FATTY ACID AND SENSORY PROFILE IN THE PROCESS OF RIPENING OF KASCHKAVAL CHEESE FROM COW'S MILK PRODUCED BY MICROWAVE TREATMENT

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Abstract
Kaschkaval cheese from cow's milk by two methods of heat treatment: conventional heat treatment of cow's milk (62°-67 °C) followed by hot brining of the cheddared curd in 14% solution of NaCl at the temperature of 72°-74 °C; microwave heat treatment of milk (f=2450MHz, p=800W, t°=62°-67 °C) followed by direct microwave treatment of the cheddared curd and dry salting were made in laboratory conditions. Produced kaschkaval cheese was placed for ripening at the temperature of 8°-10 °C for 45 days. Fatty acid profile of the samples kaschkaval cheese on the 5th, 15th, 30th and 45th day of ripening was studied. After 45 days sensory profile of mature kaschkaval cheese was analysed. It was found that the mature kaschkaval cheese, produced by microwave treatment, showed higher concentrations of monounsaturated fatty acids and lower concentrations of saturated fatty acids in comparison with the classical cheese. With the highest concentration of saturated fatty acids throughout the ripening period is established palmitic acid ($C_{16:0}$) It showed a high concentration after ripening in the classical kaschkaval cheese. Oleic acid ($C_{18:1}$) shows the highest concentration of monounsaturated fatty acids group after ripening period, its concentration is higher in the microwave kaschkaval cheese. Of the polyunsaturated fatty acids has established only linoleic acid ($C_{18:2}$). The concentrations of this fatty acid in the two samples kaschkaval cheese are almost identical.The mature kaschkaval cheese obtained by microwave treatment showed better sensory profile compared to the classical cheese.

Keywords: cheddared curd, hot brining, starter culture, lipolysis, heat treatment, dry salting

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1.INTRODUCTION

Kashkaval is the traditional type of hard, hot brined cheese in the Balkan countries, dating back to the XI–XII-th century when it was first brought to Bulgaria from the East by nomadic tribes (Caric 1993, Fox et al.1993). It belongs to the group of so-called pasta filata cheeses which are very popular in the Balkan region of Europe and Western Europe. The kaschkaval cheese is traditionally produced from sheep's or cow's milk, and the classical technology of its production is similar to a number of other types of pasta filata cheeses- Kashar (Turkey), Kachiokavalo (Italy), Provalone (Italy), Regusono (Italy) (Oksuz et al. 2001, Cetinkaya and Özütemiz 2006).

Bulgarian kaschkaval cheese is produced from short time pasteurized milk (62°-67 °C/15-20sec). Two specific processes in the production technology of kaschkaval cheese are significant for the proper conduct of the ripening process: cheddaring - active lactic acid process occuring in the curd under the influence of starter lactic acid bacteria to pH5.15 – 5.25 and hot brining - heat treatment of cheddared cheese mass (pH5.15 – 5.25) in a 12% hot solution of NaCl at the temperature of 72 °C for 1-3min, which process selects the microflora of cheddared cheese mass (up to 80 - 90% of the vegetative microflora is destroyed) and the ripening of the kaschkaval cheese starts at a greatly reduced microbial count (Simov et al. 2006, Kojev 2002).

The modern trends in dairy science at 21st century are focused in the search of alternative solutions for obtaining of products with maximum preserved nutritional composition and high functional index supplying the body as its necessary energy and health benefits. The chemical composition of milk and dairy

products fully meets the criterion "sustenance - functionality - biological benefits."
The alternative solution proposed in this study is the application of microwave treatment for making kaschkaval cheese by two aspects:

* Replacement of classical heat treatment of milk in regime - thermisation (62- 67 °C) with microwave thermal treatment in the same thermal regime;

* Replacement of classical hot brining (72°-74 °C, 14% solution of NaCl) with direct microwave treatment of cheddared curd with subsequent dry salting;

