

Comparison of the Properties of Halloumi Cheese Made from Goat Milk, Cow Milk and Their Mixture

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THE PURPOSE of this study is to compare the physico-chemical, microbiological and rheological properties of among Halloumi cheese made from 100% goat's milk (T1), 50% cow's milk and 50% goat's milk (T2), 75% cow's milk and 25% goat's milk (T3) and 100% cow's milk (T4), during the storage period at 5°C in brine solution (12% sodium chloride). The goat cheese (T1) gave the highest value in the moisture content, the total volatile fatty acids (TVFA), the ash, the highest level of Halloumi cheese, and 50% cow's milk (T2) was the lowest. There were also insignificant differences ($p < 0.05$) in water soluble nitrogen (WSN) and fat / total solid, in the four treatments of cheese. T3 was the highest in fat ratio, non protein nitrogen (NPN), salt, total solid, salt / moisture content. Total number of bacteria for all fresh samples were significantly ($P < 0.05$). The coliform and *E. coli* bacteria were less than 30 (cfu/g) and were present in the four treatments of cheese. None of them showed *Staph. aureus* during the months of storage. The molds & yeasts were found in small numbers by 13 to 16 (cfu/g) in the Halloumi cheese (3 months). The rheological characteristics of the Halloumi cheese (T4) were less in consistent and the better taste comparing with the other treatments.

Keywords: Halloumi cheese, Goat's milk, Cow milk, Cheese evaluation, TVFA, Protein hydrolysis, Keeping quality.

Introduction

Halloumi is the traditional cheese of Cyprus; its unique characteristics as a product for raw consumption or cooking (primarily grilled or fried) have made it popular in the Middle East, European Union, Australia and USA. For many years, it has been produced locally from raw ovine milk or mixtures of raw ovine and caprine milk. A similar product under the same name in Syria and Lebanon is made as semi hard to hard cheese made mainly from sheep milk, goat milk, cow milk or a mixture of them in various ratios (Davies, 1970). The manufacture of Halloumi cheese has been described by Anifantakis and Kaminarides (1982).

Traditionally ovine and caprine milk, or a mixture of the two in various ratios, were used for the manufacture of Halloumi cheese, but nowadays the large dairies use bovine milk almost exclusively. This recent transition towards bovine milk has resulted from the low levels of production

of ovine and caprine milk, but it has had an impact on the sensory quality of the cheese.

During maturation, Halloumi cheese changes markedly in taste and texture and the cheese becomes hard, salty and moderately acidic. Although the microbiology and biochemistry of these changes are poorly understood, the sensory properties of mature Halloumi are much appreciated by connoisseurs. It is a semi-hard rindless cheese preserved in brine (Anifantakis and Kaminarides, 1984).

This fresh product has a characteristic aroma, its texture is elastic and compact with no holes and it is easily sliced. It is popular with consumers and large quantities of Halloumi are sold immediately after production. Halloumi cheese made from cow's milk is more yellowish in color and lacks the sensory characteristics of the Halloumi cheese that is made from sheep's milk (Kaminarides et al., 2000). The yeasts isolated from the commercial

samples of fresh and mature Halloumi cheeses did not have any adverse effects on the flavour or produce visible defects. A new lactobacillus strain has been isolated from mature Halloumi cheese made in Cyprus, which suggests that this organism is resistant to high salt concentrations and low pH (Lawson *et al.*, 2001).

Sharri cheese is traditionally produced from ovine, bovine and mixed milk and classified as a hard and /or semi hard cheese with high salt content. The results show significant decrease in all microbiological parameters starting from total viable count, psychrophile and total LAB by increasing the brine salinity during a processing until a final product. Cheese stored on 6% and 22°C had higher scores from the panelists. The results show that, controlling the raw milk quality in microbiological aspects before processing is necessary. At the same time for making Sharri cheese the recommended concentration of brine solution is 6-9% and 22°C of storage condition. By using this condition we will have under control total viable counts, no significant changes between raw milk and final product of LAB diversity and no negative effects in human health (Mergim Mestani, 2017).

