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Volatile compounds of commercial Milano salami

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Abstract

The relationship between extracted volatiles of Milano salami, one of the main dry-cured sausages produced in I olfactory properties was studied. Volatile compounds were extracted by a purge-and-trap method, quantified using tion detector and identified by mass spectrometry. Olfactory analysis was performed by sniffing the gas chromatog Nearly 80 compounds were identified and quantified: most came from spices (60.5%), 18.9% from lipid oxidatio amino acid catabolism and 4.9% from fermentation processes. Panellists detected 19 odours by sniffing. These odo ciated with spices, lipid oxidation or fermentation and were in agreement with the contributions of each reaction aroma of the product. © 1998 Elsevier Science Ltd. All rights reserved.

Keywords: Milano salami; Fermented sausages; Aroma; Volatiles; Headspace; Sniffing

1. Introduction

Milano Salami, a typical dry-cured sausage, is made of fresh meat and fat mixed with ingredients (e.g. skimmed milk powder), additives (e.g. nitrates, nitrites, antioxidants, spices, etc.) and sometimes starter cultures. After the mixture has been stuffed into casings, the salami are ripened at 15–25°C for several days and then at 9–13°C for up to 3 months. Salami has an image among consumers related to its sensory attributes (macroscopic appearance, texture, colour, flavour, taste, etc.). Its quality depends on the quality of the raw materials and on the technology of production. Because international trade requires both a strict respect of safety and the preservation of the characteristics of typical products (Casiraghi et al., 1996), a standard was set for the salami by the Ente Nationale Italiano Unificazione (UNI, 1993) which defines the technology to be used together with some chemical and microbiological characteristics.

The microbiological aspects of maturation and safety have been widely studied, while little information is available on the effect of chemical and physical characteristics on consumer perception of salami (Casiraghi et al., 1996; Dellaglio et al., 1996). We are still ignorant of what gives various Italian salami their t as only two papers are devoted to the aro produced in Denmark (Berger et al., 1990; Zeuthen, 1992). In dry sausages such as It aroma compounds arise from proteins, c and lipids through many chemical reac ripening (Fernandez et al., 1991; Viallon The relative contribution of these numerou aroma depends on many parameters and raw material characteristics and processin are the most important. Recently the effe cultures on the production of volatile co been extensively studied in model system dry sausages (Berdagué et al., 1993; Joha 1994; Stahnke, 1994, 1995a; Montel et al. thermore, pork processing frequently inclu tion of spices which can directly or affecting such properties as their antiox affect aroma and taste (Barbut et al., 198 vious works on the aroma of dry sausa included spices (Berger et al., 1990; Ber 1993; Stahnke and Zeuthen, 1992; Stahnke

We therefore studied the volatile co Milano salami by chemical and olfactom Volatile compounds were extracted from mercial brands of salami, covering the rang available on the market. They were identi

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persons to establish the relationships between the odours perceived and the volatile compounds identified.

2. Materials and methods

2.1. Samples

Eight Milano salami (700–900 g) of different brands were bought from local supermarkets in Parma. They were packed under a gentle vacuum (<20 mmHg) and stored at 2–4°C before being analysed (up to 1 month).

2.2. Chemical composition

Water content of salami was determined by drying samples at 100–102°C (AOAC method, 950.46, 1990). pH was measured on samples homogenised in distilled water (10/1 water/sample, w/w). Nitrogen content was determined by the Kjeldahl method and protein estimated by multiplying the nitrogen content by 6.25 (Slack, 1987). Non-protein nitrogen was determined by the Kjeldahl method after protein precipitation with trichloroacetic acid as described by Bellatti et al. (1983). Collagen content was estimated by hydroxyproline determination according to the Codex method (ISO standard method 3496, 1978). Collagen content was calculated by multiplying hydroxyproline content by 7.25. Total fat was extracted by Soxhlet extraction using diethyl ether (ISO standard method 1443, 1973). Sodium chloride content was determined by the titrimetric method of Volhard (Kirk and Sawyer, 1991). Residual nitrites were determined according to the method of Slack (1987). Ash content was determined by incineration of the sample in a muffle furnace at 450°C (Kirk and Sawyer, 1991). Each analysis was performed in duplicate.

