

VOLATILE COMPOUNDS OF FLAVOURED CHEESES

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Cheese is a widespread and valuable food that is used in everyday life. Cheese made from a mixture of cow's and sheep's milk is traditionally produced on farms and in cheese factories throughout Croatia. Considering the production technology, it belongs to the group of hard cheeses.



The flavour of cheese is one of the main quality parameter of a certain type of cheese. Flavouring improves the sensory properties, but also the preservation of food and the satisfaction of gourmets. Cheeses are flavoured with different aromatic plants such as lavender, sage, basil and many others. In addition to nutritional properties, supplements are also useful due to their antimicrobial value.

Livanjski sir, a full-fat hard cheese made from a mixture of cow’s and sheep's milk, served as the base. Three herb species were used for the flavouring of cheese: lavender (*Lavandula officinalis* L.), basil (*Ocimum basilicum* L.) and sage (*Salvia officinalis* L.). Each herb species was added in two concentrations: 0.05 % and 0.25 %.

Isolation of volatile compounds was performed by solid phase microextraction (HS-SPME) using DVB/CAR/PDMS fiber at a temperature of 60 °C (n = 3). All samples were analysed by gas chromatography-mass spectrometry using a non-polar column and the results were compared. The results are presented as means ± standard deviations.

Headspace volatile compounds of Livanjski sir

Compound	t _r (min)	Peak area (%) ± STD
ethanol	1,445	3,30 ± 1,063689
acetic acid	1,557	6,99 ± 0,502096
propanoic acid	1,901	9,46 ± 0,433128
methyl isothiocyanate	2,234	1,48 ± 0,571664
butanoic acid	2,602	13,25 ± 0,321299
pentanoic acid	3,633	0,26 ± 0,083267
heptan-2-one	3,917	3,97 ± 0,10116
heptan-2-ol	4,063	1,59 ± 0,600328
benzaldehyde	5,484	0,29 ± 0,115902
sabinene	5,809	1,69 ± 0,642106
hexanoic acid	6,253	20,56 ± 1,431049
ethyl hexanoate	6,423	0,80 /
limonene	7,375	6,59 ± 2,710615
trans-β-ocimene	7,624	0,64 ± 0,295014
2-phenylacetaldehyde	7,844	0,25 ± 0,025166
γ-terpinene	8,346	0,09 ± 0,015275
heptanoic acid	8,877	0,26 ± 0,047258
non-8-en-2-one	9,159	0,36 ± 0,043589
nonan-2-one	9,471	2,77 ± 0,182483
linalool	9,757	0,51 ± 0,089629
nonanal	9,921	0,12 ± 0,034641
alloocimene*	10,864	0,10 /
octanoic acid	13,120	18,66 ± 8,7669
ethyl octanoate	13,561	0,44 ± 0,015275
dodecane	13,651	0,29 ± 0,060828
nonanoic acid	16,598	0,06 /
undecan-2-one	17,551	0,17 ± 0,026458
decanoic acid	20,840	3,12 ± 0,756395
ethyl decanoate	21,802	0,07 /
δ-decalactone	25,732	0,36 ± 0,046188
δ-dodecalactone	33,709	0,09 ± 0,015275

