

Effect of two rearing systems on quality of Cinta Senese sausages

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Meat and fat of 24 Cinta Senese pigs were used to produce frankfurter-type sausages. The animals were raised in two rearing systems: i) fenced area with concentrate as exclusive feed (C, n=12) and ii) wood/pasture fenced area and grazing on natural available resources (acorn and herbaceous pasture) (P, n=12). Physicochemical characteristics, fatty acid composition and sensory attributes of the frankfurter-type sausages were assessed. Both sausages from C and P groups showed high fat content (> 23%) likely due to the high level of intramuscular fat of Cinta Senese meat. Frankfurter-type sausages obtained from P group had higher percentage of monounsaturated fatty acids and lower percentage of saturated fatty acids than the C group, probably due to the availability of grazing resources during the fattening period. However, in both types of sausages, the polyunsaturated to saturated fatty acids ratio was higher than the recommended lower limit of 0.40. Regarding the physical traits, differences between groups were found for the colour traits: P frankfurter-type sausages had lower lightness and higher redness and yellowness than C frankfurter-type sausages, likely due to the physical exercise associated to grazing activity of P animals. Texture parameters did not differ between groups for hardness and cohesiveness, whereas chewiness and springiness were higher in C than P samples. Feeding systems changed the perception of some sensorial properties, in particular taste and odour. Overall, Cinta Senese frankfurter-type sausages could represent an innovative product for local farms, allowing, in addition, the use of second-choice meat portions, once acquitted some improvements in the recipes.

Keywords: frankfurter-type sausage, extensive farming, pasture, meat quality, pig

1 Introduction

Over time, consumers' preferences have diverged towards high quality and environmentally friendly products obtained through practices which are respectful of animal welfare. Thanks to their qualitative traits and specific rearing systems, local breeds are often able to respond to these market demands. Indeed, the interaction between environment and genotype represents both the opportunity to guarantee the survival of the breeds and their territories and a key factor to enhance the quality of their products (Pugliese & Sirtori, 2012). Unlike cosmopolitan pig breeds usually reared in intensive systems, Cinta Senese pig is reared outdoor, often grazing on natural resources, in particular during the fattening period even if grazing for the whole growing period is not rare. In this case, if the animals are raised in the wood, an accurate management of pasture is necessary to avoid damage to soil and trees. The use of pastoral and forestry resources such as acorn, chestnut and grass, reduces the feeding costs and has positive effects on meat and products quality. Commonly, the nutritional value of natural resources does not fulfil the animals' needs (Sirtori et al., 2014), and it is often necessary to rely on feed supplement consisting of commercial mixture.

Several studies demonstrated that both feed resources and type of rearing systems influence physical, chemical, and technological traits of Cinta Senese fresh and seasoned products (Franci et al., 2007, Pugliese et al., 2013). Fatty acid composition and sensorial traits are affected by those factors inasmuch the adipose tissue of outdoor pigs has a higher content of unsaturated fatty acids (Andrés et

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al., 2001, Pugliese et al., 2009). In addition to fresh meat, the main known products of Cinta Senese breed are dry-cured ham and cured lard. Nevertheless, the production of meat by-products or non-conventional products could represent an economic opportunity for producers, allowing the use of less valuable pieces of meat and the possibility to target a new range of consumers, always reflecting the high quality that distinguishes the breed. For example, frankfurter-type sausage, usually obtained from industrial processes using a low-quality raw material, if properly treated, could represent one of these opportunities. Estévez et al. (2006) demonstrated that frankfurter-type sausages obtained from Iberian pigs had different quality traits especially with regard to fatty acid profile. In recent years, the research activities have focused on the inclusion of natural extracts as "functional compounds" in the formulation of meat products, aimed to improve the appeal of products for health-conscious consumers (Dominguez et al., 2017). Indeed, promising results have been achieved on Cinta Senese frankfurter-type sausages manufactured with natural extracts in replacement of the usual food additives such as nitrite and nitrate (Parrini et al., 2020). Nevertheless, as regards secondary choice meat pig productions, such as frankfurter-type sausages, the importance of raw material, type of rearing system and pig genotype seem to be underestimated.