2.3. Assessment of lipid oxidation

Peroxide value was determined in duplicate by an iodometric method (AOAC method, 950.46, 1990) on lipids extracted according to the method of Folch et al. (1957). Each analysis was done in duplicate. Results are expressed in meq O_2. g fat^{-1}. Thiobarbituric Acid Reactive Substances (TBARS) were quantified according to the method of Tarladgis et al. (1960) modified as follows: an antioxidant (BHA 0.02%) was added to samples before homogenisation and the volume of the collected distillate was restricted to 25 ml instead of 50 ml. Each analysis was performed in triplicate. The absorbance of the chromophore was converted into μmole of malonaldehyde (MDA) using a standard curve

2.4. Analysis of volatile compounds

Volatiles were extracted by a purge-and-

2.4.1. Dynamic headspace volatile concentr

A purge-and-trap concentrator (Mode Tekmar) equipped with a capillary interfac cusing was connected to a gas chromatogra Packard, 5890). Two grams of salami were immediately transferred into a 25 ml fri The headspace of the sample was purged at 50 ml min^{-1} and swept into a poro polymer (Tenax trap) at room temperatu were thermally desorbed by heating the tr Backflushed volatiles were cryofocused at liquid nitrogen. The operating conditions a a previous paper (Meynier et al., 1998)

2.4.2. Gas chromatography (GC)

A gas chromatograph (Hewlett–Pack equipped with a flame ionisation detector v a fused silica capillary column coated with tionary phase (30 m×0.32 mm, 1 μm fil The detector temperature was 250°C and th carrier gas (hydrogen) 35 kPa (2 ml min^{-} temperature was set at 40°C for 5 m increased to 200°C at 3°C min^{-1}. Chroma recorded using an acquisition box, a comp Apex software (Stang Instruments, France pound was quantified by calibration with standard (nonane) as previously described al., 1998).

2.4.3. Gas chromatography/mass spectrome MS)

Extraction, desorbtion and chromatogra tiles of the samples were performed as des A gas chromatograph (Hewlett–Packard 5 with a mass detector (Hewlett–Packard used to identify the volatiles. Helium was t (35 kPa, 1 ml min^{-1}) and the capillary coated with a DB-5 type stationary phase mm, 1 μm film thickness). Mass spectra w in the electron impact mode (EI 70 eV). T conditions were as follows: direct coupling of the interface 250°C, temperature of ion s scan speed 0.4 scan s^{-1}, and the mass rang 33 to 250 u.a.m. The compounds were comparison of their spectra with those libraries (NBS, NIST, TNO) or standard m by matching their retention indices with literature.

used. The end of the column was fitted to a glass-3 way connection (0.32 mm i.d.) splitting the effluent (1:1, v/v). Eight trained persons in GC-olfactometry were selected. The chromatogram was divided into four 10 min parts. Each person sniffed each part of the chromatogram during successive sessions to be alert. Eluting aromas were recorded by pressing a button when the panellist detected an odour and the description was noted. Only odours perceived and described by half of the panellists were reported. To identify the molecule, we chose the compound which possessed a retention index close to that of the odour or the compound whose odour was described in the literature (Arctander, 1994a, b) and the panel was similar.

3. Results and discussion

3.1. Chemical composition and lipid oxidation (Table 1)

The water content of the salami varied from 26.0 to 45.4%. This large variation is probably due to differences in ripening time. Indeed the water content of the dry-cured products decreases as the time of ripening increases (Casiraghi et al., 1996). Protein and fat contents of the salami ranged from 22.7 to 30.8% and from 26.4 to 36.0% respectively. The non-protein nitrogen content varied from 3 to 4%, and the collagen content from 1.6 to 2.3%. This difference could be explained by the quality of the raw material which contains various proportions of collagen depending on the muscle and its degree of trimming. However, the values of water/protein, collagen/protein and fat/protein ratios were in the normal range for this type of product (UNI, 1993). NaCl content was 4.1% on average and the nitrite con-

3.2. Volatile compounds

We identified between 93 and 123 volatil in the samples. A typical chromatogram of trap extract of salami is shown in Fig. 1 pounds identified in at least half of the reported in Table 2. They were classified their most likely origin. They included 11 h 3 ketones, 10 alcohols, 11 aldehydes, 6 este 26 terpenes, 6 sulphur derivatives, 2 organi pyrazine. The total amount of desorbed vo from 3009 to 14965 ng eq nonane g^{-1}.

