Sensory and Chromatographic Evaluations of Water Soluble Fractions from Dried Sausages

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Low molecular weight water soluble compounds were extracted from Danish salami, Italian sausage, and Spanish chorizo. The extracts were fractionated by gel filtration chromatography revealing peptides with M_r <4200 Da. Fractions consisting of smaller peptides and free amino acids had enhanced savory taste impressions described as mainly bouillon, bitter, sour, salty, and plastic with odor notes of boiled potato. Determination of amino acids in the fractions before and after hydrolysis revealed the presence of mainly hydrophilic peptides in all fractions. Partial least-squares regression of the amino acid data and the sensory results indicated that bouillon taste was related to a mixture of different amino acids and peptides, that potato odor in particular correlated with high content of tyrosine, free and as the peptide residue, that bitterness was related to the level of certain hydrophobic amino acids, and that sourness was related to glutamic acid.

Keywords: *Dried sausage; gel filtration; HPLC; amino acids; peptides; taste*

INTRODUCTION

During the fermentation and ripening of dried sausage, a large number of biochemical reactions occur in the sausage mince. Some of the major reactions are the lipolytic and proteolytic breakdown reactions induced by endogenous enzymes from the meat and fat and by enzymes from microorganisms growing in the mince (Verplaetse et al., 1992).

To achieve more knowledge about the taste development taking place during the ripening of fermented sausage, it is important to evaluate the taste impression of the protein degradation products such as peptides, amino acids, and other products of protein breakdown. The taste of the liberated amino acids and peptides, in particular small peptides with a relative molecular mass (M_r) <5000 Da, is believed to make an important contribution as flavor compounds or flavor precursors (Spanier and Edwards, 1987; Còrdoba et al., 1994).

Detailed studies on peptides from fermented sausages are rare, though. Most investigations concerning protein breakdown have studied the total level of nonprotein nitrogen (NPN), which also includes nucleotides, nucleosides, amino acids, amines, and ammonia. However, in a very recent investigation Díaz et al. (1996) studied the degradation of the myofibrillar and sarcoplasmic proteins in sausages fermented for 26 days. They found that in particular the sarcoplasmic proteins were degraded, although fractions of peptides with molecular masses of 10−12 kDa rose steadily from both types of protein. In the processing of a Spanish dry-cured ham Rodríguez-Nunez et al. (1994) found a clear increase of peptides below 2700 Da, especially during the first 3−4 months of ripening. Concerning free amino acids, Toldrá and Aristoy (1993) found a very high increase at the end of the processing of the same type of Spanish dry-cured ham. Studies on peptides and amino acid profiles of dried sausages showed that the level of amino acid and smaller peptides increased during ripening. In general, the amino acids valine, leucine, isoleucine, phenylalanine, and methionine were among those showing the greatest increases in concentration (DeMasi et al., 1990; Dierick et al., 1974; Astiasaran et al., 1990). McCain et al. (1968) observed a highly significant correlation between organoleptic determinations of aged taste and the concentration of free amino acids and peptides in dry-cured ham, while Careri et al. (1993) found that lysine, tyrosine, and aspartic acid present as free amino acids were mostly related to aged flavor.

Bitter peptides in cheese are characterized as containing a larger number of hydrophobic residues (Harwalker and Elliot, 1965; Champion and Stanley, 1982; Crawford, 1977). There are very few studies dealing with the bitter taste note in fermented meat products. Aristoy and Toldrá (1995) examined extracts from an Italian Parma ham and found bitter peptides in much lower concentrations than in cheeses. The reason is probably that casein has a higher average hydrophobicity than meat proteins and therefore liberates peptides of more bitterness during hydrolysis (Guigoz and Solms, 1976). Isolation of the bitter fractions in cheese by gel filtration revealed that the composition of the peptides had high contents of lysine and arginine (Champion and Stanley, 1982; Kirimura et al., 1969). Aristoy and Toldrá (1995) observed high concentrations of lysine, β-alanine, histidine, and cysteine/cystine residues in a bitter/sour fraction from gel filtration of meat extracts. A fraction determined as brothy/umami had elevated content of phenylalanine mostly in the free form, but no bitter taste. High levels of glutamic acid, serine, glycine, histidine, alanine, methionine, and lysine could have masked the bitter-tasting phenylalanine. Amino acids such as lysine and arginine also expose a bitter taste, while glycine, serine, and alanine result in sweet taste impressions (Solms, 1971).

