# EFFECTS OF LONG AGEING ON MEAT SHELF LIFE OF ARGENTINA INDOOR AND OUTDOOR PIGS

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*Abstract*— **The objective of the present study was to determine the influence of a long storage time on the physic-chemical, nutritive and sensorial qualitative properties of pork according to the breed model. Fifty eight animals were randomly distributed in 3 treatments: O+P:pigs in outdoor conditions on pasture; O:outdoor without implanted pasture; I:indoor conditions. After slaughter (112kg), samples of *Longissimus* muscle were obtained from 36 pigs. Chilled slices without bone, with or without vacuum packed (Multivax) were analyzed fresh (1 day at 4°C±1; 18 pigs) and after 9 month of storage (9M, Freezer -21°C±1; 18 pigs). In each time (1d or 9M after thawing) the meat was evaluated at 0, 3 and 9 days of store in commercial refrigerator at 4°C±1. It was determined: intramuscular fatty acids (gas chromatography), lipid oxidation (Tbar'sindex), color (CIELABSystem), pH and toughness (WB shear force). Samples were also analyzed by an analytical panel of 8 trained assessors for overall color, brightness, odor and flavor. Statistical analysis was performed using the ProcMixed ofSAS(2004) for repeated measurements.**

**Conservation influenced only the meat toughness, higher in the 9M storaged meat. Conservation of the meat showed interaction with the aging time (D), breed system (BS) and packing (P). Conservation of frozen meat during 9 months significantly influenced the content of linoleic acid, linolenic acid, omega-3 fatty acids, polyunsaturated fatty acid percentage and trombogenic index, that diminished with the time of conservation probably due to the saturation of the double bonds and the fragmentation of carbon chains. The long storage significantly decreases the ´pig' odor and 'pig' flavor and increased rancid odor but values are negligible (less than one in a one-to-ten scale). The conservation of frozen meat for nine months is significantly influenced by the physic-chemical, nutritional and sensory features of pork, but all samples were suitable for sensory consumption.**

*Index Terms*— **ageing, meat quality, indoor, outdoor, pigs.**

## I. INTRODUCTION

In recent years, there are different views, both scientific and technical, about the productive and economic results of animal production systems and is discussed about the overall quality of the meats obtained, especially in developed countries. Given that the need to study the eating habits have increased from the changing markets, it is necessary a good knowledge of assessment practices and food consumption (health and nutrition), crucial in a country like Argentina, where food production is the basis of its economy.

The current consumer interest shown by the quality and nutritional value of foods, which results in an increasingly selective demand and a growing need for product´s differentiation (Hodges, 2003). There exist alternatives to introduce factors of differentiation in meat production such as the production system and feeding. (Gentry, McGlone, Blanton and Miller, 2002; Basso et al., 2006); the quality of adipose tissue as regards its nutritional value, organoleptic and conservation properties, is related to the composition in fatty acids (Lizardo, van Milgen, Mourot, Noblet and Bonneau, 2002).

To facilitate the exchange of pork between countries and, to differentiate between meat supply and consumer demand, it is handy to use the freezing and storage for long periods. The study of the influence of freezing on the pork quality, arises from the need to supply to the operators of the chain, particularly of refrigeration and processing industry operators, the objective information about the evolution of the product during storage and eventually, the recommendations of upper limits of conservation, in order to avoid a quantitative deterioration in the meat quality.

The objective of our study was the assessment of the differentiated pork quality, integrating the production, processing and preservation as well as consumer preferences, to promote and expand its marketing, innovation and diversification. Particularly, our objective was to determine the influence of a long storage time on the physic-chemical, nutritive and sensorial qualitative properties of pork according to the breed model.

## II. MATERIALS AND METHODS

A. Animals

Fifty four pigs INTA-MGC (initial average weight of 26.4 ±0.7 kg; final average weight of 111.6 ±7.09 kg) both sex were used. Animals were randomly distributed in 3 treatments: O+P: pigs in outdoor conditions on a 1.4 ha lot, in a pasture with alfalfa (*Medicago sativa*) and white clover (*Trifolium repens*); O: pigs in outdoor conditions on a 1.4 ha lot with no implanted pasture; I: pigs in indoor conditions located in stall with concrete floor. The pigs were fed *ad libitum* with standard commercial feed on a maize and soya basis.

B. Samples

After slaughter, samples of *Longissimus* muscle (three last ribs) were obtained from 36 pigs and translated under refrigerated conditions to the Meat Quality Laboratory of the Agronomy Faculty at the University of Buenos Aires. Chilled slices without bone, with or without vacuum packed (Multivax; Cryovac pouches of 100 microns) were analyzed fresh (1 day at 4°C ± 1; 18pigs) and after 9 month of storage (9 M, Freezer -21ºC± 1; 18 pigs). In each time (1d or 9M after thawing) the meat was evaluated at 0, 3 and 9 days of store in commercial refrigerator at 4°C±1.

