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# pH, Drip Loss, Colour, Lipids and Protein Oxidation of Meat from Pampa-Rocha and Crossbreed Pigs Produced Outdoor in Uruguay

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**Abstract** Pampa-Rocha (PP) is a local rustic pig reared on pasture in Uruguay to produce meat, mainly in a familiar scale system. Meat quality parameters for *Longissimus dorsi* (LD) and *Psoas major* (PM) muscles from PP and its crossbreeding with Duroc (PD) and Large White (PL) genetic type were determined. The pH showed no genetic type main effect. Values of pHu (24 hours *Post-mortem*) fail within advised values for pig meat and ranged for LD 5.48-5.69 and for PM 5.52-5.69. The drip loss for fresh meat, at 24 hours *Post-mortem*, showed relatively low levels with values ranged 2.23-4.50 for LD and 1.25-2.51 for PM. After five days the drip loss showed values ranged 5.21-9.33 for LD and 3.96-6.65 for PM. After ageing (1-2°C in vacuum) drip loss, at 24 hours *Post-mortem*, ranged between 1.43-2.47 for LD and 1.62-1.77 for PM while after five days, drip loss showed values ranged 3.73-3.97 for LD, and 3.31-4.12 for PM. Drip loss showed a significant main effect with PP having a lower level than PD and similar to PL. For colour study, PP showed a darker meat than PD and PL, and no main effect of ageing. The lipids oxidation level was similar for the three genetic types and no main effect was observed. The protein oxidation showed a similar level for the three genetic types and fresh meat showed more protein oxidation than aged meat.

***Keywords:*** *Pampa-Rocha pig, local breed, meat quality, ph, drip loss, colour, TBARs, carbonyls*

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## 1. Introduction

The Pampa-Rocha is a local pig produced outdoor for meat production in Uruguay. The animals are reared on pasture extensively. The meat is often consumed as fresh products and sometimes the by-products are manufactured locally. The objective of this kind of animal production is generally the self-consumption in a familial scale farming.

Taking account the growing interest for traditional meat produced outdoor, in a friendly ambient, and with access to pasture [1], the Pampa-Rocha pig seems to be a good candidate to be produced like a differential meat-producing pig. The most known example of a pig produced traditionally, in outdoor conditions, is the Iberian pig produced in Spain, which is worldwide appreciated [2,3]. Like the Iberian pig [4], Pampa-Rocha is generally crossbreed, in Uruguay, with commercial pigs, such as Duroc and Large White pigs, as a way to improve the meat quality, for exemple, the obtention of a less dark meat which is preferred by consumers.

However, to our knowledge, there is no scientific information which confirms that crossbreeding is beneficial to improve the meat quality of Pampa-Rocha pig. Therefore, the aim of the present investigation is to compare some meat quality parameters, such as pH, drip loss, colour, lipids and protein oxidation of Pampa-Rocha and its crossbreed with Duroc and Large White pigs.

## 2. Materials and Methods

### 2.1. Animals and Samples

Twenty-four male pigs from Pampa-Rocha (PP), and crossbreed with Duroc (PD, male PP X female Duroc) and Large White (PL, male PP X female Large White) breeds were used in the experiment.

The animals were castrated at the age of 96.5 ± 10.3 days with a live weight of 30.1 ± 7.87 kg. The method of surgical castration included local anaesthesia by subcutaneous injection with lidocaine 2% (0.2 ml/kg Body Weight) following European Comission Instructive actualized in December 2016 and the rules of the Honorary Commission of Animal Experimentation (CHEA-Uruguay). The whole experiment has been

conducted with the approval of the animal ethical committee of Faculty of Agronomy (Udelar-Uruguay).

The animals were fed with a commercial diet (Molino San José, San José, Uruguay) containing 3200 kcal.kg-1 of Digestible Energy, 14% Crude Protein, 0.7% Ca, 0.3 % available P, 0.7 % Lysine and 0.3 % Methionine [5]. Furthermore, the animals had permanent access to a cultivated pasture and water was offered ad libitum throughout the experiment. The pasture consisted of a mixture of Cichorum intybus, Trifolium pratense and Lolium multiflorum, which was offered in grazing stripes of 300 m2. Each group had separate access to various paddocks of 300 m2, with pasture and refuge.

