NON-VOLATILE TASTE COMPOUNDS OF DIFFERENTLY PROCESSED DUCK

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Keywords: duck, processing, free amino acid, peptides, nucleotides

Introduction

Flavour is a very important component of the eating quality of meat and much research has been aimed at determining those factors during the production and processing of meat which influence flavour quality (Mottram, 1998), among which was the study of the non-volatile substances that may stimulate the taste buds-taste compounds.

Cooked duck products are popular food in China and other parts of world. However, to our knowledge, no study on taste regarding duck meat products has so far been reported. This research focuses on the taste compounds of three processed ducks including Nanjing water-boiled salted duck (NJWSD), roasted duck (ROD) and water-boiled duck (WBD). Our work sought to determine the quantities of the majority of the taste compounds, *i.e.* free amino acid, peptides and nucleotides in processed duck, and to study the effects of different processes on the taste compounds in duck to provide a theory bases for the quality improvement of duck meat products.

Materials and Methods

Eighteen lean-type Cherry Valley ducks were taken on the day after slaughter, each of which was about 1.5kg. Six ducks were processed to NJWSD by dry curing, brining, roasting and boiling. Each duck was dry-cured using 100g stir-fried salt with *Illicium verum* Hook. f. for 2h. As for brining, the brine contained not only excessive salt, but also some spices components such as *Allium fistulosum* L. etc. The brining process was 4 h. Roasting process was 1 h at 90°C. A low boiling temperature from 85°C to 90°C was used for the tender taste, and the boiling time was 40 minutes. The WBD was processed by boiling at 100°C for 40 min (Six ducks). Another six ducks were roasted at 180°C for 40 min, then were roasted at 240°C for 10 min.

Free amino acids (FAAs) were analyzed with an 835-50 amino acid auto-analyser (Hitachi co., Japan). Peptides were analysed following the procedure described by Martín *et al.* (1998). Nucleotides were analysed following the procedure described by Flores *et al.* (1999).

Results and Discussion

Free amino acids. Total contents of FAAs varied and ranged from 504.67 to 722.78 mg 100 g^{-1} dry matter (DM) (Figure 1). NJWSD contained the highest amount of total FAAs whereas the others contained a lower amount. As for most of FAAs, no difference were found between NJWSD and ROD, which were higher than that in WBD. Glu, Ala and Thr were found to be the three major FAAs, which were generally up to 44 mg 100g-1 of DM, which was consistent with the report in Iberian ham and Parma ham (Martín *et al.*, 2001). While Cys, Phe and His were the lowest, usually less than 19 $100g^{-1}$ of dry matter (DM). Compared the threshold values and taste sensory characteristics, umami amino acids Asp and Glu with the sweety amino acid Ala could contribute to the sensory taste of processed duck. As for the contents of the above three amino acids, these were higher in NJWSD and ROD than in water-boiled salted duck. Furthermore, the Asp content in NJWSD was higher than that in ROD.

Peptides. A total of 14 peptide peaks corresponding to peptides were detected using reverse-phase HPLC (Figure 2). The method used to analyse the peptides of the perchloric acid soluble fractions did not allow the determination of their amino acid composition (Martín *et al.*, 2001). The results of small peptides were similar to that of free amino acids. No differences were found in most small peptides between NJWSD and ROD, whereas significant differences were observed between ROD and WBD. The small peptides 4, 10, 11, and the total small peptides were found in the ROD in the largest levels, which indicated more proteolytic breakdown took place leading to the formation of peptides in duck meat. The importance of peptides to the sensory perception of food has been recognised for some time. It has been demonstrated that peptides contribute to the improvement in flavour of meats during refrigerated storage (Nishimura *et al.*, 1988). The generation of peptides as they contribute to the specific flavour of duck product should be further investigated.

