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Effect of Salt Concentration on Weight Loss, Chemical Composition and Sensory Characteristics of Sudanese White Cheese

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Abstract: Sudanese white cheese was made from fresh raw cow's milk with two salt (NaCl) concentrations (4 and 6%), which were added to the milk before renneting. Cheese of each salt concentration was packed with its boiled whey into antiacid cans and plastic containers in triplicate then stored at room (35-37°C) and refrigerator (7°C) temperatures for 8 months. The effects of salt concentration on weight loss, chemical composition, microbiological and sensory characteristics were studied at 0, 60, 120, 180 and 240 days. The result indicated that salt concentration affected significantly ($p<0.05$) weight loss, chemical composition, microbiological and sensory characteristics of the cheese. Cheese samples with 6% salt had higher weight loss than those with 4% salt. Titratable acidity of the cheese samples with 4% salt showed higher values than that of cheese samples with 6% salt. Soluble proteins, Volatile Fatty Acids (VFA), tyrosine and tryptophane contents were higher in cheese with 4% salt. Total solids, crude proteins and fat contents were higher in cheese samples with 6% salt. Significant ($p<0.05$) variations were found in microbial counts of the cheese with 4% and 6% salt. Sensory characteristics of the cheese samples with 6% salt were significantly ($p<0.05$) better when compared with those made with 4% salt.

Key words: Salt concentration, weight loss, chemical composition, sensory characteristics, white Sudanese cheese

INTRODUCTION

Production of cheese in the Sudan is based on Sudanese white cheese Gibna Bayda and braided cheese Gibna Mudaffara (Osman, 1987; El Sheikh, 1997). The Sudanese white cheese being one of the most popular varieties (Abdel Razig, 1996). Pickled white cheese is the most important cheese variety manufactured in the Sudan and is more popular and preferred almost all over the country. It is characterized by sour taste and strong flavour (Dirar, 1993). Sodium chloride influences cheese ripening principally through its effects on water activity, control of various enzyme activities in cheese, synersis of the curd and physical changes in proteins which influence cheese texture and protein solubility (Fox, 1993). Salt has three major functions in cheese: it acts as preservative, contributes directly to the flavour and is a source of dietary sodium (Guinee, 2004).

The objective of this study is to investigate the effect of salt concentration on weight loss, chemical composition, microbiological and sensory characteristics of Sudanese white cheese.

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MATERIALS AND METHODS

Cheese Manufacture

This study was conducted in the laboratory of the Department of Dairy Production, Faculty of Animal Production, University of Khartoum during the period from February to December 2005. Cheese manufacture was described previously by Osman (1987). Cheese was made from fresh raw cow's milk with two salt concentrations (4 and 6%) added to the milk before renneting. Rennet tablets (Christian Hansen, Denmark) were added at a rate of one tablet/50 L to the milk at 40°C. The milk was stirred for 10 min and left till coagulation occurred. The curd was cut and left for 30 min for whey drainage. The whey was collected to be used for preservation of the cheese. The cut curd was then transferred to clean wooden mould lined with clean cloth and pressed with 36 kg weight overnight. Next day the cheese removed from the mould and cut into small cubes (5×5×5 cm). The whey of each salt concentration was boiled for 5 min and used for preservation of the particular cheese samples. The cheese samples of each concentration were packed in antiacid cans and plastics containers in triplicate and stored at both room and refrigerator temperatures for 8 months. Weight loss, chemical, microbiological and sensory characteristics were determined at 0, 60, 120, 180 and 240 days.

Chemical Analysis

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 Examination

Culture media were prepared according to manufacturers instructions. Eleven grams of each cheese type were weighed aseptically into sterile blender jar (Moulinex 719), then 89 mL of sterile 2% aqueous solution of sodium citrate warmed at 45°C was added and blended for 2 min to make 10^{-1} dilutions. Ten fold serial dilutions were also made (Houghbty *et al*., 1992).

Plate count agar was used for enumeration of viable total bacterial and psychrotrophic bacterial counts according to FDA (1980) and Frank *et al*. (1992), respectively. Mannitol salt agar was used for *Staphylococcus aureus* count according to Rayman *et al*. (1988), while Sabouraud dextrose agar was used for enumeration calculated as colony forming units (cfu) per g of cheese (FDA, 1980) of yeast and moulds according to Harrigan and McCance (1976). MacConkey broth and Brilliant green lactose bile broth were used for enumeration of coliforms and *E. coli* most probable number (M P N) per gram of sample according to Marshall (1992).The results were calculated as Colony Forming Units (cfu) per gram of cheese (FDA, 1980).