Upon microwave treatment, heat is generated in the product by reacting of the food nutrients with electromagnetic energy with frequencies in the microwave field, which causes rotation of the water molecules and the dipole conductive migration of dissolved ions in the electromagnetic field - phenomena that generate heat within the product (Mudgett 1988, Ramaswamy and Tang 2008) on the basis of so-called molecular friction. Rapid nature of heating by microwave waves reduces heat-destructive effects on nutrient composition compared to long conventional approaches to heat treatment, which provides an alternative to improve the nutritional composition (Dumuta et al. 2010, Dehghan et al. 2012) and the prospect for making kaschkaval cheese with high nutritional value.
Studies examining microwave treatment in the dairy industry are concentrated mainly on the purpose of pasteurization and sterilization of milk (Villamiel et al. 1996, Sieber et al. 1996, Kovacs et al. 2006, Korzensky et al. 2013). There are no studies regarding the application of microwave processing in the production of cheeses. In the literature there are no data about the study of the kinetics of the ripening process in cheeses produced by replacing the classical heat treatment (pasteurization) with microwave treatment.
Lipolysis is a process which in conjunction with proteolysis takes an active role in the cheese ripening and forming of good sensory profile. Buccioni et al. (2010) and Revello Chion et al (2010) report for full transfer of fatty acids from milk in cheese. According to Caric (1993) the concentration of free fatty acids in the mature cheese is between 1 and 3 g kg^{-1}. Free fatty acids are essential for the sensory profile of cheeses, because they are responsible for formation of aroma and flavor. A key aspect is the importance of short-chain fatty acids (SCFAs, C_4 - C_{12}) which is due to its low threshold of perception.
In a study (Kesenkas et al. 2009) treating the possibility of the usage of vegetable oil in the production of pasta filata (Kashar cheese), cheese without the addition of vegetable oil (control sample), showed higher content of short chain fatty acids (SCFAs, C_4 - C_{12}) – 10.81± 0.04 g $100g^{-1}$ compared to the experimental cheese with addition of vegetable oil – 1.81± 0.19 g $100g^{-1}$. Higher concentrations of short chain fatty acids in cheese Kashar increased intensity of his aroma (Guler 2005).
Besides the saturated fatty acids which concentration of total concentration of fatty acids is the highest, milk and milk products contain also unsaturated fatty acids (UFAs). Higher content of unsaturated fatty acids leads to increase in the health benefits of the product compared to saturated fatty acids (Zhang et al. 2006), because they have a positive effects on the prevention of cardio - vascular diseases and cancer (Calvo et al. 2007).
The aim of this study is to investigate the fatty acid and sensory profile in the process of ripening of kaschkaval cheese from cow's milk produced by microwave treatment.

2. MATERIAL AND METHODS

The stability of the juices depend on the For conduct of the study raw cow's milk was used; Microwave oven LG (model № MS2389 BS / 00 power 800W, frequency 2450 MHz); Electric heater Alaska (Model KP 180, SIG, GmbH); starter cultures for kaschkaval cheese (*Lb. delbr. ssp. bulgaricus, Streptococcus thermophilus, Lactococcus lactis ssp. lactis, Lactobacillus helveticus*), rennet (Biokom Trendafilov - Ltd., Sliven, Bulgaria), vacuum packaging film; vacuum - packaging machine;

2.1. Production of kaschkaval cheese

The experimental samples of kaschkaval cheese were produced in the laboratory conditions in the Department "Technology of milk and milk products" at University of Food Technologies – Plovdiv, Bulgaria. Raw cow's milk was heat treated in mode - thermisation (62°- 67 °C) by two methods of heat treatment – microwave treatment and classical conventional treatment. Classical technology for the production of cheeses and modified technology for cheese production with the application of microwave heat treatment of cow's milk and subsequent direct microwave processing of cheddared curd were applied (Figure 1). The obtained samples of kaschkaval cheese, after stabilization of their forms (3-rd day after production) was packaged in vacuum pack and placed in the ripening conditions (8° - 10 °C, for 45 days). Samples were analyzed in the whole period of ripening process on the 5th, 15th, 30th and 45th day of ripening.

2.2. Fatty acid composition

The analysis of fatty acid composition of the fatty matter of the samples of kaschkava cheese was performed on capillary gas chromatography with an apparatus Shimadzu (Japan) column DB – WAX, with length 30m, internal diameter 0.25mm. The total lipids are extracted by the method of Rose – Gothlib, then the fatty matter was derivatized with MeOH/BF_3 (methanol containing 14% boron trifluoride BF_3). Fatty acids are analyzed as methyl esters in the following conditions of chromatography. Temperature program 50 °C for 2 min, an increase of the temperature to 200 °C at a rate of 10 °C min^{-1}, an increase to 218 °C at a rate of 2 °C min^{-1}, an increase to 250 °C at a rate of 10 °C min^{-1}, retention at 250 °C for 10 min.

2.3. Sensory profile

The sensory evaluation of cheeses was carried out according to BNS 3528-88.

Cheese samples which have undergone a maturing (45 days) were evaluated in 100 point system of testing panel which consisted of six members. The evaluate indicators: packaging and labeling, appearance, color, taste and flavor, texture, cut surface. Rule of anonymity of assessed samples to objectivity of the evaluation was met.

