Textural Properties of Herby Cheese

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***Abstract*—Herby (Otlu) cheese is a traditional cheese variety which is manufactured broadly in the eastern and south-eastern regions of Turkey. In this study the textural properties of herby cheese containing various herbs sold in the markets was determined. The textural characteristics of traditional cheeses were different from industrial herby cheeses, particularly depending on manufacturing practices as well as raw milk composition, herbs, salt, etc. Traditional herby cheese had lower sensory scores for color, fracturability. Future studies should concentrate on the standardization of manufacturing process and the effect of herbs and their combination on final product properties to improve consumer perception and acceptability.**

***Index Terms*—Turkish Herby cheese, texture, sensory**

I. Introduction

Cheese is a fermented milk product produced and consumed all over the world that is known for centuries. Cheese as being an excellent source of protein and minerals such as calcium and phosphorus and essential amino acids is an important food in human nutrition. It is estimated that more than 1 000 types of cheeses differing in their characteristics such as composition, functionality, appearance and flavor are manufactured [1], [2].

Turkey is among the largest producers of cheese with more than 100 varieties such as White pickled, Kasar, Tulum, Mihalic, Herby, Abhazian, Circassian, Civil, and Orgu cheese [3], [4].

Herby (Otlu) cheese, a semi-hard salty cheese, has long been traditionally produced more than 200 years in Eastern Anatolia Region (Van, Hakkari, Bitlis) as well as in the provinces of Diyarbakir and Siirt of the South-East Anatolia Region [5]-[7].

Herby cheese is produced using herbs that are endemic to the specified regions which give the cheese its characteristic appearance and flavor. These herbs belong to the species of *Allium*, *Thymus*, *Silene*, *Ferula*, and *Anthriscus nemorosa*, the local names of which are Sirmo, Kekik, Siyabo, Heliz and Mendo, respectively (Table I). Among these herbs *Allium* is the most widely used species. It was reported that the use of different herbs and their levels in production significantly affect the chemistry, biochemistry and sensory characteristics [5], [8]-[11].

Herby cheese can be either ripened in brine or in earthenware or plastic containers using dry-salting. In the past, dry-salted cheeses were ripened underground; however, brining is more preferred nowadays [10]-[12].

The artisanal manufacturing of herby cheese is from whole unpasteurized ewe's, cow's and/or goat's milk without any addition of starter culture. The herbs used are generally a mixture of the species of *Allium*, *Choerophyllum*, *Calamintha*, *Thymus* or *Ferula* and used at a rate of 0.1–1.5%. However, in industrial production, pasteurized milk is preferred and the milk is acidified by a mesophilic starter culture, e.g., *Lactococcus lactis* subsp. *lactis* and *L. lactis* subsp. *cremoris* [13]-[15]. The cheese is ripened at 7–8^{o}C for 90–150 days; but there are no specific national standards for the ripening time [6].

As herby cheese is preserved either dry or in brine, there are differences in structure and appearance. It is rindless, white colored, medium to hard consistency and close-textured with a salty and piquant flavor [15]. This cheese has an odor imparted by the herbs that are added to it and its color may vary in tones between white and yellowish. The herbs predominate in its appearance, which is otherwise that of common white cheese [7].

Texture represents all the rheological and structural attributes perceptible by means of mechanical, tactile, and, when appropriate, visual and auditory receptors of any food matrix [16]. The factors that have impact on texture include fat globules embedded within the protein matrix, fat globules coated with casein micelle fragments that interact with the surrounding casein matrix, free pools of fat, casein matrix density, proteolysis that reduces the casein cross-linking and water content aside with the bond strength and density between chains of fused casein micelles. Increasing casein bond strength and density results in enhanced firmness of the matrix [17].

Previous studies have reported the biochemical characterization herby cheese [6], [8], [11]-[14], [18], however, the texture analyses have not been conducted. Therefore, the aim of this study was to evaluate the textural and sensorial properties herby cheeses supplied both from traditional dairy producers and industrial dairy plants.