Nucleotides. Flavour 5'-nucleotides contents were significantly different among differently processed duck, and in the order: ROD> NJWSD> WBD. The contents of flavour nucleotides in ROD and NJWSD were as high as that in some mushrooms such as king oyster mushrooms, shiitake, era mushrooms and black poplar mushrooms (Yang *et al.*, 2001), whereas flavour nucleotides decrease to undetectable levels during the long time curing process in sausages and in Parma hams (Mateo *et al.*, 1996). As we know, among the ATP derivatives, IMP is predominant in meat extract 24h after slaughter. This compound is gradually transformed into inosine and hypoxanthine in the meat flesh. As for our study, the duration of the full process was less than one day and the concentrations of flavour nucleotides especially for 5'-IMP found in NJWSD were highly beyond their umami taste threshold 35ppm. All these facts could imply that nucleotides would be very relevant to the taste of processed duck.

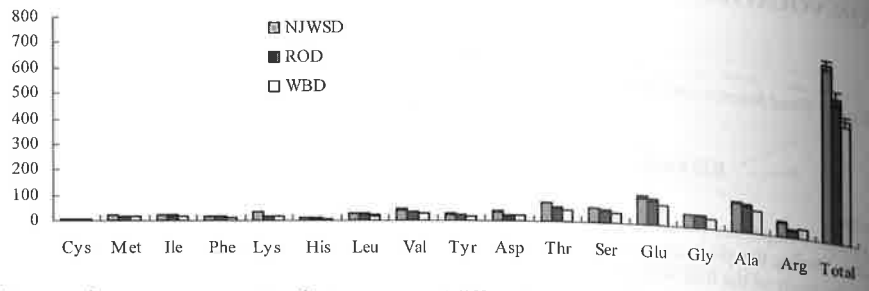

Figure 1: Free amino acids concentrations in breast meat of differently processed duck. Contents of free amino acids were in mg $100g^{-1}$ on the basis of duck meat dry matter and expressed as mean ± standard error (n=6).

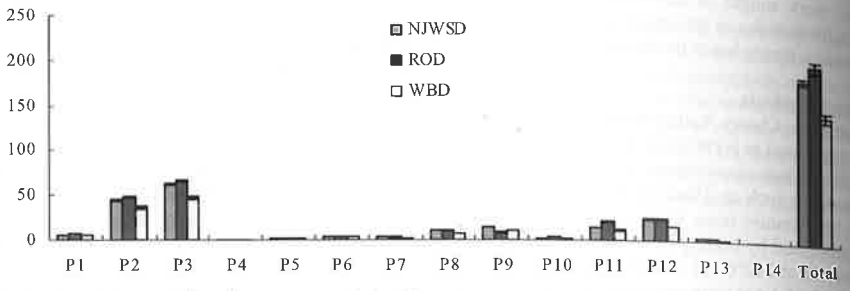

Figure 2: Peptides concentrations in breast meat of different processed duck. Contents of peptides were in the region of $100g^{-1}$ on the basis of dry matter and expressed as mean ± standard error multiplying 10^4 (n=6).

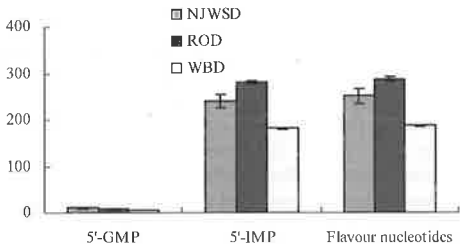

Figure 3: Nucleotide concentrations in breast meat of different processed duck[1] Contents of nucleotide were in mg 100g-1 on the basis of dry matter and expressed as mean ± standard error (n=6). 5'-IMP, 5'-Inosinic acid; 5'-GMP, 5'-Guanosine monophosphate; Flavour nucleotides: 5'-IMP + 5'-GMP.

Conclusions

Traditional NJWSD and ROD contained high levels of taste compounds. The delicate processing of NJWSD and roasting promote the proteolytic breakdown, and the latter retained more flavour nucleotides.

