

# *Effect of vegetable fat on the texture, colour and sensory properties of Macedonian white brined cheese*

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## *Abstract*

This study aimed to investigate the influence of substitution of milk fat with palm fat on the composition, yield and technological quality of White cheese, a Macedonian traditional cheese. In this study, full-fat white brined cheese was used as a control sample (WC), while experimental cheeses were prepared from cow milk with vegetable fat (WV) addition and low-fat cheese (WL), respectively. The cheeses have been analysed for physicochemical (acidity, pH, fat, fat acidity, protein), instrumental texture and colour properties (L, a, b) as well as the sensory properties after 1, 20 and 60 days. WV cheeses showed a significantly ( $P < 0.05$ ) lower degree of pH and higher titratable acidity than the WC and WL cheese samples. Cheese that contained vegetable fat showed lower degrees of lipolysis, as assessed by the acid-degree value and received significantly ( $P < 0.05$ ) better appearance, highest hardness value (5226.98 N) and cheese yield scores compared to other samples.

**Key words:** white brined cheese; lipolysis; texture profile; colour; sensory evaluation

## Introduction

The importance of maintaining adequate nutrition has become increasingly important to consumers during recent years. Foods formulation with ingredients that help in lowering health risks has been developed in cheese production in which vegetable fats and oils replaced saturated milk fat. The nutritional profile of the cheese is improved by replacing milk fat with quality vegetable fat during which cheese becomes lower in cholesterol and changed the composition of saturated and unsaturated fatty acids (Hjalmarsson, 2015). The applications of vegetable fats give rise to different properties in cheese as a result of the vast variations (Wennermark et al., 2014). Cheese imitations are usually defined as cheese-like products made by including non-dairy fats or proteins to form a cohesive cheese-like mass (Noronha et al., 2008). The functional characteristics such as meltability and textural properties are important attributes that influence the quality and the end use of this analogue product and processed cheese (Floury et al., 2009). The yield (kg cheese/kg milk) in cheese manufacturing is of particular interest since it affects commercial feasibility. Probably the most important factor affecting cheese yield is milk composition, in particular the concentration and composition of fat and protein (Fox et al., 2000).

White brined cheese in North Macedonia ("belo salamureno sirenje") is a brine cheese type with a salty taste and close texture. It is similar to the cheeses of different countries on the Balkan Peninsula, which are included in the group of autochthonous dairy products depending on the region, specificity in production technology, quality and name (Mateva et al., 2019). The production of brined cheeses has been practised for centuries, with differences in cultural habits, technological processes and difficult climatic conditions, however, in the last decade of the century the development of standardized industrial production is intensified (Hupertz et al., 2006; Sulejmani, 2014).

A few studies have been focused on the manufacturing technology, microbiology and compositional characteristics (Mojsova et al. 2013; Dabevska-Kostoska et al. 2015) but the texture profile, colour pattern and sensory evaluation of the Macedonian white brined cheese produced

with vegetable fat have not been investigated. The main objective of this investigation was to study the effects of vegetable fat on cheese composition, texture, colour and yield of the white brined cheese. Specific aims of the study were to determine the cheese yield and composition of whey during the process and examine the texture, colour and sensory properties of the final cheese. Therefore, cow's milk fat was totally and partially replaced by vegetable oils, such as palm oil to give the cheese a whiter colour, and also to reduce the production costs. The results are expected to extend the knowledge about the use of vegetable fats in cheese production. Further, the results might indicate promising formulas in the development of vegetable fat cheeses.

## Materials and methods

### Cheese manufacture and sampling

White brined cheese production was carried out in industrial scale in the dairy plant "Mlekara Tetovo" using the standard manufacturing protocol (Figure 1). The vegetable fat blend based on palm oil (Krispy, Malaysia) was added (3.00-3.50 %) to skim milk. Briefly, cow's raw milk supplied from the Tetova region (April - June 2019, North Macedonia) was standardized and pasteurized at 75 °C for 15 seconds. After the milk has been cooled to 37 °C, it is transferred into cheese vats, inoculated with 5 g/100 g starter culture (YFL-3331, CHR Hansen) followed by addition of CaCl<sub>2</sub> (FUDIX TM) at level 0.1 g/L cheese milk. The inoculated milk was held for 15 minutes, after which liquid rennet (CHY-MAX® Extra, CHR) was added at a level (7 g/100 kg cheese milk) sufficient to coagulate the milk in 55 min. The milk started to coagulate after 45 minutes and the gel was sufficiently firm after 50-55 min. The gel was cut into cubes (1.5 cm) and allowed to rest in whey for 10 min and mixed afterward for 3 times. After the whey drainage, self-pressing was performed for 30-60 min at room temperature 20 °C, until the acidity of the curd reached pH 5.30. The pressure was applied by 20 kg weight per 100 kg of cheese curd until the acidity reached 35 Thorner degrees (°Th). The weights were then removed, the cheese-cloth opened, the curd was cut into blocks of about 11.8 x 11.8 x 11.8 cm<sup>3</sup> which were kept in a 15 %

brine for 16 hours (until the cheese reached pH at 4.70). After 16 hours the cheese blocks were packed into 10 kg plastic packaging, filled with 10 % brine and ripened at temperature of 18-20 °C and of 80-90 % humidity till the acidity of the cheese reaches minimum 170 °Th, respectively.