The animals were slaughtered with a live weight of 87, 2 ± 6,10; 89,7 ± 13,5 and 89,9 ± 9,05 kg for PP, PD and PL respectively. The muscles *Longissimus dorsi* (LD) (between the 10th and 12th ribs) and *Psoas major* (PM) were removed from the carcasses immediately after sacrifice, and transported in refrigerated isothermal boxes to the laboratory.

## 2.2. Muscles Samples and Analysis

The pH value was determined at 45 min, 60 min, 90 min and 24 h *Post-mortem* using a Lutron pHmeter and a penetrating electrode. At 24 h *Post-mortem*, each refrigerated muscle (1-2°C) was divided into two equal parts: one was immediately frozen at -20°C, and the other was packaged in vacuum and stored at 1-2°C for five days (aged) and subsequently stored at -20 °C until analysis.

The drip loss was evaluated using the method described by [6], at 24 h *Post-mortem* and after five days of ageing. The drip loss was measured twice for the same sample, after a short period of essay (24 h) and a long period essay (5 days).

The colour was measured in both muscles (fresh and aged for 5 days) using a Minolta CR-10 colorimeter with D65 standard illuminant. The L* (luminosity) and a* (reddish) values were determined with successive three readings on the surface of each muscle sample. The aged samples were exposed to air for 30 minutes (blooming) before the reading of colour.

For both muscles, the lipid oxidation was determined using the method of TBARs, and the protein oxidation level was determined by the carbonyls protein assay [7].

## 2.3. Statistical Analysis

The main effects of the genetic types, muscle, processes on the study variables were analyzed using the GLM procedure of NCSS v.2007 software (329 North 1000 East Kaysville, Utah 84037 USA). Colour L*, a* drip loss, lipid and protein oxidation data were analyzed in a model that includes the genetic type and ageing as fixed effects for each muscle. The effect of the process or muscle was analyzed within each genetic type. The kinetic of pH data was analyzed using repeated measures in time over 24 hours depending on the genetic and muscle types. The differences between the means were compared pairwise with a significance of $P<0.05$ using the Tukey-Kramer test.

# 3. Results and Discussion

## 3.1. pH, Drip Loss and Colour

The pH values showed no main effect between the PP and its crossbreeds. However, there is a significant difference between the LD and the PS (Table 1). The pH showed a different pattern of declining between both muscles. Indeed, when the kinetic of pH was considered, it can be highlighted that pH decreased more rapidly in PS than LD. Furthermore, two specific moments of declining of pH, at 45 min and 24 hours, this last known as ultimate pH or pHu, are key moments, as they establish the quality characteristic of pig meat [8]. It seems that a pH below 5.60 at 45 min *Post-mortem* could lead to a PSE (Pale Soft and Exudative meat) in pig. In the present experiment, only the PS of PD showed a pH value close to this critical value, but within an acceptable limit. However, the most important key moment for pH determination is at 24 hours *Post-mortem* (pHu). Generally, a pig meat showing a pHu between 5.50-5.70 could be considered as having the most desirable quality characteristics [9]. At the same time, it is considered that a pHu higher than 5.80 for pig, can lead to a decreased shelf-life of meat, reducing its processing option of this kind of meat [10]. In the present investigation the pHu of all samples falls within this range of normal values. Indeed, taking pHu into account, the PP pig and its crossbreeds present meat with desirable quality parameters.

**Table 1. Kinetics of pH of *Longissimus dorsi* and *Psoas major* muscles from Pampa Rocha (PP), Pampa Rocha X Duroc (PD) and Pampa Rocha X Large White (PL)**

