

Reduction of Drying and Ripening Times During the Italian Type Salami Production

^{1,2}Gustavo Graciano Fonseca, ²Paulo Sérgio da Silva Porto and
²Luiz Antonio de Almeida Pinto

¹Departamento de Química, Universidade de São Paulo,
CEP 05424-970, São Paulo, SP, Brasil

²Departamento de Química, Fundação Universidade Federal do Rio Grande,
C.P. 474, Rio Grande, RS, Brasil

Abstract: Salami is a product which preparation time varies notably in function of some parameters, especially its size. This study carried out in a company to verify in industrial scale the possibility of the reduction of the days of process. Drying curves were done for salami with 60 mm diameter and 240 and 260 mm lengths, corresponding to masses of 776 and 852 g, respectively. In the current conditions, the process time was of 38 days. It was concluded that the maintenance of the 7 days of pre-ripening, a reduction in the period of the first ripening from 13 to 7 days and in the second ripening from 18 to 17, totaling 31 days, reached the desired humidity, occurring no alterations in the final product characteristics. Through non-linear regression analysis it was verified that the obtained parameters of the drying curves, had presented excellent adjustment of correlation ($R^2 > 99\%$).

Key words: Dry fermented sausage, Italian type salami, processing time

Introduction

Salami is a typical Italian seasoned sausage obtained from different types of pork meat and chopped in several different sizes according to the variety of the salami (Procida *et al.*, 1999). Numerous varieties have been developed based on local traditional recipes leading to products with different compositions, degrees of comminution of the ingredients, casing diameters, seasonings, application of smoking, use of molds and ripening time (Fernández *et al.*, 2000).

The production process depends mostly on the skill and experience of the manufacturer. In the past, dry sausages were manufactured using traditional craft methods and despite increasing industrialization, the continuous processes were developed on an empirical basis. However, both commercial competitiveness and increasing demand in the market for higher quality products have led the need of improving the conditions for ripening (Bello and Sanchez-Fuertes, 1997). Intensive research into ripening process was due to traditional empirical methods of manufacture, not being able to meet the requirements of large-scale low-cost industrial production. In the industrial production, the number of problems rises when is tried to obtain similar products to the traditional ones, with highly standardized forms in short ripening times (Fernández *et al.*, 2000; Procida *et al.*, 1999).

The manufacture of dry fermented sausages is considered to occur in three phases: formulation, fermentation and ripening/drying. The time and energy requirements for the ripening process contribute largely to the total costs of fermented sausage manufacture due to its lengthy duration. Therefore, acceleration of the ripening would result in a reduction of the storage time and would increase the profit margin and the competitiveness of the end product (Fernández *et al.*, 2000). Different strategies have been developed to reduce ripening/drying time. The first assays for accelerating the production were addressed to shorten the drying process, through the removing of as much water as possible prior to

Corresponding Author: Gustavo Graciano Fonseca, Departamento de Química, Universidade de São Paulo,
CEP 05424-970, São Paulo, SP, Brasil Tel: +55-11-3091-2282 Fax: +55-11-3091-2284

fermentation by freeze-drying of the meat, reduction of the water binding capacity of the better by using PSE meat and drying under vacuum (Pardi *et al.*, 1994). These approaches certainly reduce the drying time, but flavor development can be affected, resulting in a less intensive or unbalanced flavor due the shorter processing time.

Salami quality depends on the quality of the raw materials and the technology of production. Thus, a variety of processing practices have been developed using different raw materials, ageing times and manufacturing techniques (Toldrá *et al.*, 1997; Virgili *et al.*, 1997), chemical and enzymatic mechanisms during maturing (Careri *et al.* 1993; Buscalihon *et al.* 1994) and start cultures (Geisen *et al.*, 1992; Nuñez *et al.*, 1996; Toledo *et al.*, 1997). Moreover, most of the sensory properties of dry fermented sausages can be attributed to proteins and lipids, or to compounds produced by the further degradation of these products (amino acids and free fatty acids) during the ripening process. For this reason several authors have attempted to accelerate the ripening process by adding proteases and lipases (Blom *et al.*, 1996; Díaz *et al.*, 1996, 1997; Fernández *et al.*, 1995; Melendo *et al.*, 1996).

However, the easiest and safest way to reduce ripening times is through the optimization of the production conditions. Moreover, by an adequate control of the process, the probability of damaged product that can compromise its acceptability is reduced. Thus, the present study was carried out with the objective to verify in industrial scale the possibility of the reduction the process time of two different varieties of Italian type salami produced in a Brazilian plant by the modification of the permanence time of salami in determined ripening operational conditions.

