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Volatile Compounds, Chemical and Sensory Properties of Butters Sold in Çanakkale

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ABSTRACT

The aim of this study was to determine physical, chemical and sensory properties and volatile components of butter samples sold in Çanakkale. For this purpose, color, viscosity, refractive index, melting point, moisture (%), total acidity (%), acid degree value and fat content (%) of the samples were determined in eleven butter samples. Volatile compounds were identified by gas chromatography-mass spectrometry. Sensory properties of samples were determined by Spectrum™ method. There were significant differences among butter samples in terms of physical, chemical and sensory properties. Viscosity, refractive index, melting point, moisture, total acidity and fat content of the samples ranged between 45.40-62.0 cP, 1.3331-1.4672, 32.50-37.50 ˚C, 15.03-19.06%, 0.24-0.42%, 82-89%, respectively. Diacetyl, acetoin, acetic acid, hexanoic acid, butyric acid and δ-decalactone were major volatiles in butter samples. In addition, cooked, creamy, rancid and margarine-like were the characteristic terms developed by the panelists.

Keywords: Butter; Volatiles; Sensory; Chemical properties

Çanakkale'de Satılan Tereyağlarının Uçucu Bileşenleri, Kimyasal ve Duyusal Özellikleri

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ÖZET

Bu çalışmanın amacı Çanakkale'de satılan tereyağı örneklerinin fiziksel, kimyasal ve duyusal özelliklerinin belirlenmesidir. Bu amaçla onbir tereyağı örneğinin, renk, viskozite, refraktif indeks, erime noktası, nem (%), toplam asitlik (%), asit değeri ve yağ içeriği belirlenmiştir. Uçucu bileşenler gaz kromatografisi-kütle spektrometresi kullanılarak belirlenmiştir. Örneklerin duyusal özellikleri Spectrum™ metodu ile ortaya konmuştur. Fiziksel, kimyasal ve duyusal özellikler bakımından örnekler arasında önemli farklar olduğu bulunmuştur. Örneklerin viskozite, refraktif indeks, erime noktası, nem, toplam asitlik ve yağ içeriği sırasıyla 45.40-62.0 cP, 1.3331-1.4672, 32.50-37.50 ˚C, % 15.03-19.06,

% 0.24-0.42, % 82-89 arasında değişmektedir. Diasetil, asetoin, asetik asit, hekzanoik asit, butirik asit ve δ-dekalakton tereyağı örneklerinin önemli uçucu bileşenleridir. Ayrıca, pişmiş, kremamsı, ransit ve margarin benzeri panelistler tarafından geliştirilmiş karakteristik terimlerdir.

Anahtar Kelimeler: Tereyağı; Uçucular; Duyusal; Kimyasal özellikler

1. Introduction

Butter has 80-90% of milk fat, 10-20% of water, 0.5-0.8% of lactose and lactic acid, 0.6-0.7% of milk proteins and 0.14% of mineral substances (Üçüncü 2010). It is used in processed foods as well as pastries and meals because of its high nutritional value and flavor make it acceptable by consumers (Hocalar 2011). Packaging materials and storage conditions affect physical, chemical and sensory properties of the butter (Krasue et al 2007). Many studies aimed to investigate physical, chemical and textural properties of butter in processing conditions during storage (Senel 2006; Altun et al 2011; Arslan et al 2011; Ronholt et al 2012). Sensory characteristics of the products as well as physical and chemical properties are important properties for consumers. For example, lactones generally give fruity, creamy and buttery odors that are desired characteristics for butter. However, hexanal was described to have an oxidized odour and contributed to undesirable flavour to butter (Mallia et al 2008). There were several researches also carried out on physical, chemical and sensory properties of butter during processing and storage period (Abdel-Mageed & Fadel 1994; Widder & Grosch 1997; Krause et al 2007; Krause et al 2008; Mallia et al 2009). Nevertheless, specifically differences in sensory properties and volatile profiles of butters manufactured by different producers had been discussed in limited studies (Atamer et al 2007; Arslan et al 2011; Şenel et al 2011). The main objective of this study was to investigate and reveal differences in some physical, chemical and sensory properties and volatile profiles of some butter samples provided from the local producers in Canakkale.

