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Investigation of Microbiological Hazards in Traditional Halloumi/Hellim Manufacturing Process*

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Abstract: Halloumi/Hellim, is an important part of the milk sector in Turkish Republic of Northern Cyprus (TRNC). In addition to industrial production, traditional production is also very common. In our study, microbiological samples were collected from the potential risk points throughout the process in selected, small-scaled pilot traditional hellim producers in Nicosia. During three visits in 4 pilot producers, samples were collected for microbiological analysis. These analyses are carried out under two topics: i. Microbiological analyses of products from intermediate product and final product, ii. Operational hygiene control analyses. As the results of all analyses, we concluded that mean results of ACC ranged between $3.4x10^6$-$1.2x10^8$cfu/ml in raw milk. Considering the results of the final product analysis, mold-yeast counts were found below the level that could be detected except of one plant. Coliform and staphylococcus mean results were in the range of 6.4x101 - 8.9x102 and 1.1x103 - 2.3x104 cfu / g, respectively. Operational hygiene control analysis results are in a way to make the results found in the final product meaningful. These results show that hygiene practices are important especially at every stage after curd boiling step.

Keywords: Food safety, Halloumi, Microbiological indicators, Traditional production.

Geleneksel Hellim Üretim Prosesinde Mikrobiyolojik Tehlikelerin Belirlenmesi

Öz: Hellim üretimi, Kıbrıs'ta süt sektörünün önemli bir parçasıdır. Endüstriyel üretime ek olarak, Kıbrıs'ta geleneksel üretim de çok yaygındır. Çalışmamızda, Lefkoşa'daki seçilmiş, küçük ölçekli geleneksel Hellim üreticilerinde üretim prosesi boyunca potansiyel risk noktalarından mikrobiyolojik örnekler toplanmıştır. 4 pilot üreticinin üç defa ziyareti sırasında, mikrobiyolojik analizler için numuneler toplanmıştır. Bu analizler iki başlık altında toplanmaktadır : i. Ara ve nihai üründenlerden toplanan numunelerin mikrobiyolojik analizleri, ii. Operasyonel hijyen kontrol analizleri. Çiğ sütün aerobik koloni sayısı (AKS) ortalama sonuçları $3.4x10^6$-$1.2x10^8$ kob/ml arasında değişmektedir. Son ürün analiz sonuçlarına bakıldığında, bir işletme dışında küf-maya sayımları tespit edilebilen seviyenin altında bulunmuştur. Koliform ve stafilokok ortalama sonuçları ise sırasıyla, $6.4x10^1$ – $8.9x10^2$ ve $1.1x10^3$ – $2.3x10^4$ cfu/g aralığındadır. Operasyonel hijyen kontrol analizleri sonuçları, son üründe tespit edilen sonuçları anlamlı kılacak yöndedir. Bu sonuçlar, özellikle telemenin haşlanması aşamasından sonraki her aşamasında hijyen uygulamalrının önemli olduğunu göstermektedir.

Anahtar Kelimeler: Geleneksel üretim, Gıda güvenliği**,** Hellim, Mikrobiyolojik indikatör.

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INTRODUCTION

Many regulations were adopted and many systems were built up in order to provide food safety with the motto “from farm to fork”. Milk and dairy products can be easily exposed to microbial contaminants in both production and post-production stages and they can allow rapid development of these pollutants due to their structure (1). Therefore, in the dairy industry, providing food safety management quality systems and tracking hygiene parameters with laboratory analysis are of great importance. In addition, there are many problems in small and medium sized enterprises that produce traditional food. Hellim production is a very important part of milk industry in TRNC (2) and in addition to industrial production, traditional production is also very common across the Island. According to 2019 halloumi export statistics published by the Turkish Cypriot Chamber of Commerce, approximately 8 tons of halloumi was exported to different countries (3) In general, raw milk in traditional production and pasteurized milk in raw industrial production is used without the use of starter culture and coagulated with rennet at 33 ± 1 °C. The main feature of halloumi production technology is to produce it without using starter culture and boiling the curd in whey (4). As a result of our literature review, it is concluded that research studies are not sufficient to reflect the situation of traditional hellim production in terms of food safety in TRNC. The quality and shelf-life of hellim, like many other cheese types, are affected by several factors including the quality of milk and the hygienic practices during the whole process of production (5,6,7). In particular, adaptation of such enterprises to food safety requirements and legislation is important for public health as well as for rural development and protection of hellim cheese, the traditional product of TRNC. In our study, operational hygiene control samples were collected from the potential risk points throughout the manufacturing process in selected, small-scaled pilot traditional Hellim producers in Nicosia.

