**Release of aroma compounds from dry-fermented sausages as affected
by antioxidant and saliva addition**

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Abstract

The effect of the addition of an antioxidant and saliva on the release of aroma compounds from dry fermented sausages was studied by extracting the headspace at different times using solid phase micro-extraction technique. The compounds were analysed by gas chromatography using a FID detector and identified by mass spectrometry. The addition of butylated hydroxytoluene to dry fermented sausages produced a significant reduction of the release of most of the volatile compounds indicating an oxidation process during sampling. The addition of water and saliva to the dry fermented sausages produced a higher release of pentanal, hexanal and octanal, while pentane, 1-octanol, pentanoic acid, and propanal showed a lower rate of release. Moreover, phenylethyl alcohol, 2-butanone, 2,3-pentanedione and 2-nonanone, derived from bacterial metabolism, presented a lower release rate when water and saliva were added. The rate of release of the compounds from dry fermented sausages was not related with the compound hydrophobicity value. Further research is needed to elucidate the effect of fermented sausage matrix on the partitioning of the compounds and its effect on aroma perception.

Keywords: dry fermented sausage, flavour release, volatile, oxidation, butylated hydroxytoluene, saliva.

Introduction

The release of flavour compounds from foods to reach the gustatory and olfactory receptors in the mouth and nose has been widely described [1] and includes several stages. The first of all is the release of compounds from the food matrix to the saliva phase in the mouth. Then, there is a partitioning from the saliva to the air, followed by the dilution and transport from the air phase in the mouth to the airways of the nose [2]. In order to understand flavour perception it is necessary to know flavour ingredient interactions where the proteins, carbohydrates and fats, play an important role [3].

Aroma release has been studied using different methodologies, such as static headspace [2,4] and dynamic systems mimicking the human mouth [5-8]. The retronasal aroma perception is a dynamic process affected by many factors such as mastication and salivation, therefore the dynamic techniques used to evaluate aroma perception simulated this retronasal process. However, the orthonasal aroma perception can be better studied by static systems [9] because these systems provide useful information about quantities and aroma molecules that can be important for aroma perception.

Saliva plays an important role in sensory perception by the hydration of foods and its effect on the partition of aroma compounds in the different phases. The effect of saliva composition and ratio on the release of volatile compounds has been studied by several authors [4,6-8,10]. In general, saliva produces changes in the release of flavour compounds depending on saliva flow and composition which at the same time is affected by the nature of the stimulus that generates extra saliva on mastication [1].

Many studies about flavour release have been performed on relatively simple systems to facilitate the interpretation of results. Several studies were done in liquid systems such as oil and oil in water emulsions [4, 7] and in mixtures of sucrose and

cyclamate [11]. Other studies were performed in semi-liquid foods such as cream style dressings [10, 12] or aqueous solutions [2,9]. Only a few studies were done with solid foods, French beans [5,7] and bananas[8]. In addition, there is only one study about the release of volatile compounds from a meat product, a cooked sausage [13], where the release was studied by static headspace and in-mouth conditions.

The typical aroma of dry-fermented sausages cannot be attributed to a single compound and is due to a mixture of volatile compounds in the appropriate amounts [14]. However, the aroma perception in meat products depends on the concentration and odour thresholds of volatile compounds and on their interactions with other food components that will affect its gas phase concentration. Hundreds of volatile compounds have been identified in dry fermented sausages [15-17] although only a few of them have been identified as the main odorants responsible for the dry-cured aroma [14].

Meat products have a very complex matrix that mainly contains proteins and lipids. In this sense, dry fermented sausages are composed by almost 30 % lipids that affect the aroma release. Flavour development in dry fermented sausages is mainly formed by lipid oxidation reactions and from bacterial metabolism [18]. Many studies have been focused on the lipid oxidation phenomenon during processing but there are not studies in fermented sausages about the release of these volatile compounds from the meat matrix. However, the stability of these lipids is a major fact that should be previously controlled. Therefore, the aim of the present work was to study the effect of the addition of an antioxidant and water and saliva on the release of volatile compounds from dry fermented sausages.

MATERIALS AND METHODS

Reagents and standards

The chemical compounds used for identification were obtained from Fluka Chemie AG (Buchs, Switzerland) except hexanal, 2,4-heptadienal (*E,E*), phenylacetaldehyde, 2-octenal (*E*), nonanal and 2-nonenal (*E*) that were obtained from Aldrich (Saint Louis, MO, USA).