Headspace volatile compounds of flavoured cheeses

Compound	t _r (min)	Peak area (%) ± STD	
		lavander 0,05%	lavander 0,25%
ethanol	1,445	4,24 ± 2,118498	3,97 ± 0,510033
acetic acid	1,557	8,77 ± 0,525579	7,03 ± 1,540433
propanoic acid	1,901	9,84 ± 0,35171	7,31 ± 1,160014
methyl isothiocyanate	2,234	1,50 ± 0,513907	1,10 ± 0,401123
butanoic acid	2,602	13,58 ± 1,338108	11,45 ± 1,591446
ethyl butanoate	2,651	1,08	0,89 ± 3,74477
3-methylbutanoic acid*	3,050	0,54 ± 0,285132	/
2-methylbutanoic acid*	3,172	0,36	/
pentanoic acid	3,633	0,36 ± 0,15308	0,29 ± 0,045092
heptan-2-one	3,917	2,65 ± 0,633114	2,67 ± 0,348186
heptan-2-ol	4,063	1,18 ± 0,244404	0,95 ± 0,410041
benzaldehyde	5,484	0,23 ± 0,026458	0,19 ± 0,023094
hexanoic acid	6,253	22,26 ± 1,445902	19,92 ± 0,28746
limonene	7,375	5,67 ± 1,891278	3,57 ± 1,852278
trans-β-ocimene	7,624	0,53 ± 0,200749	0,40 ± 0,2117945
2-phenylacetaldehyde	7,844	0,38 ± 0,095349	0,69 ± 0,098489
cis-β-ocimen	7,955	/	0,10 ± 0,01
γ-terpinen	8,351	/	0,09 ± 0,026458
octan-1-ol*	8,880	/	0,11 ± 0,025166
cis-linalool oxide	8,818	/	0,39 ± 0,132791
heptanoic acid	8,877	0,33 ± 0,028868	/
non-8-en-2-one	9,159	0,15 ± 0,040415	0,27 ± 0,078102
trans-linalool oxide	9,373	/	0,25 ± 0,04
nonan-2-one	9,471	1,42 ± 0,337244	1,94 ± 0,25
linalool	9,766	0,56 ± 0,087369	8,97 ± 0,810021
nonanal	9,921	0,14 ± 0,045826	/
2-phenylethanol	10,257	0,11	/
camphor	11,476	/	0,20 ± 0,017321
borneol	12,309	0,15 ± 0,025166	1,65 ± 0,109697
terpinen-4-ol	12,760	/	3,65 ± 0,105987
octanoic acid	13,120	14,99 ± 3,694121	11,79 ± 6,377
α-terpineol	13,302	/	0,69
ethyl octanoate	13,576	0,63 ± 0,092376	0,80 ± 0,110151
dodecane	13,651	0,24 ± 0,040415	0,21 ± 0,043589
linalyl acetate	15,985	/	2,15 ± 0,1101527
nonanoic acid	16,598	0,13 ± 0,01	0,06 ± 0,005774
lavandulyl acetat	17,452	/	0,10 ± 0,02
undecan-2-one	17,551	0,15 ± 0,015275	0,19 ± 0,07
hexyl tiglate*	19,098	/	0,11
decanoic acid	20,840	4,68 ± 1,236986	3,30 ± 1,091238
ethyl decanoate	21,802	0,20 ± 0,040415	0,22 ± 0,025166
tetradecane	21,933	0,10 ± 0	/
caryophyllene	22,693	/	0,12 ± 0,015275
camuarine	23,278	/	0,10 ± 0,02
β-farnesene*	24,249	/	0,09 ± 0
δ-decalactone	25,732	0,33 ± 0,06245	0,26 ± 0,017321
dodecanoic acid	28,438	0,20 ± 0,161967	0,15 ± 0,051316
δ-dodecalactone	33,709	0,11 ± 0,030551	0,10 ± 0,005774

Compound	t _r (min)	Peak area (%) ± STD	
		basil 0,05%	basil 0,25%
ethanol	1,445	4,32 ± 0,405832	3,29 ± 1,081403
acetic acid	1,557	6,93 ± 1,985925	6,76 ± 1,140234
propanoic acid	1,901	8,38 ± 2,93869	9,20 ± 0,592312
methyl isothiocyanate	2,234	1,43 ± 0,226789	1,45 ± 0,28006
butanoic acid	2,602	9,43 ± 1,617354	10,38 ± 0,727942
ethyl butanoate	2,651	0,94 ± 0,39	0,61 ± 0,092916
heptan-2-one	3,917	4,27 ± 1,019035	3,21 ± 0,497896
heptan-2-ol	4,063	1,44 ± 0,511566	0,57 ± 0,250067
benzaldehyde	5,484	0,71 ± 0,286182	0,69 ± 0,232451
sabinene	5,801	1,88	1,80
hexanoic acid	6,253	16,13 ± 2,730513	13,32 ± 3,620331
ethyl hexanoate	6,423	2,97 ± 1,13697	8,20 ± 5,798209
limonene	7,375	5,96 ± 3,345211	5,04 ± 3,408269
1,8-cineole	7,464	0,18 ± 0,077675	0,45 ± 0,092916
trans-β-ocimene	7,624	0,59 ± 0,312623	0,50 ± 0,350428
2-phenylacetaldehyde	7,844	0,49 ± 0,233524	0,98 ± 0,22053
cis-β-ocimene	7,955	0,09	0,11
γ-terpinene	8,351	0,10	0,11
heptanoic acid	8,877	0,21 ± 0,02	0,28 ± 0,032146
non-8-en-2-one	9,159	0,26 ± 0,047258	0,29 ± 0,096437
nonan-2-one	9,471	2,06 ± 0,451331	2,01 ± 0,144338
linalool	9,766	1,95 ± 0,545008	5,05 ± 1,247117
nonanal	9,921	0,25	0,15 ± 0,07
α-thujon	10,014	0,14 ± 0,055076	/
alloocimene*	10,864	0,10 ± 0,026458	0,11
camphor	11,476	0,09	/
octanoic acid	13,120	19,69 ± 14,04437	17,49 ± 9,076145
α-terpineol	13,302	/	0,35
ethyl octanoate	13,576	1,64 ± 0,162583	1,13 ± 0,041633
dodecane	13,651	0,29 ± 0,110151	0,29 ± 0,091652
nonanoic acid	16,598	0,04 ± 0	0,08
bornyl acetate	17,223	/	0,10 ± 0,020817
undecan-2-one	17,551	0,16 ± 0,047258	0,24 ± 0,02
eugenol	20,170	0,12 ± 0,011547	0,49 ± 0,047258
decanoic acid	20,840	3,35 ± 0,547753	4,31 ± 1,669341
β-aleranene	21,611	/	0,06
ethyl decanoate	21,802	0,39 ± 0,098658	0,38 ± 0,020817
α-bergamoten*	23,372	/	0,08 ± 0,020817
germacrene D	25,169	/	0,04
δ-hecalactone	25,732	0,26 ± 0,025166	0,34 ± 0,060277
γ-cadinene*	26,473	0,13	0,09
dodecanoic acid	28,444	0,11 ± 0,037859	0,21 ± 0,147309
δ-dodecalactone	33,709	0,09	0,10 ± 0,064291