In addition to amino acids and peptides, sugars, acids, nucleotides, and other components may contribute directly or as precursors to the taste of meat and fermented meat products (Solms, 1971). Smoking and seasoning may also contribute. It is difficult to determine which compounds are the most important for the taste in food preparations. Compounds such as peptides and amino acids may contribute to the taste in a

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complex manner, exceeding the taste properties of the pure compounds due to taste interactions (Solms, 1969; Kirimura et al., 1969).

The objectives of this study were to extract water soluble, low molecular weight components from fermented sausage, to fractionate the extracts by gel filtration chromatography and reversed-phase HPLC, and to perform a sensory evaluation of these fractions.

MATERIALS AND METHODS

Samples. Danish salami (DAN), Italian sausage (ITA), and Spanish chorizo (CHO) were purchased in local retail stores. Only unsmoked sausage types were purchased since preliminary experiments showed that compounds from the smoking procedure eluted in the peptide fractions, thus interfering with the sensory evaluations.

Preparation of Extract. Extraction of low molecular weight material from the dry sausages was performed according to the procedure of Champion and Stanley (1982). This method precipitated larger proteins, endogenous and microbial enzymes, thus avoiding proteolytic breakdown of peptidic material in prepared extracts. Besides, the use of chloroform enabled the extraction of more hydrophobic peptides and removal of fat. The extraction procedure involved mixing of 75 g of minced sausage and 170 mL of chloroform/methanol (2:1, v/v) (all glass distilled at the Technical University of Denmark, analysis grade) in a Stomacher laboratory blender 400 (Holm & Halby, Alleroed, Denmark) and filtering the resulting mixture using No. 4 Whatman filter paper (Kent, England). The residue was reextracted twice. The filtrate was shaken with an admixture of water and separated, and the layer containing water and methanol was removed, evaporated under reduced pressure, freeze-dried, and redissolved in redistilled water. The crude extract was dark yellow with no sign of precipitation after storage at −30 °C. Two samples of each sausage were extracted. The extracts were subjected to gel filtration chromatography.

Gel Filtration. Gel filtration was carried out on a Gradifrac gel filtration system (Pharmacia, Uppsala, Sweden) using a Sephadex G-50 (Pharmacia) column (2.1 × 100 cm). The UV-1 monitor (Pharmacia) with flow cell operated at 226 nm. To obtain repeatable results, a buffer of 0.02 M ammonium bicarbonate (analysis grade, Bie & Berntsen, Roedovre, Denmark) in water was used as eluent instead of pure water. Flow rate was 24 mL/h. Fractions of 5 mL were collected and pooled in seven larger fractions. The seven fractions were freeze-dried twice to remove ammonium bicarbonate. The column was calibrated using molecules ranging from bovine serum albumin (67 kDa) to glycine (75 Da) (Bie & Berntsen).

Amino Acid Analysis. The seven pooled fractions were analyzed for free amino acids before and after hydrolyzation by ion exchange chromatography combined with postcolumn derivatization on a Waters HPLC system at the Department of Biochemistry and Nutrition, Technical University of Denmark, according to the procedure of Barkholt and Jensen (1989).

The amino acid analyzer consisted of two Waters M 510 high-pressure pumps with pulse dampers and microflow modules, a Waters M 710 refrigerated autosampler, a column oven, a Waters M 420 fluorescence detector with 228-nm bandpass excitation filter and 455-nm long-pass emission filter, and a Waters M 840 data and chromatographic control station.

The column was a cation exchange resin, MCI-Gel CK 10U, from Mitsubishi Chemical Industries, a styrene−divinyl copolymer benzenesulfonic acid, 10% cross-linkage, 5 ± 0.5 μm particles. The column temperature was maintained at 62.0 °C, and the flow rate was 0.4 mL/min. The elution of amino acids was performed by a pH gradient resulting from mixing the nonhalide buffers A and B. Buffer A was 0.2 M sodium citrate containing 0.05% phenol and 5% 2-propanol adjusted to pH 3.10 with nitric acid. Buffer B was 0.210 M sodium borate, 5% 2-propanol adjusted to pH 10.10 with NaOH. The gradient was as follows: initial eluant 100% A, 88% A and 12% B at 15 min, 60% A and 40% B at 24 min, 100% B at 29 min, 100% B from 29 to 39 min, and 100% A at 40 min.

