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Colour stability during prolonged storage of dry fermented sausages from Iberian pork

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Abstract. 30 units of chorizo and 30 units of salchichón "sarta" were packaged in different gas atmosphere conditions (i) vaccuum packaging (Batch 1) (ii) 70% N_2+ 30% CO_2 (Batch 2) (iii) 100 N_2 (Batch 3) (iv) 70% Argón + 30% CO_2 (Batch 4), and were stored under refrigeration (4±1ºC) during nine months. The evolution of several parameters related to colour surface (L*, a*, b*, Croma and Hue angle) were studied all throughout storage period. There were no differences for luminosity (L*) among packaging treatments for chorizo and salchichón samples (P>0.05). Red colour intensity (a*) significantly decreased for chorizo "sarta" in every batch, from initial values of 16.89±0.53 to final values ranging 14.17-15.22±0.55-0.49. With respect of differences among packaging systems of chorizo, batch 4 (70% argón+30% CO_2) showed the highest a* and C-values after 180 days and batch 2 (70% N2 + 30% CO2) the lowest, indicating more intense oxidation reactions affecting the pigment of samples packed in this gas composition. However, these differences were not evident after 270 days of storage. With respect of salchichón "sarta", a decrease in redness was evidenced alter 180 days of storage as well as a reestablishment of red colour at the end of the storage period batch 2 (70% N_2+30% CO_2) being the batch with the highest red colour intensity (P<0.001). The results obtained in this study suggest that as far as external appearance, specially colour, is concerned, shelf life of chorizo and salchichón "sarta" could be even longer. With respect of the type of gas atmosphere, this factor was not relevant for chorizo, whereas for salchichón, the gas atmosphere consisting in 70% N_2+30% CO_2 was the most convenient.

Keywords. Chorizo "sarta" – Salchichón "sarta" – Modified atmosphere packaging – Colour.

La stabilité de la couleur durant le stockage prolongé des charcuteries crues affinées de porc Ibérique

Résumé: *30 unités de "chorizo" et 30 de saucisson du type "sarta" ont été emballées sous différentes atmosphères : (i) emballage sous vide (Lot 1), (ii) 70% N_2+ 30% CO_2 (Lot 2), (iii) 100% N_2 (Lot 3), (iv) 70% Argon + 30% CO_2 (lot 4), et elles ont été ainsi stockées sous réfrigération (4±1ºC) pendant 9 mois. L'évolution des paramètres en rapport à la couleur de la superficie a été également étudiée (L*, a*, b*, Chrome et Hue) pendant la période de stockage. Il n'y a pas eu de différences de luminosité (L*) dues aux différentes compositions en gaz dans l'emballage utilisé pour les échantillons de "chorizo" et de saucisson du type "sarta" (P>0.05). Dans le cas du "chorizo sarta" l'intensité de la couleur rouge (a*) s'est significativement réduite dans tous les lots, depuis les valeurs initiales de 16,89±0,53 jusqu'aux valeurs finales de 14,17-15,22±0,55-0,49. En ce qui concerne les différences dues à la composition en gaz de l'emballage utilisé pour le "chorizo", le Lot 4 (70% argon+30% CO_2) a présenté les valeurs les plus élevées pour a* et C, 180 jours après, et le Lot 2 (70% N_2 + 30% CO_2) les moins élevées en montrant une oxydation plus intense de la pigmentation dans les échantillons emballés dans ce gaz. Néanmoins, ces différences n'étaient pas perçues après 270 jours de stockage. Concernant le saucisson "sarta", on observe une réduction de l'intensité de la couleur rouge après 180 jours d'emballage et sa récupération ultérieure vers la fin de la période d'emballage, le Lot 2 (70% N_2+30% CO_2) étant celui qui a présenté une plus grande intensité de couleur rouge dans le produit (P<0,001). Ces résultats nous suggèrent qu'en ce qui concerne l'aspect déterminé par la couleur, la durée de vie utile du "chorizo" et du saucisson du type "sarta" pourrait se prolonger plus longtemps. Et concernant le type d'emballage, ce facteur n'a pas exercé d'effet significatif dans le cas du "chorizo", et dans le cas du saucisson, le mélange 70% N_2+30% CO_2 a été le plus intéressant.*

Mots clés: *Chorizo "sarta" – Saucisson "sarta" – Emballage en atmosphères modifiées – Couleur.*

I – Introduction

Salchichón and chorizo are the most popular fermented raw cured meat, existing a great variety of them depending on the area of production (Edwards *et al*., 1999). The kind of variety "sarta" shows a diameter bigger than 22 millimetres and the sausage has got a horseshoe shape.

