COMPARATIVE STUDY ON CHEMICAL AND MICROBIOLOGICAL PROPERTIES OF WHITE CHEESE PRODUCED BY TRADITIONAL AND MODERN FACTORIES

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Abstract
This study was carried out to compare the chemical composition and some microbiological properties of Sudanese white cheese produced in traditional and modern factories. Forty white cheese samples (20 samples for each) were collected randomly from the different markets of Khartoum State, Sudan, during May to June 2014. The samples were subjected to chemical analysis and microbiological examination and the obtained data were statistically analyzed with independent-samples T-test design using SPSS. The average of total solids, fat, protein, ash, lactic acid and salt were 48.14%, 21.10%, 13.07%, 9.58%, 0.49% and 7.57% respectively, for traditionally produced cheese samples and 45.76%, 22.35%, 15.36%, 5.73%, 0.61% and 4.06% respectively, for cheese produced by modern industry. The results indicated that there were significant (P≤0.01) variations in ash and salt content and significant (P≤0.05) differences in acidity for cheese samples produced by traditional and modern processing. The microbiological results showed highly significant (P≤0.01) differences in Staphylococcus aureus and coliform bacteria detected in cheese samples collected from traditional (13; 65%) and modern producers (0%). Yeasts and molds were not found in all cheese samples from both types of processing. It is concluded that Sudanese white cheese produced in modern dairy factories is safer for consumption than those produced traditionally. Hence, some efforts should be directed towards improvement of hygienic properties of traditionally produced cheese in order to ensure its quality.

Key wards*:* cheese, hygienic properties, traditional processing, modern producers, quality.

Received: 28.11.2017 Reviewed: 22.02.2018 Accepted: 06.03.2018

1. INTRODUCTION

In ancient times, cheese was primarily a concentrated form of milk with the benefit of a prolonged shelf life (Walther *et al.*, 2008). Cheese is the most popular dairy products, produced in a great range of types and forms throughout the world (Fox *et al*., 2000). It is a dairy product with best nutritional value and health care function, and it is widely popular in many countries in the world with good taste and diverse flavor (Walther *et al.*, 2008). The popularity of cheese is enhanced by its healthy and positive image, the variety of cheeses available, and the compatibility of cheese and cheese containing products with modern trend toward greater consumption of convenience and prepared foods (Fox *et al*., 2000). The quality and composition of the cheese may vary due to the quality and composition of milk, the method of manufacture, the quality of salt added and the storage of cheese (Birghila *et al.*, 2008; Rotaru *et al.*, 2008 and Elkhider *et al.*, 2012).

Raw milk and unpasteurized dairy products may contain large numbers of *S. aureus*, usually as a result of staphylococcal mastitis (Bennet and Monday, 2003). The incidences of coliforms, B-glucuronidase positive *E. coli* and *S. aureus* were higher in soft than blue veined, semi hard, hard and fresh cheeses (De Reu *et al.*, 2002).

Owni and Hamid, 2008). It is a semi-traditional cheese of Sudan made from raw cow's milk, goat's milk or combination of both with variable qualities (Sulieman *et al.*, 2013). The highest production is during the rainy season. Sudanese white cheese production based mainly in small dairies and family plants which often resulted in different composition and poor hygienic quality (El Owni and Hamid, 2007). Traditional cheeses represent a heritage and are the result of accumulated empirical knowledge passed on from generation to

generation (Chanidis and Chroniadou, 2008). Elkhider *et al.* (2011) suggested that interventions and training of cheese producers would help to improve Sudanese white cheese quality in rural areas of eastern Sudan. Elkhider *et al.* (2012) reported that regarding the level of education there is no variation between cheese manufacturing methods in the majority of production units in New Halfa area, eastern Sudan. Also they concluded that traditional cheese methods need to be encouraged and improved to utilize the surplus milk in rural areas.

The traditional method of manufacturing Sudanese white cheese was described by Elkhider *et al.* (2012). Kosikowski (1982) described the production of modern cheese. Johnson and Lucey (2006) added that changes in cheese manufacturing protocols have resulted in a reduction of the manufacturing time and the necessity for consistent and reliable starter activity. By today, standards of industrial technology, the process of cheese making is still complicated one, which combines both art and science together (Mc Williams, 2009).

The present study was undertaken to compare the chemical composition and microbial quality of Sudanese white cheese from the markets of Khartoum, both traditionally and modern made. It is also meant to detect some of potentially food borne pathogens associated with Sudanese white cheese.

