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Original scientific paper

The effect of Swiss chard powder and starter cultures on color development and stability in dry cured pork loin

Aleksandra Silovska Nikolova[a], Zlatko Pejkovski[a], Daniela Belichovska[b] and Katerina Belichovska[a]*

[a] *Ss. Cyril and Methodius University in Skopje, Faculty of Agricultural Sciences and Food, Blvd. 16-ta Makedonska brigada 3, 1000 Skopje, North Macedonia*

[b] *Ss. Cyril and Methodius University in Skopje, Institute of Animal Science and Fishery, Blvd. Ilinden 92a, 1000 Skopje, North Macedonia*

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ABSTRACT

Dry meat products are highly demanded and valued in the market. When choosing them, the consumer, initially, notices their color. Nitrite is responsible for red-pinkish color development. Modern consumers are looking for processed meat with low contents of additives. The paper focuses on the influence of starter culture and Swiss chard powder added to dry cured pork loin on instrumentally measured L^*, a^*, b^* values, as well as on product's color stability at room temperature (20 ± 2°C), when the meat products were kept in normal daylight for a duration of up to 120 minutes. Five groups of cured pork loins were produced: I – Control (negative), using table salt and dextrose; II – Control (positive), using nitrite curing salt and dextrose; III – nitrite curing salt, dextrose and starter culture; IV – Swiss chard powder (first producer), dextrose and starter culture and V – Swiss chard powder (second producer), dextrose and starter culture. L^*-values ranged between 28.42 (group III) and 34.23 (group I). The highest share of red color (10.86) was measured in group III. The share of yellow color ranges between 2.11 (group I) and 2.84 (group IV). Starter culture had a statistically significant ($p \leq 0.05$) impact on color development and stability of cured pork loin produced with and without nitrite curing salt.

1. Introduction

Dry cured meat products have a long history of production in Europe. It is assumed that the tradition for their production originated from the Mediterranean countries due to the specific climatic conditions that allow natural drying and ripening of dry cured meat products. These products occupy a position on the consumers' shopping list due to their high nutritional value and long shelf life. As pointed out by *Iaccarino et al.*, (2006) they have a significant place in the global gastronomic heritage. Pork and beef are, most often, used as a raw material for their production.

Based on a wide variety of studies, color of meat and meat products is an important factor for consumers in deciding their choice (*Lawrie and Ledward*, 2006; *Møller and Skibsted*, 2007; *Kolev et. al.*, 2022). At the beginning of the last century, it was determined that nitrites are the main factor in development of characteristic, stable, red-pinkish color in meat products. Added nitrites in meat products, as stated by *Gøtterup et. al.* (2008), are a source of nitric oxide (NO) which reacts with myoglobin (Mb) to form nitrosomyoglobin (NOMb). Nitrates are reservoirs of nitrites. When nitrates are used in meat products, it is necessary to reduce them

***Corresponding author:** Aleksandra Silovska Nikolova, *silovska@fznh.ukim.edu.mk*

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to nitrites with the bacterial enzyme nitrate reductase (*Arnau et. al.*, 2007). Based on their technological function, nitrites and nitrates are food additives that are included in the functional class of preservatives. From a technological point of view *Alahakoon et al*. (2015) state that they are important for color and aroma development, and they prevent oxidation. In recent years, consumers have been searching the market for meat products with lower amounts of additives, mainly focusing on nitrites. (*Wolk,* 2017; *Alirezalu et al*., 2020).

In the production of meat products, Swiss chard powder can be used as a substitute for synthetic nitrite due to its high nitrate content that could be converted into nitrite by the action of starter cultures containing nitrate reducing bacteria.

Numerous authors point out the positive effects of using the starter cultures in meat industry. Their application increases the safety of the product, helps the development of color, texture, taste, aroma, generally affects the development of characteristic properties of the product, increases the durability of the product, reduces the variation in the quality of the product, and makes production more profitable due to acceleration of fermentation, etc. (*Kovačević*, 2001; *Incze*, 2002; *Martinović and Vesković Moračanin*, 2006).

This paper aims to examine whether the usage of starter cultures influences the development and stability of color in cured pork loin produced with and without nitrite salt.

2. Materials and methods

2.1. Materials

Dry pork loin, dry-salted, produced in industrial conditions was used in the analysis. As an alternative to nitrite curing salt, in dry pork loin production, Swiss chard powder from two different producers, was used in combination with starter culture BactoFerm Rosa, produced by Chr. Hansen, Denmark.

The experiment was conducted in a commercial meat processing factory (Rimes MS Group). Their usual technological method for producing dry pork loin was taken as a basis for our study. Five groups of dry cured pork loins were produced, as follows: group I: control (negative), using table salt and dextrose; group II: control (positive), using nitrite curing salt and dextrose; group III: nitrite curing salt, dextrose and starter culture (BactoFerm Rosa); group IV: Swiss chard powder (first producer), dextrose and starter culture (BactoFerm Rosa) and group V: Swiss chard powder (second producer), dextrose and starter culture (BactoFerm Rosa).

