PHYSICAL CHARACTERISTICS OF *LONGISSIMUS DORSI* MUSCLE IN BOVINES FROM DIFFERENT GENETIC TYPES REARED IN SICILY (ITALY)

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Background

The marketing of meat in industrialised countries is conditioned more and more by the demand of quality on the part of the consumer, today, who are careful about a series of problems which, besides the aspects of the intrinsic surety of the food, finish up by involving all a togetherness of other aspects of the productive system. In the specific case of meat, it is known that the organoleptic qualities, i.e. smell, taste, colour, juiciness, texture and tenderness represent the principal factors able to condition drastically the choices of the consumers at the moment of purchase (Maltin *et al*., 2003; Sgoifo Rossi *et al*., 1999) therefore, the physical characteristics of the meat has a role of primary importance regarding the qualification of the product (Destefanis, 1988). The physical characteristics of the meat are influenced by different factors such as: age, sex, race, system of breeding, methodologies of transport, slaughtering and ripeness (Villaroel *et al.*,2002). In the light of these observations and given the importance and the vastness of the subject, the Agriculture and Forest Regional Assessorship of the Sicilian Region, with the project: Quality and traceability of the Sicilian beef meat, co-ordinated and carried out by the Consorzio di Ricerca Filiera Carni (CoRFilCarni), has in progress the realisation of a detailed map of the quality of the meat produced in Sicily, so as to individuate the eventual critical points and therefore to set up the adequate strategies of intervention.

Objectives

The specific objective of this part of research is to study the physical characteristics of the beef meat produced in Sicily, derived from different genetic types kept in ordinary breeding conditions.

Materials and methods

The research was carried out on 200 male yearlings, weaned in a natural way, belonging to the following genetic types : 20 Belgian Blu (BBL) x half-bred (MTT); 26 Charolaise (CHL) x half-bred (MTT); 45 Limousine (LMS) x half-bred (MTT); 29 half-bred (MTT); 20 Charolaise (CHL); 20 Limousine (LMS); 20 Charolaise (CHL) x Belgian Blu (BBL); 20 Limousine (LMS) x Belgian Blu (BBL).

The animals, up to age of 8±1 months were kept in extensive conditions with their mothers and they utilised the available pasture for feeding. Only 6±1 months before slaughter, at a body weight of 300±20 kg, they were bred in intensive conditions, in boxes provided with external paddocks, and fed with 1.3 kg/100 kg of body weight and with wheat straw *ad libitum*. The chemical composition of the feeding (table 1) was determined according to the A.O.A.C. (2000) official methods.

All the subjects at the age of 14-16 months, at a homogeneous fattening condition, were slaughtered after fasting for 12 hours, but not from water. On each half carcass, 45' (pH_1) and 24h (pH_u) after slaughter pH value of the *Longissimus dorsi* muscle was measured with pH meter (WTW).

A sample cut of meat carrying out of two perpendicular sections at the vertebral column in correspondence with the cranial margin of the X (T10) and the XI (T11) rib (Hankins & Howe, 1946) was taken from the right half carcass of each subject, after 48 hours of refrigeration at a temperature of 4°C and relative humidity of 80%.

After the dissection of the sample cut, a slice 2,5 cm thick of the *Longissimus thoracis* muscle was prepared for the determination of colorimetric parameters (CIE L*: Lightness; a*: redness index; b*: yellowness index) using a spectrometer of imagine Spectral Scanner (DV s.r.l. Tecnologie d'avanguardia-Italia) and successively for the measurement of the Water losses and of the tenderness (Warner Bratzler Shear Force-WBS) using the INSTRON 5542.

Data obtained were subjected to the analysis of variance using the GLM procedure of the SAS (Version 8.1, 2001).

Results and discussion

The results obtained in table 2, pointed out the uniformity of the physical characteristics of the meats of different genetic types; in particular, no statistically significant differences were observed among the parameters investigated.

The values of pH_u observed (Tab. 2) indicate a good progress of the process of acidification (Hoffmann 1994) even for the BBL x MTT, CHL x BBL, LMS x BBL genetic types that are characterised by a greater muscular hypertrophy and therefore more sensible to stress (Schakelford *et al.,* 1994; Destefanis *et al*., 1993).

