COLOUR CHARACTERISTIC OF DRY-AGED ORGANIC LOINS WITHOUT NITRITE

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Abstract – The present study describes the changes on the colour characteristic of dry-aged organic loins without nitrite. The evolution of colour properties was evaluated at 0, 30 and 90 days of refrigerated storage. Colour of examined products was significantly ($P < 0.05$) affected by treatment and storage time. Sea salt in combination with acid whey (AW) was the most successful at reducing the browning reaction involved in the formation of dark colour in dry aged loins. Significant ($P < 0.05$) reduction in a* value resulting from replacement of curing salt by sea salt has been less pronounced in sample with acid whey.

Key Words – acid whey, nitrite-free, sea salt

I. INTRODUCTION

Increasing consumer awareness about the relationship between food consumption and health and wellness is stimulating the interest in healthier food which is commonly associated with natural and organic products. To face up to these dynamic changes in customers` demands the meat processing industry is trying to launch meat products that are low in salt, fat, cholesterol, nitrites and calories and contain health-promoting bioactive compounds [1]. In producing natural or organic meat products one of the major obstacles is replacement of sodium nitrite which is a chemical preservative [2].

One of the important effects of nitrite in cured meat products is the characteristic pink/red colour. It is also probable that the nitrite reaction sequences involved in cured colour development are also responsible for the antioxidant function of nitrite in cured meat. Nitrite which is a strong inhibitor of anaerobic bacteria, plays a key role in cured meat as a bacteriostatic and bacteriocidal agent. Through inhibit the growth of *Clostridium botulinum* and subsequent formation of the botulinum toxin as well as control of other microorganisms such as *Listeria monocytogenes*, nitrite contributes to the safety assurance of meat products [3]. Nitrite is also a flavour-forming agent and retards the rancidity and off-odors development in cured meat products during storage [1]. Although currently approved levels of nitrite in processed meats represent no toxicity risk, there is a strong interest and pressure from the consumer side to further reduce or even entirely eliminate the use of nitrite in meat products formulations. To meet consumer demands, a growing niche for the design and manufacturing of nitrite-free meat products has been created [1, 3]. Unrefined sea salt derived directly from evaporation of sea water, without addition of free-flow additives and retaining the natural trace minerals was the most common ingredient used to manufacture "nitrite-free" meat products [4]. Sea salt collected from the Mediterranean Sea contaminated with saltpeter (potassium nitrate) can serve as a source of nitrate [5]. However, not all sea salt contains nitrate and in some cases, as reported by Herrador *et al.* [6], the amount of nitrate in sea salt is relatively low (1.1 ppm) and not substantial enough for curing functions.

Salt addition, absence of nitrite and prolonged storage time may favour lipid oxidation in dry-aged meat products. Since oxidation affects nutritional value and causes deterioration of colour, flavour, texture and the formation of potentially toxic compounds, control of the oxidative reactions is crucial to produce high-quality meat products [7]. Thus to inhibit oxidative deterioration in nitrite-free meat products, they must contain either synthetic or natural antioxidants for protection of meat lipids against oxidation [8]. Acid whey (AW) has been suggested by Colbert *et al.* [9] to be used as a "natural" antioxidant owing to the ability to inactivate pro-oxidative heme proteins (ferrylmyoglobin) and to chelate of prooxidant transition metals by β-lactoglobulin and lactoferrin, respectively. Possible antioxidant mechanisms

of whey also include free radical scavenging by amino acids such as cysteine and tyrosine [10].
To reproduce the functionality of nitrite, sea salt and acid whey in combination with mustard seed have been tested in organic sausage [11, 12, 13, 14]. Obtained results pointed out that these ingredients had positive effect on physicochemical and sensory qualities of nitrite-free sausages. However, there is no available information in the literature concerning the effects of application of acid whey in manufacturing of dry-aged meat cuts, which are integral and have a small surface/volume ratio.
Therefore the aim of the present study was to determine the effect of acid whey on colour characteristic of no-nitrite organic dry-aged pork loins during chilling storage.