The aim of this work was to investigate how the use of natural resources in the diet can affect technological, chemical and sensorial quality traits of Cinta Senese frankfurter-type sausages.

2 Material and methods

2.1 Animals and diets

The trial was carried under the control of the public veterinary service and complying with the Italian laws on animal experimentation and ethics (LD 04/03/2014, n. 26). Meat and fat used in the study were from Cinta Senese barrows (n=24) reared under two different farming systems.

- Concentrate group (C): 12 pigs reared in a paddock and fed with an amount from 0.5 to 3 kg/pig/day of commercial diet.
- Pasture group (P): 12 pigs reared outdoor in a wood/pasture fence, in which animals had access to natural resources. During growth phase (in autumn) acorn and herbaceous pasture were available while acorn resources were available during winter. During fattening period (spring) animals grazed herbaceous resources and pigs turned on 4 pasture fences to use all the resources, avoiding damaging the soil or interfering with the grass regrowth. During the trial period (13 months) pigs had access to shelters where they received small concentrate integrations with an average rate from 0.2 to 0.6 kg/pig/day.

The concentrate mixture, composed of corn, barley, wheat bran, broad beans, and soybean meal was the same during all the trial period and for both groups. Samples of acorn were collected from the wood pasture fence, while herbage was collected from the different pasture areas. Table 1 reports the chemical composition of feed diets. The botanical composition consisted of an average of 65.4% of *Gramineae*, 25.0% of *Leguminosae* and 9.6% of other families. Acorn derived mainly from *Quercus robur*, *Quercus pubescens* and *Quercus petraea*.

Table 1 Chemical analysis of various feed

Item	Acorn	Grass	Concentrate
Dry matter (DM, %)	49.90	29.01	91.97
Crude Protein (% DM)	3.91	8.94	13.80
Lipid (% DM)	2.03	0.96	2.30
Ash (% DM)	2.69	6.55	4.50
Crude fibre (% DM)	8.21	31.77	6.50

The initial live weight of animals was about 30 kg and they were slaughtered at the same age of 15.5 months at an average live weight of 160 kg for both groups.

2.2 Preparation of frankfurter-type sausages

Meat and fat from each group (C and P) were divided in two lots (n=6 pigs/lot). For each lot, portions of trimmed pork lean (16 kg) and subcutaneous backfat (4 kg) were used. The meat was chopped into cubes of approximately 3 cm, ground in a commercial food processor and homogenized adding ice

(13.45% of the total recipe) in a cutter (Laska Cutter KU65, Austria). Following the traditional recipe, spices, seasoning additives (salt 1.55%, sucrose 0.25%, black pepper 0.04%, others 0.47%), and nitrite and nitrate (1%) as curing agents, were added. Each treatment mixture was homogenized in a cutter for 6 min, adding ice (same quantity for each lot) in order to not overcome 10°C. The mixture was mechanically stuffed (Omet Foodtech, Italy) into edible collagen casings (Fcase, Poland) of 28 mm diameter forming sausages. Sausages were steam cooked at 80°C for 90 min until an internal temperature of 72°C. Then, they were chilled through a cold-water shower, vacuum packed and stored at 4°C for 7 days. About 140 frankfurter-type sausages for each lot were produced. Henceforward, sausages were classified referring to P and C treatment groups, in order to identify raw material origin of pig meat and fat.