## Chemical analyses

Titrate acidity (TA) of cow milk and cheese is determined by titrating with 0.1 N caustic soda solution, using phenolphthalein as the indicator and expressed in Thorner degrees (°Th). The quality of the milk was monitored at the dairy laboratory of the Food Institute (Faculty of Veterinary Medicine in Skopje, Macedonia) using the infrared spectroscopy (IR) method (Foss Milkoscan 4000, Denmark) to determine protein, fat and lactose content. The pH of milk and cheese samples was measured using a digital pH meter (digital pH meter, model MP120FK Mettler Toledo, Greifensee, Switzerland). Cheese samples were analysed for moisture by the oven-drying method at 102 °C, fat, salt and total protein according to the AOAC (2007). The intensity of changes in the lipids of cheeses was evaluated

based on the FFA (free fatty acid values) analysis using titration with KOH (IDF, 1991). All chemical measurements were done in triplicate or more. Cheese samples were chemically analysed at 1, 20 and 60 days of ripening. The cheese yield was calculated by the weight of cheese before brining (after 19 to 20 h ripening at 23 to 25 °C) divided by the weight of the milk used.

## Instrumental texture analysis

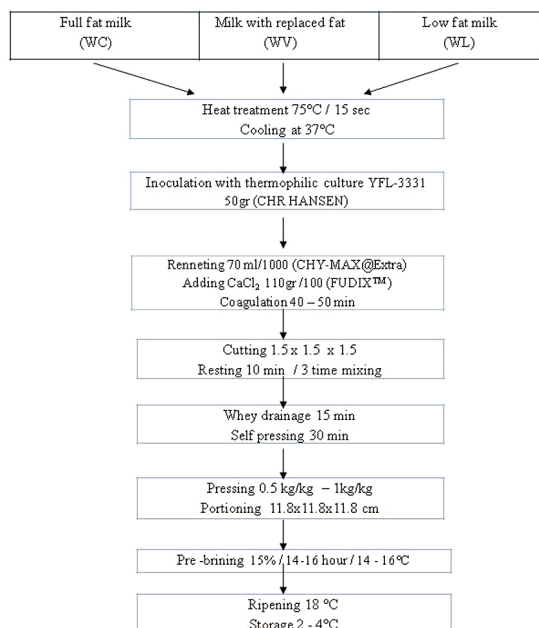
The Texture analyser TAXT plus (Ametek Lloyd Inst. Ltd, UK) equipped with a cylinder probe (10 mm in diameter) was used to analyse the textural profile of cheeses. The cheese samples were taken from at least 2 cm deep in the cheese blocks and their dimensions were 2.5 × 2.5 cm. The samples were compressed by 33 cm from the height of the initial sample, using two successive compression cycles at a speed of 0.5 mm / s (Ong et al., 2012).

## Colour assessment

Colour intensity was performed with Ocean Optics USB2000 spectrophotometer. The reference light used was D65 (standard daylight). The colour parameters of L\*, a\* and b\* of the samples were determined. A glass plate was placed over the Ocean Optics USB2000 spectrophotometer light probe and standardized using black and white reference plates. Samples were placed on the Petri dish for analysis and all samples were large enough to cover the entire light probe. The samples were placed on the glass plate over the light probe and covered with black glass to prevent outside light from interfering with the readings. This procedure was repeated three times with each sample.

## Sensory analysis

The cheeses were evaluated at 1, 20 and 60 days of ripening by 7 trained panellist's familiar with the cheese according to the described procedure for White cheese (Sulejmani et al., 2016). The samples were evaluated by criteria appearance (scale 0-5), odour (scale 0-5), texture (0-10), and flavour (scale 0-15). Water and bread were provided to panellist to rinse their mouths between samples.



**FIGURE 1.** Manufacture protocol of the White brined cheese with different fats (self-made scheme)

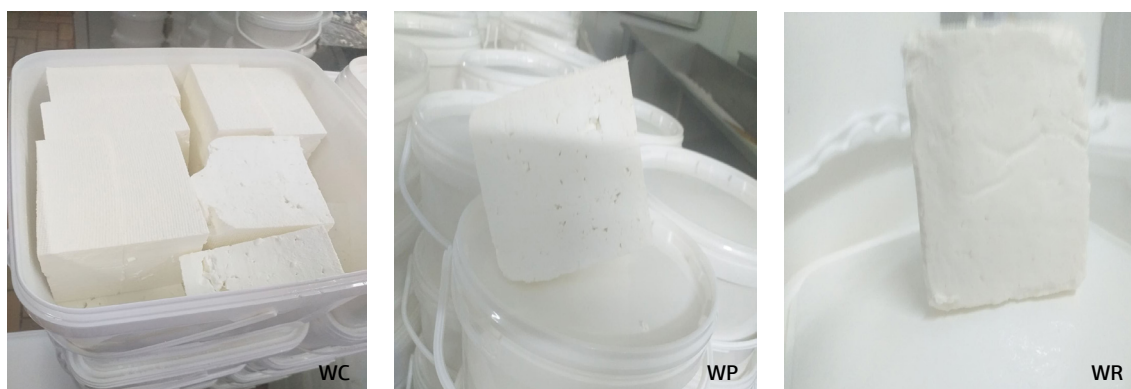


FIGURE 2. Appearance of White brined cheese with different fats

TABLE 1. Physical-chemical composition (pH, dry matter, fat, protein and lactose content) of raw cow milk and cheese whey

	WC		WV		WL	
	Milk	Whey	Milk	Whey	Milk	Whey
pH	6.61±0.04 <sup>A</sup>	6.26±0.09 <sup>a</sup>	6.63±0.02 <sup>A</sup>	6.22±0.11 <sup>a</sup>	6.61±0.05 <sup>A</sup>	6.15±0.13 <sup>a</sup>
Dry matter (%)	11.81±0.12 <sup>B</sup>	6.39±0.31 <sup>a</sup>	11.94±0.21 <sup>B</sup>	6.29±0.27 <sup>a</sup>	9.82±0.21 <sup>A</sup>	6.48±0.23 <sup>a</sup>
Fat (%)	3.46±0.15 <sup>B</sup>	0.31±0.18 <sup>a</sup>	3.56±0.12 <sup>C</sup>	0.28±0.31 <sup>a</sup>	1.50±0.15 <sup>A</sup>	0.29±0.18 <sup>a</sup>
Protein (%)	3.15±0.41 <sup>A</sup>	0.91±0.15 <sup>a</sup>	3.10±0.19 <sup>A</sup>	0.96±0.19 <sup>ab</sup>	3.12±0.34 <sup>A</sup>	1.01±0.21 <sup>b</sup>
Lactose (%)	4.45±0.12 <sup>A</sup>	4.57±0.16 <sup>a</sup>	4.47±0.18 <sup>A</sup>	4.48±0.21 <sup>a</sup>	4.51±0.21 <sup>A</sup>	4.61±0.22 <sup>a</sup>