II. MATERIALS AND METHODS

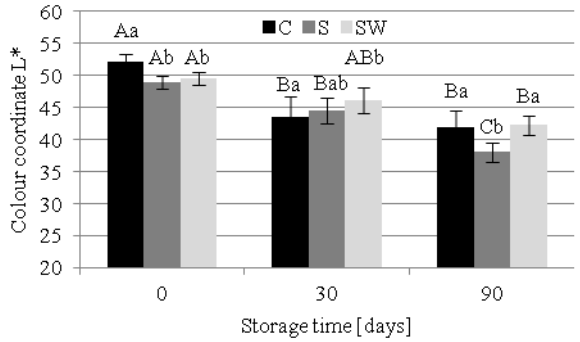
Fresh acid whey with a moisture content of 94.1±0.95% was obtained from organic plant cottage cheese production from the local dairy-processing plant. Their pH and oxidation-reduction potential were 4.61±0.01 and 372.6±3.1 mV, respectively.
Meat came from breeding certified as organic by the polish certifying body according to Council Regulation (EC) No. 834/2007 on organic production and labeling of organic products. Twelve *Longissimus thoracis* muscles with an average weight of 1.60±0.23 kg were excised at 48 h post mortem from crossbred pigs (Puławska x Polish Landrace) with a body weight of approximately 125 kg at slaughter. The loins were randomly divided in three experimental batches with four loins each: with the curing mixture (C), with sea salt (S) and with sea salt combined with acid whey (SW). The last one was immersed in acid whey for 24 hours at 4°C. At 72 h post mortem the loins were allowed to drip for 5 min and then gently surface dried. At this time, samples S and SW were salted using 2.8% sea salt in relation to meat. According to the certificate, sea salt used in this experiment contains 99.74% sodium chloride and does not contain neither nitrites nor nitrates. Sample C was cured using 2.8% curing mixture (99.5% sea salt, 0.5% sodium nitrite). All bathes were then kept in separate stainless steel trays at 4°C for 24 h to allow the salt to diffuse. Subsequently, the loins were hung at 16°C in a disinfected laboratory ageing chamber with a relative humidity of between 80 and 85% for 28 days. Every two days the samples from batch SW were sprayed (5 ml/kg) with the mixture of acid whey and 1% (w/v) glucose. At the end of the ageing period loins were considered "ready-to-eat". After the completion of ageing each of the loins was divided into three parts, individually vacuum-packed in polyethylene bags (80 mm thick) and stored in a refrigerator at 4±0.5°C. Subsamples of loins were taken randomly at 0, 30 and 90 days of refrigerated storage to analyse their instrumental colour.
Samples were evaluated for instrumental colour by using a benchtop spectrophotometer (Color® Premiere 8200, X-Rite Inc., Grand Rapids, MI, USA) following the recommendations of American Meat Science Association [15]. The instrumental conditions were an 8 mm view aperture, D65 illuminant and 10° standard observer. Samples for colour measurements were 5 cm thick and before colour determination were covered with a single layer of colourless food wrap and allowed to bloom for 30 min at 4±1°C. Colour measurement followed the Commission Internationale de l'Eclairage (CIE) colour convention [16], with outputs of L* (lightness), a* (redness) and b* (yellowness).
The experiment was carried out in three replicates. All measurements were performed in triplicate, and the data were expressed as mean ± standard deviation (SD). To assess the significance of the experimental factors on the characteristics studied a two-way analysis of variance (ANOVA) was carried out using the SPSS software package version 22.0 for Windows (SPSS, Inc., Chicago, IL, USA). When a significant F-value was found, Tukey's post hoc test was used to determine the source of significance ($P < 0.05$).

III. RESULTS AND DISCUSSION

The changes on the colour parameters of dry-aged loins during vacuum storage are shown in Figures 1-3. Mean L* values obtained in the present study were similar to those reported by other authors in dry-cured loins aged for 90 days [18].
In relation to L* values, its decrease was observed throughout storage (Figure 1), although in samples C and SW this diminution in L* value did not progress between 60 and 90 days of storage.