MATERIALS and METHODS

Pilot Producer Selection and Planning the Visits

In this study, four producers (plant A, B, C and D) with similar manufacturing conditions were selected as pilot plants. In all plants, manufacturing was being performed through the same traditional methods. They all process 1 tonnes of milk on average per day and starting at the same time of day. Three visits were performed to all pilot plants to collect microbiological samples with 1-week intervals.

Microbiological Analyses of Intermediate and Final Products

The steps in which the intermediate and final products samples were collected, and the microbiological analysis parameters and the critical limits are shown in Table 1. For the enumeration of total aerobic colony, staphylococci, Coliform bacteria, and mould; Plate Count Agar (LAB 149, UK), Baird Parker Medium Agar (LAB 085, UK), Violet Red Bile Glucose Agar (LAB 031, UK) and Yeast Glucose Chloramphenicol Agar (LAB 122, UK) were used respectively. Brain Heart Infusion Broth (LAB 049, UK) and Rabbit Plasma (X086) were used for confirmation for *Staphylococcus aureus*. For *Salmonella* spp. Analysis; Buffered Peptone Water (LAB 204, UK) Rappaport Vassiliadis Medium (R.V.S) single component (LAB 086, UK), X.L.D. Agar (LAB 032, UK), Triple Sugar Iron Agar (LAB 053, UK), Urea Broth Base (LAB 131, UK) were used. Half Fraser Broth Base (LAB 164), Fraser Broth Base (LAB 164, UK), Palcam Agar (LAB 148, UK), Tryptone Soya Yeast Extract Broth (LAB004, UK), Sheep Blood Agar (LAB028, UK) were used for isolation of *Listeria monocytogenes* (Table 2).

Table 1. Process steps which the samples were collected, analyzed microrganisms and critical limits (8,9).
Tablo 1. Numunelerin toplandığı proses basamakları, analiz edilen mikroorganizmalar ve kritik limitleri (8,9).

Samples	Microorganisms	Limits	References
Raw milk	Aerobic colony count	$<1x10^5$ cfu/ml	(7)
	Staphylococcus aureus	$1x10^2$cfu/ml	
	Salmonella spp.	0 cfu/25 ml	
Cheese brine	Coliform bacteria	$1x10^2$cfu/ml	-
	Coagulase-positive staphylococci	$1x10^2$cfu/ml	
The curd (before cooking, after pressure application)	Coagulase-positive staphylococci	$1x10^2$cfu/g	(8)
	Salmonella spp.	0 cfu/25 g	
	L. monocytogenes	0 cfu/25 g	
	Coliform bacteria*	$1x10^2$cfu/g	-
	Yeast and mould*	$1x10^2$cfu/g	
After cooking, before packaging halloumi/hellim (folded)	Coagulase-positive staphylococci	$1x10^2$cfu/g	(8)
	Salmonella spp.	0 cfu/25 g	
	L. monocytogenes	0 cfu/25 g	
	Coliform bacteria*	$1x10^2$cfu/g	-
	Yeast and mould*	$1x10^2$cfu/g	
Packed halloumi/hellim (final product)	Coagulase-positive staphylococci	$1x10^2$cfu/g	(8)
	Salmonella spp.	0 cfu/25 g	
	L. monocytogenes	0 cfu/25 g	
	Coliform bacteria*	$1x10^2$cfu/g	-
	Yeast and mould*	$1x10^2$cfu/g	

*Microorganisms analysed except the parameters given in the legal regulation, cfu: colony forming unit.