3.2.1. Volatile compounds from spices

Nearly two thirds (60.4%, 5026 ng eq no the desorbed volatiles came from spices garlic). They were mainly terpenes and to a aliphatic sulphur compounds.

Terpenes were by far the most abund volatiles (49.4%, 4114 ng eq nonane accounted for at least half of the total an orbed compounds and were mainly m Similar results have been reported for Ita ami (Berger et al., 1990; Stahnke and Ze and for French saucisson (Viallon et al., 1 the 26 terpenes identified, the most ab limonene (about 22%, 11–2155 ng eq no carene (8.3%, 49–2478 ng eq nonane g (7.7%, 63–1474 ng eq nonane g^{-1}), sabinen 1224 ng eq nonane g^{-1}), α-pinene (4.8%, 3 nonane g^{-1}), and myrcene (3.2%, 522–581 g^{-1}). Limonene is found in many essential and is particularly abundant in nutmeg an per which also contain α- and β-pinene (Maarse et al., 1989). It was not surprising

Table 1
Chemical composition and the extent of lipid oxidation in various Milano salami

		Proximate composition									Oxidation le	
Sample	pH	Water (%)	Proteins (% DM)	NPN (% DM)	Collagen (% DM)	Collagen/ protein	Fat (%DM)	Ash (% DM)	NaCl (% DM)	Nitrites (mg kg DM^{-1})	Peroxide value (meq O_2 g fat^{-1})	(μmole
1	5.42	28.9	39.3	5.61	2.6	0.07	50.6	7.5	5.7	3.1	0.040	
2	5.34	37.3	36.4	5.06	2.6	0.07	53.1	7.2	5.5	3.8	0.049	
3	5.83	40.2	44.2	5.04	3.3	0.08	47.0	9.7	7.6	7.3	0.096	
4	5.47	33.2	37.3	5.07	2.9	0.08	51.0	8.0	6.2	3.5	0.043	
5	5.90	40.2	42.5	5.02	3.8	0.09	48.3	9.1	7.3	n.d.	0.060	
6	5.45	26.0	41.6	4.45	2.5	0.06	47.3	8.9	7.3	6.6	0.072	
7	5.95	41.8	43.6	5.71	3.0	0.07	48.6	8.9	5.6	5.2	0.039	
8	5.51	45.4	41.5	5.76	3.3	0.08	48.3	9.2	6.1	8.0	0.072	
Mean	5.61	36.6	40.8	5.21	3.0	0.07	49.3	8.6	6.4	5.4	0.059	
S.D.	0.24	6.7	2.8	0.45	0.45	0.01	2.1	0.9	0.9	1.9	0.020	

Each value was the mean of duplicate. DM = dry matter, NPN = non-protein-nitrogen, MDA = malondialdehyde, TBA-RS : TBA rea