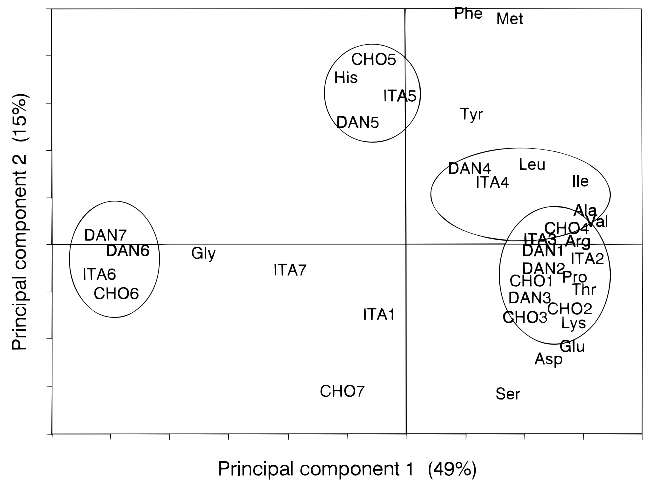

Figure 1. Score/loading plot from PCA on the peptidic amino acid content (mol %) of the seven fractions. Percentages on axes indicate the variance explained by the PC. DAN, Danish salami; ITA, Italian sausage; CHO, Spanish chorizo.

Postcolumn derivatization was performed using hypochlorite and OPA reagents made in degassed 0.50 M potassium borate, pH 10.4.

Sensory Evaluations. The seven fractions were inspected for residues of chloroform and methanol prior to sensory evaluation by static headspace gas chromatography. The sensory panel consisted of six trained judges. The judges were trained during two training sessions, including a discussion of the results. Each judge evaluated 0.2 mL of sample corresponding to 1.3 g of sausage corresponding to one slice of the sausage. The taste profile of the fractions was determined using a 0−9 scale, 9 corresponding to the highest intensity. The following descriptors were decided upon by the panel: cooked fish, phenol, pungent, sour, bitter, salty, plastic, burnt, bouillon, boiled potato, and onion odor. Of those, the following were chosen as being the main descriptors: bouillon, bitter, sour, salty, plastic, and boiled potato odor.

Statistical Analyses. The amino acid data and the sensory results were analyzed by principal component analysis (PCA) and partial least-squares regression (PLS) using the computer program Unscrambler (ver. 5.5, CAMO A/S, Trondheim, Norway). For the PLS regression the amino acid data were transformed into $\log(x + 1)$.

RESULTS AND DISCUSSION

Amino Acid Analysis. Most of the peptidic material and the major part (>99%) of the free amino acids were eluted in fractions 4 and 5 (Tables 1 and 2). The relative molecular mass of the majority of the absorbing material at 226 nm was below 4200 Da. The amino acid residues of peptides in fractions 1−3 were mainly glutamic acid, proline, glycine, alanine, valine, and lysine (cf. Table 1). The composition of the peptides in fractions 4 and 5 was similar to the peptides in fractions 1−3 except for an increased concentration of histidine, phenylalanine, leucine, and methionine residues. Besides, the amount of lysine residues in fraction 5 was minor. In general, the peptides in fractions 6 and 7 contained the largest proportion of glycine residues.

Figure 1 displays a PCA of the amino acid residues of the peptidic material in the seven fractions. The PCA shows that fractions 1−3 had similar contents of amino acid residues, while fractions 5−7 were very different. The more polar peptides were eluted in the first three fractions, while fractions 5−7, and to a lesser extent fraction 4, contained peptides with a relatively higher

