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Sensory Evaluation and Related Volatile Components of White Herby Cheese

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Abstract: The aim of this study was to evaluate new white herby cheese organolyptically and their related volatile compounds to introduce them to the Egyptian market. Celery and thyme with different concentrations (1 and 2%) were used to prepare the new cheese. Results showed that lower concentration (1%) of both celery and thyme got the highest total acceptability scores in both descriptive and hedonic tests. Fresh and cold stored herby cheeses, in addition to control sample were analyzed to identify their volatile compounds using GC-MS, employing the headspace method for the extraction process. Sixty eight volatile compounds were identified as follows: 14-alcohols, 6-aldehydes, 6-ketones, 26-esters, 7- free fatty acids and 9-hydrocarbones. Their concentrations as relative area (%) and KIs were also determined.

Key words: Celery cheese, thyme cheese, sensory analysis, hedonic study, volatile components

INTRODUCTION

Any industrial food process aims at obtaining product having specific qualitative standard fulfilling consumer's requirements. Consumers today are more sophisticated with regard to the foods they eat, they seek diversity in their diet and different sensory experiences and they expect a wide range of nutritional benefits. They are more mobile than they were a decade ago and are more likely to try new and innovative foods (Stone and Sidel, 1995). All the different parameters contributing to the determination of sensory properties (color, appearance, texture taste and aroma) are equally important for product acceptability (Pagliarini *et al*., 1991). Relating sensory language and chemical volatile compounds represents a challenge for several reasons. Also, relative amount of a compound in a food is not necessarily a measure of its sensory impact, due to different thresholds and the effects of food matrix. The sensitivity of the extraction technique must also be taken into account. Finally, only a small percentage of the volatile components in food are odor active (Drake and Civille, 2003). On the other hand, many spices or aromatic herbs used to give special aromas or flavors to foods and can be used in many varieties of cheese (Marino *et al*., 2001). Primary degradation of milk constituents by glycolysis, lipolysis and proteolysis leads to the formation of a whole range of precursors of flavor compounds. These changes are followed and/or overlapped by a series of secondary catabolic reactions, which are responsible for the unique aroma profile of a particular variety of cheese (Marilley and Casey, 2004). To introduce a new white cheese with celery or thyme to Egyptian markets, earlier studied by Foda *et al*. (2006) were done including the chemical and microbiological analysis. So, the objectives of this work were to study the consumer acceptability of white cheese containing different herbs type and concentration and to identify their volatile compounds.

MATERIALS AND METHODS

Buffalo's milk retentate was obtained in April from Dairy Industry Unit, Animal Production Research Institute, Ministry of Agriculture, Cairo, Egypt. The chemical composition of milk retentate

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was 29.2% total solids, 15.5% fat; 12% total protein and the pH was 6.7. Fresh celery (*Apium graveolens* L.) was purchased from local market and fresh green thyme (*Thymus vulgaris* L.) was obtained from Sekam Co., Bilbis, Egypt. Microbial rennet (*Mucor mehiei*) was obtained from Novo, Denmark.

Preliminary Study for Sensory Analysis

To get acceptable herby white cheese, some experiments were conducted with different added celery or thyme forms before and after pasteurization step. Boiled, minced or fresh cutted leaves were admixed with milk retentate for cheese making. The favorite forms were celery small cutted leaves and fresh green thyme leaves.

Cheese Making

White cheese was prepared, in the laboratory of National Research Center, according to Foda *et al*. (2006). Two levels of each herb (1 and 2%) were added to milk retentate, the mixture well mixed after salted (3%) and pasteurized at 73°C for 15 sec. Curds were hold at 40°C after adding the rennet, then distributed in plastic containers. Control cheese was prepared without herbs. All cheese samples were stored under refrigerator temperature (5°C±2) for 4 weeks; samples were taken fresh and every week for analysis. Three replicates were prepared for each cheese for sensory and volatile compounds evaluations.

