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Image analysis with the computer vision system and the consumer test in evaluating the appearance of Lucanian dry sausage

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ABSTRACT

The object of the investigation was the Lucanian dry sausage appearance, meant as color and visible fat ratio. The study was carried out on dry sausages produced in 10 different salami factories and seasoned for 18 days on average. We studied the effect of the raw material origin (5 producers used meat bought from the market and other 5 producers used meat from pigs bred in their farms) and of the salami factories or brands on meat color, fat color and visible fat ratio in dry sausages. The sausages slices were photographed and the images were analysed with the computer vision system to measure the changes in the colorimetric characteristics L*, a*, b*, hue and chroma and in the visible fat area ratio. The last parameter was assessed on the slice surface using image binarization. A consumer test was conducted to determine the relationship between the perception of visible fat on the sausage slice surface and acceptability and preference of this product. The consumers were asked to look carefully at the 6 sausages slices in a photo, minding the presence of fat, and to identify (a) the slices they considered unacceptable for consumption and (b) the slice they preferred. The results show that the color of the sausage lean part varies in relation to the raw material employed and to the producer or brand ($P < 0.001$). Besides, the sausage meat color is not uniform in some salami factories ($P < 0.05$–0.001). In all salami factories the sausages show a high uniformity in fat color. The visible fat ratio of the sausages slices is higher ($P < 0.001$) in the product from salami factories without pig-breeding farm. The fat percentage is highly variable ($P < 0.001$) among the sausages of each salami factory. On the whole, the product the consumers consider acceptable and is inclined to eat has a low fat percentage ($P < 0.001$). Our consumers (about 70%) prefer slices which are leaner ($P < 0.001$). Women, in particular, show a higher preference for the leanest ($P < 0.001$).

1. Introduction

Basilicata or Lucania, a region located in southern Italy, is renowned for some traditional pig-based meat products such as 'dry sausage' and 'soppressata' which have sensorial characteristics greatly appreciated by consumers.

For consumers of traditional products, such as Lucanian dry sausage, some essential qualities are: nutritional and sensory characteristics and origin designation. A meat food product is intended to furnish several nutritional elements without impairing human health (e.g. minimising fat consumption). Origin designation and raw material information are getting more and more important. Italian consumers conceive food origin as an indicator of safety. Meat from animals born and bred in Italy is considered safer than meat from abroad and meat from a local breeding farm is considered even better (Hersleth, Naes, Rodbotten, Lind, and Monteleone, 2012).

Among the sensory characteristics the eating qualities (texture, flavour, juiciness, etc.) cannot be evaluated before the purchase. Conversely, appearance is a very important criterion in choosing and buying meat and meat products (Dransfield et al., 2005; Fortomaris et al., 2006; Gotterup et al., 2008). Quality cues may be extrinsic (e.g. price, origin, information) and intrinsic; the intrinsic ones are physical properties of a product (Grunert, Bredahl, and Brunso, 2004). Appearance, meant as color and visible fat content, is an intrinsic quality cue.

The color of dry sausage mostly depends on myoglobin, oxymyoglobin, metmyoglobin and nitrosomyglobin (Uren and Babayigit, 1996). The characteristic color bright red given by nitrosylmyglobin (Moller and Skibsted, 2002) is due to the addition of nitrite and/or nitrate in order to inhibit the undesirable bacteria growth (Cassens, 1997) and the lipid oxidation (Cammack et al., 1999).

The ratio of visible fat in sausages is another important discriminating factor on purchase because this product usually has a high fat content. The consumer tends to require a lean product because a high amount of lipids is a risk factor for human health. At the same time fat content is very important at sensory and nutritional levels. Fat influences texture, flavour, juiciness and other sensory characteristics and, consequently, product acceptability.