2. Material and Methods

2.1. Butter samples

Total eleven commercial butters were evaluated in this study. All samples were provided from local market in September 2012 in Canakkale-Turkey. Samples were packaged in plastic or aluminum foil and samples were approximately 250-350 g. Until analysis, all samples were stored in a freezer and analyzed as duplicate.

2.2. Physical and chemical analysis

L, *a,* and *b* values of butter samples were determined by using Minolta Chroma Meter CR-400 model colorimeter (Minolta Inc., Japan). Viscosity was measured by Brookfield viscometer (Model DV II+ Pro, Brookfield Engineering Laboratories, Inc., MA, USA) integrated with circulating water bath (GFL, Grossburgwedel, Germany) according to Arslan et al (2011). Melting point was measured by capillary tube method according to Nas et al (2001) with minor modification. Refractive index was measured by Abbe 5 Refractometer (Bellingham-Stanly Co., Great Britain) at 40 ^{o}C. Moisture (%), fat (%) and total acidity (lactic acid %) of butters were determined according to Bradley et al (1992). The acid value (AV, mg KOH g^{-1} oil) of butters was determined according to Nas et al (2001).

2.3. Analysis of volatile compounds

Representative six samples were chosen by trained panelists for volatile analysis. Volatile compounds from butters were isolated by SPME technique (Pawliszyn 2012) according to Guneser & Karagul-Yuceer (2011). Volatiles were identified and quantified by gas chromatography-mass spectrometry (HP 6890 GC and 7895 C mass selective detector, Agilent Technologies, Wilmington, DE, USA). Nonpolar HP5 MS column (J & W Scientific, Folsom, CA) was used for separation of volatile compounds. The GC oven temperature was programmed from 40 to 230 °C at a rate of 10 °C min^{-1} with initial hold of 5 min and final hold time of 20 min. Helium was used as a carrier gas at 1.2 mL min^{-1}. Identification of volatiles was based on the comparison of the mass spectra of unknown compounds with those in the National Institute of Standards and Technology (NIST) and Wiley Registry of Mass Spectral Data, 7th Edition (Wiley). Amount of the compounds was calculated from relative abundances of flavor compounds according to Avsar et al (2004).

2.4. Sensory analysis

Spectrum™ method was used to determine the sensory attributes of the butters (Meilgaard et al 1999). Sensory evaluation was conducted by seven panelists. Panel members were staff and graduate students in the Department of Food Engineering at Canakkale Onsekiz Mart University; four were females and three were males and ages ranged from 27 to 45 years. The panel had approximately 200 h-experience on generation and definition of descriptive terms for dairy foods. The terms used to define taste and flavor of butter were shown in Table 1 (Meilgaard et al 1999; Bradley & Smukowski 2009). Duplicate samples were served in the different sessions.

2.5. Statistical analysis

Analysis of variance (one way ANOVA) was conducted to determine the differences among the butter samples with respect to physical, chemical and sensory properties. Welch test that is a non-parametric test was used for some data which did not meet the prerequisites (homogeneity of variance and equality of variance) for ANOVA. Least Significant Difference (LSD) test was used for separating means in data. Multidimensional Scaling Analysis (MDS, ALSCAL approach) was also conducted to reveal differences or similarities in butters in terms of volatile properties (Sheskin 2004). SPSS for Windows (version 17.0, SPSS Institute Inc., Chicago, IL, USA) (SPSS 2008) and Minitab 16.1 (Minitab Inc., State College, PA, USA) (Minitab 2010) were used for all statistical analyses.

