Food and Nutrition Sciences, **2014, 5, 425-434**
Published Online February 2014 (http://www.scirp.org/journal/fns)
http://dx.doi.org/10.4236/fns.2014.54050

Aroma Compounds of Some Traditional Turkish Cheeses and Their Importance for Turkish Cuisine

Fügen Durlu-Özkaya[1], İlhan Gün[2]

[1]Gastronomy and Culinary Art Department, Tourism Faculty, Gazi University, Ankara, Turkey; [2]Food Process Department Milk and Products Technology Programme, Vocational School of High Education, Mehmet Akif Ersoy University, Burdur, Turkey.
Email: fdozkaya@hotmail.com, fugen@gazi.edu.tr, igun@mehmetakif.edu.tr

Received November 20th, 2013; revised December 20th, 2013; accepted December 27th, 2013

ABSTRACT

Cheese is so important to the Turkish cuisine. It is eaten plain as part of the traditional Turkish breakfast, used in salads, and incorporated into cooked foods such as börek, pide, menemen and also used for some traditional desserts. There are several types of cheeses with different characteristics and aroma compounds, and they can be used for preparation of various foods as an additive. The formation of cheese aroma basically associated with lipids, proteins and lactose content of milk, besides raw or pasteurized milk, starter or non-starter bacteria, ripening conditions. Cheese flavoring agent is used in a variety of products such as salads, pizza, breads. General properties of some traditional Turkish cheeses, their aroma compounds and importance for Turkish cuisine are discussed.

KEYWORDS

Cheese; Aroma Compounds; Turkish Cuisine

1. Introduction

There are several types of cheeses having various structure, shape and taste due to numerous factors especially in our country which is the centre of East and West Culture. Many factors affect the cheese variety. These can be listed as: the type of the milk (cow's, sheep's and goat's milk cheese), the method of clotting (acid, coagulating enzyme cheese), the process in which whether milk is exposed to heating process or not (raw or pasteurized cheese), its fat ratio (whole, low-fat, non-fat), its structure (very hard, hard, soft cheese), its salt ratio (salted, unsalted cheese), its additives (several herbs and spices, salts for melting and cheese made by supporting its mould growth) and its ripening period (fresh, semi-ripened and ripened cheese) [1-3].

Many researchers have been studying about the flavor of dairy products especially cheese for a long time. Flavor development of cheese is conditional upon various biochemical changes of the product including lipolysis, proteolysis, lactose fermentation and formation of volatile compounds. So, aroma compounds of different cheese varieties occur and cheese has special characteristics during maturation according to milk type, rennet properties, manufacturing process and ripening conditions and additives such as spices (mint, nigella sativa, chili pepper) and different herbs. The environment conditions play an important role in cheese maturation and affect taste and odour of cheese. Many researches show that volatiles in cheese are more than 600 compounds [4]. The first stage of cheese flavor is the formation of amino acids, free fatty acids, lactic acid by degradation of protein, fat and lactose by many microorganism and its enzymes [5].

The determination of cheese aroma profile is very complex. Furthermore, it is known that though all aromatic compounds are volatile, not all volatile compounds are aromatic. Besides this, the most abundant volatiles may have few aromatic properties and the amount of aroma compounds of cheese may change during different process stage.

The formation of cheese aroma associated with lipids, proteins and lactose content of milk, besides raw or

pasteurized milk, starter or non-starter bacteria, ripening conditions *i.e.* It is known that pH value of the cheese affects the concentration of volatile aroma compounds especially free fatty acid composition. These are mainly acids dissolved in the fat phase of the cheese [6]. Fatty acids are important and predominant components of the flavour of many cheese types. Furthermore, they serve as precursors of methyl ketones, alcohols, lactones and esters during lipolysis of milk fat and the breakdown of amino acids. Esters are common cheese volatiles occurring from fatty acids, alcohols derived from lactose fermentation and from amino acid catabolism of protein [7,8]. Protein, the main components of milk, has also aromatic properties due to aromatic amino acids including phenylalanine, tyrosine, tryptophan and methionine. Lactose, lactate and citrate make a great contribution to the formation of diacetyl, acetoine, ethanol and acetate [9].

The flavour volatiles and their formation in many types of cheeses (*i.e.* Swiss Gruyere, Grana Padona, Cheddar, Ezine, Beyaz, Çökelek, Carra and Kashar cheese) have been described by many authors [8,10,11,12-14]. Several techniques have been also proposed to the identification and quantification of volatile aroma compounds in cheese. Static and dynamic headspace tecniques for GC-MS, liqued-liqued and liqued-solid direct extraction, GC-MS with SPME, GC-Olfactometery, thermal desorption. The manufacturing process and aroma characteristics of some important Turkish cheese varieties are as follows, and their general composition is given in **Table 1**.

2. Beyaz and Ezine Cheese

Beyaz cheese which is produced in all region of Turkey, especially in Thrace, Marmara, Aegean and Central Anatolia regions is known mostly as pickled, tinned or Edirne cheese [1,3]. Geographical conditions of each region, its plant habitat, animal material and technological processing are important for the formation of flavour and structure unique to these cheeses. Raw and pasteurized milks used cheese manufacturing are clotted by being added şirden (as called rennet) after heated to clotting temperature and the cheese is portionized after compressing in mat and after being salted in brine which is made specially by ripening and than it is marketed (**Figures 1** and **2**) [15]. One of the most important factors for Beyaz cheese technology is whether cheeses have

Figure 1. Beyaz cheese.

