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THE LIPOLYSIS PROFILE OF SOME GREEK ARTISANAL CHEESES: A REVIEW OF LAST YEAR'S DATA

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Abstract. In this review the lipolysis level of some Greek artisanal cheeses was studied. Researchers studied the lipolysis profile of the artisanal mountainous hard Kefalotyri cheese made traditionally in Pindos mountains from raw ewe's milk without starter cultures, during summer. Free fatty acids (FFAs) were the most abundant volatile group of this cheese with butyric acid and 3-methyl butanoic acid to be the main. Cheese showed a rather satisfactory hygienic sanitary condition. Researchers studied the lipolysis level of Kashkaval Pindos cheese a semi-hard pasta-filata cheese made from raw ewe's milk without starter addition or made by pasteurized milk with addition of a commercial cheese starter. Raw milk Kashkaval cheeses showed higher levels of lipolysis than pasteurized ones. Butyric, myristic, palmitic, stearic and oleic acids were the main FFAs. All cheeses were found to be safe. Artisanal Tsalafouti cheese resembles to fresh acid an acid rennet curd cheeses with spreadable texture and no gas openings. It is traditionally made from 'boiled' (90^0C) ewe's milk in the mountains at the end of the lactation period. Researchers found a high level of hexanoic acid in a semi-industrial way made cheese. Xinotyri of Naxos Island is an artisanal fully ripened hard raw goat's cheese. Researchers found that FFAs profile was like other goat cheeses with oleic, palmitic, myristic, stearic and capric acid to be the main. Soft Xinotyri Naxos cheese is an acid-curd goat's milk cheese typically made from raw milk. Researchers found a low lipolysis level that was not affected by using raw or pasteurized milk.

Keywords: *Lipolysis, artisanal cheeses, Kashkaval Pindos cheese.*

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1. Introduction

Cheese is known to be an excellent food due to its high nutritional value and its high biodiversity. Traditional cheeses are known to take recognition by consumers during the last years, especially those consumers who care about the nature, origin and nutritional value of food. Traditional cheeses are known to be produced locally or regionally for many years and they have an important role in the rural region food culture (Weichselbaum *et al*., 2009). Artisanal cheeses are frequently linked to certain local regions. They are made by traditional methods in dairy farms using a simple equipment by family members as a staff and without certification or label (Koutsoukis *et al*., 2017). Due to their recognition by consumers during the last years, efforts should be made to standardize the cheese making process. So, safe cheeses of high and constant quality will be produced. In this way the local economy will be supported and export of these cheeses

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outside the region of their production should be done. Trying to meet consumers demands, artisanal cheeses should be produced in an industrial scale. For the promotion of artisanal-local cheeses it is useful to produce them industrially by preserving their traditional character. The transfer of cheese making process from the local small scale to the large industrial includes milk pasteurization, addition of starters, control of ripening conditions, packaging etc. to improve cheese quality and safety. The combination of traditional and industrial cheese making process results in a product that is greatly accepted by the consumers.

Traditional raw milk cheeses are characterized by unique organoleptic and nutritional properties and are greatly appreciated by the consumers. Also, raw milk cheeses had a greater variability than pasteurized ones (Montel e*t al*., 2014). However, there is a potential health risk by using raw milk as pasteurization process eliminates the growth of pathogenic and undesirable microorganisms. To avoid the outbreaks of food-borne illnesses by the consumption of raw milk cheeses, the cheese making process of raw milk cheese should be accompanied by appropriate ripening period and continuous microbiological monitoring until cheese consumption. Also, the hygiene of the environment of milk production and cheese making and the post cheese making phase must be constantly microbiologically tested (Yoon *et al*., 2016).

Lipolysis (lipid hydrolysis) is essential for the development of cheese flavour. Lipolysis results in the formation of FFA, which may directly contribute to cheese flavor, especially short and intermediate chain FFA or act as precursors for other flavour compounds such as esters, methyl ketones and secondary alcohols which are also of importance (Fox *et al*., 1993; Molimard & Spinnler, 1996; Collins *et al*., 2003).