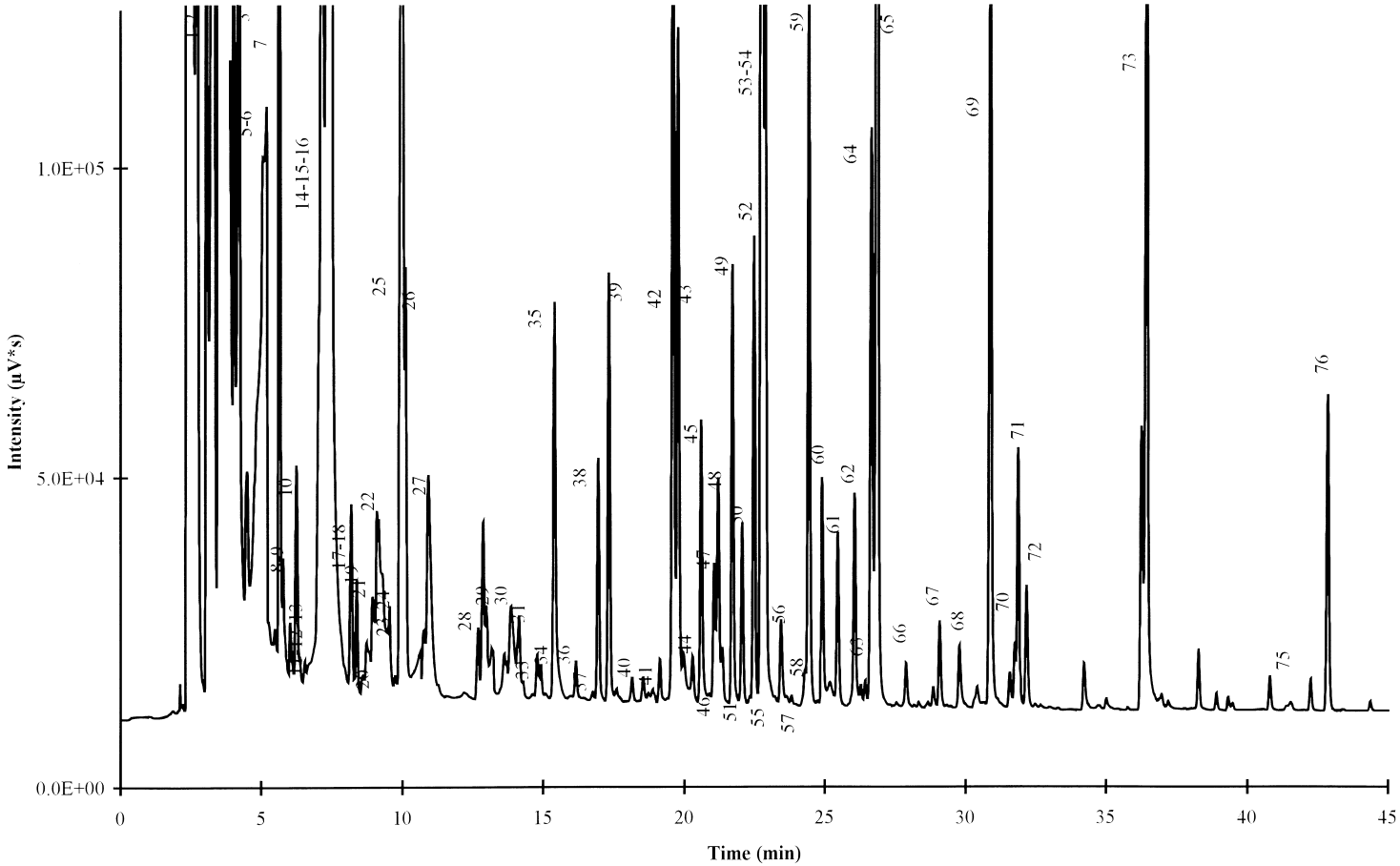

Fig. 1. Gas chromatogram of the volatile compounds desorbed from Milano salami after purge-and-trap extraction. For peak numbers see Table 2

Peak [a]	Compound	Kovats index [b]	Quantity extracted (ng eq nonane g^{-1})		Reliability of identification [c]
			mean [c]	min–max [d]	
	Spices (60.4%)		5026		
	Terpenes (49.4%)		4114		
38	α-thujene	928	76	4–228	**b**
39	α-pinene	934	403	39–1149	**a**
40	camphene	948	13	1–36	**a**
41	α-fenchene	961	3	1–7	**c**
42	sabinene	974	463	22–1224	**b**
43	β-pinene	977	642	63–1474	**a**
45	myrcene	991	267	52–581	**a**
47	α-phellandrene	1000	46	25–142	**b**
49	3-carene	1010	695	49–2478	**a**
50	α-terpinene	1016	21	1–60	**a**
51	m-cymene	1021	5	1–17	**a**
52	p-cymene	1024	84	10–243	**a**
53	limonene	1030	905	11–2155	**b**
54	β-phellandrene	1034	25	2–139	**b**
55	cineole	1037	10	1–23	**c**
56	o-cymene	1041	161	29–346	**a**
59	γ-terpinene	1059	44	6–120	**a**
60	terpene not identified	1067	15	0–53	**d**
61	terpene not identified	1078	27	1–48	**d**
63	terpinolene	1090	33	5–110	**b**
64	β-ocimene	1099	34	7–125	**c**
68	camphor	1158	10	5–15	**a**
69	terpene not identified	1178	33	2–171	**d**
70	α-terpineol	1195	10	1–21	**b**
73	safrole	1291	31	0–194	**a**
76	caryophyllene	–	48	9–111	**c**
	Aliphatic sulfur compounds (11.0%)		912		
7	1-propene-3-methylthio	701	781	59–1793	**c**
12	propane-1-methylthio	715	6	0–23	**d**
13	1-propene-1-methylthio	722	66	9–237	**c**
16	dimethyl disulfide	749	52	4–243	**b**
37	allyl methyl disulfide	924	3	2–4	**c**
62	diallyl disulfide	1087	14	1–38	**c**
	Lipid oxidation (18.9%)		1581		
	Aldehydes (12.7%)		1060		
6	pentanal	693	127	0–335	**b**
25	hexanal	800	349	181–658	**b**
35	heptanal	900	96	43–193	**b**
48	octanal	1003	176	20–418	**b**
58	2-octenal	1056	10	6–14	**b**
65	nonanal	1103	282	127–634	**b**
67	2-nonenal (E)	1146	4	1–17	**b**
72	decanal	1204	16	5–31	**b**
	Hydrocarbons (2.9%)		243		
8	heptane	698	18	0–55	**a**
24	1-octene	792	16	8–36	**b**
26	octane	802	209	77–369	**a**
	Alcohols (1.9%)		158		
4	1-penten-3-ol	680	85	18–151	**b**
19	pentanol	764	28	15–49	**b**
30	hexanol	868	27	13–50	**b**