WC - Control cheese; WV - White cheese with vegetable fat; WL - White cheeses with reduced fat; Mean ± SD with different letter in the same row indicate significant differences (Duncan Test  $P < 0.05$ )

Sensory analysis was conducted in 3 replicate trials and cheeses were evaluated in duplicate by each panellist in identical conditions (Figure 2). Sensory profiling was scored on a scale from 1 to 10 points, where higher score meant more expressed attribute.

### Statistical analysis

A randomised complete block design, which incorporated three treatments (WC, WV and WL cheeses), three ripening periods (1, 20 and 60 days) and two blocks (trials), was used to analyse the response variables related to cheese composition, texture, colour and sensory data. Duncan's multiple comparison tests were used as a guide for paired comparisons of treatment means. The significance of differences between treatments was considered at  $P < 0.05$  using SPSS version 16.0 for Windows (SPSS Inc., Chicago, IL, USA).

## Results and discussion

The chemical composition of cow's milk used for the production of cheeses with different amount of fats is shown in Table 1. The mean chemical composition of the milk used in the manufacture of White cheese was 11.81 % total solids, 3.46 % fat, 3.15 % protein, and 4.45 % lactose. The pH of the milk was 6.62. The differences in dry matter content and fat content were significant ( $P < 0.05$ ) whereas pH, protein and lactose content were not different significantly, respectively. From the obtained analysis, raw cow's milk meets the requirements according to the Book of Rules for milk quality (Official Gazette 96/2011).

The gross chemical compositions of the WC, WV and WL cheeses during ripening are presented in Table 2. The fat, salt, protein contents, and lactic acid value of the cheese samples at first day of

ripening were significantly different; however, the pH values of the cheeses made by WC and WL variables of production were non significantly affected by manufacturing method during 60 days ripening, as shown in Table 2 ( $P > 0.05$ ). The pH of the cheeses at the end of ripening was in the range 4.39- 4.51 and the value is in accordance with Feta cheese reported by Georgala et al. (2005) and Moatsou et al. (2004). The pH values decreased significantly during ripening in all types of cheeses and showed differences with cheese analogue variant ( $P < 0.05$ ). The protein content was higher in WC cheeses and the levels decreased significantly during ripening, whereas in other cheeses there was

no significant change of protein content during ripening. The values for protein and fat levels were in accordance with the findings of Sarantinopoulos et al. (2002), and Abd El-Salam and Alichanidis, (2004).

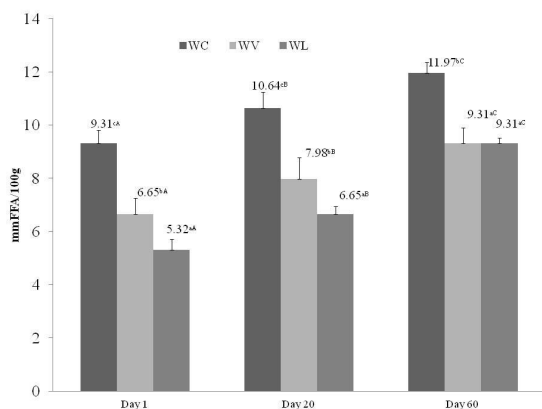
Content of the total dry matter significantly increased at the WC and WL cheese samples during 60 days of ripening. This change is accounted by the exudation of the serum from the cheese blocks to the whey due to salt gradient. As a consequence, this results in a reduction of moisture content and a concomitant increase of salt content in the product (Papademas et al., 2000). At first day of ripening, WC cheeses were characterized by

**TABLE 2.** Physical-chemical composition (pH, dry matter, fat, protein, lactose and colour) of White brined cheese with different fat