Dry fermented sausages

Dry fermented sausages were made with lean pork (80 %) and pork back fat (20 %) as described by Marco et al., [18]. The following additives were added in g per kg quantities to the meat mixture: sodium chloride (27), lactose (20), dextrin (20) (food grade quality), sodium caseinate (20), glucose (7), sodium ascorbate (0.5) and potassium nitrate (0.3). The sausages were submitted to a fast fermentation process with a total fermentation and drying time of 44 days then, the sausages were vacuum packed and stored at 4 °C for approximately 2 months and the total processing time was 111 days. At the end of the storage stage, three sausages chosen randomly were sliced, vacuum packaged and stored frozen at –20°C for 3 months before the analysis.

Release of aromatic compounds from dry fermented sausages in *in vitro* model system

The release of the aromatic compounds was studied using a 10 ml HS vial, sealed with a PTFE faced silicone septum (Supelco, Bellefonte, PA, USA) where three grams of the minced sausage were introduced. The extraction of headspace volatile compounds was performed by SPME using a 85 µm carboxen/polydimethylsiloxane StableFlex fibre (CAR/PDMS stb) (Supelco, Bellefonte, Pennsylvania, USA). The volatile compounds were extracted by exposing the SPME fibre to the headspace while the sample was maintained at 30° C for different times (0.5, 1, 2 and 3h). Each experimental point was

done in triplicate. The compounds adsorbed by the fibre were quantified and identified by gas chromatography analysis using a flame ionisation and mass-selective detectors, respectively.

The rate of release for each volatile compound in each experience was determined through the calculation of the initial slope obtained from the linear regression of the compound area vs the extraction time. The initial slope was calculated from the two or three first points depending on the compound. This parameter has been previously used to measure the rate of flavour release [19, 20].

Effect of saliva and water addition and the presence of an antioxidant, in the release of volatile compounds.

The frozen sausage was minced using a Waring blender (Waring Comercial 8010, CT, USA) and 3 g were introduced in the headspace vial. Then, three experimental conditions were analyzed, sausage alone, sausage in the presence of water (3 ml bidestilate water) and sausage in the presence of saliva (3 ml) [21].

The addition of an antioxidant during sausage preparation was also analyzed and 10 mg of butylated hydroxytoluene (BHT) were added during sausage mincing. Then, the three experimental conditions (without and with water or saliva) were evaluated.

Identification and quantification of volatile compounds

The identification was done in a gas chromatograph (GC HP 5890 series II, Hewlett Packard, Palo Alto, CA), with a HP 5972 mass selective detector (Hewlett Packard, Palo Alto, CA), following the procedure described by Marco et al. [17]. The quantification of volatile compounds was done as described Gianelli, Flores and Toldrá [22] in a DB-624 capillary column (J&W Scientific; 60m, 0.32mm id, film thickness 1.8mm) installed on a Agilent 6890 gas chromatograph (USA) equipped with a flame ionisation detector (FID). Helium was used as the carrier gas at a linear velocity of 37.0

cm/sec. The fibre was previously conditioned at 250°C during 1 h following the indications of the manufacturer. The GC oven programme began when the fibre was inserted in the injection port at 240° during 6 min in split-less mode and using a 0.75 mm id liner. Then, the volatile compounds were separated using a temperature programme and after the injection of the fibre the oven was held at 38 °C for 13 min, ramped at 100 °C at 3 °C/min and maintained at 100° during 10 min, then to 150 °C at 3 °C/min, and to 210 °C at 5 °C/min, and finally held at 210 °C for 20 min, the total run time was 82.3 min. Detector temperature was set at 240 °C. The content of each of the volatile compounds in each experience was calculated from the FID area and expressed as area units. Kovats indices (KI) of the volatile compounds were calculated. The identification of compounds was confirmed using authentic standards.

Statistical analysis

The effect of the different experimental conditions (sausage, sausage with water and sausage with saliva) and the addition of the antioxidant on the volatile compounds were tested by two-factor analysis of variance (ANOVA) using the statistic software Statgraphics plus (v 5.1). In those cases where the effect of the factors and their interactions were significant ($p < 0.05$), the means were compared using Fisher's least significant difference (LSD) test ($p < 0.05$).

RESULTS AND DISCUSSION

Forty-six compounds from dry fermented sausages were identified and quantified (Figure 1, Table 1). All of them have been previously detected in dry fermented sausages using the same extraction technique [17-18]. The volatile compounds were grouped according to their possible origin [23], to determine the effect of the different conditions on the release of volatile compounds. Two major groups were defined; those

coming from the lipid auto-oxidation process and those originated from the bacterial metabolism. Within the last group, 4 subgroups were defined; compounds coming from carbohydrate fermentation, amino acid catabolism, staphylococci esterase activity and lipid β -oxidation.