Figure 2. Ezine cheese.

Table 1. General composition of some Turkish cheeses.

Cheese type	General cheese composition			
	Dry matter (%)	Fat (in dry matter) (%)	Salt content	
			Salt (%)	Salt in dry matter (%)
Beyaz cheese (with cow milk)	40.0	45.0	3.0	7.50
Beyaz cheese (with sheep milk)	50.0	55.0	5.0	10.00
Kaşar cheese	56.0	44.0	3.0	5.36
Tulum Cheese	54.0	51.5	3.0	5.56
Lor cheese	34.0	42.0	1.0	2.94
Çökelek cheese	31.0	34.0	2.5	8.06
Van herby cheese	48.0	38.0	6.0	12.50
Kurut cheese	81.0	14.0	4.5	5.56

pores or not. For cheeses produced by raw milk, the growth of microorganisms from the coliform group causes the formation of pores on cheeses and this gives them a sponge-like structure. However raw milk's cheeses should be pickled at least during three months. The required structure for Beyaz cheese is that it should have a structure without pores [1].

Beyaz cheese is produced generally by whole cow's milk. However, except the usage of half-fat or non-fat milk for its production, there are other kinds of cheeses depending on regional changes. These are Edirne caned Beyaz cheese produced whole milk with 60% sheep's, 30% goat's and 10% cow's milk, Urfa pickled beyaz cheese produced by raw sheep's milk, Konya caned pickled goat's cheese produced by goat's milk [16]. Aroma profile of Beyaz cheese is not clear, but the research on this cheese goes on.

A research on the characterization of aroma profile in Beyaz cheese by Kocak *et al*. had indicated that full fat Beyaz cheeses had 11 in asidic fraction and 30 in neutral/basic fraction (total 41) and low fat white cheeses have 13 in asidic fraction and 21 in neutral/basic fraction (total 34) volatile compounds [17]. At the same research, according to gas chromatography-olfatometre results showed that 15 aroma-active compounds in full fat Beyaz cheeses (8 in asidic fraction, 7 in neutral/basic fraction) and 12 aroma-active compounds in low fat white cheeses (6 in asidic fraction, 6 in neutral/basic fraction) were characterized. The authers pointed out that acids, sour, fatty acid, butter, vinegar, candy apple, caramel, burned were dominant in both type white cheeses. Furthermore, some aroma-active compounds such as fruity, floral, spicy, smoked, boiled potato were also determined.

Ezine cheese is produced from ewe and goat milk's collected from Ezine, Bayramiç, Ayvacık and Çan regions in North and West of Kaz Mountain in Turkey (**Figure 2**). Ezine cheese structure is similar with White cheese, but taste and odour of Ezine cheese is different because of milk type, season and plant covering of region. Sulphur compounds, aldehydes, esters and acidic components play an important role on flavor of Ezine cheese [11]. The aroma compounds in Ezine cheese were studied with Thermal Desorption Gas Chromatography Olfactometry (TD-GCO) technique by Karagül Yüceer *et al*. [13]. Butyric acid plays an important role in Ezine cheese characteristic aroma profile. Furthermore, the characteristic aroma active compounds responsible to Ezine Cheese aroma as follows; Acetaldehyde (green apple), diacetyl (butter), hexanal (cut-grass), ethylbutanoat (sugar bubble gum), dimethylsulfide (cooked corn), (Z)-4-heptenal (oxidized fat), 1-octen-3-one (mushroom), acetic acid (vinegar) and butyric acid (rancid). Avşar *et al*. indicated that gas chromatography-mass spectrometre results obtained from Ezine cheese had 54 volatile compounds including 37 in neutral/basic fraction and 17 in acidic fraction [11]. The most predominant aroma components of this cheese were acids (acetic acid, butanoic acid, hexanoic acid, benzoic acid), esters (ethyl hexanoate, ethyl octanoate, ethyl dedonoate) alcohols (3-methyl-1-butanol, phenyl ethanol, phenol), lactones (δ-decalactone, δ-dodecalactone), phenolic components (p-cresol, m-cresol). In this research, it was note that the most important acid in 17 was acetic acid, butanoic acid, hexanoic acid. Furthermore, 3-octen-1 ol, 2 acethyl-1-phyrroline and methional are important components were noted as important odorant in neutral/basic phase of cheese.

Beyaz and/or Ezine cheeses are served as an appetizer, side dish and as an ingredient in salads, filled pies and pastries. Its use in preparing and serving Turkish food is almost imperative. These cheeses may be used in most recipes that call for cheese: vegetable and fruit salads, filled pies, as a topping for or ingredient in cooked rice and tomato-based pastas, as a filling for omelets, in sandwiches. It is eaten mostly at breakfast. Additionally it is the main ingredient in appetizers when served Turkish traditional drink "Rakı".

3. Kaşar Cheese

Kaşar cheese is one of the most consumed cheese types in Turkey (**Figures 3** and **4**). It is especially common in Thrace, Central Anatolia and East Anatolia regions as

Figure 3. Unripened kaşar cheese.

