# RESEARCH ON CHANGES IN PORK QUALITY PARAMETERS FOLLOWING DIFFERENT AGING PROCESSES

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**Abstract**

The present study aimed to investigate the effect of aging time and method on the quality characteristics of three categories of domestic pork muscle (pork loin, collar and leg). The meat samples were evaluated at three aging periods, 1 day, 5 and 10 days, for pH, refrigeration losses and colour For the analysed samples were defined two methods of ageing: wet-ageing (WA) and dry-ageing (DA). Dry-aged samples showed significantly higher refrigeration losses compared to wet matured samples, losses which increased with the aging time, especially in the case of unpacked meat. The aging method induced significant differences ($p < 0.05$) in pH values, with vacuum-packed samples showing higher pH values compared to dry-matured samples. The highest pH values were noticed for the collar samples, with a maximum of 6.062±0.038 for the 10-day wet-aged batch. The wet-aged samples were brighter (L*) at all stages of maturation, but showed higher values for b* (yellowness) after 10 days of maturation. While the dry-aged samples were significantly redder (higher a*) after 10 days of aging.

**Key words**: wet / dry-aging; colour, pork meat

Two important meat quality traits are visual acceptability, which determines the initial impression of quality, and sensory acceptability when the meat is consumed, possibly justifying the visual impact. Meat surface colour and juice losses are important indicators of visual appearance and meat acceptability. Water holding capacity is related to sensory juiciness as well as the occurrence of juice leakage in the storage container (Warner R., 2014).

Meat colour is an important quality attribute for the consumer. Along with water holding capacity, the temperature and pH history of post-mortem muscle is important for meat colour through their effect on the physical structure and light scattering. In addition, meat colour is influenced by the concentration and properties of myoglobin and, to a lesser extent, haemoglobin, pigments present in meat. The concentration of myoglobin in muscle (80-90% of all pigments) varies according to species, breed, sex, age, muscle type and level of training. In fresh meat, myoglobin can exist in three different forms: the reduced form of myoglobin (deoxymyoglobin) is purple and the oxygenated form (oxymyoglobin) is bright red, while the oxidised form (methemoglobin) is brown. The colour of fresh meat is affected by the relative abundance of these three forms (Olsson V., Pickova J., 2005).

The colour of pork is commonly associated with glycolytic potential, which is a measure of muscle capacity for anaerobic metabolism. Research suggests that high glycolytic potential encourages acidity and paleness. Thus, most data indicate that reducing glycolytic potential and free glucose can improve pig muscle colour by altering postmortem lactate levels. Animal activity may play a role in meat colour by influencing muscle fibre type and metabolism. For example, increased physical activity may encourage pigmentation and darkening of muscles, while limited activity may decrease the amount of slow contractile fibres, reduce oxidative metabolism and increase lactate production (Mancini R., 2013).

The quality of pork is very important not only for consumers but also for the industry. Four main meat quality classes have been described. The high incidence of exudative meat is an economic problem in the industry. Prediction of water holding capacity in meat is important as it is responsible for weight loss in raw, cooked and processed meat and can affect the palatability characteristics of meat. Two classes of exudative have been described: pale, soft and exudative

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(PSE) meat and a normal-coloured but exudative meat called red, soft and exudative (RSE) meat. The low incidence of dark, firm and dry (DFD) pork also affects consumers and processors because of its susceptibility to contamination. In conclusion, the ideal quality grade of pork has been defined as pinkish-red, firm and non-exudative (RFN) meat (Moya V.J. *et al*, 2001).

The aging process is a natural process, characterised by two main parameters: intensity and speed, it aims to improve the sensory qualities appreciated by consumers (tenderness, juiciness and flavour) and to reduce the hardness of the meat to a minimum. The maturation of meat can be considered the main factor affecting tenderness, therefore many studies have focused on the ultrastructural changes that occur during maturation (Bowker B.C. *et al*, 2010; Boișteanu P.C. *et al*, 2015).