The L* and a* parameters show a good lightness and red index (Lizaso *et al*. 1996). This could be due to a greater concentration of myoglobin at a muscular level for the breeding system which determines a greater physical activity of the animals.

The Water losses (Tab. 2) show normal values according to Bultot *et al*. (2002) and Offer and Knight, (1988).

The values of WBS (Tab. 2) permit us to classify the meat of these genetic types as tender showing values less than 4.54 kgf/cm2 (Shackelford *et al*., 1991).

Table 1. Chemical composition of feeding

	Concentrate	*Wheat straw*
Dry matter (%)	88.84	91.01
In DM (%)		
Crude Protein	17.97	2.81
Ether Extract	3.10	1.58
Non Structural Carbohydrates	53.43	10.40
Ash	5.29	7.19
Neutral Detergent Fibre	22.21	78.02
Acid Detergent Fibre	7.04	48.71
Acid Detergent Lignin	0.84	4.74

Table 2. Physical characteristics of *Longissimus dorsi* muscle (mean ± SE)

Genetic type	pH_1	pH_u	*L**	*a**	*b**	*Water losses (%)*	*WBS (kgf/cm^2)*
BBL x MTT	6.65±0.08	5.86±0.10	42.0±0.8	25.8±0.8	8.8±0.7	27.1±0.8	3.9±0.4
CHL x MTT	6.56±0.10	5.62±0.09	42.9±0.6	25.7±0.6	8.3±0.5	26.5±0.6	4.3±0.3
LMS x MTT	6.50±0.09	5.60±0.11	42.4±0.4	24.3±0.4	8.4±0.4	26.8±0.4	4.1±0.2
MTT	6.62±0.11	5.61±0.07	42.6±0.5	24.2±0.5	7.8±0.5	26.4±0.5	3.8±0.2
CHL	6.48±0.06	5.54±0.06	44.0±0.8	23.4±0.8	8.3±0.7	25.7±0.8	3.6±0.4
LMS	6.61±0.09	5.59±0.08	42.9±1.1	22.7±1.1	7.6±0.9	26.4±1.0	3.9±0.5
CHL x BBL	6.62±0.11	5.74±0.10	42.0±0.8	23.6±0.9	7.3±0.7	27.7±0.8	3.9±0.4
LMS x BBL	6.51±0.09	5.77±0.09	42.0±0.9	24.9±0.9	8.3±0.8	26.1±0.9	3.8±0.4
P	*0.58*	*0.46*	*0.39*	*0.08*	*0.06*	*0.42*	*0.82*

Conclusions

Following the guidelines of a system for the qualifications of the zootechnical productions (CoRFilCarni), this preliminary study has pointed out that, the employment of bulls for meat (BBL, CHL, LMS) in the cross-breeding with Sicilian half-bred (MTT) has produced meat characterised by good physical characteristics, comparable to those of the best races specialised for meat.

Acknowledgements

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SENSORY EVALUATION OF BEEF LOIN STEAKS STORED IN DIFFERENT ATMOSPHERES

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Background

Case-ready fresh meat packaging is a fast growing segment (Zilbermann, 2003), and it is therefore important to optimise the packaging method to ensure a good eating quality including a long shelf life. In Denmark, most centrally wrapped consumer unit packages of fresh beef are Modified Atmosphere Packed (MAP; usually in 70-80% O_2 and 20-30% CO_2) or vacuum-skin packed (VSP). Although oxygen maintains the desirable red colour of the fresh meat it also promotes oxidation of lipids and may therefore be detrimental for the taste. A few studies have demonstrated that sensory properties decrease during MAP storage (Jayasingh, 2002; Toerngren, 2003). Furthermore, a few studies have demonstrated that beef stored in high oxygen atmosphere develops a well-done appearance at temperature much below than expected (Hunt et al., 1999; Toerngren, 2003).

Objectives

The purpose of the present study was to examine sensory quality of beef loin steaks packed with 6 different packing systems.