Currently, it is a more and more frequent practice in the packing of these raw fermented products vacuum or in different gas atmospheres (packed in modified or protector atmospheres, EAM or EAP) with the aim of adapting the sector to the new demands and consumption tendencies. The EAM consists in the replacement of the air that surrounds the food, by a gas or more frequently by an optimum mixture of gases that permits the lengthening of it shelf-life.

The shelf-life of fermented raw cured meat products is determined by their appearance and especially by the colour they show. During the curing process of these products the myoglobin transforms into nitrosylmyoglobin and nitrosylhemocrome, which are more stable pigments than myoglobin. Nevertheless the colour of fermented raw meat products can be altered during the cold storage (Ruiz Pérez-Cacho *et al.*, 2005). The effect of the packed on these characteristics has been studied in other works (Fernández-Fernández *et al.*, 2002). For that reason the aim of this study was to determine the most convenient packing conditions for the optimum preservation of the colour of the chorizo and salchichon samples of the "sarta" kind during a cold storage of 9 months.

II – Material and methods

For the development of this study 60 (30 and 30) units of chorizo and salchichón "sarta" that weighted between 0.261 ± 0.0089 and 0.224 ± 0.0111 kg respectively were used. These products were manufactured by Montesano SA company according to the standard formulation. Both kinds of sausage present a standardized amount of fat and lean (30% and 70% respectively). The period of ripening was concluded when the decrease of both products reached a 35-37%.

Each unit of product was packed in a bell packaging of the brand Tecnotrip, mod. EV-13-CB, Nº 932334 for the vacuum packing lots, an ULMA brand Flow-Pack machine mod. PV 350 LSHIX EMB and Nº 1219098 for the rest of the lots and in different conditions: (i) vacuum (Lot 1), (ii) 70% N_2+ 30% CO_2 (Lot 2), (iii) 100 N_2 (Lot 3), (iv) 70% Argon + 30% CO_2 (Lot 4). The vacuum plastic material consisted in PA/PE 30/120 of 150 microns of thickness with an O_2 of 25-30 cm^3/m^2/bar/24h at 23ºC permeability range and a water vapour transmission of 1,7 g/m^2/24 h at 23ºC and 85% of relative humidity. The samples were stored in refrigeration for 9 months, taking samples in the beginning, after 6 months and in the end of the storing period.

The colour of the surface cut in the chorizo and salchichón "sarta" was immediately measured after the opening of the pack by three times according to the American Meat Science Association (AMSA, 1991) recommendations. The following colour coordinates were obtained: luminosity (*L**), red colour intensity (*a**, red ± green) and yellow colour intensity (*b**, yellow ± blue). *a** and *b** were used to calculate the hue angle (hue = arctan [*b**/*a**]) and the colour saturation (chroma= $[a^{*2} + b^{*2}]^{0.5}$) parameters. The data obtained were analysed by the SPSS (SPSS 13.0) software package.

III – Results and discussion

The Tables 1 and 2 present the evolution of the colour parameters instrumentally measured (*L*, a*, b**, colour saturation or C and angle of Hue or h). The values of initial luminosity in the case of chorizo and salchichón "sarta" were of 32,84±1,01 and 32,37±0,94 respectively. During the first 180 days of storage it is possible to observe in a general way that the luminosity values were reduced in comparison to the initial ones, in some cases in a statistically significant way

(P<0.05) (Lot 2:70% N_2+30% CO_2 and Lot 3: 100 N_2 for the salchichón and lot 1: vacuum, Lot 2: 70% N_2+30% CO_2 and Lot 3: 100 N_2 for the chorizo). However, after 270 days of storage it is showed that the values of luminosity increase again in the mentioned lots, even if they do not reach the initial values of luminosity registered. In a similar way Rubio *et al.*, (2007) observed that the values of luminosity in samples of salchichón stored for 210 days were even higher in comparison with the initial product (P<0.05).