2.3 Chemical, physical and sensorial analyses

A total of 24 samples (six frankfurter-type sausages for each treatment and lot) were analysed (6 x 2 x 2). Chemical composition, moisture, total crude protein, and ash contents were performed following AOAC (2019) methods. Lipids content was determined using chloroform/methanol extraction as described by Folch et al. (1957). Fatty acid methyl esters of frankfurter-type sausages were analysed through gas chromatography and the individual methyl esters were identified by their retention time, using an analytical standard (F.A.M.E. Mix, C8-C22 Supelco 18,920- 1AMP). Response factors based on the internal standard (C19:0) were used for fatty acids quantification and results were expressed as % of total fatty acid methyl esters. Samples were analysed to evaluate physical traits and three replications were performed. The pH was measured using pH meter Delta Ohm HD 8705 (Delta Ohm S.r.L., Caselle di Selvazzano, Padova, Italy) with temperature probe TP870 and pH electrode Hamilton double pore; colour parameters CIE L* (lightness), a* (redness) and b* (yellowness) were measured immediately after slicing using a Minolta colorimeter CR-200 (Minolta Camera Co., Ltd, Osaka, Japan); and texture profile analysis (TPA) was performed using a Zwick Roell Z2.5 apparatus (Ulm, Germany texture analyser) with a 1 kN-load cell at the crosshead speed of 1 mm/s and working at room temperature (22°C). The TPA curves-forces was determined by a 100-mm-diameter compression plate on 10 x 10 x 10 mm slices. Regarding TPA parameters, hardness was recorded whereas springiness, cohesiveness and chewiness were calculated.

Sensorial analysis was carried out on samples by a trained panel of 10 members and using a descriptive evaluation. Eleven attributes (lightness, redness, tactile texture, hardness, odour, off odour, off flavour, acid odour, bitter odour, tannic odour, flavour) were evaluated and each attribute was scored on a 100 mm unstructured scale. During the sessions, panellists considered a total of 4 frankfurter-type sausages (2 treatments x 2 samples) identified by an alphanumeric code. Colour and tactile texture attributes were evaluated on fresh product, while for the evaluation of the other properties frankfurter-type sausages were cooked up to the internal temperature of 70°C (Monteiro et al., 2017, Stanley et al., 2017), cut in 5 cm pieces and two pieces for each sample were randomly served to panellists.

2.4 Statistical analysis

Data (n=24) were analysed through the GLM procedure of SAS software (SAS, 2007). For physical-chemical data the following model was used:

$$y_{ijk} = \mu + R_i + L_j(R_i) + b(X_{ijk}) + \varepsilon_{ijk}$$

where y_{ijk} is the dependent variable, μ is the overall mean, R_i is the fixed effect of the i th rearing system (C, P), $L_j(R_i)$ is the fixed effect of the j th production lot nested within the i th rearing system, b is the regression coefficient on weight of frankfurter-type sausage (X_{ijk}), and ε_{ijk} is the random residual $\sim N(0, \sigma_\varepsilon^2)$.

For the texture profile, the same model was used except that the effect of linear regression on sausage weight was replaced by the linear regression on sausage height. Finally, for the sensory data, the following model was used:

$$y_{ijk} = \mu + R_i + P_j + \varepsilon_{ijk}$$

where P_j is the fixed effect of the j th panellist. Level of significance was declared at $P < 0.05$.

3 Results and discussion

Chemical composition revealed the high fat content of Cinta Senese frankfurter-type sausages (Table 1) compared to commercial products (Gonzalez-Viñas et al., 2004) and to products obtained from unspecified genotypes by Ayo et al. (2007). This could be due to higher intramuscular fat content of

Cinta Senese meat, explained by its attitude to depot more adipose tissue compared to cosmopolitan breeds (Franci et al., 2007, Sirtori et al., 2011).