		WC			WV			WL		
		Day 1	Day 20	Day 60	Day 1	Day 20	Day 60	Day 1	Day 20	Day 60
pH	Mean	4.68	4.61	4.51	4.61	4.52	4.39	4.70	4.66	4.51
	SD	0.05 <sup>bb</sup>	0.03 <sup>bb</sup>	0.07 <sup>ba</sup>	0.02 <sup>ac</sup>	0.02 <sup>ab</sup>	0.04 <sup>aA</sup>	0.03 <sup>cc</sup>	0.05 <sup>ab</sup>	0.05 <sup>ba</sup>
Acidity (°Th)	Mean	73	102	174	76	109	183	65	91	167
	SD	0.07 <sup>ba</sup>	0.05 <sup>bb</sup>	0.05 <sup>bc</sup>	0.08 <sup>ba</sup>	0.09 <sup>cb</sup>	0.07 <sup>cc</sup>	0.08 <sup>aA</sup>	0.05 <sup>ab</sup>	0.07 <sup>ac</sup>
Dry matter (%)	Mean	43.47	43.95	44.68	45.24	44.79	42.39	35.9	36.4	37.3
	SD	0.03 <sup>ba</sup>	0.33 <sup>bb</sup>	0.15 <sup>cc</sup>	0.11 <sup>cc</sup>	0.22 <sup>cb</sup>	0.10 <sup>ba</sup>	0.07 <sup>aA</sup>	0.14 <sup>aA</sup>	0.15 <sup>ab</sup>
Fat (%)	Mean	21.4	21.5	21.5	25.7	25.4	25.1	10.5	10.6	10.5
	SD	0.33 <sup>ba</sup>	0.37 <sup>ba</sup>	0.32 <sup>ba</sup>	0.37 <sup>aA</sup>	0.41 <sup>cb</sup>	0.42 <sup>cb</sup>	0.21 <sup>aA</sup>	0.22 <sup>aA</sup>	0.32 <sup>aA</sup>
Protein (%)	Mean	17.96	16.62	16.14	15.7	15.3	14.8	15.9	15.4	14.8
	SD	0.17 <sup>bc</sup>	0.22 <sup>bb</sup>	0.12 <sup>ba</sup>	0.14 <sup>aA</sup>	0.19 <sup>aA</sup>	0.18 <sup>aA</sup>	0.23 <sup>ac</sup>	0.29 <sup>ab</sup>	0.32 <sup>aA</sup>
Salt (%)	Mean	2.94	3.12	3.2	3.21	3.38	3.46	3.31	3.51	3.69
	SD	0.42 <sup>aA</sup>	0.31 <sup>aAB</sup>	0.35 <sup>ab</sup>	0.33 <sup>ba</sup>	0.28 <sup>abA</sup>	0.32 <sup>ba</sup>	0.23 <sup>ba</sup>	0.41 <sup>bb</sup>	0.39 <sup>cc</sup>
Yield	Mean	7.4	/	7.62	5.7	/	4.9	9.35	/	9.7
	SD	0.22 <sup>b</sup>	/	0.71 <sup>b</sup>	0.61 <sup>a</sup>	/	0.11 <sup>a</sup>	0.22 <sup>c</sup>	/	0.25 <sup>c</sup>
L*	Mean	102.67	101.66	100.27	101.11	101.76	100.86	98.93	101.60	100.99
	SD	1.02 <sup>bb</sup>	0.89 <sup>aAB</sup>	1.12 <sup>aA</sup>	1.10 <sup>ba</sup>	0.94 <sup>aA</sup>	1.56 <sup>aA</sup>	0.73 <sup>aA</sup>	0.90 <sup>ab</sup>	0.91 <sup>ab</sup>
a*	Mean	-2.210	-1.179	-1.80	-1.464	-1.346	-1.53	-1.314	-1.379	-1.27
	SD	±0.13 <sup>ac</sup>	±0.17 <sup>aA</sup>	±0.14 <sup>cb</sup>	±0.8 <sup>bb</sup>	±0.21 <sup>ba</sup>	±0.21 <sup>bc</sup>	±0.34 <sup>aA</sup>	±0.42 <sup>ba</sup>	±0.14 <sup>aA</sup>
b*	Mean	-3.61	-1.35	-1.17	-0.80	-3.97	-1.00	-1.11	-1.45	-0.77
	SD	±0.13 <sup>cc</sup>	±0.33 <sup>ab</sup>	±0.22 <sup>ca</sup>	±0.9 <sup>aA</sup>	±0.12 <sup>cc</sup>	±0.18 <sup>bb</sup>	±0.18 <sup>bb</sup>	±0.10 <sup>bc</sup>	±0.16 <sup>aA</sup>

WC - Control cheese; WV - White cheese with vegetable fat; WL - White cheese with reduced fat; <sup>a-c</sup>Mean ± SD with different letters in the same row indicate significant differences of different samples on the same days (Duncan Test  $P < 0.05$ );

<sup>A-C</sup> Mean ± SD with different letters are with significant differences of the same samples but different days (Duncan Test  $P < 0.05$ )



**FIGURE 3.** Lipolysis level in full (WC), low-fat cheeses (WL) and vegetable fat white brined-cheese (WV), as assessed by the acid-degree value (ADV)

<sup>(a-c)</sup>Means + SD with different letters have significant differences of different samples on the same days,  $P < 0.05$ .  
<sup>(A-C)</sup>Means + SD with different letters have significant differences of the same samples but different days; Duncan test, ( $P < 0.05$ )

higher colour brightness ( $L^*$ ) than cheese-like products and low fat cheeses (Table 2). During ripening, colour brightness significantly decreased in control cheeses ( $P < 0.05$ ), while the change was not significant in other two samples ( $P < 0.05$ ). These results are in accordance with the findings of Bielecka and Cichosz (2020). Sabbagh et al. (2010) also noticed a decrease of the  $L^*$  value probably due to the degree of lipolysis during cheese ripening. Similarly, Dinkçi et al. (2011) reported a slight increase of yellow colour during the storage of the cheese samples which are attributed to a decrease in the moisture during the ripening process. The yellowness ( $b^*$ ) increased gradually during ripening of the analysed cheeses and cheese-like products.

The lipolysis level in full fat (WC), low-fat (WL) and vegetable fat white brined-cheese (WV), as assessed by the acid-degree value (ADV), was shown in Figure 3.

The highest levels of acid degree values (ADVs) are present in WC matured cheese (11.9 mEq. KOH g/100 g cheese fat) compared to WV and WL (9.3 mEq KOH g/100 g cheese fat). Full fat cheese showed free acidity values significantly higher compared to low-fat cheese and cheese-like product with fat replacers' addition. The cheese with vegetable fat (WV) and low-fat cheese (WL) resulted in a lower (ADVs) degree due to the slower lipolysis and the formation of free volatile fatty acids. These results were in accordance with those previously

reported in the literature which showed the reduction of free acidity values with fat content decrease (Romeih et al., 2002).