2. MATERIALS AND METHODS

2.1 Collection of cheese samples

A total of forty white cheese samples were collected from the retailers of different markets in Khartoum State, Sudan. Cheese samples were collected during May to June 2014. About fifty grams of traditional cheese samples (manufactured in different traditional factories) were collected from cheese containers and put into clean, dry and sterilized plastic bags. Different weights of the modern cheese samples (produced and packed in hermetically sealed plastic containers) from two modern factories, were collected separately.

All samples were put in an ice box and transported to the laboratory of Agricultural Analysis, Department of Microbiology, Ministry of Agriculture, Animal Resources and Irrigation, Khartoum State for microbiological analysis and to the laboratory of the Department of Dairy Production, Faculty of Animal Production, University of Khartoum for chemical analysis. The samples were kept at ≤ 5 °C till analysis was carried out. During the analysis, the sacks were opened first for microbiological examination, thereafter the chemical analysis was carried out.

2.2 Cheese samples analysis

The cheese samples were analyzed for chemical composition (total solids, fat content, protein content, ash content, titratable acidity and salt) and microbiological quality (coliform counts, yeasts and mold counts and *Staphylococcus aureus* detection).

2.2.1 Chemical analysis

The fat content was determined by Gerber's method, the protein content was determined by Kjeldahl method, the ash content was determined by gravimetric method (AOAC, 2003). The **t**otal solids content was determined according to the modified method and the titratable acidity of the cheese was determined according to AOAC (2003). The salt in cheese was determined according to the method described by Breene and Price (1961).

2.2.2 Microbiological analysis

All media were obtained in dehydrated forms and prepared according to the manufactures' instructions. Manitol salt agar (DM 160), Potato dextrose agar (DM 215) and MacConkey agar (DM 148) were prepared according to the manufactures' instructions (Micromaster: Maharashtra, India). They were sterilized by autoclaving at 15 pound pressure for 15 minutes at 121 °C (Barrow and Feltham, 1993). Glassware such as Petri-dishes, pipettes, flasks, test tubes and bottles were sterilized by dry heat in a hot oven at 160 °C for one hour, whereas mixer, distilled water and tips were sterilized by autoclaving for 15 minutes at 121 °C (Barrow and Feltham, 1993).

2.2.2.1 Culturing of the cheese samples

One gram of the cheese was added to 9 ml of sterile normal saline in a test tube, it was closed and mixed thoroughly. Using another sterile pipette, 1 ml of the prepared dilution was transferred into a second dilution tube with 9 ml of normal saline. This process was repeated to make 10 fold dilutions from 10^{-1} to 10^{-4} (Richardson, 1985).

Mannitol salt agar was used for *Staphylococcus aureus* detection and the coliform count was determined using MacConkey agar. The count of yeast and mold were determined using potato dextrose agar (PDA). All media culturing were done according to Miles *et al*. (1938) method. All plates with exception to the PDA plates were incubated at 37 °C for 48 hours, while PDA plates were incubated at 25 °C for one week with daily check for microbial growth.

2.2.2.2 Examination and counting of cultures

Growth on the solids media was examined visually with naked eye for colonies appearance and changes in media. After incubation colonies were counted using a colony counter with a digital read out. Plates containing between 30 and 300 colonies were counted as colony forming units (cfu) per gram of cheese samples. The number of bacteria cfu/g from the original aliquot/sample was calculated according to the following equation:

cfu per g = Average number of colonies for a dilution × 50 × dilution factor (Miles *et al.*, 1938).

The *S. aureus* was identified according to flow chart for the identification of *Staphylococcus* species described by El Sanousi *et al.* (2015).

2.3 Statistical analysis

The data of the present study were analyzed with the independent- samples T-test design using Statistical Package for Social Studies Software "SPSS" version 17. The figures were plotted using Microsoft Office Word 2007 Charts.