The researches on meat and fat color and on the factors, which can influence this sensorial characteristic, are of great relevance. With the

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development of digital technology in each field of human activity, researchers are trying to implement innovative techniques which have high advantages compared to the traditional ones. In the present study the dry sausage colorimetric properties have been detected by using a technique as the computer vision system that presents outstanding positive aspects (Girolami, Napolitano, Faraone, and Braghieri, 2013; Leon, Mery, Pedreschi, and Leon, 2006; Quevedo, Aguilera, and Pedreschi, 2010): it evaluates the overall color of the sample and its heterogeneity (Brosnan and Sun, 2004), it analyzes images and assesses the color with a non-destructive and objective method (Timmermans, 1998; Zheng, Sun, and Zheng, 2006), it preserves the chromatic fidelity of an image when it is visualized as a digital image on a monitor, it enables the researchers to analyze the entire surface of the foods and their characteristics and defects (Brosnan and Sun, 2004; Du and Sun, 2004; O'Sullivan et al., 2003), it allows to save and record the images for later studies and comparisons and it is a cheap means for color evaluation (Briones and Aguilera, 2005)

Artisanal sausages show a typical specificity and variability depending on the meat and fat (raw material) used in the mixture and on the various ingredients added (or not), such as color stabilizing agents, anti-oxidants, spices, etc.. Within this field, the research aimed to investigate the effect of the raw material origin and of the brand on meat color, fat color and fat ratio in dry sausages. Besides, for each brand we studied the possible variability of these characteristics in the product. Finally, a consumer test was conducted to determine the relationship between the perception of fat on the sausage slice surface and acceptability and preference of this product.

2. Material and methods

The study was carried out on 50 dry sausages produced in 10 different salami factories (5 sausages for each producer) and ripened for about 18 days on average. 5 producers (1A, 2A, 3A, 4A, 5A) used meat bought from the market and 5 (6B, 7B, 8B, 9B, 10B) used meat from pigs bred in their farms; the number indicates the producer and the letter A and B the raw material. According to labels, all sausages contain pork meat, salt and spices. Five manufacturers (1A, 2A 3A, 4A and 6B) added nitrate and nitrite. L-Ascorbic acid was added as an anti-oxidant by the producers 1A, 2A, 3A and 6B. The ingredients in the label that can modify meat and fat color were not examined because they were considered as being part of the peculiar characteristics of the different brands.

For each sausage three slices, thickness about 4 mm, were cut (Fig. 1). Photos of the peeled slices were taken and the images were analysed with the computer vision system (CVS) to measure the meat and fat colorimetric characteristics and to evaluate the fat area ratio.

Fig. 1. The photo shows a dry sausage and where the 3 samples were taken from.

2.1. Computer vision system

A CMOS camera CANON EOS 450D at high-resolution (12,2 Mega pixel) was used for image acquisition. The camera was located vertically at a distance of 54 cm from the sample. The camera setting was the following: shutter speed 1/15 s, operation mode manual, aperture Av F/2.8, ISO velocity 100, flash off, focal distance 60 mm, lens: EF-S 60 mm f 2.8 macro USM. Lighting was achieved with four fluorescent lamps (Philips Master Graphica TLD 965) with a color temperature of 6500 °K and a color rendering index (Ra) close to 98%. The lamps (60 cm length) with diffused light were located 50 cm above the sample at an angle of 45° to obtain a uniform light intensity on the sample; the camera was inside a wooden box whose internal walls were covered with black opaque cloth to minimize background light. A 24 color chart Colorchecker (Gretag-Macbeth, USA) was used to create the camera profile. The Colorchecker was photographed using the implemented CVS to obtain the input device RGB signals in the theoretical range of 0–255 (the RGB values are expressed as sRGB D65 and CIELAB D50 2° observer). The camera was connected to a PC computer NEC MultySync LCD monitor with sRGB gamut (Standard RGB) and image resolution of 1600 × 1200 pixels. After the monitor calibration obtained by selecting white chromaticity at 6500 °K, gamma at 2.2 and white luminance at 140 cd/mq, the software Eye-One Match 3.2. was used to create the ICC monitor profile. The rendering intent employed was of perceptive type. For research purpose, a non-compressed file (RAW format) was preferred to a compressed file (JPEG). L*, a* and b* values from RGB images were measured from RAW photographs. For color and fat area ratio management the software Adobe Photoshop CS3 was used.

2.2. Color measurement

The colorimetric characteristics L*, a*, b*, hue ($h = \arctan(b^*/a^*)$) and chroma ($C^* = (a^{*2} + b^{*2})^{1/2}$) were measured on meat and fat. The CIELab color space is an international standard for color measurement adopted by the Commission International d'Eclairage (CIE) in 1976: L* is the lightness component, which ranges from 0 to 100 (from black to white) and the parameters a* (from green to red) and b* (from blue to yellow) are the two chromatic components (Oleari, 2008).