| *Longissimus dorsi* muscle | Time | | | |
|---|---|---|---|---|
| Genetic type | 45 min | 60 min | 90 min | 24hs |
| PP | 6.40 ± 0.35 | 6.13 ± 0.37 | 5.92 ± 0.33 | 5.48 ± 0.23 |
| PD | 6.09 ± 0.62 | 6.02 ± 0.60 | 5.74 ± 0.56 | 5.50 ± 0.28 |
| PD | 6.35 ± 0.43 | 6.17 ± 0.50 | 5.98 ± 0.40 | 5.69 ± 0.12 |
| *Psoas major* muscle | | | | |
| Genetic type | 45 min | 60 min | 90 min | 24hs |
| PP | 5.92 ± 0.25 | 5.70 ± 0.20 | 5.55 ± 0.18 | 5.61 ± 0.16 |
| PD | 5.56 ± 0.29 | 5.57 ± 0.26 | 5.45 ± 0.29 | 5.52 ± 0.29 |
| PD | 5.74 ± 0.36 | 5.72 ± 0.22 | 5.56 ± 0.15 | 5.69 ± 0.16 |
| Main effects: Genetic type NS;<br>Muscles P<0.01 (*Longissimus dorsi* > *Psoas major*) | | | | |

Values are means ± SEM. NS= no significant.

**Table 2. Drip loss (%) after 24 hours and 5 days *Post-mortem*, for fresh and aged *Longissimus dorsi* and *Psoas major* muscles from Pampa Rocha (PP), Pampa Rocha X Duroc (PD) and Pampa Rocha X Large White (PL) pigs**

| | Drip loss (%) | | | |
|---|---|---|---|---|
| | Muscle *Longissimus dorsi* (LD) | | Muscle *Psoas major* (PM) | |
| After 24 hours | | | | |
| Genetic type | Fresh | Aged | Fresh | Aged |
| PP | 2.32 ± 0.73 | 1.56 ± 0.15 | 1.25 ± 0.24 | 1.77 ± 0.40 |
| PD | 4.50 ± 1.04 | 2.47 ± 0.44 | 2.51 ± 0.83 | 1.62 ± 0.24 |
| PL | 2.23 ± 0.42 | 1.43 ± 0.17 | 2.30 ± 0.49 | 1.64 ± 0.28 |
| Main effects: | | | | |
| Genetic type P<0.01 (PD > PP= PL, PL=PD), Muscle NS, Ageing P<0.05 (Fresh > Aged) | | | | |
| After 5 days | | | | |
| Genetic type | Fresh | Aged | Fresh | Aged |
| PP | 5.21 ± 0.84 | 3.97 ± 0.29 | 3.96 ± 0.71 | 4.12 ± 0.65 |
| PD | 9.33 ± 1.32 | 5.09 ± 0.83 | 6.65 ± 1.29 | 3.31 ± 0.42 |
| PL | 6.07 ± 0.67 | 3.73 ± 0.33 | 5.56 ± 1.18 | 3.57 ± 0.49 |
| Main effects: | | | | |
| Genetic type P<0.01 (PD > PP=PL, PL=PD), Muscles P<0.05 (LD > PM), Ageing P<0.01 (Fresh > Aged) | | | | |

Values are mean ± SEM. NS= no significant.

The drip loss after 24 hours and 5 days *Post-mortem* showed a significant genetic type main effect. In both determinations, 24 hours and 5 days, PP showed a lower drip loss percentage compared to PD. At the same time PP is similar to PL, and PD is similar to PL (Table 2). After ageing, the drip loss is low in all samples at 24 hours and 5 days *Post-mortem*. Regarding the main muscle effect, only LD showed more drip loss and only after 5 days *Post-mortem*. A low drip loss is a favorable quality factor for meat. The ability of meat to retain water is an essential quality factor for Industrial process, as well as for consumer acceptance. Furthermore, there is a relation between a low pH at 45 min and a high drip loss. In fact the pH at 45 min *Post-mortem* is sometimes considered as a good parameter to anticipate the drip loss, and it consequently helps to know the better use of those meat. The pH of meat at 45 min and 24 hours seems to be associated to pre-slaughter stress and could have a genetic basis in pig [11].

In the present experiment, PS showed a relatively low pH, which would assume that the meat is near to PSE condition (Table 1). However, when the drip loss at 24 hours *Post-mortem* is analyzed in fresh PS, together with the pH at 45 min *Post-mortem*, it can be concluded that PS does not present the specific characteristics of pork PSE meat.