Lipolysis level varies considerably among cheese varieties from slight in many internal, bacterially ripened varieties such as cheddar, gouda and Swiss cheeses to extensive in hard Italian varieties, surface bacterially ripened (smear) cheeses and blue mould cheeses (Woo *et al*., 1984a, 1984b; Fox *et al*., 1993; Fox & Wallace, 1997; McSweeney & Fox, 1993; Collins *et al*., 2003). For some cheese varieties, a specific group of volatile compounds is recognized as being the major contributor to its flavor. In hard Italian cheese varieties FFAs are important contributors to cheese flavor. However, in blue-mould ripened cheeses the impact of FFA to cheese flavour is less than that of Italian varieties. This was due to the dominant influence of methyl ketones to the flavour of these cheeses (Woo *et al*., 1984a, 1984b; Mollimard & Spinnler, 1996). As pasteurization of milk inactivates the majority of indigenous milk lipase, there are significant differences between raw and pasteurized milk cheeses. Also, lipolytic enzymes do not only arise from raw milk but they are also coming from starter and adjunct culture, non-starter bacteria, the rennet paste and exogenous lipases.

A lot of information is available in the literature concerning the lipolysis level of pasteurized milk cheeses that are made at industrial scale. However, there are several artisanal cheese varieties that are produced by small-scale cheese makers at local level in different parts of the world. Artisanal cheeses are an important part of the tradition of many parts of Greece country.

Artisanal cheeses are made in a small-scale by traditional manufacture methods in farms or small dairies. Their manufacture is strongly related to the local culture and the natural resources of the region of production. They are made from raw milk by traditional methods or by pasteurized milk. Due to the more intense and strong flavour of raw milk cheeses there is an increasing consumers' preference for these cheeses as compared to

pasteurized ones. Also, the market of raw milk cheeses continuously expands (Casalta *et al*., 2009, Masoud *et al*., 2012).

Due to the recognition by consumers of artisanal cheeses during the last years, efforts have been made for the standardization of their cheese making process and for the support of local economy as well as for spreading them outside the region of origin (Pappa *et al*., 2021).

This work reviews on last year's literature data concerning the lipolysis profile of some Greek artisanal cheeses.

2. Lipolysis in artisanal Greek cheeses

2.1. Kashkaval cheese

Kashkaval cheese is a pasta filata cheese variety that is produced in many countries. Greek Kashkaval cheese is a local, hard crafted pasta filata cheese which is produced in specific Greece places such as the mountains of Pindos by using a traditional method. The traditional way of Kashkaval cheese making has been referred from the beginning of the previous century. Its production has been transferred from generation to generation. Pappa et al. (2019) studied the characteristics of Kashkaval of Pindos cheese that was traditionally made by using raw or pasteurized ewe's milk, during ripening and storage. Generally, lipolysis was not intense in Kashkaval cheese. Pasteurization of milk significantly affected the total free fatty acids (TFFAs) content of Kashkaval cheese (Table 1). Pasteurized milk cheeses had lower amount of TFFAs than raw ones (Table 1), except for the 30 days cheeses where no differences were found (Table 1). In 90 day cheese, FFAs ranged from 586.2 mg kg^{-1} in pasteurized milk Kahskaval cheese to 2160.6 mg kg^{-1} in raw milk Kahskaval cheese. Also, raw milk Kaskhaval cheeses showed higher levels of individual FFAs than pasteurized ones. This is since milk pasteurization inactivates lipolytic enzymes that are naturally present in raw milk. Butyric acid (C4:0), myristic acid (C14:0), palmitic acid (C16:0), stearic acid (C18:0) and oleic acid (C18:1) are the main free fatty acids found in both raw and pasteurized milk Kaskhaval cheeses (Table 1). Acetic acid (C2:0) is known to be mainly produced from other biochemical pathways than lipolysis e.g. the fermentation of lactic acid (Fox *et al*., 1993). Acetic acid was found in high concentrations in Kashkaval cheeses (Table 1). Pappa et al. (2020) made a semi-industrial Kashkaval of Pindos cheese by using 100% sheep milk (KS) or with the addition of 10% goat milk (KG). The Kashkaval of Pindos cheeses were manufactured considering its traditional cheese making method with some modifications. The free fatty acid content of KS and KG Kashkaval of Pindos cheeses is shown in Table 3. Seven free fatty acids were determined. Total free fatty acids increased from day 60 to day 180 in KS cheese, while in KG cheese they remained stable (Table 3). Butanoic acid 3 methyl, butanoic acid 2 methyl and butyric acid were among the most abundant volatiles found in KS cheese with their peak area $x10^3$ to be 6817.7, 7317.6 and 7814.2, respectively (Table 3). According to the method of Deeth and Fitz-Gerald (1976) the lipolysis level (total free fatty acid content) of KS and KG Kashkaval cheeses increased from 0.7 meqvg^{-1} cheese at day 1 cheeses to 1.30-1.60 meqvg^{-1} cheese at day 180 cheese (Table 4).