Sensory Evaluation

Sensory evaluation consists of descriptive and hedonic studies as follows:

Descriptive Sensory Analysis

Fifteen assessors, (7 male and 8 female, aged between 25 and 45 years), who has experience with cheese and regularly used its descriptive vocabulary, were participated. Panel members were also instructed to report any defects or unpleasant flavor. Samples of white herby cheese were cut into pieces about 3× 3× 2 cm in size and placed in a glass tumbler covered with a clock glass coded with three digit random numbers. The pieces were tempered by holding at ambient temperature (23±2°C) and then presented to the panelists in a random order for testing. Water and no salted crackers were provided to clean their palates between tasting. Panel members evaluated the cheeses for appearance, flavor, body and texture and odor using a 10 point sale with 1 being the worst and 10 the best quality. Importance was given predominantly to the attributes of flavor and appearance of the cheese. The total scores were obtained by adding the scores for the four attributes.

Consumer Assessment

Consumer preference testing took place on a blind basis at two different locations in Cairo; 45 different aged consumers were participated. Consumer study was divided into two parts, first, the people interviewed were asked about their preference related to cheese without tasting the sample. Secondly, they were asked to evaluate these cheeses after tasting. Samples were presented to consumers at room temperature in a glass tumbler covered with a clock glass coded with randomly selected 3 digit numbers. Each consumer was asked to express his preference using the 9 point hedonic scale. Consumers were provided water at room temperature and asked to rinse thoroughly after testing each cheese to clean their palate.

Isolation of Volatile Extracts of Cheese by Steam Distillation [SD] and Liquid-Liquid Continuous Extraction

Control and white herby cheese, (1% celery or thyme), fresh and stored for 2 and 4 weeks, were used to determine their volatile components, acording to the method which described by Lee and Shibamoto (2001).

Determination of Volatile Components

Volatile compounds in cheese extracts obtained by three replicate experiments were identified by comparison with the Kovats gas chromatographic retention index I (Adams, 1995) and by the mass spectral fragmentation pattern of each GC component compared with those of authentic compounds and/or NIST/EPA/NIH Mass Spectral Library (NIST 05) ASCII Version. An Agilent model 6890 gas chromatograph equipped with a 30 m×0.25 mm, (inside diameter) (df) 0.25 μm) bonded phase DB-5 fused silica capillary column (Agilent, Folsom, CA) and a flame ionization detector (FID), was used to obtain the Kovats index, which was also compared with published data (Kovats, 1965).

Statistical Analysis

Statistical analysis of data was performed by ANOVA procedure using SAS PROC GLM/ STAT (SAS, 1998). Differences among means were identified using Duncan multiple range test.

RESULTS AND DISCUSSION

Descriptive Sensory Analysis

Table 1 shows significant differences ($p<0.05$) after one week on appearance and odor, while after three weeks on flavor in white cheese with 1% celery. While, significant differences ($p<0.05$) were observed in white cheese with 2% celery after one, two and three weeks for flavor, odor and texture respectively. One week old cheeses obtained the highest total acceptability scores then decreased by prolonging the storage period.

Prolonging the cold storage 4 weeks for thyme cheese (1%) did not affect the flavor, texture or total score significantly. While, appearance and odor scores significantly decreased after 2 weeks. Prolonging the cold storage affected the appearance, texture and odor of white cheese containing 2% thyme significantly after three weeks, there was no significant differences in total score.

Table 1: Sensory characteristics of herby white cheeses made with different concentrations of celery or thyme during cold storage period

