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Effect of fresh pork meat conditioning on quality characteristics of salami

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ABSTRACT

The aim of this work was to evaluate the effect of pork meat conditioning under different relative humidity (RH) values on salami quality characteristics. During a 6 days conditioning period at 0 °C under two levels of RH (95% *vs.* 80%), meat pH and weight loss were measured. Salami characteristics (moisture, weight loss, texture, appearance properties) were evaluated during 20 days of ripening. Results showed that conditioning at 80% RH yielded a significantly drier meat, being the weight loss rate 1.6 times higher than at 95% RH. The lower water content of meat allowed a shorter salami ripening phase, guaranteeing an appropriate weight loss and the development of the desired texture, while maintaining good appearance properties. The acceleration of this production phase represents a clear economic advantage for producers and consumers, leading to higher profit margins and lower retail prices. The possibility of using FT-NIR spectroscopy as a valid tool for the rapid evaluation of salami ripening was also demonstrated.

1. Introduction

Salami are typical European dry fermented sausages manufactured mainly with pork meat and fat, with the addition of salt, curing agents (nitrate and/or nitrite), spices, sugars and eventually starter cultures. The manufacture of salami is highly complex because, apart from product parameters, several external factors affect the characteristics of the final product. Temperature, relative humidity and air velocity in the fermentation and ripening rooms as well as ripening time determine the drop in pH and water activity (a_w) of salami, thus greatly affecting color, taste, flavor and texture (Feiner, 2006).

In particular, ripening is considered one of the most important stages in salami production, because it has a primary influence on physical, chemical, and microbiological characteristics of final dry fermented pork products. Some major quality and safety standards, such as the product weight loss, the seasoning uniformity, the presence of inner fissures, as well as the whole chemical and microbiological transformations, can be related to the way the ripening stage is carried out and controlled. Water loss is a crucial aspect in ripening because it is responsible for the lowering of a_w, which determines limitations to the growth of many spoilage and pathogenic microorganisms (Grassi & Montanari, 2005).

As the relative humidity in the fermentation and ripening rooms is constantly kept lower than the a_w of salami, there is a difference in vapor pressure that causes the removal of moisture through the outside layers of the products. The water loss has to occur at the right speed and to be as uniform as possible in order to avoid case hardening that is negative for both safety and texture of salami. In addition, if a product is not dried at a suitable speed, the desired firmness (or loss in weight) will be obtained in longer time and every day of extended drying or ripening is very costly. For this reason, different experimental strategies have been proposed in order to shorten the ripening stage. In particular, the addition of lipolytic and proteolytic enzymes have been successfully applied even if there can be the risk of overmaturation and some legal limitations (Fernández, Ordóñez, Bruna, Herranz, & de la Hoz, 2000). Another suggested strategy involves the removal of as much water as possible from meat prior to fermentation by a cold pre-conditioning of fresh meat (Feiner, 2006). However, to the best of our knowledge, no studies have investigated the influence of meat pre-conditioning on salami features. On the contrary, as well reported in some reviews (Fernández et al., 2000; Ordóñez, Hierro, Bruna, & de la Hoz, 1999), several papers deal with the effects of ripening conditions on microbiological, physical and chemical properties of dry fermented sausages.

The aim of this work was to evaluate the effect of different relative humidity values during pork meat conditioning on the quality

Abbreviations: a_w, water activity; B, Blue; B1, Batch 1; B2, Batch 2; FT-NIR, Fourier transform-near infrared; G, Green; LSD, Least Significant Difference; M-NEW, meat conditioned with the new process; M-STD, meat conditioned with the standard process; ANOVA, Analysis of Variance; MIA, Multivariate Image Analysis; NEW, new meat conditioning; PCA, principal component analysis; PC1, first principal component; R, Red; RH, relative humidity; S-NEW, salami obtained from meat conditioned with the new process; S-STD, salami obtained from meat conditioned with the standard process; SNV, standard normal variate; STD, standard meat conditioning.

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characteristics of salami. In particular, two levels of relative humidity (95% *vs.* 80%) were adopted during a 6 days conditioning period at 0 °C.

2. Materials and methods

2.1. Meat and salami samples

Fresh pork shoulders (about 6–7 kg each) conditioned under two different levels of relative humidity were used for industrial salami production. Standard conditioning (STD) lasted 6 days at 0 °C with a relative humidity (RH) of 95%; the new conditioning process (NEW) was carried out at 0 °C for 6 days, but at 80% RH. Two different batches of shoulders (B1 and B2) were used for each conditioning process, and the corresponding treatments were named M-STD1, M-STD2, M-NEW1 and M-NEW2, respectively. For each treatment, three shoulders were analyzed at four different times during conditioning (0, 1, 3, and 6 days). Meat batch, type of conditioning process, and conditioning time have been considered as independent factors in order to study their main and interaction effects.

Salami production consisted of the following steps: grinding and mixing of all ingredients (pork shoulders, salt, sucrose, dextrose, spices, sodium ascorbate, natural flavors, potassium nitrate and sodium nitrite), stuffing in artificial casings, fermentation/drying for five days (at 18–20 °C and 85–88% relative humidity) and ripening for fifteen days (at 10–12 °C for 75% relative humidity).

