Evaluation of celery extract (Apium greveolens L.) as a natural curing agent in the production of Italian-type Salami with native starter cultures

Avaliação do extrato de aipo (Apium greveolens L.) como agente de cura natural na produção de salame do tipo italiano com culturas iniciadoras nativas

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ABSTRACT

The aim of this study was to evaluate celery extract as a natural curing agent in the production and characterization of Italian-type Salami with native starter cultures SxLp (S. xylosus AD1 and L. plantarum AJ2). Two formulations were produced for Italian-type Salami, to one of which was added 1.4% celery extract (T1) and to the other 0.3% commercial curing salt (T2). Maintaining the same conditions of temperature, relative humidity and air velocity, the salamis were matured for 26 days, and physicochemical, microbiological and sensorial analyses were performed. Starter culture SxLp produced a reduction in pH, promoting greater acidification of salami and reduction of nitrate, allowing color formation in the product. Moreover, the cultures remained viable (> 7 log CFU.g⁻¹), in both treatments, during the 26 days of maturation. The combination of native starter culture with celery extract promoted microbiological safety, adequate texture and the characteristic color of cured meat sausage. Salami T1, containing starter cultures SxLp and celery extract, was well accepted by the judges, most of whom would often buy the product. Thus, the application of celery extract as a curing agent together with the addition of the native starter cultures, proved to be viable for production of Italian-type salami.

Keywords: lactic acid bacteria, fermented sausage, coagulase negative staphylococci, vegetable extract, sodium nitrate.

Resumo

O objetivo deste estudo foi avaliar o extrato de aipo como agente de cura natural na produção e caracterização de salame italiano com culturas iniciadoras nativas SxLp (S. xylosus AD1 e L. plantarum AJ2). Foram produzidas duas formulações para o salame do tipo italiano, a uma das quais foi adicionado 1,4% de extrato de aipo (T1) e a outra 0,3% de sal de cura comercial (T2). Mantendo as mesmas condições de temperatura, umidade relativa e velocidade do ar, os salames foram amadurecidos por 26 dias e foram realizadas análises físico-químicas, microbiológicas e sensoriais. Cultura iniciante SxLp produziu uma redução no pH, promovendo maior acidificação do salame e redução de nitrato, permitindo a formação de cor no produto. Além disso, as culturas permaneceram viáveis (> 7 log CFU.g⁻¹), em ambos os
tratamentos, durante os 26 dias de maturação. A combinação da cultura nativa de partida com o extrato de aipo promoveu segurança microbiológica, textura adequada e a cor característica da salsicha de carne curada. O salame T1, contendo culturas iniciais SxLp e extrato de aipo, foi bem aceito pelos juízes, a maioria dos quais frequentemente comprava o produto. Assim, a aplicação do extrato de aipo como agente de cura, juntamente com a adição das culturas nativas de partida, mostrou-se viável para a produção de salame do tipo italiano.

**Palavras-chave:** bactérias lácticas, embutidos fermentados, estafilococos coagulase-negativos, extrato vegetal, nitrato de sódio.

1 INTRODUCTION

There is a growing consumer demand for meat products with natural additives/preservatives, especially those of vegetable origin, in order to reduce and/or replace the nitrite/nitrate content in these products (Riazi et al., 2016).

In meat sausages, preservatives called curing salts (sodium chloride, nitrate and sodium nitrite) are added to promote color and provide microbiological safety to products (Parthasarathy and Bryan, 2012; Choi et al., 2017), due to the control of pathogenic and spoilage microorganisms, mainly *Clostridium botulinum*, a pathogen responsible for causing botulism and food poisoning (CDC, 2007; Skibsted, 2011).

Thus, natural and organic drying in meat products is widespread and accepted on the market (Riazi et al., 2016). Dried meat products can have plant extracts added, replacing the direct addition of curing salts, since they naturally present the nitrate and favor the formation of the desired color.

To produce meat products without the direct addition of sodium nitrite, a natural source of nitrate and a reductant (microbial enzymes) should be used in combination. After the addition of both compounds to the products, the nitrate can be reduced to nitrite, which is the most promising method to introduce natural sources of nitrite in these products (Sebranek and Bacus, 2007).