### Texture profile

Textural parameter profiles are shown in Table 3. Hardness and chewiness values significantly increased ( $P < 0.05$ ) during ripening, probably due to an increase in the salt concentration of brine that resulted in the loss of moisture throughout cheese maturation (except for WV cheeses). For all cheese variants hardness changed regularly during storage. The highest hardness value was observed on day 60 at WV cheese whereas the lowest at WL cheeses. Hardness increased during ripening of Gaziantep cheese, Terrincho cheeses (Kaya, 2002; Pinho et al., 2004) but decreased during ripening of Beaten cheese, or Torta del Casar cheese (Sulejmani et al., 2014; Delgado et al 2010). The hardness values of all samples increased at the end of ripening compared to the initial values in a ratio of about 56 % for WC, 34 % for WV and 17 % for WL samples. Differences could be attributed to different proteolysis level, fat content and physical-chemical properties in each type of cheese (Marshall, 1991). The cheese containing fat was significantly firmer than the cheeses with reduced fat ( $P < 0.05$ ). In contrasts to Yu and Hammond (2000), no significant differences were found for cheese produced with vegetable fat except in cohesiveness. These findings are in consistent with the result of Lobato-Calleros et al. (1997) but the opposite situation was conducted from the Dinkçi et al. (2011) who reported significant differences in the texture and colour of Turkish Kashar cheese produced with vegetable fat and milk fat.

Cohesiveness probably decreased via casein network breakage and springiness by the loss of moisture. Our results are in consistent with Guinee, (2016) where at low temperatures ( $< 5^\circ\text{C}$ ), milk fat is predominantly solid and adds to the elasticity/rigidity of the casein matrix.

Gumminess and chewiness show significant change among the cheese with different fat and also the ripening exhibited differences among the same samples (except WV cheeses). Therefore, the increase in hardness and adhesiveness found during the maturation of Ibores cheese were exclusively

**TABLE 3.** Texture profile analysis (TPA) of White brined cheese with different fat

		WC			WV			WL		
		Day 1	Day 20	Day 60	Day 1	Day 20	Day 60	Day 1	Day 20	Day 60
Hardness (g)	Mean	2428	3069	4494	3326	3700	5226	982	1137	1185
	SD	10 <sup>ba</sup>	37 <sup>ba</sup>	84 <sup>bb</sup>	45 <sup>ca</sup>	52 <sup>ca</sup>	21 <sup>bb</sup>	39 <sup>aA</sup>	21 <sup>aAB</sup>	13 <sup>aB</sup>
Adhesiveness (g·sec <sup>-1</sup> )	Mean	-120	-72	-74	-11	-13	-21	-88	-121	-151
	SD	27 <sup>cB</sup>	47 <sup>ba</sup>	52 <sup>ba</sup>	32 <sup>aA</sup>	29 <sup>aA</sup>	38 <sup>aB</sup>	55 <sup>ba</sup>	72 <sup>cB</sup>	72 <sup>cC</sup>
Springiness (mm)	Mean	0.74	0.80	0.65	0.82	0.81	0.65	0.61	0.57	0.74
	SD	0.3 <sup>bb</sup>	0.7 <sup>bb</sup>	0.5 <sup>aB</sup>	0.4 <sup>cB</sup>	0.4 <sup>bb</sup>	0.5 <sup>aA</sup>	0.6 <sup>aA</sup>	0.3 <sup>aA</sup>	0.7 <sup>aB</sup>
Cohesiveness (ratio)	Mean	0.36	0.46	0.30	0.53	0.55	0.37	0.33	0.34	0.29
	SD	0.09 <sup>aB</sup>	0.10 <sup>bc</sup>	0.32 <sup>aA</sup>	0.47 <sup>bb</sup>	0.52 <sup>ca</sup>	0.03 <sup>ba</sup>	0.71 <sup>aAB</sup>	0.45 <sup>aB</sup>	0.32 <sup>aC</sup>
Gumminess (g·sec <sup>-1</sup> )	Mean	769	1530	749	1776	2036	2300	291	394	355
	SD	36 <sup>ba</sup>	52 <sup>bb</sup>	47 <sup>aA</sup>	51 <sup>ca</sup>	101 <sup>ca</sup>	23 <sup>aA</sup>	77 <sup>aA</sup>	76 <sup>aB</sup>	51 <sup>aB</sup>
Chewiness (g·mm)	Mean	901	1562	619	1444	1653	1528	184	234	260
	SD	40 <sup>bb</sup>	22 <sup>bc</sup>	78 <sup>ba</sup>	51 <sup>ca</sup>	33 <sup>cC</sup>	70 <sup>cB</sup>	13 <sup>aA</sup>	31 <sup>aB</sup>	38 <sup>aC</sup>
Resilience	Mean	0.16	0.18	0.10	0.22	0.23	0.21	0.09	0.1	0.07
	SD	0.90 <sup>bb</sup>	0.18 <sup>aC</sup>	0.31 <sup>ba</sup>	0.07 <sup>ca</sup>	0.41 <sup>ba</sup>	0.32 <sup>ca</sup>	0.23 <sup>aB</sup>	0.24 <sup>aB</sup>	0.38 <sup>aA</sup>

WC - Control cheese; WV - White cheese with vegetable fat; WL - White cheese with reduced fat; <sup>a-c</sup>Mean ± SD with different letters in the same row indicate significant differences of different samples on the same days (Duncan Test P<0.05);

<sup>A-C</sup>Mean ± SD with different letters are with significant differences of the same samples but different days (Duncan Test P<0.05)

related to the increase in the dry matter (or the decrease in moisture) (Delgado et al., 2011). The decrease in cohesiveness and springiness were related to the increases in polypeptide nitrogen and the decrease in casein nitrogen, which happened during the ripening process (Van Hekken et al., 2004). Creamer and Olson (1982) indicated that high acidity in cheese and high protein and total solid contents generally make the cheese harder and with less capacity of deformation, which is in line with our results. However, proteolysis reactions had no considerable effect on the texture formation in this cheese.