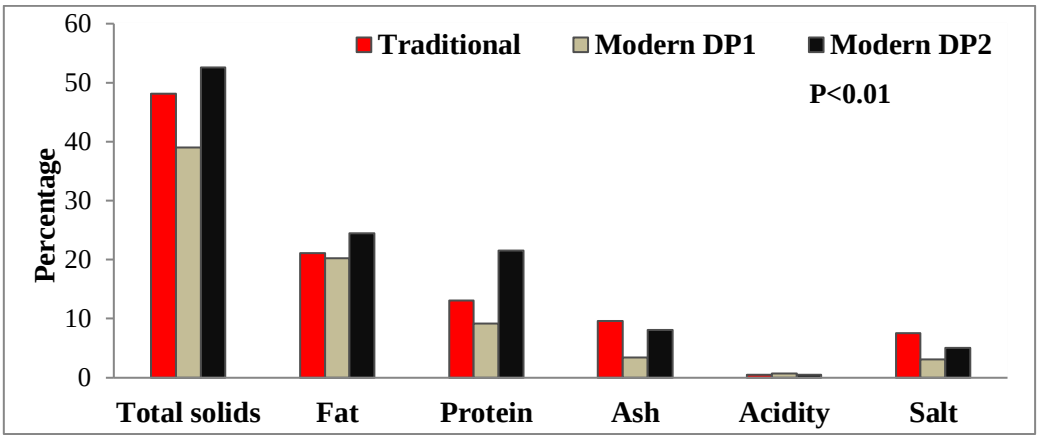
3. RESULTS AND DISCUSSION

3.1 Chemical composition

Table 1 and Figure 1 showed the chemical composition of white cheese samples collected from Khartoum markets. The average of total solids content showed values of 48.14±7.09% and 45.76±8.27% for traditionally and modern produced white cheese samples, respectively. However minimum values of 35.7% and 62.8% and maximum values of 35.6% and 62.9% were found (Table 1). The total solids content of modern cheese was in accordance of those reported by El Nasri *et al.* (2012) who found 45.00±10.63% for cheese samples packaged into plastic containers and El Zubeir and Hashim (2013) who reported 46.31-46.81% for cheese made from goat milk. On the other hand the estimated mean of total solids for traditional cheese samples (48.14±7.09) was similar to the findings stated by Warsama *et al*. (2006) and Abdalla and Mohamed (2009) who reported mean total solids of 47.48% and 48.46%, respectively. Moreover, it was slightly lower than those reported by Salih *et al*. (2012) who found 50.31% for Jibna–beida collected from some Sudanese local markets. The total solids contents for both types of cheeses were higher than those reported by Suliman *et al*. (2013) who found 31.76±0.47%. Statistically, no significant ($P>0.05$) differences in total solids of collected cheese samples were found between traditional and modern cheeses (Table 1).

The fat content of cheese samples from traditional and modern processing revealed values of 21.10±2.31% and 22.35±3.13%, respectively (Table 1 and Figure 1). However the values of 18.0% and 27.0%, and 17.5% and 29.0% were reported for minimum and maximum values, respectively (Table 1). The fat value of modern cheese was in line with those reported by Salih *et al*. (2012). Similarly El Zubeir and Hashim (2013) found 22.27% and 22.13-21.85% for white soft cheese made from raw and pasteurized milk, respectively. On the other hand the fat content of traditionally produced cheese was slightly higher than those reported by Mustafa *et al*. (2013a) who found 20.84% fat value for Sudanese white cheese. Moreover the fat values of both types of cheeses were higher than those reported by Warsama *et al*. (2006) and Suliman *et al*. (2013) who found 14.0%

and 4.20±0.41% respectively, for white cheese. However the fat values of the two types of cheeses were lower than those reported by Hamid and El Owni (2008); Abdalla and Mohamed (2009); Elkhider *et al*. (2011) and Suleiman *et al*. (2011) who found 23.79%, 25.13%, 23.38±4.8% and 29.0-29.83%, respectively. Statistically, no significant (P>0.05) differences in fat content were found between traditional and modern cheeses (Table 1).



DP1: Dairy plant 1. DP2: Dairy plant 2, P<0.01: high significant

Fig. 1: Comparison of chemical composition of Sudanese white cheese produced by traditional and two different modern dairy plants

The protein content revealed value of 13.07±2.17% with a range of 7.7 to 17.2% for traditional cheese, while the value of 15.36±6.83% with a range of 7.1 to 29.1% was reported for modern produced cheese (Table 1 and Figure 1). The protein content of traditional cheese processing was in line with those reported by Suliman *et al*. (2013) who found 13.75±0.59% value in white cheese, while the protein value of modern cheese was in accordance with Warsama *et al*. (2006) who reported 15.9% protein content for Sudanese white cheese and higher than those reported by Suleiman *et al*. (2011) who found 8.53-9.08%. On the other hand, the protein values of the cheese produced by the two types of processing were lower than those reported by Hamid and El Owni (2008); Abdalla and Mohamed (2009); Elkhider *et al*. (2011) and Salih *et al*. (2012) who found 20.41%, 23.26%, 20.20±3.68% and 22.12% values in white cheese, respectively. Abdalla *et al*. (2013) reported that storage in plastic containers would lead to significant losses in protein and fat. Statistically, no significant (P>0.05) differences were found in protein content of collected cheese samples between traditional and modern cheeses (Table 1).