There are several vegetable sources of nitrate, such as celery extract (*Apium graveolens* L.), which has been used in meat preparations as a flavoring and curing agent (Keeton et al., 2012; Jin et al., 2018). Celery extract, liquid or powder, is an alternative for application in meat products, due to the absence of pigmentation and the mild flavor that it presents (Bertol et al., 2012).

Moreover, the use of starter cultures in fermented meat sausages aims to obtain microbiologically safe products, standardized and with desirable sensorial aspects (Essid et
The application of native cultures contributes to the specificity and peculiarity of the meat product, since the diversity of metabolic activities presented in function of the enzymatic profile differs from those presented by commercially used starter cultures (Leroy and Vuyst, 2004; Landeta et al., 2013; Cruxen et al., 2018). The cultures characterized as *Lactobacillus plantarum* AJ2 (Sawitzki et al., 2007) and *Staphylococcus xylosus* AD1 (Fiorentini et al., 2009) were isolated from naturally fermented sausages and the possibility of their use as starter cultures in the production of Milano-type salami has already been confirmed.

*Staphylococcus xylosus* strains are important in the production of fermented sausages (Essid et al., 2007; Cruxen et al., 2007), as they are notable for their technological contributions, such as nitrate reductase activity that helps to maintain the color of the products (Chen et al., 2007), while catalase and superoxide dismutase act as natural antioxidants (Barrière et al., 2001). *Lactobacillus plantarum* is an lactic acid bacteria (LAB) responsible for the fermentation of foods, due to its ability to produce lactic acid as the main fermentation product, promoting safety and stability for the product (Leroy et al., 2006; da Costa et al., 2018).

Thus, the aim of this study was to evaluate celery extract as a natural curing agent in the production and characterization of Italian-type Salami with native starter cultures SxLp (*S. xylosus* AD1 and *L. plantarum* AJ2).

### 2 MATERIALS AND METHODS

#### 2.1 MATERIALS

Inspected meat, which was beef (from the foreleg) and pork (from the haunch), as well as pork back fat, was purchased in local stores in the city of Pelotas/RS, Brazil. The celery extract (*Apium graveolens* L.) was supplied by Naturex Ingredientes Naturais Ltda (Brazil).

#### 2.2 STARTER CULTURES AND GROWING CONDITIONS

The starter cultures SxLp belong to the collection of cultures at the Food Microbiology Laboratory - Department of Science and Agroindustrial Technology, Federal University of Pelotas (UFPel), Brazil. The starter cultures were isolated from naturally fermented meat sausages and characterized by Fiorentini et al. (2009) and Sawitzki et al. (2007). *Staphylococcus xylosus* AD1 was cultivated in Brain Heart Infusion broth (BHI, Merck, Darmstadt, Germany) and *L. plantarum* AJ2 was cultivated in De Man, Rogosa and Sharpe...
broth (MRS, Merck, Darmstadt, Germany) in shaker (Agimax model AG - 45) under constant agitation (100 rpm/minute) for 8 h. The cell mass of each microorganism was lyophilized (lyophilizer, Liotop, Liobrás, Brazil) and stored at -80 °C.

2.3 MANUFACTURE OF ITALIAN-TYPE SALAMI

Meat (pork and beef) and pork back fat, both cooled, were ground separately in a meat grinder (Metvisa, Brazil) on a 6 mm and 8 mm disk, respectively, packed in plastic bags and stored at -18 °C. Afterwards, the meat and the pork back fat were mixed in a mixer (Skymsen, Brazil). Subsequently, additives and condiments were added and the mass was homogenized. When the temperature of the mixture reached 18 °C, the starter cultures (10 log CFU.g⁻¹) were added to the mixture and homogenized again. The meat mixture was put into collagen casings of 50 mm diameter size (Global Casing Imp and Exp, Ukraine). The casing of the meat blend was done in a recessing machine (Malta, Brazil), and the pieces of salami were molded and tied manually, weighing about 250 to 300g each. The sausages were then stored in a chamber for fermentation/maturation (Frilux®) with temperature between 14 and 15 ºC, relative humidity between 76 and 79% and air velocity between 0.2 and 0.5 m/s for 26 days.