### Sensory evaluation

Sensory profile of white brined cheese as affected by fat replacement and reduction are presented in Table 4. Appearance, flavour and total acceptance were significantly affected by fat replacement and reduction, while texture and color were not. Cheese containing vegetable

fat had low flavor notes and was inferior to that of cheese made from whole milk which was with best results and flavor notes. The milk fat product perceived higher sensory scores even though the vegetable fat product was sensory and texturally acceptable. The texture of higher-fat cheeses is generally more acceptable than texture of their lower-fat counterparts (Muir et al., 1997).

Low-fat cheeses were characterized by a lower overall score compared to all other cheese samples. This could be due to the significantly lower fat content in the low-fat cheese (Table 2). In addition, significantly higher scores were attributed to both, cheese-like product and full-fat cheese samples in comparison to low-fat cheese (Table 4). Low-fat white brined cheese-like products received significantly similar scores for body texture compared to full-fat cheese. These findings are in agreement with data reported and Felfoul et al. (2015, 2016) for Gouda and Katsiari and Voutsinas (1994) for Feta cheeses. According to the panellists, full-fat cheese (WC) showed a significantly higher overall



**TABLE 4.** Sensory profiling of of White brined cheese with different fat

		WC			WV			WL		
		Day 1	Day 20	Day 60	Day 1	Day 20	Day 60	Day 1	Day 20	Day 60
Appearance	Mean	14.7	15.9	16.4	17.6	18.8	19.1	11.9	12.3	14
	SD	0.58 <sup>ba</sup>	0.49 <sup>ba</sup>	0.42 <sup>ba</sup>	0.23 <sup>ca</sup>	0.23 <sup>ca</sup>	0.45 <sup>ca</sup>	0.31 <sup>aa</sup>	0.41 <sup>aa</sup>	0.29 <sup>ab</sup>
Texture	Mean	18.4	20.2	22.3	19.8	23.2	25	14.1	16	18.3
	SD	0.82 <sup>ba</sup>	0.70 <sup>ab</sup>	0.53 <sup>ab</sup>	0.23 <sup>ba</sup>	0.43 <sup>ca</sup>	0.09 <sup>aa</sup>	0.29 <sup>aa</sup>	0.34 <sup>ab</sup>	0.40 <sup>ac</sup>
Colour	Mean	12.4	13.2	14.1	12.3	13.1	13.6	11.2	11.4	12.1
	SD	0.33 <sup>ba</sup>	0.40 <sup>ba</sup>	0.37 <sup>ba</sup>	0.71 <sup>ba</sup>	0.39 <sup>bab</sup>	0.50 <sup>bb</sup>	0.63 <sup>aa</sup>	0.71 <sup>aab</sup>	0.38 <sup>ab</sup>
Flavour	Mean	31.3	36.4	39.2	27.3	29.8	32.2	25.8	27.5	30.1
	SD	0.18 <sup>ca</sup>	0.20 <sup>cb</sup>	0.06 <sup>cc</sup>	0.21 <sup>ba</sup>	0.25 <sup>bb</sup>	0.15 <sup>bc</sup>	0.19 <sup>aa</sup>	0.21 <sup>ab</sup>	0.22 <sup>ac</sup>
Overall		77	86	92	77	85	90	63	67	75

WC - Control cheese; WV - White cheese with vegetable fat; WL - White cheese with reduced fat; <sup>a-c</sup>Mean  $\pm$  SD with different letters in the same row indicate significant differences of different samples on the same days (Duncan Test  $P < 0.05$ );

<sup>A-C</sup>Mean  $\pm$  SD with different letters are with significant differences of the same samples but different days (Duncan Test  $P < 0.05$ )

impression with an overall score 92 compared to white brined cheese-like product (WV) and low-fat (WL) with 90 and 75, respectively (Table 4). Fat substitution had a significant effect on the overall assessment of the cheeses. However, all cheeses were appreciated as acceptable by the panellists. This result was in agreement with findings on low-fat Gouda cheese-like product (Felfoul et al., 2015).

## Conclusion

The replacement of milk fat at Macedonian White cheese-like products decreased the dry matter, pH and the acid degree values (ADVs) but increased the hardness, gumminess, chewiness, cheese yield and the contribution of whiteness  $L^*$ . The replacement of milk fat and reduction of milk fat induced some

differences of flavour and colour of cheese-like products and declined their sensory quality. However, the replacement of milk fat improved the texture characteristics of cheese-like products, but they are still unequal compared to control cheese. In conclusion, cheeses with vegetable fat may offer a perfect possibility as an alternative to traditional cheeses offering the similar or more suitable nutritional and texture characteristics without harmful effects on sensory characteristics of cheese.

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## Utjecaj biljne masti na teksturu, boju i senzorska svojstva makedonskog bijelog sira u salamuri

### Sažetak

Cilj ovog istraživanja bio je istražiti utjecaj zamjene mliječne masti palminom masti na sastav, prinos i tehnološku kvalitetu bijelog sira, makedonskog tradicionalnog sira. U ovom istraživanju, punomasni bijeli sir u salamuri služio je kao kontrolni uzorak (WC), dok su eksperimentalni uzorci bili pripremljeni od kravljeg mlijeka uz dodatak biljne masti (WV) i nemasni sir (WL). Sirevima su određivana fizikalno-kemijska svojstva (kiselost, pH, mast, kiselost masti, proteini), parametri teksture pomoću odgovarajuće aparature, parametri boje (L, a, b), te senzorska svojstva nakon 1, 20 i 60 dana. WV sirevi pokazali su značajno ( $P < 0,05$ ) niži stupanj pH i veću titracijsku kiselost od WC i WL uzoraka sira. Sir koji je sadržavao biljnu mast pokazao je niže vrijednosti za stupanj lipolize, koji je određivan preko stupnja kiselosti prilikom senzorske ocjene dobio je značajno ( $P < 0,05$ ) više ocjene za izgled, imao je najveću vrijednost tvrdoće (5226,98 N) i najveće rezultate prinosa sira u usporedbi s ostalim uzorcima.

