0.82^{b}	1.06^{c}	1.34^{d}	NE
	Plastic	15 days	0.66^{a}	0.90^{c}	1.20^{c}	1.54^{d}	0.64^{a}	0.94^{c}	1.26^{c}	1.5^{e}
		30 days	0.84^{b}	1.14^{c}	1.48^{d}	NE	0.78^{b}	1.02^{c}	1.38^{d}	NE
Ash %	Glass	15 days	5.40^{a}	4.75^{a}	4.05^{a}	3.75^{b}	4.90^{a}	4.65^{a}	4.45^{a}	4.05^{ab}
		30 days	2.95^{b}	2.80^{c}	2.55^{c}	NE	3.00^{c}	2.15^{c}	1.75^{d}	NE
	Plastic	15 days	5.20^{a}	4.85^{a}	4.35^{a}	3.85^{b}	5.35^{a}	4.85^{a}	4.25^{a}	3.65^{b}
		30 days	2.90^{b}	2.00^{cd}	1.85^{d}	NE	3.2^{c}	2.20^{c}	2.05^{c}	NE
Total solids %	Glass	15 days	40.35^{a}	39.55^{a}	36.30^{ab}	31.70^{c}	40.15^{a}	38.50^{a}	31.35^{c}	27.85^{d}
		30 days	36.30^{ab}	35.30^{b}	33.70^{c}	NE	31.05^{d}	29.60^{d}	26.25^{e}	NE
	Plastic	15 days	41.50^{a}	37.75^{a}	32.80^{c}	28.55^{d}	40.75^{a}	36.80^{a}	34.15^{b}	30.50^{d}
		30 days	37.40^{b}	36.30^{ab}	34.70^{c}	NE	33.25^{c}	29.35^{d}	25.05^{e}	NE
Protein %	Glass	15 days	11.90^{b}	9.80^{c}	9..80^{c}	8.90^{c}	11.60^{b}	10.40^{b}	9.50^{c}	8.90^{c}
		30 days	14.30^{a}	13.80^{a}	12.50^{b}	NE	14.90^{a}	14.50^{a}	13.40^{a}	NE
	Plastic	15 days	11.30^{b}	10.70^{b}	10.10^{c}	9.50^{c}	11.30^{b}	11.00^{b}	10.10^{b}	9.20^{c}
		30 days	13.70^{a}	12.60^{b}	6.23^{d}	NE	14.80^{a}	13.30^{a}	12.20^{ab}	NE
Fat %	Glass	15 days	21.50^{a}	19.50^{ab}	19.50^{ab}	18.00^{c}	12.00^{e}	11.50^{e}	11.00^{e}	9.50^{fg}
		30 days	20.50^{a}	18.00^{c}	17.50^{c}	NE	10.00^{f}	8.50^{g}	6.50^{h}	NE
	Plastic	15 days	22.50^{a}	18.50^{b}	17.50^{c}	16.00^{d}	12.00^{e}	11.50^{e}	10.50^{f}	9.00^{fg}
		30 days	19.50^{ab}	19.00^{b}	16.50^{cd}	NE	11.00^{e}	8.00^{g}	6.50^{h}	NE

The same superscript letter in columns indicated significant differences (P< 0.05)
NE = Non estimated values due to spoilage of cheese

Table 3: Effect of some factors on the compositional quality of Sudanese white cheese (variation of mean squares)

Measurements	Acidity %	Ash %	Total solid %	Protein %	Fat %
	S. L	S.L	S. L	S. L	S.L
Fat level	0.143 $^{N.S}$	0.19 $^{N.S}$	0.001***	0.001***	0.001***
Storage period	0.001***	0.001***	0.001***	0.001***	0.001***
Packaging	0.001***	0.11 $^{N.S}$	0.538 $^{N.S}$	0.001***	0.001***
Ripening time	0.001***	0.001***	0.001***	0.001***	0.001***
Fat+ Storage period	0.26 $^{N.S}$	0.42 $^{N.S}$	0.001***	0.001***	0.001***
Packaging+ Ripening time	0.24 $^{N.S}$	0.01**	0.001***	0.001***	0.30 $^{N.S}$
Fat+ Packaging	0.21 $^{N.S}$	0.01**	0.001***	0.001***	0.001***
Storage period+ Ripening time	0.77 $^{N.S}$	0.01**	0.001***	0.001***	0.001***
Fat+ Ripening time	0.10 $^{N.S}$	0.36 $^{N.S}$	0.001***	0.001***	0.001***
Storage period+ packaging	0.001***	0.01**	0.001***	0.001***	0.001***
Fat+ Storage period+ Packaging	0.59 $^{N.S}$	0.001***	0.001***	0.001***	0.10 $^{N.S}$
Fat+ Storage period+ Ripening time	0.30 $^{N.S}$	0.001***	0.05*	0.001***	0.001***
Storage period+ Packaging+ Ripening time	0.26 $^{N.S}$	0.05*	0.142 $^{N.S}$	0.001***	0.05*
Fat+ Storage period +Packaging+ Ripening time	0.001***	0.001***	0.001***	0.001***	0.05*

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