The present study is to establish the relationships between the major constituents that influence the yield and composition of Halloumi cheese made from different milks. The major of milk production in Egypt was cows' milk, while the goat milk is not available and more expensive. So, the aim of this study was to compare the chemical, microbiological and sensory characteristics of Halloumi cheese made from goat milk, cow milk, and mixture of them, which were used for the manufacture of Halloumi cheese in Egypt.

Materials and Methods

Milk

Whole fresh goat's and cow's milk or mixtures of these milks were obtained from herds of Sakha Animal Production Research Station, Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture, Egypt.

Rennet

Standard liquid rennet was used in the manufacture of cheese in these stations.

Cheese making

Forty liters of fresh milk were used to make Halloumi cheese for all these treatments; 100% goat's milk (T1), 50% cow's milk and 50% goat's milk (T2), 75% cow's milk and 25% goat's milk (T3) and 100% cow's milk (T4). The coagulation milk by rennet at 35°C for 45 min after that the curd was cut to 1 cm³ then coagulum was precipitated for 10 min, the curd was pressed of 550 pa for 1hr, after that was cut into blocks (10×10×30 cm) and put the blocks in hot whey at 90°C-95°C for 1hr, then drained, cooled and dry salt at 3%w/w was added and sprinkled with dry peppermint leaves, in final storage the cheese was put in brine solution (12% NaCl) as described by Anifantakis and Kaminarides (1982).

Experimental planning and sampling

The resultants of Halloumi cheese samples were taken at 0, 1, 2 and 3 months to evaluate physico-chemical, microbiological and organoleptic properties. The sample from each treatment was divided into three portions as follows:

*The first was used for chemical analysis.

*The second was ground under sterilized conditions and immediately used for microbiological examinations.

*The third was used for the organoleptical and rheological properties.

Cheese yield

Cheese yield (fresh) = kg of cheese / kg of milk × 100.

Physicochemical analyses

Milk and cheese samples

The milk used for cheese making was weighed, and analyzed for fat, protein, lactose, solid not fat (SNF), and total solids (TS) by milko scan, model 133B. Also, analyzed Halloumi cheese samples as follows: total solid, total protein, non protein nitrogen (NPN), water soluble nitrogen (WSN), ash, fat, and titratable acidity were determined according to standard methods of A.O.A.C. (2000). The pH values were measured in milk and Halloumi cheese samples using pH meter (Hanna HI Instrument model 8021 Germany), while, total volatile fatty acids (TFVA) were determined as given by Kosikowski (1982).

Textural profile analysis

Textural profile of Halloumi cheese was measured at 23°C as described by Kosikowski (1982). Using an Instron Universal Tasting

Machin model 1195, StableMicro system. (SMS) LTD., Godalming, UK, loaded with Dimension software SMS program. Likewise, Penetration Microbiological Estimation

Total plate counts of bacteria, coliform, *E. coli*, *Staph. aureus*, and molds & yeasts were determined according to the method described by Houghtby et al. (1992).

Sensory Evaluation

The organoleptic properties of the resultant Halloumi cheese were assessed by a test panel of 10 persons according to the scheme described by Nelson and Trout (1981).

Statistical Analysis

Results were statistically analyzed by one way complete design to study the effect of treatment using SAS (2004). However, the significant differences among means were tested using Duncan's Multiple Range Test (Duncan, 1955).

Results and Discussion

Physio-chemical properties of the four treatments of milk

The physio-chemical properties of the all treatments of milk used for production of Halloumi cheese are given (Table 1). Goat milk (T1) had the highest content of total solids, fat, protein, ash, casein, and acidity, whereas (T4) cow milk had the lowest values of total solids, fat, protein, except for pH value and casein\ fat ratios were highest. Total solids, fat, SNF, ash and acidity were significant higher ($P < 0.05$) in T3 than in T2. The results in this study was agreed with those reported by Anifantakis and komimres (1982).