Considering the effect of rearing system, the C group showed higher moisture content in frankfurter-type sausages than P group ($P < 0.05$), despite the recipe was the same. No significant differences were found for crude protein, lipid and ash contents (Table 2). Estévez et al. (2006) did not report differences on chemical composition of frankfurter sausages obtained from two different pig groups: Iberian pigs extensively reared on natural resources and white pigs intensively reared with commercial concentrate. Nilzén et al. (2001) working on fresh meat, reported that moisture was not influenced by the rearing system. Nevertheless, in agreement with our study, Pugliese et al. (2005) observed higher moisture percentage in fresh meat of pigs reared indoor (concentrate feed) compared with fresh meat of outdoor animals grazing in woods, attributing the results to lower crude protein and ether extract values. Overall, Cinta Senese frankfurter-type sausages of the present study had higher monounsaturated fatty acids (MUFA) and lower saturated fatty acids (SFA) than the same product obtained from cosmopolitan breeds (Ayo et al., 2007, Alirezalu et al., 2019). Estévez et al. (2006) suggested that the fatty acid profile of frankfurter-type sausages obtained from Iberian pigs was different from that of cosmopolitan breeds. According to the last cited study and also considering Cinta Senese frankfurter-type sausages produced with different curing agents, fatty acid profile seemed mainly related to meat characteristics of the local breed (Parrini et al., 2020). Frankfurter-type sausages from P group exhibited higher percentage of MUFA and lower percentage of SFA than C group ($P < 0.05$; Table 2). These results were probably due to the availability of green herbage for P group. In fact, the contribution of the type of feed on the qualitative characteristics of the meat is known, especially by comparing a natural outdoor diet against a confined system with commercial diet (Pugliese & Sirtori, 2012). Furthermore, less SFA levels could be linked to the higher physical activity of grazing pigs than sedentary ones, as suggested by Daza et al. (2009). Significant but numerically small differences were detected between C and P frankfurter-type sausages for the content of polyunsaturated fatty acids (PUFA) and PUFA n-6 family, with slightly higher contents for C than P group (Table 2). Pugliese et al. (2013), comparing Cinta Senese pigs fed with chestnuts in the last month of the fattening period with animals fed with commercial mixture, reported higher MUFA and PUFA in seasoned backfat of the former group. Concerning PUFA n-3 family, no significant differences between groups were observed, even if we expected a higher PUFA n-3 content for P than C group due to grazing (Nilzén et al., 2001). Also, Estévez et al. (2006) reported no increase of PUFA n-3 in frankfurter sausages from pigs raised on extensive grass system. Nevertheless, respect to the Iberian pig products of the last cited study, Cinta Senese frankfurter-type sausages showed double content of PUFA, but other factors such as the used recipe and the manufacturing process could have affected these results. The PUFA/SFA ratio (nutritional ratio) of frankfurter-type sausages was 0.42 for P group and 0.46 for C group ($P < 0.05$; Table 2).

Table 2 Chemical and fatty acid composition of frankfurter-type sausages according to the experimental farming system

Trait	Pasture	Concentrate	RSD
Moisture (%)	49.54 ^b	52.57 ^a	0.57
Crude Protein (%)	15.11	15.53	0.43
Lipid (%)	24.88	23.29	4.12
Ash (%)	2.55	2.58	0.07
Fatty acids (% on total FAME)			
SFA	33.41 ^b	37.55 ^a	0.49
MUFA	51.09 ^a	46.46 ^b	0.63
PUFA	15.49 ^b	15.98 ^a	0.31
PUFA n-3	1.04	1.15	0.04
PUFA n-6	14.41 ^a	14.80 ^b	0.28
n-6/n-3	12.99 ^b	13.84 ^a	0.18
PUFA/SFA	0.42 ^b	0.46 ^a	0.01

Frankfurter-type sausages had an average weight of 63.14 ± 9.98 g

FAME – fatty acid methyl esters; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids; RSD – residual standard deviation

^{a,b}Means with different superscript letters within a row are significantly different ($P < 0.05$)

These values were positively higher than the healthiness threshold for lipids (>0.40) reported by Wood et al. (2004). Additionally, the obtained ratios were higher than those retrieved from other studies on frankfurter-type sausages (Ayo et al., 2007, Alirezalu et al., 2019) which reported 0.35 as the highest value from unspecified breed. Nevertheless, the nutritional ratio was lower in P group than in C group, in agreement with Estévez et al. (2006) who reported the lowest values in Iberian pigs fed grass. The n-6/n-3 ratio, which is considered an important healthy indicator for coronary heart diseases (Okuyama & Ikemoto, 1999), showed the same trend of PUFA/SFA ratio, with slightly higher values in C frankfurter-type sausages respect to P group ($P < 0.05$; Table 2), probably as a result of the higher content of PUFA n-6 in C group.