Figure 4. Ripened (Old) kaşar cheese.

well as it are produced nearly in all regions. Although traditional Kaşar cheese is made by sheep's milk, today the usage of cow's milk has been common in many cities such as Adapazarı and Kars. It ranges from regions and it is produced as blocks of 6 - 10 kg or 12 kg. When assessed in compliance with their appearance, shells and surfaces of cheeses produced in our Eastern cities are moldy and have amber color, but those produced in our Western cities are not moldy and have yellow color [18]. The production technique of Kaşar cheese is as same as that of beyaz cheese, however their compression process are different. Their main difference begins with putting teleme, as called structure of curd obtained after pressing, into the fermentation. In traditional production, the compatibility of acidity growth is determined by the processes such as "*yaprak açma*" and "*sicim çekme*". At the end of this process, if the mass has a structure which is smooth, stretchable and undetachable, this means that teleme has become appropriate structure for boiling. When the desired acidity degree is obtained, teleme is cooked in the boiling water of 70˚C - 80˚C having salt of 3% - 5% by being cut as small slices and is made dough. Then, this dough is molded roundly and then it is shaped. After its preparation, kaşar cheese is kept on the shelves, in a sack or in appropriate shops during six months in order to provide its ripening. Kaşar cheese can be kept in a cold place during two even three years [1,3]. The most known kaşar cheeses can be given example such as Kars kaşar cheese made by cow's milk, Kırklareli kaşar cheese made by goat's milk, Trabzon Kadırga kashar cheese made by whole sheep's and goat's milk, Tonya and Muş kaşar cheeses made by cow's milk and Bayburt kaşar kırığı made by mixing lor to the teleme [18].

Besides Kaşar cheese produced by traditional method, fresh (unripened) kaşar cheeses which are made by adding melting salt, acid regulator and substances for keeping water are began to be produced in our country in order to be used in many fast-food restaurants. It is not certainly known which kind of risks theses cheeses, having a significant differences in compliance with their cost, have [2].

Kars Kaşar cheese is very important cheese type in East Anatolia and is ripened 3 or 4 mounts, so flavour profile of cheese differs from fresh Kaşar cheese produce with melting salts. Gas choromatography-olfactometry analysis of Ripened Kashar cheese showed that acetic acid, butanoic acid and 3-methylbutanoic acid were contributed to formation of characteristic Kaşar cheese aroma [11]. Besides these acids, aroma extract dilution analysis (AEDA) results were showed that diacethyl, 3-methyl-1-buthanol, 2 - 3 butanediol, hexanal and methional components among to neutral and basic phase in cheese were played an important role on aroma. Avşar *et al*. reported that Kaşar cheese was 113 volatile compounds, but 41 of them were aroma active components affects on aroma [11]. Butanoic acid, which has a rancid taste, was detected to have the highest concentration in Kaşar cheese. The other important acids were acetic, hexanoic and benzoic acids were determined as predominant acids. Eleven acids including acetic, butyric, hexanoic and 3-methyl butanoic acids were identified in Kaşar cheese ripened 6 - 10 months using solid phase microextraction by Hayaloglu *et al*. [12]. This acids generally responsible for fruity flavours in cheese. Furthermore, ethanol, 2-methyl 1-propanol, 2-methyl 1-butanol, 3-methyl 1-butanol, 2-butanol and 2-pentanol were determined in twenty Kaşar cheese samples. Ethyl acetate, ethyl butanoate and ethyl lactate were major ethyl ester group. The amount of δ-octalactone which is responsible for buttery and fruity aroma were 21.2 - 83.0 µg/kg in cheese samples [11]. Besides phenol, 3 methyl-1-butanol and p-cresol which is responsible for cowy-barny were detected. The major ketones were identified as 2-propanone, 2-butanone, 2-pentanone, 2-heptanone, 3-hydroxy 2-butanone and diacetyl in samples [12]. Aldehydes were found in low concentrations, but 2-methyl propanal, 2-methyl butanal and 3-methyl butanal were predominant within six aldehydes. Terpens are volatile compounds originating exclusively from plants that can be found in dairy product. α-pinene and *p*-cymene are generally the major terpenes in cheese and the samples. b-pinene and limonene were also important terpens in Kaşar cheeses aroma [12].

Kaşar cheeses, both ripened and unripened, most often accompanies with beyaz cheese at breakfast. Unripened kaşar also used on pizzas, in sandwiches and salads and as the main ingredient in Turkey's classic fast food "tost". In English, it's called as toasted sandwich. Additionally it is used for tomato soup, macaroni as a flavouring and for preparation of pane. These cheeses may be used in most recipes that call for cheese: vegetable and fruit salads, filled pies, tomato-based pastas, as a filling for omelets, in sandwiches or on baked foods in the same way as mozzarella cheese. Because of it's rancid taste, was detected to have the highest concentration in Kaşar cheese, can be used as a savory food with several kind of wines.

4. Tulum Cheese

One of the methods used by Turkish people from Middle-Asia to today in order to increase the endurance of the cheese is put the cheese in leather bag as called Tulum in Turkey. Tulum is one of the most used in Toros plateaus except Thrace region and it is prepared for the consumption in family. For its production, whole milks as well as non-fat milk left over from butter production are used. Tulum which is called as "*Tulkuk*" or "*tulûk*" is made by capricorn's, milk-fed lamb's, sheep's or goat's

skin (**Figure 5**).

In Burdur region, Tulum which is made by Capricorn's or sheep's skin in which cheese or çökelek is put is called as "*bağalak*" or "*bağana*", it is called as "cheese bağanası" which is made by sheep's skin in Konya. "Tomas cheese" which is among the cheeses produced in Tulum in Malatya took its name from the word of tomas which means in Greek as "leather" [3,16,19,20].