C. Determinations

Fatty acids were extracted according to the technique described by Folch, Lees and Sloane (1957) and analyzed as methyl esters by gas chromatography (Shimatzu 14-B capillary column Resteck 2560); trombogenic index was calculated according to Ulbricht and Southgate (1991). There were determined, the lipid oxidation (Tbar's index; µg of malonaldehyde/ g meat) (Robards, Kerr and Patsalides, 1988), the color (CIELAB System, L* (lightness), a* (redness), b* (yellowness) and C* as $\gamma(a^{*2} + b^{*2})$), using a Minolta Chroma Meter-CR300 and the pH (Testo 205). Tenderness was measured with an Instron 4442 Universal Testing Machine (Canton, MA, USA) with a Warner Bratzler shearing attachment on cooked samples (water bath heating at 70 $^0$C for 50 minutes). Cooking losses were determined by weight difference. The slices were cooked in double contact grill to reach 71ºC ± 1ºC in the center of the sample (cold point), monitored by thermocouples. The samples were analyzed by an analytical panel of 8 trained assessors according to international standards and experience in sensory analysis of meat (ISO 1987, 1992, 1993, 1994). Each assessor received samples (1x1x1m cubes) in containers coded with three digit random numbers. The following descriptors were assessed: the overall color, brightness, odor, flavor, taste, tenderness, untuosity, juiciness and persistence, using an unstructured linear scale of 10 cm without anchorage. The ends of the scales corresponded to the intensity of the attribute: light pink, not bright, extremely soft, very tender, dry, not oily, low persistence (lower limit: 0) and red, shiny and extremely strong (intense), tough, juicy, persistent, very oily (upper limit: 10).

Statistical analysis of data was performed using the Proc Mixed of SAS (2004) for repeated measurements. Differences between treatments were analyzed by Tukey test ($p < 0.05$).

## III. RESULTS AND DISCUSSION

The direct effect of conservation (Table 1) was observed only in the meat toughness, higher in the 9M storaged meat, presumably due to fluid loss. The aging days under refrigeration (0, 3 and 9d) showed a decrease in the red index and an increase of pH, lipid oxidation and toughness. The breeding system influenced raw b* and C* parameters, higher in O+P meat while the vacuum packing influenced the color in raw and cooked meat. Meat preserved under vacuum was more brighter, less colored and showed less pH and lipid oxidation.

The conservation of the meat (S) showed interaction with the aging time (D) for luminosity (raw and cooked meat), b* and cooked C* parameters, with the breeding system (BS) for luminosity, pH and lipid oxidation values and with packing system (P) for raw a* and b*parameters and cooked L*. While O+P group showed lesser Tbar´s index in fresh meat, in storaged (9M) meat showed higher lipid oxidation values probably due to de higher linolenic and PUFA content.

**Table 1.** Effect of packing and ageing on pH, color, shear force, and TBAR's of 'outdoor' and 'indoor' pork.

| Traits | Storage (S) | | Days (D) | | | Breed system (BS) | | | Packing (P) | | Probability | | | | | | | RMSE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | fresh | 9m | 0 | 3 | 9 | I | O | O+P | V | NoV | S | D | BS | P | SxD | SxBS | SxP | |
| **Raw meat** | | | | | | | | | | | | | | | | | | |
| **L *** | 52.9 | 53.7 | 52.5 | 53.1 | 53.7 | 52.6 | 53.4 | 53.9 | 54.1 | 52.6 | ns | ns | ns | .0006 | .0379 | .0004 | ns | 3.36 |
| **a *** | 9.44 | 9.37 | 10.2$^{a}$ | 9.34$^{ab}$ | 8.95$^{b}$ | 9.53 | 9.16 | 9.53 | 10.0 | 8.77 | ns | <.0001 | ns | sig | ns | ns | .0006 | 1.28 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **b *** | 5.17 | 5.32 | 4.56 | 5.22 | 5.42 | 4.97$^{a}$ | 4.91 $^{a}$ | 5.83$^{b}$ | 3.77 | 6.71 | ns | sig | .0013 | sig | <.0001 | ns | .0001 | 1.67 |
| **C *** | 11.0 | 11.1 | 11.3 | 10.9 | 10.9 | 11.1$^{ab}$ | 10.7$^{a}$ | 11.5$^{b}$ | 10.9 | 11.3 | ns | ns | .0016 | .0492 | ns | ns | ns | 1.58 |
| **TBAR µg/g** | 0.22 | 0.19 | 0.10$^{a}$ | 0.21$^{b}$ | 0.25$^{b}$ | 0.19 | 0.21 | 0.21 | 0.15 | 0.27 | ns | <.0001 | ns | ns | ns | <.0001 | ns | 0.10 |
| **pH** | 5.63 | 5.66 | 5.55 | 5.69 | 5.69 | 5.69 | 5.68 | 5.57 | 5.60 | 5.69 | ns | .0001 | sig | .0002 | ns | .0092 | ns | 0.19 |
| **Shearforce,N** | 30.6 | 34.0 | 31.7$^{a}$ | 32.2$^{ab}$ | 33.9$^{b}$ | 32.7 | 32.2 | 32.0 | nd | nd | <.0001 | .0496 | ns | nd | ns | ns | nd | 1.56 |
| **Cooked meat** | | | | | | | | | | | | | | | | | | |
| **L*** | 70.8 | 65.3 | 70.4 | 66.4 | 67.9 | 67. 7 | 68.3 | 68.2 | 70.6 | 65.6 | sig | sig | ns | sig | <.0001 | .0014 | <.0001 | 2.67 |
| **C *** | 13.3 | 12.3 | 13.2 | 12.9 | 12.8 | 12.6 | 12.5 | 13.3 | 12.5 | 13.1 | sig | sig | sig | .0002 | <.0001 | .0310 | ns | 1.57 |