Whole cuts (longissimus dorsi) were 1) aged in vacuum, sliced to steaks and re-packed to 3 different atmospheres with different oxygen content, and 2) beef loin steaks were aged in 3 different atmospheres - O_2/CO_2, N_2 and under vacuum.

Materials and Methods

Source of meat: Six animals (cows and heifers) of Danish Friesian, Red Danish and Crossbreds, approx. 2-4½ years old, carcass weight (263-304 kg), were slaughtered at a Danish slaughterhouse, low voltage electrically stimulated and chilled so that no part of the carcass reached <10°C in the course of 12 hours after stunning. The carcasses were selected according to pH (5.5-5.6) and stored at 2°C for 3 days before boning. *Longissimus dorsi* (LD) was then excised from each carcass half and separated for different packaging systems, Table 1.

Table 1. *Packing systems and cut used during ageing and display*

Ageing conditions (2°C)			Display conditions, steaks (2°C)			Abbreviation
Cut	*Atmosphere*	*Days*	*Repacked*	*Atmosphere*	*Days*	
loin	Vacuum	19*	Yes	Air	2	Vac + Air
loin	Vacuum	14*	Yes	50% O_2/ 50% CO_2	6	Vac + 50%O_2
loin	Vacuum	14*	Yes	80% O_2/ 20% CO_2	6	Vac + 80%O_2
steaks	100% N_2	19*	Only top film	Air	2	N_2 + Air
steaks	50% O_2/ 50% CO_2		No		21*	50%O_2
steaks	Vacuum-skin pack		No		20*	VSP

* From packaging. Meat was packed 3 days after slaughter
Air capacity: approx. 79% N_2, approx. 21% O_2

Packaging and storage conditions: LD muscles (left and right side) were cut into 3 parts and randomised with respect to packing systems. LD was cut into steaks (2 cm thick) after boning or after aging. Storage temperature was 2 °C from boning to analysis. All steaks were moved to light surroundings (1,110-1,249 lux) for 2 days prior to the analysis (22-24 days after slaughter).

Vacuum bags for loins were made of transparent plastic with max. O_2 permeability: 4 cm^3/m^2/d, bar, (Bemis, Packagervej, Denmark APS). Vacuum: 5-10 mbar vacuum.

The *vacuum-skin packing (VSP)* consists of an upper co-extruded film with barrier properties and a bottom semi-rigid film usually in the form of a tray that maintains the original form of the product: Max. O_2 permeability (upper film and bottom): 2 $cm^3/m^2/$ x d x bar (Cryovac, Sealed Air Corporation). Vacuum: 5-10 mbar (Multicvac packing machine).

MAP (O_2): Tray (13x18x4 cm) covered with transparent film, O_2 permeability: 10 $cm^3/m^2/d$, bar (Cryovac. Sealed Air Corporation). Flowpack, BDF, Fuji.

MAP (N_2): Tray (12x16x3,5) in transparent bags (23x30 cm, NEN 40 HOB/LLDPE 75, AMCOR, oxygen permeability: 0,45 $cm^3/m^2/$ d, bar). One O_2 scavenger was placed in each pack (AGELESS, Mitsubishi Gas Chemical Company, INC). Multivac A300/16 packing machine (5 mbar vacuum, 750 mbar filling). Two days before the analysis, the bags were removed and the steaks exposed to air through O_2 permeable film.

Traditionally wrapped (Air): Tray (12x16x3.5) and transparent high O_2 permeable film (PE).

Atmosphere content was measured at time of packing and before analysis for MAP packed steaks (Check Mate 9900, BPI Dansensor)

Vacuum packed loin

MAP steak

VSP steak

*Cooking and sensory evaluation***:** Steaks were equilibrated after storage at room temperature (approx. 20°C) to an internal temperature of max. 15°C prior to cooking on a preheated frying pan (155°C), turned every 2 minutes until an internal temperature of 62±1°C had been reached. Steaks were cut and served in pieces of 2½ x 3 cm. Samples were evaluated by 8 trained assessors using a 15-point non-structured line (0=slight and 15= intense). The attributes were tenderness, juiciness, Warmed Over Flavour (WOF), meat-flavour and doneness (internal colour).