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GENERATION OF MEATY FLAVOURS DURING THE PROCESSING OF DRY FERMENTED SAUSAGES

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Keywords: aroma, curing, dry fermented sausage, meaty flavour

Introduction

Hundreds of flavour compounds have been identified in dry fermented sausages using different techniques (Berdagué *et al.*, 1993; Stahnke, 1994), but many of them do not have an important aromatic impact due to their high detection thresholds. Very few attempts have been made to apply olfactometric techniques to asses the aromatic impact of these volatile compounds (Blank *et al.*, 2001). Of the aromatic compounds which have been identified, esters are often found which provide fruity notes, and aldehydes providing herbal aromas (Stahnke, 1994). There are no compounds identified as meaty or cured flavours. Some authors, such as Wirth (1991), suggest that fermented sausages made with the addition of nitrate, rather than nitrite, have a better taste. In a previous work, Marco *et al.*, (2006) confirmed that the different use of nitrite or nitrate affects the volatile compound profiles of dry fermented sausages.
The aim of this study was to determine the generation of meaty aroma compounds in a fermentative process under the addition of different curing agents.

Materials and Methods

Preparation of dry fermented sausages and sampling. Two different batches containing nitrate (NO_2^-) or nitrite (NO_3^-) were manufactured as described by Marco *et al.*, (2006). Four sausages were collected at days 0, 14, 31, 45 (finished sausage) and 105 (vacuum stored) for the different analyses.
Volatile compounds GC-MS analyses. Volatile compounds were extracted, analyzed and quantified as described by Marco *et al.*, (2004).
Volatile compounds GC-O analyses. Volatile compounds were extracted using solid phase micro-extraction (SPME) using the same procedure cited for GC-MS analyses. The compounds adsorbed by the fibre were desorbed in a gas chromatograph (GC 8000 Top, CE Instruments, Milan, Italy) injection port for 6 min at 240°C in split-less mode, the split valve was opened after 1 min. The compounds were separated using a DB-624 capillary column (J&W Scientific, 60 m, 0.32 mm i.d., film thickness 1.8 µm). Helium was used as carrier gas with a linear velocity of 35.14 cm/s. The capillary column was split (2:1) into deactivated and uncoated capillaries connected with the sniffing port and FID, respectively. Six trained assessors evaluated the odours from the GC-effluent by smelling and recording the odour descriptors. For each assessment, evaluation of the odour took place over two different time intervals (0-35 and 35-70 min) in order to avoid olfactory fatigue for the assessors.

Results and Discussion

Among the 105 volatile compounds identified in the headspace of dry fermented sausages in this work, sixty different aromatic notes were described. Nine of these were described by the assessors as meat related flavours (fig. 1).

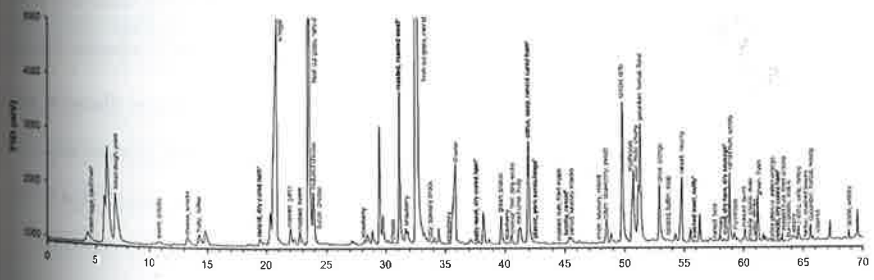

Figure 1: Aromatic regions within the GC-FID chromatogram of dry fermented sausages.

