

Effect of Type of Storage Container on Weight Loss, Chemical Composition, Microbiological Properties and Sensory Characteristics of Sudanese White Cheese (*Gibna Bayda*)

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Abstract: The effect of storage container on weight loss, chemical composition, microbiological properties and sensory characteristics of Sudanese white soft cheese was investigated. The cheese was made from fresh raw cow's milk with 6% salt (NaCl), added to the milk before renneting. Cheese was packed with its boiled whey into both anti-acid cans and plastic containers in triplicate then stored at room (35-37°C) and refrigerator (7°C) temperatures for periods of zero, 60, 120, 180 and 240 days. The results showed that storage container had significant ($P<0.05$) effect on the weight loss, chemical composition and microbiological quality of Sudanese white soft cheese at different periods. Cheese samples stored in anti-acid cans had higher weight loss ($25.43\pm2.89\%$) than those kept in plastic containers ($15.28\pm3.91\%$). Titratable acidity, total solids, crude proteins, fat, soluble proteins, ash, tyrosine and tryptophane contents of the cheese packed in anti-acid cans were significantly ($P<0.001$) higher than those stored in plastic containers. Cheese samples kept in plastic containers had higher coliform and *E. coli* counts than those stored in anti-acid cans. Psychrotrophic bacterial count of the samples packed in anti-acid cans fluctuated in numbers during storage and were significantly ($P<0.001$) higher than those of the cheese kept in plastic containers. Yeasts and moulds were decreased in numbers in the cheese stored in plastic containers while they were not detected in samples packed in anti-acid cans through out the storage periods. Cheese samples stored in anti-acid cans showed improvement in color, flavor and texture, while those packed in plastic containers had lower values. Weight losses in the cheese samples kept in anti-acid cans were higher in comparison with those kept in plastic containers, while cheese samples kept in plastic containers had higher total bacterial counts, coliforms, *E. coli*, yeast and mould counts from day zero till day 120.

Key words: White cheese, *Gibna Bayda*, anti acid cans, plastic containers, storage, chemical, microbiological properties, sensory characteristics.

INTRODUCTION

The manufacture of *Gibna Bayda* which is a soft cheese variety is much simpler than that of semi-hard cheese or hard cheese types. The skills required for making *Gibna Bayda* is relatively small (Oman, 1987). Cheese making is aimed to make milk preservation attractive and durable. Its shelf life varies from few days to several years (Walstra *et al.*, 1999). The white cheese is manufactured from cow's, sheep's, goat's, and/or the mixture of these animal milks. However, shortages of fresh milk supplies have led to increased use of reconstituted milk for cheese making (Osman, 1987). Sudanese white cheese is preserved in its whey in tins sealed with soldering or in plastic containers tightly covered to prevent oxidation (Osman, 1987). Salt concentration and storage conditions were significantly ($p<0.05$) affected weight loss, chemical composition, microbial content and sensory characteristics of Sudanese white cheese Hamid *et al.* (2008). Plastic containers are now widely used for packing of white cheese in the Sudan. Bilal (2000) reported that samples of Sudanese white cheese stored in plastic containers lost less weight than those stored in cans. Plastic containers are sterile but may be contaminated if not handled in appropriate manner (Banwart, 1981). Weight loss increased significantly ($p<0.05$) throughout the storage period. Crude proteins, total solids and ash contents significantly