Table 2. Mediums, incubation conditions and analysis method references (10-13).
Tablo 2. Kullanılan besiyerleri, inkübasyon koşulları ve analiz metodu referansları (10-13).

Microorganisms	Analytical reference method	Media name	Incubation conditions		
			Incubation temp.	Incubation period	O_2 requirement
Aerobic colony count	ISO 4833	Plate Count Agar (LAB 149)	30°C ± 1 ºC	72 h ±3 h	Aerobic
Staphylococci *Staphylococcus aureus*	ISO 6888-1:1999 + A1:2003	Baird Parker Medium Agar (LAB 085) + Egg Yolk Tellurite Emulsion (X 085)	35 º- 37 ºC	24 h ± 2 h	Aerobic
		Brain Heart Infusion Broth (LAB 049) Rabbit Plasma (X086)	Confirmation for *Staphylococcus aureus*		
Salmonella spp.	ISO 6579:2002 + A1:2007	Buffered Peptone Water (LAB 204)	37 ºC ± 1 ºC	18 h ± 2 h	Aerobic
		Rappaport Vassiliadis Medium (R.V.S) single component (LAB 086)	41.5 ºC ± 1 ºC	24 h ± 3 h	
		X.L.D. Agar (LAB 032)	37 ºC ± 1 ºC	24 h ± 3 h	
		Triple Sugar Iron Agar (LAB 053) Urea Broth Base (LAB 131)	Confirmation		

Table 2. Mediums, incubation conditions and analysis method references (10-13) (Continued).
Tablo 2. Kullanılan besiyerleri, inkübasyon koşulları ve analiz metodu referansları (10-13) (Devamı).

Microorganisms	Analytical reference method	Media name	Incubation conditions		O_2 requirement
			Incubation temp.	Incubation period	
Coliform bacteria	ISO 4832:2006	Violet Red Bile Glucose Agar (LAB 031)	30 ºC - 37 ºC	24 ± 2 h	Microaerophilic
		Brilliant Green Bile Broth (LAB051)	Confirmation		
Listeria monocytogenes	ISO 11290-1: 1996 + A1:2004	Half Fraser Broth Base (LAB 164)	30 ºC	24 h ± 2 h	Aerobic
		Fraser Broth Base (LAB 164)	37 ºC	24 h	
		Palcam Agar (LAB 148)	37 ºC	24 h ± 3 h	
		Tryptone Soya Yeast Extract Broth (LAB004)	Confirmation for *Listeria* spp.		
		Sheep Blood Agar (LAB028)	Confirmation for *L. monocytogenes*		
Yeast and mould	ISO 6611: 2004	Yeast Glucose Chloram phenicol Agar (LAB 122)	25 ºC	5 days	Aerobic

Operational Hygiene Control and Analysis

In order to perform ATP Bioluminescence (ATP Bio) method, samples were collected from the interior side of the package materials that contact with the final product with the help of special swabs designed for this method. 10x10 cm^2 sized sterile plate templates were used in order to provide standard sampling. After the samples were collected from the surfaces, they were placed in the ATP Biodevice and the value was read. The results were given as RLU/100 cm^2 unit and evaluated according to the critical limits indicated in Table 2. Air sampling device (CGoldenwall™ Air sampler HAS-100B, China) was used for the hygiene control of the microbiological load of air in cold storage rooms and production areas. The number of yeast-mould and aerobic colony count (ACC) were measured for determination microbiological load of air. For the measurement of the microbial load in staffs' hands, a sterile swab moistened with sterile physiological saline water, was used for sampling and staphylococci, coliform bacteria counts were investigated. In order to measure the microbiological load of the surfaces in contact with the food, sterile swabs and 10x10 cm^2 sized sterile plate templates were used in order to provide standard sampling. Surface swab samples were collected from 5 different points which were determined as control points. These were: 1. Mixing spoon, 2. Curd collection strainer, 3. Curd cloth (after the curds were taken out from pressure), 4. Packaging material and 5. Hellim folding and processing table. ACC and coliform bacteria count were investigated for those surfaces. Critical limits were given in Table 3.