Materials and Methods

The present study was conducted in one of the largest food companies and exporters in Latin America, located in the State of Rio Grande do Sul, Brazil, during the year of 2005.

Processing Stages

Processing includes diverse operations: preparation and cooling of raw materials, mixing, inlaying and drying/ripening (divided in three distinct phases), embedding and packing.

Preparation, Mixture and Embedding of the Mass

After a minimum 24 h cooling time for swine meat and 48 h unfreezing and cooling time for bovine meat, the raw materials were milled. The cooling of the meat was made among 2-7°C. The meat was cut in wide straps to increase the surface in contact with air to favor a certain loss of humidity. The milling of meat was made in 5-8 mm for swine and 3-5 mm for bovine one and in 5-10 mm knives for lard milling that was not cooled to make the work easier. Milled meat portions were weighted and mixed with condiments and additives. Each batch of Italian type salami was necessarily constituted by bovine meat, swine meat and lard. Salt, sugar, GDL (glucone-delta-lactone), ripening salts, dry milk and casein were used as condiments.

From the mixer, the batch was conducted to the inlaying equipment. The salami desired size was regulated and artificial gut coil added to start the inlay. The gut received a previous treatment that consists of diving it into a tank with warm water (40°C). To each gut coil 25 g of Delvovid (Degussa BioActives) was added. The salami was placed in wooden laths and then taken for the drying/ripening chambers.

Drying and Ripening

During the drying/ripening time, salami crosses through three distinct stages: The first one, pre-ripening, during 7 days at 16-18°C temperature range and 86-92% relative humidity; the

Table 1: Operational conditions in the pre-ripening chambers

Step	Time (h)	RH (%)	Temperature (°C)
1	16	88	12
2	10	90	18
3 ^a	20	90-92	18
4 ^a	20	90-92	18
5 ^a	20	90-92	18
6 ^b	20	88-90	18
7 ^b	20	88-90	18
8	20	88-90	17
9	24	86-88	16

a,b: Steps with same Relative Humidity (RH) and temperature conditions, but different air speeds

Table 2: Operational conditions in the ripening chambers

Ripening	Time (days)	RH (%)	Temperature (°C)
1	13	82-88	10-12
2	18	76-80	12-14

RH: Relative Humidity

subsequent one, the first stage of ripening, during 13 days at 10-12 °C temperature range and 82-88% relative humidity and the last one, the second stage ripening during 18 days at 12-14 °C temperature range and 76-80% relative humidity. The air speed varied from 0.1 to 0.8 m sec⁻¹. The stages were carried out in cooled chambers, called pre-ripening and ripening chambers. Table 1 and 2 show the operation conditions for pre-ripening and ripening (first and second stages) chambers.

After drying/ripening stages, salami was washed with water, through an aspersion with coils, to remove the developed mildew. After 24 h of drying, salami was covered with vegetal oil and anti-mildew (potassium sorbet solution 2.5%).

Analytical Procedures

Drying curves were obtained utilizing triplicate salami samples. Salami had 240 and 260 mm length and 60 mm of diameter corresponding to 776 and 852 g, respectively. The preparation, mixing and inlaying of the mass had been carried out as described in previous section. The drying/ripening was carried out in three distinct stages, according to Table 1 and 2.

The samples were weighed every 8 hours in pre-ripening, every 12 h in the first stage ripening and every 24 h in the second stage ripening. The produced salami possessed 56.5% initial wet basis moisture content and the desired final moisture content is 35%. It was determined according to AOAC (1990) method. In the current operational conditions (38 days time process), the salami average final moisture content was 33.7%. Drying curves were determined from experimental data and fitted applying statistical analysis with non-linear regression through the least squares method.

Results and Discussion

Experimental data were fitted using a polynomial model. It was evidenced that the third order model reached the best correlation (R^2). Figure 1 and 2 show the drying curves fitted to a third order model for the samples of 240 and 260 mm length, respectively, whose experimental assays were obtained in the current industrial conditions. According to Fig. 1, the experimental data for samples with 240 mm length follow the model until approximately the thirteenth day; after that they diverge. In Fig. 2 the same behavior can be observed for samples with 260 mm length. Physically, the explanation for this lump in the drying curves is that the process conditions are not more able to promote the dehydration of the product due the existence of a dynamic equilibrium among humidity of the product and environment (Treybal, 1981). The sample reaches the equilibrium with the 82 to 88% relative humidity and 10 to 12 °C temperature.

