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A STUDY ON WHEYLESS, SOFT CHEESE MANUFACTURE.

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ABSTRACT

The objective of this study was to compare between wheyless cheese and traditional soft cheese made from buffalo's milk. The chemical composition of cheese was also demonstrated as the ripening period progressed. Soft cheese made from standardized buffalo's milk (4.5% fat and TS 16%) was served as a control, whereas buffalo's skim milk, balm oil and increased total solids to 30% by adding skim milk powder (Treatment I) and milk protein concentrate (Treatment II) or 50%skim milk powder and 50% protein concentrate (Treatment III)were cared out. The results showed that treatment III had higher yield, salt, SN/TN and NPN/TN, content relative to the control, treatment I and treatment II. Ripening period in refrigerator storage decreased the acidity, SN/TN, NPN/TN, and TVFA compared with storage at room temperature. Recovery of TS had the values of 77.95,70.11,83.54 and 81.98% case of treatments control, I, II and III respectively. The corresponding values for fat recovery were 62.47,85.14,75.65and 72.11and for protein recovery were 75.95,74.89,77.98 and 79.59%respectively.Cheese in treatment III and II scored higher values for flavour compared to control and treatment I cheese. On the other hand, cheese in treatment III and II had a more compact body and smoother texture. In general, cheese made from fresh skim milk , palm oil and 50%skim milk powder and 50% protein concentrate achieved higher score in body and texture and flavour at the end of storage period in refrigerator or at room temperature.
Keywords: Soft cheese, Traditional, Imitation.

INTRODUCTION

Cheese analogues are being used increasingly due to their cost-effectiveness, attributable to the simplicity of their manufacture and the replacement of selected milk ingredients by cheaper vegetable products (Eymery & Pangborn, 1988). Cheese analogues extend the supply and lower the cost (Ahmed, et al 1995).Sales of cheese analogues are closely linked to developments in the convenience food sector (Anonymous, 1989). Unfortunately, lack of any detailed statistics makes it impossible to indicate what the total importance of cheese analogues on the world dairy market actually is (Anonymous, 1989). Development of cheese analogues involves the use of fat and/or protein sources other than those native to milk, together with a flavour system simulating as closely as possible that of the natural product. It is also necessary to develop a suitable processing regime capable of combining these ingredient to provide the required textural and functional properties. Cheese analogues may be regarded as engineered products (Shaw, 1984). Calcium caseinates are being widely used in the manufacture of cheese analogues. The water-soluble phosphate groups of the caseinate are located at one end of the protein, while the other end carries non-polar fat soluble groups. The so-called emulsifier salts operate as calcium-chelating

agents which improve the emulsifying properties of caseinate by increasing its hydrosolubility (Eymery & Pangborn, 1988). Functional properties of caseinates in imitation cheese systems have been investigated by Hokes (1982) and Hokes et al,.(1989). Vegetable proteins are used in partial or total replacement of caseinate like soybean or- peanut protein isolate (Ahmed et al., 1995; Anonymous, 1982; Chen et al., 1979; Guirguis et al., 1985). The use of vegetable fats can give the cheese a consistency that makes it more suitable for certain applications (Anonymous, 1989). Soybean fat conferred hardness and adhesiveness to the cheese analogues, but decreased their cohesiveness and springiness, while the opposite effect was due to soybean oil and butterfat (Lobato-Calleros et al., 1997). A cheese analogue is an oil-in-water emulsion, similar to natural cheese. Fat droplets are incorporated in a protein gel matrix which functions as an emulsifier (Eymery & Pangborn, 1988). The most important negative property of imitation cheese is its flavour, which cannot approach the flavour of real cheese (Anonymous, 1989). However, consumer panelists in one study were not able to distinguish readily between natural and imitation cheese as eaten on pizza (Lindsay, et al. 1980). Flavour systems are broadly used to increase the resemblance of the imitation cheese to their natural counterparts, some being artificial whereas others might be of natural origin such as the range of enzyme-modified cheeses (EMC) presently available (Shaw, 1984; Middleton, 1989).
In the preasent paper we investgate the different between composition and quality of cheese made from standrized buffalo's milk and the cheese analogues manufacture by using fresh skim bufalo's milk , vegetable fats, skim milk powder and protein concentrate.This was done on the fresh and stored cheese.