Compound	t _r (min)	Peak area (%) ± STD	
		sage 0,05%	sage 0,25%
ethanol	1,445	1,99 ± 0,720625	2,28 ± 0,22301
acetic acid	1,557	7,26 ± 0,991077	6,72 ± 1,105004
propanoic acid	1,901	10,43 ± 1,556931	8,60 ± 1,312593
methyl isothiocyanate	2,234	1,36 ± 0,210792	1,07 ± 0,566657
butanoic acid	2,602	11,53 ± 1,900272	9,05 ± 0,596769
ethyl butanoate	2,651	0,52	0,79 ± 0,299555
heptan-2-one	3,917	4,88 ± 0,921466	2,56 ± 0,922894
heptan-2-ol	4,063	0,89 ± 0,288271	0,67 ± 0,20502
α-pinene	4,893	0,29 ± 0,159478	0,88 ± 0,073711
camphene	5,248	0,47 ± 0,223389	1,40 ± 0,104403
benzaldehyde	5,484	0,18 ± 0,047258	0,15 ± 0,07
limonene	5,801	1,46 ± 0,315119	1,03 ± 0,408207
hexanoic acid	6,253	15,39 ± 1,31371	10,65 ± 0,875386
ethyl hexanoate	6,423	0,82 ± 0,005774	1,63 ± 0,72148
α-terpinene	6,958	/	0,06 ± 0,02
p-cymen	7,258	0,17 ± 0,051316	0,51 ± 0,133167
limonene	7,375	7,41 ± 1,594125	6,32 ± 2,952643
1,8-cineole	7,464	0,67 ± 0,165025	2,03 ± 0,500233
trans-β-ocimene	7,624	0,78 ± 0,250599	0,56 ± 0,37072
2-phenylacetaldehyde	7,844	0,88 ± 0,266896	1,15 ± 0,388887
cis-β-ocimene	7,955	0,10 ± 0,015275	0,09
γ-terpinene	8,346	0,11 ± 0,015275	0,21 ± 0,036056
heptanoic acid	8,877	0,20 ± 0,037859	0,16 ± 0,065064
non-8-en-2-one	9,159	0,70 ± 0,159478	0,28 ± 0,045826
α-terpinolene	9,349	/	0,30 ± 0,073711
nonan-2-one	9,471	4,65 ± 0,822131	2,08 ± 0,517333
linalool	9,766	0,63 ± 0,037859	0,80 ± 0,132035
nonanal	9,921	0,13 ± 0,015275	0,13
α-thujone	10,014	2,73 ± 0,896456	8,10 ± 1,571189
β-thujone	10,416	0,32 ± 0,147309	1,01 ± 0,196977
alloocimene*	10,864	0,10 ± 0,035119	0,09
camphor	11,476	2,00 ± 0,461122	5,67 ± 0,837397
borneol	12,309	0,34 ± 0,085049	1,02 ± 0,176163
octanoic acid	13,120	13,63 ± 2,302803	11,20 ± 7,295768
α-terpineol	13,302	/	0,21
ethyl octanoate	13,576	1,13 ± 0,590028	1,45 ± 0,049329
dodecane	13,651	0,31 ± 0,060828	0,22 ± 0,075056
nonanoic acid	16,598	0,13 ± 0,092376	/
bornyl acetate	17,223	0,26 ± 0,086603	0,66 ± 0,072111
undecan-2-one	17,551	0,30 ± 0,060277	0,24 ± 0,06245
decanoic acid	20,840	3,02 ± 0,975551	2,54 ± 1,91374
ethyl decanoate	21,802	0,16 ± 0,017321	0,31 ± 0,100167
tetradecane	21,933	0,07	/
caryophyllene	22,693	tr	0,09
α-humulene	24,049	0,23 ± 0,135769	0,65 ± 0,255343
δ-decalactone	25,732	0,23 ± 0,045092	0,20 ± 0,137477
dodecanoic acid	28,438	0,14	0,15
viridiflorol	29,435	/	0,12
ethyl dodecanoate	29,632	/	0,06
δ-dodecalactone	33,709	0,09	0,12

Symbols in tables:

t_R = retention time on HP-5MS column;

STD = standard deviation

/ = not detected; tr = traces (< 0,1 %);

* = correct isomer is not identified;

^a = compound identified only by mass spectra comparison with Wiley9 and/or NIST17 mass spectral libraries

In all samples, the most abundant compounds are carboxylic acids, especially the fatty acids butanoic, hexanoic and octanoic acid as well as propanoic and acetic acid. Terpenes were also identified in all the cheeses studied. A higher number of terpenes was identified in the flavoured cheeses than in the cheese without additives. For all flavoured cheeses: the higher the proportion of a particular aromatic plant in the cheese, the higher the number and proportion of terpenes, with the terpenes specific to a particular plant standing out.