Table 1. Free fatty acids (mg kg-1) of hard Xinotyri cheese, fresh soft Xinotyri cheese and Kashkaval cheese during ripening and storage

Cheese type	Ripening time	Treatment	C2:0	C4:0	C4ISO	C5ISO	C6:0	C8:0	C10:0	C12:0	C14:0	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	Total	Reference
Hard Xinotyri cheese	6	1		71.0			75.4	90.7	113.3	83.0	161.7	363.0		219.8	676.5	138.8	114.0	2107.2	Bontinis et al. (2012)
	22	1		140.0			209.4	363.1	688.8	405.0	1220.2	2547.7		1261.6	4157.3	601.0	368.7	11962.9	
	45	1		145.5			268.3	504.3	873.2	492.0	1516.9	3992.0		1464.7	5144.2	714.0	452.7	15567.8	
	90	1		172.4			268.7	494.3	886.1	512.6	1609.0	4621.1		1499.8	5690.0	817.0	483.0	483.0	
	180	1		286.3			398.3	763.7	1228.6	643.0	1854.8	4357.7		1591.0	7256.0	1088.3	588.0	588.0	
Fresh soft acid-curd Xinotyri goat's cheese	1	1	111.6				87.0	99.6	98.2	123.1	185.6	556.7		251.8	641.7	181.4	92.3	2429.1	
	1	2	102.7				94.9	85.7	87.2	70.6	118.3	201.5		143.1	312.0	125.7	77.6	1419.3	Pappa et al. (2017)
	15	1	119.2				91.7	102.3	107.5	109.3	182.1	561.9		238.1	623.3	163.6	87.6	2386.5	
	15	2	72.9				92.7	79.7	84.1	70.6	110.9	207.3		142.8	288.7	137.0	76.7	1363.4	
	30	1	74.7				107.7	196.6	186.8	152.8	220.8	668.2		266.0	1000.4	272.1	130.2	3276.3	
	30	2	62.1				94.4	86.8	90.2	72.9	116.7	229.6		144.9	437.6	163.7	79.2	1578.3	
	60	1	54.6				134.1	300.4	290.4	228.9	298.5	888.1		349.8	2559.6	417.0	175.0	5696.4	
	60	2	67.9				83.1	133.3	135.0	137.4	156.2	366.29		195.7	487.8	229.2	83.7	2075.7	
Kashkaval cheese	1	1	269.7	5.7	4.7	7.1	27.2	2.5	10.4	27.5	33.7	102.1	11.0	53.7	56.5	2.3		615.1	Pappa et al. (2019)
	1	2	142.7	3.9	1.8	4.4	27.7	1.9	7.3	17.5	14.9	80.8	5.4	31.2	42.4	0.5		351.9	
	30	1	561.3	28.8	8.0	14.5	30.6	6.4	24.2	28.2	122.9	276.9	13.4	99.4	175.1	8.2		1387.8	
	30	2	192.6	12.0	2.9	7.0	31.7	2.8	15.5	25.8	47.1	125.6	7.4	54.3	76.6	3.2		604.4	
	60	1	779.5	49.8	18.5	17.2	29.4	7.7	46.3	29.4	126.9	284.2	13.8	100.9	195.5	12.0		1707.0	
	60	2	188.0	26.5	10.7	8.4	29.6	3.5	20.1	34.7	65.2	163.2	10.3	54.0	113.6	4.6		650.0	
	90	1	856.9	55.8	50.1	18.0	31.7	11.2	44.0	52.9	187.5	397.9	20.2	138.9	280.6	15.1		2160.6	
	90	2	292.9	47.9	26.6	13.6	26.3	4.2	20.2	32.1	66.2	148.6	9.8	58.1	106.5	7.0		586.2	
	180	1	967.9	234.4	61.5	56.0	31.5	16.7	67.6	62.3	222.9	444.7	26.4	136.1	335.4	17.4		2680.5	
	180	2	330.7	98.4	33.5	20.1	30.7	4.7	31.5	30.3	89.1	201.7	12.5	74.3	147.1	8.4		887.0	