Manuscript received July 28, 2016; revised September 28, 2016.

doi: 10.18178/ijfe.3.1.23-28

TABLE I. SOME HERBS USED IN THE MANUFACTURE OF HERBY CHEESE

Latin name of the herb		Local name of the herb
Liliaceae	*Eremurus spectabilis*	Ciris
	Allium schoenoprasum	Sirmo Yabani sogan
	Allium fuscoviolaceum	Sirmo, Catlangic,
	Allium scorodoprasum	Sirmo
	Allium aucheri	Sirmo, Sirim
	Allium paniculatum	Sirmo, Handuk
	Allium akaka	Kuzukulagi
	Allium cardiostemon	
Lamiaceae	*Ocimum basilicum*	Reyhan
	Ziziphora clinopodioides	Kekik (Thyme)
	Mentha spicata	Yarpuz
	Thymus migricus	Kekik, Zahter
	Thymus kotschyanus	Kekik, Zahter
Apiaceae	*Ferula rigidula*	Heliz
	Ferula orientalis	Heliz
	Ferula L. sp.	Hitik, Hiltik
	Prangos ferulacea	Heliz
	Prangos pabularia	Heliz, Kerkur
	Anethum graveolens	Dereotu
	Carum carvi	Tarakotu
	Anthriscus nemorosa	Mendo
Caryophyllaceae	*Silene vulgaris*	Siyabo
	Gypsophila L. sp.	Coven
Brassicaceae	*Nasturtium officinale*	Tere
Ranunculaceae	*Ranunculus polyanthemos*	Cunk

II. MATERIAL AND METHODS

A. Material

Twenty-nine herby cheese samples were purchased from different dairy producers 17 being producers using traditional manufacturing process (1 to 17) and 12 being industrial manufacturers (18 to 29). The freshest of each cheese was chosen based on its labeled shelf life.

B. Methods

Texture properties of cheese samples were evaluated on replicated samples with a Texture Analyser TA-XT Plus (Stable Micro Systems) texturometer, using a two-bite compression of cylindrical samples of 36 mm of diameter. A load cell of 5-kg was used to eliminate noise during measurement. Experiments were evaluated by compression tests which generated plot of force (g) vs. time (s). The probe used to measure the textural profile of cheese samples were carefully cut into pieces (45 mm diameter x 45 mm height) with a cheese slicer. After being cut, the cheese samples were left at room temperature (25^{o}C) for 20 min prior to testing and at least 3 measurements were performed on each cheese. The samples were compressed by 75% of their original depth twice using a crosshead speed of 5 mm s^{-1} and the speed of the probe was fixed during the pre-test, compression and the relaxation of the samples [19].

The data obtained from the force-relaxation curve were used to calculate maximum and residual force, while the data obtained from TPA curve were used for the calculation of textural parameters. The parameters recorded include hardness, adhesiveness, springiness, cohesiveness, gummines, resilience and chewines.

In food acceptance tests, the sensory panel was asked to describe the sensory attributes of texture, color, taste, aroma intensity and fracturability of the cheese samples; by assigning a liking score on a 5-point hedonic scale where 1 = 'strongly disliked'; 2 = 'moderately/ slightly disliked'; 3 = 'indifferent'; 4 = 'moderately/ slightly liked'; and 5 = 'strongly liked'. The tests were performed in individual booths lighted by a fluorescent white lamp at 10:00 a.m. Approximately 50 g of cheeses at 7 ℃ was placed in plastic cups coded with random 3-digit numbers for identification. The samples were presented monadically for each panelist. Unsalted crackers and mineral water were provided to cleanse the palate between tasting periods [20].

Hierarchical Cluster Analysis (HCA) based on textural characteristics was carried out by the unweighted pair group method using arithmetic averages (UPGMA) with a dissimilarity matrix by JMP 7.

III. RESULTS AND DISCUSSION

The rheology and texture of cheese is affected by chemical composition; microstructure such as the structural arrangement of the components; the ratio of solid fat to liquid fat; and macrostructure which is a reflection of the presence of heterogeneities i.e. curd granule junctions and cracks [21].