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($p < 0.05$) increased from day zero to day 120 (El Owni and Hamid, 2008). Storage periods showed significant differences ($p < 0.05$) with psychrotrophic, total bacterial counts, coliforms, and yeast and molds counts. Similarly the different types of packaging (plastic and glass) showed significant differences ($p < 0.05$) with psychrotrophic, coliforms, yeast and molds counts (Nour El Daim and El Zubeir, 2006). Total bacterial count (TBC), coliforms, *E. coli*, *Staphylococcus aureus* and psychrotrophic bacterial counts significantly ($p < 0.05$) decreased during storage, while yeast and mould increased as storage time progressed (El Owni and Hamid, 2008). Log count of *Staphylococcus aureus* were 3.40885 ± 4.82087 , 4.97803 ± 1.1807 and 0 and the log count of *E. coli* were 5.23337 ± 0.53085 , 0 and 5.33815 ± 0.771346 , respectively from restaurants, supermarket and groceries (Warsama *et al.*, 2006). Significant ($p < 0.05$) variations were found between color, and texture. The flavor scores of cheese samples and saltiness were significantly different ($p < 0.01$ and $p < 0.001$, respectively) as was reported by Hamid and El Owni, (2007). Color, taste, flavor, texture and saltiness of the processed cheese showed noticeable changes during storage period (Nour El Daim and El Zubeir, 2007).

The objective of our work was to study the effect of storage containers on weight loss, chemical composition, microbiological properties and sensory characteristics of white soft cheese at different stages of storage.

MATERIALS AND METHODS

Cheese manufacture:

The study performed between February 2003 and October 2004 in the laboratory of the Department of Dairy Production, Faculty of Animal Production, University of Khartoum. Cheese (*Gibna*) with 6 % salt (NaCl) was made from fresh raw cow's milk. As described before, (Hamid *et al.* (2007). Cheese samples of each concentration were packed in anti-acid cans and plastics containers in triplicates then stored at room and refrigerator temperatures for periods of 0, 60, 120, 180 and 240 days. Weight loss, chemical, microbiological analyses and sensory characteristics were determined after each storage period.

Chemical analysis:

Analysis of titratable acidity, total solids, crude proteins and ash contents were determined according to AOAC (1990). Fat contents were determined according to Foley *et al.* (1974). Soluble proteins were determined according to Ling (1963). Volatile fatty acids were determined according to Kosikowski (1982). Tyrosine and tryptophane contents were determined by the method of Vakaleris and Price (1959).

Microbiological analysis:

Culture media were prepared according to the manufacturers instructions. Eleven grams of each cheese type were weighed aseptically into sterile blender jar (Moulinex 719), then 99 ml of sterile 2 % aqueous solution of sodium citrate warmed at 45°C was added and blended for 2 minutes to make 10^{-1} dilutions. Ten fold dilutions were made using 0.1% peptone water as diluent. Plate count agar was used for enumeration of total bacteria and psychrotrophic bacterial counts according to FDA (1980) and Frank *et al.* (1992), respectively. Mac Conkey broth and Brilliant green lactose bile broth were used for enumeration of coliforms and *E. coli* most probable numbers according to Marshall (1992). Mannitol salt agar was used for *Staphylococcus aureus* count according to Rayman *et al.* (1988), while Sabouraud dextrose agar was used for enumeration of yeasts and moulds according to Harrigan and Mc Cance (1976).

Sensory evaluation:

The quality of the cheese was judged by 10 untrained panelists for color, flavor, texture and saltiness.

Statistical analysis:

Statistical Package for Social Sciences (SPSS-version 10) was used for statistical analysis. General Linear Models were used to estimate the effect of storage period on weight loss, chemical composition, microbiological and sensory characteristics of Sudanese white cheese. Duncan's Multiple Range tests were carried out for mean separation between the treatments.

RESULTS AND DISCUSSION

Results in Table 1 show the main effects of type of storage containers on weight loss, titratable acidity, Total solids, Crude protein, fat, Soluble protein, ash, Volatile fatty acids, Tyrosine and tryptophane contents. of the white cheese (*Gibna Bayda*).were significantly ($P < 0.05$) affected by storage container.

High weight loss ($25.43 \pm 2.89\%$) was found in the cheese packed in antacid cans and the low ($15.28 \pm 3.91\%$) in cheese kept in plastic containers (Table 1).

Titrateable acidity of the cheese stored in anti-acid cans was significantly ($P < 0.05$) higher ($1.20 \pm 0.66\%$) when compared with that kept in plastic containers ($0.95 \pm 0.13\%$).