			mean [c]	min–max [d]	
44	1-octen-3-ol	981	18	13–24	**b**
	Ketones (1.2%)		120		
5	2-pentanone	685	103	11–220	**b**
33	2-heptanone	889	17	8–32	**b**
	Amino acid catabolism (11.8%)		985		
1	3-methylbutanal	649	80	10–233	**b**
2	2-methylbutanal	662	341	34–1254	**b**
57	phenylacetaldehyde	1048	7	2–15	**b**
14	3-methyl-1-butanol	734	208	35–719	**b**
15	2-methyl-1-butanol	737	344	76–906	**b**
66	2-phenylethanol	1120	5	0–14	**b**
	Microbial esterification or fermentation (4.9%)		410		
11	propyl acetate	714	116	8–619	**b**
9	ethyl propanoate	703	88	6–218	**c**
18	ethyl butanoate	759	67	0–285	**c**
28	ethyl 2-methylbutanoate	851	27	1–149	**c**
29	ethyl 3-methylbutanoate	855	55	8–300	**c**
46	ethyl hexanoate	996	5	3–10	**c**
21	1,3-butanediol	777	37	14–55	**b**
23	2,3-butanediol	790	15	3–47	**b**
	Contaminants + unknown origin (3.8%)		321		
22	butanoic acid	783	24	0–78	**c**
71	dodecane	1199	8	1–46	**a**
74	tridecane	1299	2	1–4	**a**
75	tetradecane	1398	5	0–18	**a**
77	pentadecane	–	–	0–3	**a**
20	toluene	769	22	10–35	**b**
31	p-xylene	872	20	0–38	**c**
32	m-xylene	877	5	1–18	**b**
34	styrene	892	10	6–14	**b**
27	tetrachloroethene	819	38	2–100	**c**
10	2-methyl-2-propanoic acid	711	60	0–150	**c**
36	2,6-dimethyl pyrazine	914	20	7–35	**b**
17	3-methyl-2-pentanone	753	5	0–13	**b**
3	1-methoxy-2-propanol	672	102	0–429	**c**
	Total volatiles		**8325**		

[a] Peak sequence in the gas chromatogram.
[b] The Kovacs indices are calculated for the DB5 capillary column.
[c] The extracted quantities are the median expressed in ppb of nonane.
[d] Minimum and maximum extracted quantities (ng eq nonane g salami^{-1}). Value 0 means that trace amounts were detected (< 0.
[e] The reliability of identification is indicated by the following symbols. **a** = mass spectrum and retention time agreed with sta spectrum and Kovats index agreed with literature data. **c** = mass spectrum agreed with literature (NBS, NIST, TNO). **d** = tentative by mass spectrum.
Origin : AA : Amino acid catabolism, ME : Microbiological esterification, unknown origin.

molecules in Italian salami because it is often seasoned with such spices as ground black pepper and garlic. Three compounds were not identified but they can be classified as monoterpenes from mass spectrometry data and probably also arise from spice.