Storage period (weeks)	Appearance (30 points)	Flavor (30 points)	Body and texture (20 points)	Odor (20 points)	Total score (100 points)
Celery (1%)					
Fresh	21.40±0.99^{b}	25.93±1.13^{b}	17.66±0.91^{a}	18.66±0.57^{b}	84.33±2.05
1	25.20±0.64^{a}	26.20±0.64^{b}	19.66±0.90^{a}	20.00±0.00^{a}	91.60±1.57
2	22.26±0.81^{b}	26.83±0.93^{b}	19.26±0.55 ^{a}	19.26±0.55^{a}	88.10±2.03
3	20.53±0.49^{b}	27.66±0.75^{a}	19.00±0.69^{a}	19.60±0.28^{a}	86.80±1.16
4	23.78±0.76^{b}	28.92±0.72^{a}	17.78±0.95^{a}	18.07±5.08^{b}	83.92±6.41
Celery (2%)					
Fresh	22.60±1.31^{ab}	25.86±1.03^{b}	18.13±0.73^{a}	18.73±0.56^{b}	85.32±2.70
1	26.06±0.88^{a}	27.46±0.58^{a}	18.40±0.89^{a}	18.40±0.57^{b}	90.33±1.51
2	22.60±1.06^{ab}	26.33±0.90^{a}	16.80±1.01^{a}	19.33±0.36^{a}	85.00±2.11
3	22.00±0.83^{b}	28.20±0.47^{a}	18.13±0.55^{a}	18.06±0.55^{a}	86.40±1.25
4	25.60±1.08^{a}	28.33±0.53^{a}	15.13±1.19^{b}	16.80±0.98^{c}	85.86±2.04
Thyme (1%)					
Fresh	24.66±0.54^{a}	26.00±0.85^{ab}	19.06±0.39^{a}	19.20±0.47^{a}	88.93±1.54
1	26.00±0.85^{a}	27.93±0.80^{b}	18.93±0.46^{a}	19.93±0.46^{a}	92.79±1.72
2	22.20±1.00^{b}	27.20±0.85^{a}	17.20±1.03^{a}	18.86±0.66^{b}	85.46±2.03
3	20.06±0.70^{b}	27.86±0.55^{a}	18.06±0.47^{a}	18.46±0.42^{b}	87.13±2.01
4	22.13±0.80^{b}	27.73±0.88^{b}	18.53±0.89^{a}	16.93±1.13^{c}	85.33±2.04
Thyme (2%)					
Fresh	24.00±0.68^{a}	27.13±0.75^{a}	18.40±0.71^{a}	19.06±0.49^{a}	88.60±1.37
1	25.81±0.82^{a}	26.12±.62^{ab}	18.00±0.47^{a}	19.20±0.45^{a}	89.13±1.50
2	25.20±0.98^{a}	25.53±1.16^{a}	17.60±0.88^{a}	19.26±0.28^{a}	87.40±1.54
3	23.60±1.60^{a}	27.46±0.94^{a}	17.13±1.00^{a}	19.26±0.35^{a}	87.46±2.69
4	21.66±0.69^{b}	29.80±0.20^{a}	15.66±1.24^{b}	18.20±0.57^{b}	85.33±1.87

Means with different letter (s) within the same column are significantly different ($p< 0.05$), Means±SE

In general, herbs type had no significant effect on the sensory parameters (Table 2), while increasing herbs concentration from 1-2% only increased cheese appearance significantly. Prolonging the cold storage had significant effects on cheese appearance and total score after one week, while affected cheese odor after three weeks. These results are in agreement with those obtained by Tarakci *et al*. (2004), who reported that increasing the concentration of black cumin in Tulum cheese from 0.5-3% caused higher consistency, higher bitter taste and aroma than control.

Hedonic Sensory Analysis

Table 3 shows the mean liking scores obtained before and after tasting herby cheeses which contained 1 and 2% of celery or thyme. It could be noticed that white cheese containing 1% celery obtained higher score than 2% celery either before or after tasting. Also, adding 1% thyme to white cheese obtained the higher score (8 = like very much) either before or after tasting compared with

Table 2: Effect of herbs type, concentration and cold storage period on the sensory characteristics of white herby cheeses