This trend is in agreement with those reported by Pateiro *et al.* [17] who noticed significant decrease of lightness during the manufacturing process of dry-cured loin.

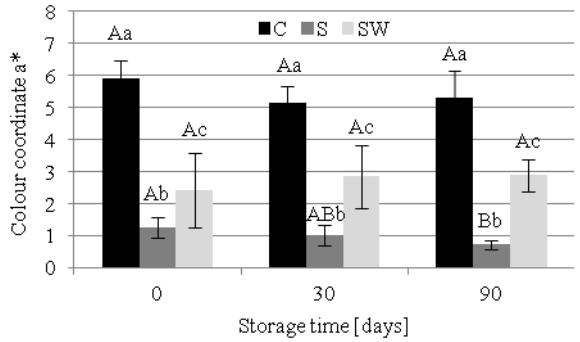
Figure 1. Colour coordinate L* of dry-aged organic loins



[A,B,C] Means with different superscripts under the same treatment are statistically different ($P < 0.05$)
[a,b,c] Means with different superscripts under the same storage time are statistically different ($P < 0.05$)

The lowest decrease (14.7%) of lightness was found in sample SW. This shows that sea salt in combination with acid whey were the most successful at reducing the formation of dark colour in dry aged loins.

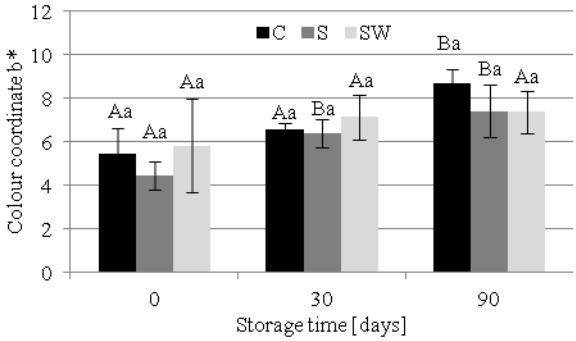
Figure 2. Colour coordinate a* of dry-aged organic loins



Legend as in figure 1

For nitrite-free meat products redness (a*) is the most important colour parameter. Storage time did not change the a* values in loins, with the exception of salted samples (S) in which a significant reduction of the a* colour parameter was found after 90 days of refrigerated storage ($P < 0.05$). This is in agreement with previous findings by Cava *et al.* [18], who reported that redness did not significantly change in vacuum-packed dry-cured loin during 90 days of refrigerated storage. Curing salt replacement by sea salt caused a significant reduction in a* value ($P < 0.05$), which has been less pronounced in sample with acid whey. Wójciak *et al.* [14] hypothesized that β-lactoglobulin which is an acid whey protein could serve as a source of glutathione - a low molecular thiol compound which has great antioxidant properties and thiol amino acids. Their reduced forms remove free radical and protect meat products against discoloration. This may result in significantly higher a* values in SW samples than in samples with sea salt only. Lactic acid bacteria present in AW may take part in conversion of Mb(Fe^{3+}) to cured meat pigment NO-MB(Fe^{2+}) as some strains are capable of generating NO from alternative chemical sources to nitrate or nitrite [19].

Figure 3. Colour coordinate b* of dry-aged organic loins



Legend as in figure 1

During refrigerated storage yellowness (CIE b* value) tended to rise in all samples, with significant ($P < 0.05$) increases in samples C and S at day 90 and 30, respectively. The addition of acid whey did not significantly ($P > 0.05$) affect the b* value.

IV. CONCLUSION

Sea salt and acid whey positively affected colour parameters of dry-aged organic loins. Their combination successfully reduced the browning reaction involved in the formation of dark colour

in dry aged loins. Antioxidant activities of acid whey probably stabilise the red colour of the loins. This resulted in significantly higher a* values in SW samples than in samples with sea salt only. Further researches are needed to assess the applicability of such nitrite-free technology.

ACKNOWLEDGEMENTS

The research described here was supported by the Ministry of Agriculture and Rural Development, grant PKre-029-29-29/13 (688).

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