Statistic: Data were analysed in an analysis of variance model (mixed procedure, SAS version 8.2). Fixed effect in the model were main effects.
Sensory data: $Y_{ijk} = \mu$ + packing systems $_i$ (fixed) + animal $_j$ (random) + assessors $_k$ (random) + e $_{ijk}$

Results and discussion

Results of the sensory evaluations are shown in table 2.

Tenderness: There were significant differences between packing systems (P<0.0001). Steaks aged and displayed in MAP (50% O_2/50% CO_2) gained the lowest score for tenderness: 6.5 point, which is 3 points lower than the traditionally aged and displayed steaks (vac+air: 9.5 point). Only steaks aged in N_2 (display packed in air) gained the same high levels of tenderness as the traditionally packing system. These results are in agreement with Jayasingh et al. (2002; ground beef) and Toerngren (2003; beef steak) who also found that MA-packing with O_2 and CO_2 decreased tenderness. It is expected that O_2 is responsible for the reduced tenderness in MAP, since Toerngren did not find that ageing in 50% CO_2/50% N_2 decreased tenderness. The explanation for the negative effect of O_2 on tenderness could be protein oxidation. Rowe et al. 2004 found that increased oxidation of muscle proteins early postmortem could have negative effects on meat tenderness.

Beef steaks aged in vacuum-skin pack (VSP) were less tender than beef steaks aged in N_2. In an earlier study (Clausen et al. 2003) we also found that VSP steaks were less tender than the corresponding meat vacuum aged as a whole cut (app. 2 kg). The difference was significant at 4 and 11 days after packaging (meat was packed 3 days after slaughter). Vázquez et al. (2004) also found that the meat tenderisation process was slowed down in VSP beef steaks compared to traditional vacuum packed beef steaks.

Juiciness: There were significant differences between packing systems ($P<0.0001$). Beef steaks exposed to O_2 in higher concentration than normal air were less juicy. The reduced juiciness is probably caused by O_2 since Toerngren (2003) found that ageing in 50% CO_2/50% N_2 did not reduce juiciness compared to traditional packaging (vacuum aged and packed in air for two days). Jayasingh (2002) also found ground meat packed in 80% O_2/20% CO_2 tasting less juicy than the control.

Warmed Over Flavour (WOF): WOF varied between packing systems ($P<0.0001$). The highest degree of WOF was found in steaks aged and display packed in 50% O_2 for 20 days (8.4 point). Also steaks display packed in O_2 for 6 days scored high in WOF (50% O_2: 5.9 point 80% O_2: 5.7 point). As seen from table 2, development of WOF varied from 1.9 to 12.3 between animals (50% O_2 for 20 days). WOF is primary known from stored and reheated cooked meat and is caused by oxidation of fatty acid (Konopka and Grosch, 1991). However, in this experiment it appears that the oxidation already occurred in the raw meat stored in MAP with high oxygen content. Jakobsen and Bertelsen (2000) and Jayasingh (2002) also found increased lipid oxidation during storing in O_2 atmosphere. The degree of WOF probably depends of antioxidant content like tocopherol in fresh meat. Consumers sensitive to WOF will probably dislike O_2-MAP meat with high WOF.

Meat flavour: Meat flavour differed between packing systems ($P<0.0001$). Once again, steaks packed in MAP with O_2 deviated from the others and with less meat flavour, too.

Colour: Visual internal colour of the steaks (cooked to 62°C±1°C) varied between packing systems ($P<0.0001$). Steaks stored in MAP with O_2 for 6 or 20 days appeared well done (high score), and the VSP steaks scored the lowest points and had the most reddish-pink color. Hunt et al. (1999) demonstrated that patties containing the myoglobin forms oxymyoglobin and metmyoglobin turned brown at 55°C. These results indicate that oxygen penetrates beef steaks and oxidizes deoxymyoglobin in 6 days. Toerngren (2003) found that loin steaks looked nearly well done after two days' storage in MAP with 80% O_2 and well done after 18 days. MA-packed steaks with 80% O_2 were less brown than beef packed with 50% O_2. The explanation could be that CO_2 helps O_2 to penetrate into the meat as CO_2 is dissolved in meat (Jakobsen & Bertelsen 2002).