Table 1. Mole Percent Amino Acid Residues in the Peptidic Material in Spanish Chorizo (CHO), Italian Sausage (ITA), and Danish Salami (DAN)[a]

amino acid	fraction 1			fraction 2			fraction 3			fraction 4			fraction 5			fraction 6			fraction 7		
	CHO	ITA	DAN	CHO	ITA	DAN	CHO	ITA	DAN	CHO	ITA	DAN	CHO	ITA	DAN	CHO	ITA	DAN	CHO	ITA	DAN
Asp	5.3	2.3	8.4	6.0	5.0	4.5	10.1	6.7	5.3	6.6	3.8	2.9	3.2	1.5	2.3	0.7	0.0	0.4	9.3	3.6	0.0
Thr	4.6	2.5	2.5	3.6	4.5	3.4	3.5	4.5	3.4	3.0	2.6	2.5	0.0	1.6	1.6	0.0	0.0	0.0	0.0	2.3	0.0
Ser	5.5	3.6	10.3	5.3	6.2	3.0	4.9	4.8	4.7	3.3	3.1	3.2	1.0	1.2	1.7	0.0	0.4	0.4	13.0	4.8	0.0
Glu	17.1	15.2	17.4	20.3	13.4	14.5	17.2	12.8	10.8	13.1	8.2	11.0	8.5	8.9	5.5	0.8	0.3	1.1	19.1	7.3	0.0
Pro	15.2	23.9	5.8	20.2	19.7	24.6	20.8	24.3	27.2	18.3	20.1	14.4	5.1	10.5	4.5	0.0	0.0	0.0	0.0	2.2	0.0
Gly	13.3	5.6	17.5	8.5	6.2	7.4	9.5	7.0	8.0	8.5	6.2	6.6	41.7	27.9	48.1	95.0	96.4	93.5	44.4	54.3	79.8
Ala	10.0	7.3	8.5	8.4	9.6	10.4	6.8	5.8	9.6	8.4	4.6	10.8	5.3	4.3	6.4	0.0	0.0	0.0	0.0	1.9	0.0
Val	8.0	8.0	6.7	7.3	8.4	11.1	7.1	8.7	8.8	10.4	8.4	7.4	4.3	6.0	3.9	0.8	0.0	0.0	0.0	3.8	0.0
Met	1.3	0.0	1.7	0.9	0.7	1.5	0.7	1.1	1.1	2.1	1.6	2.2	2.6	2.5	2.3	0.0	0.0	0.0	0.0	0.0	0.0
Ile	2.4	1.6	3.4	3.3	3.0	3.1	3.7	3.9	2.9	5.7	5.5	3.7	2.0	3.3	2.5	0.9	0.2	0.0	1.9	2.1	0.0
Leu	3.3	1.5	7.2	3.3	5.9	2.5	3.6	5.1	3.2	7.7	5.7	7.9	4.3	7.4	4.9	0.0	0.5	0.3	8.0	4.5	0.0
Tyr	0.8	0.0	2.2	0.9	1.6	1.0	0.9	1.6	0.6	0.5	0.8	0.0	1.9	1.1	1.6	0.0	0.4	1.6	0.0	0.0	0.0
Phe	1.4	0.0	2.2	1.0	2.1	1.0	1.4	2.5	1.1	1.6	1.7	1.1	4.9	3.5	3.8	0.0	0.2	0.7	0.0	1.8	0.0
His	6.3	7.4	0.3	1.2	1.5	0.6	1.5	3.4	1.2	0.9	18.3	21.1	13.6	17.6	6.5	0.9	1.4	1.5	0.0	9.3	19.0
Lys	9.3	1.0	3.7	7.5	7.1	10.3	6.5	5.9	10.6	7.2	6.5	4.8	1.6	2.1	1.5	0.9	0.3	0.6	4.3	2.2	1.2
Arg	1.8	0.0	2.4	2.4	3.5	1.0	1.6	1.8	1.4	1.3	0.9	1.0	0.6	1.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
total (mg/L)	216	83	92	383	966	143	275	473	193	2319	2518	2630	5180	6121	3106	280	1086	1553	39	175	80

[a] Fractions 1−7 were collected by gel filtration chromatography.

proportion of nonpolar residues. Apart from fraction 7, the fractions from the three different sausage types were very much alike. Reversed-phase HPLC analysis (data not shown) supported the PCA conclusion that fraction 4 and especially fractions 5−7 contained a relatively higher proportion of nonpolar residues.