Cheese yield

The average cheese yield of the all treatments of Halloumi cheese are illustrated in Fig. 1 produced from T1, T2, T3 and T4 after 1 day (fresh) was 12.5, 11.0, 12.0, and 10.0%, respectively. The highest value of cheese yield from T1, T3, T4 and T2. The results can be attributed to differences in chemical composition of the milk used for making Halloumi cheese (Table 1).

TABLE 1. Physio-chemical properties of the four treatments of milk for production Halloumi cheese

Physicochemical	Treatment*			
	T1 *100Goat milk	T2 50Cow milk	T3 75Cow milk	T4 100Cow milk
Total solids (%)	12.2±0.05a	11.9±0.07b	11.7±0.02c	11.5±0.07d
Fat (%)	4.21±0.02a	4.03±0.06b	3.93±0.02c	3.8±0.04d
Total protein (%)	2.91±0.02a	2.65±0.05b	2.61±0.02b	2.58±0.03c
Casein (%)	2.32±0.02a	2.12±0.04b	2.12±0.02b	2.06±0.02c
Casein/fat (%)	52.85±0.41b	52.79±0.60b	54.07±0.34a	54.35±0.24a
Casein /protein (%)	80±0.14a	80.0±0.00a	79.9±0.08a	80.1±0.13a
S.N.F (%)	7.8±0.03b	7.9±0.01a	7.8±0.01b	7.7±0.01c
Lactose (%)	4.24±0.02b	4.41±0.02a	4.48±0.01a	4.41±0.05a
Ash (%)	0.84±0.01a	0.81±0.02b	0.68±0.02c	0.73±0.02d
pH	6.4±0.05c	6.6±0.05ab	6.5±0.01b	6.6±0.04a
Acidity, as lactic acid (%)	0.19±0.01a	0.18±0.01a	0.19±0.01b	0.18±0.01b

* T1:100% goat's milk. T2: 50% cow's milk with 50% goat's milk, T3: 75% cow's milk with 25% goat's milk. T4:100% cow's milk. ^{abcd} Letters indicate significant differences between Halloumi cheese treatments.