MATERIALS AND METHODS

Fresh buffalo's milk was obtained from the herd belonging to Mehalet Mossa from, Animal Prod. Res. Inst., Min.of Agric.

Skim milk powder (SMP)imported from USA was obtained from the local market. Palm oil (PO) imported from Malizea and milk protein concentrate (MPC) imported from USA were also purchased from the local market. The stabilizer imported from Malizea, whereas liquid animal rennet, sodium chloride and calcium chloride were obtained from the local market.

The control soft cheese was made from buffalo's milk standardized to contain 4.5% fat and 16% TS, whereas the experimental samples were manufactured using fresh skim milk of different treatments as follows:-

In treatment (I), SMP was used to increase TS to 30%, whereas in treatment (II) MPC was used in this respect to increase the TS to the same level. In treatment (III), a mixture of SMP and MPC (1: 1) was used the same purpose.

In all treatments, PO was added at the rate of 19% (w/w), stabilizer was added at 3% whereas, sodium chloride was added at 2%. Such additions were done at 50°C with continuous stirring for homogenization using mechanical stirring at3500 rpm, whereas heat treatment of 72°C for few

seconds was applied for the control and the thee treated mixtures. Calcium chloride was added before renneting at the levels of 0.02% for the control and 1% (w/w) for the prepared mixtures. This was done before renneting at 40°C.

The method of Fahmi and Sharrara (1950) was followed for making the control soft cheese, whereas the prepared mixtures of different treatments were packed in plastic containers and kept at 40°C for coagulation.

All resultant cheese samples were analyzed during storage in refrigerator or at room temperature.

Chemical analysis:-

Milk samples were analyzed for titratable acidity (TA), total solids (TS), fat and total protein contents according to Ling (1963).Fat and oil in soft cheese were determined as given by Ling (1963) and Hefnawy (1988). The pH values were determined using a pH meter type SA 710. The curd tension was determined using the method of chandrasekhara et al. (1957)whereas curd syneresis was done given by Mehanna and Mehanna (1989). The rennet coagulation time (RCT) was determined according to Drake and Swanson (1995). Whereas, all cheese samples were chemically examined for pH using pH meter type SA 710 and titratable acidity (TA). Cheese was also analyzed for total nitrogen (TN), soluble nitrogen (SN), non protein nitrogen (NPN) and ash contents according to Ling (1963). Salt content of cheese was estimated using Volhard method according to Richaredson (1985). Total volatile fatty acids (TVFA) was determined as described by Kosikowski (1978) and expressed as ml of 0.1N NaOH 100g cheese.

Organoleptic examination:-

The cheese samples were organoleptically scored using score card for flavour (50 points), body and texture (35 points) and appearance & colour 15 points). This was done by the trained staff of Sakh Animal Production Research Station as given by Nelson and Trout (1981) and Hassan et al. (1983).

Statistical analysis:-

The obtained data were statistically analyzed for analysis of variance average and Duncan's test according to SPSS computer program (SPSS, 1998).

RESULTS AND DISCUSSION

Chemical composition of milk used in soft cheese manufacture. As shown in Table (1) Titratable acidity, TS, Fat and total protein contents of fresh buffalo's milk were lowere in the control, whereas pH values were slightly higher than those of treatment I ,II and III. highly increased of total protein content in the mixtures was found as a result of adding skim milk powder and protein concentrate to skim buffalo's milk.