1: Cheese made from raw milk, 2: Cheese made from pasteurized milk

Table 2. Free fatty acids (peak area x 10^3) in mountainous Kefalotyri cheese and Tsalafouti cheese during ripening

		Ripening days		Reference
Cheese type	Free fatty acids	Day-90	Day-180	Pappa et al. (2021)
Mountainous Kefalotyri cheese	Acetic acid	225.5	270.2	
	Butyric acid	2238.3	1629.6	
	Butanoic acid 2 methyl	251.3	201.3	
	Butanoic acid 3 methyl	595.5	744.8	
	Hexanoic acid	262.9	247.5	
	Total free fatty acids	3573.7	3093.5	
		Ripening days		Reference
Cheese type	Free fatty acids	Day-30		Pappa et al. (2022a)
Tsalafouti cheese	Hexanoic acid	2837.07		
	Octanoic acid	1960.85		
	Total free fatty acids	4797.92		
Tsalafouti cheese	Free fatty acids	Day-30		Pappa et al. (2022b)
	Butanoic acid-2ethyl	435.2		
	Hexanoic acid	813.93		
	Octanoic acid	3833.5		
	Free fatty acids	Day-30		
Tsalafouti cheese	Acetic acid	1173.4		Pappa et al. (2023)
	Hexanoic acid	4287.68		
	Octanoic acid	2378.13		
	Total free fatty acids	7839.21		

Table 3. Free fatty acids (peak area x 10^3) of semi-industrial produced Kashkaval of Pindos cheese made from 100% sheep milk (KS) or a mixture of 90% sheep milk-10% goat milk (KG) during ripening and storage

Kashkaval cheese	60 Day		90 Day		180 Day		Reference
Free fatty acids	KS	KG	KS	KG	KS	KG	Pappa et al. (2020)
Propanoic acid, 2 methyl	3636.63	2314.9	3558.8	1486.6	5052.8	2061.3	
Butanoic acid, 2 methyl	7317.6	1667.7	9961.35	1880.55	24,456.6	2256.15	
Butanoic acid, 3 methyl	6817.7	4928.25	7821.7	4091.3	26,031.7	3465.6	
Hexanoic acid	3494.3	2094.93	3479.07	4079.5	5315.05	4191.97	
Hexanoic acid, 2 ethyl	137.9		1114.6	1198.65		802.3	
Butyric acid	7814.2				13,580.2		
Octanoic acid					1061.7		
Total free fatty acids	29,218.3	11,005.8	25,935.5	12736.6	75,498.05	12,777.3	

Table 4. Changes of total free fatty acid (TFFA) content (meqv g^{-1}) of Kashkaval of Pindos cheese made from 100% sheep milk (KS) or a mixture of 90% sheep milk and 10% goat (KG) milk during ripening and storage

Time (Days)	Cheese	TFFA (meqv g^{-1})	Reference
1	KS	0.7	Pappa et al. (2020)
1	KG	0.7	
6	KS	1.0	
6	KG	0.9	
30	KS	1.2	
30	KG	1.2	
60	KS	1.1	
60	KG	1.1	
90	KS	1.1	
90	KG	1.2	
180	KS	1.3	
180	KG	1.6	