3. Results and Discussion

3.1. Physical and chemical properties

Physical and chemical properties of butter samples were shown in Table 2. *L*, *-a* and *b* values of the samples were significantly different ($P \leq 0.05$). *L*, *-a* and *b* values ranged between 88.34-96.11, 1.92-4.42 and 15.07-33.11, respectively. Sample 2 had the lowest *L* and *b* values, meanwhile the lowest *-a* value was observed in the sample 3. Hence, the highest *-a* value was observed in sample 8. Similar results were reported by other studies (Shukla et al 1994;

Table 1- Descriptive terms used for sensory evaluation of butters

Çizelge 1- Tereyağlarının duyusal değerlendirmesinde kullanılan tanımlayıcı terimler

Descriptors	*Definition*	*References*
Cooked	Aromatics associated with cooked milk	Milk heated to 85 °C for 30 min.
Whey	Aromatics associated with whey powder	Solubilize five g whey powder in 100 mL water
Creamy	Creamy aromatics associated with milk fat	Milk cream
Rancid	Aromatics associated with butyric acid	10 µL butyric acid in methanol
Margarine-like	Aromatics associated with margarine	Margarine at 25 °C
Sweet aromatics	Aromatics associated with sweet	5 mg vanillin in milk
Oxidized	Aromatics associated with stale/oxidized fats	Stored butter or vegetable oil
Storage/plastic	Aromatics associated with warehouse	Assignment by panelist
Stale	Aromatics associated with stale flavor	Assignment by panelist
Sweet	Taste sensation elicited by sugars	2% sucrose solution in water

Jinjarak et al 2006). *L*, *a* and *b* values of butters were determined as 88.67, -1.07 and 24.12, respectively by Shukla et al (1994). Moreover, Jinjarak et al (2006) revealed that no significant differences in *L, a* and *b* values of sweet cream, whey and cultured butter. It was found that *L* values of sweet cream, whey and cultured butter were 82.62, 85.89 and 85.14, while *b* values were 20.04, 20.96 and 22.46, respectively. The color of butter is the most important sensory quality parameter in terms of consumer preference. The color changes depending on many processing factors such as seasonal variations in milk content, microbial quality and storage conditions. It was emphasized that more yellowish color in butter associated with natural and "easier to spread" by consumer. Moreover, lack of color uniformity and mottled color in butter occurred by mixed churnings and an uneven distribution of moisture respectively (Krasue et al 2007; Bradley & Smukowski 2009). In the present study, samples 4 and 7 had the higher *b* values than other butters.

There were significant differences in terms of viscosity, refractive index and melting points of butter samples. Viscosities of butters ranged between 45.4-62.7 cP. Sample 11 had the highest viscosity while the lowest viscosity was observed in sample 6. Melting points of butters ranged between 31-37.5 ^{o}C. While sample 4 had the highest melting point (37.50 ^{o}C), the lowest melting points were observed in sample 10 and 5. The lowest refractive indexes were observed in samples 1 and 5 (Table 2). Sagdıc et al (2004) determined the melting points of traditional yayik butters produced from goat's, ewe's and cow's milk. The melting points were found to be 31.75 ^{o}C, 33.05 ^{o}C and 32.05 ^{o}C for goat's, ewe's and cow's milk butters, respectively. Fatouh et al (2003) investigated the melting point of the various buffalo butter oil fractions obtained by multi-step dry fractionation. They determined that the slip melting points were ranged between 24.2-45.0 ^{o}C for liquid and solid fraction of butter oil that obtained at different temperatures (15-40 ^{o}C). Glibowski et al (2008) investigated the rheological and textural properties of some table fats. They indicated that apparent viscosities of butter (82% milk fat) and sweet cream butter (74% milk fat) were 457 and 427 Pa at 20 ^{o}C, respectively. Nikolova et al (2007) investigated the refractive indexes of total 11 butter and margarine samples by using a specially designed laser refractometer. Refractive indexes of butter samples ranged between 1.4347-1.4491 at 40 ^{o}C. This range was in agreement with our findings in the present study. Body and textural characteristics of butter were also important for acceptability

Table 2- Physical and chemical properties of butter samples (n= 2, ±SE)

