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USE OF DIFFERENT SALTING TECHNIQUES IN HALLOUMI CHEESE: EFFECT ON SENSORY, MICROBIOLOGICAL AND CHEMICAL PROPERTIES

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In this study Halloumi cheese samples were produced from 1:1 mixtures of ewe's and cow's milk. Cheese samples were divided into two groups. Samples of the first group were dry salted and then vacuum packed. Next group samples were ripened in tin packs containing brine solution of 13% salt content. The changes in chemical, microbiological and sensory properties of the samples were investigated during the ripening period. It was found that the samples of the first group had higher dry matter and fat contents and acidity values but lower salt and ash contents than the samples of second group. It was also observed that salt and ash contents and acidity values increased in both groups during the ripening period while pH values decreased. In microbiological view, coliforms, total viable, yeast and mould counts were higher in the first group than in the second one. Coliforms decreased in both groups during the ripening period. On the other hand, total viable, yeast and mould counts decreased in second group. According to sensory evaluations, the first group samples were more preferred. The yield of cheese was determined as 15.40%.

Keywords: Halloumi cheese, ripening, package and salting techniques

Halloumi cheese is classified as a semi-hard cheese according to moisture content (DAVIS, 1976; SCOTT, 1986; ROBINSON, 1991). It is white-yellowish in colour and has a taste like fresh cheddar cheese (SHALKER et al., 1987). Traditionally it is produced from ewe's and goat's milk or mixtures of these milks. In recent years cow's milk is also used in Halloumi cheese production due to decreases in ewe's and goat's milk supplies (ANIFANTAKIS & KAMINARIDES, 1981; 1983; ROBINSON, 1991). It is widely popular in Cyprus and other countries of the Eastern Mediterranean but, more recently, the product has gained international acceptance and recognition; total export of Halloumi cheese from Cyprus have risen to approximately 2500 metric tonnes (ANON., 2000).

Halloumi cheese has a characteristic aroma, its texture is elastic and compact with no holes and it is easily sliced. It is popular with consumers and, while large quantities of Halloumi are sold immediately after production, a proportion of the total output is immersed in whey previously used to heat-treat the cheese modified by the addition of

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NaCl. Halloumi cheese is generally ripened in brine solutions as like beyaz (white pickled cheese), feta, akawi and domiati cheeses (DAVIS, 1976; SCOTT, 1986; ROBINSON et al., 1991). In recent years vacuum packaging is also in use (ANIFANTAKIS & KAMINARIDES, 1981; 1983; TOMA et al., 1990; ROBINSON, 1991). TOMA and co-workers (1990) have reported that cryovac packing leads to improving organoleptical quality properties of Halloumi cheese. Some investigators have recorded (ANIFANTAKIS & KAMINARIDES, 1983; ECONOMIDES et al., 1987; KELES et al., 2001) that moisture, protein, salt and ash contents were between 39.00–42.53%, 23.00–30.37%, 22.72–24.44%, 1.44–6.64%, 3.66–7.17%, respectively. Same authors reported that the pH values were between 4.80–6.30. During maturation, Halloumi changes markedly in taste and texture and the cheese becomes hard, salty and moderately acidic (PAPADEMAS & ROBINSON, 2000).