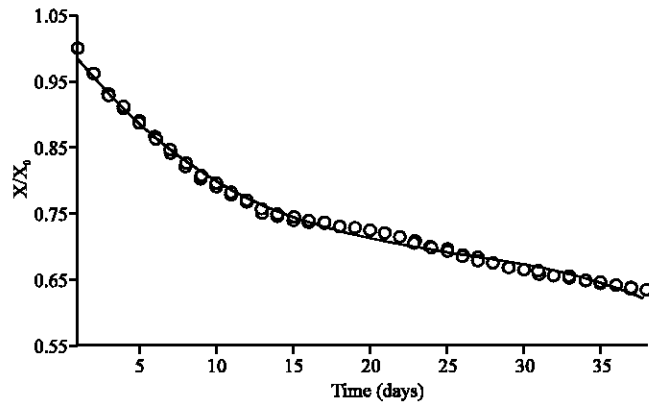


Fig. 1: Drying curve fitted to a third order model for the samples of 240 mm length/current conditions

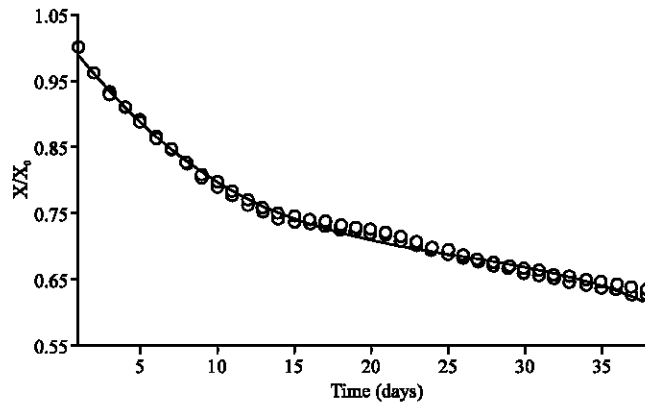


Fig. 2: Drying curve applied to a third order model for the samples with 260 mm length/current conditions

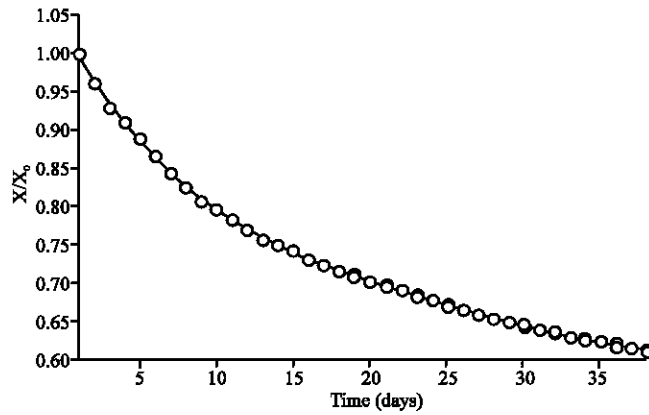


Fig. 3: Drying curve fitted to a third order model for the samples with 240 mm length/proposed conditions

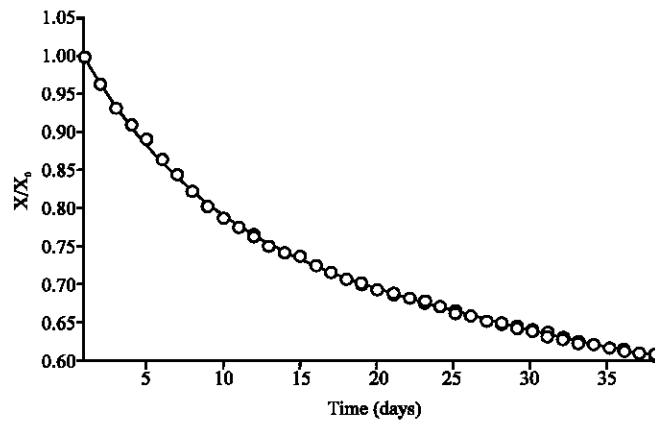


Fig. 4: Drying curve applied to a third order model for the samples with 260 mm length/proposed conditions

Table 3: Models and correlations for the two Italian type salami standards and conditions (current and proposed)