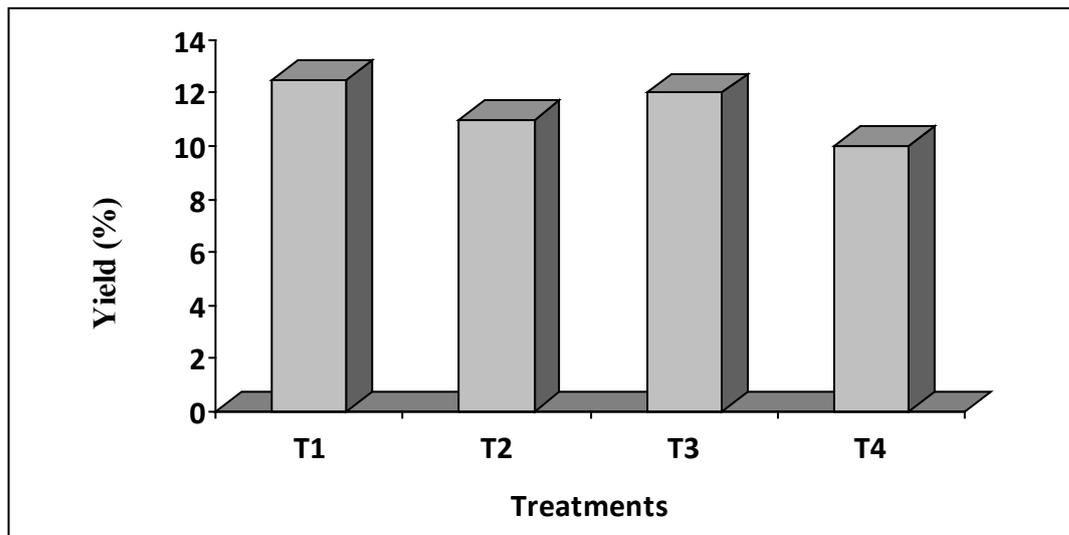


Fig. 1. The yield of Halloumi cheese made from four treatments of milk

Physio-chemical properties of cheese

The results of the chemical composition of all the experimental Halloumi cheese fresh and after 3 months are shown in Tables 2 and 3. Cheese from T1 and T4 had higher significant differences ($P < 0.05$) in moisture content than treatments 2 and 3, although, T3 was significantly lower ($P < 0.05$) as compared to T2, moisture content, pH, and ash, these results can be attributed to differences in chemical composition of the milk used for making Halloumi cheese (Table 1) the four treatments cheese did not show any significant differences ($P \leq 0.05$) in WSN content and Fat/DM. However, the effect of F/DM on meltability, which was important factor for Halloumi, was greatly modified by reducing the pH of the cheese according to findings of Panayiotou theophil and Andrew wilbey (2007

Treatment (T3) had a higher in fat, protein, NPN, salt, TS and salt in moisture this results is mainly attributed to the total protein of casein to fat present the highest moisture, and pH content was observed in cheese made from 100% cow milk (T4). The moisture contents of Halloumi cheese from all treatments were within the Egyptian Standards (1970) for semi-hard cheeses (40-50%). Also, the obtained results of the produced Halloumi cheese were in agreement with that obtained by Anifantakis and Kaminarides (1982). TVFA content were higher in cheese made from 100% goat milk (T1) at the period storage could be due to the high goat milk composition and increased fat content, the results

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in Tables 2 and 3 showed the highest fat, protein, fat / Dm, salt, moisture content after 3 months in all treatments, although, WSN was not significant in period storage and all treatments, the average values of salt was among of (2.75 – 4.56%) the difference in salt content of all treatments were mainly due to the variation in moisture content of Halloumi cheese, whereas the average value of salt was increased with period storage according to findings of Milci *et al.* (2005).

Microbiological analysis

The evaluation of bacteria counts when fresh and then after 3 months in Halloumi cheese samples are shown in Table 4. The total plate count of bacteria for all fresh samples is significantly ($P < 0.05$). Higher values were obtained for cheese made from raw goat milk than other treatments cheese, on the other hand the total count decreased until the end of cold storage period (3 months) were $4.3, 3.6, 3.1,$ and 3.1×10^3 (cfu/g) for cheese made from T1, T2, T3 and T4, respectively. These results were in agreement with Milci *et al.* (2005). They reported that, the total aerobic bacteria counts decreased during the storage. The observed decrease in bacteria growth could be due to the decrease in the amount of remaining sugar (lactose) in cheese and resulting in fewer nutrients for their growth promotion. Nezhad *et al.* (2013) and Mergim Mestani (2017) found a significant decrease in all microbiological parameters starting from total viable count, psychrophile and total LAB by increasing the brine salinity during a processing until a final product.

TABLE 2. Physio-chemical properties of Halloumi cheese made from different treatments of milk