The mean of ash for traditional cheese was 9.58±3.14% with a range of 3.8 to 15.6%, while a value of 5.73±3.47% with a range of 3.0 to 13.5% was reported for modern cheese (Table 1 and Figure 1). The ash values of cheese samples from modern processing were relatively similar to those reported by Hamid and El Owni (2008); Elkhider *et al*. (2011); Salih *et al*. (2012) and Mustafa *et al*. (2013a) who found 5.35%, 5.13±2.07%, 5.57% and 4.45% for white cheese, respectively. On the other hand, the ash content in traditional cheese samples determined in the present study were higher than those reported by Warsama *et al*. (2006); Hamid and El Owni (2008); Abdalla and Mohamed (2009); Elkhider *et al*.(2011); Suleiman *et al*.(2011); El Nasri *et al*. (2012); Salih *et al*. (2012); El Zubeir and Hashim (2013) and Mustafa *et al*. (2013a) who found 6.2%, 5.34%, 3.5%, 5.13±2.07%, 2.35-2.85%, 7.00±2.73%, 5.57%, 2.25-2.44% and 4.45% for white cheese, respectively. The results

showed that there were highly significant (P<0.01) differences between the ash content of the cheese samples that was produced traditionally compared to those made by modern industry (Table 1). The variations in ash content between different cheeses probably arise from different levels of salt used as stated by Abdalla and Ahmed (2010) who reported that ash content increased with an increase in salt level in the cheese. Moreover they stated that the low ash content of pasteurized milk cheese could be explained by the diffusion of salts from the curd into the pickling solution as the result of high moisture content of pasteurized milk cheese. These findings were confirmed with those of Zaki *et al*. (1974) who reported that the ash content of white soft cheese increased with an increase in sodium chloride level.

The average acidity of traditional cheese samples was 0.49±0.18%, with a range of 0.28% to 0.84%, while the average of 0.61±0.18% with a range of 0.28% to 0.92% was reported for cheese samples produced by modern methods (Table 1 and Figure 1). The titratable acidity of modernly produced cheese was in line with those reported by Abdalla and Mohamed (2009) and Suleiman *et al*. (2011) who found 0.65% and 0.6-0.72%, respectively. However it was higher than those reported by Warsama *et al*. (2006) who found 0.04%. Moreover the values estimated were lower than those reported by Hamid and El Owni (2008); El Nasri *et al*. (2012) and Salih *et al*. (2012) who found 1.03%, 0.85±0.12% and 1.85%, respectively. On the other hand, the titratable acidity content in traditional cheese samples determined in the present study were higher than those reported by Warsama *et al*. (2006) who found 0.04%. The present values were lower than those found by Hamid and El Owni (2008); Abdalla and Mohamed (2009); Elkhider *et al*. (2011); Suleiman *et al*. (2011); El Nasri *et al*. (2012) and Salih *et al*. (2012) who found 1.03%, 0.65%, 0.71±0.44%, 0.6-0.72%, 0.85±0.12% and 1.85%, respectively. The results showed significant (P<0.05) differences in titratable acidity of cheese samples between those which were produced traditionally or by modern industry (Table 1). Abdalla and Ahmed (2010) reported that the high acidity of raw milk cheese could be due to the fact that storage temperature activated the natural microflora of raw milk and resulted in the development of acidity as a result of lactose fermentation.

The average salt of traditional cheese samples was 7.57±2.28, with a range of 5.0 to 15.0%, while a mean of modern cheese samples 4.06±1.29% with a range of 3.0 to 7.0% was found (Table 1 and Figure 1). This study showed that there were highly significant (P<0.01) variations in salt content of the cheese samples between traditionally made and those made by modern processing (Table 1). The salt value of modernly produced cheese was in line with those reported by Salih *et al*. (2012) who found 4.76%. On the other hand the salt content in traditional cheese samples found in the present study was higher than those stated by Salih *et al*. (2012). Salt controls microbial growth, enzyme activity, biochemical changes during ripening and development of flavor and aroma of cheese (Guinee, 2004).