2.4. Statistical analysis

The statistical analysis of the data is carried out by determining the standard deviation (SD), with triple repetition of the analyses. It is performed with the Excel 2007 software application of the Microsoft Office 2007 suite (Microsoft Corporation, USA).

3. RESULTS AND DISCUSSION

The results of the fatty acid profile of the samples kaschkaval cheese during the ripening period are presented in Table 1 and Table 2.

Of saturated fatty acids with high molecular weight in the lipid composition of the cheese with the highest concentration throughout the ripening period was established palmitic ($C_{16:0}$) fatty acid. The concentration of this fatty acid had not changed substantially in the period of ripening but its concentration into microwave cheese was lower compared to classical cheese. Ripening process started with a concentration of palmitic ($C_{16:0}$) fatty acid in microwave kaschkaval cheese (5th day) – 33.18±0.11 g $100g^{-1}$ and respectively in the classical cheese (5th day) – 37.07±0.14 g $100g^{-1}$ (Table 1).

At the end period of ripening (45th day) a slight increase in these values was noticed – content of palmitic acid in microwave kaschkaval cheese- 33.78±0.10 g $100g^{-1}$ compared to 38.57±0.12 g $100g^{-1}$ in the classical kaschkaval cheese.

A high concentration of oleic ($C_{18:1}$) fatty acid was established. It occupied the most – significant proportion of monounsaturated fatty acid (MUFAs) in samples kaschkaval cheese. It showed the tendency of higher concentration in microwave kaschkaval cheese at the whole period of ripening – 30.59±0.11 g $100g^{-1}$ (5th day) to 30.22±0.05 g $100g^{-1}$ (45th day) as compared to conventional kaschkaval cheese – 27.14±0.09 g $100g^{-1}$ (5th day) to 25.23±0.12 g $100g^{-1}$ (45th day).

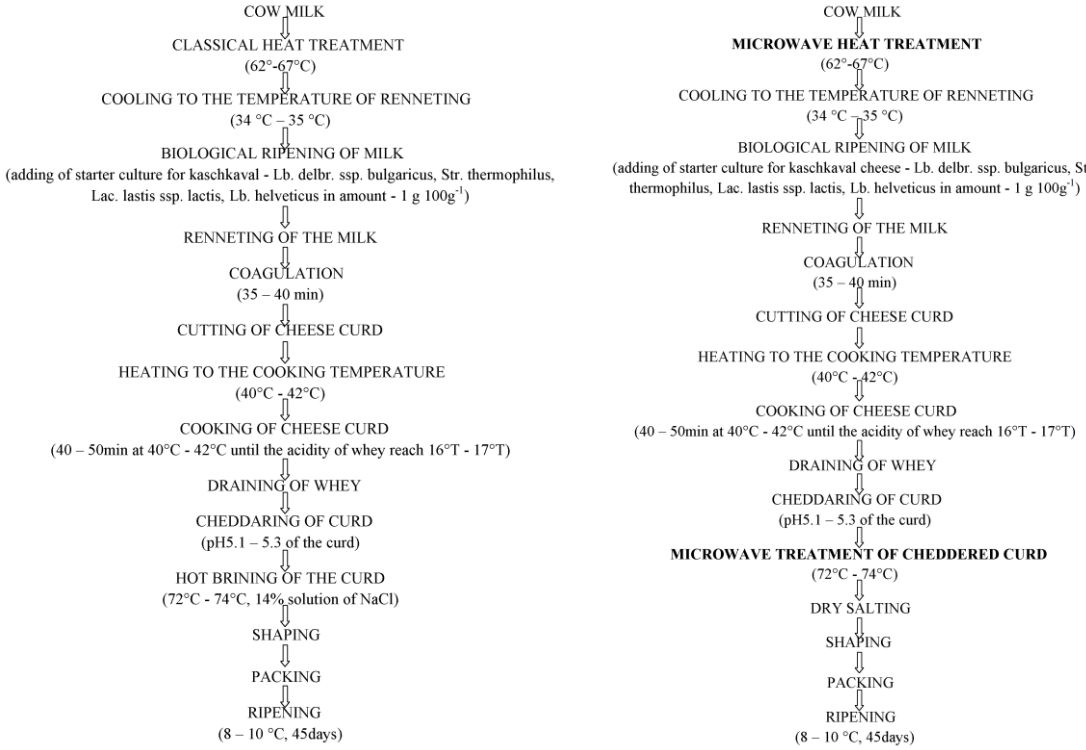

Fig. 1. Technological schemes for production of kaschkaval cheese. a) classical kaschkaval cheese; b) kaschkaval cheese made by microwave treatment