Çizelge 2- Tereyağı örneklerinin fiziksel ve kimyasal özellikleri (n= 2, ±SE)

Butters	*Colour values*			*Melting point (˚C)*	*Viscosity (cP)*	*Refractive index*	*Moisture (%)*	*Lactic acid (%)*	*Acid value (mg KOH g^{-1} oil)*	*Fat (%)*
	L	*-a*	*b*							
1	94.27±0.47	3.15±0.17	30.05±0.15	37.50±0.50	50.05±2.35	1.3331±0.01	15.87±0.41	0.42±0.01	0.88±0.01	84.0±0.01
2	88.34±0.78	3.49±0.12	15.07±0.18	32.50±0.50	52.65±0.25	1.4541±0.01	14.86±0.85	0.24±0.01	0.89±0.01	85.0±0.01
3	95.31±0.15	1.92±0.05	19.38±0.14	32.00±0.00	53.05±0.15	1.4541±0.01	15.23±0.57	0.22±0.01	0.55±0.01	83.5±2.12
4	93.23±1.13	2.75±0.16	33.14±0.59	33.50±0.50	50.65±0.15	1.4552±0.01	17.30±0.48	0.32±0.01	0.83±0.05	82.0±0.01
5	91.05±0.14	3.04±0.05	30.31±1.33	31.50±0.50	53.30±1.50	1.3334±0.01	16.67±0.20	0.38±0.01	1.11±0.01	81.5±1.50
6	96.11±0.01	2.93±0.00	31.34±0.02	33.00±1.00	45.40±1.30	1.4554±0.01	15.30±0.08	0.26±0.02	0.61±0.05	85.0±0.01
7	92.34±1.93	2.43±0.08	33.11±2.11	33.00±0.01	59.25±6.25	1.4562±0.01	12.67±0.74	0.30±0.01	0.89±0.01	86.5±0.70
8	95.37±1.22	4.42±0.14	31.05±0.34	33.50±0.50	54.35±1.15	1.4672±0.01	15.66±0.43	0.24±0.01	1.19±0.08	85.0±0.01
9	93.06±1.62	3.29±0.10	27.70±1.09	33.50±0.50	52.75±2.65	1.4551±0.01	14.36±0.54	0.24±0.02	1.22±0.15	86.0±1.00
10	93.09±2.83	3.12±0.05	30.78±1.49	31.00±1.00	54.10±2.80	1.4555±0.01	15.18±0.36	0.26±0.01	0.99±0.00	84.0±1.00
11	91.78±0.32	2.94±0.14	29.70±0.20	32.50±0.50	62.70±3.70	1.4551±0.01	16.45±0.07	0.30±0.01	1.17±0.05	83.0±0.01
LSD	4.00	0.34	3.01	1.82	0.06	0.02	1.24	0.05	0.18	ns

ns, not significant (P≥0.05); SE, standard error by consumer. Body and textural characteristics of butter was effected by water content, chemical composition, fatty acid composition, polymorphism and structure of milk fat crystal network and also processing steps especially churning and tempering. For example, present of globular water in small droplets in the butter may cause an increase in viscosity or an increase in unsaturated fatty acids level in milk fat fraction may lead to decrease in melting point (Wright et al 2001). It was indicated that high quality butter should melt evenly and disappeared slowly. Moreover, body of high quality butter should be firm and show a distinct waxy and close-knit texture (Bradley & Smukowski 2009). In the present study, samples 5 and 10 had lowest melting points. Viscosities of the samples 2, 3, 5, 7-11 were higher than other samples. Significant differences were observed in moisture contents, total acidities and acid values (mg KOH g^{-1} oil) of the butters ($P \leq 0.05$) while there were no differences among the samples in terms of fat content (%) (Table 2). Moisture (%), total acidity and fat (%) contents ranged between 12.67-17.30%, 0.22-0.42 and 81.5-86.5%, respectively. The highest moisture (17.30%) and the lowest fat content (81.5%) were observed in the samples 4 and 5, respectively. Sample 7 had the highest fat content (86.5%) (Table 2).