The base formulation of Italian-type salami consisted of 70% pork, 20% beef, 10% pork back fat, 2.7% salt (Diana, Brazil), 0.5% salami condiments (Bremil, Brazil), 1.0% antioxidant (Kraki, Brazil), 0.2% milk powder (Nestlé Nest, Brazil) and 0.0125% of each native starter culture SxLp, in a 1:1 ratio. Two salami formulations were elaborated: T1 - with addition of 1.4% of celery extract (Naturex, Brazil); and T2 - with addition of 0.3% commercial cure salt B002 (Bremil, Brazil). The experiment consisted of two biological replicates and the analyses were performed in duplicates.

2.3.1 Physicochemical analyses

The determination of pH (DM-22, Digimed®) and acidity of salamis was carried out at the initial time and at 1, 2, 3, 4, 5, 6, 7, 14, 21 and 26 days of ripening according to the method described by AOAC (2012). The evaluation of weight loss was calculated, in the same periods, by the ratio between the salami mass immediately after its preparation and the mass of each reading, when weighed individually, on analytical scales (Shimadzu, AUY 220, Brazil). At times 1, 3, 5, 7, 14, 21 and 26 of ripening, the water activity (Novasina AG, Tecnal, Switzerland) was determined.
The concentration of nitrate (T1) and nitrite (T2) was determined at the initial time, and residual nitrite in the final product (26 days of ripening) (BRASIL, 1999). Analyses of the centesimal composition (AOAC, 2012), sodium (AOAC, 2012), texture (Bourne, 1978), color and thiobarbituric acid reactive substances (TBARS) were carried out in the final product. To determine TBARS, the methodologies proposed by Raharjo, Sofos and Schmidt (1992) and Yildiz-Turp and Serdaroglu (2010) were adapted. The color of the salamis was obtained through the parameters L, a* and b*, with measurements performed with a colorimeter (Minolta CR 300, Japan).

2.3.2 Microbiological analyses

2.3.2.1 Viability of starter cultures SxLp

The viability of the cultures SxLp followed the protocol for coagulase-negative Staphylococcus (CNS) and LAB (APHA, 2002). Analyses were performed from samples of salami at 0, 7, 14, 21 and 26 days of ripening.

2.3.2.2 Evaluation of the microbiological quality of salamis

The presence of Salmonella spp. was evaluated, and coliforms at 45 °C and coagulase-positive Staphylococcus counts were made, according to APHA (2002), after 26 days of ripening. These analyses were carried out with the purpose of ensuring the quality and microbiological safety of the salamis provided to the evaluators during the sensorial analysis.

2.3.3 Sensory evaluation

To evaluate salami with celery extract (T1) regarding its sensory characteristics, the protocol followed ISO 11136:2014 (ISO, 2014). The sensory analysis was performed at 7 days of ripening with 54 non-trained evaluators, who consume salami regularly. It took place between 9 and 11 a.m., in individual booths under fluorescent light, relative humidity 68% ± 2 and temperature 22 °C ± 1. The evaluation was used for the attributes of flavor, aroma, color, consistency and overall impression, using a structured hedonic scale of 9 points, with variation from ‘I liked it very much’ (9 points) to ‘I disliked it very much’ (1 point). The intention of purchase test was also applied through the structured hedonic scale of 5 points. The project was approved by the Human Research Ethics Committee of the Medical Faculty of UFPel, under registration 28117314.1.0000.5317.
2.4 STATISTICAL ANALYSIS

The results were submitted to analysis of variance (ANOVA) and the means were compared by the Student t-test with a level of 5% of significance.

3. RESULTS AND DISCUSSION

3.1 CHARACTERIZATION OF ITALIAN-TYPE SALAMI

3.1.1 Physicochemical analyses

The starter cultures (SxLp) promoted increased acidification and a reduction in pH values during the fermentation phase (0-7 days), which presented no difference (p> 0.05) between the treatments (Fig. 1). However, pH increased from the 14th day, due to decarboxylation reactions and deamination of amino acids, releasing ammonia and alkalizing the medium (Benito et al., 2004). At the end of the process, the pH values stabilized at approximately 5.06 (T1) and 5.15 (T2). Jin et al. (2018) observed similar behavior, where the salamis with 0.8% of celery powder added had pH values similar to that of the control (0.01% of sodium nitrite), which also increased with ripening of the product.