Tulum cheese is included in the group of hard cheeses which have a certain ripening process and which are not consumed immediately. For its production, whole or non-fat sheep's, goat's or cow's milk are used [21,22]. The curd obtained from raw or pasteurized milk's renneting is pressed. And then the teleme is salted and brought into small pieces by cutting them into small slices by hand or by special knives. It is put into tulum prepared before or into plastic or metal boxes. It is kept during about three months for its ripening. Tulum cheese has a high nutrition level, it has not pores and it has sharp odor. It is a sorrow cheese that ignites nasal fossae. The color of the cheeses made into the tulum is yellow on the parts of which are contacted with the leather and their inner part is white [22].

Some of the common tulum cheeses which have approximately thirty different types in compliance with their production method because of their raw material and package differences can be listed as *tomas cheese* in Malatya, *şavak tulum cheese* produced by sheep's milk in Erzincan, Afyon tulumu produced by goat's milk, çimi cheese made by goat's milk, *green mouldy tulum cheese* made in Konya region, *Ordu çökelekli tulumu* (Olaman) and *İzmir pickled tulum cheese* (**Figure 6**) [3,16].

This cheese type is also produced in East Anatolia region in Bingöl, Elazığ, Erzincan, Erzurum and Tunceli cities. It is known that tulum cheese which is produced in Munzur mountains on the plateaus of three thousand meters and which have thousand years of history is sold in abroad after being packaged [23]. Its one of the most important characteristic is that Kemah salt is used for its production. Kemah salt is obtained by the fact that natural salty water is kept under the sun. Its difference from normal salt is that it provides not melting, breaking of the cheese and it makes the water of the cheese dropping away. Erzurum Şavak tulum cheese produced by White Karaman sheep's grazed in Erzincan's clear and cool plateaus is a cheese having a sharp odor, white and cream color, soft-hard structure which is not easily broken [22-24].

Figure 5. **Tulum cheese.**

Figure 6. **İzmir brined tulum cheese.**

The volatile compounds of Tulum cheese ripened in goat's skin or plastic bags at 90 day of ripening by solid-phase microextraction gas chromatography-mass spectrometry were determined by Hayaloglu *et al*. [4]. The main components were short-chain fatty acids, 2-butanone, diacetyl, and primary alcohols. The principal acids in Tulum cheeses were ethanoic and butanoic acids. Several report show that ethyl esters are very important in Tulum cheese aroma [4,11]. Hayaloglu *et al*. emphasesed that ethyl ester is very important in 16 esters such as propyl, and butyl esters [4]. The concentrations of ethyl acetate, ethyl butanoate, ethyl lactate, propyl acetate, and 3-methylbutyl acetate were high and were the principal volatile compounds in the cheeses. The mean concentrations of methyl ketones; 2-butanone and diacetyl were the most abundant ketones in Tulum cheeses. According to the results of the researches, plastic had similar aroma patterns, but the concentrations of some components were different [12]. The concentration of methyl ketones, including 2-propanone, 2-pentanone, 2-hexanone, 3-hydroxy 2-pentanone, and diacetyl, were influenced by the packaging material. Hayaloglu *et al*. found that 11 acids, 16 esters, 12 methyl ketones, 7 aldehydes, 22 alcohols, 7 sulfur compounds, 6 terpenes, and 19 miscellaneous compounds in cheese ripened in skin bag [12]. The auther pointed out that the amount of 2-methyl butanal in total aldehydes were increased during ripening in casing material has low permeability properties than skin bag. Sulfur compounds are also very important compounds in cheese ripening. Hydrogen sulfide and methanethiol are mainly produced by degradation of Met or Met-containing peptides. Hayaloglu indicated that the most abundant sulfur compounds in Tulum cheese are dimethyl disulfide and dimethyl sulfone [4]. Among the alcohols, ethanol, 2-methyl 1-propanol, 2-methyl 1-butanol, 3-methyl 1-butanol, 2-butanol, 2-pentanol, 1-methoxy 2-propanol, and phenethyl alcohol are important. Avşar *et al*. determined that the amount of 3 methyl-1 butanole were 1715.1 - 2234.1 µg/kg [11]. The other some impor-

tant volatile compounds were identified as follows; ethyl octanoate, ethyl decanoate, acetic acid, butanoic acid, p-cresol, benzoic acid.

İzmir Tulum cheese which is produced by pressing to goat leather bag and by putting into sack, metal boxes or barrels is one of the most known cheeses of which production method is different from others. The basic production difference is that the teleme is firstly made a long-narrow portion so it is exposed to the dry-salting process for the cheese mass has high salt concentration. After this process, it is cut into smaller slices (average 20 × 10 × 8 cm^3) and stored in brine which is made by the whey [2,3]. The aroma profile analysis of İzmir Tulum cheese showed that, the major volatile compounds of this cheese were 2,2,4,6,6-pentamethylheptane, ethylhexanoate, p-cresol, γ-dodecalactone, ethyltetradecanoate. Furthermore, according to aroma extract dilution analysis (AEDA) results, diacethyl, 3-hydroxy butanone, ethylbutanoate, 1-octen-on, acetic acid, propanoic acid, butanoic acid, pentanoic acid and hexanoic acid play an important role on aroma [11].