Sensory Evaluation

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

Statistical Analysis

Statistical Package for Social Science (SPSS 10) Programme was used. 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 also carried out for mean separation between the treatments.

RESULTS

Titratable acidity of the cheese with 4% salt was significantly ($p<0.05$) higher than that with 6% salt. Total solids, fat and ash contents of the cheese with 6% were significantly ($p<0.05$) higher in comparison with those of 4% salt.

Soluble proteins, volatile fatty acids, tyrosine and tryptophane of the cheese with 4% were higher when compared with those made with 6% salt (Table 1).

Data in Table 2 show the changes in weight loss and chemical composition of white cheese during storage as affected by salt concentration. Total solids, crude protein, fat and ash contents of the cheese

Table 1: Effect of salt concentration on weight loss and chemical composition of Sudanese white cheese

	Salt concentration (%)	
Weight loss and chemical composition (%)	6	4
Weight loss	22.74±19.63^{a}	17.98±16.89^{b}
Titratable acidity	0.95±0.57^{b}	1.20±0.710^{a}
Total solids	43.66±11.5^{a}	38.68±13.72^{b}
Crude protein	15.52±5.97^{a}	14.21±4.000^{b}
Fat	22.59±7.18^{a}	17.43±6.960^{b}
Soluble protein	0.46±0.23^{b}	0.50±0.260^{a}
Ash	3.52±0.94^{a}	2.79±1.030^{b}
VFA (0.1 N mL NaOH/100 g cheese)	10.43±6.80^{b}	14.64±12.66^{a}
Tyrosine mg/100 g cheese	43.17±53.12^{b}	50.33±55.65^{a}
Tryptophane mg/100 g cheese	108.82±83.7^{b}	131.12±105.54^{a}

Mean values bearing different superscripts within rows and columns are significantly different ($p<0.05$)

Table 2: Effect of storage periods and salt concentration on chemical composition and weight loss of processed Sudanese white cheese

	Chemical composition									
Storage periods	Weight loss (%)		Titr.-acidity (%)		Total solids (%)		Crude protein (%)		Fat (%)	
(days)	6	4	6	4	6	4	6	4	6	4
0.0	0.0^{g}	0.0^{g}	0.32±0.001^{h}	0.47±0.004^{g}	43.77±1.41^{d}	41.0±6.4^{g}	15.20±0.76^{d}	14.97±0.18^{e}	18.30±0.39^{h}	19.5±0.53^{f}
60	21.98±17.55^{g}	23.32±16.5^{e}	0.82±0.58^{f}	1.35±0.54^{e}	44.22±6.9^{e}	42.54±7.32^{f}	17.48±3.5^{b}	14.64±2.7^{f}	29.91±3.7^{b}	18.52±5.1^{g}
20	29.98±16.2.5^{b}	22.53±12.6^{f}	1.11±0.47^{d}	1.36±0.54^{e}	45.53±5.7^{b}	42.81±5.54^{e}	18.93±4.26^{a}	16.76±2.3^{e}	23.48±5.8^{e}	20.83±4.3^{d}
180	35.63±13.07^{a}	18.76±18.18^{h}	1.55±0.10^{a}	1.46±0.54^{b}	49.75±5.9^{a}	33.23±20.2^{j}	12.75±1.38^{h}	12.65±7.8^{h}	26.47±4.3^{a}	13.48±8.8^{j}
240	26.11±22.03^{c}	25.28±17.4^{e}	0.98±0.53^{e}	1.36±0.87^{c}	35.01±21.6^{h}	33.80±30.4^{i}	13.55±8.4^{g}	11.65±7.3^{i}	19.8±12.6^{e}	14.82±9.7^{i}

	Chemical composition									
Storage periods	Soluble prot. (%)		Ash (%)		VFA (0.1 N mL NaOH/100 g ch.) (%)		Tyrosine (mg/100 g ch.) (%)		Tryptophane (mg/100 g ch.) (%)	
(days)	6	4	6	4	6	4	6	4	6	4
0.0	0.18±0.005^{h}	0.23±0.08^{g}	3.47±0.18^{d}	3.23±0.13^{e}	4.47±0.22^{h}	4.90±0.17^{h}	11.77±0.3^{i}	17.00±3.1^{i}	3.8±0.18^{h}	7.3±0.31^{gh}
60	0.31±0.06^{f}	0.45±0.11^{e}	3.95±0.71^{a}	3.29±0.56^{e}	9.62±4.9^{g}	12.2±6.9^{f}	63.58±25.3^{h}	118.68±44.2^{g}	12.22±7.01^{g}	23.48±10.6^{f}
120	0.55±0.08^{d}	0.66±0.06^{b}	3.86±0.47^{f}	2.88±0.37^{f}	15.58±9.95^{c}	21.93±18.2^{a}	122.2±0.0^{f}	183.1±79.2^{a}	26.59±13.2^{ef}	43.98±18.5^{d}
180	0.69±0.07^{a}	0.57±0.29^{d}	3.67±0.37^{c}	2.18±1.27^{i}	12.89±3.23^{e}	20.14±!13.50^{b}	167.4±25.3^{d}	154.9±119.2^{e}	59.91±34.7^{c}	55.27±47.3^{c}
240	0.60±0.38^{c}	0.60±0.38^{c}	266±1.64^{g}	2.38±1.6^{h}	9.59±6.2^{g}	14.01±8.4^{d}	179.2±116.6^{c}	181.96±128.6^{b}	113.34±70.9^{b}	121.65±74.1^{l}