Conclusions

Beef steaks packed and stored in modified atmosphere containing O_2 (50 or 80%) for 6 and 20 days at 2°C were less tender and juicy, had less meat flavour and more warmed over flavour than steaks exposed to normal air for two days. Furthermore, steaks exposed to O_2 (50 or 80%) looked well done, even if they were cooked to an internal temperature of only 62°C.

After 20 days' of ageing, vacuum-skin packed beef steaks were less tender than steaks aged in N_2.

Table 2. Mean (incl. min. and max.) sensory score (8 trained assessors using a non-structured line scale, anchored to the extremes; 0= slight, 15=intense) of beef loin steaks stored in 6 different packaging systems (see table 1) (n=6).

	Tenderness	Juiciness	Warmed Over Flavour	Meat - flavour	Internal Colour Doneness
Vac + Air (Traditional)	9.5^{a} 6..8-12..0	10.6^{a} 9.2-11.2	1.4^{c} 0.6-3.3	8.8^{a} 7.4-10.6	7.1^{c} 6.5-7.4
Vac + 50% O_2	7.8^{b} 3..3-10..5	7.9^{c} 6.7-9.4	5.9^{b} 3.1-10.5	6.8^{b} 4.1-8.4	12.3^{a} 11.4-13.0
Vac + 80% O_2	8.4^{b} 4..5-10..4	9.6^{b} 8.1-10.7	5.7^{b} 2.2-10.4	6.8^{b} 4.4-9.2	11.0^{b} 8.3-12.8
N_2 + Air	9.6^{a} 5..2-12..9	10.8^{a} 8.9-11.9	0.7^{c} 0.1-1.4	9.3^{a} 7.9-10.9	5.9^{d} 4.2-7.7
50% O_2	6.5^{c} 3.6-9.7	8.8^{b} 6.9-11.2	8.4^{a} 1.9-12.3	5.3^{c} 3.7-8.4	12.4^{a} 10.7-13.2
VSP	8.5^{b} 5.9-12.1	11.2^{a} 9.0-12.0	0.5^{c} 0.1-1.4	9.0^{a} 7.4-10.1	3.9^{e} 2.7-6.1
Significance	***	***	***	***	***

Different letters in same row are significantly different ($P<0.05$)

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VOLATILE CHARACTERIZATION OF BLOOD SAUSAGE "MORCILLA" DE BURGOS

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Background

"*Morcilla de Burgos*" is a popular cooked blood sausage (black pudding) produced in the region of Burgos, in the north of Spain. It consists of a mixture of chopped onion, rice, animal fat, blood, salt and different spices such as black pepper, paprika and cumin. According to a general scheme, onion and frozen fat are chopped at low temperature; also rice (raw or pre-cooked according to local procedures), salt, spices and blood are added and mixed. Then, the mixture is stuffed in natural casings of around 35-45 mm of diameter, which have been preserved with salt and are rinsed in clean water prior to use. The product is boiled for around 1 h at 94-95 ºC, air cooled to 8-10 ºC and finally store chilled at 4 ºC. This product is commercialised in local markets as a fresh product with a shelf-life of around 8-10 days.
Previous studies have been made about composition, physic-chemical and sensory characterization of this product. Depending on the amount of onion (between 15 and 70%) and the mixture of spices used, it is possible to distinguish between three different types of *morcilla*: type I, around 15% of onion and little spiced; type II elaborated with around 40% of onion and high spiced, and type III with an amount of onion between 45 to 70% and half spiced. These three types of *morcilla* are distributed in different geographic zones of Burgos, type I in the North, type II in the South and type III in the centre (Santos 2001, Santos et al., 2003). The presence of onion could be an important and characteristic feature in the flavour profile of *morcilla de Burgos*, together with the spices mixture that can be the key point to distinguish this type of blood sausage from others made in other places.

Objectives

The purpose of this study was to determinate the volatile profile of the blood sausage *morcilla de Burgos* by Solid Phase Micro Extraction (SPME) and GC-MS and determinate the influence of the percentage of onion in the total volatile profile.