The most common free amino acids in the three sausages were proline, alanine, valine, isoleucine, and leucine, and in CHO and DAN, also glutamic acid (cf. Table 2). Phenylalanine was present in fraction 5 in all three sausages. Those data are consistent with the amino acid data from the crude extract (data not shown) as well as with data in the literature (DeMasi et al., 1990; Dierick et al., 1974; Reuter et al., 1968). There was a remarkably large content of histidine in DAN in both fractions 4 and 5 in comparison with ITA and CHO. Histidine may arise from histidine dipeptides present in skeletal muscle, the concentration depending on muscle type (Carnegie et al., 1983). It is unknown why the Danish sausage contained larger amounts of this amino acid. However, the Danish sausage was made partly of beef meat; the Spanish and Italian sausages were all pork sausages.

Sensory Evaluation. Table 3 displays the results from the sensory evaluation of fractions 4 and 5. Apart from fraction 3 of ITA, fractions 1−3, 6, and 7 were tasteless and were not included in the table. Fraction 3 of ITA had a slightly bitter taste, not detectable in fraction 3 of DAN and CHO. This could be due to the higher concentration of peptide material in fraction 3 of ITA and also to the amino acid composition of the peptides (cf. Table 1). There are probably two reasons for the lack of taste in fractions 1−3, 6, and 7. First, the amount of peptides in those fractions could have been below the sensory threshold value in comparison with the threshold values for the pure amino acids (cf. Table 2). Second, the peptide sizes in fractions 1 and 2 were probably too large to result in taste impressions (Spanier and Edwards, 1987).

The highest taste intensities appeared in fractions 4 and 5, which contained a mixture of small peptides and free amino acids (cf. Table 2). The judges denoted the fractions as savory. The taste impressions were characterized as mainly bouillon, bitter, sour, salty, and plastic with odor notes of boiled potato. These observations indicate that small peptides and free amino acids, separately or as a mixture, may contribute to the overall flavor of dried sausage. However, the observations also indicate that the characteristic cured flavor of dried sausage does not lie within the taste of the watersoluble, nonvolatile part of the sausage. Spectrophotometric measurements revealed coelution of Cl^- (or NaCl) in fraction 4 and, in particular, in fraction 5. NaCl is a well-known flavor enhancer. Except for the salty taste, NaCl may enhance the taste of the amino acids, resulting in a more desirable overall taste (Ugawa et al., 1992).

The composition of the peptides in fractions 4 and 5 (mainly glutamic acid, proline, glycine, alanine, valine, histidine, and leucine, cf. Table 1) resembles observations of Aristoy and Toldrá (1995), who found high proportions of proline, glycine, alanine, valine, and leucine and also arginine and serine in savory fractions from gel filtration of dry-cured ham extract. The question is to what extent a mixture of amino acids influences the overall taste compared to the peptides. Aston and Creamer (1986) examined the influence of amino acids on taste in Cheddar cheese by comparing

Table 2. Free Amino Acids (Milligrams per Liter) in Spanish Chorizo (CHO), Italian Sausage (ITA), and Danish Salami (DAN)[a]

amino acid	fraction 4			fraction 5			threshold in water[b] (mg/L)	taste
	CHO	ITA	DAN	CHO	ITA	DAN		
Asp	**106**[c]	17	**57**	**336**	**96**	30	30/1000	sour/umami
Thr	277	156	202	866	964	274	2600	sweet
Ser	155	32	139	727	218	287	1500	sweet
Glu	**728**	**75**	**592**	**1757**	**397**	**1479**	50/300	sour/umami
Pro	553	469	308	877	2403	479	3000	sweet-bitter
Gly	150	54	126	576	450	323	1300	sweet
Ala	**1264**	**606**	**1364**	**2600**	**3684**	**2164**	600	sweet
Val	**701**	**885**	**559**	**1030**	**3346**	**578**	400	bitter
Met	212	140	160	**794**	**1438**	**523**	300	bitter
Ile	642	709	645	**1084**	**3082**	752	900	bitter
Leu	1344	1368	1081	**2430**	**6223**	1402	1900	bitter
Tyr	201	249	0	611	0	593	nd[d]	bitter
Phe	70	12	37	**2355**	**2379**	**1436**	900	bitter
His	78	33	**3437**	85	50	**2621**	200	bitter
Trp	0	0	122	87	128	0		
Lys	**628**	467	**577**	493	**916**	294	500	sweet/bitter
Arg	7	0	17	74	296	109	500	bitter
total (mg/L)	7316	5521	9422	16780	26070	13343		

[a] Fractions 4 and 5 were collected by gel filtration chromatography. [b] Kato et al. (1989). [c] Values shown in bold are above the threshold values. [d] Not determined.