Mean values bearing different superscripts within rows and columns are significantly different ($p<0.05$), TVBC = Total Viable Bacterial Count

Table 3: Effect of salt concentration on the microbiological quality during storage of Sudanese white cheese

Storage period days	Microbiological analysis											
	TVBC (cfu mL^{-1})		Coliforms		*E. coli* MPN		*Staph. aureus* count g^{-1}		Psychrotropptic count g^{-1}		Yeasts and mould counts g^{-1}	
	6% salt	4% salt	6% salt	4% salt	6% salt	4% salt	6% salt	4% salt	6% salt	4% salt	6% salt	4% salt
0.0	6.51± 0.3^{e}	8.53± 0.02^{a}	3.04± 0.0^{a}	5.04± 0.0^{a}	2.25± 0.14^{a}	2.25± 0.14^{a}	2.61± 0.4^{b}	3.44± 0.3^{a}	6.33± 0.1^{a}	6.37± 0.10^{a}	2.23± 0.03^{b}	2.97± 0.5^{a}
60	7.63± 0.32^{b}	7.48± 0.2^{c}	2.17± 0.17^{c}	2.25± 0.14^{c}	0.51± 0.92^{c}	0.98± 1.03^{b}	ND	ND	3.32± 3.5^{e}	3.23± 3.4^{d}	1.94± 2.1^{c}	1.23± 2.2^{e}
120	7.46± 0.72^{c}	6.03± 1.2^{f}	ND	0.49± 0.88^{d}	ND	0.32± 0.58^{d}	ND	ND	1.60± 2.9^{g}	2.44± 2.6^{e}	1.19± 2.2^{f}	1.29± 2.3
180	7.09± 0.5^{d}	5.83± 3.6^{h}	ND	0.28± 0.57^{e}	ND	ND	ND	ND	1.61± 2.92^{g}	3.43± 3.6^{b}	ND	1.14± 2.16^{g}
240	5.04± 3.1^{i}	5.93± 3.6^{g}	ND	ND	ND	ND	ND	ND	1.30± 2.4^{h}	1.81± 3.3^{f}	ND	1.74± 3.14^{d}

Mean values bearing different superscripts within rows and columns are significantly different ($p<0.05$); ND = Not detected; TVBC = Total Viable Bacterial Count

Table 4: Effect of salt concentration on sensory characteristics of Sudanese white cheese

Sensory characters	Salt level scores (%)	
	6	4
Colour	5.70±1.39^{a}	4.88±1.76^{b}
Flavour	5.00±1.56^{a}	4.69±1.77^{b}
Texture	5.65±1.68^{a}	5.16±1.91^{b}
Saltiness	5.25±1.60^{a}	2.73±1.60^{a}

Mean values bearing different superscripts within rows and columns are significantly different ($p< 0.05$)

samples with 6% salt were significantly ($p<0.05$) higher than those with 4% salt from day zero to day 240. Titratable acidity and soluble protein contents of cheese samples with 4% salt were significantly ($p<0.05$) higher than those with 6% salt from day zero to day 240. Similarly this result indicated that VFA, tyrosine and tryptophane contents of the cheese samples with 4% salt were significantly ($p<0.05$) higher than those with 6% salt from day zero to day 240.

Total bacterial count of the cheese with 4% salt was significantly ($p<0.05$) higher than those with 6% salt at the beginning of storage (day zero) as shown in Table 3. Moreover significant differences ($p<0.05$) were observed in the total bacterial counts throughout storage periods.

The cheese samples with 4% salt had higher coliforms count (5.04 log MPN g^{-1}) than that with 6% salt (3.04 log MPN mL^{-1}) at day zero and thereafter. The results show that *E. coli* counts of the cheese samples with both 4 and 6 at day zero were similar. At day 60 onwards *E. coli* counts of the two cheese samples decreased till day 120 then it was completely absent at days 180 and 240.