Breed system: I: indoor, O: outdoor without pasture, O+P: outdoor with implanted pasture; Packing: V: vacuum, NoV: without vacuum. Shear force was measured on meat without vacuum packing. Nd: no determined RMSE: root mean square error; Probability SxDxBSxP: no significant ($p<0.05$)

The conservation of the meat in frozen form for 9 months (Table 2) significantly influenced the content of linoleic acid, linolenic acid, omega-3 polyunsaturated fatty acid percentage (PUFA) and trombogenic index, that decrease with conservation time, probably due to the saturation of double bonds and fragmentation of carbon chains. However, in the short term, the linolenic acid content and consequently the n-3FA and trombogenic index, increases percentually with the aging time on refrigerator in commercial shops, fresh meat is preserved in nine months.

The breeding system produced significantly higher content of oleic acid and monounsaturated fatty acids content (MUFA) for meat from the treatment O + P. The aging of refrigerated meat under vacuum preserved linoleic and arachidonic acid content, but was lower in oleic acid The saturated fatty acids (SAT) showed SxBS interaction, while on fresh meat, SAT content was similar for the breeding systems, in long storaged meat, the SAT content was significantly higher in the I group.

**Table 2.** Effect of packing and ageing on fatty acid profile (%tot FA) of 'outdoor' and 'indoor' pork.

| **Traits** | **Storage (S)** | | **Days (D)** | | | **Breed system (BS)** | | | **Packing (P)** | | **Probability** | | | | | | | **RMSE** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **fresh** | **9m** | **0** | **3** | **9** | **I** | **O** | **O+P** | **V** | **NoV** | **S** | **D** | **BS** | **P** | **SxD** | **SxBS** | **SxP** | |
| **C16:0** | 23.0 | 24.0 | 24.3 | nd | 22.8 | 24.1 | 23.4 | 23.1 | 23.7 | 23.4 | sig | sig | ns | ns | .0021 | ns | ns | 1.44 |
| **C18:0** | 11.9 | 12.3 | 12.0 | nd | 12.2 | 12.2 | 12.2 | 11.9 | 12.3 | 11. 9 | ns | ns | ns | ns | ns | ns | ns | 1.67 |
| **C18:1c9** | 44.0 | 44.4 | 43.8 | nd | 44.6 | 43.2$^{a}$ | 44.1$^{ab}$ | 45.3$^{b}$ | 44.73 | 43.7 | ns | ns | .0049 | .0369 | ns | ns | ns | 2.11 |
| **C18:2 linoleic** | 10.3 | 8.93 | 9.61 | nd | 9.60 | 9.59 | 9.83 | 9.40 | 9.13 | 10.1 | .0049 | ns | ns | .0418 | ns | ns | ns | 1.94 |
| **C18:3 linolenic** | 1.14 | 0.66 | 0.52 | nd | 0.63 | 0.55 | 0.56 | 0.61 | 0.61 | 0.53 | .0001 | .0470 | ns | ns | ns | ns | ns | 0.22 |
| **C20:4** | 2.39 | 2.13 | 2.14 | nd | 2.38 | 2.32 | 2.25 | 2.20 | 2.03 | 2.49 | ns | ns | ns | .0267 | ns | ns | ns | 0.85 |
| **-n3** | 1.24 | 0.35 | 0.69 | nd | 0.91 | 0.77 | 0.80 | 0.81 | 0.81 | 0.79 | <.0001 | .0011 | ns | ns | ns | ns | ns | 0.26 |
| **SAT[1]** | 37.3 | 38.9 | 38.3 | nd | 37.9 | 39.3 | 38.1 | 37.0 | 38.5 | 37.8 | sig | ns | sig | ns | ns | .0455 | ns | 1.69 |
| **MUFA[2]** | 48.2 | 48.6 | 48.3 | nd | 48.5 | 47.7$^{a}$ | 48.2$^{ab}$ | 49.4$^{b}$ | 48.8 | 48.0 | ns | ns | .0148 | ns | ns | ns | ns | 2.01 |
| **PUFA[3]** | 14.7 | 11.8 | 13.0 | nd | 13. 6 | 13.0 | 13.7 | 13.2 | 12.7 | 13.9 | <.0001 | ns | ns | ns | ns | ns | ns | 2.52 |
| **Tromb. index** | 0.78 | 0.56 | 0.64 | nd | 0.70 | 0.68 | 0.68 | 0.65 | 0.67 | 0.67 | <.0001 | .0286 | ns | ns | ns | ns | .0468 | 0.09 |