Parameters	Appearance (30 points)	Flavor (30 points)	Body and texture (20 points)	Odor (20 points)	Total score (100 points)
Herbs type*					
Celery	22.91±0.2^{a}	27.55±0.22^{a}	17.91±0.20^{a}	18.80±0.18^{a}	87.36±0.84^{a}
Thyme	23.91±0.34^{a}	27.13±0.23^{a}	17.96±0.24^{a}	18.74±0.19	a87.76±1.34^{a}
Herbs concentration (%)**					
1	22.53±0.30^{b}	27.40±0.22^{a}	18.43±0.22^{a}	18.91±2.3^{a}	87.70±1.32^{a}
2	24.07±0.33^{a}	27.27±0.23^{a}	17.44±0.27^{a}	18.63±2.2^{a}	87.42±0.87^{a}
Storage period (weeks)***					
Fresh	23.17±0.38^{b}	26.23±0.41^{c}	18.32±0.33^{a}	18.92±0.26^{a}	86.80±2.87^{b}
1	25.40±0.49^{a}	27.35±0.29 ^{bc}	18.75±0.34^{a}	19.13±0.23^{a}	90.72±0.72^{a}
2	23.07±0.49^{b}	26.48±0.40^{c}	17.72±0.29^{ab}	19.18±0.24^{a}	86.49±0.81^{b}
3	21.55±0.57^{c}	27.80±0.36^{ab}	18.08±0.33^{a}	18.85±0.24^{a}	86.95±1.87^{b}
4	23.32±0.46^{b}	28.83±0.25^{a}	16.82±0.57^{b}	17.77±0.43^{b}	86.83±0.90^{b}

Different letters within the same column are significantly different ($p<0.05$), Means±SE, *Each number represents 150 values, **Each number represents 150 values, ***Each number represents 60 values

Table 3: Mean liking scores obtained in the survey before and after tasting white cheeses containing different herbs concentrations

	Before tasting				After tasting			
Cheese samples	Score	Score frequency	Total consumers (%)	Means	Score	Total consumers frequency	(%)	Means
Celery (1%)	8	10	22	6.4	8	3	6	5.8
	7	14	31		7	19	42	
	6	9	20		6	5	11	
	5	10	22		5	10	22	
	2	2	4		4	4	8	
Celery (2%)	8	7	15.5	5.9	2	4	8	5.4
	7	7	15.5		8	7	15.5	
	6	12	26.5		7	3	6.5	
	5	15	33.5		6	10	22	
	4	2	4		5	13	29	
	2	2	4		4	8	17.5	
Thyme (1%)	8	18	40	6.8	2	4	8	6.8
	7	9	20		8	16	35.5	
	6	11	24		7	14	31	
	5	5	11		6	9	20	
	4	2	4		5	2	4	
Thyme (2%)	8	10	22	6.3	8	4	8	5.8
	7	20	44		7	15	33.5	
	6	2	4		6	9	20	
	5	7	15.5		5	6	13	
	4	4	8		4	9	20	
	2	2	4		2	2	4	

2% thyme. These results are in agreement with those obtained by Coskun *et al*. (1996), who reported that cheeses with lower concentration (1 and 2%) herb were mostly preferred by the panelists in term of total score than higher herb concentration (4 or 5%). On the other hand, both descriptive and hedonic evaluation presented same results, while Barcenas *et al*. (2001) found important differences between consumer's concept and sensory preference responses for most cheeses under test.

Analysis of Volatile Compounds

Sixty eight volatile compounds were identified in control and herby white cheeses, during storage period 4 weeks, could be placed into the following categories: aldehydes, ketones, fatty acids, hydrocarbons, esters and alcohols (Table 4-7).

Carbonylic compounds, namely aldehydes and ketones play a key role in developing of cheese flavor (Castillo *et al*., 2007; Panseri *et al*., 2008). Six aldehydes were isolated from control and herby white cheeses, fresh control cheese contained higher total aldehydes contents, decreased after 2 weeks and then increased after 4 weeks, in contrarily with herby cheeses. The main aldehyde (valeric aldehyde), which found in all cheeses, reached the highest amount in both herby cheese after 2 weeks, then decreased after 4 weeks, in contrarily with control cheese. The second main aldehyde was 3-Methyl butanal which provides malty aroma (Castillo *et al*., 2007), was found with high amount in fresh control and decreased by prolonging the storage period. Also, Kondyli *et al*. (2002) found that control full fat feta-type cheese contained higher amount of 3-methyl butanal than low fat. The aldehyde (3-Methyl thiopropanal) was commonly found in fresh celery cheese and during storage period, while control cheese contained low amount and thyme cheese was free.