The acidification process is important because it contributes to inhibiting the undesired microbiota, promoting the pH reduction until reaching the isoelectric point of the proteins causing the water to be released from the sausage. This reduces water activity and confers desirable properties, such as the sliceability of the product (Pinto et al., 2001). In addition, Lactobacillus is one of the LAB that are desirable for the acidification process, since it is homofermentative, producing lactic acid as the main metabolite of the fermentation, promoting the necessary acidity of salami (Shimokomaki et al., 2006). Sawitzki et al. (2008) observed values for acidity in Milano-type Salami with L. plantarum AJ2 of 1.00 ± 0.06 g/100g lactic acid, a lower result than the one found in this study, which presented in the final product values of 1.54 ± 0.113 and 1.37 ± 0.16 for T1 and T2, respectively.

The water activity of the meat product was the main parameter that determined the end of the ripening period. The $a_w$ values were gradually reduced until the end of the maturation process, in both treatments (Fig. 1). In the elaboration of meat sausage with the addition of Allium hookeri, Song et al. (2014) also verified that the water activity decreased significantly during 60 days of ripening. In the present study, the product was considered ready for consumption when it reached $a_w$ of 0.88 (T1 and T2), since the technical regulation of identity and quality of the Italian-type salami (BRASIL, 2000) recommends a maximum of $a_w$ of 0.90. Because they are consumed raw, fermented meat sausages must have $a_w$ lower than 0.91,
ensuring the preservation of the product, since this makes the multiplication of pathogenic bacteria difficult.

The weight reduction of the product in function of the ripening time was related to the decrease in the water content of the product. This reduction contributes to the texture of the final product and the development of the salami’s characteristic flavor. When producing fermented salami produced with sheep meat and native starter cultures, Cruxen et al. (2018) obtained results of approximately 45% weight loss, similar to those found in the present study, which were 40.5% (T1) and 42.5% (T2), and these did not differ between treatments (p > 0.05).

Fermented meat sausages are also characterized by their low humidity content (Fabbri et al., 2011). In the present study, no difference (p > 0.05) was observed between the humidity values obtained for both treatments (Tab. 1). However, after 26 days of ripening, the percentages were higher than those recommended by the legislation (BRASIL, 2000), which recommends humidity less than 35% in the final product. The factors that may have contributed to this difference are the relative humidity of the air, air velocity and temperature of the ripening chamber, which did not present significant variation during the period of fermentation/ripening of sausages. The increase in ripening time could possibly lead to the reduction of humidity up to the levels recommended by the legislation. In addition, humidity also influences the sensory characteristics, since lipolysis and proteolysis reactions require an aqueous medium to occur, influencing the color, texture, firmness of the meat product, increasing the conservation and hindering the development of microorganisms (Ladera et al. al., 2013).

Regarding the percentage of proteins and lipids, a difference (p > 0.05) was observed between the treatments, where the protein content was higher in T1 and that of lipids was higher in T2 (Table 1). Although the same percentage of beef (20%), pork (70%) and pork back fat (10%) were used in the preparation of the salami, which are the main ingredients contributing to the composition of proteins and lipids, the difference between treatments can be attributed to a lack of uniformity in the samples (pork back fat and meat). However, it was observed that both the protein content and the lipid content complied with the legislation (BRASIL, 2000), which establishes a minimum of 25% of proteins and a maximum of 32% of fats.

It was observed that there was no difference (p > 0.05) between treatments (T1 and T2) for ash composition. On the other hand, T1 presented a lower amount of sodium (p > 0.05)
than T2 (Table 1). However, the values found for both analyses are in agreement with the legislation (BRASIL, 2000).

Sodium nitrate (NaNO₃) added to meat products will have an action if it is reduced to sodium nitrite (NaNO₂). This reduction occurs due to the action of bacteria from the families Staphylococcaceae and Micrococcaceae. Studies have shown that S. xylosus is able to reduce nitrate by the action of the enzyme nitrate reductase (Talon et al., 1999; Barrière et al., 2001; Cruxen et al., 2017). In the present study, S. xylosus AD1 was able to convert the nitrate present in the celery extract, added as a curing agent, to nitrite (T1). Nitrite is responsible for the color development and antimicrobial activity. In fermented meats, nitrite is reduced to nitric oxide by the action of the enzyme nitrite reductase, when the pH of the medium is between 5.6 and 6.2 (Arnau et al., 2007). In treatment T2, we can observe that the residual nitrite content, at the end of the ripening time, differed (p> 0.05) from the treatment of celery extract (T1) (Tab. 1). This difference probably occurred because in T1 the addition was nitrate, which had to be reduced to nitrite, while in T2, nitrite was already present, requiring no conversion. Despite this difference, residual nitrite values in both treatments were considered low (6.43 mg.kg⁻¹ for T1 and <5.00 mg.kg⁻¹ for T2), since Brazilian legislation establishes a limit nitrite residual of 150 mg.kg⁻¹ of product (BRASIL, 2019). It was found that the nitrate present in the celery extract can be used as a source of nitrite in meat sausage, but it is necessary to provide conditions for the reactions to occur, such as CNS presence and low pH, by the production of lactic acid by LAB.