Samples 2 and 9 had the lowest moisture contents (14.86% and 14.36%). Our results are in agreement with the findings of other studies (Hayaloglu 1999; Sancak et al 2002; Arslan et al 2011). Turkish Food Codex (Anonymous 2005) for butter, milk fat based spreadable products and anhydrous milk fat require up to 16% moisture and at least 80% milk fat in butter. Moisture contents of samples 4, 5 and 11 did not comply with the Codex. Moreover, Arslan et al (2011) showed that total acidities of traditional butters were ranged between 0.51-3.44%. Differences among the butter samples in terms of acidity and acid value may also be due to the changes in the production steps, storage periods and microbial quality. The acid values of butter samples ranged between 0.55-1.22 mg KOH g^{-1} oil in the present study. The lowest acid value was found in the samples 3 and 6. Atamer et al (2007) determined that acid values of churn butter samples which were produced by the traditional methods ranged between 1.06-2.67 mg KOH g^{-1} oil. The amount of lactic acid obtained from butter was related to the composition of raw materials and washing process used in the butter production (Atamer et al 2007). Acid value is associated with excess of free fatty acid due to hydrolysis of triglycerides in fat and oil. Adequate hydrolysis of triglyceride can be favorable for flavor formation. However, higher acid value is an indicator of undesirable processing and storage conditions such as high temperature and relative humidity in storage, high lipase activity in the butter due to insufficient thermal processing (Wilbey 2009). Low acid value and high acidity in butter indicate low quality butter and bad preservation condition (Bendixen 1940; Koczon et al 2008). Both parameters effect the consumption rate of butters. While, high acid value shows oxidation and rancidity in butters, high total acidity (% lactic acid) can be associated undesirable microflora and/or using of low quality milk for the production of butter.

3.2. Analysis of volatile compounds

The major volatile compounds determined in butter samples were acids, aldehydes, ketones and lactones (Table 3). It was found that the amount of diacetyl in the butter samples ranged between 64.40-648.50 μg kg^{-1} butter. Diacetyl is one of the most important aroma compounds in butter. It is also responsible for sweet and creamy flavor of other dairy products such as cheese, milk and fermented milks. In general, diacetyl was formed by lactose and citrate metabolism of lactic acid bacteria, especially *Lactococcus lactis* ssp. *Lactis biovar*. *diacetylactis* and *Leuconostoc* spp. (Jay et al 2005). Other aroma compounds that determined in butter samples at high levels were acetic acid (except sample 9), butyric acid and acetoin. They ranged between 15.67-62642 μg kg^{-1}, 1113-89605 μg kg^{-1} and 785-3880 μg kg^{-1}, respectively. Butyric acid is formed by hydrolysis of free fatty acid and frequently identified in many cheese types (Parliament & McGorrin 2000; Curioni & Bosset 2002), while acetic acid is produced by lactose metabolism of hetero fermantative lactic