Table 3. Critical limits for hygiene control analyses.
Tablo 3. Hijyen control analizleri için kritik limitler.

Sampling points	Microorganisms	Critical limits	Reference
Producers' air	Aerobic colony count	2 X 10^3 cfu/m^3	(9)
	Yeast and mould	1 X 10^3 cfu/m^3	
Staffs' hands	Staphylococci	1 X 10^2 cfu/hand	(Modified from) (10)
	Coliform bacteria	1 X 10^2 cfu/hand	
Surfaces in contact with food	Aerobic colony count	1 X 10^2 cfu/100 cm^2	(Modified from) (11)
	Coliform bacteria	0 cfu /100 cm^2	
ATP- biolum	300 RLU (Relative Light Unit)/100 cm^2		(12)

RESULTS and DISCUSSION

Evaluation of Raw Milk Microbiological Analyses Results

There were very different results (Table 4) in ACC and staphylococci counts, although raw milk was brought from the same source simultaneously to the enterprises and under the same conditions by the supplier. All of the colonies counted on the BPA agar were presented as Staphylococci because of the negative results of the *S. aureus* confirmation test. Salmonella spp. were not isolated in any of the samples. When the results were compared with reference values (Table 1), it has been determined that the results were below the critical limits in terms of S. aureus and Salmonella spp. Counts. On the other hand, the mean results for ACC exceed in all samples, even the min value. Microbiological quality of raw milk is usually assessed by ACC and this parameter is routinely used for estimation of raw milk quality. The quality of raw milk is the major determinant that influences the quality and safety of dairy products (14, 15). Milci et al. (16) underlined the presence of different types of microorganisms due to the low quality of milk that used in hellim production.

Table 4. Microbiological analysis results of raw milk.
Tablo 4. Çiğ süt mikrobiyolojik analiz sonuçları.

Pilot producer codes	Aerobic colony count (cfu/ml) Mean* (Min-Max)	Staphylococci (cfu/ml) Mean* (Min-Max)
A	$3.4x10^6$ ($1.3x10^5$-$1x10^7$)	$1.1x10^4$ ($5.8x10^3$-$2.8x10^4$)
B	$7.4x10^7$ ($2.5x10^6$-$.5x10^8$)	$2.7x10^4$ ($8x10^3$-$4.5x10^4$)
C	$1.2x10^8$ ($3.2x10^6$-$2.3x10^8$)	$7.3x10^4$ ($3x10^3$-$1.1x10^5$)
D	$6.3x10^7$ ($3.5x10^7$- $1.2x10^8$)	$1x10^5$ ($1.7x10^4$-$9.7x10^5$)

*Arithmetic mean of 3 replicated analysis results of samples collected during 3 visits from each pilot producer (n = 3x3 / producer), cfu: colony forming unit.