Materials and methods

Sample preparation: Seven blood sausages of different manufacturers, four of them belonging to *morcilla* type III, 2 from the type III, and 1 from the type I were used in this study. All samples were vacuum packaged and were purchased from different local supermarkets. Each analysis was performed twice for every producer and each blood sausage was analysed for duplicate.
After peeling the sausages, they were homogenised in a lab blender, and 2 g of this homogenised were introduced in a headspace vial and heated at 70ºC (optimal consumption temperature) in a water bath for 5 min and allowed to equilibrate for 10 min with a 2 cm x 50/30 µm divinylbenzene/carboxen/polidimethylsiloxane (DVB/Carboxen/PDMS) Stable-Flex SPME fibre (Supelco. Bellefonte, USA). The fiber was conditioned prior to sampling at 270 ºC for 1 h. The SPME fibre was then injected into the GC injection port, and thermally desorbed in the GC injection for five minutes.
GC-MS Conditions: Gas chromatographic analyses were performed with an Agilent Technologist 6890N Series GC System (Agilent Technologist, Palo Alto. CA. USA) coupled to a Waters Autospec mass spectrometer (Waters. Milford, USA). The SPME fiber was injected into the GC injection port, and thermally desorbed at 150ºC. Compounds were separated on 30 m length x 0.25 mm I.D fused silica capillary column coated with 0.25 µm film thickness of silphenylene polysiloxane (Quadrex Corporation. New Haven. USA). The temperature of the column was programmed starting at 30 ºC after injection for 5 min, afterwards temperature was increased at a rate of 3 ºC/min from 30 to 120 ºC and held there for 5 min. Helium gas with a flow of 0.9 L/min was used as the GC carrier gas. During desorption of the SPME fibre the injector split valve was closed. The effluent from the capillary column went directly into the mass spectrometer, operated in the electron impact (EI) mode with an ionisation voltage of 70 eV.
Compounds were identified by comparing their mass spectra with a NIST spectrum library. These compounds were related to the different ingredients used in the elaboration of *morcilla* de Burgos, by

comparing them with previous published spectra obtained from different *Allium cepa* L. varieties, and spices (see references on table 1), and also from samples analysed, in the same conditions mentioned above, and belonging to the same onion variety and the same spices used for the elaboration of the product taken from one of the producers factory (data not shown).

Results and discussion

The results obtained show 60 different volatile compounds found in *morcilla de Burgos*, taking into account all the compounds that appear in all different samples analysed. Forty six of these compounds have been tentatively identified using the NIST library, and they are listed according to their appearance time in Table 1. As it was expected, all seven samples of *morcilla* presented a different volatile profile due to the particular way each producer elaborates their product, although all samples belonging to the same geographical area show more similarities in their profiles than to the others. In table 1 is also shown that *morcilla* type III has the higher number of volatile compounds (33), followed by *morcilla* type II with 25 and finally *morcilla* type I with 22. Only 10 of the compounds found were common to all three types of *morcilla*, four of them have been related to the presence of onion (2-methyl 2-pentenal, dipropyl disulphide, 1-propenyl propyl disulphide and dipropyl trisulphide), 3 could be related with black pepper (β-myrcene, 3Δ carene and δ limonene), 2 with oregano (see table 1) and one has not been associated to any ingredient. Dealing with the number of compounds becoming from onion, it has been shown that their number increase with the percentage of onion in *morcilla* composition. In that sense, eleven compounds were found in *morcilla* type III, which have a percentage of onion between 50 and 70%, 6 of these compounds appear in blood sausages belonging to type II, and finally only 4 of these compounds are recognised in *morcilla* type I, the one with a low percentage of onion in their composition (around 15%). In general, the most abundant compounds are those related with some spices, as black pepper (δ limonene), oregano and so on, and those associated with onion, such as dipropyl disulphide, which is the more abundant in some *morcilla* type III, as it is shown in Figure 1. However, it is remarkable that only few volatile compounds are related to rice and fat, and none have been identified related to cooked-blood. This feature can be due to the high intensity and high number of compounds associated with spices and onion, that can mask other volatiles, as well as the extraction method and column used in the present work, which is very specific to detect sulphured compounds.
Besides these general features, it is possible to see that some specific and characteristic compounds appear in the three different *morcilla* types that seem to agree with the different spices mixture used in their manufacture. In *morcilla* type I apart from some compounds, related to oregano and black pepper, appears the volatile, 1,3,8 p-menthatriene, which is characteristic from parsley (Belitz and Grosch, 1999), this spice is typically used in the north zone of Burgos. Moreover, in this type of *morcilla* appears decanal, 2-propanol 1-butoxi, and hexanal that could become from rice (see table 1), which is more abundant than in blood sausages elaborated in the other geographic zones. In *morcilla* type II it has been identified the compound cuminaldehyde, which is the more abundant substance in the chromatograms and it is related to cumin that it is used in abundance in that southern zone of Burgos. Finally, *morcilla* type III present some compounds such as 2-butenal 2-methyl, 1,3-butanediol or benzene 1,2-dimethyl that several authors had associated to paprika (Mateo et al., 1997; Guadayol et al., 1997). Together with these compounds, the presence of volatile compounds derivate from onion is also characteristic of *morcilla* belonging to this zone, as it has been mentioned above.
All these results agree with those obtained by Santos et al. (2003), where a trained sensory panel characterised *morcilla* type I by the blood flavour, black pepper predominant taste and by the abundance of rice, *morcilla* type II where characterised by the strong spicy taste, mainly by the addition of cumin and other spices, together with a background flavour and taste of onion, and *morcilla* type III by their strong onion flavour, with some burn notes due to paprika.