Total solids content of the cheese kept in plastic containers was ($38.05 \pm 6.58\%$) which is lower than those stored in antiacid cans ($44.28 \pm 6.19\%$).

Crude protein contents and fat contents of the cheese samples packed in anti-acid cans were significantly higher ($16.35 \pm 3.06\%$ and $21.09 \pm 6.36\%$) than those kept in plastic containers ($13.37 \pm 6.22\%$ and $18.93 \pm 8.45\%$).

The cheese samples stored in anti-acid cans had higher ($0.51 \pm 0.22\%$) soluble protein contents in comparison with those packed in plastic containers ($0.45 \pm 0.27\%$).

Cheese samples kept in antiacid cans had higher ($3.44 \pm 0.63\%$) ash contents than those stored in plastic containers ($2.88 \pm 1.29\%$).

The VFA of cheese stored in plastic containers were higher [13.13 ± 2.77 (0.1 N ml NaOH/100 gm cheese)] than those stored in antiacid cans (11.94 ± 1.2) (0.1 N ml NaOH/100 gm cheese)].

Tyrosine and tryptophane contents of the cheese samples stored in antiacid cans were higher [55.63 ± 6.11 and 140.30 ± 14.93 mg/100gms cheese) than those packed in plastic containers (37.88 ± 5.27 and 99.63 ± 8.95 mg/100 gms cheese).

Table 1: Effect of type of containers on weight loss and chemical composition of Sudanese white cheese (*Gibna Bayda*) during storage
Weight loss and chemical composition (%)

	The type of container	
	Plastic container	Antiacid can
Weight loss	15.28 ± 3.91^b	25.43 ± 2.89^a
Titrateable acidity	0.95 ± 0.13^b	1.20 ± 0.66^a
Total solids	38.05 ± 6.58^b	44.28 ± 6.19^a
Crude protein	13.37 ± 6.22^b	16.35 ± 3.06^a
Fat	18.93 ± 8.45^b	21.09 ± 6.36^a
Soluble protein	0.45 ± 0.27^b	0.51 ± 0.22^a
Ash	2.88 ± 1.29^b	3.44 ± 0.63^a
VFA (0.1 N mL NaOH/100 gm cheese)	13.13 ± 2.77^a	11.94 ± 1.20^b
Tyrosine mg/100 gm cheese	37.88 ± 5.27^b	55.63 ± 6.11^a
Tryptophane mg/100 gm cheese	99.63 ± 8.95^b	140.30 ± 14.93^a
Level of significant	***	***

In this and in the following tables: Mean values bearing different superscripts within rows are significantly different ($P < 0.05$).

*** = ($P < 0.001$).

NS = Non significance

Results in Table 2 presented that changes in weight loss of the cheese stored in plastic containers increased significantly ($P < 0.001$) from zero at day zero to $20.73 \pm 3.06\%$ and $24.08 \pm 5.30\%$, at days 60 and 120, respectively, then gradually decreased to $19.24 \pm 2.30\%$ and $11.67 \pm 2.30\%$ at days 180 and 240, while the weight loss of the cheese kept in antiacid cans increased from zero at day zero to $24.57 \pm 7.20\%$, $28.43 \pm 3.6\%$, $34.44 \pm 7.6\%$ and $39.72 \pm 4.4\%$ at days 60, 120, 180 and 240, respectively. Moreover, the weight losses of the cheese kept in anti acid cans were significantly ($P < 0.001$) higher than those kept in plastic containers. The titrateable acidity of cheese kept in plastic containers and anti acid cans significantly increased as these storage period progressed from day zero through to day 240

Total solids content of cheese in plastic containers increased from $42.38 \pm 1.81\%$ at day zero to $45.01 \pm 5.40\%$ at day 60 then decreased significantly to $22.39 \pm 23.30\%$ at day 240. While the total solids content of the cheese kept in antiacid cans increased from $42.38 \pm 1.81\%$ at day zero, decreased to $41.75 \pm 8.20\%$ at day 60 then increased progressively to 44.52 ± 7.20 , 46.33 ± 6.10 and 46.42 ± 4.79 at days 120, 180 and 240.