Table 3. Sensory Evaluations (Mean ± SD)[a] of Spanish Chorizo (CHO), Italian Sausage (ITA), and Danish Salami (DAN)

taste impression	fraction 4			fraction 5		
	CHO	ITA	DAN	CHO	ITA	DAN
sour	0.1 ± 0.2	0.0 ± 0.0	2.3 ± 3.3	1.7 ± 2.7	1.5 ± 1.7	2.1 ± 2.8
bitter	0.8 ± 2.6	0.5 ± 1.3	0.2 ± 0.1	0.7 ± 1.6	1.1 ± 3.7	0.4 ± 0.4
plastic	1.1 ± 2.6	1.0 ± 2.0	0.0 ± 0.0	0.6 ± 2.3	0.8 ± 3.8	0.0 ± 0.0
bouillon	3.0 ± 2.4	1.4 ± 1.6	3.6 ± 1.2	4.1 ± 1.2	4.0 ± 1.6	3.9 ± 1.2
potato[b]	0.2 ± 0.2	0.9 ± 2.9	0.0 ± 0.0	1.6 ± 2.8	0.8 ± 1.5	1.2 ± 1.8

[a] Scale: 0 = no taste impression and 9 = very strong taste impression. Average of two replicates. [b] Denoted as an odor.

the taste of a synthetic mixture of amino acids, calcium lactate, and sodium chloride with those of the original water soluble extract (WSF). They found that the synthetic mixture lacked part of the taste intensity of the WSF. The missing taste, especially bitter, was presumably due to peptides.

Figure 2 shows a PLS regression of the free amino acids, the amino acid residues of the peptides, and the sensory results. Salty taste was not included in the regression analysis since correlation of saltiness to amino acids was considered irrelevant. Totally, the three principal components (PCs) explain 67% of the variation in the amino acid data and 79% of the variation in the sensory data (cf. Figure 2). A variance plot of each sensory descriptor shows that bouillon is mainly described by PC1 and PC3, bitter by PC2, sour and plastic by PC2 and PC3, and potato by PC3 and slightly by PC1 (data not shown). For all sausages, fraction 5 had the highest intensity of bitterness, potato, bouillon, and sourness. Not surprisingly, this coincides with the highest concentration of peptides and free amino acids in fraction 5 (cf. Tables 1 and 2). Bouillon taste is probably caused by a conglomerate of most of the peptides and amino acids, though peptides containing higher amounts of threonine, serine, lysine, proline, isoleucine, valine, and aspartic acid seem to have no positive impact on bouillon taste (Figure 2a).

In particular, it seems as if free amino acids and residues with sulfur-containing or aromatic side chains and the sweet-tasting alanine and glycine (cf. Table 2) are correlated to bouillon notes. The amount of several of the amino acids is above the threshold level for taste impression (cf. Table 2).

Boiled potato odor is induced by the same amino acids as bouillon (Figure 2a), although tyrosine as the free amino acid or as the peptide residue seems to be correlated to a higher degree (Figure 2b). Potato odor has also been detected in fractions from gel filtration of Cheddar cheese extracts (Salles et al., 1995), but in that case the fractions did not contain detectable levels of free tyrosine—the peptidic tyrosine content was not stated. Potato odor does not arise from coextraction of volatile compounds during preparation of extracts since the freeze-drying procedure in the end of the process would have removed any volatiles present. However, it seems likely that potato odor could have arisen from amino acid breakdown taking place in the finished extract or in the final fractions. According to Whitfield and Last (1991) the aroma of boiled potato is believed to partly relate to Strecker degradation of amino acids. Phenylacetaldehyde, which is a degradation product of phenylalanine and tyrosine, and different sulfur-containing compounds arising from methionine and cysteine are considered to be some of the most important compounds to boiled potato aroma (Whitfield and Last, 1991). Apart from tyrosine, free methionine and peptidic methionine are also correlated to potato odor (cf. Figure 2).