Evaluation of the Results of Microbiological Analyses of Products

Salmonella spp., *L. monocytogenes* and *S. aureus* were not isolated in any of the samples. As reported previously, a variety of microbial species has been isolated from hellim including thermophilic spore-forming anaerobes such as *Bacillus* and *Clostridium*, LAB (*Lactobacillus* spp. and *Enterococcus faecium*). However, we did not detect foodborne pathogens such as *Listeria monocytogenes*, it was also reported to be persistent in hellim in recent studies (17,18). Packed cheeses also contained coliform bacteria. This may be due to seconder contamination during folding process of the cheese. Because samples were collected after the food handlers folded them and as presented in Table 5, food handlers' hands contaminated with coliform bacteria. Cheese brine for plant A and plant B also observed to carry coliform bacteria load and this reflected as coliform bacteria load in final-packed products. Keles et al. (19) concluded in their study that, hellim cheeses contained initially $1.7x10^4$–$1.7x10^5$cfu/g coliform bacteria but the number of microorganisms decreased during the maturation period. Atasever et al. (20) also isolated coliform bacteria in the amount of $5x10^4$ and $6.4x.10^4$ cfu/g in their study but they concluded that this number decreased during maturation period.

The number of coliform bacteria is higher than the number we determined. This may be due to different hygienic conditions of the producers. However, Demirci and Arıcı (21) detected coliform bacteria in 6 out of 19 hellim samples in Turkey, in another study, coliform bacteria weren't detected in any cheese samples (n=8) in TRNC but were determined in all cheese samples (n=11) collected

from Turkey in the range between 0.30 and 4.78 log cfu/g (22). As Gün and Şimşek (22) concluded, halloumi is being manufactured through similar production methods in Turkey and TRNC although it appears to have different characteristics. Different number of coliform bacteria can also be concluded in this idea. In TRNC, halloumi production is carried out from the milk distributed by the Milk Cooperative. The Cooperative collects the milk from the dairy farms and distributes to the producers after all necessary controls are made. In other words, raw milk with common quality characteristics is used in production.

In our study, after subjected to brine, load of Staphylococci increased for all samples. Özçil (23) collected total 34 hellim samples from the various markets in Nicosia. In this study, no *Salmonella* spp. was observed in any samples, 2 out of 34 samples were containing *Staphylococcus aureus*. Yeast and mould counts decreased in the curd after cooking in plant B but for other pilot plants the number decreased under detectable levels. Yeast and mould number was also high in final-packed product for plant B due to the high yeast and mould load of cheese brine. For the other plant's yeast/mould was not detected in brine. Gün and Şimşek (22), determined yeast and mould in 4 samples in the range of 0.30 and 3.70 log cfu/g. Atasever et al. (20) detected $6.6x10^5$ and $2.1x10^6$cfu/g yeast and mould in two experimental groups as beginning microflora. They mentioned that yeast and mould count decreased during the maturation period. This number of yeast and mould is higher than the number we obtained for one of the pilot plants. This may be due to good manufacturing practice of that producer. As Bintsis and Papademas (5) reviewed in their study that some yeasts were isolated and identified in the microbiological analyses of hellim. *Debaryomyces hansenii*, *Candida parapsilosis*, *Candida boidinii*, *C. versatilis*, *Pichia membranifaciens* were isolated from the cheese produced with sheep milk. *Cryptococcus albidus*, *Pichia membranifacies* isolated from the cheese produced with cow milk (5). Microbiological analysis results of intermediate and final products collected during production process were presented in Table 5.

Table 5. Microbiological analysis results of intermediate and final products collected during production process.
Tablo 5. Üretim prosesi boyunca toplanan ara ürün ve son ürün numunelerinin mikrobiyolojik analiz sonuçları.