Mouldy-ripened variety of traditional Turkish cheese is Küflü cheese produced in the Centre and East of Turkey. The moulds growing in the cheese contribute to aroma compounds formation occurs from proteolysis with their enzymatic properties. The researchers found one hundred and thirty-eight volatile compounds of Küflü cheese by gas chromatography-mass spectrometry (GC-MS) using a solid-phase microextraction technique [25]. In Küflü cheese samples, 11 acids, 21 esters, 20 ketones, 6 aldehydes, 32 alcohols, 8 sulphur compounds, 10 terpenes and 30 miscellaneous compounds are identified. While the principal class of volatile components in Küflü cheeses were ketones and alcohols, terpenes and sulphur compounds were found at substantial levels in the majority of the samples. Furthermore aldehydes and lactones were also determined at low levels. Ethyl esters and branched-chain alkyl esters were also identified at significant levels. Ethyl hexanoate, ethyl octanoate, 3-methylbutyl acetate and 3-methylbutyl butanoate were present in the highest concentrations. Methyl ketones formed by enzymatic oxidation of FFA to β-ketoacids were the largest group of volatile compounds in Küflü cheese. Total of 20 ketones were identified in Küflü cheese including 2-butanone, 2-pentanone, 2-heptanone and 2-nonanone, 3-hydroxy-2-butanone (acetoin). Kuflu cheese samples had a small quantities amongst the volatile compounds. Benzaldehyde has also been found in all samples.

Tulum cheese is a crumbly cheese with a sharp taste; salty, herbal, spicy, with some peppery notes. It is slightly sour with some nutty flavors. The texture in the mouth is grainy; the cheese dissolved into a pleasant creamy paste. The salty flavor lingered, with some sweetness as it finished. It can be consumed for breakfast and would be great in salads with vegetable and fruit. Tulum cheese take place in Turkish cousine as appetizer with olive oil, walnut and black cumin. Additionally it can be used in börek or similar foods.

5. Lor Cheese (Cheese Produced Using Whey)

It is a kind of cheese produced almost in every region of our country. It has a high concentration of protein and other food components and it is animal protein source those having low-income level [26]. Its production method shows little difference among the regions where it is produced; for this difference, type and quality of whey which is its raw material is an important factor. The most important factors for lor cheese which can have white, light-grey and yellow-like colors are differences in regional, climatic and animal types. In our many regions, lor is produced by the whey obtained from cow's milk and in some other regions it is obtained by the whey of cheeses produced by cow's milk [2,3,27,28]. When lor is produced by different heating processes and under the inappropriate conditions, its quality is badly affected and this causes obtaining different structure, taste and appearance of the cheese. The whey, which is obtained by full-fat goat's, sheep's and cow's milk, is boiled directly or by mixing milk in proportion of 30%. The clot obtained by this process is collected by filtering by gauze or mat [29]. It is ripened in a cool place and entered into market. Although there are lor cheeses having special production techniques unique to their region, Trakya lor cheese made by the whey of kaşar cheese, Ayvalık Kirlihanım cheese made by white sheep cheese, Ayvalık sepet lor cheese made filtering into a basket, Marmara lor cheese, *Kars lor cheese*, *Antalya lor cheese*, *Artvin Yusufeli kurtlu lor cheese* made by Mihaliç whey are the cheeses available in the literature [16].

Dolaz cheese is also a traditional cheese produced using whey by nomads in the Lakes region. Because of high heat treatment, the color of this cheese is brown and it's taste is acidic. Dolaz cheese has also cooked odour (**Figure 7**). Average acetaldehyde, acetone, ethanol, acetic acid, diacetyl and 1-butanol contents of traditional Dolaz cheese were 0.0526 mg/kg, 0.0018 mg/kg, 2.6056 mg/kg, 1.1455 mg/kg, 0.0079 mg/kg and 0.0046 mg/kg, respectively [30].

Lor cheese is a very low salt, low fat form of beyaz cheese with a high protein content. That makes it a favorite with health-conscious folks, those recovering from an illness and even body-builders. Lor is eaten at breakfast with other low calorie fare, and it's also used to make lighter, less salty versions of börek. It can be used as a major ingredient for pies as stuffed phyllo dough with with meat or vegetables. There are also many

dessert recipes that call for lor. It can be served for breakfast or as an appetizer after mixing with various herbs, spices and walnut [31].

6. Çökelek Cheese

Çökelek's raw material is different from that of lor cheese. It is obtained by boiling of milk, yogurt or ayran (drink yogurt) (**Figure 8**). Its production method is easy and it has a low or non salt proportion. There are various çökelek types except for the çökelek industrially produced. They are those having regional characteristics, consumed fresh, prolonged by being put into the tulum or earthenware jug and then kept and protected under the sun [32]. For example, they are called in West Anatolia and Thrace as "e*kşimik*", in Bolu, Mediterranean and Blacksea region "*keş*", in West Anatolia region "cacık (*otlu çökelek*)" [33], in Trabzon "*minci*" or "*minzi*", in Rize and Erzurum "*kurçi* or *kurç*", in Bitlis "*jaji*" [31, 32]. They are consumed in family or sold in public bazaars. Apart from those, there are some types in which wild herbs are added in order to give them taste or odor. They are also press into tulum or earthenware jug [33].