The protocol applied to determine the colorimetric characteristics is reported in Girolami et al. (2013). In particular, L*, a*, and b* values were measured on the digital image of the sausage slice visualized on the monitor by pointing the cursor at the centre of the meat and fat areas to be evaluated and clicking on it. For each colorimetric analysis on the dry sausage slice twelve repetitions were made on the meat and three on the fat, using their average for the subsequent statistical analysis. A great number of repetitions was needed for the meat because of its high color heterogeneity. In order to facilitate the repetitions, a square grid was developed on the displayed slice. The surface area examined for each repetition was of 121 (11 × 11) pixels for the meat and of 9 (3 × 3) pixels for the fat. The pixels size was 0.0364 mm^2 and, consequently, the FOV (field of view) was 4.4044 mm^2 for the meat and 0.3276 mm^2 for the fat. We chose areas of such sizes both in order to have homogeneous surfaces and for the software given options. For the fat analysis we chose a more restricted FOV because the fat spots had smaller surfaces. Both FOVs were chosen after numerous trials.

Almost every brand (except the producer 9B) employed local mild red pepper (Senise pepper) powder; the effect of this spice on fat color was not taken into consideration because it colored yellow-orange only a minimal part of this tissue.

In order to understand what is commonly considered in evaluating the color sausage slice, a consumer test was carried out employing 117 people, of which 51 were men and 66 were women.

2.3. Evaluation of the visible fat area ratio

The visible fat area ratio has been computed as percentage of fat area/slice total area. The sausage slice surface can have intramuscular, intermuscular and subcutaneous fat. The visible fat area ratio was assessed on the slice surface using image binarization (Fig. 2). The binarization converts an image of up to 256 grey levels to a black and white image. The contour line of the slice photo was manually drawn and then the image was analysed. In image analysis using a correct threshold value to divide lean and fat is very important. But it is difficult to identify objectively the correct threshold value on a heterogeneous surface as in the case of the dry sausage. For this reason a trained sensory panel of seven people was employed. On the monitor each person chose a threshold value which could evaluate the fat ratio more exactly and the fat ratio values were considered as repetitions, using their average for the subsequent statistical analysis. The selection of the panel members was conducted using the Ishihara plates (Ishihara, 1991) to identify possible vision anomalies (e.g. Daltonism) in the red spectrum. The plates we used were 21 and were read with the daylight behind the subject at intervals of 15 s; the minimum passing score, was 17/21.

2.4. Visible fat ratio acceptability and preference

In order to evaluate the visible fat ratio acceptability and preference of the sausage slice, a consumer test was carried out by employing 743 people, 349 men and 394 women. The consumers belonged to 5 age categories: less than 31 years old, from 31 to 40, from 41 to 50, from 51 to 60, more than 60 years old. The consumers were asked to look carefully at the 6 sausages slices in the photo (Fig. 3) minding the presence of fat (each slice belonging to one of these fat percentage classes: 1 = 0–10%, 2 = 11–15%, 3 = 16–20%, 4 = 21–25%, 5 = 26–30% and 6 = 31–35% of fat) and identify (a) the slices they considered unacceptable for consumption and (b) the slice they preferred.

2.5. Statistical analysis

Data were analyzed using SAS (1990). Data on meat and fat color were subjected to ANOVA with three factors: producer (1 to 10), origin of the raw material (internal and external) and item (1 to 5). Three slices for item were used; each slice (experimental unit) was assessed twelve and three times for meat and fat color, respectively, and the mean values used for the analyses. The standard deviation of the twelve replicates of each slice (experimental unit) was analyzed using ANOVA with three factors: producer (1 to 10), origin of the raw material (internal and external) and item (1 to 5). Visible fat area ratio was analyzed using ANOVA with three factors: producer (1 to 10), origin of the raw material (internal and external) and item (1 to 5). Three slices for item were used; each slice (experimental unit) was assessed by seven trained observers and the mean value used for the analysis. Data gathered from the preference test (each assessor was allowed to choose only one out of six slices) were analyzed to determine statistical significance based on the frequency of each response (chi-squared one sample test) where the expected frequency was 16.6%. Data concerning acceptability (each assessor was allowed to choose zero to six slices) were analyzed using chi-squared for k samples with an expected frequency of 50% (acceptable vs. not acceptable).