Texture profile analysis (TPA) is used to evaluate the texture of cheeses which simulates the compression of molar teeth during mastication. This will allow the prediction of texture characteristics prior to product consumption [22]. By TPA that generates values such as hardness, adhesiveness, cohesiveness, springiness, elasticity, and gumminess the textural parameters of cheese could be defined [23].

Table II shows the results from the TPA values of herby cheese as hardness, adhesiveness, springiness, cohesiveness, gumminess, chewiness and resilience. There were significant variations in the textural properties depending on the differences in the manufacturing practices (industrial and artisanal).

Hardness is described as the force applied by the molar teeth to compress the food; adhesiveness, the ability of food to adhere to the teeth when chewed; chewiness, number of chews necessary for food to be swallowed; springiness, total amount of recovery after press; cohesiveness, degree to which the chewed mass sticks together; resilience reflects the re-deformation capacity of tissue after penetration and how well a product fights to regain its original shape and size; and gumminess, the energy necessary to disintegrate a semi-solid food to a state which is ready for swallowing, and it is related to the primary parameters of hardness and cohesiveness resilience [24].

All industrial herby cheeses had significantly higher textural values than those of artisanal herby cheeses (Table II), due to the differences in cheese manufacturing parameters such as raw milk, herbs used, processing technology, ripening conditions, packaging, and temperature, etc.

TABLE II. TEXTURAL PROPERTIES OF HERBY CHEESE

	Sample No	Hardness (g)	Adhesiveness (g s^{-1})	Springiness (mm)	Cohesiveness	Gumminess (g s^{-1})	Chewiness (g mm^{-1})	Resilience
Traditional Herby Cheese	1	5278,2660	-36,4520	0,8610	0,3130	1650,7520	1421,9350	0,1190
	2	14520,3800	-154,0800	0,6340	0,0540	787,7020	499,1380	0,0330
	3	6002,6180	-58,4710	0,7350	0,3000	1801,1540	1324,1160	0,1180
	4	7874,3460	-18,0780	1,0270	0,5990	4718,2360	4846,7030	0,2260
	5	8035,1640	-2,8140	0,9310	0,4870	3912,3660	3641,2120	0,2050
	6	7041,9560	-369,8730	0,5000	0,1290	905,1270	452,5630	0,0460
	7	17568,4200	-15,2775	0,9310	0,6715	11728,9000	10916,000	0,3005
	8	5598,5580	-60,2995	0,6805	0,2270	1259,8160	868,4970	0,0780
	9	8815,8700	-0,5930	0,9245	0,8190	7204,2870	6666,5610	0,4135
	10	3043,0530	-29,1860	0,5905	0,2410	724,2050	428,0160	0,0970
	11	6774,4450	-233,5870	0,6430	0,2330	1551,1870	989,4530	0,0590
	12	7105,0860	-213,6230	0,6700	0,2400	1699,5560	1171,6970	0,0640
	13	7794,6150	-199,3020	0,6820	0,2340	1774,7110	1250,5960	0,0630
	14	9147,7300	-14,2360	0,7870	0,5295	4847,2100	3809,4700	0,1970
	15	7873,8510	-74,0595	0,6635	0,2425	1908,5770	1277,3220	0,1040
	16	10260,0500	-24,9840	0,6250	0,2850	2872,8240	1800,6280	0,1290
	17	15437,8500	-24,7575	0,7425	0,5490	8338,3160	6369,7850	0,2615
	Average	**8716,0150**	**-89,9808**	**0,7428**	**0,3620**	**3393,2310**	**2807,8640**	**0,1479**
Industrial Herby Cheese	18	8281,3790	-69,6580	0,6810	0,1930	1601,7490	1090,3000	0,0670
	19	8237,3010	-231,5890	0,9210	0,6000	4943,7160	4552,1350	0,2040
	20	4052,8520	-415,6300	0,9980	0,6580	2667,6770	2661,0740	0,1800
	21	18849,4400	-34,8490	0,6880	0,3410	6424,390	4420,7440	0,1220
	22	16265,9600	-333,3090	0,8990	0,7270	11833,390	10632,4800	0,2860
	23	11192,6600	-11,5770	0,9180	0,7400	8286,4330	7609,5710	0,3160
	24	7536,6860	-149,264	0,9010	0,5925	4360,9130	3915,0990	0,1955
	25	22966,5700	-1,6290	0,9035	0,7495	17146,2100	15500,5400	0,3730
	26	10890,5500	-23,1745	0,8765	0,7260	7899,8090	6926,4170	0,3060
	27	24322,2000	-0,8840	0,8640	0,7520	8125,3110	7019,1420	0,8050
	28	3844,2060	-57,6315	0,8315	0,4450	1701,6750	1416,5130	0,1750
	29	4892,7410	-38,8900	0,7670	0,6220	2971,7940	2307,9640	0,2855
	Average	**11777,7100**	**-114,0071**	**0,8540**	**0,5955**	**6496,9220**	**5670,9980**	**0,2763**

