EFFECT OF A RECYCLABLE FILM ON THE COLOR AND SENSORY EVALUATION OF FROZEN 'BLACK PIG' MEAT

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I. INTRODUCTION

In recent years, the value of products made from 'black pig' meat has risen in southern European countries. This classification refers to animals raised extensively and possessing unique characteristics that yield meat products with exceptional sensory qualities and high nutritional value. Notably, their fat is rich in oleic acid and contains fewer saturated fats compared to that of ruminants (cattle, sheep, goats) [1]. The designation 'black pig' corresponds, in most cases, to animals resulting from a cross between the *Alentejano* and *Duroc* breeds, or to animals resulting from a cross between the *Ibérico* and *Duroc* breeds. The products of these crosses, both fresh meat and processed products (mainly cured products such as hams and sausages), have been very popular and are widely consumed, especially in Portugal and Spain [2].

The packaging of food products is crucial for their preservation and protection against physical, chemical, and microbiological factors that influence food quality, safety, hygiene and shelf life. [3]. Recently, biodegradable and recyclable films and packaging have been explored due to their non-toxic properties and environmental benefits. These materials offer a viable solution for reducing the use of conventional plastics, derived from petroleum [3,4]. Additionally, the need to extend food shelf life and enhance protection has led to an increased use of these films and packaging materials [5,6].

This study aimed to evaluate the effect of a recyclable film compared to a conventional one on the physical and sensory characteristics of *secretos* (a commercial product based on the *latissimus dorsi* muscle) from crossbred pigs (*Alentejano* x *Duroc*), frozen and stored at -18°C for 24 months. Analyses included objective color measurement using the CIELab system and sensory evaluation. The results showed that recycled packaging is a good alternative, maintaining meat quality while promoting more environmentally friendly practices.

II. MATERIALS AND METHODS

Sampling and sample preparation

The meat samples under study were prepared from a commercial cut known as *secretos*, a piece of the *latissimus dorsi* muscle. Three different production batches were studied for each type of packaging (recyclable film and conventional film). BN3050 film (SealedAir) was used as the recyclable film and PA/PE 225300 mm 100 MY - 09001345 as the conventional film. The meat was frozen by passing it through a cryogenic tunnel using liquid nitrogen at an ambient temperature of around -80ºC for 10 minutes, with the meat portions leaving at a temperature of approximately -18ºC, according to

the manufacturer. After this operation, the portions of *secretos* were vacuum-packed, with each bag containing three portions of 150g each. All the samples were kept at -18 ºC with a relative humidity (RH) of 100 per cent until the date of analysis. Five different storage times were considered: 0, 6, 12, 18 and 24 months. Three samples were taken for each batch, each type of packaging and each storage time. For the sensory test, the *latissimus dorsi* muscle was heated to a core temperature of 75°C under the same cooking conditions, and a certain amount of the sample was presented to the sensory evaluator. For the evaluation of the sample, a 100-point scale was used.

Colour

Colour measurements were carried out using the CIELab colour system, with the coordinates L*, a*, b*. The coordinate *L** defines lightness or black and white. The *a **axis is relative to the green–red and the *b** axis represents the blue–yellow. A Konica Minolta colorimeter (CR 400) was used with D65 illuminant. Five readings were taken on the raw samples, in five different locations on each sample, both in meat and fat.

Sensory analysis

The sensory analysis was carried out by a panel of 10 trained tasters. A quantitative descriptive analysis was carried out, using a scale from 0 to 100. The descriptors evaluated were: colour intensity, off colors, hardness, fibrosity, juiciness, flavor intensity, off flavours and overall assessment. The panel was selected and trained in accordance with the guidelines set out in ISO 8586-1:1993 [7]. The tests took place in a sensory analysis room prepared in accordance with ISO 8589:2012 [8]. For the sensory test, the *latissimus dorsi* muscle was cooked to a core temperature of 75°C under consistent conditions. A specified portion of the sample was then provided to the sensory evaluator for assessment.

Statistical analysis

The data was processed using the Statistica 12 program. A multifactorial analysis of variance (ANOVA) was carried out, considering the factors type of packaging (with two levels: conventional film and recyclable film) and shelf life (with five levels: 0, 6, 12, 18 and 24 months). The multiple comparison of means was carried out using Tukey's honest significant difference test (Tukey HSD).

III. RESULTS AND DISCUSSION

Colour

Colour analysis results from the meat and fat can be found in Table 1 and Table 2, respectively. There were no significant differences in a* between the samples stored in the recyclable film modality and the control, both in fat and meat, throughout the trial. In the L* and b* parameters there were found statically significant ($p>0.05$) differences between 0 and 6 months between the samples stored with recyclable film method and the control in meat.

Table 1 – Colour measurement (L*, a*, b*) in meat of 'black pig' *secretos*. Values presented as mean ± standard deviation. In the same column, different letters represent significant different means ($p<0.05$)

		Meat		
Time (month)	Modality	L*	a*	b*
0	Control	58,5a±7,6	11,7a±1,8	42,7a±7,9
6	Control	74,5b±10,4	7,3a±4,3	55,0b±10,2
	Recyclable Film	76,6b±7,8	8,2a±3,5	62,8b±11,4
12	Control	68,9b±7,2	10,4a±2,5	55,9b±6,4
	Recyclable Film	69,2b±10,8	8,9a±2,9	54,6b±8,8

18	Control	71,4b±1,4	9,7a±0,6	56,1b±2,2
	Recyclable Film	71,2b±0,8	9,7a±0,6	55,9b±1,5
24	Control	71,3b±0,7	9,7a±0,5	56,0b±1,1
	Recyclable Film	71,3b±0,7	9,7a±0,5	56,0b±1,2

Table 2 – Colour measurement (L*, a*, b*) in the fat 'black pig' *secretos*. Values presented as mean ± standard deviation.