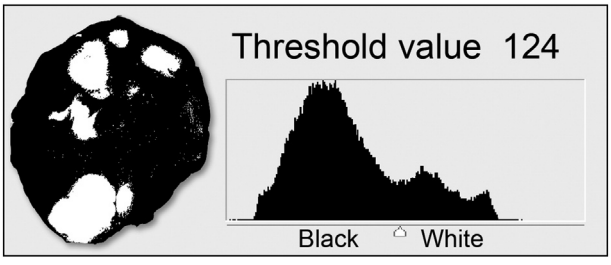

Fig. 2. The photo shows a sausage slice binarized (white = fat; black = lean part) and an example of a threshold value visualized on the monitor.

3. Results and discussion

3.1. Color

3.1.1. Meat color

The results show that the colorimetric characteristics L*, a*, b*, h and C* of the sausage lean part vary in relation to the raw material employed and to the producer or brand. Besides, the sausage meat color is not uniform in some salami factories.

3.1.1.1. Raw material. Sausages made in salami factories which used meat from pigs bred in their farms show a higher lightness ($P < 0.001$) and a lower index a* and b*, hue and chroma ($P < 0.001$) (Table 1) as compared with products obtained using meat bought from the market. These results may be attributed to the origin of the raw material which could be different in terms of breed, weight at slaughter, commercial cut, etc.

The variance analysis of the standard deviation values indicates a significant variability for red index value a* and chroma ($P < 0.001$) in the sausages manufactured in the salami factories with breeding. The choice of the raw material influences the product color when, for instance, the myglobin amount is different. The color of dry sausage mostly depends on myoglobin, oxymyoglobin, metmyoglobin and nitrosomyglobin (Uren and Babayigit, 1996). This has a considerable importance to obtain a product which meets the consumers' requirements. The higher the myglobin content in meat is, the darker the red color of the final product will be. The content of this protein varies in relation to many factors, among them genetic type, breeding, feeding, muscles used in the mixture, etc. To stabilize the sausage color some producers added nitrates, nitrites and anti-oxidants in the mixture (Moller and Skibsted, 2002). Unfortunately, from this research it was not possible to infer the effect of these ingredients on the color of the product.

3.1.1.2. Brand. Almost all the differences among the producers are significant ($P < 0.05$–0.001). *Salami factories using meat bought from the market* (Table 1). Salami factory 3A produced a darker sausage (lower lightness) and the 4A a lighter one ($P < 0{,}001$). Red index a* is lower in the product of brand 3A and higher in the brand 1A ($P < 0.001$). Yellow index b* is lower in the salami factory 4A and higher in the 1A ($P < 0.001$). Sausage hue is in red spectrum and ranges from a minimum of 22.26 (brand 4) to a maximum of 27.53 (brand 1) in the CIELab color space and the differences between the mean values are almost all statistically significant ($P < 0.01$–0.001). Chroma varies considerably among almost all salami factories: the lowest value is in the sausages of the producer 5A and the highest in those of 1A ($P < 0.001$). *Salami factories using meat from pigs bred in their farms* (Table 1). The darkest sausage was produced by salami factory 10B and the lightest one by 6B ($P < 0.001$). The red index a* is lower in the product with the brand 7A and higher in the sausage with the brand 6B ($P < 0.001$). The producer 6B's sausages show a higher yellow index, hue and chroma, the contrary happens in the products of the brand 10B ($P < 0.001$). Hue ranges from 21.88 (brand 10B) to 26.16 (brand 6B) and the differences are significant ($P < 0.001$). The variance analysis of the standard deviation in both groups of salami factories shows a higher color variability ($P < 0.05$–0.001). This means that each brand has its own peculiar colorimetric characteristics.

3.1.1.3. Meat color variability in each brand. Salami factory 8B produced sausages with a high variability in color ($P < 0.05$–0.001) while this characteristic is uniform in brands 5A (no significant differences). The