In order of elution, the volatile compounds responsible for these aromas were: 3-methyl-butanal (rancid, dry-cured ham), 1-pentanol (roasted, roasted meat), 2-hexenal (salty meat, dry-cured ham), heptanal (citrus, soap, rancid cured ham), 2-heptanol (plastic, pork scratchings), methional (brothy, rancid), 2,4-heptadienal (cooked meat, nutty), unknown (cured, dry ham, dry sausage), and heptanoic acid (rancid, dry-cured ham). Of these, 2-heptanol, the unknown

compound and heptanoic acid were found only in trace amounts. 1-pentanol, 2-hexenal, heptanal and methional showed an increase during the drying stage but their amounts began to decrease during the vacuum storage. By contrast, 3-methyl-butanal and 2,4-heptadienal increased during storage (Figure 2). Only two compounds, methional and 2-hexanal were detected in significantly higher amounts in the samples with added nitrates, whilst no differences were found in the rest. All the meaty aroma compounds identified are derived from the lipid oxidation process except 3-methyl-butanal which comes from amino acid degradation (Marco *et al.*, 2006).

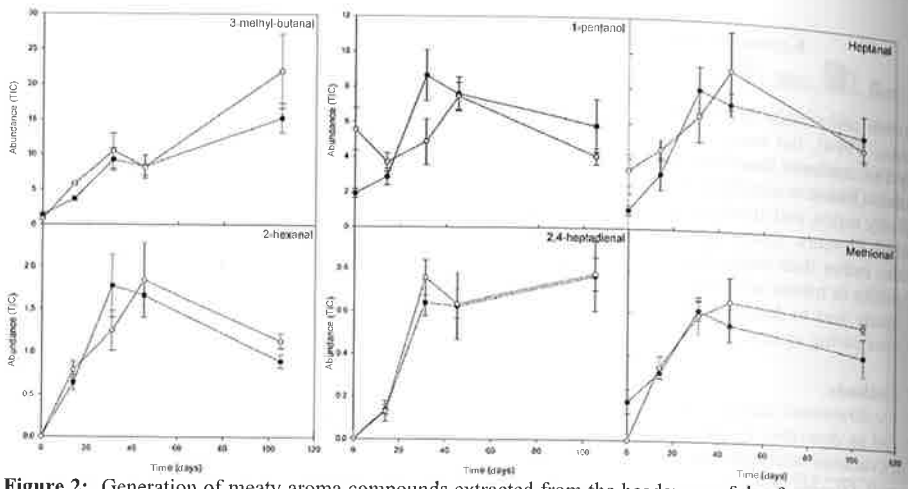

Figure 2: Generation of meaty aroma compounds extracted from the headspace of dry fermented sausages, quantified as $AU \times 10^{-6}$ per g of dry matter. NO_2^- (●) and NO_3^- (○) batches.

Conclusions

Meaty aromas in dry fermented sausages are primarily generated during the drying process. However, during vacuum storage these compounds mainly decrease as they are derived from the lipid oxidation process. It is interesting to note the effect of vacuum storage on the generation of the volatile compounds responsible for the meaty aroma in dry fermented sausages.

Acknowledgements

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FATTY ACIDS AND MINERALS AFFECT THE LIVER-LIKE OFF-FLAVOUR IN COOKED BEEF

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Keywords: beef, flavour, liver-like, fatty acids, minerals

Introduction

Flavour is an important organoleptic trait that consumers use in the determination of acceptability. Meat flavour is a result of reducing sugars and amino acids, differences in fatty acid composition that are responsible for species-specific flavour, off-flavour development due to lipid oxidation, microbial by-products, or other degradative mechanisms (Miller, 2001). Current research in our laboratory has specifically concentrated on the liver-like off-flavour. Miller (2001) indicated that the causes of the livery off-flavour in beef are lipid oxidation, heme iron content and elevated degrees of doneness. James and Calkins (2006) reported that slow cooking (36-40min) and subsequent holding for 1 h of specific muscles from the chuck and round prior to serving reduced off-flavour intensity while Meisinger (2005) found that heme-iron concentration and pH significantly (P=0.0004) accounted for 55% of the variation in the liver-like off-flavour of the *M. rectus femoris* (knuckle center). Although heme-iron content, lipid oxidation, and pH have been implicated as contributing to the liver-like off-flavour, these relationships are weak. Therefore, the objective of this research was to identify factors affecting the liver-like off-flavour in knuckles.