The aroma release curves for these compounds were obtained by SPME analysis [19]. Figure 2 shows the aroma release curve for the compounds that come from the lipid auto-oxidation process. These compounds are essential for the characteristic flavour of meat products especially for the contribution of aldehydes to rancid, herbal and citric notes in fermented sausages [14]. In general, there was an increase in the recovery of aroma compounds from the sausages with an increase in the extraction time. Nevertheless, there were differences in release depending on the experimental conditions. In the experiments done in the absence of BHT, the quantities of aroma compounds trapped by the fibre reached a plateau after 2 h of exposing time however, this plateau was reached in only 1 h in the presence of BHT. This higher release may be explained by the oxidation of the sausage under the extractions conditions. The plateau indicates the total amount extracted [20] and in figure 2 can be seen that there were no differences in the total amount extracted when saliva and water were added however there was a significant lower amount extracted in presence of BHT.

The initial slopes of those compounds derived from the lipid oxidation process and generated in the dry fermented sausage under the different experimental conditions are shown in Table 2. The rate of release of several compounds was affected by the experimental conditions. Pentane, 1-octanol, pentanoic acid and propanal showed a higher release in the sausage alone while the release of pentanal, hexanal and octanal was higher in the presence of water and saliva. Also, nonanal showed a higher release when saliva was added. In addition, the effect of BHT was significant for all the

compounds except several alkanes and two alcohols. BHT produced a reduction in the slopes meaning that the rate of release of these compounds was reduced by its addition. It can be suggested that the BHT addition to meat products is necessary to avoid the oxidation of the lipid fraction during sampling.

The higher release of linear aldehydes, pentanal, hexanal and octanal, in the presence of water and saliva is partially in accordance with the results obtained by van Ruth and Roozen [6] in the study of flavour release in mouth conditions from sunflower oil and its emulsion. During mouth conditions the addition of water increased hexanal release but with artificial saliva a decreased release was detected. The decrease in the release of compounds by the addition of saliva detected was explained by the presence of proteins (mucin and α -amylase) in the artificial saliva that are responsible for the binding of aroma compounds [24]. The increase in hexanal release with the addition of water under mouth conditions was originated from the larger sample volume that results from the influence of the mastication device.

In the present study the meat product evaluated is more complex than oil or emulsion. In dry fermented sausages, the acidification process that occurs during the fermentation stage produces the coagulation of myofibrillar proteins. During the later drying stage, a gel is formed and gives the firmness to the final product [25]. However, nothing has been reported about the interactions between this gel protein matrix containing fat and flavour compounds. Until now, there are a few studies about the binding ability of sarcoplasmic and myofibrillar proteins obtained from fresh pork muscle and dry-cured ham [26, 27]. These authors reported the ability of sarcoplasmic and actomyosin proteins to bind several compounds including hexanal, although the binding was highly affected by the ionic strength and protein conformation. Therefore,

the addition of water and saliva could have affected the binding of hexanal to the myofibrillar proteins producing a release from the gel matrix.

Figure 3 shows the aroma release curve for the compounds derived from bacterial metabolism. The recovery of aroma compounds from the sausages was increased within the extraction time. However, there were differences in the plateau and the time to reach it. The experimental conditions, addition of water and saliva, affected the plateau and also the BHT addition. The effect of BHT was observed in those compounds derived from the degradation of amino acids (Figure 3A). The catabolism of amino acids, val, leu, ile, phe, etc., generates branched aldehydes, alcohols and acids that are important contributors to the aroma of sausages [14].

The differences in the rate of release were determined using the initial slope as reported previously. The initial slopes of the compounds derived from amino acid catabolism and generated in the dry fermented sausage under the different experimental conditions are shown in Table 3. Only a few of them were affected by the two factors studied. Phenylethyl alcohol showed a reduction in the rate of release with the addition of saliva and water. Moreover, BHT addition produced a significant reduction in the rate of release of 2-methyl-butanal and benzaldehyde.

The esters compounds derived from the Staphylococci esterase activity detected in sausages are responsible for fruity notes [18]. The rate of release of the ester compounds was significantly affected by the addition of BHT except for 2 and 3-methyl-butanoate and ethyl octanoate (Table 3, Figure 3D). The addition of BHT produced a reduction of the release of ester compounds (Table 3). In this case, only ethyl hexanoate showed a lower release rate in the presence of water than in sausage and with saliva.