Of polyunsaturated fatty acids (PUFAs) in mature cheese (45-th day) no differences were found in the concentration of linoleic ($C_{18:2}$) fatty acid – 2.42±0.13 g $100g^{-1}$ in microwave kaschkaval cheese and 2.41±0.06 g $100g^{-1}$ in the conventional kaschkaval cheese. Of short-chain fatty acids (SCFAs, C_4 - C_{12}) having the greatest importance for the formation of the aroma and taste of a mature product - the biggest part loan lauric ($C_{12:0}$) fatty acid – 10.63±0.09 g $100g^{-1}$ (45 day microwave kaschkaval cheese) and 13.36±0.14 g $100g^{-1}$ (45 day conventional cheese).

Higher levels of both lauric acid and other fatty acids from this group were reported in the conventional kaschkaval cheese but those higher levels of short-chain fatty acids (SCFAs, C_4 - C_{12}) had an impact on the total content of saturated fatty acids (SFA) in the mature cheese (45th day) which in conventional cheese occupy 70.03 g $100g^{-1}$ of the total fatty acid content, while in the microwave kaschkaval cheese were identified lower levels of saturated fatty acids (SFA) - 65.15 g $100g^{-1}$.

The obtained results can be explained by thermal instability of unsaturated fatty acids, which is confirmed by the reported lower concentrations of unsaturated fatty acids in the classical cheese for the preparation of which is attached classical thermisation of cow's milk, which requires longer time to reach the required temperature (62°- 67 °C) and followed by hot brining of cheddared curd (72°-74 °C, 14% solution of NaCl).

Due to faster nature of microwave treatment to reach the required temperature (62° - 67°C) and the elimination of hot brining of curd in brine solution and its replacement with direct microwave treatment of cheddared curd in mature cheese produced by microwave method is established higher levels of monounsaturated fatty acids (MUFAs), thereby increasing its biological potential.

Table 1. Concentration of free fatty acids in the kaschkaval cheese during the ripening period (5,15 days)

Free fatty acids	Concentration of fatty acids (g $100g^{-1}$)			
	Type of the sample kaschkaval cheese			
	Microwave kaschkaval		*Classical kaschkaval*	
	5	*15*	*5*	*15*
Saturated fatty acids				
Butyric acid (C4:0)	ND	0.43±0.08	ND	ND
Caproic acid (C6:0)	0.29±0.08	0.60±0.05	ND	0.45±0.03
Caprylic acid (C8:0)	1.80±0.07	1.87±0.08	1.48±0.08	2.33±0.08
Capric acid (C10:0)	2.77±0.10	2.64±0.02	3.33±0.06	3.57±0.07
Lauric acid (C12:0)	10.31±0.09	10.02±0.03	12.32±0.04	12.37±0.06
Myristic acid (C14:0)	0.35±0.11	0.35±0.07	0.43±0.08	0.44±0.06
Palmitic acid(C16:0)	33.18±0.11	33.09±0.04	37.07±0.14	36.00±0.05
Margaric acid (C17:0)	0.61±0.06	0.62±0.11	0.84±0.11	0.80±0.06
Stearic acid (C18:0)	14.54±0.07	14.11±0.02	11.42±0.11	11.19±0.05
Arahidic acid (C20:0)	ND	0.25±0.10	ND	ND
Heinecosanoic acid (C21:0)	0.15±0.11	ND	0.45±0.04	0.39±0.11
Monounsaturated fatty acids				
Palmitoleic acid (C16:1)	2.14±0.04	2.12±0.09	2.37±0.09	2.21±0.11
Heptadecaenoic acid (C17:1)	0.31±0.14	0.32±0.12	0.41±0.13	0.39±0.04
Oleic acid (C18:1)	30.59±0.11	30.83±0.03	27.14±0.09	27.71±0.04
Polyunsaturated fatty acids				
Linoleic acid (C18:2)	2.96±0.10	2.75±0.04	2.74±0.10	2.15±0.10

**ND – Not detected*

More prolonged classical heat treatment leads to the increase of the levels of saturated fatty acids (SFA) in the classical kaschkaval cheese, probably caused by the saturation of the unsaturated fatty acids, which explains the lower amounts of unsaturated fatty acids in the mature classical kaschkaval cheese. The sample kaschkaval cheese treated with microwaves showed lower concentration of saturated fatty acids, which may also be associated with weaker thermal- destructive effect of microwave treatment on the cow's milk fats. After completion of the ripening process (45 days) is carried evaluation of sensory profile of the mature cheese. The results of sensory profile of mature kaschkaval cheese are presented in Figure 2.