Postmortem aging is a common industry practice to improve meat tenderness and palatability (Nair M.N. *et al*, 2019). Although the most well-known effects of meat aging are related to tenderisation, reduction of the hardness of muscle tissue and enrichment of the product's flavour, during the aging process a number of colour changes also occur in the meat. Meat colour is an extremely important factor influencing consumers' purchasing decisions as it is considered a visual measure of freshness and quality. In addition, meat discolouration limits shelf life after meat preparation for retail sale, and this is a significant economic problem for the meat industry. Discolouration occurs over time as oxymyoglobin is converted to metmyoglobin, with consumers rejecting brown meat that has high levels of metmyoglobin (Mancini R.A., Hunt M.C., 2005; Hopkins D.L. *et al*, 2013).

Two components are mainly discussed in the literature in regard to factors involved in meat colour: pigments and structural or achromatic elements. Pigments (myoglobin, the main pigment in meat) affect the hue and strength of colour by differential absorption of light of different wavelengths. Others such as cytochromes exist but have little effect on darker pigmented meat and are more involved in species containing lesser amounts of myoglobin. Structural elements are represented by physical effects such as diffraction and refraction, which contribute to the colour perceived by a consumer by reflecting the light from both the surface of the meat and below it. The importance of structural elements or achromatic factors is lesser than pigment biochemistry because their potential to change after rigor is limited (Hughes J.M. *et al*, 2019; Jacob R., 2020).

However, the final perceived colour is affected by many factors, such as species, animal genetics and nutritional background, post-mortem muscle changes (especially pH dynamics and meat temperature drop), inter- and intramuscular effects, post-mortem storage temperatures and time, and a whole host of variables related to processing (including antimicrobial interventions), packaging, and product presentation.

Meat aging is generally categorized into wet and dry aging. Dry aging means exposing unpacked carcasses or wholesale cuts to air at controlled temperature, relative humidity, and airflow. Due to the dried surface, dry aging contributes to shrinkage and large trim loss, but also presents hygienic risk through production and distribution. However, it has the advantage of generating unique and distinct flavours such as brown-roasted flavours. Wet aging involves vacuum packaging of meat, it prevents weight loss caused by evaporation of moisture, it improves product yield and prevents microorganism growth. However, wet-aged meat has a bloody and metallic flavour (Lee C.W. *et al*, 2016; Hwng S.I., Hong G.P., 2020).

From these perspectives, the study aimed to evaluate the effect of aging time and method on pH, chilling losses and colour for three anatomical regions of the pork carcass: pork loin, collar and pork hind leg.

## MATERIAL AND METHOD

The first stage of the research involved purchasing samples of pork loin, pork hind leg and pork collar from the food market of Iași, cutting them into pieces large enough to form batches, preparing them for refrigeration and storing them for maturation.

The differentiation of the batches was done first by anatomical region (loin / collar / hind leg), by aging method used (dry - DA / wet - WA) and aging time (1 day / 5 days / 10 days). Therefore, the coding of the samples was carried out for the purpose of identification, as shown in Table 1.

The operations carried out in order to form the batches, the actual aging and the proposed determinations were carried out in the Meat Processing Workshop, respectively in the Meat and Meat Products Technology Laboratory of the "Ion Ionescu de la Brad" University of Life Sciences.