The carbohydrate fermentation process originates an important abundance of volatile compounds [18]. The main compound produced in highest abundance was acetic acid

(Table 3). Both factors, antioxidant and experimental conditions, affected the release of volatile compounds coming from carbohydrate fermentation process (Figure 3B). The BHT addition produced a significant decrease in the release of the three compounds, acetic acid, acetone and 2-butanone. However, only 2-butanone showed a lower rate of release when water and saliva were added to the sausage (Table 3).

In addition, the staphylococci are also responsible for the lipid β -oxidation producing important aroma notes [18]. Several of these compounds were released from the sausage (Figure 3C and Table 3). The addition of BHT produced a significant reduction of the release of 2,3-pentanedione and 2-heptanone however, 2-pentanol showed a higher release in the presence of BHT. In addition, the presence of water and saliva also reduced the rate of release of 2,3-pentanedione and 2-nonanone.

In summary, most of the compounds derived from the bacterial metabolism, 2-butanone, 2,3-pentanedione, 2-nonanone and phenylethyl alcohol, showed a lower rate of release when water and saliva were added except for ethyl hexanoate. Several authors have studied the effect of saliva composition and volume on the release of volatile compounds. van Ruth and Roozen [7] indicated that the increase in saliva volume produced a decrease of the release of aroma compounds in rehydrated French beans. In addition, van Ruth et al. [4] reported that saliva composition affected air/liquid partition coefficients of aroma compounds in water and oil model systems, producing a salting out effect for hydrophilic compounds and binding of hydrophobic compounds by the proteins present in the saliva.

In order to have an idea of the hydrophobicity of the compounds, the Log Kow of each compound is shown in tables 2 and 3. This parameter is the partition coefficient in octanol/water of each volatile compound. We did not find a relation between release rate and hydrophobicity value because the compounds that showed a higher release in

the presence of water and saliva, pentanal, hexanal and octanal, showed intermediate Log Kow values. On the other hand, the compounds that showed a decrease in release with the presence of water and saliva had high and low hydrophobicity values such as 1-octanol and 2,3-pentanedione with Log Kow values of 2.81 and -0.85, respectively.

Actually, only one work has studied the release of aroma compounds from a meat product, cooked sausage [13]. This study determined the effect of fat content on flavour release through headspace and nospace analyses and it showed similar results for both techniques. They showed that there was not an effect of fat on temporal release of volatile compounds in cooked sausages. However, the study was done adding the volatile compounds and not studying their own generation through the cooking process. As fat is responsible for the generation of lipid oxidation products through the processing or cooking process, these results are not showing the real perception that a human subject perceived when eating a sausage with a low fat content, because not all the volatile compounds from lipid oxidation would have been formed in the same quantity as supposed in this study.

Conclusions

In summary, the addition of BHT produced a significant reduction of the release of most of the volatile compounds due to a sample oxidation during the analysis. The addition of water and saliva to the sausages produced different effects on compounds derived from the auto-lipid oxidation process, a higher release of pentanal, hexanal and octanal was observed while compounds such as pentane, 1-octanol, pentanoic acid, and propanal showed a lower rate of release. In addition, water and saliva produced a lower rate of release of phenylethyl alcohol, 2-butanone, 2,3-pentanedione and 2-nonanone, derived from bacterial metabolism. The rate of release of the compounds from dry

fermented sausages was not related with the compound hydrophobicity value. Therefore, further studies are necessary to elucidate the interaction of flavor compounds with the meat matrix to determine the partitioning of the compounds and their effect on aroma perception.

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Figure 1. Chromatogram of the aroma compounds from dry fermented sausage after 3 h of extraction at 30°C.

Figure 3. Release of total volatile compounds from dry fermented sausages derived from the bacterial metabolism process in the different experimental conditions: sausage (●), sausage with water (▼) and sausage with saliva (■). The open symbols represent the same conditions with the addition of BHT. Data is represented as the mean and its standard error. Volatile compounds derived from a) amino acid catabolism, b) carbohydrate fermentation, c) lipid β -oxidation and d) staphylococci esterase activity.

Table 1. Volatile compounds extracted from the headspace of dry fermented sausages.