The evaluation of lipid oxidation in meat products aims to quantify the malonaldehyde present in the sample, one of the main peroxide decomposition products formed during the oxidative process and associated with rancidity in foods (Choi et al., 2011). Moreover, the celery extract has in its composition betalains, which also have antioxidant activity and promote the elimination of free radicals (Georgiev et al., 2010). Wang et al. (2018) verified that the TBARS values in pork salami did not differ between the treatments (control - with 150 ppm of nitrite and T1 - with addition of 3% of celery). These results corroborate those obtained in this study, 1.10 and 1.24 mg of malonaldehyde.Kg⁻¹/sample in T1 and T2, respectively, which did not differ among themselves (Tab. 1).

The development of the texture during fermentation is determined by the reduction of the pH, whereas the stage of ripening is determined by the loss of water. Another factor that influences the texture of the salamis, as far as sliceability and firmness go, is the formation of gel, due to the coagulation of the myofibrillar proteins solubilized by the salt. This coagulation
by acidification involves the formation of more stable aggregates associated with the release of water. The gel formed is stabilized by the release of water, which occupies spaces between the aggregates and forms a matrix that involves fats and connective tissues, determining the texture of sausages (Kerry et al., 2002). In the present study, the values found for shear force were 31.16 N (T1) and 58.60 N (T2), differing from each other (p > 0.05) (Table 1). Jin et al. (2018), when producing salami with 0.8% celery extract, obtained 1.98 kgf (19.80 N) of shear force at 28 days of ripening, which was lower than values obtained in the present study.

Table 1. Centesimal composition, sodium, residual nitrite, thiobarbituric acid reactive substances (TBARS) and texture (shear force) of Italian-type salami with native starter cultures

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T1</td>
</tr>
<tr>
<td>Humidity (%)</td>
<td>47.46 ± 2.23a</td>
</tr>
<tr>
<td>Proteins (%)</td>
<td>29.73 ± 1.31a</td>
</tr>
<tr>
<td>Lipids (%)</td>
<td>19.79 ± 1.09b</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>7.55 ± 0.09a</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>696.26 ± 0.01b</td>
</tr>
<tr>
<td>Residual nitrite (mg.kg⁻¹)</td>
<td>6.43 ± 0.55a</td>
</tr>
<tr>
<td>TBARS (mg)</td>
<td>1.10 ± 0.05a</td>
</tr>
<tr>
<td>Malonaldehyde.kg⁻¹</td>
<td></td>
</tr>
<tr>
<td>Shear force (N)</td>
<td>31.16 ± 0.18b</td>
</tr>
</tbody>
</table>

The means followed by the same letter in the line, for each treatment, did not differ p < 0.05 by the Student t-test. T1: with addition of 1.4% celery extract, T2: with addition of 0.3% commercial curing salt.

Due to the different salami formulations, for samples of the T1 treatment, nitrate concentration (278 mg.kg⁻¹) at the initial time was determined because the celery extract contained only this compound, and for the T2 treatment the concentration of nitrite (62.80 mg.kg⁻¹), since commercial curing salt was used.

The effects of curing agents (natural and commercial) on the color of the salamis during 26 days of ripening are shown in Table 2. A difference (p > 0.05) in color was observed only for the parameter $L^*$, indicating that the addition of celery extract (T1) made the samples darker than those with commercial curing salt addition (T2). The parameter $L^*$ of the control sample (T2) presented a value significantly higher than T1 (with addition of celery extract). This difference can be attributed to the direct addition of nitrite in T2.
The results of ΔE found for samples T1 and T2 presented ΔE of 5.37; however, visually no color differences were observed between the samples, possibly due to this value being very close to 5. According to Ramos and Gomide (2007), ΔE greater than 5 indicates that the samples can be differentiated through the perception of color by the human eye, and values above 12 imply absolute color difference and can be perceived even by untrained judges.