Indeed, the PSE condition includes a relatively high drip loss in pig meat [11]. Globally, the values of drip loss found in the present investigation were relatively low, having value ranging between 2.23-4.50% for LD and 1.25-2.51% for PS. This level of drip loss in both muscles is of the same order or even lower to previous report with different genetic types of pigs. [12,13,14,15,16].

The colour of meat has a great impact on the decision of purchase for consumers. This is true for all kinds of meat, including meat pig from local breeds such as PP and its crossbreeds. In the present investigation, Colour meat of PP and crossbreeds were analyzed, in fresh and aged condition, by means of the determination of lightening (L*) and redness (a*).

The lightening of PP meat is significantly lower in comparison to its crossbreeds PD and PL. At the same time, PD and PL showed the same lightening (Table 3). Also, PM showed a lower lightening than LD, and no significant differences were observed after ageing of meat for five days (Table 3).

Meat from PP seems to be darker than those from PD and PL, at least for LD. Also, PP meat from LD seems to be darker than meat from the same muscle of the Iberian pig, a Spanish local breed, similar to PP [16] . In the case of PM, the lightening seems to be similar or even higher than the Iberian pig [17]. In their investigation, the authors evaluated the lightening of Psoas major of five different breeds of Iberian pig. Although PP had kinship ties (three hundred years ago or more) with the Iberian pig [18], the different genetic history of the two breeds probably explains the differences observed nowadays in their meat quality parameters [2].

**Table 3. Lightening (L*) and redness (a*) values in fresh (F) and aged (A) *Longissimus dorsi* (LD) and *Psoas major* (PM) muscles from Pampa Rocha (PP), Pampa Rocha X Duroc (PD) and Pampa Rocha X Large White (PL) pigs**

| | | Muscles | | | |
|---|---|---|---|---|---|
| | | *Longissimus dorsi* | | *Psoas major* | |
| Genetic type | | L* | a* | L* | a* |
| PP | F | 37.9 ±0.38 | 5.60 ±0.45 | 35.3 ±0.55 | 8.39±0.41 |
| | A | 34.2 ±0.44 | 9.32 ±0.57 | 32.3 ±0.61 | 7.80±0.25 |
| PD | F | 39.0 ±0.56 | 5.26 ±0.30 | 36.4 ±0.36 | 6.72±0.44 |
| | A | 35.3 ±0.96 | 5.72 ±046 | 35.3±0.28 | 10.8±0.21 |
| PL | F | 34.9 ±0.54 | 10.0 ±0.51 | 32.7 ±0.92 | 11.0±0.56 |
| | A | 39.6 ±0.68 | 6.07 ±0.46 | 38.3 ±0.54 | 5.11±0.34 |
| Main effects | | L* | | a* | |
| Genetic type | | P<0.01 ( PP<PD,PL; PD=PL) | | P<0.01 (PD<PL; PP=PD, PL) | |
| Muscles | | P<0.01 (PM<LD) | | P<0.01 (PM>LD) | |
| Ageing | | NS | | NS | |

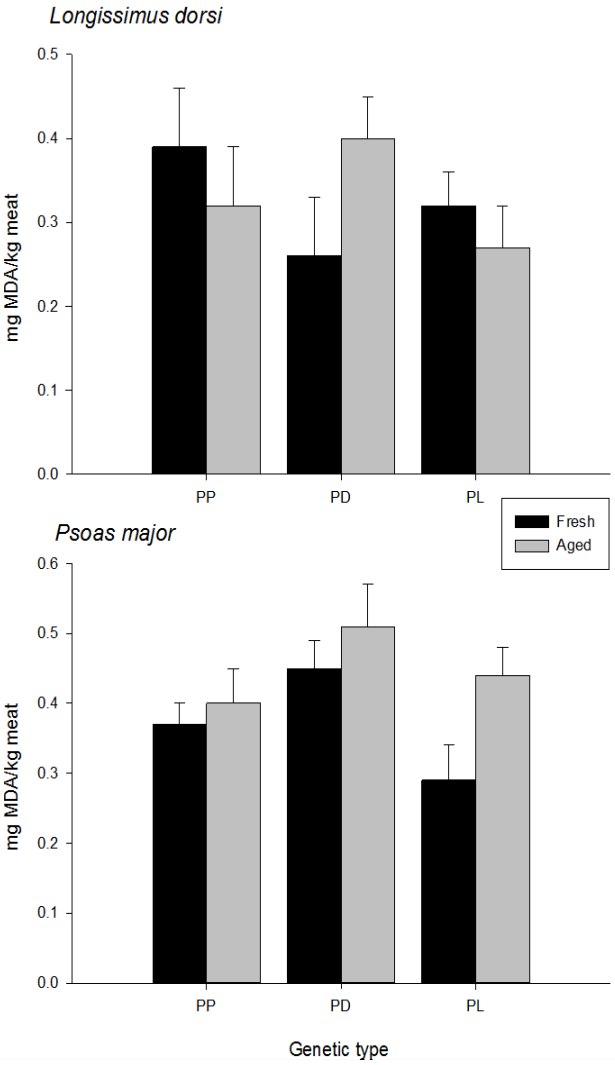
Values are means ±SEM. NS= no significant.