Component	Storage (months) at 5°C	*Treatment				
		T1	T2	T3	T4	Mean± sd
Moisture %	Fresh	43.13±0.01	43.15±0.04	43.57±0.02	43.40±0.1	43.40±.01A
	1	42.49±0.01	42.26±0.02	41.98±0.01	42.43±0.01	42.3±.02B
	2	42.40±0.04	42.17±0.05	41.81±0.04	42.24±.03	42.29±.04C
	3	41.52±0.05	41.49±0.01	41.49±0.01	41.46±.01	41.49±.02D
	Mean± sd	42.38±.04a	42.26±.03b	41.33±.02c	42.38±.02a	
WSN %	Fresh	0.32±0.0	0.32±0.0	0.32±0.0	0.33±0.0	0.32C
	1	0.36±0.0	0.38±0.0	0.37±0.0	0.38±0.0	0.37C
	2	0.42±0.0	0.43±0.0	0.43±0.0	0.43±0.0	0.43B
	3	0.47±0.0	0.45±0.0	0.46±0.0	0.45±.0.0	0.46A
	Mean± sd	0.39±0.0	0.39a	0.39a	0.39a	
Salt %	Fresh	2.92±0.01	2.75±0.01	3.15±0.01	3.16±0.01	2.99D
	1	3.16±0.01	3.78±0.01	4.17±0.01	4.15±0.02	3.82C
	2	3.85±0.03	4.08±0.01	4.55±0.01	4.14±0.02	4.15B
	3	4.07±0.01	4.11±0.02	4.56±0.01	4.15±0.02	4.22A
	Mean± sd	3.50d	3.68c	4.11a	3.90b	
TS %	Fresh	56.87±.04	56.85±04	56.43±.03	56.66±.10	57.12±0.79D
	1	57.51±.03	57.75±04	58.05±.04	57.53±.05	57.72±0.04C
	2	57.6±.03	57.82±.05	58.19±.04	57.76±.03	57.84±0.04B
	3	58.48±.05	58.55±.04	58.55±.04	58.54±.04	58.53±0.04A
	Mean± sd	57.63±0.04c	57.74±0.04b	58.06±0.04a	57.62±0.05c	
pH	Fresh	6.05±0.01	6.02±0.05	6.06±0.01	6.08±0.01	6.05±0.02A
	1	5.45±0.01	5.55±0.02	5.55±0.01	5.58±0.01	5.53±0.01B
	2	5.457±0.01	5.46±0.01	5.53±0.01	5.55±0.01	5.50±0.01C
	3	5.39±0.05	5.43±0.01	5.52±0.01	5.53±0.01	5.47±0.02D
	Mean± sd	5.59±0.02d	5.66±0.02c	5.67±0.01b	5.69±0.01a	

*See Table 1. ^{abcd} Letters indicate significant differences between Halloumi cheese treatments and ^{ABCD} Letters indicate significant differences between storage periods of Halloumi cheese

Data presented in Table 4 showed that the total coliform and *E.coli* were detected in all samples in fresh cheese this might be due using raw milk without heat treatment, on the other hand, the total coliforms were not detected in all samples during the cold storage period. This may be due to increase the salt in cheese, storage in brine solution, and the role of lactic acid bacteria in preservation of the products and their metabolites on the growth coliforms. These results were in agreement with those of Panayiota theophil and Andrew wilbey (2007).

Data illustrated in Table 4 indicated that molds&yeasts were absent in all cheese when fresh and after 3 months during storage period. The molds&yeasts were detected in cheese during storage were 16, 14, 15 and 13 for the all treatments,

respectively, the yeast in Halloumi cheese did not have any adverse effects on the flavour. According to Lawson et al. (2001) who found that the yeasts isolated from the commercial samples of fresh and mature Halloumi cheeses did not have any adverse effects on the flavour or produce visible defects, has been isolated from mature Halloumi cheese made in Cyprus, which suggests that this organism is resistant to high salt concentrations and low pH.

The results in Table 4 showed that the *Staph. aureus* was not detected in all samples and also during period of storage. The decrease of microbial counts at the end of storage period could be due increasing the acidity during storage period. The bacteria growth has been isolated in high numbers from many traditional raw milk cheeses. The

TABLE 3. Physio-chemical properties of halloumi cheese made from different treatments of milk