Sulphur-containing molecules represented 11.0% (912 ng eq nonane g^{-1}). All were non-cyclic compounds and possessed a thio function. The most abundant was 1-propene-3-methyl-thio (59–1793 ng eq non aliphatic sulphur compounds have been garlic (Maarse et al., 1989). In previous v aroma of salami, these molecules were p amounts (Stahnke and Zeuthen, 1992) mentioned (Berger et al., 1990). This s garlic may be used in different amoun production.

of Milano salami, which is low when compared with other fermented sausages (Berdagué et al., 1993; Viallon et al., 1996). Such a low level of lipid oxidation could be attributed to the anti-oxidative activity of the spices (Barbut et al., 1985; Pokorny, 1991) and nitrites (Ramarathan et al., 1991).

The main volatiles arising from lipid oxidation were aldehydes (12.7% of the total volatiles, 1581 ng eq nonane g^{-1}). Hydrocarbons, alcohols and ketones were present in small proportions (2.9, 1.9 and 1.4%, respectively). Aldehydes were linear aliphatic aldehydes from C_4 up to C_{10}. The main ones were hexanal (181–658 ng eq nonane g^{-1}) and nonanal (127–634 ng eq nonane g^{-1}). They are produced during the oxidative degradation of unsaturated fatty acids (Frankel, 1980; Grosch, 1982).

Hydrocarbons included *n*-alkanes and *n*-alkenes with 7 and 8 carbons. These molecules are formed from the rearrangement of the alkylic radical formed by β-splitting of the alcoxy-radical (Frankel, 1980). Ketones were 2-methyl-ketones, namely 2-pentanone and 2-heptanone. They may be formed by β-oxidation of fatty acids during fungal growth (Grosch, 1982). Alcohols were aliphatic linear alcohols which generally result from degradation of lipid hydroperoxides (Frankel, 1980).

3.2.3. Amino acid catabolism

The volatiles arising from amino acid degradation accounted for 11.8% of the total volatiles (985 ng eq nonane g^{-1}). They were two branched short-chain aldehydes (2-methyl-butanal, 3-methyl-butanal) and the corresponding alcohols (2-methyl-butanol, 3-methyl-butanol). One aromatic aldehyde was found in very small amounts. 2-methyl-butanal and 3-methyl-butanal are produced during the degradation of isoleucine and leucine respectively through a non enzymatic Strecker reaction (Berdagué et al., 1993; Barbieri et al., 1992) or by micro-organisms (Bailey et al., 1992). 2-methyl or 3-methyl alcohols can be formed by reduction of the corresponding aldehydes (Hertz and Chang, 1970). Phenylacetaldehyde is a product of phenylalanine catabolism (Berdagué et al., 1991).

3.2.4. Fermentation or microbial esterification

Six esters were desorbed and accounted for 4% of the volatiles. Most were ethyl esters. Our result is in agreement with those previously obtained in dry sausages (Charrier, 1992; Stahnke, 1994; 1995a). Esters could be formed in a complex chain of reactions such as : alcohol → aldehyde → acid → ester. This hypothesis is strongly supported by the fact that we observed a highly significant correlation between the amounts of 3-methyl-butanol and some esters (ethyl 2- and ethyl 3-methylbutanoate) ($r^2 = 0.90$ and 0.88, respectively) and

oxidised to the corresponding acid and t
with ethanol by micro-organisms (Stahnke

1,3 And 1,2 butanediol were identifi
formed by fermentation of carbohydrat
1983; Johansson et al., 1994).

3.2.5. Miscellaneous origin

A compound 1-methoxy-2-propanol (10
ane g^{-1}) of unknown origin was form
synthesis is possible in an environment
amino acids and ammonia, as exists in
meat products (van Praag et al., 1968).

Alkanes with more than 10 carbon ato
sent in trace amounts. They probably come
feed and were stored in adipose tissues.

Aromatic hydrocarbons accounted for 5
ane g^{-1} of volatiles. Toluene should co
cyclization of unsaturated carbonylic cha
by lipid degradation (Min et al., 1977).
styrene are present in plants liable to be
mals (Berdagué et al., 1993).

Minor compounds included acids, tetra
and 2,6-dimethyl-pyrazine.

3.3. Odour profile

The odours described in salami (Table
ciated with compounds of various origins
amino acids and microbial esterification a
tion).