Table 1

**Structure and coding of sample batches**

| Anatomical region | Aging time (days) | Aging method | Sample code |
|---|---|---|---|
| Pork loin (L1) | 1 | DA | L1US1 |
| | | WA | L1UM1 |
| | 5 | DA | L1US5 |
| | | WA | L1UM5 |
| | 10 | DA | L1US10 |
| | | WA | L1UM10 |
| Pork collar (L2) | 1 | DA | L2US1 |
| | | WA | L2UM1 |
| | 5 | DA | L2US5 |
| | | WA | L2UM5 |
| | 10 | DA | L2US10 |
| | | WA | L2UM10 |
| Pork hind leg (L3) | 1 | DA | L3US1 |
| | | WA | L3UM1 |
| | 5 | DA | L3US5 |
| | | WA | L3UM5 |
| | 10 | DA | L3US10 |
| | | WA | L3UM10 |

DA – dry aging; WA – wet aging

Wet aging was performed according to Zhang R. *et al* (2022) by sealing the samples in bags to retain their moisture. The process can be defined as anaerobic ripening in vacuum barrier packaging under refrigerated storage conditions. Vacuum packaging is the most commonly used aging method by the meat industry mainly because once the air is removed, its oxidizing effect is also eliminated, which delays meat discoloration and lipid oxidation (Vitale M. *et al*, 2014). Dry aging was carried out by the classical aging process, i.e. by keeping a piece of meat in a controlled environment in the open air (Dashdorj D. *et al*, 2016).

For the determination of refrigeration losses for each maturation period, an initial weighing of all samples (Gi) was performed. Then, at the end of the maturation period, specific to each sample, a new weighing was performed, noting the final weight (Gf) (Ciobanu M.M., Boișteanu P.C., 2020). Refrigeration losses (Pg) were calculated using the formula Pg(%)=(Gf×100)/Gi, expressed as a percentage.

The pH was determined using a HANNA HI 99163 Meat pH meter by inserting the electrode into the meat after prior calibration in buffer solutions of known pH (acidic solution - pH = 4.01 and neutral solution - pH = 7.01). After calibration and between readings, the probe of the meter was cleaned with distilled water so as not to influence the results obtained.

Colour determination of pork samples was carried out with the Konica Minolta Chroma Meter CR-410 on meat samples with a thickness of 40 - 70 mm, these being sections perpendicular to the longitudinal axis of the muscle fibre. The colour of the samples was read using illuminator C at an observation angle of 2°. Meat colour was expressed by tristimulus spectral coordinates L*, a*, b* in CIEL*a*b* colourimetric space, and the data were displayed and stored in SpectraMagicTM NX software. Prior to the start of the readings and between each sample, the device was calibrated on the white calibration plate.

The data obtained on the effect of aging period and aging method on refrigeration losses, pH and meat colour were analysed using the two-way ANOVA test, a function of the XLSTAT program in Microsoft Excel. Significant differences between samples were considered at p-values < 0.05, and a comparison of means was performed using the Duncan test.

## RESULTS AND DISCUSSIONS

The results on refrigeration losses and pH recorded after 1, 5 and 10 days of dry/wet aging for the three anatomical regions are shown in Table 1. Refrigeration losses, monitored by weighing samples before and after the specific maturation period, showed significant differences ($p < 0.05$) due to the aging method and aging time. Moreover, a significant interaction ($p < 0.05$) was observed between time and ripening method, while anatomical region did not impart significant differences in refrigeration losses for the evaluated samples ($p > 0.05$).

In the results on pH variation as a function of the three factors, there was a significant influence ($p < 0.05$) of the maturation method and the type of muscle. Thus, the pork collar samples showed higher pH values compared to the hind leg and loin batches, and dry maturation resulted in lower pH values compared to wet maturation. The pH of the samples showed a steady increase until day 10 of maturation, caused by the formation of alkaline reaction products resulting from protein breakdown in post-slaughter processes (Stanišic N. *et al*, 2012), but this was not significant ($p > 0.05$).