Materials and Methods

Samples were obtained using the screening procedure previously described by Jenschke *et al.*, 2006. Briefly, two trained sensory panelists tasted a 10g piece of the knuckle centre. Knuckles identified as having an off-flavour (n=30) and knuckles not having an off-flavour were vaccum-packaged and shipped to the Loeffel Meat Laboratory at the University of Nebraska. Following a 7d aging period at 1°C, the *M. rectus femoris* was isolated and cut into 2.54cm thick steaks, freezer wrapped and frozen (-16°C) until sensory analysis was conducted. Steaks were cooked to an internal temperature of 70°C on an electric broiler (FSR200, Farberware Inc., Prospect, IL). Internal temperature was monitored with a digital thermometer (Omega Engineering, model 450-ATT, Stamford,CT) with a type T thermocouple (Omega Engineering, Stamford, CT). Once the internal temperature reached 35°C, the steak was turned once until the final temperature was reached. The steak was then cut into 1.27cm x 1.27cm x 2.54cm cubes and served warm to the panelists, approximately 5 minutes post cooking. Panelists for this study were selected and trained according to the guidelines and procedures outlined by Meilgaard *et al.*, (1991). Six samples, identified using three-digit codes, were served on each day. Eight-point descriptive attribute scales (Muscle fibre tenderness: 1=extremely tough, 8=extremely tender; Connective tissue: 1=abundant, 8=none; Juiciness: 1=extremely dry, 8=extremely juicy; Off-flavour intensity: 1=extreme off-flavour, 8=no off-flavour) were used. Off-flavours were rated using a 15-point intensity scale (0=extremely bland; 15=extremely intense). Heme iron was determined using the acidified acetone extraction procedure while pH was determined using a penetrating pH probe. Moisture and ash (expressed as percentages) were quantified using a LECO Thermogravimetric Analyzer-601 while percent fat was determined using an ether extraction method. Minerals were isolated and quantified using an inductively-coupled argon plasma spectrometer. Fatty acids were extracted using a 2:1 chloroform:methanol solution and methylated using boron fluoride-methanol. Data were analysed using the REG procedure of SAS (Version 9.1.3), and the stepwise option was used to determine the final variables to be included in the model while the CORR procedure was used to generate correlation coefficients.

Results and Discussion

Table 1 includes the minerals and fatty acids tested in this study. The final model for predicting liver-like off-flavour is: Liver-like off-flavour rating=-0.21+ 0.0008 (Na) + 0.13 ((20:2 (n-6))- 0.005 (16:1) – 0.002 ((18:1 (n-7)) – 0.033 (20:3) which explained 46% of the variation in the liver-like off-flavour. It should also be noted that non liver-like samples had 3.5 times more vaccenic acid (18:1 n-7) when compared to liver-like samples. Simple correlations from our data indicated that vaccenic (r=-0.32; P=0.02), *cis*-11,14-eicosadienoic (20:2 n-6) (r=0.34; P=0.02) and eicosapentaenoic acid (20:5) (r=0.28; P=0.05) significantly affected the liver-like off-flavour in this study. Camfield *et al.*, (1997) reported simple correlation coefficients of fatty acids and their effect on the livery off-flavour. Vaccenic acid (r= -0.32; P<0.05) and *cis*-11,14-eicosadienoic acid (r=0.38; P<0.05) individually accounted for a significant amount of variation in the livery off-flavour which is in agreement with our data. Yancey (2002) reported in the *M. Gluteus medius* that palmitoleic (16:1), heptadecenoic (17:1), and elaidic (18:1 n-9t) acids were negatively correlated to the livery off-flavour and individually accounted for about 20% of the variation in the livery off-flavour. Although not significant, our results indicate that palmitoleic acid may also play a role in the development of the liver-like off-flavour (r=-0.25;

P=0.08). Meisinger (2005) indicated that heme iron might be a cause of the livery off-flavour in beef, but our d
suggests that neither heme iron nor total iron play a role in the development of the liver-like off-flavour.