In Halloumi cheese production high temperature is applied to curd as boiling in water (80–90 °C for 10–30 min). According to FOX (1987) high temperature applications to curd inactivate most of the microorganisms and enzymes. According to ANIFANTAKIS & KAMINARIDES (1985) fresh Halloumi cheese has 8.0×10^2–4.0×10^3 CFU g^{-1} microbial counts of total viable mesophiles and after ripening period of 60 days this count had reached to 1.0×10^7–2.0×10^8 CFU g^{-1}. KELES and co-workers (2001) have reported that total viable counts were 1.8×10^6–1.3×10^7 CFU g^{-1} in initial stage and it reached to 4.2×10^6–1.6×10^7 CFU g^{-1} after 90 days of ripening. WILLIAMS and SYSON (1984) have reported that total viable counts were 4.0×10^8 CFU g^{-1} and that no *E. coli* was found. In an other report DEMIRCI & ARICI (1989) have examined 19 Halloumi cheese samples obtained from Northern Cyprus retail markets, coliforms were found in 6 samples and average value for total viable mesophile counts was 2.64×10^6 CFU g^{-1}. KELES and co-workers (2001) have reported that coliform counts were 1.7×10^4–1.7×10^5 CFU g^{-1} at initial stage of ripening and after 60 days coliforms were examined. According to the same author, faecal streptococci were at a rate of 1.2×10^5–3.3×10^5 CFU g^{-1} at initial stage and 1.5×10^5–1.2×10^6 CFU g^{-1} were found on the 90th day. Mould and yeast counts were 6.0×10^4–3.0×10^6 CFU g^{-1} at the beginning and 1.6×10^4–3.9×10^6 CFU g^{-1} on the 90th day of ripening.

The yields of Halloumi cheese were reported as follows according to milk used in production: from ewe's milk it was between 17.72–20.59% (ANIFANTAKIS & KAMINARIDES, 1983; ECONOMIDES et al., 1987; KELES et al., 2001) and from cow's milk it is between 8.85–10.00% (CHATER, 1984; ECONOMIDES et al., 1987; KELES et al., 2001).

The aim of this study was to evaluate the effects of different salting techniques on chemical, microbiological and sensory properties of Halloumi cheese produced from cow's and ewe's milk mixtures.

1. Materials and methods

Mixtures of cow's and ewe's milk were used for producing Halloumi cheese samples. Cow's milk (C) was obtained from Veterinary Faculty Farm of Selcuk University, Konya, Turkey and ewe's milk (E) was obtained from a farm near around.

Halloumi cheese samples were produced in Milk and Meat Products Unit of Department of Food Science and Technology. Cheese production was repeated 3 times and 100 l of milk was used in every application. Cheese samples were produced according to traditional Halloumi cheese production procedure (ANIFANTAKIS & KAMINARIDES, 1981; 1983; KAMINARIDES et al., 1984; ECONOMIDES et al., 1987; FOX, 1987; SHALKER et al., 1987).

Rennet was added to milk at 30 °C. After coagulation was completed (30 min after rennet addition) curd was cut in 1 cm^3 size. Curd was heated to 40 °C and whey was drained. Curd was pressed for 90 min of 7-kg weight per 1-kg curd and was cut to pieces of 10×10×3 cm. Pieces of curd were boiled in whey of 80 °C till gaining elasticity for 10 min. Cheese samples were divided into two groups. First group samples were dry salted as a ratio of 2.5% NaCl. Second group samples were dipped into brine solution of 13% NaCl. Dry salted samples were vacuum packed and pickled samples were put in tin packs, brine solution of 13% NaCl were poured on and then tins were sealed. Cheese samples were stored at 7±1 °C for ripening.

Cheese samples were examined for chemical and microbiological aspects on the first day of production and on the 15, 30, 60 and 90th days of ripening. Sensory analyses were carried out on the 30, 60 and 90th days of ripening.

Moisture contents of the samples were examined by the reference method of BRITISH STANDARD (1963). Fat contents were examined by Gerber Method (MARSHALL, 1992); acidity values, salt and ash contents were examined by the methods of TURKISH STANDARD (1974). pH values were determined by MARSHALL's (1992) method with a digital pH meter (NEL Mod.821) at 25±1 °C.

Total viable mesophilic colony counts were determined in plate count agar (Oxoid). Plates were incubated at 30±1 °C for 72±1 h (HARRIGAN & MCCANCE, 1976). Coliform counts were determined in violet red bile agar (Oxoid). Plates were incubated at 30±1 °C for 24±1 h (HARRIGAN & MCCANCE, 1976). Faecal streptococci counts were determined in Barnes' thallium acetate tetrazolium glucose agar. Plates were incubated at 45±1 °C for 48±1 h. Yeast and mould counts were determined in potato dextrose agar (Oxoid). Ten percent tartaric acid solution was used for acidification of medium for calibrating pH to 3.5. Plates were incubated at 22±1 °C for five days (MARSHALL, 1992).