Production process	Pilot producer codes	Coliform bacteria	Staphylococci	Yeast and mould
The curd (before cooking, after pressure application) Mean (Min-Max) (cfu/g)	A	$3.6x10^{2}$** ($3.2\ x10^{2}$-$4\ x10^{2}$)	$3.4x10^{4}$* ($1x10^{4}$-$5.2x10^{6}$)	$5.2x10^{3}$*** ($2x10^{3}$-$8.6x10^{3}$)
	B	ND	$4x10^{7}$*** ($5x10^{6}$-$7.8x10^{7}$)	$3x10^{4}$*** ($1.5x10^{4}$-$4.5x10^{4}$)
	C	ND	$1.1x10^{5}$*** ($9.2x10^{4}$-$1.3x10^{5}$)	$1.2x10^{4}$* ($3x10^{3}$-$2.8x10^{4}$)
	D	ND	$1.8x10^{9}$* ($1.2x10^{9}$-$2.7x10^{9}$)	$1.6x10^{4}$* ($1.2x10^{4}$-$2.6x10^{4}$)
Cheese brine Mean (Min-Max) (cfu/ml)	A	$3.3x10^{1}$* ($2.4x10^{1}$-$4x10^{1}$)	$3.3x10^{3}$* ($4x10^{2}$-$5.5x10^{3}$)	ND
	B	$2.4x10^{3}$** ($2x10^{3}$-$2.8x10^{3}$)	$9.3x10^{3}$* ($2.2x10^{3}$-$2.1x10^{4}$)	$1.3x10^{4}$*** ($2.3x10^{3}$-$3x10^{4}$)
	C	ND	ND	ND
	D	ND	$9.1x10^{3}$*** ($3x10^{2}$-$1.8x10^{4}$)	ND

Table 5. Microbiological analysis results of intermediate and final products collected during production process (Continued).
Tablo 5. Üretim prosesi boyunca toplanan ara ürün ve son ürün numunelerinin mikrobiyolojik analiz sonuçları (Devamı).

Production process	Pilot producer codes	Coliform bacteria	Staphylococci	Yeast and mould
After cooking, before packaging halloumi/hellim (folded) Mean (Min-Max) (cfu/g)	A	$1x10^{3}$*** ($1x10^{1}$-$1x10^{3}$)	$6.2x10^{2}$*** ($2x10^{2}$-$1x10^{3}$)	ND
	B	$1.8x10^{3}$** ($1.7x10^{3}$-$1.8x10^{3}$)	$5.6x10^{3}$*** ($3x10^{3}$-$8.2x10^{3}$)	$2.1x10^{3}$*** ($1.8x10^{2}$-$4x10^{3}$)
	C	$1.4x10^{2}$** ($6x10^{1}$-$2.2x10^{2}$)	ND	ND
	D	$7.3x10^{2}$** ($1.1x10^{2}$-$1.4x10^{3}$)	$2.5x10^{3}$* ($3x10^{2}$-$8x10^{2}$)	ND
Packed halloumi/hellim (final product) Mean (Min-Max) (cfu/g)	A	$6.4x10^{1}$*** ($3x10^{1}$-$1x10^{2}$)	$1.1x10^{3}$*** ($3x10^{2}$-$2.1x10^{3}$)	ND
	B	$49x10^{2}$** ($4.5x10^{2}$-$5.2x10^{2}$)	$2.3x10^{4}$* ($1x10^{4}$-$4.1x10^{4}$)	$1.4x10^{4}$*** ($1.2x10^{4}$-$1.6x10^{4}$)
	C	$1.1x10^{2}$*** ($3x10^{1}$-$1.8x10^{2}$)	$7.4x10^{3}$* ($9x10^{2}$-$2.2x10^{4}$)	ND
	D	$8.9x10^{2}$* ($5x10^{1}$-$1.8x10^{3}$)	$1.5x10^{4}$* ($3x10^{3}$- $4x10^{4}$)	ND

*****Arithmetic mean of 3 replicated analysis results of samples collected during 3 visits from each pilot producers (n = 3x3/producer)
****** Arithmetic mean of 3 replicated analysis results of samples collected from only 1 visit of the pilot producers (n = 1x3/producer). Results were under detectable level for the other two visits.
******* Arithmetic mean of 3 replicated analysis results of samples collected from 2 visits of the pilot producers (n = 2x3/producer). Results were under detectable level for 1 visit
cfu: colony forming unit.