High significant (P<0.01) differences in total solids, fat, protein, ash, titratable acidity and salt content were found between the traditionally and modernly produced cheese samples from the two different modern factories (dairy plant 1 and dairy plant 2) as shown in Figure 1. The present study suggested that variations in the chemical composition might be due to the different manufacturing methods and milk composition that affects the chemical composition of the produced cheese, which supported Turkoglu *et al*. (2003) and Tarakci and Kucukoner (2006). Similarly Dueruet *et al*. (2001) reported that different factors influence the quality of white cheese and therefore its nutritive value. These factors include: composition of food materials, the nature of the compounds, the type of packaging system and the preservative added (Dueruet *et al*., 2001). Also Abdalla *et al*. (2012) concluded that metal tin containers and polyethylene lined containers made either of plastic or metal would improve the quality of Sudanese white soft cheese.

3. 2 Microbiological characteristics

The coliform bacteria was detected in 13 samples (65%) out of 20 samples in traditional cheese samples, while it was absent in cheese samples from modernly produced chesses. The detection of coliform bacteria in cheese samples revealed 13 samples (32.5%) out of 40 samples. The coliform bacterial count showed that the traditional white cheese collected from Khartoum markets has an average of log 3.98±0.55 cfu/gm, while it was not detected in cheese samples from the modern cheese processing (Table 2). Statistical analysis showed highly significant (P<0.01) differences in coliform bacterial count in collected cheese samples from traditionally made cheese compared to those made by modern processing (Table 3). The coliform bacterial count of the traditional cheese samples determined in the present study were lower than those reported by Warsama *et al*. (2006) who reported that the log count of coliform bacteria were 6.56±0.53, 6.54±0.25 and 6.49±0.23 for cheese samples collected from restaurant, supermarkets and groceries, respectively. Also it was lower than those found by Nour El Diam and El Zubeir (2006); Elkhider *et al*. (2011) and Khan *et al*. (2014) who found log 6.49, log 6.48±1.52 and log 7.39, respectively. Moreover it was higher than those reported by Salih *et al*. (2012) who found log of 1.74 cfu/ml. The high coliform count in cheese might be due to poor processing conditions or post processing contamination as stated by Nour El Diam and El Zubeir (2006). It could also be due to production of milk and cheese under poor conditions as stated by Ceylan *et al*. (2003) and Warsama *et al*. (2006). The absence of coliform bacteria in the cheese samples from modern processing suggested good hygienic conditions.

Yeasts and molds counts recorded nil in all cheese samples from both traditional and modern processing (Table 2). The result of traditional cheese samples was similar to those reported by Abdel Razig and Babiker (2009) who reported that the mold and yeasts recorded nil in all cheese samples during storage. However the results were unlike the findings of Nour El Diam and El Zubeir (2006); Elkhider *et al*. (2011); Salih *et al*. (2012) and Mustafa *et al*. (2013b) who reported the presence of yeasts and molds and found log 5.23±1.05 and log 4.40±1.05, 1.86×105 and 4.47×104 in Sudanese white cheese, respectively. Idris and Alhassan (2010) reported that packaging of cheese in metal containers was better as low coliforms, *E. coli* and yeast counts were obtained. Moreover Abdalla *et al*. (2014) reported that the plastic containers is suitable for cheese intended for short storage before consumption, while tin one could be used when longer storage is meant.

Table 3 showed that *Staphylococcus aureus* were detected in 13 samples (65%) out of 20 samples in traditional cheese samples, while it was absent in cheese samples from modern processing. The results showed that there were highly significant (P<0.01) differences in *Staphylococcus aureus* detection between cheese samples that made by traditional factories and those made by modern processing (Table 3). The presence of *Staphylococcus aureus* in traditional white cheese were in accord with the finding of Araujo *et al*. (2002); Khakpoor and Safarmashaei (2011) and Hathout *et al*. (2013) who found 20%, 10% and 33.33% in the collected cheese samples, respectively. Similarly Jaber (2011) found values of 53.33%, 50%, and 13.33% *Staphylococcus aureus* isolations from white cheese in three different local market of Basra city; AL-basra, AL-ashar and AL-jumhurya, respectively. Also the results were in line to that reported by El-Hag *et al*. (2014) who reported that *Staphylococcus aureus* was found in samples of white cheese obtained from the traditional processing units but not in pasteurized milk. Moreover the results supported the finding of Warsama *et al*. (2006) who reported the presence of *Staphylococcus aureus* in white cheese samples collected from Khartoum North markets. Elkhider *et al*. (2011) suggested that the level of hygiene, production methods, source of raw milk and its handling could be the main factors of the high loads.