Sensory properties were determined by sensory panels of members according to procedures of INTERNATIONAL DAIRY FEDERATION (1987). Panelists evaluated sensory characteristics with a total of 100 points with maximum scores of 45, 30, 15 and 10 for flavour, texture, appearance, and colour, respectively. The vocabulary used to characterise the samples was generated by six residents of Konya, Turkey, who were familiar with Halloumi cheese. The individuals were given samples, and were asked to

taste them and describe any aspects of flavour, texture, appearance and colour that were distinctive. Once the individual tasters had provided a list of descriptors, a round table discussion produced a final vocabulary comprising 20 terms: eight covering flavour (tasteless, salty, bitter, acid, creamy, fodderly, milky and minty), six for textural characteristics (soft, crumbly, springy, loose, moist and chewy), three for appearance (swollen, split and mouldy), and three for colour (unburnished, dirty and yellow).

Yields were calculated in percentage by the formula:

$$\text{Cheese yield} = \text{Cheese amount/milk used in production} \times 100$$

The chemical, microbiological and sensorial data were subjected to analysis of variance according to DUZGUNES and co-workers (1987) using SPSS 10.0 for windows. The result of the chemical and microbiological evaluations were analysed with ANOVA in SPSS. Duncan's test was used in all data where appropriate. In addition, Pearsons' correlation test was used.

2. Results and discussion

Chemical, microbiological and sensory properties of cheese samples during 90 days of ripening are shown in Tables 1–3.

According to Table 1 moisture contents within the groups were found similar during the ripening period, but differed between groups after 15 days of ripening in each stage ($P<0.05$). Moisture contents were between 39.33±4.12–42.90±3.01% at the end of ripening.

Table 1. Chemical properties of Halloumi cheese samples during ripening period

Property	Ripening period				
	1st day	15th day	30th day	60th day	90th day
I. group					
Moisture (%)	39.48±2.15	39.48±3.23	39.32±2.14	39.39±3.02	39.33±4.12
Fat (%)	26.39±4.74	27.50±2.68	26.56±3.96	27.44±2.20	27.11±3.15
Salt (%)	2.32±0.58^{b}	2.73±0.67^{ab}	2.93±0.63^{a}	2.96±0.54^{a}	3.76±1.42^{a}
Ash (%)	3.84±0.70	4.07±0.40	4.02±0.60	4.03±0.86	4.36±1.11
Acidity (% l.a)	0.34±0.16^{b}	0.46±0.15^{ab}	0.49±0.12^{a}	0.57±0.17^{a}	0.59±0.22^{a}
pH	5.64±0.10^{a}	5.54±0.15^{ab}	5.40±0.16^{b}	5.17±0.27^{c}	4.73±0.22^{d}
II. group					
Moisture (%)	40.84±3.99	42.53±2.70	42.54±2.19	43.21±2.25	42.90±3.01
Fat (%)	26.17±2.18	25.61±1.87	25.33±2.33	25.56±2.08	24.89±2.22
Salt (%)	4.25±0.67^{c}	5.29±0.90^{b}	5.63±1.41^{ab}	6.23±1.04^{ab}	6.42±0.64^{a}
Ash (%)	5.42±1.00^{d}	6.37±0.47^{c}	6.71±0.58^{bc}	7.31±0.33^{a}	7.15±0.32^{ab}
Acidity (% l.a)	0.35±0.13	0.41±0.13	0.41±0.12	0.45±0.12	0.46±0.12
pH	5.60±0.13^{a}	5.52±0.22^{ab}	5.40±0.24^{bc}	5.27±0.22^{c}	4.86±0.18^{d}

Different letters within the same raw indicate statistically significant difference ($P<0.05$).