Evaluation of Operational Hygiene Control Results

The results of hygiene analyses for surfaces and staffs' hands, cold air storage air microbiological analysis results and end product package material ATP Bioanalysis results are given in Table 6, 7, 8 and 9, respectively. No result above the specified limit was detected for air hygiene control (Table 8). Although high heat treatment applied to the hellim during production process is sufficient for the destruction of both coagulase (+) *S. aureus* and *E. coli* or coliform bacteria.

It is possible that unsuitable hygienic conditions after this stage, especially the lack of personnel hygiene and contaminated tools and equipment, may lead to a decrease in microbiological quality of the product (23, 24). All of the microbiological swabs mean results collected from the inner surface of the packaging materials in contact with the hellim were all acceptable according to the reference values. The ATP Bio results (Table 9) of the same packaging materials confirm that this point is not a risk for the end product.

Table 6: Hygiene control analysis of surfaces in contact with intermediate and final products (cfu/100 cm^2).
Tablo 6: Ara ürün ve son ürün ile temas eden yüzeylerin hijyen control analiz sonuçları (kob/100 cm^2).

Surface codes	Pilot producer codes / Visits / Analyses	A			B			C			D		
		1.visit	2.visit	3.visit	1.visit	2.visit	3.visit	1.visit	2.visit	3.visit	1.visit	2.visit	3.visit
S1	ACC	ND	ND	ND	ND	ND	ND	ND	ND	ND	1×10^3	3.3×10^1	6×10^2
	Coliform bacteria	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.5×10^2	ND	8.3×10^1
S2	ACC	3.1×10^1	1×10^2	9.8×10^2	6×10^2	1×10^3	5.4×10^1	8×10^2	ND	ND	1×10^3	3.5×10^1	3.8×10^1
	Coliform bacteria	2.1×10^2	3.8×10^1	7×10^2	5×10^2	7.5×10^2	ND	7×10^2	ND	ND	8×10^2	1.3×10^2	6
S3	ACC	1.2×10^3	1.2×10^3	4.3×10^1	1×10^3	2×10^2	8×10^2	ND	9.5×10^2	9.9×10^2	9.6×10^2	8	1.2×10^3
	Coliform bacteria	4.5×10^2	7.1×10^2	ND	ND	3×10^1	5.8×10^1	ND	6.5×10^2	6.6×10^2	1.7×10^1	ND	2.3×10^1
S4	ACC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Coliform bacteria	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
S5	ACC	8.1×10^2	4.3×10^1	8	3.1×10^1	2.1×10^2	7.9×10^2	8.2×10^1	4	3.3×10^1	1×10^3	3.2×10^2	2.4×10^1
	Coliform bacteria	45×10^2	ND	ND	ND	2	1.3×10^1	ND	ND	ND	8×10^2	2	ND

Each cell marked with grey is the result that is above the specified limits, ND: not detectable
S1: Mixing spoon, S2: Curd collection strainer, S3: Curd cloth, S4: Packing material, S5: Halloumi/Hellim folding and processing table.
ACC: Aerobic colony count, cfu: colony forming unit.

Table 7. Hygiene control analysis results of staffs' hands (cfu/hand).
Tablo 7. Personel elleri hijyen control analiz sonuçları (kob/el).

Analyzed bacteria	A*			B*			C*			D*		
	1.visit	2.visit	3.visit	1.visit	2.visit	3.visit	1.visit	2.visit	3.visit	1.visit	2.visit	3.visit
Coliform bacteria	$2x10^1$	$<1x10^1$	$<1x10^1$	$<1x10^1$	$<1x10^1$	$<1x10^1$	$>1x10^3$	$>1x10^3$	$2.1x10^1$	$>1x10^3$	$>1x10^3$	$>1x10^3$
Staphylococci	$<1x10^1$	$<1x10^1$	$<1x10^1$	$>1x10^4$	$8.1x10^1$	$1.7x10^1$	$>1x10^4$	$1.2x10^2$	$1.7x10^1$	$>1x10^4$	$>1x10^4$	$>1x10^4$

*codes of the pilot producers, cfu: colony forming unit.