Crude protein contents of the cheese samples packed in antiacid cans increased from $15.08 \pm 0.56\%$ at day zero to $18.03 \pm 3.14\%$ at day 120 then decreased to $15.03 \pm 3.14\%$ at day 180 and increased to $17.60 \pm 2.80\%$ at day 240. While protein contents of cheese stored in plastic containers were increased from $15.08 \pm 0.56\%$ at day zero to $17.68 \pm 3.99\%$ at day 120, then decreased to $10.38 \pm 6.30\%$ and $7.60 \pm 7.86\%$ at day 180 and day 240 respectively.

The fat contents of the cheese packed in plastic containers was higher than that packed in anti acid cans up to day 180. However, at the end of the storage period the fat contents of the cheese kept in antiacid cans were higher ($22.93 \pm 7.12\%$) than those kept in plastic containers ($21.69 \pm 2.20\%$) at day 240.

Significant variations were found in soluble protein contents of cheese kept in plastic containers and antiacid cans from day 60 until day 240. Soluble protein contents of cheese kept in antiacid cans increased from $0.20 \pm 0.03\%$ at day zero to $0.70 \pm 0.08\%$ at day 180 then decreased to $0.67 \pm 0.11\%$ at day 240, while those of the samples stored in plastic containers increased from $0.20 \pm 0.03\%$ at day zero to $0.59 \pm 0.11\%$ at day 120 then reduced to $0.50 \pm 0.05\%$ at day 240.

Table 2: Effect of storage period and type of container on weight loss and chemical composition of Sudanese white cheese (*Gibna Bayda*) during Storage

Storage period day	Chemical composition									
	Weight loss %		Titra. acidity %		Total solids %		Crude protein %		Fat %	
	PC	AC	PC	AC	PC	AC	PC	AC	PC	AC
0.0	0.00 ^e	0.00 ^e	0.39± 0.08 ^b	0.39± 0.08 ^b	42.38± 1.81 ^e	42.38± 1.81 ^e	15.08± 0.56 ^d	15.08± 0.56 ^d	18.90± 0.78 ^f	18.90± 0.78 ^f
60	20.73±3.06 ^e	24.57±7.20 ^d	1.30± 0.66 ^c	0.87± 0.50 ^f	45.01± 5.40 ^b	41.75± 8.20 ^f	16.11± 3.50 ^e	16.03± 3.40 ^e	23.43± 3.40 ^e	19.99± 0.60 ^e
120	24.08±5.30 ^e	28.43±3.60 ^e	1.23± 0.43 ^d	1.24± 0.41 ^f	43.83± 3.80 ^d	44.52± 7.20 ^e	17.68± 3.99 ^e	18.03± 3.14 ^e	22.40± 2.70 ^b	21.91± 6.90 ^e
180	19.24±2.30 ^e	34.44±7.60 ^b	1.18± 0.66 ^c	1.83± 0.43 ^e	36.66± 22.30 ^e	46.33± 6.10 ^e	10.38± 6.30 ^e	15.03± 3.14 ^e	22.40± 2.70 ^b	21.91± 6.90 ^e
240	11.67±2.30 ^f	39.72±4.40	0.69± 0.62 ^e	1.64± 0.49 ^e	22.39± 23.30 ^e	46.42± 4.97 ^e	7.60± 7.86 ^e	17.60± 2.80 ^e	21.69± 2.20 ^b	22.93± 7.12 ^e
Level of sign.	***		***		***		***		***	
0.0	0.20± 0.03 ^e	0.20± 0.03 ^e	3.35± 0.19 ^d	3.35± 0.19 ^d	4.68± 0.30 ^f	4.68±0.30 ^f	14.38± 3.60 ^f	14.38± 3.60 ^f	5.55±1.96 ^e	5.55± 1.96 ^e
60	0.39± 0.09 ^e	0.36± 0.13 ^b	3.61± 0.77 ^a	3.63± 0.68 ^a	13.78± 7.50 ^d	8.04±1.20 ^e	102.24± 53.40 ^f	80.01± 33.6 ^b	21.42±11.50 ^f	14.28± 8.30 ^e
120	0.59± 0.11 ^d	0.62± 0.08 ^e	3.23± 0.62 ^d	3.49± 0.19 ^b	25.38± 8.20 ^a	12.13±2.80 ^d	126.2± 59.7 ^e	149.01± 74.8 ^d	28.69±16.20 ^e	92.33± 35.30 ^b
180	0.55± 0.28 ^e	0.70± 0.08 ^e	2.71± 1.64 ^f	3.14± 0.40 ^e	13.25± 1.20 ^d	19.78± 10.10 ^b	133.08± 81.60	189.14± 80.90 ^b	69.48±42.70 ^e	70.03± 44.60 ^f
240	0.50± 0.05 ^f	0.67± 0.11 ^b	1.47± 0.43 ^e	3.58± 0.90 ^e	8.53± 2.99 ^e	15.07±3.92 ^e	92.21± 6.95 ^e	268.97±14.93 ^e	160.16±18.80 ^e	47.97± 5.70 ^e
Level of sign.	***		***		***		***		***	

