

# THE IMPACT OF PROCESSING METHODS ON THE QUALITY OF SUDANESE WHITE CHEESE PRODUCED BY SMALL SCALE IN NEW HALFA AREA

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## *The impact of processing methods on the quality of Sudanese white cheese produced by small scale in New Halfa area*

This study was carried out to compare the effects of production and processing methods of Sudanese white cheese produced in small production units on cheese quality. The study was based on surveying 10 small scale producers in New Halfa area (eastern Sudan) during the period of February to July, 2008. The production was carried out mainly by private sector (70%), while 30% were owned by governmental institutes. Milk used in the cheese making was fresh cow milk purchased from nomads (90%) compared to only 10% from dairy farms. Regarding the level of education, 60% of cheese producers finished secondary school and 40% were university graduates. The average age of cheese producers ranged between 35–50 years. The results showed no variation between cheese manufacturing methods in the majority of production units in New Halfa. The supervision by the health authority comprised about 80% of production units. Significant ( $P < 0.05$ ) variation was found in fat and ash content and non significant differences were observed for total solids, protein content and the acidity of the Sudanese white cheese due to variation in education, training, ownership, health visits, heat treatment and marketing methods. Moreover, the producers owning the plant for cheese processing produced cheese with significantly ( $P < 0.05$ ) high counts for total bacteria, yeast, mould and coliform. However training and the regular health visits were found to improve the hygienic quality. The study suggested that interventions and training of cheese producers would help to improve Sudanese white cheese quality in New Halfa area. In conclusion, traditional cheese methods need to be encouraged and improved to utilize the surplus milk in rural areas.

**Key words:** milk products / Sudanese white cheese / manufacturing / composition / small producers / Sudan

## *Vpliv tehnologije proizvodnje na kakovost sudanskega belega sira v majhnih proizvodnih enotah na območju Halfe*

Namen študije je bil primerjati proizvodnjo in vpliv tehnologije proizvodnje belega sudanskega sira na kakovost sira v majhnih proizvodnih enotah. Zajeli smo 10 malih proizvajalcev na območju Halfe (vzhodni Sudan) v obdobju med februarjem in julijem 2008. Proizvodnja poteka večinoma pri privatnih proizvajalcih (70 %), medtem ko je 30 % proizvodnih enot v državni lasti. Večino svežega kravjega mleka za proizvodnjo odkupijo od nomadov (90 %), le 10 % ga proizvedejo na farmah krav molznic. Šestdeset odstotkov proizvajalcev sira je imela srednješolsko, 40 % pa visokošolsko izobrazbo. Večina proizvajalcev je bila stara med 35 in 50 leti. Rezultati kažejo, da med večino proizvodnih enot na območju New Halfa ni razlik v tehnologiji proizvodnje, saj večina proizvajalcev uporablja dodatek 7–10 % soli in 2–3 tablete sirišča na 220 litrov mleka. Večinoma kot embalažo uporabljajo plastične posode (80 %), samo 20 % proizvajalcev uporablja polietilenske vrečke. Dvajset odstotkov proizvajalcev sir prodaja kar v proizvodni enoti, 80 % pa izven nje. Nadzor kakovosti inšpekcija izvaja v 80 % proizvodnih enot. Statistično značilne razlike ( $p < 0,05$ ) smo našli pri vsebnosti maščobe in masti, neznačilne pa pri vsebnosti beljakovin in kislosti sudanskega belega sira, kar je tudi posledica razlik v izobrazbi, izkušnjah, lastništvu, toplotni obdelavi in načinu trženja. Pri proizvajalcih, ki so lastniki proizvodnega obrata, smo našli v siru statistično značilno ( $p < 0,05$ ) več bakterij, kvasovk, plesni in koliformnih bakterij. Usposabljanja proizvajalcev in redne inšpekcije izboljšujejo higiensko kakovost. Ugotovljamo, da nadzor in izobraževanje proizvajalcev izboljšuje kakovost sudanskega belega sira na območju New Halfa area in da je potrebno spodbujati tradicionalne metode predelave viškov mleka v ruralnih območjih.