Table 1: Minerals and fatty acids quantified.

Fatty Acids			Minerals
14:0	18:1 (n-7)	20:4	Zn
14:1	18:2	20:5	Fe
15:0	18:3	22:5	P
16:0	20:0	22:6	Mn
16:1	20:1	24:0	Mg
17:0	20:2		Ca
18:0	20:2(n-6)		Cu
18:1	20:3		Na

Conclusions

Data from this study indicate individual fatty acids and minerals play a significant role in the development of the li
like off-flavour. Future studies to manipulate the fatty acid and mineral profiles of muscle might prove beneficia
lowering the incidence of the liver-like off-flavour in beef.

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VOLATILE AROMA COMPOUNDS OF COOKED SUCKLING LAMB MEAT

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Keywords: lamb, suckling lamb, volatile, meat aroma

Introduction

In the Mediterranean Europe Area, sheep/dairy farms are frequent and, in addition to milk, meat from suckling lambs aged between 25 and 45 days and with a carcass weight lower than 7 kg is largely produced on these farms (Sañudo *et al.*, 1998). Suckling lamb meat is a product in demand because of its high eating quality, which could be partly due to its mild flavour compared to meat from older animals (Martínez-Cerezo *et al.*, 2005).

Volatile compounds in meat have been widely studied for their effects on meat flavour and their potential as tracers of animal feeding system (Vasta and Priolo, 2006). According to the origin, volatile compounds of cooked meat can be divided into three groups, those coming (directly or formed by animal metabolism) from feed ingested by animals and those formed during heating of meat by means of lipid oxidation and the Maillard reaction (Mottram, 1998).

To our knowledge there are no studies dealing with aroma compounds of meat suckling lamb. These studies could be useful to gain a better understanding of the flavour of this distinctive product and for traceability of the feeding diet of suckling lambs (Prache *et al.*, 2005). Considering these facts, the purpose of the present study was to develop an initial approach to determining the volatile compounds of suckling lamb meat.

Materials and Methods

Ten carcasses of Churra breed suckling lambs were randomly sampled in a local slaughterhouse. All lambs had been reared by ewes' milk exclusively. The right-hand pelvic limb of each carcass was boned, then the meat, thus obtained, was homogenised and a portion of 100 g was taken for volatile extraction. A Likens-Nickerson simultaneous distillation-extraction apparatus was used; diethyl-ether was the extraction solvent and a dispersion of the meat in water at boiling temperature was the source of volatiles. The extraction process lasted 4 hours. Then, ether solution with the extracted volatiles was concentrated by distilling in a Kuderna-Danish concentrator (until 1 ml solution) in a 50 ºC water bath. Separation and identification of volatiles were carried out by GC-MS (Hewlett Packard-6890 Series GC system - Hewlett Packard-5973 Inert MSD Mass Selective Detector) equipped with a HP-5MS column (30 m x 0.25mm x 0.25 µm) and He as carrier gas. Four microlitres of the solution were injected (injector temperature was 230ºC, and split mode 50:1). Initial oven temperature was 50ºC which was increased to 95ºC at a rate of 10 ºC min^{-1} and then to 270ºC at a rate of 10ºC min^{-1}. The MS detector was activated after 6 min of injection. Compounds were identified by comparing the mass spectra with those contained in the Willey 275 database and then comparing their Kovacs' Index with those in the literature, if available. Quantification was carried out by area percentage.