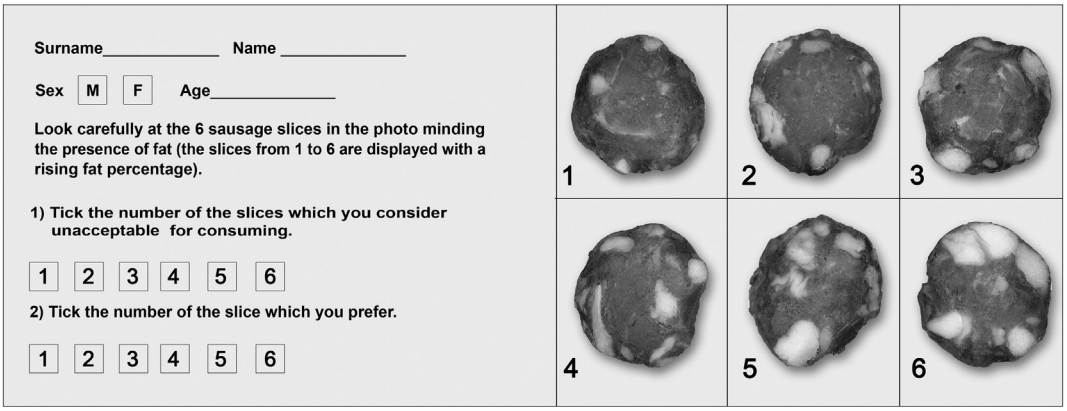

Fig. 3. *Consumer test.* The form and photo employed to evaluate the visible fat ratio acceptability and preference.

other brands, in some cases, produced sausages with a slight variability in color.

The color variability found in the sausages can depend on the techniques employed in the manufacturing process (choice of the raw material, ripening conditions, seasoning, etc.). The artisanal products are not expected to be uniform, differently from what happens in the industrial productions. Their non-uniformity can be considered a typical characteristic. It can have positive aspects because it satisfies the consumers' variable needs, but also negative aspects for the color variability of the product in the same brand. What may follow is the consumers' disorientation because on purchase they do not have a firm indicator any more.

The comparison between our results and those obtained by other researchers is quite difficult because we didn't find out studies concerning the same factors. At the same time, our bibliographical research showed that the sausage color measurement has always been effected without taking into account its un-uniformity due to the contemporary presence of meat and fat (Ansorena, De Pena, Astiasaràn, and Bello, 1997; Chasco, Lizaso, and Beriain, 1996; Dell'Aglio, Casiraghi, and Pompei, 1996; Gimeno, Ansorena, Astiasaràn, and Bello, 2000; Gimeno, Astiasaran, and Bello, 2001; Liaros, Katsanidis, and Bloukas, 2009; Olivares, Navarro, Salvador, and Flores, 2010; Papadima and Bloukas, 1999; Rubio, Martìnez, Garcìa-Cachan, Rovira, and Jaime, 2008). In these researches 'lightness' is always higher than the one obtained in the present study, while the red a* and yellow b* indices are always lower. The reason may be due to the contemporary measurement of meat and fat color by the colorimeter. Considering its technical characteristics, the colorimeter can't measure meat and fat separately. Girolami et al. (2013) showed that the colorimeter did not generate coordinates corresponding to the true color of meat.

In a different consumer test carried out to understand what is taken into account in evaluating the slice color, 79% of the interviewed answered that in evaluating the sausage color they consider not only the color of the lean part but also of fat. If a surface is not homogeneous, as it happens for the sausage slice, our eyes see all the colors at the same time and the predominant color (meat) will determine the color of the entire surface even if the other color (fat) has a not-easily-measurable effect on the prevalent one.

3.1.2. Fat color

Yellow index b*, hue and chroma vary significantly in relation to the employed raw material, while in almost all salami factory (brand) the sausages show a high uniformity in fat color.

3.1.2.1. Raw material. Sausages made in salami factories using meat from pigs bred in their farms show a fat with higher index b * and chroma ($P < 0.001$) and lower hue ($P < 0.01$) (Table 2).

3.1.2.2. Brand. Salami factories using meat bought from the market (Table 2). Salami factory 3A produced sausages with the darkest fat, the opposite happened for 4A ($P < 0.001$). The product of the brand 2A has the fat with the lowest yellow index b*, the opposite for 1A ($P < 0.001$). The sausages of some brands show significant differences for chroma ($P < 0.05$–0.001). *Salami factories using meat from pigs bred in their farm* (Table 2). Red index a* and yellow index b* are the lowest

Table 1
Meat. Colorimetric characteristics (mean ± S.E.) in relation to brand and raw material.