Staphylococcus aureus counts of the cheese with 4% salt was significantly ($p<0.05$) higher when compared with that of cheese with 6% salt at day zero.

The results indicated that psychrotrophic bacterial count in the cheese with 6% decreased during storage at slower rate than those of cheese with 4% salt. Yeast and moulds counts in the cheese with 4% salt were significantly ($p<0.05$) higher than those of cheese with 6% salt.

Texture and saltiness of the cheese with 6% salt were better than those of the cheese with 4% salt. The colour of the samples with 6% salt had higher scores at day 180 than those with 4% salt. The flavour scores of the cheese with 4% salt was high at day zero. However at day 240 all cheese samples decreased in flavour scores (Table 4).

DISCUSSION

Cheese samples with 6% salt had higher weight loss than those with 4% salt. These results were in agreement with Bilal (2000).

The low acidity of the samples with 6% salt was probably attributed to inactivation of lactic acid development because of high salt level. These findings concur with those of Hamid (1998).

This result indicated that crude protein contents increase with an increase in salt concentration. This could be attributed to low moisture content in the curd because of high salt concentration (Kosikowski, 1982). The high the brine concentration, the higher were the salt, fat and protein contents and lower was the moisture content (Madadlou *et al*., 2007). These results were not in accordance with those of Khalid and El Owni (1991). The increase in fat contents of the samples with 6% salt was possibly due to inhibition of lipolytic bacteria by high salt level.

Similar results were reported by El-Zayat *et al*. (1989) who found that soluble protein contents of cheese increased during storage at lower rate as sodium chloride increase.

Volatile fatty acids of the samples with 4% salt were significantly higher in comparison with those of 6% salt. The findings were consistent with those of El-Zayat *et al*. (1989). These results were in harmony with the findings of Kristiansen *et al*. (1999). The increase in tyrosine and tryptophane contents of the cheese with 4% salt was probably due to breakdown of proteins by proteolytic agents at low salt concentration (Hayaloglu *et al*., 2002). Similar findings were reported by Madadlou *et al*. (2007). The low protein contents of the cheese samples at later stages of storage could be due to degradation effect of proteolytic agents on proteins. This result agreed with the findings, which reported by Nuser (2001) and Warsama *et al*. (2006).

The increase in the values of titratable acidity was possibly attributed to increased activity of lactic acid-producing bacteria during storage (Litoploulou-Tzanetaki and Tzanetakis, 1992). However, the soluble proteins of cheese with 6% salt were likely due to inhibition of proteolytic agents by high salt level (Walstra *et al*., 1999). Similar results were cited by Hayaloglu *et al*. (2002).

The high TBC of the cheese samples with 4% salt could be due to high microbial contents of raw milk used for cheese making, while the low count in the cheese with 6% salt was possibly attributed to inactivation of microorganisms by high salt level (Walstra *et al*., 1999). These results were coincided with those reported by Aly and Galal (2002) who found that coliforms decreased as the storage period progressed. Similarly the high coliform counts in the cheese samples with 4% salt in comparison with those with 6% salt could be explained by the fact that high salt concentrations suppressed the growth of bacteria (Kosikowski, 1982). Moreover the presence of *E. coli* at early stages might be due to their multiplication in soft cheeses (Frank and Marth, 1978). However *Staphylococcus aureus* was absent at day 60 onwards. That was probably attribute to high acidity of the cheese samples in addition to their low initial numbers (Walstra *et al*., 1999).

The low count of psychrotrophic bacteria was possibly due to the effect of high salt concentration on their growth (Litopoulou-Tzanetaki and Tzanetakis, 1992). These findings were in accordance with those reported by Roostita and Fleet (1996). The highest yeasts and moulds in cheese with 4% could be due to increase level of lactic acids, which enhances their growth (Walstra *et al*., 1999).

The improvement in the texture and saltiness probably might be attributed to the effect of high level of salt on the proteolytic agents and moisture contents of the cheese (Fox, 1993). The lactic acid does not only contribute the taste of fresh cheese but it also helps cheese maintain its convenient body, structure and protects it against some kind of microbiological spoilage (Ceylan *et al*., 2003).The high flavour scores of the cheese with 4% salt at day zero might be due to increase action of lipolytic and proteolytic agents on the fat and protein degradation. At day 240 all cheese samples reduced in flavour scores which was probably attributed to the presence of bitter flavour compounds that resulted from further degradation of proteins (Hofi *et al*., 1976).

The present study concluded that the salt concentration and storage conditions were significantly ($p<0.05$) affected weight loss, chemical composition, microbial content and sensory characteristics of Sudanese white cheese.

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