These values were similar to those reported by ANIFANTAKIS and KAMINARIDES, 1981; 1983; 1985; ECONOMIDES and co-workers, 1987; DEMIRCI and ARICI, 1989; TOMA and co-workers, 1990; KELES and co-workers, 2001.

Fat contents of the samples were not different both within and between groups. At the end of ripening fat contents were found between 24.89±2.22–27.11±3.15%. Fat contents were found similar to the results of several investigators (ANIFANTAKIS & KAMINARIDES, 1981; 1983; 1985; ECONOMIDES et al., 1987; DEMIRCI & ARICI, 1989; TOMA et al., 1990; KELES et al., 2001).

Salt contents of samples in both groups increased during ripening. Differences among ripening stages in second group were found significant ($P<0.05$). Differences between the groups were found significant in all stages of ripening ($P<0.01$). At the end of ripening period salt content of first group samples were found 3.76±1.42% and the second group samples were found 6.42±0.64%. These results were similar to those of several investigators (ANIFANTAKIS & KAMINARIDES, 1981; ECONOMIDES et al., 1987; DEMIRCI & ARICI, 1989; TOMA et al., 1990; KELES et al., 2001).

Ash contents of samples in both groups increased during ripening as the salt contents. Differences among ripening stages in first group are not significant ($P>0.05$) but in second group they were found significant ($P<0.05$). Differences between the groups were found significant in all stages of ripening ($P<0.01$). On the 90th day, ash contents of the first group samples were 4.36±1.11% and those of the second group samples were 7.15±0.32%. Ash contents were similar to those reported by DEMIRCI and ARICI (1989) and KELES and co-workers (2001).

Acidity values increased during the ripening period in both groups. But only in first group it was significant ($P<0.05$). Acidity values of vacuum packed samples were found higher than the brined ones also but differences were not significant ($P>0.05$).

pH values decreased during the ripening. Decreases were found significant in each groups ($P<0.05$). Several investigators (TEKINSEN et al., 1998; 1999; TOMA et al., 1990; KELES et al., 2001) have reported that pH values decreased during ripening time.

Total viable mesophile counts in the first and second groups 3.2×10^6 CFU g^{-1} and 8.3×10^6 CFU g^{-1}, respectively, in the initial stages. At the end of ripening period they were 1.1×10^7 CFU g^{-1} and 7.5×10^6 CFU g^{-1}. Counts were increased till 60th day in the first group. The differences in the second group samples for total count were not significant ($P>0.05$). On the other hand, counts of first group samples were somewhat higher than the second ones. Probably the causes of the differences were salt contents and pH values. Counts were similar to those reported by several investigators (CHATER, 1984; ANIFANTAKIS & KAMINARIDES, 1985; KELES et al., 2001).

Coliform counts in the first and second groups were 7.5×10^4 CFU g^{-1} and 6.4×10^4 CFU g^{-1}, respectively, in the initial stages. Counts decreased during the ripening and on day 90 coliforms were not detected in either groups.

Table 2. Microbiological (Log_{10} CFU g^{-1}) properties of Halloumi cheese samples during ripening period

Microbes	Ripening period				
	1st day	15th day	30th day	60th day	90th day
I. group					
Total viable counts	6.16±0.61[b]	6.97±0.73[a]	7.03±0.61[a]	7.24±0.50[a]	6.82±0.51[a]
Coliforms	4.35±0.70[a]	3.00±1.32[b]	2.96±0.40[b]	0.34±1.01[c]	Not detected
Faecal streptococci	5.31±0.22[c]	5.35±0.43[c]	5.44±0.41[b]	5.93±0.52[a]	5.51±0.56[abc]
Yeasts and moulds	5.08±0.93	5.65±0.38	5.56±0.33	5.56±0.69	5.57±0.61
II. group					
Total viable counts	6.69±0.49	6.37±0.26	6.65±0.61	6.11±0.70	6.21±0.78
Coliforms	4.25±0.97[a]	2.13±2.06[b]	2.74±2.06[b]	0.86±1.33[c]	Not detected
Faecal streptococci	5.09±0.48	5.25±0.56	5.54±0.67	5.31±0.93	5.36±0.55
Yeasts and moulds	5.84±0.86[a]	5.56±0.50[a]	5.64±0.69[a]	4.42±0.87[b]	4.59±0.97[b]

Different letters within the same raw indicates statistically significant difference ($P<0.05$).