For each salami type (named S-STD1, S-STD2, S-NEW1, and S-NEW2), a total of thirty samples (about 230 g each) were analyzed at five different times during drying and ripening: 0, 5, 10, 15 and 20 days (ripening time). In this case, meat batch, meat conditioning type, and salami ripening time have been considered as independent factors in order to study their main and interaction effects.

2.2. Meat and salami weight loss

Change in water content of pork shoulders during conditioning and of salami during ripening was evaluated by monitoring the weight loss. Three shoulders per conditioning treatments and six samples per salami type were weighted at each sampling time. Results are expressed as a percentage of the initial weight.

2.3. Meat pH

During conditioning of pork shoulders, pH was measured by means of a pH-meter (EC500, Extech Instruments, Nashua, NH) equipped with the electrode for solid samples. Measurements were carried out in triplicate for each conditioning treatment and time.

2.4. Salami moisture

For each salami type and ripening time, nine slices 0.5 cm thick were cut out from three samples and separately minced by a heavy duty blender (Waring Laboratory, Torrington, CT) for 30 s at the highest speed. Moisture content of each minced slice was then determined by a gravimetric method drying samples in an oven at 105 °C for 16 h. Results are the average of the nine determinations and are expressed as g/100 g.

2.5. Salami texture

Mechanical behavior of salami was evaluated by means of two different empirical rheological tests performed by a TA.HDPlus Texture Analyser (Stable Micro System, Godalming, UK) equipped with a 5 kN load cell and controlled by the Texture Exponent TEE32 V 3.0.4.0 software (Stable Micro System, Godalming, UK).

Table 1
Results of multi-factor ANOVA (probability value) for pork shoulder analytical parameters.

	pH	Weight loss
Main Effects		
Batch (A)	0.0017	0.7704
Conditioning process (B)	0.0111	<0.0001
Conditioning time (C)	0.0034	<0.0001
Interactions		
AB	0.0006	0.9224
AC	0.0001	0.9408
BC	0.9091	<0.0001

2.5.1. Compression of the whole salami

One sample for each salami type and ripening time was subjected as a whole to a compression test in five different points along the major axis. A spherical probe (2.5 cm diameter) was used at a crosshead speed of 2 mm/s. Results are expressed as whole firmness, calculated as the average load at 30% deformation (N).

2.5.2. Compression of salami test pieces

Nine test pieces (2.5 cm width, 2.5 cm length, 1.5 cm height) were cut out from the center of three different samples for each salami type and ripening time. Each test piece was compressed with a flat plate (10 cm diameter) using a crosshead speed of 1 mm/s. Results are expressed as hardness, corresponding to the load at 50% deformation (N).

2.6. Salami image analysis

At each ripening time, the images of eight slices (0.5 cm thick) cut out from the center of two different samples for each salami type were acquired. Image acquisition and elaboration were carried out as reported in Fongaro, Alamprese, and Casiraghi (2015). In particular, Red (R), Green (G), Blue (B), and intensity mean values measured in the RGB space color, as well as the heterogeneity parameter (ranging from 0 for homogeneous surfaces to 1 for heterogeneous surfaces) (Fongaro & Kvaal, 2013) were calculated by using Image-Pro Plus (v. 7.0, MediaCybernetics, Inc., Rockville, MD). The multivariate image analysis (MIA) method developed in our previous work (Fongaro et al., 2015) is able to distinguish different areas in salami slices, on the basis of different saturation levels of Red, which can be associated to different levels of meat oxidation. In fact, the color of salami lean part becomes darker during ripening, due to dehydration and oxidation of myoglobin. By means of the MIA method, different areas of salami slice surface were quantified: high level of meat oxidation (Area 1), intermediate level of meat oxidation (Area 2), meat not yet oxidized (Area 3) and fat (Area 4). MIA was applied using the MACCMIA software (v. 1.81, McMaster Advanced Control Consortium, McMaster

Table 2
Pork shoulder weight loss and pH (mean and standard error values) as a function of batch and conditioning type and time.

Experimental factor	pH	Weight loss (%)
Batch		
B1	5.76 ± 0.01^{a}	1.44 ± 0.01^{a}
B2	5.82 ± 0.01^{a}	1.44 ± 0.01^{a}
Conditioning process		
STD	5.81 ± 0.01^{a}	1.13 ± 0.01^{b}
NEW	5.77 ± 0.01^{a}	1.74 ± 0.01^{a}
Conditioning time (days)		
0	5.85 ± 0.02^{b}	
1	5.77 ± 0.02^{ab}	0.73 ± 0.01^{a}
3	5.78 ± 0.02^{ab}	1.45 ± 0.01^{b}
6	5.76 ± 0.02^{a}	2.14 ± 0.01^{c}

$^{a–c}$: for each experimental factor and each variable, different superscript letters indicate significant differences amongst mean values as calculated by LSD test ($P < 0.001$).