Component	Storage (months)	*Treatment				
		T1	T2	T3	T4	Mean± sd
Fat %	Fresh	26.34±0.7	25.30±0.10	25.58±0.06	25.10±0.7	25.58C
	1	26.56±0.4	26.20±0.3	26.68±0.4	25.27±0.4	25.93B
	2	26.63±0.4	26.6±0.15	26.87±0.2	25.63±0.4	25.93B
	3	26.86±0.2	26.70±0.15	26.88±0.10	25.87±0.2	26.08 A
	Mean± sd main± sd sd	26.59a	26.2a	26.05a	25.47b	
Protein %	Fresh	19.25±0.02	19.01±0.03	19.21±0.04	18.95±0.04	19.11D
	1	19.42±0.02	19.22±0.03	19.45±0.03	19.18±0.04	19.32C
	2	19.45±0.02	19.31±0.03	19.42±0.04	19.21±0.05	19.35B
	3	19.48±0.03	19.22±0.25	19.59±0.04	19.28±0.03	19.39A
	Mean± sd sd	19.40a	19.19b	19.42a	19.15b	
NPN% (NPN×6.38)	Fresh	0.32±0.001	0.320.001	0.38±0.001	0.38±0.001	0.34D
	1	0.77±0.001	0.83±0.001	0.77±0.001	0.77±0.001	0.78C
	2	0.83±0.001	0.83±0.001	0.89±0.001	0.89±0.001	0.86B
	3	0.83±0.001	0.83±0.001	1.02±0.03	0.89±0.001	0.88A
	Mean± sd sd	0.70b	0.70b	0.77a	0.73ab	
Fat/DM%	Fresh	46.32±1.16	44.79±0.19	45.33±0.69	44.30±0.79	45.44±0.18A A
	1	46.18±0.71	45.37±0.54	45.96±0.59	43.92±0.59	44.92±0.18B
	2	46.23±0.68	46.00±0.29	46.18±0.24	44.44±.03	44.79±0.18C
	3	45.93±1.51	45.60±0.25	45.91±0.17	44.19±0.47	44.55±0.18D
	Mean± sd sd	46.14±1.1a	45.44±1.1a	45.84±1.2a	44.21±1.3b	
Salt/moisture%	Fresh	6.77±0.02	6.47±0.03	7.40±0.04	7.17±0.02	6.95±0.03D
	1	7.44±0.03	8.94±0.02	9.93±0.03	9.78±0.02	10.46±0.03C
	2	9.08±0.03	9.68±0.03	10.88±0.04	9.80±0.02	11.05±0.03B
	3	9.80±0.02	9.76±0.04	10.99±0.04	10.00±0.02	11.24±0.03A
	Mean± sd sd	8.27±0.03d	8.72±0.03c	9.80±0.04a	9.18±.02b	
Ash%	Fresh	5.49±0.02	5.59±0.02	5.15±0.04	5.58±0.05	4.94±0.04D
	1	5.88±0.01	5.15±0.04	5.52±0.06	5.26±0.03	5.45±0.04C
	2	6.12±0.04	5.88±±0.03	6.25±0.01	6.19±0.02	6.16±0.03B
	3	6.65±0.02	6.54±0.02	6.59±0.05	6.42±0.07	6.58±0.04A
	Mean± sd sd	6.04±0.02a	5.53±0.02d	5.88±0.04b	5.86±0.04c	
TVFA (0.01N NaOH)	Fresh	6.68±0.03	3.49±0.05	4.55±0.04	4.35±0.04	5.02±0.04D
	1	7.64±0.05	6.50±0.04	7.63±0.04	6.95±0.04	7.18±0.05C
	2	12.19±0.07	10.64±0.05	10.62±0.03	10.20±0.05	10.91±0.05B
	3	14.68±0.03	12.85±0.04	12.52±0.04	12.85±0.04	13.23±0.04A
	Mean± sd sd	10.30±0.02a	8.37±0.05d	9.08±0.04b	8.59±0.04c	

*See Table 1. ^{abcd} Letters indicate significant differences between Halloumi cheese treatments and ^{ABCD} Letters indicate significant differences between storage periods of Halloumi cheese

increase in salt content during maturation was related to the salt in the brine solution, these results are in agreement with Photis and Richard (2000).

Rheological properties of cheese

The results of rheological examination are presented in Table 5. The data showed that the hardness of cheese is described as the force required to penetrate the sample with the molar teeth (from soft to firm) (Lee et al., 1978). The cohesiveness, gumminess of cheese made from 100% cow milk (T4) were significantly ($P < 0.05$) lower than in other cheese may be due mainly to the lower fat and TS content (Table 1). The hardness and elasticity were lower during storage period; the fresh was 5.75, after three months was 5.33 but the gumminess and cohesiveness

were increased with the storage period. Cheese made from (T1) 100% goat milk was softer and showed significant higher value, the cheese made from (T2) 50% cow milk exhibited a higher elasticity than others may be related to increase the ash content and TVFA content in cheese which influenced cheese elasticity in the different treatments of milk. Awad et al. (2002) reported that the difference among the cohesiveness values of cheese samples was originated from the difference in manufacturing technique and the raw material used. On the other hand, it was known that the storage time and the ripening period affected the cohesiveness value of cheese.