In Isparta, Sütçüler district çökelek known as "*tortu*" or "*ekşimik*" is obtained by adding milk to the ayran or yogurt may by buttermilk as called by-product of butter , sheep's or goat's milk [32]. Another regional çökelek is çörekotlu tulum çökelek cheese in which nigella sativa and starch are added, put into the tulum or cloth. İts regional name is *Çoban tulumu* [33]. *Sürk* which means

Figure 7. Dolaz cheese.

Figure 8. Çökelek cheese.

curd in Arabic is similar to kurut which is our traditional products. However it shows difference because of its red-like color and its spices used for its production [34].

Çökelek cheeses produce from cow, sheep or goat's milk by acidificating of milk or yoghurt in Turkey. Çökelek cheese curd take place by heating of yoghurt, so this cheese aroma is different from milk curd [31]. Gün *et al*. investigated that aroma active compounds çökelek cheese made from milk, yogurt and tuluk yogurt by using GC-Olfactometry method in which humans senses are used [35]. There was significant differenses in aroma active coumpounds of Çökelek cheeses made with tree different traditional way. Total 18 defined and 13 undifened aroma active coumponds were determined in all cheese types. As aroma active coumponds, dimethyl sulfide (cooked milk), ethyl butyrate (ester), ethyl pentanoate (candy gum), ethyl hexanoate (ester), methional (cooked potato), butyric acid (ransid), phenylacetaldehyde and 2-phenylethanol (rose, flower), hexanoic acid (wet dirty towels).

Çökelek is quite similar with lor and their serving looks like each other.

7. Cheeses with Herb and Savour

Most substances used for savour in foods are consisted of herbal sources. Some of them are spices. Herbal substances used for food savour substance give taste, odor and color as well as they have anti-oxidant and anti-micro bacterial properties [3,36].

The most common cheese among cheeses with herb and savour are Van Otlu cheese. For the productions of different cheeses with herb approximately 60 regional plants are available, however for each cheese production process, nearly 25 of them are used [37,38]. It is known that these herbs not only add taste to the cheeses, but also they increase the nutrition level, facilitate digestion, prevent harmful pathogenic microorganisms and give it a different color and appearance [38].

Especially, Çatak soğanı, ranunculus viridis, sirik, sirmo, mendo, heliz, kenger and many other herbs are those preferred for the traditional production. This cheese for which production sheep's milk is mostly used can be obtained by mixing sheep's milk with cow's or goat's milk.

Van Otlu (herby) cheeses are produced in compliance with two different methods as brine and dry-salting. For brine salting, cheese blocks are kept into salty water and then put into metal or plastic barrels. For dry-salting cheese blocks are salted by salt during 3 - 4 days and then put into plastic barrels in which they are put in as cheese on one line and as cacık (*otlu çökelek*) on the other line [33] (**Figure 9**).

For herby and savour cheeses groups, *Erzincan keçene otlu küp cheese* (sirmo), *Siirt otlu cheese* (sirmo, sof),

Table 2. Some herby and savour cheeses.

City	Tradational name	Raw material/Additives	Type of packaging
Van Otlu Peyniri	Van herby cheese	Sheep milk/Sirmo, thyme, helis, mendo, cünk, dill, mint, catır	Crock, plastic barrel
Erzincan	Erzincan keçene herby cupe cheese	Whole Sheep milk or Sheep's milk—cow's milk mixture/sirmo	Cupe
Siirt	Siirt herby cheese	Sheep milk/sirmo, sof	Cupe, plastic barrel
Trabzon	Trabzon herby cheese	Cow milk/mint, thyme	-
Hatay	Sürk	Butter ayran/nigella sativa , black pepper, clove, thyme, red pepper, cummin, coriander, coconut, mahaleb, mint, garlic, cinnamon, allspice, ginger, salt	-
Burdur	Akçakatık	Yogurt/mint, clove	Cloth, karın (goat's stomach)

Figure 9. Van otlu cheese.

Trabzon otlu cheese (peppermint, thyme), *sürk* (nigella sativa, black pepper, carnation, thyme, red pepper, cumin, coriander, small coconut, mahaleb, peppermint, mint, garlic, cinnamon, pimento, ginger), *Akçakatık* (nigella sativa, carnation) [16,33,34,39,40-42]. All added spices affect the aroma of cheese, but there is no any research on amount of volatile compounds. Several properties of some savour added and herby cheeses are listed in **Table 2**.

Herby cheeses include several kind of herbs added taste to the cheeses and increase the nutrition level. These herbal substances used for food savour substance give taste, odor and color to the cheese. Herby cheeses are usually consumed at breakfast with tea. It can be used for preparing omelette with hery cheese, and savory pastry as a major ingredient.

8. Conclusion

Anatolia has become a centre in which Asian, European, African, Egyptian and Mesopotamian culture ways are intersected because of its geographical situation during the history. This intersection has become an important factor, as it is for many fields, for shaping of traditional products and forming of product variety. In our country of which area is quite big, there are many cheese types. This variety is shaped in compliance with the production technique of the cheese, quality of the milk used, its protein, fat and bacteria content, processing conditions, temperature and humidity levels of storage during the ripening process. In spite of such a rich product variety, most of our traditional cheese types have only been produced and consumed in their own region. Classification of many cheese types produced in Anatolia by considering several characteristics, standardization of them by developing their production technologies and introduction of them to the world should be our preferential terms. Volatile componds play an important role in flavour perception of cheese and these components occur during ripening of cheese by lipolysis, proteolysis and metabolism of lactose, lactate and citrate. Aroma compounds of traditional cheeses are still investigated. In this study, some information about the aroma profile of some cheese types and their consumption were discussed.