Table 5. Free fatty acids of industrial and artisanal Manouri cheese samples

	Retention time (min)	Cheese samples				Reference
		S1	S2	S3	S4	
		Relative peak area (%)				
Butanoic acid (C4:0)	4.11	2.17	0.55	0.28	2.60	Bintsis et al. (2024)
Hexanoic acid (C6:0)	11.88	4.21	1.23	2.75	7.15	
Heptanoic acid (C7:0)	16.26	0.09	n.d	0.24	0.27	
Octanoic acid (C8:0)	21.42	14.28	2.44	16.93	21.85	
Nonanoic acid (C9:0)	25.74	0.33	1.40	0.54	0.47	
Decanoic acid (C10:0)	30.72	30.29	5.98	42.83	46.02	
Dodecanoic acid (C12:0)	38.8	2.73	2.70	7.81	4.91	
Tetradecanoic acid (C14:0)	46.44	0.79	6.85	2.64	1.41	
Hexadecanoic acid (C16:0)	53.52	0.74	18.86	1.88	0.76	
Oleic acid (C18:1, cis-9)	58.39	3.65	21.75	n.d	n.d	
Stearic acid (C18:0)	58.86	0.49	10.90	n.d	n.d	
Total free fatty acids		59.86	74.95	75.90	85.45	

S1: artisanal Manouri from dairy A, S2: artisanal Manouri from dairy B, S3: industrial Manouri from dairy B, S4: industrial Manouri from dairy C. Values were expressed as relative peak area (%) =100×(peak area of individual FFAs/total peak area of identifed FFAs)

Table 6. Evolution of lipolysis during ripening and storage of hard Xinotyri cheese

Cheese ripening and storage time (days)	Acid degree value (ADV)	Reference
6	1.70	Bontinis et al. (2008)
22	7.47	
45	8.45	
90	8.67	
180	9.75	

Acid degree value (ADV): meq KOH $100g^{-1}$ fat

2.1. Soft Xinotyri cheese

In Greece, several acid-curd cheeses are traditionally produced from raw, thermized or pasteurized milk. These cheeses are consumed fresh or after ripening for various times.

Soft Xinotyri cheese is an acid-curd goat's milk cheese variety that is produced traditionally in Naxos Island of the Cycladic complex. Soft Xinotyri cheese is not shaped and is consumed as fresh or ripened and it is cold stored. At Naxos Island, soft Xinotyri is typically produced from raw milk. However, there is in the use of pasteurized milk for making soft Xinotyri cheese due to safety reasons and consumers demands. Pappa et al. (2017) studied the lipolysis level of soft Xinotyri cheese that was made from raw or pasteurized milk without the addition of starter cultures, during aerobic storage at 4^0C for 60 days. Samples were taken after 1, 15, 30 and 60 days of aerobic storage at 4^0C. The results showed no significant differences in individual as well as in total FFA content between raw and pasteurized milk soft Xinotyri cheese. This probably happens as the time of 60 days is short enough to arise important differences in lipolysis level between raw and pasteurized milk cheeses. Regardless the use of raw or pasteurized milk the most abundant free fatty acids found in soft Xinotyri cheese were oleic (C18:1), palmitic (C16:0), myristic (C14:0), capric (C10:0) and caprylic (C8:0) acids (Table 1). Raw milk cheeses had a higher amount of lauric acid (C12:0) than pasteurized ones by day 15 (Table 1). Also, raw milk cheeses had higher levels of palmitic acid (C16:0) and stearic acid (C18:0) than pasteurized milk cheeses throughout and by the end of storage-day 60 (Table 1). The total free fatty acid (TFFA) content of soft Xinotyri cheese throughout storage indicates a low lipolysis level for both raw and pasteurized milk cheeses (Table 1).

2.2. Hard Xinotyri cheese

Xinotyri cheese is a hard short-ripened farmhouse cheese that is made from raw goat milk from indigenous breeds in the mountains of Naxos Island in the Cyclades complex. Often goat's milk is mixed with a small amount (5%) of ewe's milk. No starter cultures are added. The artisanal cheese ripening is done for 45 days, after which the cheese is ready for sale (Bontinis *et al*., 2008). However, in summer its ripening time is shorter (around 30 days). The ripened (45-day-old) cheese is then stored at 40C for up to 180 days under aerobic conditions (Bontinis *et al*., 2008). Bontinis et al. (2012) studied the lipolysis profile of traditional Greek hard goat Xinotyri cheese during ripening. Free fatty acids content was found to increase significantly during hard Xinotyri cheese ripening and storage (Table 1). Oleic, palmitic, myristic, stearic and capric acid were the most abundant free fatty acids determined in hard Xinotyri cheese (Table 1). Total free fatty acid content of 6-day hard Xinotyri cheese differ significantly of that of 45 days cheese and of cheeses of the following days (Table 1). Hard artisanal Xinotyri cheese showed an intense lipolysis with total FFA content to be 20,024 $mgkg^{-1}$ at 180 days cheese. A 15% percent of the total free fatty acids were short and medium chain acids (C4:0 to C12:0). An intense accumulation of palmitic acid (12-fold) followed by myristic acid (11,5-fold), capric acid (10.8-fold) and oleic acid (10.7-fold) was found during ripening and storage of hard Xinotyri cheese (Table 1). Bontinis et al. (2008) studied the characteristics of hard raw traditional Xinotyri cheese during ripening and storage. Lipolysis level was found to increase during ripening and storage of hard Xinotyri cheese (Table 6). Free fatty acid content as estimated by Acid Degree Value