TABLE 4. Microbiological enumeration of Halloumi cheese made from different treatments of milk

Microbiological enumeration (cfu/g)	Storage (months)	*Treatment			
		T1	T2	T3	T4
Total bacterial	Fresh	6.5×10^3	4.4×10^3	3.5×10^3	3.8×10^3
	3	4.3×10^3	3.6×10^3	3.1×10^3	3.1×10^3
Coliform	Fresh	30	30	20	20
	3	ND	ND	ND	ND
molds & yeasts	Fresh	ND	ND	ND	ND
	3	16	14	15	13
E.coli	Fresh	20	20	15	15
	3	ND	ND	ND	ND
<i>Staph. aureus</i>	Fresh	ND	ND	ND	ND
	3	ND	ND	ND	ND

*See Table 1.

TABLE 5. Rheological properties of halloumi cheese made from different treatments of milk

Rheological properties	Storage (months)	*Treatment				Mean± sd
		T1	T2	T3	T4	
Hardness (kg)	Fresh	6.46±0.07	5.91±0.07	5.55±0.07	5.09±0.07	5.75A
	3	5.58±0.07	5.36±0.07	5.29±0.07	5.14±0.07	5.33B
	Mean± sd	6.02a	5.61b	5.42c	5.11d	
Elasticity (mm)	Fresh	6.45±0.02	7.90±0.02	7.12±0.02	6.98±0.02	7.61A
	3	6.19±0.02	7.42±0.02	7.14±0.02	6.89±0.02	6.89B
	Mean± sd	6.32d	7.46a	7.13b	6.91c	
Cohesiveness (kg × mm)	Fresh	0.23±0.01	0.21±0.01	0.17±0.01	0.15±0.02	0.19B
	3	0.26±0.01	0.23±0.01	0.18±0.01	0.17±0.02	0.21A
	Mean± sd	0.24a	0.22b	0.18c	0.16d	
Gumminess (kg)	Fresh	1.48±0.02	1.60±0.02	1.62±0.02	1.45±0.02	1.54A
	3	1.38±0.02	1.6±0.02	1.67±0.02	1.33±0.02	1.49B
	Mean± sd	1.43c	1.6b	1.64a	1.38d	
Chewiness (kg × mm)	Fresh	9.43±0.04	10.52±0.04	11.53±0.04	10.26±0.04	10.37B
	3	9.88±0.04	10.65±0.04	11.64±0.04	10.50±0.04	10.60A
	Mean± sd	9.66d	10.59b	11.44a	10.38c	

*See Table (1). ^{abcd} Letters indicate significant differences between Halloumi cheese treatments and ^{ABCD} Letters indicate significant differences between storage periods of Halloumi cheese

The rheological role of casein in cheese is to provide a continuous elastic framework for individual cheese granules. Cheese made from (T3) 75% cow milk had a significantly ($P<0.05$) greater gumminess and chewiness than the other cheese, the gumminess is the product of hardness, cohesiveness and chewiness of cheese made from (T3) was less hard but more cohesive than others, these results were in agreement with Kaminarides *et al.* (2000), Awad (2011) described the chewiness to be number of chews required to swallow a certain amount of sample. This property expressed mathematically as the product of gumminess; the same trend of those property include those factors that affect the curd moisture content (as temperature of coagulation and drain whey), cheese composition, pH, casein and serum protein, Ca content, salt, fat and manufacturing of cheese for its many desirable functional and texture. In addition, increasing the moisture content might result in an increase in the level of free moisture in cheese, this increased the hardness.

Organoleptical properties

Results given in Table 6 showed the organoleptical evaluation of Halloumi cheese made in the four treatments. The total organoleptical of T4 and T3 were significantly

Egypt. J. Sus. Agric. Sci. **43**, No.2 (2017)

higher ($P<0.05$) than T2, while T1 did not differ significantly within T2. The flavor in T4 was significant ($p<0.05$) higher T2, but no significant difference with T1 and T3, these results are in agreement with Anifantakis and Kaminarides (1984).