Five odours were unambiguously attri
penes and 3 others could be tentatively
terpenes. They included major compou
myrcene, o-cymene and limonene, and also
pounds such as cineole, α-phellandrene, γ-t
terpinolene. They were described as fruit
fresh rather than spicy. In the present
odours were related to spices than in pre
(Berdagué et al., 1993; Stahnke, 1994, 19
out on experimental dry sausages prepared
ces.

Three odours could be related to non
sulphur compounds, which play a key rol
vour because of their very low threshold
(Mottram, 1991). One, described as onion
or gas, was attributed to 1-propene-3-met
were described as butyric-unpleasant and
toasted. No compound was identified by G
corresponding retention indices, because i
at minute concentration. According to t
these butyric and meaty odours could be
3,3′-thiobis-1-propene and dipropyl trisu
were found in the aroma of onion and

Kovacs index	Odour	Compound identified [a]	Tentative identification
666	Butter, caramel, rancid	2-Methylbutanal (662)	
686	Chocolate	n.i.	
708	Gas, onion, unpleasant	1-Propene-3-methylthio (701)	
740	Musty, fruity		Propyl acetate (714)
763	Fruity, apple, floral		Ethyl butanoate (75
801	Grass, floral	Hexanal (800)	
854	Butyric, unpleasant		3-3′-thiobis-1-prope
900	Potatoes	Heptanal (900)	
904	Mashed potatoes		2,6-Dimethylpyrazin
927	Potatoes, pop corn	n.i.	
972	Mushroom	1-Octen-3-ol (981)	
998	Lemon, fruity, green	Myrcene + α-phellandrene (991/1000)	
1028	Menthol	Limonene + β-phellandrene (1030/1034)	
1038	Floral, rose		Cineole (1037)
1050	Fruity, fresh		0-Cymene/γ-terpine (1041/1059)
1070	Mushroom, floral		Octanol (1071)
1089	Fruity, eucalyptus	Terpinolene (1090)	
1217	Potatoes, butter		Decanal (1204)
1307	Meaty, bread, toasted		Dipropyl trisulfide

Number of panellists: 8 persons who smelled for 10 min each successive part of the chromatogram. n.i. = non identified.

[a] Molecule found at a retention index close to that of the odour and having an odour close to that described in the literature.

[b] Molecule found at a retention index close to that of the odour or having an odour close to that described in the literature.

frequently employed in Milano salami. These compounds have very low thresholds of perception (Mottram, 1991).

Some odours can be clearly related to volatile compounds arising from lipid oxidation: grass to hexanal, potatoes to heptanal, mushroom to 1-octen-3-ol. Potatoes–butter odour was tentatively attributed to decanal. Hexanal possesses a characteristic smell of green grass and 1-octen-3-ol exhibits a typical odour of mushroom (Schieberle and Grosch, 1987; Meynier et al., 1998). Aldehydes are often reported to be responsible for the rancid odours of foods (Asghar et al., 1988). Nevertheless, no fatty or rancid odour directly associated with lipid oxidation compounds was detected in the salami tested.

One odour described as butter, caramel and rancid was attributed to 2-methylbutanal, in agreement with Arctander (1994b) and its retention index. This compound arises from amino acid catabolism. In previous studies, 3-methyl-butanal was found in higher proportion and was described as a potent aroma of dry-sausage or ham aroma with sour, cheesy and nail polish-like attributes (Andersen and Hinrinchen, 1995; Stahnke, 1994, 1995a, 1995b). However, 2-methyl-butanal was the major compound in the present study.

Two odours were attributed to esters: propyl acetate and ethyl butanoate. Both were described as fruity, which is in agreement with previous reports. Esters are essential for the typical aroma of fermented sausages either by adding a fruity note or by masking rancid odours (Stahnke, 1994; Careri et al., 199 not always found in salami (Berger et al., 1 and Zeuthen, 1992). This could be expl poor ability of some microbial flora to p (Stahnke, 1994, 1995a).

4. Conclusion

About 95% of the identified volatiles c with known chemical pathways and/or substances. Most of the volatiles and c approximately) were associated with spice dation provided low amounts of volatiles (volatiles), which was consistent with the l odour in Milano salami. Two esters microbial fermentation added fruity and f the aroma of salami, while only one comp from amino acid catabolism contributed t aroma. Consequently, we assume that the the aromas of different brands of Mila mainly related to the nature and the amou included in the formula.

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pounds of salami.

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