(ADV) increased from 6-day-old cheese (1.70 meq KOH 100 g^{-1} fat) to 22-day-cheese (7.47 meq KOH 100 g^{-1} fat) and thereafter (Table 6). The final value of 9.75 meq KOH 100 g^{-1} fat in the 180-day-old cheese (Table 6) shows the intense lipolysis level found in hard Xinotyri cheese (Bontinis *et al*., 2008).

2.3. Mountainous Kefalotyri cheese

Kefalotyri is a traditional hard Greek cheese that is made from ewe's or goat's milk or mixtures of them. Sometimes cow's milk can be used. Kefalotyri cheese is produced in various parts of Greece with technologies that vary from place to place. Kefalotyri cheese is thought to be the ancestor of many hard Greek cheeses. A very popular Kefalotyri cheese is the artisanal mountainous Kefalotyri cheese that is still traditionally manufactured in the mountains of Pindos, Greece. This artisanal Kefalotyri cheese is made by using raw ewe's milk without the addition of starter cultures, during summer (Anifantakis, 1991). Pappa et al. (2021) studied the biochemical characteristics of mountainous raw milk Kefalotyri cheese that was made without the addition of starter cultures, during ripening and storage. Five free fatty acids were determined in Kefalotyri cheese (Table 2). Free fatty acids were the most abundant group of volatiles found. However, butyric acid and 3 methyl butanoic acid were the most abundant free fatty acids determined with their peak area$x10^3$ to be 2238.3 and 595.5, respectively (Table 2).

2.4. Tsalafouti cheese

Tsalafouti is a traditional Greek cheese that resembles to fresh acid and acid/rennet curd cheeses. It has a spreadable texture with no gas openings. Due to its high moisture level, Tsalafouti cheese has a relative low-fat content that makes it a healthy alternative for consumers that are on diet. Due to its pleasant organoleptic characteristics which are much appreciated by the consumers there is an increasing trend for making Tsalafouti cheese during the last years. Artisanal Tsalafouti cheese is traditionally made in the mountains mainly of the Greek regions Agrafa and Tzoumerka from ewe's milk at the end of the lactation period. The milk is 'boiled' (90^0C) and then is left to acidify. Milk ripens naturally by the action of indigenous microbiota, mainly mesophilic lactic acid bacteria (LAB) which grow slowly at approximately 10^0C for 15-20 days (Pappa *et al*., 2022a, 2022b).

Pappa et al. (2022a) studied the characteristics of traditional Tsalafouti that was made by using artisanal technology at the end of the lactation period, during summer, in the mountains of Tzoumerka, in Northwestern Greece (Theodorina village, height 1000m). Two free fatty acids were determined in Tsalafouti cheese (Table 2). These acids were hexanoic acid (2837.07 peak area $x10^3$) and octanoic acid (1960.85 peak area x 10^3) (Table 2). As consumer's demand for Tsalafouti product is regular throughout the year and its seasonal manufacture during summer at the end of the lactation period limits its expansion to the markets, Pappa et al. (2022b) used a semi-industrial method to produce Tsalafouti. Tsalafouti was produced by applying the artisanal manufacturing process under semi-industrial (pilot-plan) conditions by using a commercial multi starter culture containing of a mixture of the mesophilic strains *Lactococcus lactis* subsp. *lactis* and *Lactococcus lactis* subsp. *cremoris*. Free fatty acids were not found in high amounts. However, hexonoic acid (C6:0) was the most abundant free fatty acid determined (Table 2). Also, Pappa et al. (2023) studied the

biochemical characteristics of Tsalafouti cheese that was industrially produced from ewe's milk in two Greek dairy companies. Three free fatty acids were determined in industrial Tsalafouti cheese (Table 2). These acids were acetic acid (1173.4 peak area$x10^3$), hexanoic acid (4287.68 peak area$x10^3$) and octanoic acid (2378.13 peak area$x10^3$) (Table 2).