Table 2

**Effects of aging time, aging method and muscle type on refrigeration losses and pH of pork**

| Muscle type | Aging method | Aging time (days) | Parameters | |
|---|---|---|---|---|
| | | | Refrigeration losses (%) | pH |
| Pork loin | Dry aging | 1 | 1.46$^{d}$ | 5.756±0.197$^{e}$ |
| | | 5 | 5.179$^{bc}$ | 5.832±0.090$^{de}$ |
| | | 10 | 10.812$^{a}$ | 5.886±0.143$^{bcde}$ |
| | Wet aging | 1 | 0.728$^{d}$ | 5.83±0.101$^{de}$ |
| | | 5 | 1.564$^{cd}$ | 5.838±0.072$^{de}$ |
| | | 10 | 2.533$^{cd}$ | 5.908±0.099$^{bcde}$ |
| Pork collar | Dry aging | 1 | 0.492$^{d}$ | 5.888±0.091$^{bcde}$ |
| | | 5 | 5.542$^{bc}$ | 5.904±0.241$^{bcde}$ |
| | | 10 | 11.004$^{a}$ | 5.986±0.063$^{abcd}$ |
| | Wet aging | 1 | 0.767$^{d}$ | 6.004±0.194$^{abc}$ |
| | | 5 | 1.797$^{cd}$ | 6.054±0.086$^{ab}$ |
| | | 10 | 2.364$^{cd}$ | 6.062±0.038$^{a}$ |
| Pork hind leg | Dry aging | 1 | 0.707$^{cd}$ | 5.844±0.092$^{de}$ |
| | | 5 | 6.497$^{b}$ | 5.89±0.082$^{bcde}$ |
| | | 10 | 14.88$^{a}$ | 5.914±0.097$^{abcde}$ |
| | Wet aging | 1 | 0.584$^{d}$ | 5.806±0.119$^{e}$ |
| | | 5 | 3.317$^{bcd}$ | 5.838±0.102$^{de}$ |
| | | 10 | 3.616$^{bcd}$ | 5.886±0.063$^{bcde}$ |
| p-value | | | | |
| Muscle type | | | 0.148 | <0.0001 |
| Aging method | | | 0.000 | 0.023 |
| Aging time (days) | | | 0.000 | 0.151 |
| Aging time*Aging method interaction | | | 0.001 | 0.904 |
| Muscle Type*Aging time*Aging method interaction | | | 0.772 | 0.377 |

a,b,c,d,e Superscripts on different means within column differ significantly, $p \leq 0.05$

The results of instrumental colour analysis after wet and dry aging for 1, 5 and 10 days are shown in Table 2. Both muscle type, maturation method and time*aging method interaction significantly ($p < 0.05$) influenced the CIE a* values. In the case of wet aging, a steady increase in a* value over time was observed, similar to the results reported by Jaspal M.H. *et al* 2021, for wet aging of buffalo meat. In contrast, dry maturation detected a decrease in a* values during the first 5 days of maturation, followed by an increase until day 10 of maturation.

Regarding the lightness of the samples, it was observed that both the factors studied and their interaction had significant influences ($p < 0.05$); samples subjected to dry maturation showed a progressive decrease until day 10 of maturation, while for wet maturation the L* values were relatively close for the three maturation periods. Wet aging resulted in higher L* values, with samples showing higher lightness. CIE b* values were significantly affected ($p < 0.05$) by anatomical region and maturation time, but also by the interaction of time*aging method. The lowest b* values were recorded for batch 2, represented by the pork collar, with the loin and hind leg samples showing close values. The two types of aging showed different behaviours in terms of b* values, thus during wet aging b* values showed a slight decrease (day 5) followed by an increase until day 10. In contrast to wet aging, dry aging showed an increase during the first 5 days, and by the end of the observation period b* values decreased.