Bitter notes correlate in particular with the amino acids lysine, valine, leucine, proline, and isoleucine and with peptides containing high proportions of the same amino acids in addition to glutamic acid and arginine. Most of those amino acids are hydrophobic in nature, reconfirming that bitterness of protein breakdown products is related to hydrophobicity. Aristoy and Toldrá (1995) also observed high levels of lysine residues in bitter/sour fractions from meat extracts, while Champion and Stanley (1982) found high amounts of both peptidic lysine and arginine in bitter fractions from cheese extracts. Especially the Italian sausage fraction

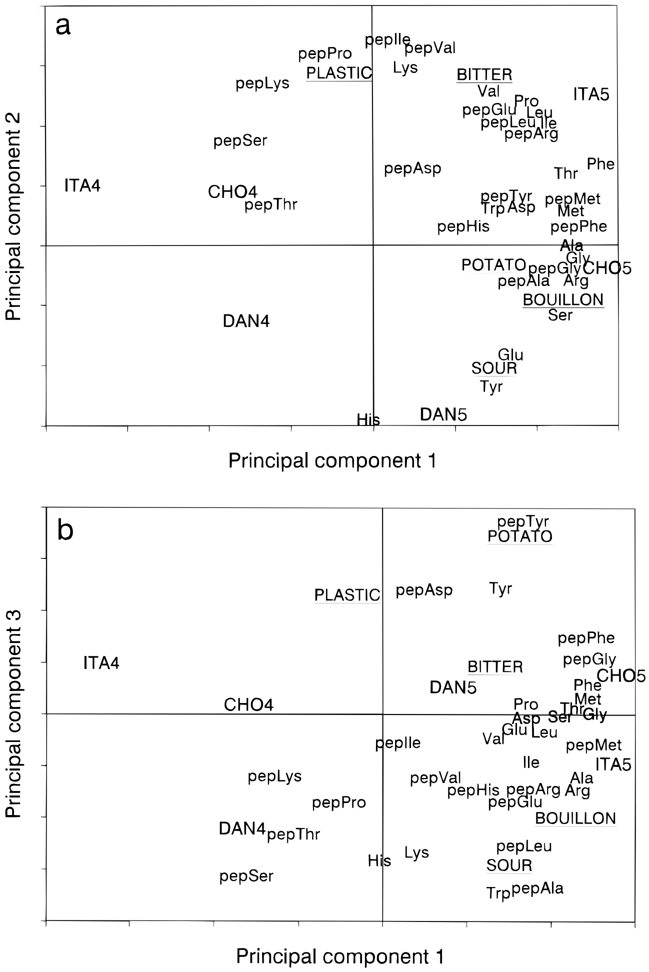

Figure 2. Score/loading plots from PLS regression on sensory scores and amino acid data of fractions 4 and 5. The three PCs explain, respectively, 35%, 25%, and 7% of the variance in the amino acid data and 19%, 31%, and 29% of the variance in the sensory data. PepSer (e.g.) is peptidic serine.

is characterized by bitter taste. This may be due to the, in general, longer ripening period of Italian sausage compared to Danish sausage.

The Danish sausage fractions are characterized by being more sour than the other sausage fractions. This is not due to elevated content of lactic acid compared to the other sausage types. The Danish sausage had a pH of 5.6, while the Italian and Spanish sausages had pH values of 5.3 and 4.8, respectively. Unfortunately, it was not possible to obtain information about ripening time from the retailer. The sour note correlates with tyrosine and glutamic acid. Glutamic acid is indeed sour, and the amount is well above the threshold value (cf. Table 2).

The plastic note correlates with peptides containing large amounts of lysine, proline, isoleucine, and valine. The nature of this correlation is unknown.

Conclusions. Extracts of water soluble compounds from different sausage types were subjected to gel filtration chromatography. Only later running fractions containing free amino acids, smaller peptides, and NaCl possessed perceivable taste impressions. The impressions were denoted as bouillon-like, salty, sour, and bitter with notes of plastic and potato odor. It was not possible to state whether the amino acids or the peptides contributed mostly to the overall taste. Coelution of NaCl in the tasty fractions possibly enhanced the taste impressions. Partial least-squares regression of the amino acid data and the sensory results indicated that bouillon taste was related to a mixture of different amino acids and peptides, that potato odor in particular correlated with high content of tyrosine, free and as the peptide residue, that bitterness was related to the level of certain hydrophobic amino acids, and that sourness was related to glutamic acid.

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