Condition	Model	R ² (%)
240 mm/776 g current	$\left(\frac{X}{X_0}\right) = 1,017 - 0,031 t + 0,001 t^2 - 1,38 \times 10^{-5} t^3$	99,72
240 mm/776 g proposed	$\left(\frac{X}{X_0}\right) = 1,016 - 0,029 t + 8,899 \times 10^{-4} t^2 - 1,05 \times 10^{-5} t^3$	99,91
260 mm/852 g current	$\left(\frac{X}{X_0}\right) = 1,020 - 0,032 t + 0,001 t^2 - 1,410 \times 10^{-5} t^3$	99,72
260 mm/852 g proposed	$\left(\frac{X}{X_0}\right) = 1,021 - 0,031 t + 9,556 \times 10^{-4} t^2 - 1,130 \times 10^{-5} t^3$	99,94

Therefore, a reduction of the first stage ripening time to 7 days was proposed. According to the results, 6 days in the first stage ripening would be enough, but a safety margin was selected. Analogously, Fig. 3 and 4 indicate the drying results obtained for salami samples with 240 and 260 mm length, respectively, whose experimental assays were obtained according to the proposed conditions. As it could be observed, both situations presented a constancy in the humidity reduction, without occurring points out of the model, what is physically justified by the existence of drying during all the process, without periods of stagnation. This linear drop was also observed by Cavenaghi (1999) and Garcia *et al.* (2000) during salami manufacturing.

Table 3 shows the models and correlations obtained for the two Italian type salami standards (240 mm/776 g and 260 mm/852 g) and the two different conditions (current and proposed). Comparing the two conditions, the experimental data from the proposed conditions presented a better correlation coefficient (R²) when fitted to the polynomial curve, what suggests its higher affinity to the model.

The ripening of inlayed salami is carried out through very different criteria depending on the typology of the products (Pardi *et al.*, 1994). Salami, if correctly ripened, is a steady product, but notable modifications can occur on flavor, mainly related to excessive losses of water and transformations of the adipose tissue, that can be easily oxidized at the surface (Môheler, 1980). Thus,

special care must be taken to maintain the desirable characteristics of the final product. The use of controlled acclimatization allowed the attainment of products with high standardization profile, what was observed by the behavior of the triplicate samples, for each studied situation, supplying sufficiently adjusted models. The maintenance of the temperature of pre-ripening in the range of 16 and 18°C and relative humidity between 86 and 92% revealed convenient for fast salami dehydration.

It is important to keep the relative humidity high in the first days (90%) to prevent the extreme drying of the surface and controlled during the following stages, until reaching the desirable color, acidification and final moisture content of the product (Pardi *et al.*, 1994). The proposed process alterations on the first and second stages of ripening did not provoke neither physical nor sensorial alterations in the final product. Two types of problems of physical order referring to an inadequate technological process of salami drying were avoided: incrustation, characterized by an internal barrier (crust) that forms due the fast moisture loss which hinders the adequate drying of the internal section of the salami, or wrinkling, which is the deformation of the salami caused by moisture loss.

According to Brazilian Legislation, the maximum humidity content for salami is 35% (Brazil, 2000). However, Cavenaghi and Oliveira (1999) analyzed six commercial marks of salami from Brazil and determined humidity contents varying from 30.9 to 37.1%. From the economic point of view, it is important to keep this parameter very well controlled to avoid neither loses in the product mass (due moisture loss more than necessary) nor injury the consumer (that buy a product with more moisture instead of meat) and consequently suffer legal penalties.

A modification of the currently used salami ripening process was proposed and analyzed in this work: the maintenance of the 7 days pre-ripening, with a reduction in the first stage ripening from 13 to 7 days and in the second stage from 18 to 17, totaling 31 days. These alterations allowed moisture content reduction in the analyzed samples with no collateral effects on the characteristics of the final product. The current 38 days protocol produces salami with final average moisture content of 33.7%, which means an extra loss of 1.3% of humidity.

It is believed that through the observation of conditions already used the industries allied to simple transport phenomena tools are the still more efficient way to reduce the ripening time of inlayed salami. This way, damage risks in the final quality of the product are eliminated by a rigid control in the process conditions.