Table (1): Acidity, pH and chemical composition of buffalo's milk used in control cheese manufacture as well as the prepared mixture used for different treatments*

Property	Control	I	II	III
Acidity%	0.16±0.066c	0.17±0.078b	0.18±0.074a	0.17±0.085b
pH	6.68±0.045a	6.66±0.025b	6.65±0.065c	6.66±0.065b
T.S %	16±0.048b	30±0.098a	30±0.085a	30±0.048a
Fat %	4.5±0.058b	19±0.069a	19±0.054a	19±0.085a
TP %	4.8±0.069b	15.00±0.085a	15.20±0.014a	15.40±0.058a

*** Means within the same row (a, b and c) with different superscripts differed significantly (P< 0.05).**

The average rennet coagulation time (RCT) of treatments I and control were higher than that of other treatments (Table 2). Also, the highest curd tension values (45.60gm) was found with treatment III whereas, the lowest value was in a control (40.50gm).

Results in Table (2) show that the higher curd tension was in control compared with all treatments but the lowest values were recorded in treatment III. The higher curd tension values were obtained with a treatment III .Cured syneresis was the highest at any given syneresis time in the control, whereas syneresis significantly decreased in treatments I, II and III. Such differences were statistically significant.

Table(2): Rennet coagulation time (RCT), curd tension and curd syneresis of the control milk and the prepared mixtures used in cheese manufacture.

Treatments	RCT (sec.)	Curd Tension (gm)	Curd Syneresis (gm/15gm of curd) after			
			10(min.)	30(min.)	60(min.)	90(min.)
Control	325± 0.014a	40.50± 0.045d	3.90± 0.047a	5.20± 0.047a	7.10± 0.098a	7.80± 0.047a
I	210± 0.087b	42.20± 0.046c	1.30± 0.058b	2.00± 0.049b	2.48± 0.045b	2.48± 0.025b
II	198± 0.054c	44.10± 0.058b	1.12± 0.014c	1.94± 0.025c	2.20± 0.056c	2.25± 0.058c
III	186± 0.087d	45.60± 0.078a	1.10± 0.054d	1.76± 0.063d	1.98± 0.058d	2.10± 0.048d

*** RCT: Rennet Clotting Time.**

*** Means within the same column (a, b and c) with different milk differed significantly (P< 0.05).**

Yield of cheese is one of the most important economic parameter which is searched by processes. From Table (3), we found that adding skim milk powder and protein concentrate to buffalo's milk significantly increased the yield values of soft cheese compared with those of control.

The highest yield was recorded for the cheese made from buffalo's skim milk with added skim milk powder and protein concentrate compared to control, treatment I and treatment II.

The highest fat recovery was noticed in treatment I (85.14%), compared with control, treatment II and III (62.47, 70.65 and 72.11% respectively). Values of RP were the minimum (74.89%) in treatment I, whereas the maximum (79.59%) for treatment III.

Table (3): Effect of different treatments on the fresh cheese yield (%) and recoveries (%) of total solids (RTS), Fat (RF) and Protein (RP).

Treatments	Yield	RTS	RF	RP
Control	20.18±0.028d	77.95±0.039c	62.47±0.045d	75.59±0.058c
I	21.56±0.058c	70.11±0.087d	85.14±0.047a	74.89±0.058d
II	22.27±0.058b	83.54±0.047a	70.65±0.098c	77.98±0.058b
III	23.78±0.045a	81.98±0.089b	72.11±0.095b	79.59±0.087a

*** Means within the same Colum (a, b and c) with different milk differed significantly (P< 0.05).**

Such trend of results refracts variation in protein content in the milk used as well as technological properties of such milk which also affect RP.

The available data from the literature revealed that RP had the values of 95 and 96% in soft cheese made from 5% salted normal and high fat cow's milk respectively (Dariani et al., 1980).