According to the differences among packed lots, these weren't significant (P>0.05) excepting the chorizo samples after 180 days of storage presenting the lot 3 (100% N_2) the maximum values of luminosity and the lot 2 (70% N_2 30% CO_2) the minimum. According to the evolution of the red colour in the different studied products, the intensity of red colour (*a**) was significantly reduced in the case of chorizo "sarta" in every lot, from initial values of 16.89±0.53 to final ones of 14.17-15.22±0.55-0.49. The loss of intensity in red colour is mainly owed to the oxidation of nitrosylmyoglobin an the formation of metmyoglobin, due to the presence of residual oxygen quantities (Andersen and Skibsted, 1992).

Table 1. Instrumental colour evolution (L*, a*, b*, C, h) (mean± standard error of the mean) on chorizo "sarta" stored under modified atmosphere packaging at 4ºC during 9 months

Time (days)	Packaging*	L* ± SE		a* ± SE		b* ± SE		C ± SE		H ± SE	
0		32.84$^{1/1/1/-}$	1.01	16.89$^{1/1/1/1}$	0.53	10.22$^{1/1/-/-}$	0.55	19.77$^{1/1/1/-}$	0.71	30.83$^{-/-/-/1}$	0.9
180	1	29.17ab^{2}	0.45	14.46ab^{2}	0.39	8.86ab^{2}	0.29	16.99ab^{2}	0.45	31.5	0.6
	2	28.57b^{2}	0.38	13.38b^{3}	0.34	8.24b^{2}	0.3	15.73b^{3}	0.43	31.48	0.52
	3	30.66a^{12}	0.53	14.05ab^{2}	0.35	9.32ab	0.37	16.90ab^{2}	0.46	33.24	0.78
	4	30.54a	0.51	15.04a^{12}	0.54	9.99a	0.47	18.08a	0.7	33.311	0.55
	$P_{envasado}$	***		*		*		*		NS	
270	1	31.2412	0.63	15.222	0.49	9.1812	0.4	17.792	0.61	30.94b	0.67
	2	31.791	0.61	14.802	0.33	9.611	0.28	17.662	0.41	32.90a	0.5
	3	30.012	0.7	14.172	0.55	9.01	0.53	16.822	0.73	31.96ab	0.67
	4	30.13	0.48	14.332	0.33	9.44	0.3	17.18	0.43	33.17a^{1}	0.39
	$P_{envasado}$	NS		NS		NS		NS		*	

Lot 1 = (vacuum); Lot 2= (70% N_2+ 30% CO_2); Lot 3=100 N_2; Lot 4= 70% Argon + 30% CO2. Significance levels: ns=>0.05:*=p<0.05: **= p<0.01: ***= p<0.001. a,b,c: different letters in the same column within the same storage time, mean significant differences between lots (P<0.05).
Test of Tukey 1,2,3: different superscripts in the same column within the same lots, mean significant differences between storage time (P< 0.05). Test of Tukey

Regarding the differences related to the gas composition of the pack, the lot 4 (70% argón+30% CO_2) showed the maximum values of *a** and C after 180 days and the lot 2 (70% N_2 + 30% CO_2) the minimum, pointing a more intense composition of the pigment in the samples packed in this gas. Nevertheless, these differences weren't perceptible after 270 days of storage.

Regarding the salchichón "sarta", a reduction in the intensity of red colour is observed after 180 days of packing and the following recovering of it in the end of the storage, being the Lot 4 (70% argon+30% CO_2) the one that showed a mayor intensity of red colour in the product after 270 days of storage(P<0.001). The loss of intensity in red colour is owed to the formation of metmyoglobin (of brown colour) from the nitrosylmyoglobin (MbFe(II)NO) (Lindahl *et al*, 2001). The reduction of intensity in red colour and the following recovering of it have been observed in previous studies in dry-cured ham (Andrés *et al.*, 2005) as well as in cured-fermented product (Rubio *et al*., 2008). Andersen *et al.* (1998) also observed that the mentioned recovering of colour was more important if an adecuate exclusion of oxygen in the pack was performed. On

the other hand, it can be supposed that the loss of humidity in the product during it storage can be related.