Compounds	KI ^a	Compounds	KI
Lipid Auto-oxidation		Bacterial metabolism	
Pentane	500	<i>Staphylococci Esterase Activity</i>	
Propanal	523	Ethyl Acetate	641
Butanal	620	Ethyl 2-methyl-butanoate	876
Pentanal	737	Ethyl 3-methyl-butanoate	880
Octane	800	Ethyl hexanoate	1028
Propanoic acid	797	Ethyl octanoate	1225
1-pentanol	823	<i>Amino Acid Catabolism</i>	
Hexanal	840	3-methyl-butanal	690
Nonane	900	2-methyl-butanal	699
2-hexenal (Z)-	902	3-methyl-1-butanol	790
1-hexanol	921	Benzaldehyde	1021
Heptanal	942	Phenol	1104
Pentanoic acid	983	Phenylacetaldehyde	1110
Decane	1000	Phenylethyl Alcohol	1197
2-heptenal, (Z)-	1011	<i>Lipid β-oxidation</i>	
Octanal	1044	2-pentanone	730
Hexanoic acid	1070	2,3-pentanedione	740
2,4-heptadienal (Z,Z)	1077	2-pentanol	751
Undecane	1100	2-heptanone	931
2-octenal, (Z)-	1116	1-octen-3-ol	1028
1-octanol	1122	2-nonanone	1143
Nonanal	1153	<i>Carbohydrate Fermentation</i>	
Dodecane	1200	Acetone	526
2-nonenal (Z)-	1222	2-butanone	643
Octanoic Acid	1256	Acetic acid	720

^a KI: Kovacs index calculated for DB-624 capillary column (J&W Scientific: 60 m, 0.32 mm id., 1.8 μ m film thickness) installed on a gas chromatograph equipped with a FID detector.

Table 2. Slopes of the aroma compounds (derived from the lipid oxidation process) generated in dry fermented sausages in the presence of water, saliva and antioxidant.

Compound	Log Kow ^a	Sausage		Sausage with water		Sausage with saliva		P _{Exp} ^c	P _{BHT}	P _{ExB}
		- BHT ^b	+ BHT	- BHT	+ BHT	- BHT	+ BHT			
Pentane	2.80	195.3a ⁴	41.3a	13.1b	32.4b	23.6b	19.9b	*	ns	ns
Octane	4.27	1.6	0.6	2.6	1.0	1.7	1.7	ns	ns	ns
Nonane	4.76	15.1	21.4	7.8	38.7	20.6	22.6	ns	ns	ns
Decane	5.25	2.0	3.1	0.0	5.6	6.7	6.9	ns	ns	ns
Undecane	5.74	7.0	2.4	6.9	0.0	8.4	0.0	ns	*	ns
Dodecane	6.23	0.0	2.9	0.0	1.3	0.0	0.0	ns	ns	ns
1-pentanol	1.33	35.9	0.0	12.9	0.0	16.7	0.0	ns	***	ns
1-hexanol	1.82	20.3	0.0	0.0	23.3	0.0	0.0	ns	ns	*
1-octanol	2.81	9.9a	10.6a	0.9b	6.8b	5.2b	5.0b	**	ns	ns
Propanoic acid	0.58	13.2	3.4	17.8	1.7	13.1	3.4	ns	**	ns
Pentanoic acid	1.56	9.1a	0.0a	4.9b	0.0b	5.6b	0.0b	***	***	***
Hexanoic acid	2.05	46.9a	17.9a	47.4b	40.8b	45.3a	17.8a	*	***	*
Octanoic acid	3.03	44.7	32.2	48.9	34.6	40.6	30.4	ns	*	ns
Propanal	0.33	129.9a	0.0a	54.4b	8.6b	43.7b	3.7b	*	***	**
Butanal	0.82	8.9	0.0	6.7	0.0	8.8	0.0	ns	***	ns
Pentanal	1.31	43.1b	8.5b	75.8a	24.7a	76.5a	9.8a	***	***	*
Hexanal	1.80	202.8b	78.7b	503.1a	70.8a	418.9a	122.0a	**	***	**
Heptanal	2.29	24.2	8.1	30.3	9.2	38.8	11.3	ns	**	ns
Octanal	2.78	32.3b	6.1b	53.4a	10.2a	65.0a	20.6a	**	***	ns
Nonanal	3.27	85.4b	32.1b	97.8b	31.3b	133.6a	55.7a	**	***	ns
2-hexenal (Z)-	1.58	12.2	0.0	21.6	0.0	19.7	0.0	ns	***	ns
2-heptenal (Z)-	2.07	123.4	13.1	122.9	29.1	123.4	9.1	ns	***	ns
2-octenal (Z)-	2.57	138.1	20.4	154.5	27.2	127.3	19.1	ns	***	ns
2-nonenal (Z)-	3.06	61.3	5.6	78.8	6.4	55.9	6.1	ns	***	ns
2,4-heptadienal (Z,Z)-	1.86	22.2	0.0	23.9	3.2	19.2	0.0	ns	***	ns

Different letters in the same row indicates significant differences at p<0.05 among experimental conditions.