Table 1: Chemical composition of Sudanese white cheese from traditional and modern producers

Source of samples / Parameters	Traditional			Modern			Sig. Level
	Mean± sd	Minimum	Maximum	Mean± sd	Minimum	Maximum	
Total solids (%)	48.14±7.09	35.7	62.8	45.76±8.27	35.6	62.9	NS
Fat (%)	21.10±2.31	18.0	27.0	22.35±3.13	17.5	29.0	NS
Protein (%)	13.07±2.17	7.7	17.2	15.36±6.83	7.1	29.1	NS
Ash (%)	9.58±3.14	3.8	15.6	5.73±3.47	3.0	13.5	**
Acidity (%)	0.49±0.18	0.28	0.84	0.61±0.18	0.28	0.92	*
Salt (%)	7.57±2.28	5.0	15.0	4.06±1.29	3.0	7.0	**

**: significant at (P<0.01)
*: significant at (P<0.05)
NS: no significant

Table 2: Comparison of some microbiological loads in traditional and modern produced Sudanese white cheese

Source of samples / Parameters	Traditional			Modern
	Mean± std error	Minimum	Maximum	Mean± std error
Coliform count (log)	3.98±0.55	0	7.10	0
Yeasts count(log)	0	0	0	0
Molds count (log)	0	0	0	0

Table 3: Occurrence of *Staphylococcus aureus*, coliform bacteria and yeasts and mold in Sudanese white soft cheese produced by traditional and modern processing

Parameters / Source of samples		Traditional	Modern		Total
			DP1	DP2	
Staphylococcus aureus	**No of samples**	20	10	10	40
	Positive samples	13 (65%)	0	0	13 (32.5%)
Coliform	**No of samples**	20	10	10	40
	Positive samples	13 (65%)	0	0	13 (32.5%)
Yeasts and molds	**No of samples**	20	10	10	40
	Positive samples	0	0	0	0

DP1: Dairy plant 1
DP2: Dairy plant 2

The absence of *Staphylococcus aureus* from cheese produced by the modern factories indicate the improvement of the processing methods and the initial quality of raw milk received by the dairy factories. This study showed that the presence of coliform bacteria in some traditional cheese samples was accompanied by the presence of *Staphylococcus aureus*, which indicate that there was a correlation between *Staphylococcus aureus* and coliform. Similar to the present study, Hamid and El Owni (2007); Abdalla *et al*. (2012) and Salih *et al*. (2012) reported the presence of coliform bacteria beside *Staphylococcus aureus* in Sudanese white cheese. Efstratiou *et al*. (1998) reported that total coliforms correlated better with *Staphylococcus aureus* and salmonellas. They added that regression analysis revealed that total coliforms have a better value as predictors of the presence of Salmonella and *Staphylococcus aureus*, in moderately polluted areas.

The study was able to identify some potentially foodborne pathogens, such as *Staphylococcus aureus* especially in traditional samples compared to the modern cheese samples. The bacteria found in cheese samples collected from traditional type of processing suggested that the level of hygiene, processing methods,

sources of raw milk and its handling could be the main factors attributed to the presence of contamination which might affect the quality of Sudanese white cheese. Also from the results of this study the presence of pathogenic organisms necessitate attention and concerns about the safety of this traditional white cheese. It is recommended for the manufacturing of good quality cheese, the use of high quality milk from healthy animals, good manufacturing procedures and monitoring of the products during storage and marketing (Warsama *et al*., 2006). Nour El Diam and El Zubeir (2006) concluded that the Sudanese white cheese processing improves the hygienic quality and shelf life. Sulieman *et al*. (2007) showed that the tin-cans coated with antirust containers are the best for maintaining Jibna-beida of good quality. Nour El Diam and El Zubeir (2006) concluded that the Sudanese white cheese processing improves the hygienic quality and shelf life. Sulieman *et al*. (2007) showed that the tin-cans coated with antirust containers are the best for maintaining Jibna-beida of good quality.

4. CONCLUSION

The present study concluded that variations in the chemical composition might be due to the different processing methods and milk composition that affects the chemical composition of the produced cheese. The microbiological examination of the Sudanese white cheese revealed improvement in the microbial quality in modern produced cheese as shown by the absence of *Staphylococcus aureus*, coliform bacteria and yeasts and molds. Sudanese white cheese that produced in modern dairy plants is safer for consumption, while those produced traditionally need more effort to improve their quality.

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