Ash contents showed Progressed increase from day zero to the day 60. Therefore the highest ash contents were recorded for cheese kept in antiacid cans (3.58±0.90) at day 240 and the lowest (1.47±0.43%) for the cheese stored in plastic containers.

Volatile fatty acids of the cheese kept in antiacid cans significantly ($P < 0.001$) increased from 4.68 ± 0.30 at day zero to 19.78 ± 10.10 at day 180 then decreased to 15.07 ± 3.92 at day 240, while those kept in plastic containers increased to 25.38 ± 8.20 at day 120 then decreased to 13.25 ± 1.20 and 8.53 ± 2.99 at days 180 and 240, respectively.

Tyrosine contents of the cheese samples stored in anti-acid cans significantly increased from 14.38 ± 3.60 mg/100 gm cheese at day zero to 268.97 ± 14.93 mg/100 gm cheese at day 240, whereas those of the cheese kept in plastic containers increased from 14.38 ± 3.60 mg/100 gm cheese at day zero to 126.20 ± 59.70 mg/100 gm cheese at day 120, then decreased to 92.21 ± 6.95 mg/100 gm cheese at day 240.

Tryptophane contents of the cheese kept in plastic containers increased in values from day zero till the end of the storage period (240). While those stored in anti-acid cans increased in values from day zero till 120 then decreased to (70.03±44.60) and (47.97±5.70) at days 180 and 240 respectively.

Total bacterial count of the cheese samples kept in plastic containers and anti-acid cans at day zero were 7.52 ± 1.07 log cfu/ml The total bacterial count of the cheese kept in plastic containers and anti-acid cans showed irregular pattern during storage, while there is almost no change in number in cheese kept in anti-acid cans. (Table 3).

Table 3: Effect of type of containers on the microbiological quality of Sudanese white cheese (*Gibna Bayda*) during storage