REFERENCES

[1] M. Üçüncü, "Cheese Technology from A to Z," Cilt: I, Meta Basım, Bornova/İzmir, 2004.

[2] I. Gün, "Student Lesson Book of Cheese Technology," MAKÜ Meslek Yüksekokulu, Burdur, Basılmamıştır, 2006, p. 80.

[3] F. Durlu-Özkaya and I. Gün, "Traditional Turkish Cheeses," *International Symposium on Historical Cheeses of Countries around the Archipelago Mediterraneo Proceeding Book*, Thessaloniki, 6-8 December 2007, pp. 65-88.

[4] A. A. Hayaloğu, S. Çakmakçı, E. Y. Brechany, K. C. Deegan and P. L. H. McSweeney, "Microbiology, Biochemistry and Volatile Composition of Tulum Cheese Ripened in Goat's Skin or Plastic Bags," *Journal of Dairy Science*, Vol. 90, No. 3, 2007, pp. 1102-1121. http://dx.doi.org/10.3168/jds.S0022-0302(07)71597-7

[5] P. L. H. McSweeney and M. J. Sousa, "Biochemical Pathways for The Production of Flavour Compounds in Cheese During Ripening: A Review," *Lait*, Vol. 80, No. 3, 2000, pp. 293-324. http://dx.doi.org/10.1051/lait:2000127

[6] P. M. G. Curioni and J. O. Bosset, "Key Odorants in Various Cheese Types as Determined by Gas Chroma-

tography-Olfactometry," *International Dairy Journal*, Vol. 12, No. 12, 2002, pp. 959-984. http://dx.doi.org/10.1016/S0958-6946(02)00124-3

[7] M. Yvon and L. Rijnen, "Cheese Flavour Formation by Amino Acid Catabolism," *International Dairy Journal*, Vol. 11, No. 4-7, 2001, pp. 185-201. http://dx.doi.org/10.1016/S0958-6946(01)00049-8

[8] J. O. Bosset and R. Liardon, "The Aroma Composition of Swiss Gruyvere Cheese. II. The Neutral Volatile Components," *Lebensmittel Wissenschaft und Technologie*, Vol. 17, 1984, pp. 359-362.

[9] T. M. Cogan and C. Hill, "Cheese Starter Cultures," In: P. F. Fox, Ed., *Cheese*: *Chemistry*, *Physics and Microbiology*, 2nd Edition, Chapman & Hall, London, 1993, pp. 193-255. http://dx.doi.org/10.1007/978-1-4615-2650-6_6

[10] L. Moio and F. Addeo, "Grana Padano Cheese Aroma," *Journal of Dairy Research*, Vol. 65, No. 2, 1998, pp. 317-333. http://dx.doi.org/10.1017/S0022029997002768

[11] Y. K. Avşar, Y. Karagül-Yüceer, G. Akdemir-Evrendilek and O. Eştürk, "The Determination of Aroma Profile of Economycally Important Traditional Cheese (Erzincan Tulum Cheese, Ezine Beyaz Cheese, Kars Kaşar Cheese, İzmir Tulum Cheese) and the Use of Aroma Active Agents Determining of Its Originally/Quality," TÜBİTAK Carier Project, Project No: 104-O-530, Hatay, 2009.

[12] A. A. Hayaloglu, "Volatile Composition and Proteolysis in Traditionally Produced Mature Kashar Cheese," *International Journal of Food Science and Technology*, Vol. 44, No. 7, 2009, pp. 1388-1394. http://dx.doi.org/10.1111/j.1365-2621.2009.01968.x

[13] Y. Karagül Yüceer, M. Işleten and M. Mendeş, "Ezine Cheese I. Aroma Characterization," *Gıda*, Vol. 34, No. 6, 2009, pp. 373-380.

[14] I. Gün, "Effects of Alternative Casing Materials on Quality Properties of Tulum Cheese," Ph.D. Dissertation, Süleyman Demirel University, Graduate School of Applied and Natural Sciences, Department of Food Engineering, Isparta, 2012.

[15] C. Koçak, "Coagulating Techniques and Curd Proccessing," Her Yönüyle Peynir. II.Milli Süt ve Ürünleri Sempozyumu, T.Ü.T.Z.F. Yayın No. 125, 1991, pp. 100-107.

[16] A. Ünsal, "Süt Uyuyunca," Yapı Kredi Kültür Sanat Yayınları, İstanbul, 1997, 224 s.

[17] C. Koçak, E. Şenel, F. Sezen and C. Akal, "Studies on the Characterization of Aroma Profile in White Cheese," *IDF Cheese Ripening Technology Symposium*, Monona Terrace, 21-24 May 2012.

[18] M. Eralp, "Research on Some Traditional Turkish Cheeses," *Ankara University Agriculture Faculty Annual*, Vol. 3, No. 3-4, 1953, pp. 227-230.

[19] A. Kurt, H. H. Gündüz and M. Demirci, "Researches on Tomas Cheese," *Atatürk Üniversitesi Ziraat Fakültesi Dergisi*, Vol. 10, No. 1-2, 1979, pp. 37s-49s.

[20] H. H. Gündüz, "Tomas Cheese. I. Tomas Cheese Natural Flora," *Gıda*, Vol. 7, No. 5, 1982, pp. 227-230.