Table 2. Instrumental colour evolution (L*, a*, b*, C, h) (mean± standard error of the mean) on salchichón "sarta" stored under modified atmosphere packaging at 4 ºC during 9 months

Time (days)	Packaging*	L* ± SE		a* ± SE		b* ± SE		C ± SE		H ± SE	
0		32.37$^{-/1/1/-}$	0.94	11.35$^{1/1/1/1}$	0.22	4.01$^{1/1/1/1}$	0.11	12.04$^{1/1/1/2}$	0.23	19.45$^{2/2/2/2}$	0.34
180	1	30.86	0.5	8.783	0.17	3.162	0.07	9.333	0.18	19.802	0.25
	2	29.792	0.39	8.333	0.17	2.982	0.08	8.863	0.17	19.792	0.54
	3	29.982	0.46	8.543	0.13	3.033	0.07	9.063	0.15	19.502	0.25
	4	30.43	0.64	8.312	0.16	3.003	0.08	8.843	0.17	19.852	0.38
	$P_{envasado}$	NS		NS		NS		NS		NS	
270	1	30.74	0.54	9.59ab^{2}	0.15	3.80a^{1}	0.09	10.32ab^{2}	0.17	21.57b^{1}	0.41
	2	31.0412	0.42	9.82a^{2}	0.15	3.82a^{1}	0.07	10.54a^{2}	0.16	21.26b^{1}	0.27
	3	30.9512	0.51	9.21b^{2}	0.15	3.64a^{2}	0.08	9.91b^{2}	0.16	21.59b^{1}	0.39
	4	31.77	0.5	8.71c^{2}	0.12	3.36b^{2}	0.08	9.34c^{2}	0.12	21.081	0.45
	$P_{envasado}$	NS		***		***		***		NS	

Lot 1 = (al vacío); Lot 2 = (70% N2+ 30% CO2); Lot 3 = 100 N2; Lot 4 = 70% Argon + 30% CO2. Significance levels: ns =>0.05:*=p<0.05: **= p<0.01: ***= p<0.001. a,b,c: different letters in the same column within the same storage time, mean significant differences between lots (P<0.05).
Test of Tukey. 1,2,3: different superscripts in the same column within the same lots, mean significant differences between storage time (P< 0.05). Test of Tukey

Chroma or saturation of colour follows similar evolution to the one explained for *a** in salchichón and chorizo, being significantly reduced during the first 180 days of storage and increasing afterwards during the end of the period of storage, although if it doesn't reach the initial values of 12.04±0.23. The mayor value of Chroma on the surface of salchichón from lot 4 (70% argón+30% CO_2) has to be remarked comparing to the rest of the lots. This parameter represents the brightness of colour on the surface of the product (Sarasibar *et al.*, 1989). *b** is a parameter normally related to the lipid oxidation. In the case of chorizo "sarta" results hardly affected by the time of storage and only after 180 days, differences owed to the mixture of used gases are observed, showing the Lot 4 (70% argón+30% CO_2) the maximum value. Other authors have observed that the variation of *b** in this product cab be related to the presence of carotenoids (β-caroteno and criptoxantina) included in the páprika pepper, typical spice used in chorizo (Gimeno *et al.*, 2000). The nitrificant salts reduce the intensity and stability of the paprika developing a yellow discoloration of the red paprika of low pH (Sarasibar *et al.*, 1989). In the case of salchichón "sarta" the maximum values of *b** have to be remarked in lot 4 at the end of the period of storage, because they can point a mayor lipid oxidation.

IV – Conclusions

The results obtained in this study suggest that regarding the appearance determined by the colour, the-shelf life of the chorizo and salchichón "sarta" could be extended for a longer time. Regarding the packing time, this factor didn't exert a significant effect in the case of chorizo, and in the case of salchichón, the mixture 70% argon+30% CO_2 was more convenient.

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