**Ključne besede:** mlečni izdelki / siri / sudanski beli sir / izdelava / sestava / mali proizvajalci / Sudan

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## 1 INTRODUCTION

Cheese is an important dairy product and an integral part of a healthful diet due to its substantial contribution to human health. Cheese was primarily a concentrated form of milk with the benefit of a prolonged shelf life (Walther *et al.*, 2008). White-brined cheeses (also known as white-pickled cheeses) are the most popular varieties of cheeses manufactured in the North-east Mediterranean area and the Balkans (Bintsis and Papademas, 2002). El Owni and Osman (2009) reported that the major cheese type that is traditionally produced in Sudan is white cheese (*Gibna Bayda*). The making of *Gibna Bayda* in Darfur varies from one place to the other. The variation is due to the method of processing, salting before or after renneting or during moulding and due to the way of treating the whey (El Owni and Hamid, 2007). Moreover, the quality of cheese depends on a variety of factors like raw milk composition, technological parameters, bacteria species, storage, transportation and delivery conditions (Rotaru *et al.*, 2008). Similarly Hamid and El Owni (2007) reported that Sudanese white cheese production based mainly in small dairies and family plants which often resulted in different composition and poor hygienic quality.

Cheese is a rich source of essential nutrients; in particular proteins, bioactive peptides, amino acids, fat, fatty acids, vitamins and minerals (Walther *et al.*, 2008). Moreover, Frazier and Westhoff (1978) reported that packing of cheese is to minimize losses of moisture and penetration of oxygen which would help in mould growth. Elkhider *et al.* (2011) found high bacterial load in Sudanese white cheese samples collected from different producers in rural area of New Halfa suggesting that the level of hygiene, production methods, source of raw milk and its handling could be the main factors of these high loads. They attributed the variations in the chemical composition to the different manufacturing methods and milk composition. In this study the factors of production and processing of Sudanese white cheese are highlighted together with their influence on cheese quality.

## 2 MATERIALS AND METHODS

### 2.1 STUDY AREA

New Halfa is a Sudanese rural town that is located at Kassala State about 400 km South-east of Khartoum and 50 km North of Kashm Elgriba, at Western bank of Atbara River. The town was established in 1960 to place the immigrated people of Old Halfa town due to construction of high dam in Egypt.

In New Halfa most of the livestock is concentrated in rural areas in the hands of nomads. Fresh liquid milk is not the only dairy product, during rainy season when milk is relatively plentiful, Shukria women process part of the milk from their cows into butter-milk (roub) and clarified butter oil (ghee). Sudanese white cheese is made from cow's (Butana and Gash type), ewe's and goat's milk or mixture of these. In New Halfa area white cheese is produced in what could be called farm-hut plants. These are small, seasonal huts of mud or corrugated, galvanized iron. Each hut has an expanded verandah of wire screens. The huts are scattered around the major town within a distance of about 15–50 km. In the surroundings of New Halfa about 20 such small plants or scales are found and recognized by the local council of the town.

### 2.2 COLLECTION OF DATA

The survey was conducted to obtain information on the production procedures and the socioeconomic aspects among the owners of the 10 selected producers. Questionnaire, observations and the direct interview were conducted during the period from February to July, 2008. The obtained information includes the name, age, education level, marital status, training, experience in cheese production and the type of building. Milk sources, rate of salt and rennet used in the cheese, water supply, quantity of milk used in cheese making per day and other products were also investigated. Further samples of cheese were collected monthly for 6 months in order to evaluate the quality of the cheese.

### 2.3 CHEMICAL AND MICROBIOLOGICAL ANALYSIS

The analyses of protein, fat, total solids, ash and titratable acidity of the collected Sudanese white cheese were performed according to AOAC (1990).

All media used in this study were obtained in dehydrated form and prepared according to the manufacturers' instruction. Glassware were sterilized in hot oven (1 hour, 170 °C for two hours), whereas media and distilled water were sterilized by autoclaving at 121 °C for 15 minutes (Marshall, 1992). Five grams of the cheese samples were added to warm (45 °C) 15 ml of 2% sodium citrate and incubated for 2 minutes. Then one ml from the mixture was transferred to 9 ml sterile normal saline in a screw capped bottle and the serial dilutions were prepared (Richardson, 1985). The total bacterial count was done using standard plate count agar according to Houghtby *et al.* (1992). The coliform count was

performed as was described by Christen *et al.* (1992) on MacConkey agar. The sabouraud dextrose agar was selected for enumeration of yeast and mould (Frank *et al.*, 1992). Culturing, incubation and counting were done according to Christen *et al.* (1992).