The pH values were in line with results obtained in other studies on frankfurter sausages (Ayo et al., 2007, Alirezalu et al., 2019). Considering colour traits, significant differences between treatments were observed (Table 3). In particular, P frankfurter-type sausages had lower lightness values and higher redness and yellowness values than C group. This was probably due to the characteristics of the raw meat. In fact, the red colour was probably linked to the haem pigment and to iron content affected by physical exercise associated to grazing activity of P group. Colour characteristics suggested that Cinta Senese frankfurter-type sausages were less bright and more red and yellow than products from meat of Iberian and white pigs analysed by Estévez et al. (2006). Lindhal et al. (2001) suggested that the breed could have influenced colour attribute results and reported higher redness value and iron content in muscles of traditional pig breeds in comparison to improved breeds. Ranucci et al. (2018) associated the colour of the product to the type of muscles used during the manufacturing process. The results of TPA suggested that hardness and cohesiveness did not differ between products obtained from different farming systems, whereas springiness and chewiness values of P frankfurter-type sausages were lower than those of C frankfurter-type sausages ($P < 0.05$; Table 3). Cavestany et al. (1994) reported that differences in texture profile of meat were affected by various factors such as fat content, origin, recipe formulation and crude protein characteristics. In addition, several studies on frankfurter-type sausages (Sousa et al., 2017, Ranucci et al., 2018) linked the modification of texture characteristics to the effect of fat reduction and fat replacers addition. In our study, the use of the same recipe for both groups could have led to the lack of differences for hardness. Despite this, chewiness differed substantially between the two groups. In fact, C samples required more energy for their chewing than P group (Table 3). Further analyses on the raw meat quality characteristics used in the different treatments could be useful to explain the reason of texture traits behaviour.

Table 3 Physical traits of Cinta Senese frankfurter-type sausages according to the experimental farming system

Trait	Pasture	Concentrate	RSD
pH	6.08 ^b	6.19 ^a	0.04
Colour trait			
L*	57.96 ^b	69.52 ^a	4.08
a*	20.27 ^a	16.96 ^b	0.24
b*	16.35 ^a	11.14 ^b	0.82
TPA analysis			
Hardness (N)	75.31	76.59	13.67
Cohesiveness	0.64	0.68	0.07
Springiness (mm)	1.49 ^b	1.78 ^a	0.27
Chewiness (N x mm)	70.56 ^b	93.53 ^a	22.24

L* - lightness; a* - redness; b* - brightness; TPA – texture profile analysis; RSD – residual standard deviation

^{a,b}Means with different superscript letters within a row

The results of sensory evaluation (Figure 1) confirmed the instrumental findings emphasizing that most of the analysed attributes was influenced by feeding system. In fact, panellist evaluated P frankfurter-type sausages as significantly redder than C sausages. No significant differences in hardness and tactile texture were highlighted. Nevertheless, off odours and off flavours were significantly higher in P than C group samples. Panellists evaluated P samples as significantly more

acid and tannic, and characterized by bitter odour than C samples. Panellists probably associated characteristics that were not common to their usual food customs (odour and flavour) to P group. According to Font-i-Furnols and Guerrero (2014) the preferences and the choice could be affected by panellists' experience or acquired knowledge beyond the personal characteristics. Nevertheless, the specific odour and off odour-flavour results showed low values on a 0 to 100 mm scale and generally the panellists expressed a positive opinion on the Cinta Senese frankfurter-type sausages.