Conclusions

According to the results obtained in this study, it can be conclude that *morcilla de Burgos* has a volatile profile characterized by the presence of flavour notes becoming from onion, black pepper and oregano, as common feature of all different *morcilla* types of the region, although each producer present a slightly different volatile profile according to the kind of ingredients and percentages of raw material employed. Volatile onion compounds are mainly sulphur derivates, and they are more abundant in *morcilla* type III (11 compounds found), followed by *morcilla* type II (6), and finally by *morcilla* type I (4), in accordance with the percentage of onion used for elaborating the blood sausage in the different zones of production described.

It is also possible distinguish the *morcilla* of each zone by some characteristic spices used. In that sense, *morcilla* type I is not so spicy and only it appears a slightly note of parsley. In *morcilla* II the characteristic spicy among others used to be cumin, and in *morcilla* type III paprika.
More studies should be done to obtain more evidence to this preliminary study and to compare the volatile profile of *morcilla de Burgos* with other blood sausages elaborated in Spain and other countries.

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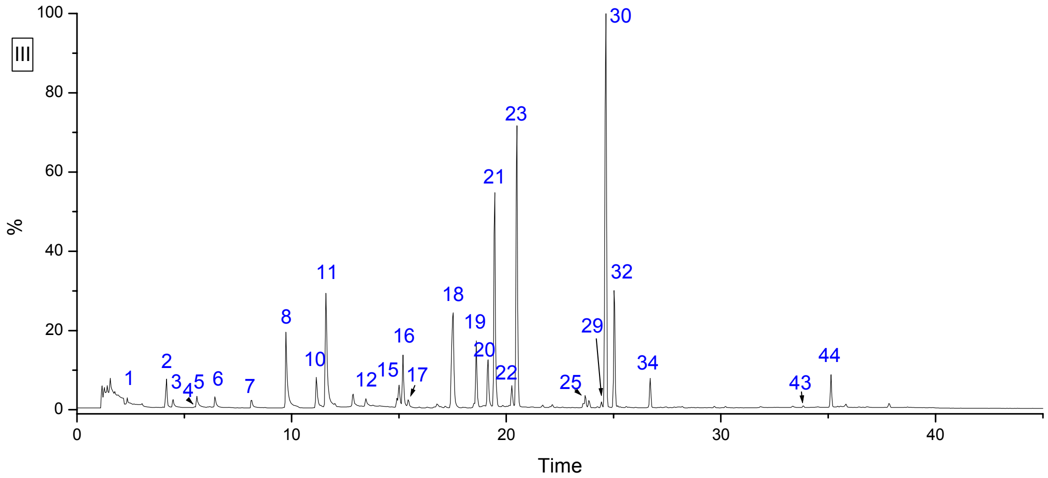

Figure 1. Chromatogram of volatile compounds of one sample of *morcilla de Burgos* type III.