References

- AOAC, 1990. Association of Official Analytical Chemists. Official Methods of Analysis, Washington.
- Bello, J. and M.A. Sanchez-Fuertes, 1997. Development of mathematical model to describe the acidification occurring during the ripening of dry fermented sausage. *Food Chem.*, 59: 101-105.
- Blom, H., B.F. Hagen, B.O. Pedersen, A.L. Holck, L. Axelsson and H. Næs, 1996. Accelerated production of dry fermented sausage. *Meat Sci.*, 43: 229-242.
- Brazil. Ministério da Agricultura, Pecuária e Abastecimento, 2000. Normative Instruction No. 22.
- Buscalihon, S., G. Gandemer and G. Monin, 1994. Time-related changes in intramuscular lipids of French dry-cured ham. *Meat Sci.*, 37: 245-255.
- Careri, M., A. Mangia, G. Barbieri, L. Bolzoni, R. Virgili and G. Parolari, 1993. Sensory property relationships to chemical data of Italian-type dry-cured ham. *J. Food Sci.*, 58: 968-972.
- Cavenaghi, A.D., 1999. Associated use of starters cultures in the production of Italian type salami. Msc. Thesis, USP, São Paulo (In Portuguese).
- Cavenaghi, A.D. and M.N. Oliveira, 1999. Influence of some physical-chemical and sensorial characteristics in the quality of Italian type salami manufactured in Brazil. *Revista Nacional da Carne*, 23: 44-48 (In Portuguese).

- Díaz, O., M. Fernández, G.D. García de Fernando, L. de la Hoz and J.A. Ordóñez, 1996. Effect of the addition of papain on dry fermented sausage. *J. Sci. Food Agric.*, 71: 13-21.
- Díaz, O., M. Fernández, G.D. García de Fernando, L. de la Hoz and J.A. Ordóñez, 1997. Proteolysis in dry fermented sausages: The effect of selected exogenous proteases. *Meat Sci.*, 46: 115-128.
- Fernández, M., L. de la Hoz, O. Díaz, I. Cambero and J.A. Ordóñez, 1995. Effect of the addition of pancreatic lipase. *Meat Sci.*, 40: 351-362.
- Fernández, M., J.A. Ordóñez, J.M. Bruna, B. Herranz and L. de la Hoz, 2000. Accelerated ripening of dry fermented sausages. *Trends Food Sci. Technol.*, 11: 201-209.
- García, F.T., U.A. Gagleazzi and P.J.A. Sobral, 2000. Variation of the physical and chemical properties of Italian type salami during dehydration and fermentation. *Braz. J. Food Technol.*, 3: 151-158 (In Portuguese).
- Geisen, R., F.K. Lilcke and L. Krbckel, 1992. Starter and protective cultures for meat and meat products. *Fleischwirtsch.*, 72: 894-898.
- Melendo, J.A., J.A. Beltrán, I. Jaime, R. Sancho and P. Roncalés, 1996. Limited proteolysis of myofibrillar proteins by bromelain decreases toughness of coarse dry sausage. *Food Chem.*, 57: 429-433.
- Móheler, K., 1980. *The Smoking. Science and Technology of the Meat. Theory and Practice.* Acirbia, Zaragoza (In Spanish).
- Núñez, F., M.M. Rodríguez, M.E. Bermúdez, J.J. Córdoba and M.A. Asensio, 1996. Composition and toxigenic potential of the mould population on dry cured Iberian ham. *Intl. J. Food Microbiol.*, 32: 185-197.
- Pardi, M.C., I.F. Santos, E.R. Souza and H.S. Pardi, 1994. *Hygiene and Technology of the Meat Vol. 1.* Editora da UFF, Goiânia (In Portuguese).
- Procida, G., L.S. Conte, S. Fiorasi, G. Comi and K.G. Favretto, 1999. Study on volatile components in salami by reverse carrier gas headspace gas chromatography-mass spectrometry. *J. Chromatogr. A*, 830: 175-182.
- Toldrá, F., M. Flores and Y. Sans, 1997. Dry-cured ham flavor. Enzymatic generation and process influence. *Food Chem.*, 59: 523-530.
- Toledo, V.M., M.D. Selgas, M.C. Casas, J.A. Ordóñez and M.L. García, 1997. Effect of selected mould strains on proteolysis in dry fermented sausages. *Z. Lebensm.-Unters.-Forsch.*, 204: 385-390.
- Treybal, R.E, 1981. *Mass Transfer Operations.* 3rd Edn., McGraw-Hill, Auckland.
- Virgili, R., G. Parolari, C.S. Bordini and C. Schivazappa, 1997. Sensory and analytical investigations into six types of European hams: Parma, Serrano, Bayonne, Italian country-style, Iberian and Corsican. *Ind. Conserve*, 72: 134-143.