Methyl ketones, together with their reduction products are considered the most important compounds for the aroma of soft and mold-ripened cheeses and also present in most hard and semi hard varieties (Gomez-Ruiz *et al*., 2002). Table 4 shows that methyl ketones were the most ketones presented in control and white herby cheeses as occurred in other cheese varieties, but with different concentrations. Fresh control contained higher amount of total ketones decreased by prolonging the cold storage, in contrarily with thyme cheese. Both celery and thyme reduced the 3-methylhexan-2-one, which presented as main ketone in fresh control cheese. These results could be due to the antimicrobial effect of celery and thyme. Banks *et al*. (1992) reported that the concentration of ketones in cheese depends on the amount and composition of fat in original milk and their appearance as a result of microflora lipolysis action in cheese.

Table 4: Relative abundance of aldehydes and ketones identified in control and herby (celery and thyme) cheeses stored for 4 weeks

		Cheese sample								
		Control			Celery			Thyme		
Compounds	KI*	Fresh	2 weeks	4 weeks	Fresh	2 weeks	4 weeks	Fresh	2 weeks	4 weeks
Aldehydes										
3-methyl butanal	646	9.18	-	4.12	5.90	3.87	0.54	4.67	3.82	2.80
Valeric aldehyde	687	28.49	0.36	14.88	28.41	36.70	15.90	27.72	35.90	1.84
3-methyl thiopropanal	902	0.01	-	0.04	0.12	0.10	0.04	-	-	-
Methional	905	0.03	-	0.04	0.10	0.03	-	0.05	0.02	0.09
Benzaldehyde	961	0.01	-	0.01	0.06	0.02	-	0.01	-	-
Decanal dimethyl acetal	1377	-	-	0.22	0.11	0.50	0.83	0.28	-	-
Total		37.73	0.36	19.31	34.71	41.22	17.31	32.73	39.74	4.73
Ketones										
3,4-hexanedione	794	1.56	1.10	1.54	1.47	1.64	-	-	1.23	2.30
4-methyl-3- pentan -2-one	838	0.17	-	-	0.04	0.11	-	0.05	0.02	-
3-methylhexan-2-one	843	5.26	1.60	0.06	0.09	0.09	-	0.12	0.40	0.56
5- methyl heptan-3- one	939	0.04	-	0.03	0.06	-	-	0.01	0.02	-
O-decalactone	1465	0.02	0.72	0.06	0.02	0.05	0.19	0.11	-	0.80
1,10-dihydronootkatone	1769	0.01	-	-	0.10	-	-	0.02	0.05	-
Total		7.06	3.42	1.69	1.78	1.89	0.19	0.31	1.72	3.66

Relative abundance expressed as percentage on total volatile compounds detected. *Kovat Index , -: Not detected

Fatty Acid, Hydrocarbons and Esters

Free fatty acids and esters are another series of important flavor constituents in white cheese, play positive contribution to the typical flavor (Parliament *et al*., 1982). Also, aliphatic and branched-chain and other minor fatty acids hydrolyzed from milk fat by lipases, provide characteristic flavor to many cheeses (Ha and Lindsay, 1993). Fatty acids are not only aroma compounds by themselves, but also serve as precursors of methyl ketones, alcohols lactones and esters. Seven fatty acids were identified in control and herby cheeses (Table 5). Fresh control and celery cheeses had lower total volatile fatty acids compared with thyme cheese, decreased by prolonging the cold storage. Herby cheeses (celery or thyme) had higher amount of butanoic acid, these amounts decreased after two week and disappeared in four weeks. Butanoic acid is an important flavor compound which imparts a desirable sharp, piquant taste; it may be produced by fermentation of lactose and lactic acid (Castillo *et al*., 2007). Branched-chain fatty acid such as 2-metyl butanoic acid was commonly found in thyme cheese either fresh or during cold storage. Yvon and Rijnen (2001) reported that this compound probably derives from isoleucine and impart sweaty aroma. Also, Barron *et al*. (2005) found that n-Butanoic acid and branched chain acids, contributed to higher scores for sharp, rancid, rennet brine odors and rennet flavours. While, acetic acid, methyl ketones and their reduction products contributed to the higher scores for buttery and toasty odors.