During cheese ripening, in refrigerator or at room temperature the titratable acidity increased significantly ($P \leq 0.05$) while pH values decreased significantly ($P \leq 0.05$) in all treatments of cheese (Table 4).This may be attributed to growth of lactic acid bacteria which produce lactic acid. Nearly similar finding was obtained by Marth and Steele (2001). Domiati cheese had the same trends of acidity during the storage period. The increase obtained in acidity may be also due to the moisture evaporation. Kebary et al., (2006) stated that moisture content of Domiati cheese decreased significantly while fat values increased significantly as pickling period proceeds. This may be due to the contraction of curd as a result of developed acidity during pickling period, which helps to expel the whey from the curd. Table (4) shows an increase in TN during pickling. This may be du to the corresponding decrease in moisture content. Kebary et al., (2006) found that the TN contents of Domiati cheese decreased as pickling period proceeds. This was explained through their data as a result of the degradation of proteins into SN compounds and subsequently the loss of some SN from the degraded proteins in pickling solution. The salt content was significantly ($P < 0.05$) affected by treatments and storage period in refrigerator and at room temperature in control. The ash content was significantly ($P < 0.05$) increased by storage in refrigerator and at room temperature and all treatments. The ash content increased with the advancement of storage period and this result is in agreement with the findings of EL-Owin andHamid (2008) who reported increasing ash content during storage period. The increasing in ash content could be attributed to decrease in moisture (Abdalla and Abdel Razig.1997).

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The NPN/TN was significantly higher in fresh refrigerator cheese of treatment III (0.746%),whereas those from control, treatment (I) and (II) (0.737,0.739 and 0.742%) were insignificantly different. At room temperature cheese, the values were 0.737, 0.739,742 and 0.746% in case of control and treatments I, II and III respectively with significant differences while treatment (III) cheese had the highest content. The NPN/TN content gradually increased with nearly the same rate in all samples with the prolongation of the ripening period.

Table(5)reveals the proteolysis indices expressed as SN/TN and NPN/TN. The values of SN/TN gradually increased on ripening cheese from control and all treatments such increase was significant.

The differences in TVFA, shown in Table (5)due to the treatments were significant in fresh cheese. However, in control cheese, the TVFA had the highest corresponding average values of 6.66 ml 0.1N NaOH/100g in fresh cheese. Whereas, the lower average value was treatment I, being 5.22 ± 0.096 in fresh cheese. TVFA content gradually increased with nearly the same rate in all samples with the prolongation of the ripening period.

Role of adequate lipolysis and proteolysis in improving quality of soft cheese was previously inclusion in some recent studies (Bilal, 2000 and Hayaloglou et al., 2005).This was more obvious in the present study since value of TVFA, SN/TN and NPN/TN were greatly correlated with the sensorial properties of the cheese.

Table (5): Some ripening indices during storage of cheese at different temperatures.

Storage at	Storage period(days)											
	Fresh				15				30			
	Control	I	II	III	Control	I	II	III	Contro	I	II	III
Refrigerator temperature												
NPN/TN (%)	0.737± 0.005d	0.739± 0.007c	0.742± 0.009b	0.746± 0.004a	0.786± 0.006d	0.796± 0.007c	0.812± 0.004b	0.818± 0.001a	0.802± 0.002d	0.814± 0.006c	0.836± 0.003b	0.848± 0.004a
SN/TN (%)	7.46± 0.121d	10.22± 0.142c	10.68± 0.135b	10.98± 0.125a	7.80± 0.142d	10.64± 0.135c	11.22± 0.145b	11.38± 0.165a	8.20± 0.156d	11.32± 0.178c	11.68± 0.189b	11.92± 0.187a
TVFA	6.66± 0.114a	5.22± 0.141d	5.32± 0.124c	5.46± 0.158b	10.22± 0.198a	9.20± 0.154d	9.42± 0.154c	9.62± 0.189b	12.68± 0.185a	11.40± 0.147d	11.62± 0.165c	11.82± 0.185b
Room temperature												
NPN/TN (%)	0.737± 0.004d	0.739± 0.001c	0.742± 0.002b	0.746± 0.004a	0.820± 0.003d	0.822± 0.005c	0.836± 0.004b	0.842± 0.006a	0.866± 0.008d	0.876± 0.004c	0.880± 0.007b	0.898± 0.008a
SN/TN (%)	7.46± 0.154d	10.62± 0.147c	10.98± 0.198b	11.18± 0.187a	8.98± 0.178d	11.42± 0.189c	11.96± 0.185b	12.22± 0.158a	10.22± 0.174d	12.40± 0.198c	12.80± 0.124b	13.08± 0.158a
TVFA	6.66± 0.112a	6.22± 0.142d	6.32± 0.123c	6.46± 0.135b	12.10± 0.145a	10.40± 0.175d	10.60± 0.189c	10.80± 0.178b	14.20± 0.165a	12.20± 0.154d	12.42± 0.125c	12.92± 0.145b