The flavor score value of all treatments of Halloumi cheese was gradually increased with the storage period progressed. The Halloumi cheese made from T4 recorded the highest score of flavor (86.91) followed T3 (83.56), T1 (83.17), and T2 (80.25). While, score texture and appearance in the all treatments cheese and at the progressed storage period not significant differences. It has been determined that Halloumi cheese can be stored successfully for 3 months (90 days) at 5°C.

These results are in harmony with Stelios *et al.* (2015) who studied the propose Halloumi cheese curd cooking at 93–95 C for 30 min as it not only reduces cheese making time and higher sensory scores for the end product cheese.

Conclusion

The results of the present study for manufactured Halloumi cheese from different types of milk showed that Halloumi cheese from (T3) are higher in fat, NPN, salt, TS, and salt in

moisture, and less hard but more cohesive than others. The assessment panel preference was for Halloumi cheese made from T4 and T3. Raw goat milk (T1) gave higher moisture content, TVFA, and ash and had the highest yield of Halloumi cheese but T2 was the lowest. Non significant differences in WSN content and fat/Dm content

for all treatments. Total coliform and *E. coli* were detected in all samples in fresh cheese and the total coliform and *E. coli Staph. aureus* were not detected during the storage period, but the molds & yeasts were detected during storage which were 16,14,15 and 13 for all treatments (T1, T2, T3 and T4, respectively). It is recommended to produce Halloumi cheese in Egypt from cow milk (T4) obtained high score in organoleptic properties.

TABLE 6. Organoleptic evaluation of halloumi cheese made from different treatments of milk

Organoleptic evaluation	Storage (months)	*Treatment				
		T1	T2	T3	T4	Mean± sd
Flavour(50)	Fresh	41.67±2.89	35.00±8.66	35.00±13.23	43.33±2.89	38.75±8.01B
	1	42.33±4.04	36.00±4.00	41.00±1.00	42.33±2.52	41.17±3.04AB
	2	41.67±2.89	39.33±8.15	45.00±5.00	46.67±2.89	43.17±5.34AB
	3	45.00±0.00	44.00±3.61	44.67±4.51	48.67±1.16	45.58±5.71A
	Mean± sd	42.67±2.84ab	39.33±6.49b	41.42±7.61ab	45.25±3.39a	
Texture(40)	Fresh	35.00±5.00	33.33±7.64	35.00±5.00	35.00±5.00	34.58±4.98A
	1	33.33±4.16	32.00±3.46	33.33±2.89	34.67±2.51	33.33±2.99A
	2	31.67±2.89	35.00±5.00	35.00±5.00	38.33±2.89	35.00±4.26A
	3	29.00±3.61	29.67±7.51	33.00±5.20	35.00±0.00	31.67±4.91A
	Mean± sd	32.25±4.12a	32.50±5.63a	34.08±4.01a	35.75±3.11a	
Appearance (10)	Fresh	8.67±0.58	8.33±1.16	8.33±2.08	8.67±0.58	8.50±1.09A
	1	7.00±0.00	8.33±1.16	7.33±1.53	8.00±0.00	7.67±0.99A
	2	8.33±1.53	8.33±2.08	8.67±0.58	9.67±0.58	8.75±1.42A
	3	9.00±1.00	8.67±0.58	8.00±1.00	6.33±2.52	8.00±1.65A
	Mean± sd	8.25±1.14a	8.42±1.17a	8.08±1.44a	8.17±1.70a	
Total (100)	Fresh	85.33	76.67	78.33	78.00	78.33A
	1	82.67	79.33	81.67	85.00	81.67A
	2	81.67	82.67	88.67	94.67	88.67A
	3	83.00	82.33	85.67	90.00	85.67A
	Mean± sd	83.17ab	80.25b	83.56a	86.91a	

*See Table (1). ^{abcd} Letters indicate significant differences between Halloumi cheese treatments and ^{ABCD} Letters indicate significant differences between storage periods of Halloumi cheese

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