The main volatile fatty acid in fresh celery cheese was butyric acid in contrarily to thyme cheese; this could be explained by the presence of diversified flora. Iso valeric acid was the main component either in fresh control or herby cheese decreased after 2 weeks and then disappeared, while pentanoic acid presented in fresh and after 2 weeks in herby cheeses. Moio *et al*. (2000) reported that the presence of straight-chain fatty acid with odd number of carbon atoms, such as pentanoic may be due to partial fermentative origin.

Table 5: Relative abundance of free fatty acids identified in control and herby (celery and thyme) cheeses stored for 4 weeks

		Cheese sample								
		Control			Celery			Thyme		
Compounds	KI*	Fresh	2 week	4 weeks	Fresh	2 weeks	4 weeks	Fresh	2 weeks	4 weeks
Free fatty acids										
Butanoic acid	816	0.11	0.10	0.15	0.25	0.16	-	0.33	0.13	-
Butyric acid	822	0.15	-	-	0.74	0.28	-	-	0.17	-
Iso valeric acid	833	0.63	-	-	0.83	0.35	-	3.80	0.28	-
Pentanoic acid	909	0.06	-	0.03	0.07	0.02	-	0.02	-	-
(Z) -2-methyl -2-butanoic acid	1655	-	-	0.03	-	0.03	-	0.03	0.01	0.08
Isopropyl myristate-hexadecanoic acid	1939	0.02	-	0.09	0.04	0.04	0.48	0.02	0.05	0.90
Octadecadienoic acid	2094	0.01	0.65	0.04	0.02	0.44	0.26	0.01	0.02	-
Total		0.98	0.75	0.34	1.95	1.32	0.74	4.21	0.66	0.98
Hydrocarbons										
Norbornene	746	2.56	2.80	1.87	2.76	0.62	0.25	2.15	2.38	1.60
1-octene	791	-	-	-	1.92	-	0.16	0.80	-	-
(Z)-2-Octene	809	5.54	3.60	0.35	1.66	0.40	-	2.04	0.32	-
5-Isopropyl-2-methyl bicycle-hex-2-ene	931	0.10	-	0.15	0.02	0.03	0.59	0.05	0.08	-
N, N-dimethyl formamide	954	0.09	-	0.05	0.12	0.03	-	0.05	0.03	-
Methoxy methyl benzene	984	0.04	-	0.04	0.03	0.02	-	0.06	0.06	-
P-cymene	1026	0.01	0.93	0.03	0.11	0.02	0.28	0.03	0.03	-
1-methyl -3-(1-methyl ethyl)-benzene	1082	-	-	-	0.05	-	-	-	0.02	-
1-octadecene	1774	0.01	0.78	0.08	0.04	0.04	0.51	0.02	0.05	0.80
Total		8.35	8.11	2.57	6.71	1.16	1.79	5.21	2.99	2.41

Relative abundance expressed as percentage on total volatile compounds detected. *Kovat Index, -: Not detected

Table 6: Relative abundance of esters identified in control and herby (celery and thyme) cheeses stored for 4 weeks