Storage period days	Microbiological analysis									
	TBC (cfu/ml)		Coliforms count		<i>E. coli</i> count		<i>Staph. aureus</i> count		Psychrotrophic count	
	PC	AC	PC	AC	PC	AC	PC	AC	PC	AC
0.0	7.52±1.07 ^b	7.52± 1.07 ^b	4.04± 1.04 ^d	4.04± 1.04 ^d	2.18± 0.12 ^e	2.18± 0.12 ^e	3.03	3.03	6.35± 0.08 ^e	6.35± 0.08 ^e
60	7.45±0.21 ^b	7.67± 0.26 ^e	1.16± 0.21 ^b	1.09± 1.15 ^e	1.01± 1.06 ^e	0.48± 0.16 ^f	ND	ND	3.08± 3.25 ^e	3.46± 0.72 ^b
120	7.49±0.70 ^b	5.99± 1.18 ^e	0.49± 0.08 ^d	ND	0.32± 0.18	ND	ND	ND	1.09± 1.97 ^e	2.95± 1.11 ^d
180	5.92±3.6 ^f	7.01± 0.66 ^d	ND	ND	ND	ND	ND	ND	ND	ND
240	3.58±3.6 ^f	7.39± 1.18 ^e	ND	ND	ND	ND	ND	ND	1.89± 3.40 ^e	3.15± 0.30 ^e
Level of sign.	***		***		***		***		***	

Coliforms were not detected in the cheese kept in anti-acid cans at day 120 till the end of the storage period at day 240. Whereas the cheese stored in plastic containers showed reduced counts (0.49 ± 0.08 log MPN/ml) at day 120 then completely disappeared in days 180 to 240.

The results in Tables 3 show that storage containers significantly ($P < 0.001$) affected *E. coli* counts of the cheese samples during storage and the counts of the cheese kept in plastic containers decreased from 2.18 ± 0.12 at day zero to 0.32 ± 0.18 log MPN/ml at day 120 then disappeared completely at days 180 and 240. *E. coli* counts of the cheese packed in antiacid cans decreased to 0.48 ± 0.16 log MPN/ml at day 60 but were not detected at days 120, 180 and day 240.

Staphylococcus aureus count of the cheese samples in both containers was 3.03 log cfu/ml at day zero. The organism was not detected in the two cheese types at day 60 onwards.

Psychrotrophic bacteria count of the cheese kept in anti-acid cans and plastic containers fluctuated in numbers from day 120 with a noticeable reduction in day 240.

The results indicated that yeasts and moulds were detected only at day zero in the cheese stored in anti-acid cans (2.65 ± 0.48 log cfu/ml), while the two organisms increased in numbers in samples kept in plastic containers at day 60 then gradually decreased to 1.74 ± 0.14 log cfu/ml at day 240.

The storage containers significantly affected the color and the flavor of the cheese (Table 4). The cheese samples kept in antiacid cans had higher color and flavor scores (5.74 ± 0.63 and 5.45 ± 1.10) than cheese packed in plastic containers (4.85 ± 2.14 and 4.25 ± 1.92). The texture of the cheese kept in antiacid cans was significantly ($P < 0.001$) better (6.00 ± 1.05) when compared with that kept in plastic containers (4.80 ± 2.19). The saltiness of the cheese samples were significantly ($P < 0.001$) affected by storage containers. The cheese samples kept in plastic containers had higher saltiness scores (5.37 ± 1.67) than that stored in antiacid cans (4.61 ± 1.04).

Results in Table 5 show changes in the sensory characteristics as affected by the storage containers during storage. Significant differences ($p < 0.05$) were observed in the color scores of the cheese kept in plastic containers and anti-acid cans from days 60 to 240. The color scores of the cheese stored in anti-acid cans were significantly better from days 180 to 240.

The texture of the cheese samples was affected significantly ($P < 0.001$) by type storage container (Table 5). The cheese kept in anti-acid cans and plastic containers showed an increase in the texture scores from 5.31 ± 0.20 at day zero to 6.69 ± 0.64 at day 120 then decreased to 5.77 ± 0.89 and 4.04 ± 0.78 at day 180 and 240 respectively, and that stored in plastic containers showed an increase in the texture scores from day zero 5.31 ± 0.20 to 5.68 ± 0.72 at day 120 then decreased to 4.23 ± 1.72 and 3.30 ± 0.51 at day 180 and 240 respectively.

The flavor of the cheese samples followed the same trend as the texture of the cheese.