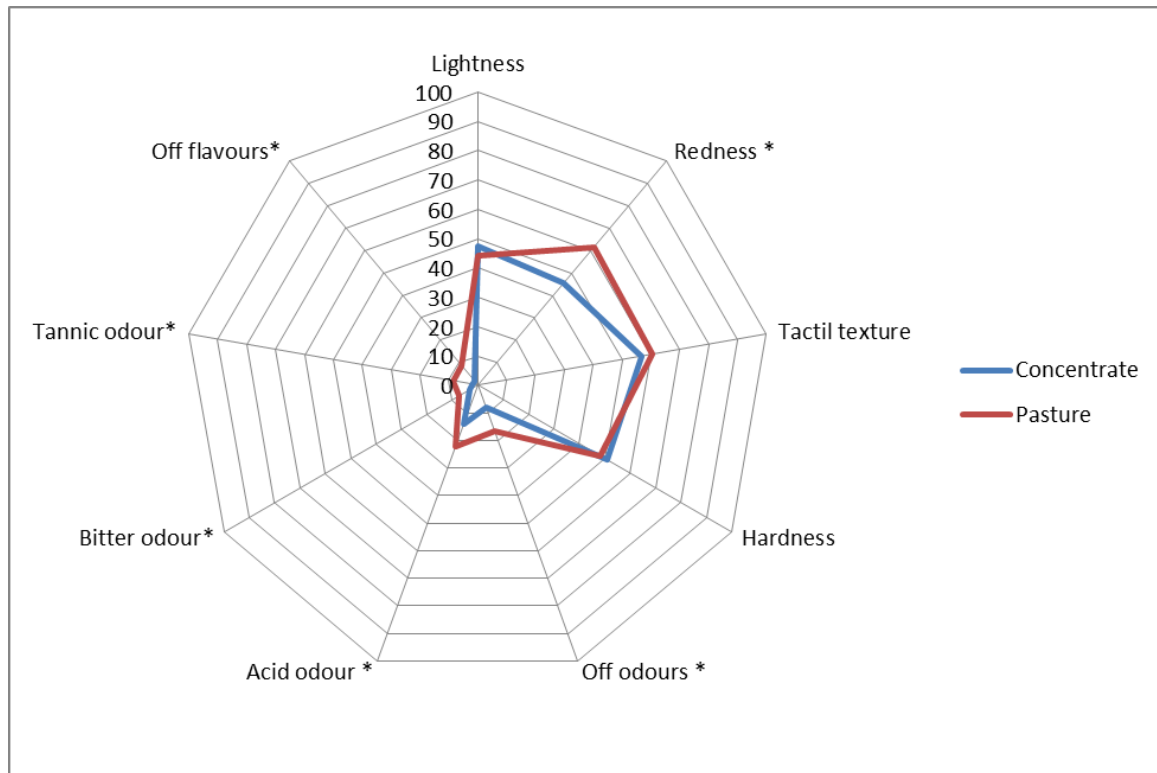


Figure 1 Sensorial traits of Cinta Senese frankfurter-type sausages (* $P < 0.05$)

4 Conclusions

Cinta Senese frankfurter-type sausages could represent an innovative product to implement the use of less value pig meat portions and could also be considered an interesting alternative in terms of valorisation of local breeds product linked to the territory. In addition, there is a sustainability value thanks to the use of natural resources for animals feed which was considered in this study for P groups. Both C and P frankfurter-type sausages showed a high content of fat. This aspect could be improved by manufacturers through an implementation of the recipe, that could consist for instance in reducing fat quantities without compromising the curing process. The feeding system affected the fatty acid profile (especially MUFA and SFA) and colour traits of both C and P groups. The feeding system seems also to slightly affect the perception of some sensorial properties (taste and odour) and this should be taken into high consideration since sensorial characteristics could represent a key factor for the characterization of Cinta Senese frankfurter-type sausages. Finally, some aspects concerning the products shelf life and the qualitative traits over time could be investigated in future studies.

Acknowledgements

We acknowledge the support of Azienda Oasi Dynamo and Azienda Agricola Savigni (Pistoia, Italy).

Funding

This research was funded by Tuscany Region (PSR 2014–2020) and was conducted as part of PIF Project “ValMonTi”.

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