In the case of redness (a*), PP showed similar redness of its meat in comparison to PD and PL. However, PD showed a lower redness of its meat compared to PL (Table 3). Also, PM showed more redness than LD. This is an expected results because Psoas major presents more content of myoglobin which is the main protein responsible for the redness of meat. Indeed, the redness level increases as the level of myoglobin present in meat increases [17]. In comparison to other breeds of pig, the redness of PP and its crossbreeds is slightly lower for LD and similar for PM, depending of the breeds, including Iberian pig and its crossbreeds. [4,10,15,16].

## 3.2. Lipids and Protein Oxidation

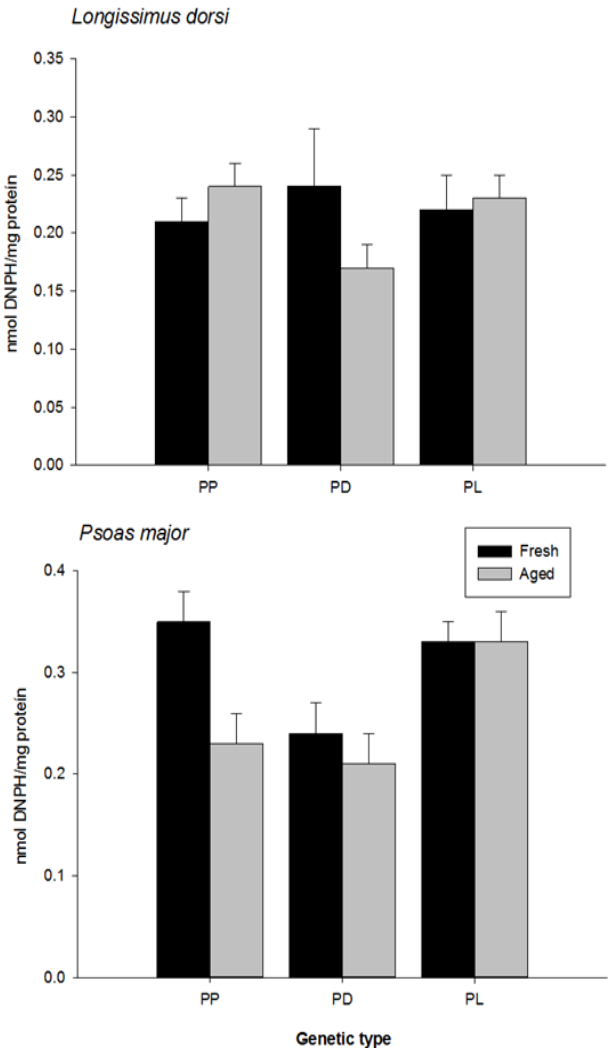
Both lipids and proteins oxidation showed a significant main effect. PP showed a similar level of lipids and proteins oxidation in comparison to PD and PL (Figure 1).

However, PD showed opposite results: a higher lipids oxidation and a lower proteins oxidation (Figure 1 and Figure 2), in both cases in respect to PL.