*** Means within the same row (a, b and c) with different cheese differed significantly (P< 0.05).**

*** TVFA expressed as ml 0.1- N NaOH/100g of cheese.**

The organoleptic evaluation, shown in Table (6) revealed that as ripening advanced, the flavour, body&texture and colour and appearance of cheese were improved. This was true in the control cheese and cheese from all treatments.

In fresh cheese and after 15 days of storage period, cheese from treatments III higher scores as a compared to other treatments in refrigerator.

Table (6): Organoleptic evaluation of cheese from different treatments as affected by storage period in refrigerator temperature.

Treatments	Storage period (days)	Flavour (50)	Body& Texture (35)	Appearance and Colour (15)	Total score (100)
Control	Fresh	38±0.123c	27±0.112c	10±0.104c	75±0.125c
	15	40±0.124b	28±0.105b	11±0.112b	79±0.145b
	30	42±0.147a	29±0.114a	12±0.036a	83±0.159a
I	Fresh	40±0.158c	28±0.125c	10±0.119c	78±0.178c
	15	42±0.159b	30±0.145b	12±0.014b	84±0.174b
	30	44±0.187a	32±0.142a	13±0.104a	89±0.195a
II	Fresh	40±0.147c	29±0.147c	11±0.107c	80±0.154c
	15	44±0.159b	30±0.123b	12±0.014b	86±0.169b
	30	45±0.198a	32±0.158a	13±0.118a	90±0.147a
III	Fresh	42±0.187c	30±0.145c	12±0.032c	84±0.159c
	15	46±0.195b	32±0.187b	13±0.025b	91±0.152b
	30	47±0.185a	34±0.189a	14±0.019a	95±0.178a

*** Means within the same Colum (a, b and c) with different age of cheese differed significantly (P< 0.05).**

The organoleptic evaluation, shown in Table (7) revealed also that as ripening advanced, the flavour, body&texture and colour and appearance of cheese were improved. In fresh cheese and after 15 days of storage period, cheese from treatments III higher scores as a compared to other treatments storage period at room temperature. This also was previously noticed when storage was done in refrigerator.

Table (7): Organoleptic evaluation of cheese from different treatments as affected by storage period at room temperature.

Treatments	Storage period (days)	Flavour (50)	Body& Texture (35)	Appearance and Colour (15)	Total score (100)
Control	Fresh	36 ±0.154c	26±0.122c	10±0.102c	72±0.258c
	15	39±0.145b	28±0.142b	11±0.103b	78±0.365b
	30	41±0.187a	30±0.132a	12±0.112a	83±0.747a
I	Fresh	38±0.198c	27±0.112c	10±0.122c	75±0.258c
	15	40±0.152b	29±0.114b	12±0.114b	81±0.654b
	30	42±0.145a	31±0.174a	13±0.121a	86±0.547a
II	Fresh	39±0.169c	28±0.125c	11±0.211c	78±0.484c
	15	42±0.158b	30±0.154b	12±0.235b	84±0.369b
	30	44±0.187a	31±0.142a	13±0.214a	88±0.541a
III	Fresh	40±0.147c	30±0.145c	12±0.314c	82±0.365c
	15	43±0.156b	32±0.136b	13±0.124b	88±0.258b
	30	45±0.158a	34±0.156a	14±0.235a	93±0.487a

*** Means within the same Colum (a, b and c) with different age of cheese differed significantly (P< 0.05).**

CONCLUSION

The results of this research showed the positive effect of adding skim milk powder and protein concentrate on the taste, rheological, and Physicochemical properties of cheese. Adding skim milk powder alone or with protein concentrate in combination increased dry matter content in the cheese samples. On the other hand, cheese from treatment III and II had a more compact body and smoother texture. In general, cheese made using 50%protein concentrate and 50% skim milk powder achieved higher score in body and texture and flavour compared to cheese made from buffalo's milk.