Parameter	Raw material A					
	Brand					
	1	2	3	4	5	Total mean
L*	26.21 ± 0.33	25.04 ± 0.33	19.61 ± 0.33	28.96 ± 0.33	23.41 ± 0.33	24.65 ± 0.17
a*	30.36 ± 0.31	31.12 ± 0.31	27.66 ± 0.31	29.53 ± 0.31	27.93 ± 0.31	29.32 ± 0.16
b*	16.11 ± 0.28	14.44 ± 0.28	14.02 ± 0.28	12.24 ± 0.28	12.56 ± 0.28	13.87 ± 0.14
h	27.53 ± 0,29	24.53 ± 0.29	26.38 ± 0.29	22.26 ± 0.29	23.92 ± 0.29	24.92 ± 0.14
C*	34.46 ± 0,39	34.37 ± 0.39	31.08 ± 0.39	32.06 ± 0.39	30.65 ± 0.39	32.52 ± 0.39
Parameter	Raw material B					
	Brand					
	6	7	8	9	10	Total mean
L*	27.26 ± 0.33	26.22 ± 0.33	24.88 ± 0.33	26.37 ± 0.33	23.23 ± 0.33	25.59 ± 0.17
a*	32.32 ± 0.31	26.15 ± 0.31	27.15 ± 0.31	30.73 ± 0.31	26.28 ± 0.31	28.53 ± 0.16
b*	16.16 ± 0.28	11.35 ± 0.28	11.56 ± 0.28	14.66 ± 0.28	10.85 ± 0.28	12.92 ± 0.14
h	26.16 ± 0.29	22.84 ± 0.29	22.68 ± 0.29	25.09 ± 0.29	21.88 ± 0.29	23.73 ± 0.14
C*	36.22 ± 0.39	28.63 ± 0.39	29.59 ± 0.39	34.11 ± 0.39	28.44 ± 0.39	31.40 ± 0.20

Table 2
Fat. Colorimetric characteristics (mean ± S.E.) in relation to brand and raw material.

Parameter	Raw material A					
	Brand					
	1	2	3	4	5	Total mean
L*	62.89 ± 1.05	62.73 ± 1.38	56.24 ± 1.03	63.40 ± 1.17	60.04 ± 1.13	60.87 ± 0.54
a*	16.11 ± 0.66	12.68 ± 0.86	14.16 ± 0.64	14.37 ± 0.73	14.68 ± 0.71	14.54 ± 0.33
b*	11.44 ± 0.57	3.03 ± 0.77	6.98 ± 0.57	4.25 ± 0.65	8.09 ± 0.63	7.20 ± 0.32
h	72.60 ± 0.64	77.25 ± 0.84	75.05 ± 0.63	75.50 ± 0.71	74.26 ± 0.69	74.59 ± 0.34
C*	20.02 ± 0.75	13.18 ± 1.00	15.97 ± 0.75	15.12 ± 0.85	16.99 ± 0.82	16.57 ± 0.40
Parameter	Raw material B					
	Brand					
	6	7	8	9	10	Total mean
L*	59.49 ± 1.08	59.70 ± 1.23	61.83 ± 1.06	58.61 ± 1.08	58.24 ± 1.03	59.61 ± 0.51
a*	16.91 ± 0.68	11.28 ± 0.77	14.68 ± 0.66	17.07 ± 0.68	15.84 ± 0.64	15.32 ± 0.32
b*	11.38 ± 0.60	7.09 ± 0.69	9.56 ± 0.59	11.27 ± 0.60	9.24 ± 0.57	9.77 ± 0.31
h	71.45 ± 0.66	77.57 ± 0.75	73.74 ± 0.64	71.36 ± 0.66	73.01 ± 0.63	73.25 ± 0.32
C*	20.62 ± 0.79	13.47 ± 0.89	18.03 ± 0.77	20.70 ± 0.79	18.59 ± 0.75	18.47 ± 0.38

in the product of the salami factory 7B and the highest in 9B ($P < 0.001$) and 6B ($P < 0.001$) respectively. Fat hue is the lowest in the sausage of the brand 9B and the highest for brand 7B ($P < 0.001$); the opposite happens for chroma ($P < 0.001$).

3.1.2.3. Sausage fat color variability in each brand. Fat color was uniform in the products of almost all brands, whereas differences became apparent when products from different factories were compared. These results may be due to the different ingredients used in each factory. This could also explain the lack of differences within factories.

3.2. Visible fat area ratio

3.2.1. Binarization

3.2.1.1. Raw material. The visible fat ratio of the sausage slices evaluated using binarization is higher in the product from salami factories without pig-breeding farm (19.73 vs. 16.21; $P < 0.001$).