**Ključne riječi:** bijeli sir u salamuri; lipoliza; parametri teksture; boja; senzorska ocjena

### References

1. Abd El-Salam, M.H. Alichanidis, E. (2004): Varieties ripened under brine. In: *Cheese, Chemistry, Physics and Microbiology*, 3<sup>rd</sup> edn (eds P.F. Fox, P.L.H. McSweeney, T.M. Cogan & T.M. Guinee), vol. 2, pp. 227-251. Elsevier Science and Technology, London.
2. AOAC (2007): *Official Methods of Analysis*. 16th ed. Association of Official Analytical Chemists, Inc. Arlington, Virginia, USA.
3. Bielecka, M., Cichosz, G. (2020): The effect of milk fat replacement and the addition of *Lactobacillus paracasei* LPC-37 on the sensory properties of cheeses. *Mljekarstvo* 70 (1), 28-39.
4. Creamer, L. K., Olson, N. F. (1982): Rheological evaluation of maturing Cheddar cheese, *Journal of Food Science* 47, 631-646.  
<https://doi.org/10.1111/j.1365-2621.1982.tb10138.x>
5. Dabevska-Kostoska, M., Velickova, E., Kuzmanova, S., Winkelhausen, E. (2015): Traditional White brined cheese as a delivery vehicle for probiotic bacterium *Lactobacillus casei*. *Macedonian Journal of Chemistry and Chemical Engineering* 34 343-350.  
<https://doi.org/10.20450/mjce.2015.519>
6. Delgado, F.J., Rodriguez-Pinilla, J., Gonzalez-Crespo J., Ramirez, R., Roa, I. (2010): Proteolysis and texture changes of a Spanish soft cheese ("Torta del Casar") manufactured with raw ewe milk and vegetable rennet during ripening. *International Journal of Food Science and Technology* 45, 512-519.  
<https://doi.org/10.1111/j.1365-2621.2009.02157.x>
7. Delgado, F.J., González-Crespo, J., Cava, R., Ramirez, R. (2011): Proteolysis, texture and colour of a raw goat milk cheese throughout the maturation. *European Food Research and Technology* 233, 483-488.  
<https://doi.org/10.1007/s00217-011-1536-3>
8. Dinkçi, N., Kesenkaş, H., Seçkin, A.K., Kınık, Ö. Gönç, S. (2011): Influence of a vegetable fat blend on the texture, microstructure and sensory properties of kashar cheese. *Grasas y aceites*, 62 (3).  
<https://doi.org/10.3989/gya.091810>
9. Felfoul, L., Bornaz, S., Baccouche, A., Sahli, A., Attia, A. (2015): Low-fat Gouda cheese made from bovine milk-olive oil emulsion: physicochemical and sensory attributes. *Journal of Food Science and Technology* 52, 6749-6755.  
<https://doi.org/10.1007/s13197-015-1736-0>
10. Felfoul, I., Sahli, A., Bali, S. O., Hamadi, A., Bornaz, S. (2016): Comparative study of white brined cheeses obtained from whole milk and milk-olive oil emulsion: Physicochemical and sensory properties. *Mljekarstvo* 66 (4), 304-311.  
<https://doi.org/10.15567/mljekarstvo.2016.0406>
11. Floury, J., Camier, G., Rousseau, F., Lopez, C., Famelart, C. (2009): Reducing salt level in food: Part 1. Factors affecting the manufacture of model cheese systems and their structure-texture relationships. *LWT - Food Science and Technology* 42, 1611-1620.  
<https://doi.org/10.1016/j.lwt.2009.05.026>
12. Fox, P.F., Guinee, T.P., Cogan, T.M., McSweeney, P.L.H. (2000): *Fundamentals of Cheese Science*. Aspen Publishers, Gaithersburg, MD.
13. Georgala, A., Moschopoulou, E., Aktypis, A., Massouras, T., Zoidou, E., Kandarakis, I., Anifantakis, E. (2005): Evolution of lipolysis during the ripening of traditional Feta cheese. *Food Chemistry* 90, 73-80.  
<https://doi.org/10.1016/j.foodchem.2004.09.007>
14. Guinee, T.P. (2016): Protein in cheese products: structure-function relationships. In: McSweeney, P.L.H., O'Mahony, J.A. (Eds.), *Advanced Dairy Chemistry*, vol. 1B Proteins. 4 ed. Springer, New York, pp. 347-415.