The frozen outer part of pork loin (*m. longissimus dorsi*) was used. Bones, connective and adipose tissue were previously removed from it. The raw material was thawed by dry defrosting. Technology for production of dry cured pork loin includes salting the pork loin. Salted pieces were left in carts for 21 days in a dark room, with a constant mode of calm cooling, at a temperature of 0–40°C and a relative humidity of 85 to 90%. This was followed by cold smoking for 40 minutes. During the remaining 19 hours and 20 minutes, it was smoked twice more for 40 minutes each time, the chamber temperature was 22 °C, and the relative humidity 82%. The carts were then transferred into the air conditioning chamber where fermentation took place. At the beginning, the temperature was 22 °C and the relative humidity 82%. Then the temperature was gradually lowered to 12 °C and relative humidity was, also, lowered to 72%.

2.2. Methods

Instrumental color analysis was performed after ripening, on the fresh cross section and every 30 minutes for a 120 minute period of air exposure. The color measurements were performed at a room temperature (20 ± 2°C) and samples were kept at normal daylight. All measurements were performed five times in non-overlapping zones. A color difference meter (Dr. Lange) was used to determine these parameters. Before the start of the measurement it was calibrated with a black and white calibration plate, according to the standard procedure of the manufacturer. The color characteristics are expressed in three coordinates L* a* b*, (*CIE*, 1976).

The data collected in the experiment were processed and edited using the program Excel XP. The normality of the distribution of the values was checked by analyzing the homogeneity of the variances. If the homogeneity was confirmed, the analysis was continued with the multivariate general linear model (GLM) or the ANOVA test (comparison of three or more groups), and the associations between the parameters with the multivariate linear descriptive analysis (LDA) (IBM SPSS Statistics 23, release 23.0.0.0).

3. Results and discussion

3.1. Dynamics of L-value*

Table 1 shows that L*-values measured after production (0 minutes) on fresh cross-section ranged between 28.42 and 34.23. The L*values were lower than L*-values measured in similar dry cured meat products. When it comes to Spanish dry cured-hams, *Pérez-Alvarez et al.* (1998) determined that L*-values ranged between 34.8 and 38.8, while *Laureati et al.* (2014) stated that the value for Italian prosciutto ranged between 37.9 and 38.0. According to some authors, the lower L*-value in our study is due to the decrease in water content during drying and ripening. The lower water content contributes to a higher density in the piece of meat, which in turn causes a more intense absorption of light and the color is perceived as darker (*Hunt*, 1980; *De Maere et al.*, 2016).

In groups where starter culture was added (III, IV and V), even after 120 min of light exposure of the fresh cross-section at room temperature, no statistically significant ($p \leq 0.05$) changes were observed in terms of the L*-values, compared to the groups in which no starter cultures were added (I and II) (Table 1).

3.2. Dynamics of a*-value

It is understandable (Table 2) that group I cured pork loin, where only common table salt was added, has the lowest a*-value (3.09). The highest a*-value, i.e. the largest share of red color, was observed in group III (10.86), in which nitrite curing salt and starter culture were added. Starter culture had a statistically significant ($p \leq 0.05$) impact on the share of red color compared to group II positive control, where nitrite curing salt was added. In groups IV and V, where Swiss

Table 1. Dynamics of L*-values in cured pork loin exposed at room temperature (20 ± 2°C) to normal day light for periods of up to 120 minutes

Duration of exposure to light	Groups of dry pork loin				
	I	II	III	IV	V
	$\bar{X} \pm SD$				
0 minutes	34.23 ± 1.24^{aB}	31.60 ± 1.17^{bB}	28.42 ± 0.97^{cA}	28.98 ± 1.47^{cBA}	31.19 ± 1.47^{bA}
30 minutes	33.88 ± 1.24^{aB}	31.28 ± 1.16^{bB}	28.15 ± 0.96^{cBA}	28.69 ± 1.45^{cBA}	30.88 ± 1.45^{bBA}
60 minutes	33.53 ± 1.23^{aB}	30.97 ± 1.15^{bB}	27.87 ± 0.95^{cB}	28.26 ± 1.43^{cB}	30.36 ± 1.43^{bB}
90 minutes	34.22 ± 1.25^{aB}	31.61 ± 1.17^{bB}	28.29 ± 0.97^{cBA}	28.80 ± 1.46^{cBA}	31.00 ± 1.46^{bBA}
120 minutes	37.87 ± 1.44^{aA}	32.54 ± 1.20^{bA}	28.49 ± 0.97^{eA}	29.21 ± 1.45^{dA}	31.52 ± 1.48^{cA}

$\bar{X}$ – mean value, SD standard deviation, statistically insignificant effect; means with a different letter ($^{a-d}$) within a row are statistically significantly different ($p \leq 0.05$; significance of group differences), means with a different letter ($^{A-C}$) within a column and parameter are statistically significantly different ($p \leq 0.05$; significance of sampling differences).