The cheese saltiness during storage showed insignificant differences ($P < 0.05$) as affected by storage container. The saltiness of the cheese kept in plastic containers showed higher scores of saltiness during the storage periods from day 60 till day 240.

Table 4: Effect of storage container on the sensory characteristics of Sudanese white cheese (*Gibna Bayda*) during storage

sensory character	Storage container	
	Plastic container (PC)	Antiacid container (AC)
Color	4.85 ± 2.14^b	5.74 ± 0.63^a
Flavor	4.25 ± 1.92^b	5.45 ± 1.10^a
Texture	4.80 ± 2.19^b	6.00 ± 1.05^a
Saltiness	5.37 ± 1.67^a	4.61 ± 1.04^b

Table 5: Changes in sensory characteristics of Sudanese white cheese (*Gibna Bayda*) During Storage.

Variable	Color		Texture		Flavor		Saltiness	
	PC	AC	PC	AC	PC	AC	PC	AC
The storage periods (days)								
0.0	5.03 ± 0.42^d	5.04 ± 0.42^f	5.31 ± 0.20^f	5.31 ± 0.20^c	4.18 ± 0.43^d	4.18 ± 0.43^c	4.18 ± 0.43	4.18 ± 0.43
60	5.33 ± 1.01^c	5.57 ± 0.54^e	5.45 ± 0.71^d	6.45 ± 0.35^c	5.20 ± 0.39^b	5.63 ± 0.80^b	3.64 ± 0.81	3.35 ± 0.63
120	6.25 ± 0.31^b	5.85 ± 0.54^b	5.68 ± 0.72^d	6.69 ± 0.64^b	5.50 ± 0.98^a	6.02 ± 1.15^b	4.34 ± 0.85	3.66 ± 1.15
180	4.48 ± 2.68^a	5.93 ± 0.56^e	4.23 ± 1.72^d	5.77 ± 0.89^b	3.95 ± 2.40^e	5.70 ± 1.04^c	3.87 ± 2.20	4.20 ± 1.70
240	3.31 ± 1.93^c	4.53 ± 0.33^f	3.30 ± 0.51^e	4.04 ± 0.78^i	5.71 ± 1.02^c	4.48 ± 2.80^c	3.34 ± 1.82	2.19 ± 1.18
Level of sign.	***				NS			

Discussion:

Weight loss of the cheese kept in antiacid cans was higher than those stored in plastic containers. Similar results were reported by Bilal (2000) who found that the cheese samples stored in polyethylene bags lost weight less than those stored in cans. The increase in weight loss was due to the rapid loss of moisture from the cheese in anti-acid cans due to the increase of acidity which affected the contraction of the curd. (Kur, 1992).

The results of titratable acidity were in line with the findings of Bilal (2002) who stated that titratable acidity of the cheese stored in cans was higher (0.39%) than that stored in polyethylene bags. The increase in acidity of the cheese stored in antiacid cans was mainly due to increase in lactic acid bacteria which produce a considerable amount of lactic acid (El Owni and Hamid, 2008).

The findings of the total solids contents were in accordance with the results of (Bilal, 2000; Abdalla and Mohamed, 2009). The lower total solids content of the cheese samples kept in plastic containers might be due to increased action of proteolytic and lipolytic micro flora on the cheese components.

The crude protein contents of the cheese samples kept in antiacid cans and plastic containers had no significant variations from day zero to day 60. These findings did not agree with the results of Bilal (2000) who explained that protein contents of the cheese packed in polyethylene bags were higher (23.45%) than those stored in antiacid cans (22.54%). The lower protein contents of the cheese samples kept in plastic containers were possibly due to heavy proteolytic action during storage (Abdel-Salam, 1987; Abdalla and

Mohamed, 2009).

The results of fat contents were in agreement with those of Bilal (2000). She reported that fat contents of the cheese stored in antiacid cans were higher than those stored in polyethylene bags. The high fat contents of the cheese samples kept in antiacid cans could be due to low moisture content in the cheese samples due to development of high acidity within cans (Ahmed, 1985; Khalid and El Owni, 1991; Nofal *et al.*, 1981).