### 3 RESULTS

This study included current small scale cheese traditional producers in 10 production units at different locations in New Halfa at Kassala State, to evaluate their methods of cheese making.

#### 3.1 SOCIOECONOMIC STATUS OF CHEESE PRODUCERS

The survey showed that 2, 4 and 4 of the producers were under the age of 40 years, 40 to 44 years old and between 44 and 50 years, respectively. Similarly, 20% of the producers were found to practice cheese making for 5 years, 20% for 10 years and 30% for 15 years. Moreover, only two producers were reported to practice cheese making for more than 20 years.

The results indicated that there were no significant differences ( $P > 0.05$ ) in the education level of the producers, 6 (60%) producers completed their secondary education, while the rest of the producers (40%) had university degrees. Furthermore, 80% of the producers were not trained on cheese production. The result showed that 30% of the production units were run on own, and 70% on renting facilities. Also 80% of the producers constructed concrete buildings and the 20% constructed

corrugated building with iron roof. All production units were water supplied through pipeline.

The quantity of milk used for cheese making varies between producers (Table 1) and during seasons (summer and winter). Moreover, 9 producers purchase milk from nomads, and only one producer uses milk from a dairy farm. Two producers only pasteurized milk before processing, while plastic containers were common packaging materials (80%) compared to polyethylene bags that were used by only 2 producers. Similarly, 20% of producers sold their products locally, while the rest of the producers (80%) practiced outside selling of the cheese. The supervision by the health authority comprised about 80% of production units.

#### 3.2 CHEESE MANUFACTURING PROCEDURES

Cheese manufactures purchase fresh cow's milk from the nomads, in rural areas around the production units at about 6 a.m. and the process of collection continues until about 11 a.m. daily. Milk is brought in tins or plastic containers on donkeys or cars. The milk is bulked into large plastic barrels (capacity of 200–220 liters) and is stored at ambient temperature until the start of processing. For cheese processing from the farm relatively small amount of fresh cow's milk (50 liters) was used, it was first heated to 45 °C. Processing began with sieving the milk through a piece of clean cloth into plastic barrels. It was done by putting a fine cheese-cloth over the top of another clean barrel and the salt was put on it, followed by pouring the milk from the first barrel on the salt and into the empty barrel. The milk dissolved the salt as it filtered clean through the cheese cloth. The amount

**Table 1:** Variations of the production methods of the Sudanese white cheese in New Halfa  
**Preglednica 1:** Razlike v proizvodnji sudanskega belega sira na območju New Halfa

Producers	Milk sources	Milk quantity (liter)	Rennet quantity	Salt level (%)	Production quantity / month	Products type
1	Nomads	400–700	2–3	10	100–120	White cheese+ ghee
2	Nomads	500–1000	2–3	8	200–500	White cheese+ yoghurt
3	Nomads	600–800	4	10	200–300	White cheese+ ghee
4	Nomads	500–1500	2–3	10	500–750	White cheese+ ghee
5	Nomads	200–1200	2–3	10	300–500	White cheese+ braded cheese
6	Nomads	100–200	2–3	10	200	White cheese+ ghee
7	Nomads	500–1500	2–3	8	500–700	White cheese+ braded cheese+ ghee
8	Nomads	800–1600	6–12	10	400–600	White cheese+ braded cheese+ ghee
9	Nomads	500–1000	4	10	500–700	White cheese+ braded cheese
10	Farm	50–100	0.5–1	7	-	White cheese+ braded cheese+ ghee

**Table 2:** Composition (Mean  $\pm$  SE.) of the Sudanese white cheese produced by the small scale producers in New Halfa  
**Preglednica 2:** Sestava sudanskega belega sira pri malih proizvajalcih na območju New Halfa