Table 3- Some volatile compounds determined in butter samples

Çizelge 3- Tereyağı örneklerinde belirlenen bazı uçucu bileşenler

			Concentration of volatiles (μg kg^{-1} butter)[b]					
No	Volatile compounds	RI[a]	6	9	11	2	4	5
1	Ethanol	<600	211.8	354	382.4	1053	282	543
2	Diacetyl	<600	64.4	648.5	113.4	180	157.9	415.4
3	Acetic acid	615	4601.4	15.67	157891	13907	62642	23128
4	Acetoin	708	1818	915	2376	785	3880	2881
5	Hexanal	803	16.4	10.3	4.2	3.9	23.2	44.7
6	Butyric acid	832	1966.1	1113	89605	9451	19004	11787
7	*p*-xylene	875	20.9	87.7	54.01	287	69.8	168.2
8	2-Heptanone	893	85.7	165.7	172.8	640	2366	204.5
9	Oxime methoxy-phenyl	902	707.5	184	23.7	nd	nd	nd
10	Pinene	937	54.4	436	335	95.4	1136	65.8
11	Hexanoic acid	1006	342.8	587	43747	2945	3479	2611
12	Limonene	1032	61.03	267	84.9	403	3851	1200
13	N-(2-mercaptoethyl)-1,3-thiazolidine	1035	13.7	182	61.03	98.4	192.1	112.7
14	2,7,10- trimethyldodecane	1039	nd	nd	nd	151.8	761	113.1
15	Isoamylbutanoate	1155	204.7	218	70.2	77.3	380	396.5
16	3,5-dimethyl octane	1057	nd	nd	nd	58.5	1423	31.0
17	Terpinene	1061	795	61.2	122.1	235.8	731	153.0
18	2-Nonanone	1092	6.8	35.1	29.81	302.1	411	123.1
19	δ-Caprolactone	1096	30.9	40.0	47.85	14.57	75.1	125.9
20	Nonanal	1104	10.7	23.3	53.7	42.2	139	53.7
21	Octanoic acid	1172	19.0	15.7	16816	647.1	10952	916
22	Ethyl octanoate	1196	nd	nd	nd	46.3	167	36.9
23	δ-Octalactone	1285	8.4	21.4	13.2	44.1	135	20.5
24	Decanoic acid	1362	64.7	168.6	136.8	107.5	1470	728
25	δ-Decalactone	1504	5.6	15.3	8.7	8.5	157.7	16.7

[a], retention index on HP 5 MS column; [b], relative abundances of flavor compounds; nd, not determined

acid bacteria and/or citric acid metabolism of homo and hetero fermentative lactic acid bacteria (Mayo et al 2010). Similar to diacetyl, acetoin is produced by lactic acid bacteria by using α-acetolactate synthase and α-acetolactate decarboxylase enzymes in lactose or citrate metabolism (Hickey et al 1983). The amount of butyric acid and diacetyl in butter were found 3600 μg kg^{-1}, 340 μg kg^{-1}, respectively (Schieberle et al 1993). Samples 2, 4 and 5 and sample 11 had very high amount of butyric acid which is incompatible with Schieberle et al (1993). This difference may be related to types of butters, their age or storage conditions and extraction methods of volatile compounds.

Hexanoic, octanoic and decanoic acids were also determined in all samples. They ranged between 342.8-43747 μg kg^{-1}, 15.7-16816 μg kg^{-1} and 64.7-168.6 μg kg^{-1}, respectively. Sample 11 had higher amount of hexanoic and octanoic acids than the other samples. Peterson & Reineccius (2003) determined twenty aroma active compounds in fresh sweet cream butter by using static headspace extraction methods with GC-MS and GC/O analysis. The researchers stated that the amount of diacetyl, butyric acid and hexanoic acid in fresh sweet cream were 6.6 μg kg^{-1}, 192 μg kg^{-1} and 732 μg kg^{-1}, respectively.

Aldehydes including hexanal and nonanal were also detected in the butters. These compounds are formed by decarboxylation of branched-chain keto acids by the Strecker metabolic pathways of lactic acid bacteria and can also be formed by secondary oxidation of fatty acids. Hexanal is well known secondary oxidation product of linoleic acid and nonanal can be formed by β-oxidation of oleic acid. Both compounds cause off-flavor in milk and dairy products (Kochhar 1996; Guneser & Karagul-Yuceer 2011).

Limonene, pinene and terpinene were determined at high concentrations in butters (Table 4). Terpenes and sesquiterpenes were found in plants as secondary metabolites. Therefore, these compounds might be transferred directly from forage to dairy products (Mariaca et al 1997; Viallon et al 2000). Similar to our results, Rae-Lee et al (1991) identified limonene and *p*-cymene at low levels in unsalted butter heated at different temperatures (100-150 ^{o}C).