Similar results were reported by several investigators (TEKINSEN et al., 1998; 1999; KELES et al., 2001). DEMIRCI and ARICI (1989) detected coliforms in 6 samples out of 19 collected from retail market and WILLIAMS and SYSON (1984) reported that *E. coli* was not found in Halloumi cheese samples. Between the groups there was no significant difference ($P>0.05$), but coliform counts of vacuum-packed samples were higher than the pickled ones in every stage of ripening.

Faecal streptococci were 2.3×10^5 CFU g^{-1} in the first group and 1.8×10^5 CFU g^{-1} in the second group at the beginning of ripening. On day 90 the counts were 6.9×10^5 CFU g^{-1} and 6.4×10^5 CFU g^{-1}, respectively. Slight, but not significant differences were found among ripening. Results reported by KELES and co-workers (2001) were similar to ours.

Yeast and mould counts were 6.8×10^5 CFU g^{-1} in the first group and 2.1×10^6 CFU g^{-1} in the second group at the beginning of ripening. On day 90 the counts were 8.5×10^5 CFU g^{-1} and 1.5×10^5 CFU g^{-1}, respectively, however, their presence appeared to have no adverse effect on quality, in that no off-flavours, visible colonies or any swelling of packets or tins due to CO_2 production (WESTALL & FILTENBORG, 1998) were detected. Between groups no difference was found. Results were similar to those of different studies (TEKINSEN et al., 1998; KELES et al., 2001) conducted for several brined type cheeses.

From organoleptical view, vacuum-packed samples were preferred. Results were similar to the reports of KELES and co-workers (2001) and TOMA and co-workers (1990). In all stages of ripening where organoleptical analyses were performed, the differences between the groups were found significant ($P<0.01$).

Table 3. Sensory properties of Halloumi cheese samples during ripening period

Property	Ripening period				
	1st day	15th day	30th day	60th day	90th day
I. group					
Flavour (45)[a]	–	–	40.36±5.29	40.78±4.63	40.98±4.28
Texture (30)	–	–	27.87±2.74	27.73±3.58	28.16±3.32
Appearance (15)	–	–	13.80±1.52	13.27±1.84	13.62±1.51
Colour (10)	–	–	9.33±0.95	9.13±1.20	9.29±1.04
Total (100)	–	–	91.36±8.41	90.91±9.83	92.04±8.14
II. group					
Flavour (45)[a]	–	–	39.42±4.75	38.44±5.55	37.98±5.00
Texture (30)	–	–	26.36±2.98	26.11±3.28	25.29±3.46
Appearance (15)	–	–	11.91±1.82	11.87±1.80	11.82±2.58
Colour (10)	–	–	8.29±1.08	7.84±1.86	8.11±2.07
Total (100)	–	–	85.98±6.58	84.27±9.93	83.20±7.12

–: Sensory analyses were not performed in those stages
[a]: Highest points for organoleptical properties are shown in parenthesis

The yield of Halloumi cheese was 15.40%. Yields for Halloumi were reported according to milk used in production: from ewe's milk it is between 17.72–20.59% (ANIFANTAKIS & KAMINARIDES, 1983; ECONOMIDES et al., 1987; KELES et al., 2001) and from cow's milk it is between 8.85–10.00 (CHATER, 1984; ECONOMIDES et al., 1987; KELES et al., 2001). Yield was different from those reports because ewe's and cow's milk mixtures were used in manufacturing experimental cheese samples in this study.

3. Conclusions

According to the results of the study, vacuum-packed samples (group 1) were worse from microbiological point of view than the pickled (group 2) ones, however, brine salted samples were given less scores in sensory analyses. We can say that vacuum packaging in Halloumi cheese manufacture can be used on the base of the consumers' preference.

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