3.2.1.2. Brand. In their products the fat percentage ranged from a minimum of 17.66 (brand 2A) to a maximum of 22.50 (brand 1A; $P < 0.001$), while in the salami factories using meat from their own pigs, the values are respectively 14.47 (brand 7B) and 20.39 (brand 6B) ($P < 0.001$) (Table 3).

3.2.1.3. Sausage. Fat percentage is highly variable among the sausages of each salami factory ($P < 0.001$). More specifically, among the salami factories without pig-breeding farms the variability is low in the products of 1A (from 19.31 to 24.41%) and high in those of 4A (from 11.95 to 23.67). In the salami factories with pig-breeding farms the lower range is in brand 10B (from 14.79 to 18.87) and the higher in brand 6B (from 15.47 to 27.59%) (Table 3).

The lack of uniformity observed in this study may be due to the fact that each factory may have used different raw materials. In particular, cuts with different amounts of inter-muscular fat may have been used along with the inclusion of different amounts of added fat. The artisanal nature of Lucanian sausages may explain differences in the production process resulting in high product variability.

Many authors used image analysis for intramuscular visible fat ratio evaluation in meat (Chandraratne et al., 2003; Kuchida, Konishi, Suzuki, & Miyoshi, 1998; Kuchida et al., 2000) and put into correlation the results with those obtained from chemical analysis, in order to find a new technique able, with some limits, to replace the latter which is expensive and long time taking. The correlations obtained were very high as fat distribution was probably very uniform. On the contrary, the image analysis in this study was only able to evaluate what is on the surface not the fat inside the product, because of its heterogeneous structure.

3.2.2. Consumer test

In the scope of studying 'appearance', we used a consumer test aimed at detecting the relationship between the perception of the fat ratio on the surface of the sausage slice and its acceptability and preference.

3.2.2.1. Acceptability. The results (Table 4) show that, without considering sex and age, the interviewed consumers considered particularly acceptable ($P < 0.001$) the slices n. 1 (76.11%), n. 2 (89.89%), n. 3 (86.66%) and n. 4 (86.79%) whose fat percentages, evaluated by means of the binarization method, are of 6.91, 14.97, 17.31 and 22.78 respectively

Table 3
Values (mean ± S.E.) of visible fat ratio in relation to sausage and brand evaluated using the binarization.

Brand	Sausage					Total mean
	1	2	3	4	5	
1A	23.23 ± 0.27	22.83 ± 0.27	22.68 ± 0.27	19.31 ± 0.27	24.40 ± 0.27	22.50 ± 0.12
2A	20.93 ± 0.27	17.07 ± 0.27	15.41 ± 0.27	16.19 ± 0.27	18.68 ± 0.27	17.66 ± 0.12
3A	20.76 ± 0.27	23.17 ± 0.27	13.95 ± 0.27	24.30 ± 0.27	21.51 ± 0.27	20.74 ± 0.12
4A	22.78 ± 0.27	17.24 ± 0.27	21.84 ± 0.27	11.95 ± 0.27	23.67 ± 0.27	19.50 ± 0.12
5A	22.85 ± 0.27	18.31 ± 0.27	19.39 ± 0.27	18.10 ± 0.27	12.69 ± 0.27	18.36 ± 0.12
6B	15.47 ± 0.27	24.12 ± 0.27	27.59 ± 0.27	18.37 ± 0.27	16.38 ± 0.27	20.39 ± 0.12
7B	12.54 ± 0.27	20.10 ± 0.27	13.22 ± 0.27	15.26 ± 0.27	11.18 ± 0.27	14.47 ± 0.12
8B	11.15 ± 0.27	20.53 ± 0.27	13.62 ± 0.27	15.73 ± 0.27	14.25 ± 0.27	15.05 ± 0.12
9B	17.24 ± 0.27	15.23 ± 0.27	8.55 ± 0.27	18.72 ± 0.27	13.06 ± 0.27	14.56 ± 0.12
10B	14.79 ± 0.27	17.32 ± 0.27	15.02 ± 0.27	18.87 ± 0.27	16.94 ± 0.27	16.60 ± 0.12

Table 4
Consumer test. Acceptability values (%) of the sausage slices in relation to the presence of fat considering all the interviewed consumers, sex and age category.