The other important contributors of volatiles in butter were lactones formed by hydrolysis and cyclisation of hydroxy-fatty acid triglycerides (Nursten 1997; Sarrazin et al 2011). δ-caprolactone, δ-octalactone and δ-decalactone were identified in butter samples (Table 3). δ-caprolactone was found at the highest concentration in sample 5 (125.9 µg kg^{-1} butter) while sample 4 had the highest concentration of δ-octalactone (135 µg kg^{-1} butter) and δ-decalactone (157.7 µg kg^{-1} butter). In a study conducted by Schieberle et al (1993) on different kinds of butters, the amount of δ-decalactone and (Z)-6-dodeceno-γ-lactone were determined between 2150-5000 µg kg^{-1} butter and 57-260 µg kg^{-1} butter, respectively. Lozano et al (2007) investigated the effect of cold storage and packaging material on commercial butter. The researchers identified δ-hexalactone, δ-octalactone, δ-decalactone, δ-dodecalactone and γ-nonalactone in sweet cream butter wrapped with foil and wax parchment paper. Researcher also observed an increase in these lactones for both butter samples during 6 and 12 months of storage at 4 ^{o}C and -20 ^{o}C. Figure 1 shows geometric representation of butters in terms of all volatile compounds. Butters 2, 5, 6 and 9 had similar flavor characteristics whereas butters 4 and 11 had quite different flavor profile than others in terms of volatile compositions.

3.3. Sensory analysis

Creamy, cooked and margarine were characteristic attributes in butter samples (Table 4). There were no significant differences in whey, margarine-like, sweet aromatic and sweet attributes among

Table 4- Sensory properties of butter samples (n= 2, ±SE)

Çizelge 4- Tereyağı örneklerinin duyusal özellikleri (n= 2, ±SE)

Sample	*Cooked*	*Whey*	*Creamy*	*Rancid*	*Margarine - like*	*Sweet aromatic*	*Oxidized*	*Storage/ plastic*	*Stale*	*Sweet*
1	2.03±0.23	1.15±0.27	2.31±0.21	1.19±0.31	1.25±0.44	0.56±0.24	1.12±0.31	1.69±0.40	1.28±0.28	1.44±0.17
2	1.66±0.12	1.16±0.33	2.69±0.31	2.69±0.27	1.50±0.35	0.47±0.18	1.94±0.18	1.12±0.24	1.12±0.22	1.09±0.15
3	2.22±0.13	1.03±0.41	2.37±0.24	1.12±0.51	1.72±0.35	0.19±0.13	1.03±0.43	1.44±0.36	1.50±0.23	1.25±0.22
4	2.34±0.16	1.12±0.49	2.62±0.18	1.50±0.50	1.91±0.51	0.56±0.24	1.09±0.34	0.87±0.21	1.81±0.19	1.47±0.18
5	2.84±0.20	1.34±0.40	3.19±0.27	1.53±0.23	1.56±0.44	0.59±0.27	1.31±0.37	0.87±0.31	1.41±0.26	1.47±0.18
6	2.72±0.17	0.78±0.21	3.56±0.20	0.37±0.12	2.84±0.49	1.00±0.16	0.53±0.17	1.44±0.26	0.72± 0.16	1.19±0.18
7	2.28±0.20	0.81±0.26	2.72±0.28	0.91±0.21	1.91±0.34	0.37±0.18	1.47±0.19	1.31±0.21	1.22± 0.22	1.19±0.13
8	2.66±0.23	0.84±0.28	3.84±0.17	0.53±0.17	2.75±0.50	0.69±0.23	0.31±0.12	0.28±0.14	0.62±0.24	1.65±0.17
9	2.37±0.19	0.72±0.22	3.06±0.22	0.84±0.19	2.62±0.39	0.75±0.30	0.87±0.33	0.59±0.25	1.22±0.24	1.50±0.17
10	2.50±0.22	0.94±0.36	3.25±0.23	0.28±0.09	2.34±0.45	0.69±0.26	0.41±0.15	0.18±0.07	1.03±0.31	1.59±0.17
11	1.87± 0.19	0.72±0.31	3.56±0.15	0.22±0.12	2.81±0.50	0.78±0.26	0.19±0.12	0.06±0.04	1.47±0.28	1.34±0.11
LSD value	0.53	ns	0.64	0.79	ns	ns	0.75	0.71	0.68	ns