Table 1. Volatile compounds identified in the different types of *morcilla*

Nº	COMPOUND	I	II	III	SOURCE	REFERENCE
1	Propanethiol			X	onion	Järvenpää, 1998
2	Furan 2,4dimethyl			X	onion	*
3	Acetic acid, anhydride with formic acid		X	X	paprika	*
4	Dimethyl disulfide			X	onion	Järvenpää, 1998
5	2 butenal 2 methyl			X	paprika	*
6	methylbenzene			X	rice	Mahatheeranont, 2001
7	hexanal	X		X	paprika/fat/rice	Mahatheeranont, 2001
8	2-methyl-2-pentenal	X	X	X	onion	Järvenpää, 1998
9	1,3 butanediol			X	paprika	Mateo, 1997
10	ethylbenzene			X	rice	Mahatheeranont, 2001
11	Benzene 1,2 dimethyl			X	paprika/rice	Guadayol, 1997
12	3,4 dimethyl thiophene			X	onion	Järvenpää, 1998
13	2 propanol 1 butoxi	X			Rice	Mahatheeranont, 2001
14	bicyclo(3.1.0)hex-2-ene-2-methyl-5(1-methylethyl)	X	X		oregano	*
15	Methyl isopropyl disulphide		X	X	onion	*
16	α pinene	X	X		black pepper	Belitz-Grosch, 1999
17	methyl 1 propenyl disulphide			X	onion	Järvenpää, 1998
18	bicyclo(3,1,1)heptane-6,6dimethyl-2-methylene	X	X	X	oregano	*
19	β myrcene	X	X	X	black pepper	Belitz-Grosch, 1999
20	α phellandrene	X	X	X	spices	*
21	3 Δ carene	X	X	X	black pepper	Belitz-Grosch, 1999
22	benzene 1 methyl 2 (1methylethyl)	X	X	X	oregano	*
23	δ limonene	X	X	X	black pepper	Belitz-Grosch, 1999
24	1,3,6-octatriene 3,7-dimethyl	X			spices	*
25	4-Carene		X		spices	*
26	cyclohexadiene 1 methyl 4(1methylethyl)	X			oregano	*
27	cyclohexene 1 methyl 4(1methylethylidene)	X			oregano	*
28	1-Terpinen-4-ol			X	oregano	Dudai, 2003
29	Linalool	X		X	spices	*
30	Dipropyl disulphide	X	X	X	onion	Järvenpää, 1998
31	1,3,8 p-menthatriene	X			parsley	Belitz-Grosch, 1999
32	1-propenyl propyl disulphide	X	X	X	onion	Järvenpää, 1998
33	cyclohexen-1ol-1-methyl-4(1-methylethyl)			X	oregano	*
34	Methyl propyl disulphide		X	X	onion	*
35	3 cyclohexen-1ol 4-metil-1(1-methylethyl)	X	X		oregano	*
36	cyclopentan-1-al 4-isopropylidene 2-methyl		X		spices	*
37	Decanal	X			rice	Mahatheeranont, 2001
38	Cuminaldehyde		X		cumin	Aldrich, 2000
39	benzene 1-metoxi 4-methyl 2-(1-methylethyl)			X	oregano	*
40	linalyl butyrate			X	oregano	*
41	1,3cyclohexadien 1-carboxaldehide 2,6,6-trimethyl		X		spices	*
42	α Thujenal		X		spices	*
43	Carvacrol			X	oregano	Belitz-Grosch, 1999
44	Dipropyl trisulphide	X	X	X	Onion	Järvenpää, 1998
45	cyclohexen 4-etenyl 4-methyl 3-(1-methyletenyl) 1-(1-methylethyl)		X		spices	*
46	Copaene	X			spices	*

I, II, III: m*orcilla* types; *: our own data;