2.5. Manouri P.D.O. cheese and Artisanal Manouri cheese

Manouri is a protected designation of origin (P.D.O.) Greek whey cheese with a high fat content (minimum 70% fat-in dry matter) and a creamy body, delicate texture and superior sensory quality. Bintis et al. (2024) studied the volatile content of Manouri (P.D.O.) and Artisanal Manouri cheeses. Artisanal Manouri is produced mainly in Western Macedonia place of Greece. It is seasonally produced by using caprine milk following a special cheesemaking procedure. To produce Artisanal Manouri cheese, whey that is obtained during the production of the white-brined cheese Batzos is used. Bintis et al. (2024) describe the manufacture procedure of Artisanal Manouri cheese that is nowadays made in only two dairies of Western Macedonia, Greece. Manouri P.D.O. cheese is produced by using the whey from ovine and caprine cheeses such as Feta, Graviera, Kefalotyri. Bintis et al. (2024) refer the cheese making procedure of Manouri P.D.O. cheese. Manouri cheese is known to be consumed freshly without any ripening. Bintis et al. (2024) manufactured four Manouri whey cheeses. Two of them were made according to the traditional process. One artisanal Manouri cheese-named S1-was made in dairy A that is in Milochori, municipality of Eordea, while the other artisanal Manouri cheese-named S2- was made in dairy B, located in Mikro Sirini, municipality of Grevena. The other two cheeses were industrial Manouri P.D.O. cheeses that were made in dairy B -cheese named S3- located in Mikro Sirini and in dairy C-cheese named S4 located in Alexandria, municipality of Alexandria. All Manouri cheese samples were chosen from the same batch. Free fatty acids (FFAs) were found to be the most abundant class of volatile compounds in both Artisanal and P.D.O. Manouri cheeses, especially the medium chain (C6:0 to C12:0) ones. Decanoic (C10:0) acid was the predominant fatty acid found, and it reaches up to 46% of the RPA (Relative Peak Area) mainly in S3 and S4 industrial P.D.O. Manouri cheese samples (Table 5).

3. Conclusions

Although there is an extensive knowledge on the lipolysis level of certain cheese varieties, the lipolysis profile of some artisanal Greek cheeses is not well known to the wide public. This review has collected the last years' literature data on the lipolysis profile of some Greek artisanal cheeses and gave a more complete knowledge on these cheeses providing also a small description of their general properties-characteristics and manufacture procedure. The use of raw milk affected the lipolysis level of artisanal cheeses. Lipolysis in raw milk cheeses is different from that of pasteurized milk ones as pasteurization inactivates some enzymes that could play an important role in cheese ripening such as milk lipases. The lipolysis level differed among the cheeses referred in this study, indicating that lipolysis could be a useful index for characterizing these cheeses. The applied cheese making technology and the cheese age influenced the level of lipolysis of artisanal Greek cheeses. Cheeses made from raw milk process strong and unique flavors and are still sold in many

parts of the world although due to hygienic reasons most cheeses are made nowadays from pasteurized milk.

Raw milk Kashkaval of Pindos cheeses showed higher lipolysis levels than the pasteurized ones. In general, no differences in lipolysis were observed between sheep milk and goats' (10%) Kashkaval cheeses. Lipolysis of soft Xinotyri cheese was not affected using raw or pasteurized goat's milk. An intense lipolysis was observed in hard Xinotyri cheese. FFAs were the main volatiles found in mountainous Kefalotyri cheese. FFAs of Tsalafouti cheese were not found in high amounts. Free fatty acids (FFAs) were found to be the most abundant volatiles in both Artisanal and P.D.O. Manouri cheeses.

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