ns, not significant (P≥0.05); SE, standard error

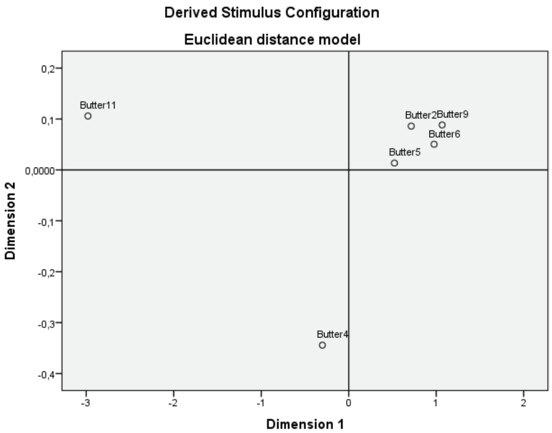

Figure 1- Multidimensional scaling map of butter samples in terms of volatile compounds

Şekil 1- Uçucu bileşenler açısından tereyağı örneklerine ait çok boyutlu ölçeklendirme haritası

the butters. Moreover, significant differences were observed among the butters in terms of cooked, creamy, rancid, oxidized, storage/plastic and stale ($P<0.05$). Whey and rancid were more intense attributes for the samples 1-5 than the other samples (Table 4). Sample 5 had the highest cooked aroma meanwhile sample 8 had the highest creamy attribute. Creamy and margarine-like attributes were higher in the samples 6-11 than others. However some undesirable flavors including rancid, storage/plastic, oxidized and stale were also determined in some samples. It was also performed a multidimensional scale analysis (MDS chart and MDS data were not shown) for volatile compounds and sensory attributes to reveal the relationship of between sensory attributes and characterization of volatile compounds. It was found that cooked, whey and creamy intensities of butter samples were related to diacetyl, 2-heptanone, octalactone, decalactone and caprolactone. Moreover, octalactone closely related with cooked and creamy flavors while the same relationship was observed between whey, rancid flavor and decalactone.

Unsuitable processing and storage conditions, packaging materials and using low quality milk in the production of butter may lead to increase in these undesirable attributes. Krause et al (2008) determined an increase in refrigerated/stale flavor and a decrease in milk fat and cooked/nutty flavor in stick and bulk butters stored at 5 ^{o}C and -20 ^{o}C for 24 months. Sensory language for 27 commercial butters was developed by Krause et al (2007). They found that diacetyl, cooked, grassy, milk fat flavors and salty taste were key characteristics for butters. Jinjarak et al (2006) characterized sensory attributes of sweet cream, whey and cultured butter. Significant differences were found in yellow, shiny, acidic odor, melt rate, porous, hard, spreadable, cheese odor, mouth coating, nutty, cardboard odors, acidic, nutty, diacetyl and grassy flavors of butters. They revealed that whey butter had more nutty and cardboard odor than sweet and cultured butters. Hence, cultured butter had more acidic odor and flavor, and grassy flavor than sweet and whey butter.

4. Conclusions

Some physical, chemical and sensory properties of butter samples collected from local market in Canakkale were investigated in this study. Significant differences among the samples in terms of physical, chemical and sensory characteristics were determined. Color measurements, melting points, acidities and viscosities of the samples varied. In general, samples had similar refractive indexes. On the basis of high concentrations of diacetyl, acetic acid, acetoin, δ-caprolactone, δ-octalactone and δ-decalactone played important roles in flavor of butter samples. All butter samples had similar sensory characteristics in terms of whey, margarine-like, sweet aromatic and sweet taste. Further studies are needed to determine the effects of textural properties, storage conditions, packaging types and processing conditions on butters.

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