		Fat		
Time (month)	Modality	L*	a*	b*
0	Control	75,9±3,3	5,9±1,0	57,6±8,0
6	Control	76,7±7,1	7,7±3,9	57,6±8,8
	Recyclable Film	78,9±5,2	7,6±2,9	60,5±8,2
12	Control	66,2±10,4	9,4±2,9	48,2±11,7
	Recyclable Film	72,2±9,3	9,5±3,1	56,6±6,9
18	Control	75,2±1,9	9,2±0,8	56,3±2,3
	Recyclable Film	75,5±1,8	9,2±0,6	56,3±2,1
24	Control	75,3±1,4	9,2±0,5	56,3±1,9
	Recyclable Film	75,3±1,4	9,2±0,5	56,3±1,9

Since positive values for the b* parameter correspond to yellow coloring, the variation between yellow (+b) and blue (-b) [9], our results indicate a closer approximation to the yellow tone at six months of conservation in the case of conventional film. In a study conducted by Hawthorne in pork meat [10], significant fluctuations in the values of the b* parameter were identified with the use of modified atmosphere, and a comparison was made between the use of conventional films and recyclable films.

Sensory Analysis

The results of the sensory evaluation of these meat samples can be found in Table 3. Considering the color intensity evaluation, no statistically significant differences ($p>0.05$) were found between the modalities over time, and tasters did not detect off-colors in any of the modalities during the conservation period. Texture is a crucial factor in meat quality assessment. In these samples, hardness and juiciness were higher in the control modality, and significant differences ($p<0.05$) were found in these descriptors. However, there were no significant differences ($p>0.05$) in fibrosity between the methods over time. Flavor intensity was also higher in the control modality, with significant differences ($p<0.05$) in this attribute. Throughout the storage period, no unwanted colors or undesirable flavors were detected in any of the modalities, and the tasters could not distinguish between the samples stored in the two different modalities during the 24 months of frozen storage.

In studies by other authors comparing the use of modified atmosphere for preserving pork meat with conventional film and recyclable film, no differences in sensory attributes were observed either [6,10]. The type of packaging used can affect the sensory perception of meat [6,10,11]. In a study carried out by Hawthorne [10] evaluating the use of modified atmosphere in conventional films and recyclable films for preserving pork meat, no significant differences were detected in the sensory attributes studied. Several authors have reported that the use of vacuum packaging seems to have a positive impact on sensory parameters, especially those related to the presence of oxygen, such as color [12,13].

Table 3 – Effect of film type on sensory evaluation of 'black pig' *secretos*. Values presented as mean ± standard deviation. In the same column, different letters represent significant different means ($p<0.05$).

Time (month)	Modality	Colour Intensity	Off Colours	Hardness	Fibrosity	Juiciness	Flavour Intensity	Negative Flavours	Overall Appreciation
0	Control	58,0±18,2	0±0	50,8abc±4,1	21,0±24,0	70,7b±11,1	72,6abc±11,0	0,3±1,8	73,6±11,1
6	Control	61,2±21,8	0,6±2,4	51,78abc±7,1	18,7±23,1	69,4ab±13,0	74,4abc±11,9	0±0	74,8±10,8
	Recyclable Film	61,8±14,7	0,6±2,7	49,7abc±10,3	14,2±15,2	66,6ab±10,9	70,2abc±11,2	0±0	72,4±10,9
12	Control	60,7±9,8	0,5±1,0	51,8a±3,2	18,7±16,6	69,2ab±5,2	74,0b±6,8	0±0	74,5±5,6
	Recyclable Film	61,3±8,2	0,5±01,0	49,8abc±1,9	14,2±9,3	66,5ab±6,2	69,7ac±6,4	0±0	72,1±5,9
18	Control	59,8±5,1	0,5±0,8	51,7ac±2,3	18,5±13,4	68,8ab±2,6	73,5bc±5,2	0±0	73,9±3,6
	Recyclable Film	60,5±4,1	0,5±0,8	49,7bc±0,8	13,9±7,3	65,8a±3,5	69,1a±4,6	0±0	71,6±3,4
24	Control	59,9±3,1	0,5±0,7	51,8a±1,9	18,2±11,6	68,7ab±1,6	73,7b±4,2	0±0	74,0±2,7
	Recyclable Film	60,5±2,3	0,5±0,7	49,6b±0,6	13,8±6,3	65,8a±2,4	69,2a±3,7	0±0	71,4±2,5

IV. CONCLUSION

The recyclable films showed similar performance to the control in colour parameters and sensory evaluation over time. Related to sensory analysis, although hardness, juiciness and flavor intensity were higher in the control modality, there were no significant differences in brightness, colour intensity, presence of off colors, fibrosity, negative flavours and overall appreciation between the modalities. And very importantly from a trading point of view, the tasters did not distinguish between the samples preserved in the different modalities. The recyclable films proved to be a viable alternative, maintaining the sensory and visual quality of the meat and fat over time.

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