The variation in cheese varieties are mostly due to differences in manufacturing methods (e.g., pre- and post-coagulation operations), starter cultures and/or ripening conditions which lead to the development of characteristic flavor, and the consumer preference for the functionality of the product [25]. Both rheological parameters and texture are influenced by factors that include casein-casein, casein-water, and casein-fat interactions, the state of water (either bulk, or bound to the casein matrix), pH and the state of calcium (either ionic or bound to the casein matrix), temperature, sodium chloride content, and the extent of proteolysis [17].

Romieh et al. [26] reported that fat delays the formation of a solid protein matrix and acts as a lubricant, yielding a cheese with higher smoothness and softness. Similar Adda et al. [27] stated that cheeses of higher fat content are more elastic. Kaminarides et al. [28] reported that increasing the salt and ash contents increased the hardness of the processed cheese. Korish and Abd-Elhamid [29] mentioned that the lowest values of hardness, springiness and chewiness in Kareish cheese, might be a result of the increase in cheese moisture content. de Sousa Carvalho et al. [30] mentioned that the gumminess of Prato cheese decreased in the maturation

period, whereas Bourne [24] stated that gumminess as being directly proportional to the firmness decreased with reduced firmness.

The final cheese attributes are largely defined by physical, chemical, and microbiological reactions that occur during the ripening process. The ripening period varies from two weeks to two years, depending on the type of cheese. These biochemical reactions during ripening are influenced by composition and the processing steps. Flavor compounds and gas occur either from the activity of the coagulant, indigenous milk proteases (e.g. plasmin) and lipases (e.g. lipoprotein lipase), starter culture bacteria and their enzymes, or secondary microflora (bacteria, yeasts, and/or fungi) and their enzymes. For instance, the microflora continues to metabolize residual lactose, lactate, and citrate in the cheese, as well as catabolizing fatty acids and amino acids. Additionally, dehydration and development of curd compacting continue throughout the ripening period, of which significantly determinates the rheology of cheese. Longer ripening times obviously result in more pronounced changes [31], [32].

Lawrence et al. [33] explained that the protein-to-moisture ratio affect total network density, and therefore, significantly affect the texture. Greater protein concentration corresponds to a denser network, which is consequently detected to be firmer.

Chemical changes in the protein network of the cheese curd are directly related to pH and texture. The modulus of deformability (stiffness) and adhesiveness (stickiness) generally decreases as the pH increases.

Textural properties are of considerable importance to the consumers as well as to manufacturer, packager, distributor and retailer of cheese industry [34], and are often expressed in sensory terms. Consumers have identified texture as one of the most important drivers in perception of cheese quality [35]. Furthermore, consumers associate specific textures, color, taste, aroma and visual appearance with specific varieties of cheese, and deviations from the expected texture result in decreased acceptability/liking scores [36], [37].

Fig. 1 shows the dendogram obtained from HCA which was performed to classify the herby cheese samples regarding dissimilarities according to TPA results. As can be seen from the figure, three different clusters were observed (namely, C1, C2, C3). The manufacturing process, industrial or traditional, was the parameter for formation of the clusters. The TPA and HCA results were similar regarding the classification of the cheese samples based on their textural properties.