About the indicator package and mark the two samples of kaschkaval cheese were evaluated with the highest grade – 10 points; About the indicators appearance and color cheese obtained by microwave treatment shows higher average grades of 4.83 points and 4.83 points versus 4.16 points and 4.33 points awarded to the classical cheese at maximum of 5 points for each of the tested indicators. About the indicator taste and smell cheese obtained by microwave treatment gets higher average score - 44.16 points in comparison with 41.16 for the classical cheese of maximum of 45 points. About the indicator consistency kaschkaval obtained by microwave treatment gets higher average rating - 19.5 points versus 18.16 points for the classical cheese of maximum of 20 points.

The cut surface of the two cheese samples showed a good result for the mature product. The kaschkaval cheese produced with microwave treatment was awarded with maximum grade for this indicator - 15 points versus 14.5 points for the classical kaschkaval cheese. Considering the total number of awarded points – kaschkaval produced with microwave treatment gets 98.32 points of maximum 100 points, while the classical kaschkaval cheese was awarded with 92.31 points. The results showed a very good sensory profile of the mature cheese obtained after the microwave treatment in comparison to the classical cheese, which is an objective result in favor of the application of microwave treatment as an alternative approach for the production of kaschkaval cheese and steamed cheeses.

Table 2. Concentration of free fatty acids in the kaschkaval cheese during the ripening period (30,45 days)

Free fatty acids	Concentration of fatty acids (g 100g^{-1})			
	Microwave kaschkaval		*Classical kaschkaval*	
	30	*45*	*30*	*45*
Saturated fatty acids				
Butyric acid (C4:0)	0.62±0.05	0.62±0.11	ND	ND
Caproic acid (C6:0)	0.84±0.10	0.79±0.09	0.73±0.04	0.21±0.01
Caprylic acid (C8:0)	2.4±0.07	2.33±0.08	2.92±0.05	2.31±0.03
Capric acid (C10:0)	3.03±0.06	2.96±0.09	3.87±0.09	3.86±0.06
Lauric acid (C12:0)	10.92±0.10	10.63±0.09	12.80±0.08	13.36±0.14
Myristic acid (C14:0)	0.23±0.09	0.35±0.10	0.45±0.07	0.46±0.08
Palmitic acid(C16:0)	34.84±0.11	33.78±0.10	37.25±0.05	38.57±0.12
Margaric acid (C17:0)	ND	ND	ND	0.72±0.07
Stearic acid (C18:0)	11.38±0.07	13.69±0.12	11.18±0.02	10.30±0.14
Arahidic acid (C20:0)	ND	0.25±0.10	ND	ND
Heinecosanoic acid (C21:0)	ND	ND	ND	ND
Monounsaturated fatty acids				
Palmitoleic acid (C16:1)	0.94±0.08	2.21±0.11	2.39±0.01	2.33±0.03
Heptadecaenoic acid (C17:1)	ND	ND	ND	0.24±0.06
Oleic acid (C18:1)	32.06±0.04	30.22±0.05	26.53±0.04	25.23±0.12
Polyunsaturated fatty acids				
Linoleic acid (C18:2)	2.74±0.08	2.42±0.13	1.88±0.08	2.41±0.06
Distribution of groups fatty acids in mature cheese (45-day), g 100g^{-1}				
Saturated fatty acids	65.15±0.78		70.03±0.65	
Monounsaturated fatty acids	32.43±0.16		27.56±0.21	
Polyunsaturated fatty acids	2.42±0.13		2.41±0.06	

**ND – Not detected*

4. CONCLUSIONS

The kaschkaval cheese produced by microwave treatment of cow's milk and the direct microwave treatment of cheddared curd showed a higher concentrations of monounsaturated fatty acids and lower concentrations of saturated fatty acids as compared to cheese manufactured according to traditional technology which results in enhancing its biological potential. As regards the content of polyunsaturated fatty acids represented by linoleic ($C_{18:2}$) fatty acid were not found significant differences in the concentrations of this fatty acid in the two cheese samples. Good sensory profile of mature cheese, produced by microwave treatment, compared to cheese manufactured in a traditional way was established, which reveals the real possibility of application of microwave processing as a viable alternative in the production of kaschkaval cheese.

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