Attributes	Protein (%)	Sig. level	Fat (%)	Sig. level	T. S (%)	Sig. level	Ash (%)	Sig. level	Acidity (%)	Sig. level
Education	20.19 $\pm$ 0.62	0.96	23.57 $\pm$ 0.70	0.64	51.50 $\pm$ 0.93	0.69	4.94 $\pm$ 0.34	0.43	0.75 $\pm$ 0.06	0.09
University (40%)	20.14 $\pm$ 0.76		23.04 $\pm$ 0.86		50.92 $\pm$ 1.13		5.37 $\pm$ 0.42		0.59 $\pm$ 0.08	
Training	20.34 $\pm$ 0.54	0.49	22.82 $\pm$ 0.59	0.05	51.23 $\pm$ 0.80	0.91	5.47 $\pm$ 0.28*	0.01	0.64 $\pm$ 0.05	0.06
No (80%)	19.50 $\pm$ 1.08		25.50 $\pm$ 1.17*		51.43 $\pm$ 1.61		3.68 $\pm$ 0.56		0.87 $\pm$ 0.11	
Ownership of processing area	20.36 $\pm$ 0.58	0.56	22.86 $\pm$ 0.67	0.16	51.24 $\pm$ 0.86	0.95	5.49 $\pm$ 0.31*	0.03	0.65 $\pm$ 0.06	0.31
Own (30%)	19.74 $\pm$ 0.88		24.53 $\pm$ 0.97		51.34 $\pm$ 1.31		4.22 $\pm$ 0.47		0.76 $\pm$ 0.09	
Health visit	20.34 $\pm$ 0.54	0.49	22.82 $\pm$ 0.59	0.05	51.23 $\pm$ 0.80	0.91	5.47 $\pm$ 0.28*	0.01	0.64 $\pm$ 0.05	0.06
No (20%)	19.50 $\pm$ 1.08		25.50 $\pm$ 1.17*		51.43 $\pm$ 1.61		3.68 $\pm$ 0.56		0.87 $\pm$ 0.11	
Heat treatment of milk	20.46 $\pm$ 1.08	0.77	23.92 $\pm$ 1.21	0.61	51.08 $\pm$ 1.61	0.90	3.83 $\pm$ 0.57	0.01	0.62 $\pm$ 0.11	0.46
No (80%)	20.10 $\pm$ 0.54		23.22 $\pm$ 0.61		51.31 $\pm$ 0.80		5.43 $\pm$ 0.28*		0.71 $\pm$ 0.06	
Marketing	20.34 $\pm$ 0.54	0.49	22.82 $\pm$ 0.59	0.05	51.23 $\pm$ 0.80	0.91	5.47 $\pm$ 0.28*	0.01	0.64 $\pm$ 0.05	0.06
In side processing area (80%)	19.50 $\pm$ 1.08		25.50 $\pm$ 1.17*		51.43 $\pm$ 1.61		3.68 $\pm$ 0.56		0.87 $\pm$ 0.11	
Out side processing area (20%)										