Main effects: Genetic type P<0.05 (PD>PL, PP=PD, PL). Muscle P<0.01 (LD<PM), Ageing NS

**Figure 1.** Lipid oxidation in *Longissimus dorsi* and *Psoas major* muscles, in fresh and aged samples from Pampa Rocha (PP), Pampa Rocha X Duroc (PD) and Pampa Rocha X Large White (PL). Values are means ± SEM




Main effects: Genetic type P<0.01 (PD<PL, PP=PD.PL), Muscle P<0.01 (LD<PM) Ageing P<0.05 (Fresh>Ageing)

**Figure 2.** Protein oxidation in *Longissimus dorsi* and *Psoas major* muscles, in fresh and aged samples from Pampa Rocha (PP), Pampa Rocha X Duroc (PD) and Pampa Rocha X Large White (PL). Values are means ± SEM

For muscles comparison, LD showed, for both kinds of oxidation parameters, a lower level than PM. This is not an unexpected result, because LD and PM are different in their metabolism. Indeed, PM is a more oxidative muscle compared to LD, then it is more susceptible to the oxidation process, as well as for lipids than for proteins [14]. When ageing is considered, there is no effect of the conservation of meat in vacuum at 1-2°C for five days on the oxidation of lipids (Figure 1). To the contrary, for protein, the ageing process caused a significant main effect on the protein oxidation of meat, and showed more oxidation for fresh meat (Figure 2).

Lipids oxidation results in the generation of free radicals, which promote the oxidation of pigments such as myoglobin. This effect leads to a reduction of the nutritional quality and the shelf-life of pork meat [19]. In the present investigation, PP showed a similar lipid oxidation than its crossbreeds (Figure 1). Furthermore, the ageing process (five days at 1-2°C in vacuum) can be used for PP meat and its crossbreeds, apparently without negative influence of the lipid oxidation. Probably, feeding PP and crossbreeds with a mixture of pasture consisting in *Cichorum intybus*,

*Trifolium pratense* and *Lolium multiflorum* could explain the limited lipid oxidation of meat, even after five days of ageing. This kind of pasture are rich in polyphenols and other antioxidant components [20]. This has been confirmed by a screening of the content in total polyphenols of the pasture used in our experiment (results not shown). Indeed, the last month of the experiment, samples of *Cichorum intybus*, *Trifolium pretense* and *Lolium multiflorum* showed contents of 533, 314 and 91 mg/100g wet tissue, respectively, expressed as gallic acid equivalent, using the Folin-Ciocalteu method [20].

However, this protection against the lipid oxidation process was not enough to counteract the protein oxidation after five days of ageing (Figure 2). The protein oxidation affects amino acids which form carbonyls. This last components change negatively the nutritional quality and the protein digestibility of meat [19]. It is evident that any negative impact, due to the oxidation processes, on meat quality for PP and crossbreeds could reduce the industrial potential of their meat. The relation between conservation, industrial use and oxidation process of meat from PP and its crossbreeds has to be carefully understood to obtain the best quality of meat and to ensure acceptability by both consumers and industrial meat processors.

Further studies have to be done to confirm the effect of lipids and proteins oxidation, particularly myoglobin, before and after ageing. That information could be useful for meat processors as a way to control the shelf-life of meat and to establish the best way to process meat from PP and its crossbreeds.

## 4. Conclusion

Taking into account all the results observed in the present investigation, the PP meat and its crossbreeds showed adequate values for pH for LD muscle, even though the PM muscle presented conflictive results, which should be confirmed and considered in future investigation. The drip loss showed a low level for PP in comparison to its crossbreeds, particularly PD. For the colour parameter, PP is darker than its crossbreeds and this point has to be particularly considered in future investigations, to improve the whiten of meat, an important condition for consumers The resistance against oxidation of PP meat and crossbreeds seems to be adequate, even after five days of ageing. Of course, that resistance to the meat oxidation is linked to the animal's access to pasture, which is rich in antioxidant components. The access to pasture should be included in the rearing system established for this kind of local pork meat production. This condition could lead toward the definition of a protected designation of origin (PDO) in Uruguay, like other worldwide known meat products.

## Conflict of Interest

The authors declare that there is no conflict of interest.

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