		Cheese sample								
		Control			Celery			Thyme		
Esters	KI*	Fresh	2 weeks	4 weeks	Fresh	2 weeks	4 weeks	Fresh	2 weeks	4 weeks
Ethyl acetate	618	-	-	0.55	2.67	0.95	0.95	0.29	1.07	1.10
Methyl propionate	626	0.49	-	0.43	-	0.81	0.81	0.45	0.95	0.65
Ethyl propionate	717	16.40	4.85	29.18	16.34	12.70	3.07	11.63	19.99	5.16
Ethyl -2-methyl propionate	758	13.91	7.70	5.34	15.85	9.55	-	6.32	2.24	1.10
Iso pentyl formate	788	3.98	2.60	0.95	-	0.41	-	1.10	0.54	2.80
Ethyl butyrate	798	1.37	1.02	0.89	6.52	1.01	-	3.76	0.84	0.56
Butylacetate	813	1.32	0.70	0.03	0.16	0.03	-	0.16	0.02	-
Iso propyl butyrate	835	0.16	2.50	3.08	0.39	0.03	-	2.25	0.26	2.10
Ethyl-3-methyl butanoate	848	-	-	0.11	0.39	0.30	-	-	-	-
3-methyl butyl acetate	871	1.71	0.99	0.58	1.60	0.07	0.92	0.04	-	-
Allyl butyrate	885	0.07	-	0.09	0.10	0.03	-	0.78	0.34	-
Propyl butyrate	893	0.34	-	0.08	0.57	0.50	0.40	0.22	0.06	-
Ethyl pentanoate	896	0.15	1.67	0.10	0.13	0.10	2.40	0.09	0.03	1.10
(z)-3-hexenyl acetate	1005	-	-	0.04	0.02	-	-	0.10	-	-
Methyl benzoate	1088	0.03	-	0.03	0.02	0.03	-	0.01	-	-
Benzylbutyrate	1318	-	-	-	0.01	-	-	-	0.48	-
Iso bornyl propionate	1380	0.07	1.48	0.20	0.11	-	1.79	-	0.21	-
Lavandulyl-2-methyl butyrate	1567	0.02	40.38	6.21	0.09	4.14	41.50	1.20	0.06	8.50
Hexyl benzoate	1579	0.03	1.04	0.13	0.06	0.05	0.71	0.04	0.07	0.90
Benzyl benzoate	1761	0.02	2.21	0.43	0.24	0.25	3.22	0.31	0.76	1.25
(Z)-11-tetradecenyl acetate	1812	-	1.39	-	-	0.02	0.16	0.03	-	1.10
Methyl-14-methylpentadecanoate	1886	0.03	0.46	0.02	0.01	0.02	-	-	0.02	0.70
(Z)-9-hexadecaenyl acetate	1916	0.01	-	0.12	0.02	0.01	0.12	-	-	0.70
16-hexadecanoate	1934	0.02	0.58	-	0.02	0.03	0.46	0.03	0.04	0.60
Ethyl (Z) -7-hexadecanoate	1980	-	-	0.06	0.09	-	2.07	0.11	0.08	1.90
Hexadecenyl acetate	1989	-	2.35	0.07	0.02	0.19	-	0.04	0.04	9.50
Total		40.11	71.92	48.72	45.43	31.23	58.58	28.99	28.10	38.62

Relative abundance expressed as percentage on total volatile compounds detected. * Kovat Index , -: Not detected

Table 7: Relative abundance of alcohols identified in control and herby (celery and thyme) cheeses stored for 4 weeks

		Cheese sample								
		Control			Celery			Thyme		
Alcohols	KI*	Fresh	2 weeks	4 weeks	Fresh	2 weeks	4 weeks	Fresh	2 weeks	4 weeks
3-methyl-3-butan-1-ol	636	1.47	-	4.24	0.87	5.26	0.13	2.94	7.30	6.70
Pentan -2-ol	732	-	3.73	6.28	-	4.77	10.40	0.56	2.41	6.34
Methyl pentanol	770	-	0.59	5.68	-	9.13	1.32	7.64	5.15	0.77
Cyclo pentanol	782	-	2.10	3.55	4.59	0.65	-	3.86	3.34	2.60
Hexenol (E-3)	851	-	-	0.10	0.13	0.60	-	0.52	-	-
Hexene-1- ol (Z-3)	857	0.26	-	0.33	1.13	-	-	0.36	0.12	-
4,5-di methyl thiazol	933	0.01	-	0.01	0.03	0.03	-	-	0.02	-
4-methoxyphenyl methanol	1278	-	-	0.18	0.02	-	-	0.54	0.90	5.91
Thymol	1280	-	-	-	-	-	-	7.61	6.82	17.88
2-phenoxy ethanol	1316	-	-	-	-	0.05	1.44	0.23	-	-
2,6-dimethoxy phenol	1346	0.02	0.61	0.03	0.02	-	-	0.30	0.02	-
(Z) -11-tetradecen -1-ol	1678	-	-	0.02	-	0.08	1.30	0.18	0.01	0.01
3,7,11,15-tetramethyl hexadecan-1-ol	1951	0.13	5.17	0.88	0.16	0.23	3.99	0.48	0.36	7.99
(Z,E) -2,13-octadecadien-1-ol	2076	0.01	0.34	0.04	0.02	0.05	0.22	0.01	0.03	-
Total		1.90	12.59	21.30	6.97	20.85	18.81	25.23	26.48	48.20