**Table 3:** Microbial loads of the Sudanese white cheese produced by the small scale producers in New Halfa

**Preglednica 3:** Mikrobiološka obremenitev sudanskega belega sira pri malih proizvajalcih na območju New Halfa

Attributes	Total bacterial count	Sig. level	Yeast	Sig. level	Mould	Sig. level	Coliform	Sig. level
Education	5.8 $\times$ 10 <sup>6</sup> $\pm$ 6.2 $\times$ 10 <sup>6</sup>	0.31	9.4 $\times$ 10 <sup>5</sup> $\pm$ 4.0 $\times$ 10 <sup>6</sup>	0.91	3.7 $\times$ 10 <sup>4</sup> $\pm$ 1.8 $\times$ 10 <sup>4</sup>	0.89	4.4 $\times$ 10 <sup>3</sup> $\pm$ 1.5 $\times$ 10 <sup>3</sup>	0.25
University (40%)	1.6 $\times$ 10 <sup>7</sup> $\pm$ 7.6 $\times$ 10 <sup>6</sup>		8.7 $\times$ 10 <sup>5</sup> $\pm$ 4.9 $\times$ 10 <sup>5</sup>		4.1 $\times$ 10 <sup>4</sup> $\pm$ 2.2 $\times$ 10 <sup>4</sup>		3.3 $\times$ 10 <sup>3</sup> $\pm$ 1.9 $\times$ 10 <sup>3</sup>	
Training	5.6 $\times$ 10 <sup>6</sup> $\pm$ 5.3 $\times$ 10 <sup>6</sup>	0.08	9.0 $\times$ 10 <sup>5</sup> $\pm$ 3.4 $\times$ 10 <sup>5</sup>	0.92	4.6 $\times$ 10 <sup>4</sup> $\pm$ 1.5 $\times$ 10 <sup>4</sup>	0.24	2.7 $\times$ 10 <sup>2</sup> $\pm$ 1.3 $\times$ 10 <sup>3</sup>	0.03
No (80%)	2.7 $\times$ 10 <sup>7</sup> $\pm$ 1.0 $\times$ 10 <sup>7</sup>		10.0 $\times$ 10 <sup>6</sup> $\pm$ 6.9 $\times$ 10 <sup>5</sup>		5.1 $\times$ 10 <sup>3</sup> $\pm$ 3.1 $\times$ 10 <sup>4</sup>		6.8 $\times$ 10 <sup>3</sup> $\pm$ 2.5 $\times$ 10 <sup>3</sup>	
Ownership of processing area	3.4 $\times$ 10 <sup>6</sup> $\pm$ 5.6 $\times$ 10 <sup>6</sup>	0.04	4.1 $\times$ 10 <sup>5</sup> $\pm$ 3.5 $\times$ 10 <sup>5</sup>	0.01	3.6 $\times$ 10 <sup>4</sup> $\pm$ 1.7 $\times$ 10 <sup>4</sup>	0.84	3.3 $\times$ 10 <sup>2</sup> $\pm$ 1.5 $\times$ 10 <sup>3</sup>	0.11
Own (30%)	2.5 $\times$ 10 <sup>7</sup> $\pm$ 8.6 $\times$ 10 <sup>6</sup>		2.1 $\times$ 10 <sup>6</sup> $\pm$ 5.4 $\times$ 10 <sup>5</sup>		4.3 $\times$ 10 <sup>4</sup> $\pm$ 2.6 $\times$ 10 <sup>4</sup>		4.4 $\times$ 10 <sup>3</sup> $\pm$ 2.1 $\times$ 10 <sup>3</sup>	
Health visit	5.6 $\times$ 10 <sup>6</sup> $\pm$ 5.3 $\times$ 10 <sup>6</sup>	0.08	9.0 $\times$ 10 <sup>5</sup> $\pm$ 3.5 $\times$ 10 <sup>5</sup>	0.92	4.6 $\times$ 10 <sup>4</sup> $\pm$ 1.6 $\times$ 10 <sup>4</sup>	0.24	2.7 $\times$ 10 <sup>2</sup> $\pm$ 1.3 $\times$ 10 <sup>3</sup>	0.03
No (20%)	2.7 $\times$ 10 <sup>7</sup> $\pm$ 1.1 $\times$ 10 <sup>7</sup>		9.7 $\times$ 10 <sup>5</sup> $\pm$ 7.0 $\times$ 10 <sup>5</sup>		5.1 $\times$ 10 <sup>3</sup> $\pm$ 3.1 $\times$ 10 <sup>4</sup>		6.8 $\times$ 10 <sup>3</sup> $\pm$ 2.5 $\times$ 10 <sup>3</sup>	
Heat treatment of milk	3.1 $\times$ 10 <sup>7</sup> $\pm$ 1.0 $\times$ 10 <sup>7</sup>	0.03	8.5 $\times$ 10 <sup>5</sup> $\pm$ 7.0 $\times$ 10 <sup>5</sup>	0.92	5.9 $\times$ 10 <sup>3</sup> $\pm$ 3.1 $\times$ 10 <sup>4</sup>	0.25	6.5 $\times$ 10 <sup>3</sup> $\pm$ 2.6 $\times$ 10 <sup>3</sup>	0.04
No (80%)	4.6 $\times$ 10 <sup>6</sup> $\pm$ 5.2 $\times$ 10 <sup>6</sup>		9.3 $\times$ 10 <sup>5</sup> $\pm$ 3.5 $\times$ 10 <sup>5</sup>		4.6 $\times$ 10 <sup>4</sup> $\pm$ 1.6 $\times$ 10 <sup>4</sup>		3.3 $\times$ 10 <sup>2</sup> $\pm$ 1.3 $\times$ 10 <sup>3</sup>	
Marketing	5.6 $\times$ 10 <sup>6</sup> $\pm$ 5.3 $\times$ 10 <sup>6</sup>	0.08	9.0 $\times$ 10 <sup>5</sup> $\pm$ 3.5 $\times$ 10 <sup>5</sup>	0.92	4.6 $\times$ 10 <sup>4</sup> $\pm$ 1.6 $\times$ 10 <sup>4</sup>	0.24	2.7 $\times$ 10 <sup>2</sup> $\pm$ 1.3 $\times$ 10 <sup>3</sup>	0.03
In side processing area (80%)	2.7 $\times$ 10 <sup>7</sup> $\pm$ 1.1 $\times$ 10 <sup>7</sup>		9.7 $\times$ 10 <sup>5</sup> $\pm$ 7.0 $\times$ 10 <sup>5</sup>		5.1 $\times$ 10 <sup>3</sup> $\pm$ 3.1 $\times$ 10 <sup>4</sup>		6.8 $\times$ 10 <sup>3</sup> $\pm$ 2.5 $\times$ 10 <sup>3</sup>	
Out side processing area (20%)								