[21] C. Koçak, A. Gürsel, Y. K. Avşar and A. Semiz, "Some Properties of Tulum Cheeses Sold in Ankara Markets," *Turkish Journal of Agriculture and Forestry*, Vol. 20, 1996, pp. 121-125.

[22] A. A. Hayaloğlu, P. F. Fox, M. Güven, S. Çakmakcı, "Cheeses of Turkey: 1. Varieties Ripened in Goat-Skin Bags," *Lait*, Vol. 87, 2007, pp. 79-95. http://dx.doi.org/10.1051/lait:2007006

[23] V. Dağdemir, "Determination of Marketing Magrin and Production Cost of Erzincan Tulum Cheese in Erzincan," *Turkish Journal of Agriculture and Forestry*, Vol. 24, 2000, pp. 57s-61s.

[24] L. Öztek and A. Kurt, "Research on Manufacturing Techniques of Şavak Tulum Cheese," *Atatürk Üniversitesi Ziraat Fakültesi Dergisi*, Vol. 15, No. 3-4, 1984, pp. 1-5.

[25] A. A. Hayaloglu, E. Y. Brechany, K. C. Deegan and P. L. H. McSweeney, "Characterization of the Chemistry, Biochemistry and Volatile Profile of Kuflu Cheese, A Mould-Ripened Variety," *LWT-Food Science and Technology*, Vol. 41, No. 7, 2008, pp. 1323-1334.

[26] M. Demirci, O. Şimşek and M. Arıcı, "Determination of Microbiological Properties and Composition of Lor Cheese Sold in Tekirdağ," *Food*, Vol. 16, No. 5, 1991, pp. 292-294.

[27] E. Ergüllü, "Research on Some Properties of Whey and Lor Cheese," *Food*, Vol. 7, No. 2, 1982, pp. 63-66.

[28] S. S. Kırdar and I. Gün, "A Study on Hygienic Quality of Lor Cheese Sold in Burdur Public Market," *Gıda Bilimi ve Teknolojisi Dergisi*, Vol. 4, No. 2, 1999, pp. 44-47.

[29] S. Özdemir, N. Demircioğlu, S. Çelik and I. Bakırcı, "A Research on Some Properties of Lor Cheese Consumed in Erzurum Market," *Süt Mikrobiyolojisi ve Katkı Maddeleri. VI. Süt ve Süt ürünleri Sempozyumu Tebliğler Kitabı*, 2000, pp. 524-531.

[30] O. D. Okur and Z. Güzel-Seydim, "Determination of Production Method, Microbial and Volatile Flavor Components and Sensory Properties of Traditional Dolaz Cheese," *Gıda*, Vol. 36, No. 2, 2011, pp. 83-88.

[31] F. Durlu-Özkaya, "Milk and Dairy Technology," In: F. Durlu-Özkaya, S. Coşansu and K. Ayhan, Eds., *Her Yönüyle Gıda*, Sidas Media Ltd.Sti., 2013, 401 p.

[32] S. S. Kırdar, "A Research on Çökelek Cheese," *Geleneksel Gıdalar Sempozyumu*, 23-24 Eylül Van 2004, pp. 357-361.

[33] A. Çetinkaya, "Traditional Turkish Cheeses," *Uğurer Agriculture Book*, 2005, 221 p.

[34] M. B. Güler, "Additives for Production of Sürk Cheese," *Dairy Microbiology and Additives. VI. Süt ve Süt Ürünleri Sempozyumu Tebliğler Kitabı*, Mayıs 2000, Tekirdağ, 2000, pp. 443-449.

[35] I. Gün, O. Güneşer, Y. Karagül-Yüceer, Z. Güzel-Seydim, F. Torun and S. Çakıcı, "Determination of Aroma Active Compounds of Çökelek Cheese Produced from Different Methods by Gas Chromatography Olfactometry (GCO)," *III. Traditional Foods Symposium*, Konya, 10-12 Mayıs 2012, p. 531.

[36] A. Akgül, "Spices of Turkey. I. General Features," *Food*, Vol. 14, No. 2, 1989, pp. 105-109.

[37] A. Kurt, "Researchs on Van Herby Cheese," Atatürk Üniversitesi Ziraat Fakültesi Yayınları, Araştırma Bülteni

No. 33, Erzurum, 1968, p. 29.

[38] N. Akyüz and H. Coşkun, "Production of Van Otlu Cheese and Some Characteristics of Cheeses Affected by Herbs Added to the Cheese. Cheese with All Features," Hasad Publishing Ltd., Sti., 1996, pp. 210-216.

[39] S. S. Kırdar, "A Research on Akçakatık Cheese Manufacturing," *Geleneksel Gıdalar Sempozyumu*, Van, 23-24 Eylül 2004, pp. 354-356.

[40] H. Coşkun, "Otlu Cheese," *Journal of Food Technology Association*, Publish No 31, 2005, 52 p.

[41] U. Kamber, "Traditional Anatolian Cheeses," Miki Matbaacılık San. Tic. Ltd. Şti. İvedik/Ankara, 2005, p. 225.

[42] I. Gün and B. Şimşek, "Determination of Fatty Acid Profile of Akçakatık Cheese Produced in Burdur," *Tür- kiye* 9. *Gıda Kongresi*, Bolu, 26-26 Mayıs 2006, p. 511.