Table 8. Results for microbiological analysis of air microbiological load (cfu/ m^3).
Tablo 8. Hava mikrobiyolojik yük analiz sonuçları (kob/m^3).

Analyzed bacteria		A*			B*			C*			D*	
		1.visit	2.visit	3.visit	1.visit	2.visit	3.visit	1.visit	2.visit	3.visit	1.visit	2.visit	3.visit
A1	Aerobic colony count	$1.9x10^2$	$1.8\ x10^2$	$1.8\ x10^2$	$8x10^2$	$1.5\ x10^2$	$5\ x10^1$	$1.8\ x10^2$	$1.8\ x10^2$	$2\ x10^2$	$2\ x10^2$	$9.3\ x10^1$	$2\ x10^2$
	Yeast and mould	$1\ x10^2$	$1.2\ x10^2$	$4.3\ x10^1$	$8.3x10^2$	$1.3\ x10^2$	6	$9.1\ x10^2$	$1\ x10^2$	6	$7.1\ x10^1$	$1\ x10^2$	$7.3\ x10^1$
A2	Aerobic colony count	ND	2	5	ND	1	ND	$1\ x10^1$	ND	$1.7\ x10^1$	3	1	3
	Yeast and mould	4	ND	ND	ND	ND	ND	4	ND	ND	2	5	ND

*codes of the pilot producers, cfu: colony
ND: not detectable, A1: Air of manufacturing area, A2: Air of cold storage rooms, cfu: colony forming unit.

Table 9. Final product package material ATP Bioluminescence analysis results (RLU/100 cm^2).
Tablo 9. Son ürün paket materyali ATP Bioluminescence analiz sonuçları (RLU/100 cm^2).

Pilot producer codes	A*			B*			C*			D*		
Visits	1.visit	2.visit	3.visit	1.visit	2.visit	3.visit	1.visit	2.visit	3.visit	1.visit	2.visit	3.visit
Results	18	5	8	24	6	6	13	14	3	16	10	10

*codes of the pilot producers, cfu: colony, RLU: relative light unit.

Indicator organisms play very important role to estimate the general microbiological status in dairy food and environment (25,26). That was our starting point for aiming to make a survey on control points of traditional hellim manufacturers. As it is seen in Table 10; the number of results that exceed critical limits were high especially for contact surfaces.

Table 10. Number of results that exceed critical limits.
Tablo 10. Kritik limitlerin üzerinde tespit edilen analiz sonuçlarının sayısı.

Sampling points		N	# results above limit	% results above limit
A*	Surfaces in contact with food	30	12/30	40
	Staffs' hands	6	0/6	0
	Producers' air	12	0/12	0
B*	Surfaces in contact with food	30	16/30	53
	Staffs' hands	6	1/6	17
	Producers' air	12	0/12	0
C*	Surfaces in contact with food	30	6/30	20
	Staffs' hands	6	4/6	67
	Producers' air	12	0/12	0
D*	Surfaces in contact with food	30	16/30	53
	Staffs' hands	6	6/6	100
	Producers' air	12	0/12	0

*codes of the pilot producers

As a result, it was determined that the final product did not constitute a serious public health threat. Packaging materials and the air microbial load have been found to be suitable in all plants and there is no contamination risk for the final product. Microbiology of cheese brine has been found to be an important source of mould and yeast load for the final product. In case of folding of the cooked cheese, staphylococci and coliform contamination from the personnel reflected in the final product. The amount of microbial load on the tables where the cheeses were folded and left in brine should be cleaned more carefully. Coliform and staphylococcus mean results were in the range of $6.4x10^1$ - $8.9x10^2$ and $1.1x10^3$ - $2.3x10^4$ cfu/g, respectively. Operational hygiene control analysis results are in a way to make the results found in the final product meaningful. These results show that hygiene practices are important especially at every stage after curd boiling step.

Conflict of interest

The authors declare that they have no conflict of interest.

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