SAT[1] saturated fatty acids; MUFA[2] monounsaturated fatty acids; PUFA[3] polyunsaturated fatty acids.[4]: (C14:0+C16:0+C18:0)/(0.5 x C18:1 + 0.5 x other PUFA+ 0.5 x n6+3 x n3+ n3/n6).Breeding system: I: indoor, O: outdoor without pasture, O+P: outdoor with implanted pasture; Packing: V: vacuum, NoV: without vacuum. RMSE: root mean square error; Probability SxDxBSxP: no significant ($p<0.05$).

The long storage of the meat (Table 3) significantly decreases the ´pig' odor and flavor; the rancid odor increased but values are negligible (less than one in a one-to-ten scale). Also de ageing under refrigerated conditions decreased ´pig´ odor

from 0 to 3-9 days and increased rancid odor at 9 days with the same negligible values. Color was influenced by breeding system and packing, more dark without vacuum; the vacuum packing delayed the occurrence of rancid odor.
Storage time showed interaction with ageing time (SxD) for color, brightness and rancid flavor. In fresh meat, color increased from 0 to 3 days and then remains constant, while there were not differences among values in storaged meat; brightness decreased from 0 to 9 days in fresh meat but increased from 0-3days to 9 days in storaged meat; finally, rancid flavor only increased from 0 to 9 days in storaged meat.

**Table 3.** Effect of packing and ageing on sensory attributes of 'outdoor' and 'indoor' pork.

| Traits | Storage (S) | | Days (D) | | | Breed system (BS) | | | Packing (P) | | Probability | | | | | | | RMSE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | fresh | 9m | 0 | 3 | 9 | I | O | O+P | V | NoV | S | D | BS | P | SxD | SxBS | SxP | |
| **Colour** | 4.54 | 5.95 | 4.27 | 5.86 | 6.00 | 5.68$^{a}$ | 4.78$^{b}$ | 5.29$^{a}$ | 5.00 | 5.50 | sig | sig | .0018 | .0148 | .0070 | ns | ns | 1.99 |
| **Brightness** | 1.62 | 1.67 | 1.79 | 1.22 | 2.51 | 1.52 | 1.50 | 1.92 | 1.54 | 1.76 | ns | sig | ns | ns | <.0001 | ns | ns | 1.62 |
| **'Pig'Odour** | 5.26 | 4.21 | 4.59 | 4.92 | 4.65 | 4.80 | 4.71 | 4.70 | 4.84 | 4.63 | <.0001 | ns | ns | ns | ns | ns | ns | 1.96 |
| **Rancid odor** | 0.39 | 0.57 | 0.34$^{a}$ | 0.35$^{a}$ | 0.7$^{b}$ | 0.45 | 0.42 | 0.57 | 0.39 | 0.57 | .0170 | .0002 | ns | .0147 | ns | ns | ns | 0.71 |
| **'Pig'Flavor** | 5.21 | 4.42 | 5.33$^{a}$ | 4.62$^{b}$ | 4.57$^{b}$ | 4.77 | 4.85 | 4.83 | 4.71 | 4.93 | <.0001 | .0246 | ns | ns | ns | ns | ns | 1.95 |
| **Rancidflavor** | 0.46 | 0.45 | 0.34 | 0.56 | 0.47 | 0.53 | 0.42 | 0.42 | 0.41 | 0.54 | ns | ns | ns | ns | .0011 | ns | ns | 0.93 |

Breeding system: I: indoor, O: outdoor without pasture, O+P: outdoor with implanted pasture; Packing: V: vacuum, NoV: without vacuum. RMSE: root mean square error; Probability SxDxBSxP: no significant ($p<0,05$)

## IV. CONCLUSION

The frozen meat conservation for nine months is significantly influenced by the physic-chemical, nutritional and sensory properties of pork. The maturation days and animal husbandry system were less significant. However, the samples were found unfit for sensory consumption throughout the storage and aging time considered in this study.

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