Fig. 2 shows the sensory scores of herby cheeses. In sensory attributes of herby cheeses no significant differences were observed, except color, fracturability and overall acceptability. The differences in these three sensory parameters are mainly depending on the manufacturing process, ripening conditions, cheese composition and use of different herbs. The high scores for fracturability, ability to break food into pieces when it is bitten using the incisors, was thought to be related to dry salting and long ripening period. Hedonic rating test showed that the average overall acceptability of industrial herby cheeses was slightly higher than that of traditional samples, indicating that good production practices and standardization was positively effective on obtaining cheese quality.

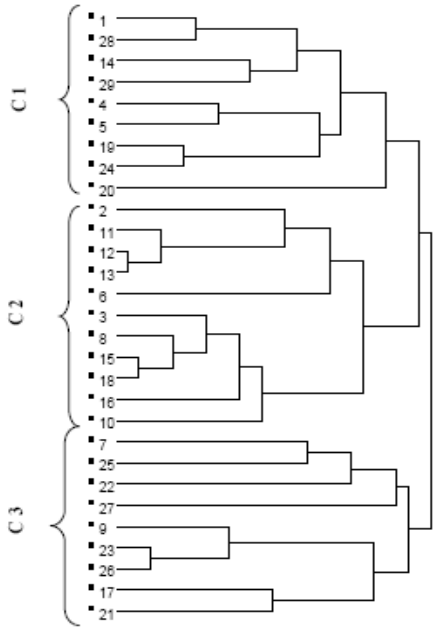

Figure 1. Classification of the herby cheese by hierarchical cluster analysis (HCA) on the basis of textural parameters

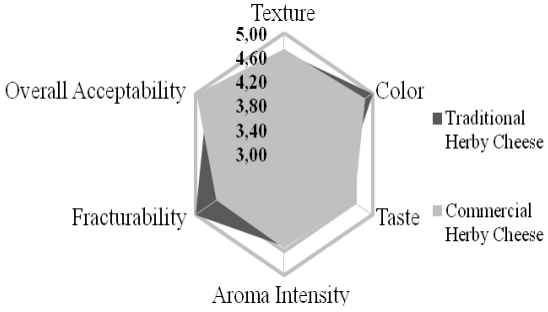

Figure 2. Sensory scores of herby cheeses

Being a complex sensory property, cheese texture can either measured directly by sensory evaluation or by instrumental techniques. Up to a certain extent these instrumental methods like small strain methods (transient and dynamic oscillation) or large strain tests (e.g. texture profile analysis, uniaxial compression and torsion) are related to sensory characteristics [34], [38], [39].

Cheese flavour is the result of the breakdown of milk components by indogeneous or exogeneous enzymes which produce a series of volatile and non-volatile compounds. The enzymes from cheese-related microorganisms, particularly lactic acid bacteria, are the chief factors responsible for the formation of many such compounds that are essential for cheese flavour [40]. Differences in texture do not affect only the feel of the cheese in the mouth and hand can also impact flavor. Researchers found that textural differences in cheeses affect consumers' chewing activity, which in turn affect aroma release from the cheese [41].

IV. Conclusion

In Turkey, herby cheese production is largely based on artisanal processes in small-scale dairies and family farms. Raw milk composition, processing of raw milk, thermal history, pH, herbs, salt, indigenous or cultured microflora and their metabolic activities, and ripening conditions could affect the composition, textural and sensory properties of herby cheese. The sensory evaluations indicated that the acceptability of industrial herby cheeses was higher since most of the panelists preferred cheeses with standard color, aroma and textural properties. Considering both TPA and sensory evaluation results, it could be concluded that standard processing techniques should be used in the production of herby cheese to improve consumer perception and acceptability

Although recent studies on herby cheese have increased interest data are not sufficient, therefore, further research is needed to understand the effects of herbs on biochemical reactions which are determinative on texture and characteristic aroma.

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