15. Hjalmarsson, M. (2015): The effect of vegetable fat on cheese yield and cheese properties. Master Thesis, Swedish University of Agriculture Sciences, Uppsala, Sweden.
16. Huppertz, T., Upadhyay V. K., Kelly A. L., Tamime A. Y. (2006): Constituents and Properties of Milk from Different Species. In Brined Cheese I. Tamime, A. Y (eds.), Blackwell Publishing Ltd, Mystery of Cheese Ripening, , pp 1-42.
17. IDF (1991): *Determination of Free Fatty Acids in Milk and Milk Products*. Bulletin No 265. Brussels, Belgium: International Dairy Federation
18. Katsiari, M.C., Voutsinas, L.P. (1994): Manufacture of low-fat Feta cheese. *Food Chemistry* 49, 53-60. [https://doi.org/10.1016/0308-8146\(94\)90232-1](https://doi.org/10.1016/0308-8146(94)90232-1)
19. Kaya, S. (2002): Effect of salt on hardness and whiteness of Gaziantep cheese during short-term brining. *Journal of Food Engineering* 52, 155-159. [https://doi.org/10.1016/S0260-8774\(01\)00098-X](https://doi.org/10.1016/S0260-8774(01)00098-X)
20. Lobato-Calleros, C., Vernon-Carter, E. J., Guerrero-Legarreta, I., Soriano-Santos, J., Escalona-Beundia, H. (1997): Use of fat blends in cheese analogs: Influence on sensory and instrumental textural characteristics. *Journal of Texture Studies* 28, 619-632. <https://doi.org/10.1111/j.1745-4603.1997.tb00142.x>
21. Marshall, R. J. (1991): Combined instrumental and sensory measurement of the role of fat in food texture. *Food Quality Preference* 2, 117-124. [https://doi.org/10.1016/0950-3293\(90\)90050-5](https://doi.org/10.1016/0950-3293(90)90050-5)
22. Mateva, N., Levkov, V., Srbinska, S., Santa, D., Mojsova, S., Sulejmani, E. (2019): *Characteristics of Traditional Cheeses Produced in the Republic of North Macedonia*. In Traditional Cheeses from Selected Regions in Asia, Europe, and South America. Celile Aylin OLUK, Oya Berkay KARACA (Eds.) Bentham Science Publishers Vol. 1, 1-52.
23. Moatsou, G., Hatzinaki, A., Psathas, G. Anifantakis, E. (2004): Detection of caprine casein in ovine Halloumi cheese. *International Dairy Journal* 14, 219-226. [https://doi.org/10.1016/S0958-6946\(03\)00174-2](https://doi.org/10.1016/S0958-6946(03)00174-2)
24. Mojsova, S., Jankuloski, D., Sekulovski, P., Angelovski, L., Ratkova, M., Prodanov, M (2013): Microbiological properties and chemical composition of Macedonian traditional white brined cheese. *Macedonian Veterinary Review* 36, 13-18.
25. Muir, D. D., Banks, J. M., Hunter, E. A. (1997): A comparison of the flavour and texture of Cheddar cheese of factory or farmhouse origin, *International Dairy Journal* 7 (6-7), 479-485.
26. Noronha, N., O'Riordan, D. E., O'Sullivan, M. (2008): Influence of processing parameters on the texture and microstructure of imitation cheese. *European Food Research and Technology* 226 (3), 385-393. <http://dx.doi.org/10.1007/s00217-006-0549-9>.
27. Official gazette of the Republic of Macedonia; No.96 (2011).
28. Ong, L., Dagastine, R.R., Kentish, S.E., Gras, S.L. (2012): The effect of pH at renneting on the microstructure, composition and texture of Cheddar cheese. *Food Research International* 48, 119-130. <https://doi.org/10.1016/j.foodres.2012.02.020>
29. Papademas, P. (2000): Halloumi cheese: the product and its characteristics. PhD Thesis, School of Food Biosciences, University of Reading, Reading.
30. Pinho, E.M., Alves, M.M., Ferreira, I.M. (2004): Chemical, physical, and sensorial characteristics of "Terrincho" ewe cheese: changes during ripening and intravarietal comparison. *Journal of Dairy Science* 87, 249-257. [https://doi.org/10.3168/jds.S0022-0302\(04\)73163-X](https://doi.org/10.3168/jds.S0022-0302(04)73163-X)
31. Romeih, E.A., Michaelidou, A., Billiaderis, C.G., Zerfridis, G.K. (2002): Low-fat white brined cheese made from bovine milk and two commercial fat mimetics, physical and sensory attributes. *International Dairy Journal* 12, 525-540.
32. Sabbagh, N., Gheisari, H. R., Aminlari, M. (2010): Monitoring the chemical and microbiological changes during ripening of Iranian probiotic low-fat white cheese. *American Journal of Animal and Veterinary Sciences* 5, 249-257.
33. Sarantinopoulos, P., Kalantzopoulos, G., Tsakalidou, E. (2002): Effect of *Enterococcus faecium* on microbiological, physicochemical and sensory characteristics of Greek Feta cheese. *International Journal of Food Microbiology*, 76, 93-105
34. Sulejmani, E. (2014): Study on the specific chemical and biochemical changes in the beaten cheese during ripening. PhD thesis. Ss. Cyril and Methodius University, Skopje, Macedonia.
35. Sulejmani, E., Musliu, Z. H., Srbinska, S. (2014): Influence of Starter Culture, Temperature and Processing Technology on the Quality of Macedonian White Brined Cheese. *Biotechnology in Animal Husbandry* 30 (4), 579-588. <https://doi.org/10.2298/BAH1404579S>
36. Sulejmani, E., Pollozhani, H., Idrizi, X. (2016): Sensory profiling and rheological properties of white brined cheese produced by different starter. *Journal of Hygiene Engineering and Design* 1, 309 - 311.
37. Wennermark, B., Granroth, B., Kruse, B., Tudesjö, C., Atkinson, G., Bergqvist, G., Malmros, H., Alander, J., Karlsson, J., Thieme, J., Johnston, K., Bjornsholt, K., Ingvarsson, L., Håkansson, M., Pedersen, M., Persson, M., Wennermark, M., Johansson, M., Hjorth, M., Persson, P., Shaw, P., Leth Miller, R., Eriksson, S., Fyke, T. (2014): Handbook Vegetable oils and fats. 4. ed. Karlshamn: AAK.
38. Yu, L., Hammond, E.G. (2000): Production and characterization of a Swiss cheese-like product from modified vegetable oils. *Journal of the American Oil Chemists' Society* 77, 917-924. <https://doi.org/10.1007/s11746-000-0145-y>
39. Van Hekken, D. L., Tunick, M. H., Park, Y. W. (2004): Rheological and proteolytic properties of Monterey Jack goat milk cheese during 6 months aging. *Journal of Agriculture and Food Chemistry* 52, 5372-5377. <https://doi.org/10.1021/jf049918q>