^aLog Kow: Log of Octano/water partition coefficient. ^bWithout the addition of butylated hydroxytoluene (- BHT) or with addition (+ BHT).

^c P_{exp}: Probability value of the experimental conditions (sausage alone or with water or saliva), P_{BHT}: Probability value of BHT addition, P_{ExB}: P value of the interaction. P value: <0.05 (*), <0.01 (**), <0.001 (***), ns: no significant.

Table 3. Slopes of the aroma compounds derived from bacterial metabolism and generated in dry fermented sausages in the presence of water, saliva and antioxidant.

and aromatic.

Compound	Log Kow ^a	Sausage		Sausage with water		Sausage with saliva		P _{Exp} ^c	P _{BHT}	P _{ExB}
		- BHT ^b	+ BHT	- BHT	+ BHT	- BHT	+ BHT			
<i>Compounds derived from amino acid catabolism</i>										
3-methyl-butanal	1.23	6.5	0.0	0.0	0.0	2.1	4.2	ns	ns	ns
2-methyl-butanal	1.23	10.5	0.0	7.9	0.0	7.7	0.0	ns	***	ns
3-methyl-1-butanol	1.26	7.5	4.7	1.8	5.8	3.1	8.8	ns	ns	ns
Benzaldehyde	1.71	102.3	18.2	75.4	33.7	99.9	23.7	ns	***	ns
Phenol	1.51	15.8	12.3	13.8	13.4	14.6	11.2	ns	ns	ns
Phenylacetaldehyde	1.54	27.9	23.9	25.1	20.9	13.9	17.5	ns	ns	ns
Phenylethylalcohol	1.57	14.2a	9.2a	0.0b	2.5b	5.6b	0.0b	***	ns	*
<i>Compounds derived from esterase activity</i>										
Ethyl acetate	0.86	21.1	0.0	1.9	3.6	6.8	5.3	ns	*	*
Ethyl 2-methyl butanoate	2.26	20.6	18.2	25.4	37.4	68.3	11.5	ns	ns	**
Ethyl 3-methyl butanoate	2.26	11.8	1.7	6.1	7.9	3.7	6.4	ns	ns	ns
Ethyl hexanoate	2.83	35.8a	7.5a	7.9b	0.0b	35.1a	0.0a	*	***	ns
Ethyl octanoate	3.81	4.0	3.7	3.4	2.9	2.9	2.6	ns	ns	ns
<i>Compounds derived from carbohydrate fermentation</i>										
Acetic acid	0.09	1051.4	212.9	452.2	332.7	1172.2	148.3	ns	**	ns
Acetone	-0.24	35.7	0.0	15.2	0.0	20.6	1.2	ns	***	ns
2-butanone	0.26	15.1a	0.0a	0.0b	0.0b	4.7b	0.0b	*	**	*
<i>Compounds derived from lipid β-oxidation</i>										
2-pentanone	0.75	2.6	0.0	7.6	0.0	4.0	0.0	ns	ns	ns
2,3-pentanedione	-0.85	22.7a	0.0a	7.1b	0.0b	4.3b	0.0b	**	***	**
2-pentanol	1.26	0.0	31.2	0.0	23.6	0.0	40.8	ns	***	ns
2-heptanone	1.73	4.6	0.0	3.2	2.7	4.7	0.0	ns	**	ns
1-Octen-3-ol	2.60	26.2	25.1	19.9	11.24	22.9	14.9	ns	ns	ns
2-nonanone	2.71	18.8a	22.21a	5.8b	10.2b	5.9b	7.8b	**	ns	ns

Different letters in the same row indicates significant differences at $p < 0.05$ among experimental conditions.

^aLog K_{ow}: Log of Octano/water partition coefficient. ^bWithout the addition of butylated hydroxytoluene (- BHT) or with addition (+ BHT).

^cP_{exp}: Probability value of the experimental conditions (sausage alone or with water or saliva), P_{BHT}: Probability value of BHT addition, P_{ExB}: P value of the interaction. P value: <0.05 (*), <0.01 (**), <0.001 (***), ns: no significant.