of salt used resulted in the final concentration of 8–10% (w/w) as shown in Table 1.

During the cool winter months, milk is generally warmed to 30–35 °C in order to support the souring process, whereas during the hot summer months extra salt is used to retard defective microbial growth and give acid-forming microflora an advantage over others. Cream, which rises to the top at any stage in the process, is normally collected and boiled to give ghee (calcified butter oil) which gives a substantial added value. Four or five rennet tablets of about 10 grams (Christian Hansen, Denmark) are then crushed, dissolved in a little water and added to the salted, filtered milk, with constant stirring for about 2 minutes, using long wooden paddle. The barrel is then covered with cheese-cloth and left to stand undisturbed for 4–6 hours to allow the milk to coagulate. The point of corrected curd formation is judged by the finger touch of experienced personnel, or by gently dropping a slender stick into the coagulum and subsequently retrieving it. If curd has been formed then the stick would bear no traces of the original white milk. The curd is then transferred into wooden moulds lined with cheese-cloth, placed on wooden benches, where it is left to drain overnight. The cut curd is poured into a wooden moulds lined with clean cloth. Suitable weights are put on the mould cover for about 6 hours. The drained whey is collected into clean buckets and used for cheese preservation.

Next day the cheese is removed from the moulds and cut into small cubes of about 10 × 10 × 10 cm. The cut cheese is preserved into its own whey, by packing into a plastic container of about 12 kg cheese capacity. The containers are left unsoldered till next morning, in order to allow further drainage of whey. They are topped up with more whey and hermetically sealed by welding. Usually they are labeled and then stored at room temperature (35–37 °C) until marketing. The packed fresh cheese is transported to the main center, i.e. New Halfa town, where the manufactures label is fixed. Under normal conditions the cheese is stored for 1–3 days, but it may be consumed immediately after preparation.

### 3.3 CHEMICAL AND MICROBIOLOGICAL QUALITY OF SUDANESE WHITE CHEESE

No significant differences were observed for total solids and protein content and the acidity of the Sudanese white cheese due to variations of education, training, ownership, health visits, heat treatment and marketing methods (Table 2). However significantly ( $P < 0.05$ ) lower fat ( $22.82 \pm 0.59\%$  vs.  $25.50 \pm 1.17\%$ ) was found among the producers who received training

and had regular health visits and who could market their cheese at site of processing (Table 2). The ash content was significantly higher ( $P < 0.01$ ) among the producers who received training, had regular health visits and practiced on site selling of the cheese ( $5.47 \pm 0.28\%$  vs.  $3.68 \pm 0.56\%$ ). Similarly the owners who rented the facility produced cheese with significantly ( $P < 0.05$ ) higher ash value ( $5.49 \pm 0.31\%$ ) compared to those who owned it ( $4.22 \pm 0.47\%$ ). However marketing of cheese outside the processing area revealed significantly ( $P < 0.01$ ) less ash ( $3.68 \pm 0.56\%$ ) compared to those who sold their products outside the processing area ( $5.47 \pm 0.28\%$ ).