Sausage slice	Acceptability							
	All consumers	Sex		Age category, years				
		female	male	<31	31–40	41–50	51–60	>60
1	76.11	84.73	66.38	19.48	16.78	19.93	19.11	17.34
2	89.89	93.15	86.21	22.48	22.54	22.09	21.96	20.62
3	86.66	88.07	85.06	20.98	21.86	20.10	20.54	22.63
4	86.79	84.52	89.37	20.84	21.36	20.06	21.61	21.90
5	54.58	52.03	57.47	12.67	14.07	13.79	13.04	13.32
6	14.94	11.17	19.20	3.54	3.39	3.49	3.75	4.20

(Table 4). 14.94% of consumers considered acceptable even the slice n. 6, in spite of its highest fat content (35.73%). The same trend was noted in both sexes ($P < 0.001$) even if the male showed a lower acceptability percentage for the slice n. 1 (66.38 vs. 84.73 of female) and a higher percentage for the slice n. 6 (19.20 vs. 11.17 of female). With the consumers' age growing, there are no statistically significant differences. The same result was obtained for the two sexes within each age category.

3.2.2.2. Preference. Even if the spectrum of acceptability is wide enough, it narrows when the consumer is asked which slice he prefers. So 40.95% of the consumers preferred the slice n. 2 with 14.97% of fat and 30.81% the n.1 (17.31% of fat) ($P < 0.001$) (Table 5). Women in particular prefer the sausage n.1 which is the leanest (37.66% vs. 23.05% of men) ($P < 0.001$). The preference for the slice n. 1 doesn't change with the age while higher percentages for the slice n. 2 are observed or the age categories under 30 (10.41%) and from 31 to 40 (9.73%) ($P < 0.01$).

On the whole, the product the consumer considers acceptable and is inclined to eat has a low fat percentage. This confirms what is reported by Resurreccion (2003) in her paper about the consumer's choice concerning meat and meat products. Our consumers (about 70%) prefer the first two slices which are leaner. Women, in particular, show a higher preference for the leanest (n.1). The fat percentage in sausages (and in salami in general) is of great importance because it influences the technological, organoleptic and nutritional characteristics of these products. On the one hand, the fat content of meat and meat products determines better organoleptic characteristics, as for example flavour, odour and tenderness. On the other hand, it can have negative effects on human health because of their saturated fat acid content (Webb and O'Neill, 2008). It should be kept in mind that the nutritional characteristics should be evaluated in relation to the product intake amount. Provided the product is safe, what influences human health is not only its nutritional quality but also the eaten amount, particularly when the limit for a balanced diet is overpassed. Products with a very high fat content, such as bacon and fatback, are commonly eaten but they should be employed within a certain limit. When this limit is exceeded, they do not have only a nutritional aim but also satisfy hedonistic, social, economical, psychological and cultural urges (Graziani and Tora, 2011).

Table 5
Consumer test. Preference values (%) of the sausage slices in relation to the presence of fat considering all the interviewed consumers, sex and age category.

Sausage slice	Preference							
	All consumers	Sex		Age category, years				
		female	male	<31	31÷40	41÷50	51÷60	>60
1	30.81	37.66	23.05	26.74	26.85	35.71	31.88	34.04
2	40.95	40.97	40.92	44.77	48.32	37.14	38.41	34.75
3	6.62	5.60	7.78	12.21	4.70	4.29	5.80	4.96
4	8.24	7.89	8.65	9.88	6.71	11.43	8.70	4.26
5	9.05	5.60	12.97	2.91	9.40	7.14	10.87	16.31
6	4.32	2.29	6.63	3.49	4.03	4.29	4.35	5.67

4. Conclusions

CVS, previously validated on meat, in this study has proved to be applicable also to meat products, such as sausages, both in terms of color and visible fatness assessment.

The image analysis with the computer vision system employed to measure the sausage appearance (colorimetric characteristics and visible fat area ratio) showed that the color of the product lean part varies in relation to the raw material and to the producer or brand. Besides, the sausage meat color is not uniform in some salami factories.

The fat ratio of the sausage slices evaluated using binarization is higher in the product from salami factories without pig-breeding farms. The fat percentage is highly variable among the sausages of each salami factory. The consumer prefers the leaner slices. The appearance variability found in the sausages can depend on the techniques employed in the manufacturing process. The artisanal products are not expected to be uniform, differently from what happens in the industrial productions. Their non-uniformity can be considered a typical characteristic.

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