Table 2. Dynamics of a*-values in cured por k loin exposed at room temperature (20 ± 2°C**)** to normal day light for periods of up to 120 minutes

Duration of exposure to light	Groups of dry pork loin				
	I	II	III	IV	V
	$\bar{X} \pm SD$				
0 minutes	3.09 ± 0.97^{eA}	9.62 ± 1.08^{bA}	10.86 ± 0.84^{aA}	7.34 ± 0.69^{cA}	6.73 ± 0.68^{dA}
30 minutes	3.06 ± 0.96^{eA}	9.50 ± 1.07^{bA}	10.75 ± 0.84^{aA}	7.23 ± 0.68^{cBA}	6.62 ± 0.67^{dBA}
60 minutes	3.03 ± 0.95^{eA}	9.41 ± 1.06^{bA}	10.64 ± 0.83^{aA}	7.10 ± 0.67^{cBA}	6.50 ± 0.65^{dBA}
90 minutes	2.92 ± 0.91^{eA}	9.12 ± 1.02^{bA}	10.48 ± 0.81^{aBA}	6.95 ± 0.65^{cCB}	6.32 ± 0.64^{dCB}
120 minutes	2.30 ± 0.86^{eB}	8.53 ± 1.01^{bB}	10.10 ± 0.73^{aB}	6.63 ± 0.63^{cC}	5.99 ± 0.60^{dC}

$\bar{X}$ – mean value, SD standard deviation, statistically insignificant effect; means with a different letter ($^{a-d}$) within a row are statistically significantly different ($p \leq 0.05$; significance of group differences), means with a different letter ($^{A-C}$) within a column and parameter are statistically significantly different ($p \leq 0.05$; significance of sampling differences).

chard powder and starter culture were added, the a*-values ranged between 6.73 (group V) and 7.34 (group IV). The difference seen between these two groups, although small, was statistically significant ($p \leq 0.05$). This difference may be caused by the different content of nitrates contained in the Swiss chard powder, since products from two different producers were used.

It is clear (Table 2) that a*-value declined in all groups at the end of light exposure, after 120 minutes, which is consistent with the information in the relevant professional literature, where it is stated that exposure to light and air causes a decrease in the a*-value, i.e., a decrease in the share of red color. (*Hunt et al*., 2012; *Kolev at al*., 2022). A smaller decrease in the a*-value was observed in the groups of cured pork loin in which starter culture was added (III, IV and V).

3.3. Dynamics of b*-value

The share of yellow color (Table 3) on a fresh cross-section after production ranged between 2.11 (group I) and 2.84 (group IV). The b*-values obtained were lower than the results obtained for similar dry cured meat products. *Marušić et. alt*. (2014 found that b*-values ranged between 7.3 and 10.4 in Dalmatian smoked prosciutto.

It was observed that no statistically significant difference in the change of b*-value during exposure to light and heat existed in any group of cured pork loin.

4. Conclusion

In view of the results obtained, BactoFerm Rosa starter culture was shown to have a positive effect on the parameters related to color measurement in cured pork loin. This starter culture had a positive impact on development and durability of a beautiful red color, even after 120 minutes of exposing the pork loin to air, normal day light and room temperature (20 ± 2°C). Usage of starter cultures in meat industry has a positive effect on color development and stability. The starter culture could affect the reduction of nitrites in the finished product.

Table 3. Dynamics of b*-values in cured pork loin exposed at room temperature (20 ± 2°C**)** to normal day light for periods of up to 120 minutes

Duration of exposure to light	Groups of dry pork loin				
	I	II	III	IV	V
	$\bar{X} \pm SD$				
0 minutes	2.11 ± 0.75^{cA}	2.68 ± 1.12^{baA}	2.70 ± 0.96^{baA}	2.84 ± 1.09^{aA}	2.26 ± 0.85^{cbA}
30 minutes	2.09 ± 0.74^{cA}	2.66 ± 1.11^{baA}	2.68 ± 0.95^{baA}	2.81 ± 1.08^{aA}	2.24 ± 0.84^{cbA}
60 minutes	2.07 ± 0.74^{cA}	2.63 ± 1.10^{baA}	2.65 ± 0.94^{baA}	2.77 ± 1.06^{aA}	2.20 ± 0.83^{cbA}
90 minutes	2.05 ± 0.73^{cA}	2.60 ± 1.09^{baA}	2.61 ± 0.93^{baA}	2.71 ± 1.04^{aA}	2.15 ± 0.81^{cbA}
120 minutes	2.03 ± 0.72^{cA}	2.51 ± 1.09^{cbaA}	2.59 ± 0.92^{baA}	2.67 ± 1.02^{aA}	2.11 ± 0.80^{cbA}

$\bar{X}$ – mean value, SD standard deviation, statistically insignificant effect; means with a different letter ($^{a-d}$) within a row are statistically significantly different ($p \leq 0.05$; significance of group differences), means with a different letter ($^{A-C}$) within a column and parameter are statistically significantly different ($p \leq 0.05$; significance of sampling differences).

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