Table 2. Color parameters at the 26th day of ripening of Italian-type salami

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T1</td>
</tr>
<tr>
<td>L</td>
<td>48.81±1.91b</td>
</tr>
<tr>
<td>a*</td>
<td>15.34±0.90a</td>
</tr>
<tr>
<td>b*</td>
<td>10.47±0.77a</td>
</tr>
</tbody>
</table>

Same letters in the line do not differ statistically at the significance level of 5%. T1: with addition of 1.4% celery extract, T2: with addition of 0.3% commercial curing salt.

3.1.2 Microbiological analyses

In the raw material (meat), the CNS viable cell count was 8.78 log CFU.g⁻¹, while LAB was 3.43 log CFU.g⁻¹. Treatment products T1 and T2 presented CNS and LAB count at initial time of 8 log CFU.g⁻¹ and 7 log CFU.g⁻¹, respectively. In addition, they remained viable throughout the ripening process, reaching counts at 26 days of 7 log CFU.g⁻¹ and 8 log CFU.g⁻¹ for CNS and LAB, respectively.

In the present study, it was possible to observe that starter cultures SxLp were not inhibited by the added vegetable extract in the product. This result is important because these cultures are responsible for the physicochemical, microbiological and sensorial characteristics of sausages (Cruxen et al., 2019). Lactobacillus spp. multiply rapidly during the first days of fermentation due to the production of lactic acid in the exponential phase, promoting a significant decrease of pH. It was possible to observe that these bacteria remained viable, corroborating studies developed by Cruxen et al. (2018) and Schilling et al. (2018).

Studies indicate a decrease in counts of CNS bacteria during the fermentation processes of fermented sausage production due to acidification promoted by LAB (Cruxen et al., 2018). In the present study this did not occur; from the beginning of the fermentation to the end of the ripening period, CNS remained viable, with cell counts of 6 to 8 log CFU.g⁻¹.

Regarding the microbiological safety of salami, it was verified at the 26 days of ripening that the treatments presented satisfactory results for the analyses of Salmonella spp.,
coagulase-positive *Staphylococcus* and coliforms at 45 °C, remaining within the standards recommended by the legislation (BRASIL, 2001).

### 3.1.3 Sensorial analysis

For all the sensorial attributes evaluated, the values attributed to the Italian-type salami with celery extract (T1) reached 7.5 points on the hedonic scale, indicating that the judges liked the product moderately, presenting 80% product acceptability. With the purchase intention test, it was found that the product (T1) developed would be acquired always/very frequently/frequently by 74.08% of the judges.

The sensory characteristics of a product are the result of the complex interaction between physicochemical, biochemical and microbiological processes. These processes present a fundamental role in the formation and equilibrium of chemical compounds and in the modification of molecules responsible for appearance and texture. The use of native starter cultures is a differential in the sensory parameters of meat sausage, giving them specific attributes (Cruxen et al., 2017). Jin et al. (2018) evaluated the celery extract (0.8%) as a meat sausage curing agent and found that the addition of the compound did not interfere with the product acceptance. The results obtained in the present study also indicate that the addition of celery extract, even in a higher concentration (1.4%) to that in the cited study, did not affect the acceptability of the product and the intention of purchase by the judges.

### 4 CONCLUSION

The addition of 1.4% of celery extract was efficient as a source of nitrate, ensuring color stabilization and native starter cultures contributed to the reduction of nitrate to nitrite, acidification, microbiological safety and the texture of Italian-type salami. Due to the physicochemical and microbiological parameters that meet the conventional standards and the positive effect of the product on the sensorial characteristics, the application of celery extract and the addition of native starter cultures proved to be a viable alternative for the production of Italian-type salami.

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CONFLICT OF INTEREST
The authors declare that they have no conflict of interest.

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Figure 1. Values of pH (a), acidity (b), water activity (c) and weight loss (d) during the fermentation/ripening period of Italian-type salami. T1: with addition of 1.4% of celery extract, T2: with addition of 0.3% of commercial curing salt.