Initially soluble protein contents of the cheese kept in plastic container were higher than those kept in antiacid cans probably due to the high proteolytic activities in the latter. However, at day 120 and throughout the storage period soluble proteins in the cheese stored in antiacid cans were higher than those of plastic containers probable due to continuous proteolysis during ripening of cheese in the latter containers.

The high ash contents of the cheese stored in antiacid cans could be due to the lower moisture content and absorption of salt by the curd. The results in this study were in accordance with the findings of Bilal, (2000); El Owni and Hamid, (2008); Abdalla and Mohamed, (2009).

The cheese kept in plastic containers had higher VFA than those in antiacid cans. That could be explained by increased activity of lipolytic agents in plastic containers during storage.

The increase in tyrosine and tryptophane contents of the cheese packed in antiacid cans was possibly due to degradation of proteins by microorganisms (Karakus and Alperden, 1992).

The bacterial count of the cheese samples kept in plastic containers was lower than those packed in antiacid cans at day 60. That might be due to the effect of high acidity in the cheese samples in plastic containers on the microbial contents. Our results were in agreement with those reported by Ahmed (1985).

Cheese kept in plastic containers showed a decreasing rate of growth in *E. coli* from day zero to day 120, while those kept in antiacid cans their *E. coli* count decreased at day 60 and completely absent at day 120. This could be due to high acidity of the cheese samples which affected the survival of this microorganism. Our findings were in agreement with those of Ahmed and Khalifa (1989). The absence of *S. aureus* was attributed partly to inhibitory effect of high lactic acid or might be due to the fact that low initial levels of *Staphylococcus aureus* in the cheese at day zero and were not increased during storage (Hamama *et al.*, 2000).

Psychrotrophic bacterial count of the cheese samples kept in antiacid cans decreased with storage time. That could be due to the low level of lactic acid (Table 3). Banwart (1981) reported that psychrotrophs multiply in refrigerated foods and that they decrease in numbers after 4 months of storage at 7°C.

The growth of yeasts and moulds in the cheese samples kept in plastic containers could be due to presence of oxygen in the plastic containers Ahmed (1985) reported similar results.

The results indicated that cheese kept in antiacid cans were better in flavor than those stored in plastic containers. These results agree with the findings of Bilal (2000) who reported that color and taste were best in the cheese stored in cans in comparison with those stored in polyethylene bags.

Texture of the cheese kept in anti-acid cans were better than those in plastic containers. The high texture scores could be attributed to absence of yeasts which causes defect in cheese texture.

The cheese samples kept in anti-acid cans had higher saltiness scores in comparison with those packed in plastic containers. However, Bilal (2000) stated that saltiness and texture were significantly ($P < 0.05$) high in cheese stored in polyethylene bags.

The deterioration in colour of the cheese stored in plastic containers could be related to the effect of light on the containers (Bosset *et al.*, 1994).

Texture of the cheese samples kept in antiacid cans was better than those kept in plastic container. That was likely due to high activities of proteolytic agents in the cheese in antiacid cans, while those in the plastic containers the presence of yeasts and moulds might have affected the texture negatively (Table 5). Flavor of the cheese kept in antiacid cans stored at refrigerator was better than those kept in plastic containers at the same temperature at days 60 and 120. This could be due to the fact that the cheese kept in plastic containers showed growth of yeasts which might have affected the flavor.

Saltiness of the cheese samples kept in plastic containers and antiacid cans had no significant variation throughout the storage period. This was contrary to the findings of El Owni and Hamid (2008) and Abdalla and Mohamed (2009).

It would be concluded that storage containers affected the weight loss, chemical composition, microbiological properties and sensory characteristics of Sudanese white soft cheese. Therefore storing the cheese in antiacid cans was better than storage in plastic containers and the quality was also better in cheese kept in antiacid cans.

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