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دراسة على تصنيع الجبن الطري منخفض الشرش

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الهدف من هذه الدراسة هو مقارنة بين الجبن منخفض الشرش والجبن الطري التقليدية المصنوع من اللبن الجاموس. مع تحليل التركيب الكيميائي للجبن طازجا وكذلك أثناء فترة التسوية. وقد كان الجبن الطري المصنوع من اللبن الجاموس ٤.٥٪ دهن و١٦%جوامد الصلبة (كنترول)، في حين أن اللبن الجاموس الخالي من الدسم، زيت النخيل وزيادة نسبة الجوامد الصلبة إلى ٣٠٪ وذلك بإضافة اللبن الفرز المجفف (المعاملة الأولى) وتركيز بروتين اللبن المركز (المعاملة الثانية) أو ٥٠٪ اللبن الفرز المجفف و ٥٠٪ بروتين اللبن المركز (المعاملة الثالثة).و أظهرت النتائج أن المعاملة الثالثة كانت أعلى تصافى، ونسبة الملح،و نسبة النتروجين الذائب على النتروجين الكلى وكذلك نسبة النتروجين الغير بروتيني على النتروجين الكلى ،ياتى بعدها الكنترول ثم المعاملة الأولى والثانية. أثناء فترة التخزين في الثلاجة انخفضت الحموضة، و نسبة النتروجين الذائب على النتروجين الكلى وكذلك نسبة النتروجين الغير بروتيني على النتروجين الكلى والأحماض الذهنية الطيارة وذلك مقارنة مع التخزين في درجة حرارة الغرفة. بينما كانت نسبة الاسترجاع للجوا مد الصلبة هي ٧٧.٩٥، ٥٤.٨٣،١١.٧٠و٨١،٩٨٪ من الكنترول ثم المعاملة الأولى والثانية و الثالثة على التوالي. وكانت نسبة الاسترجاع للدهن هي ٦٥.٧٠،١٤.٨٥،٤٧.٦٢و١١.٧٢ وكانت نسبة الاسترجاع للبروتين٥٩.٧٥ ،٩٨.٧٧،٨٩.٧٤و٥٩،٧٩٪ للجبن على التوالي.و من ناحية اخرى كانت درجات التحكيم الحسى للنكهة اعلى في المعاملة الثانية و المعاملة الثالثة مقارنة بالنسبة للكنترول و المعاملة الأولى. كان الجبن في المعاملة الثانية و المعاملة الثالثة التركيب أكثر إحكاما والملمس ناعم. بشكل عام فان الجبن المصنوع من اللبن الجاموسى الطازج الخالي من الدسم، وزيت النخيل و٥٠٪ مسحوق البن الفرز المجفف و ٥٠٪ بروتين اللبن المركز قد اعطت أعلى درجات من التحكيم الحسى في التركيب والملمس والنكهة في نهاية فترة التخزين في الثلاجة أو على درجة حرارة الغرفة.

Table (4): Acidity, pH and chemical composition of cheese from different treatments as affected by storage time and storage temperature.