Relative abundance expressed as percentage on total volatile compounds detected. *Kovat Index, -: Not detected

Among hydrocarbons, nine compounds have been isolated in the volatile fraction of cheese samples. Fresh control cheese contained the highest amount of hydrocarbons, these amounts decreased in all cheeses by prolonging the cold storage 4 weeks. Panseri *et al*. (2008) reported that the great quantity of hydrocarbons in Bitto cheese seem arise from the degradation of plant materials.

Total esters components reached the highest amount in control cheese after 2 weeks then decreased after 4 weeks, in the contrarily with celery cheese (Table 6). Thyme cheese had the same amount of esters either fresh or after 2 weeks and then increased during storage period. The main ester was propionate and its branches, reached the highest amount in control after 4 weeks, thyme cheese after two weeks, while in celery cheeses the amount decreased by prolonging the storage period. Preininger and Grosch (1994) reported that esters, especially those containing few carbon atoms, contribute in a synergistic way to the aroma of cheese since they have a low perception threshold concentration which is 10-fold lower than their alcohol precursors. Hence, esters could be considered as key constituents of the aroma of cheese varieties, providing fruity notes that minimize the strong aroma produced by free fatty acids (Castillo *et al*., 2007).

Alcohols

Fourteen different alcohols were identified in the volatile fraction of control and herby white cheeses, these compounds may be rapidly produced from aldehydes under the strong reducing condition present in cheese, or from other metabolic pathways, such as lactose metabolism and amino acids catabolism (Molimard and Spinnler, 1996). Alcohols indirectly can be responsible for cheese flavor because of their ability to form esters with free fatty acids (Gripon *et al*., 1991). The highest amount of alcohols presented in thyme cheese either fresh or during stored period compared with other cheese samples. Prolonging the storage period increased the alcohols amount in control or thyme cheese, while the highest alcohols amount was found in celery cheese after 2 weeks.

The main alcohol in control cheese was 3-methyl-3-butan-1-ol, which disappeared after 2 weeks, then appeared with higher amount in 4 week, in contrarily with herby cheeses (Table 7). The primary alcohol, 3-methyl-3-butan-1-ol can be formed by reduction of the aldehydes, which formed by Strecker degradation of amino acid Leuine (Larsen, 1998). Enzyme-catalyzed transamination of amino acids results in the formation of an intermediate amide, which is subsequently decarboxylated, forming an aldehyde which can be reduced to alcohol by dehydrogenase (Marilley and Casey, 2004). Pentan-2-ol was not found in fresh cheeses neither control nor celery, but presented during cold storage period. Fresh thyme cheese contained low amount of pentan-2-ol increased by storage period 4 weeks. Methyl pentanol (pentanol branch) found only in fresh thyme cheese, while cyclo pentanol found only in fresh herby cheese decreased by prolonging the storage period with thyme and completely disappeared with celery. Thymol was the main components only in thyme cheese reached its maximum amount after 4 weeks.

CONCLUSION

It could be concluded that:

- Herby cheese after one week of cold storage got the highest total acceptability scores
- Descriptive and hedonic sensory tests showed that 1% herb got highest score than 2%
- Herbs type had no significant effect of sensory characteristics, while increasing herbs concentration from 1-2% increased cheese appearance significantly
- Prolonging the cold storage for 4 weeks caused significant effects only on cheese appearance and total score after one week, while cheese odor was affected after three weeks

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