Table 3

**Effects of aging time, aging method and muscle type on instrumental color (CIE L *, a *, b *) of pork**

| Muscle type | Aging method | Aging time (days) | Parameters | | |
|---|---|---|---|---|---|
| | | | L* | a* | b* |
| Pork loin | Dry aging | 1 | 57.592±0.690$^{a}$ | 10.276±1.048$^{ef}$ | 9.844±0.766$^{d}$ |
| | | 5 | 57.398±2.481$^{b}$ | 7.604±1.163$^{f}$ | 14.574±0.760$^{a}$ |
| | | 10 | 44.012±2.921$^{c}$ | 15.944±3.750a$^{bc}$ | 14.17±1.468$^{a}$ |
| | Wet aging | 1 | 58.376±0.545$^{a}$ | 10.532±1.001$^{e}$ | 13.086±1.067$^{abc}$ |
| | | 5 | 59.428±0.924$^{a}$ | 10.42±0.781$^{e}$ | 12.924±0.546$^{abc}$ |
| | | 10 | 56.792±1.520$^{a}$ | 11.932±1.786$^{de}$ | 14.702±0.544$^{a}$ |
| Pork collar | Dry aging | 1 | 50.284±3.746$^{b}$ | 16.716±2.307$^{a}$ | 10.344±1.372$^{cd}$ |
| | | 5 | 40.354±5.572$^{c}$ | 16.948±1.705$^{a}$ | 10.478±2.101$^{cd}$ |
| | | 10 | 37.402±4.199$^{d}$ | 16.132±3.636$^{abc}$ | 7.106±3.002$^{d}$ |
| | Wet aging | 1 | 52.518±3.788$^{b}$ | 15.044±2.467$^{abcd}$ | 10.662±1.431$^{cd}$ |
| | | 5 | 49.522±5.201$^{b}$ | 15.694±1.823$^{abcd}$ | 11.208±1.071$^{bcd}$ |
| | | 10 | 51.478±2.591$^{b}$ | 15.18±2.366$^{ab}$ | 11.51±1.914$^{bcd}$ |
| Pork hind leg | Dry aging | 1 | 51.618±2.764$^{b}$ | 14.636±2.305$^{bcd}$ | 13.18±0.981$^{abc}$ |
| | | 5 | 44.238±3.237$^{c}$ | 10.876±1.571$^{de}$ | 13.766±1.199$^{ab}$ |
| | | 10 | 36.956±4.424$^{d}$ | 15.812±4.061$^{abc}$ | 11.894±2.372$^{bcd}$ |
| | Wet aging | 1 | 61.118±2.421$^{a}$ | 11.572±1.361$^{de}$ | 14.288±1.040$^{a}$ |
| | | 5 | 50.336±5.024$^{b}$ | 13.646±1.579$^{cd}$ | 13.368±2.468$^{ab}$ |
| | | 10 | 50.984±2.156$^{b}$ | 14.988±3.552$^{bcd}$ | 13.916±0.675$^{ab}$ |
| p-value | | | | | |
| Muscle type | | | <0.0001 | <0.0001 | <0.0001 |
| Aging method | | | <0.0001 | 0.001 | 0.215 |
| Aging time (days) | | | <0.0001 | 0.234 | 0.004 |
| Aging time*Aging method interaction | | | <0.0001 | 0.029 | 0.012 |
| Muscle Type*Aging time*Aging method interaction | | | 0.001 | 0.892 | 0.578 |

a,b,c,d,e,f Superscripts on different means within column differ significantly, $p \leq 0.05$; L * = Lightness, a * = redness, b * = yellowness

## CONCLUSIONS

In this study, changes during time- and method-differentiated aging were analysed for pH, refrigeration losses and colour parameters. Moreover, the evaluations were performed on three different types of muscles, the three anatomical regions responding differently to the two aging factors.

In general, it was observed that significant differences were found for refrigeration losses and colour parameters. pH varied mainly between muscle types, but also due to the maturation method, higher values were recorded for packaged samples, but remained within the freshness limits (5.8 - 6.2). Colour attributes L* and a* varied significantly mainly due to the aging method, with packaged samples showing higher lightness and redness. The values of CIE b* were significantly influenced by the aging time, in addition to the differences given by the type of muscle. Thus, the two types of aging had different behaviours over time, the dry aging caused an increase in the b* value, followed by a decrease, the opposite effect recorded for the wet aged samples.

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