Storage at	Storage period (days)											
	Fresh				15				30			
	Control	I	II	III	Control	I	II	III	Control	I	II	III
Refrigerator temperature												
TA %	0.15± 0.021d	0.18± 0.011c	0.20± 0.020b	0.22± 0.014a	0.69± 0.013d	0.89± 0.015c	0.96± 0.017b	0.98± 0.016a	1.12± 0.014d	1.32± 0.019c	1.36± 0.015b	1.38± 0.018a
pH	6.50± 0.027a	6.46± 0.018b	6.42± 0.025c	6.40± 0.021d	6.10± 0.022a	5.96± 0.014b	5.94± 0.018c	5.90± 0.014d	5.70± 0.021a	5.46± 0.022b	5.40± 0.023c	5.30± 0.032d
Fat %	18.2± 0.12 c	19.1± 0.13 a	19.0± 0.14 b	19.1± 0.01 a	18.5± 0.02 c	19.1± 0.12	19.2± 0.12 b	19.4± 0.13 a	18.7± 0.02 c	19.5± 0.12 a	19.3± 0.14 b	19.5± 0.12 a
Moisture%	60.12± 0.028a	58.52± 0.024b	56.85± 0.028c	52.68± 0.029d	56.61± 0.032a	56.62± 0.027b	54.24± 0.032c	51.10± 0.029d	55.81± 0.032a	53.81± 0.033b	51.62± 0.039c	50.60± 0.045d
TN%	2.43± 0.045a	2.35± 0.047b	2.30± 0.049c	2.30± 0.34c	2.68± 0.038a	2.56± 0.058b	2.50± 0.047c	2.52± 0.048c	2.77± 0.078a	2.75± 0.045b	2.70± 0.058c	2.70± 0.054c
Salt%	3.96± 0.029b	4.01± 0.058b	4.08± 0.045a	4.10± 0.056a	4.22± 0.58c	4.27± 0.047b	4.30± 0.046a	4.32± 0.058a	4.35± 0.048d	4.40± 0.098c	4.44± 0.058b	4.48± 0.085a
Ash%	5.50± 0.059c	5.52± 0.058c	5.55± 0.089b	5.62± 0.056a	5.55± 0.078c	5.57± 0.70c	5.60± 0.025b	5.65± 0.048a	5.58± 0.065c	5.60± 0.058c	5.68± 0.045b	5.71± 0.025a
Room temperature												
TA %	0.15± 0.012d	0.19± 0.024c	0.22± 0.022b	0.24± 0.021a	1.34± 0.023d	1.46± 0.014c	1.66± 0.025b	1.70± 0.033a	1.86± 0.045d	2.02± 0.013c	2.16± 0.025b	2.20± 0.026a
pH	6.55± 0.029a	6.44± 0.065b	6.40± 0.025c	5.96± 0.065d	5.44± 0.045a	5.26± 0.047b	5.14± 0.032c	5.10± 0.025d	5.00± 0.065a	4.90± 0.036b	4.82± 0.047c	4.80± 0.56d
Fat%	17.8± 0.01 c	19.0± 0.14 b	19.1± 0.13 b	19.2± 0.12 a	18.0± 0.01 c	19.2± 0.10 b	19.3± 0.01 a	19.2± 0.12 b	18.2± 0.13 c	19.4± 0.11 a	19.3± 0.14 b	19.4± 0.21 a
Moisture%	60.12± 0.124a	58.54± 0.156b	56.88± 0.178c	52.70± 0.135d	54.46± 0.18 a	52.60± 0.14 b	50.22± 0.18 c	49.20± 0.12 c	52.60± 0.118a	49.50± 0.122b	48.20± 0.125b	47.60± 0.174c
TN%	2.46± 0.056a	2.38± 0.074b	2.32± 0.056c	2.32± 0.058c	2.98± 0.058a	2.84± 0.056b	2.82± 0.065c	2.80± 0.074c	3.10± 0.058a	3.05± 0.056b	3.00± 0.035c	3.00± 0.054c
Salt%	3.96± 0.098c	4.02± 0.087b	4.06± 0.058a	4.00± 0.078c	4.42± 0.058d	4.46± 0.089c	4.50± 0.065b	4.54± 0.078a	4.58± 0.085c	4.62± 0.065b	4.66± 0.057a	4.68± 0.045a
Ash%	5.50± 0.058d	5.52± 0.087c	5.55± 0.098b	5.62± 0.054a	5.54± 0.089d	5.60± 0.058c	5.64± 0.078b	5.68± 0.069a	5.65± 0.087c	5.16± 0.074d	5.72± 0.085b	5.78± 0.57a

*** Means within the same row (a, b and c) with different cheese differed significantly (P< 0.05).**