The producers owing the plant for processing produced cheese with significantly ( $P < 0.05$ ) high count for total bacteria ( $2.5 \times 10^7 \pm 8.6 \times 10^6$ ) and yeast ( $2.1 \times 10^6 \pm 5.4 \times 10^5$ ) compared to those who rented the plant (Table 3). The same table also shows higher counts of mould and coliform bacteria among the owners of the processing units. Training and the regular health visits were found to improve the hygienic quality of cheese produced by those who received them especially for the coliform bacterial count that revealed significantly ( $P < 0.05$ ) lower values. The coliform count was also lower among the producers selling their products at the processing areas, however the present study did not notice any significant differences among microbiological quality tests between the graduated and non graduated cheese producers (Table 3).

## 4 DISCUSSION

The Sudanese white cheese is produced in small production units around New Halfa area. In these production units, cheese is produced throughout the year and the higher production is during the rainy season (Elkhider *et al.*, 2011). They reported that recently New Halfa rural areas are also famous for Sudanese white cheese because it occupies a better geographical location for the cheese business, being both close to source of the raw material, milk from nomads, and close to some markets such as Khartoum, Kassala and Port Sudan. They also attributed that to the large number of cattle population (Butana and Gash type) in the area (fresh cow's milk). Similar findings were reported before by El Owni and Hamid (2007) that in Darfour State the main source of milk for cheese is the fresh cow's milk due to large numbers of Baggara cattle (local type) in the area. Private sector was the dominant for the cheese production in New Halfa area. The manufacturing procedures described in this study were similar to those reported by Hamid and El Owni (2008). However, slight variation was found compared to those reported by Aly and Galal

(2002) and Ceylan *et al.* (2003). The amount of salt used by the producers varied from 7–10% which is similar to that reported by Hamid *et al.* (2008) and Idris and Alhasan (2010). Salting has an effect on cheese yield, weight loss, chemical composition, microbiological and sensory characteristics of the Sudanese white cheese (Hamid and El Owni, 2008). The way of salting differs among the producers of cheese (El Owni and Hamid, 2007).

Cheese yield was higher in some production units (Table 1), which might be due to the variation of milk quantity and constituents, which affected manufacturing and various characteristics of cheese (Aly and Galal, 2002). The high yield was possibly due to the fact that milk producers were located near the processing plants and the milk was immediately transported to the cheese producers. The chemical composition of Sudanese white cheese from rural areas revealed more or less similar values to those reported previously (Warsama *et al.*, 2006 and Hamid and El Owni, 2008). The variation found in the fat content of cheese samples supported Nour El Diam and El Zubeir (2007) who indicated that the higher presence of fat on cheese was not required, thus the excess fat could be manufactured into the expensive products (butter, cream and ghee). Producers were found to process other various types of dairy products (Table 1). However the high bacterial load found in the cheese samples investigated during the present study (Table 3) were explained by Elkhider *et al.* (2011) that the level of hygiene and production methods, raw milk quality and its handling were poor. Moreover, Sudanese white cheese is usually manufactured in rural areas where hygienic conditions are poor in addition to poor handling and packaging facilities (Maher *et al.*, 2001 and Hamid and El Owni 2008). The high microbial loads found during the present study could also be due to the high coliform count as shown in Table 3. Higher total bacterial count was found previously in Khartoum, Khartoum North and Omderman;  $5.6 \times 10^8 \pm 3.7 \times 10^8$ ,  $2.9 \times 10^8 \pm 2.4 \times 10^8$  and  $2.7 \times 10^8 \pm 2.1 \times 10^8$ , respectively; (El Zubeir *et al.*, 2006). Similarly Warsama *et al.* (2006) found that the incidence of coliforms were higher in Sudanese white cheese. Nour El Diam and El Zubeir (2006) recommended that hygienic handling during milking, processing of cheese, storage (packaging and preservation) and marketing should be improved and controlled. We can conclude that Sudanese white cheese in New Halfa area is produced according to traditional methods, primarily in small-scale household business with slight variations in the methods.

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