Results and Discussion

A total of 68 volatile compounds were detected in suckling lamb meat using this methodology. The most abundant chemical families were carboxylic acids and esters (16 detected, 35% of total area), and aldehydes (16 detected and 30% of total area) (Table 1). The large majority of compounds were previously observed in cooked meats, and an important part of them came from lipids as was also expected for cooked lamb meat (Mottram, 1998; Elmoore *et al.*, 2000; Vasta and Priolo, 2006). The most abundant compounds were fatty acids (*e.g.* tetradecanoic, hexadecanoic, dodecanoic, or octadecenoic acids), feed-ingested fat-soluble volatiles such as 3,7,11,15-tetramethyl-hexadecene (phytene), or lipid-derived compounds originated by thermal degradation (oxidation products, e.g. hexadecanal, octadecenal, and octadecanal).

By comparing our results with those of other studies dealing with lamb volatiles (Elmoore et al., 2000; Vasta and Priolo, 2006), the present data showed elevated presence of medium and long chain acids and esters, higher relative abundance of phytane, and no o lower levels of low molecular weight compounds (e.g. hexanal, short-chain branched fatty acids, propanol, etc). Extraction methodology could account for the observed differences; the Likens-Nickerson simultaneous distillation-extraction apparatus is effective in collecting meat flavour volatiles of the mid- to high-molecular weight range.

With regard to phytene, it seems to be a grass-derived compound (Elmoore et al., 2004) which will be ingested with the ewes' milk by suckling lambs and then retained in the lambs' fat tissues. Based on this fact, it would be beneficial to study the potential use of this compound, as a plant biomarker, as suggested by Prache *et al.* (2005), for traceability of age at slaughter and type of rearing (ewes' milk vs milk-substitute).

Table 1: Volatile compounds detected in cooked suckling lamb (only the most abundant are shown in the table).

Compound *(number of compounds)*	Relative abundance (area %)[&]	Samples[*]	Method of Identification[#]	Observed KI[#]
Hydrocarbons (3)	15.4			
3,7,11,15-tetramethyl-hexadecene	15.2	10	MS+KI	1846
Aldehydes (16)	30.0			
Nonanal	0.4	10	MS+KI	1104
Tetradecanal	0.4	9	MS+KI	1613
Hexadecanal	22.8	10	MS+KI	1818
Octadecenal	3.8	5	MS+KI	1919
Octadecanal	2.7	6	MS+KI	2022
Ketones (4)	4.5			
2-Tridecanone	0.9	6	MS+KI	1498
2-Pentadecanone	2.1	10	MS+KI	1696
2-Heptadecanone	1.4	10	MS+KI	1902
Alcohols and hydroxyketones (5)	1.2			
1-Hexadecanol	0.7	9	MS+KI	1882
Carboxilic acids and esters (16)	35.2			
Decanoic acid	1.2	10	MS+KI	1372
Dodecanoic acid	4.3	10	MS+KI	1572
Tetradecanoic acid	15.3	10	MS+KI	1764
Hexadecanoato metil éster	1.0	8	MS+KI	1926
Hexadecanoic acid	8.5	10	MS+KI	1963
Methyl-octadecenate	0.6	6	MS	2104
Methy-octadecanoate	0.4	7	MS	2129
Octadecenoic acid	3.1	9	MS+KI	2145
Octadecanoic acid	1.3	10	MS	2163
Furan and furanoids (6)	2.0			
δ-Decalactone	0.8	10	MS+KI	1714
γ-Undecalactone	0.8	9	MS+KI	1932
Sulphur containing (8)	6.7			
A sulphur containing compound	1.0	10	MS	1196
A sulphur containing compound	2.6	10	MS	1687
A sulphur containing compound	1.5	10	MS	1747
A sulphur containing compound	1.4	10	MS	1945
Others and unknown (10)	4.1			
Isobuthyl-phtalate	0.7	9	MS	1875
Dibuthyl-phtalate	0.9	6	MS	1969

[&]: Percentage of the area of the peak with respect to the total sum of areas. [*]: Number of samples in which the compound appeared. [#]: MS, coincidence with the mass spectrum of the library; KI, coincidence with Kovats' Index (KI) obtained in literature.

Conclusion

Volatile compounds of suckling lamb meat have been determined. Among them, phytene could be considered for further studies as a potential tracer of feeding system or age.

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