COLOR AND LIPID OXIDATION CHANGES IN DRY-CURED LOINS TREATED WITH HIGH HYDROSTATIC PRESSURE: DEVELOPMENT OF A RESPONSE SURFACE MODEL TO OPTIMIZE THE COMBINATION OF PRESSURE AND TIME OF TREATMENT.

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Background

In the recent years the use of high pressure treatment on meat and meat products has increased in the meat industry trying to eliminate the possibility of growth of spoilage and pathogen microorganisms. Furthermore, high hydrostatic pressure treatments have been used to tenderise meat, gelling proteins and obtain novel products.

In Spain, dry-cured meat products are an important part of the meat industry. New trends in the presentation of the products comprise slicing and vacuum packaging. Dry-cured loin packed must be free of spoilage and pathogens microorganism, so high pressure treatments are used to pasteurise and sterilize it. To our knowledge, there are no studies in which oxidative changes and discoloration of dry-cured meat products treated with high hydrostatic pressure are evaluated.

Objectives

The object of the present study was to develop a mathematical model describing the relationship between discoloration and lipid oxidation in dry-cured loin and the combined effect of time and pressure in a high hydrostatic pressure treatment. The model should form the basis for proposing an optimal high hydrostatic pressure treatment to maintain the colour preferred by the consumer and at the same time keeping lipid oxidation at minimum possible.

Material and Methods

Dry-cured loin samples

Four dry-cured loins from pigs fed on a commercial diet were used for the experiment. Loins were liberated of casings and sliced using a slicing machine obtaining 3mm thickness slices.

Vacuum packaging, high pressure treatment and storage conditions

Loin slices were vacuum packaged in polyethylene bags containing 10 slices. Packages were pressurized at pressures during the times in accordance with the combinations obtained from the experimental design. After pressure treatment bags containing the pressurized slices were stored under refrigeration at +4ºC in the dark for 30, 45 and 60 days.

Chemical Analysis

On days 0, 30, 45 and 60 the following analyses were carried out:

Colour was measured on the dry-cured loin slices immediately after opening of the package using a Minolta Colorimeter CR-300 using the L*, a*, b* coordinates (CIELAB colour system) (CIE, 1986). Red colour was expressed as the a*-value, the higher the a*-value the redder the sample. The measurement was repeated on five randomly selected locations on each loin slice.

Lipid oxidation was measured using a complete dry-cured loin slice of each pack and homogenised using a kitchen blender. The extent of lipid oxidation was estimated as TBA-Rs using a modified version of Salih y cols., (1987) method. TBA-Rs were measured on three slices from each pack and were expressed as mg malondialdehyde (MDA)/kg meat.

Mathematical and statistical analysis

Response Surface Methodology (RSM) was used to study the simultaneous effects of two treatment variables: pressure and time of treatment. The experiment was based on a central composite rotatable design (Cochran and Cox, 1957). Five levels of each factor (variable) were chosen in accordance with the principles of the central composite design with analysis of 12 combinations of two variables being performed (Table 1). Assessment of error was derived from four replications of one treatment combination (2150bar, 17.5minutes) as suggested by the design. Variance for each factor assessed was partitioned into linear, quadratic and interactive components in order to determine the suitability of the second order polynomial function and the relative significance of these components.

$$Y = \beta_0 + \sum_{i=1}^{K} \beta_i x_i + \sum_{i=1}^{K} \beta_{ij} x_2 + \sum_{i<j} \beta_{ij} x_i x_j$$

Desirability surface and contour for the highest redness (CIE a*-value) and the lowest lipid oxidation (TBA-Rs number) and profile for predicted value and desirability were obtained according Derringer and Suich, (1980).

Results and Discussion

Increasing the pressure conditions from 800 to 4059 Bar increased CIE-a* value at day 0, while TBA-Rs were shown to increase with increasing pressure and time of pressurization (Figure 1). For the day 60 of storage, the increase in the pressure had a decrease effect on CIE-a*, while TBA-Rs were increased (Figure 2) .

The effect of the different high pressure treatments affected the colour (measured as Cie a-value) and TBA-Rs after pressurization and during refrigerated storage (Table 2). The evolution of Cie a*-value was different during the storage at +4ºC tended to maintain the initial values, with slight modifications depending on pressure and time of pressurization combination. In contrast, TBA-Rs tended to increase throughout the refrigeration storage, and the intensity of the increasing depended upon the intensity of the pressurization process.

Conclusions

In conclusion, response surface models seem promising to predicting and to obtain the optimum conditions of treatment (combination of pressure and time of pressurization) on chemical changes in vacuum packaged dry-cured loin. To reduce discoloration and to keep lipid oxidation at lowest level in vacuum packaged dry-cured loins the developed model suggests that the optimum high pressure conditions should be approximately 1194.8 Bar and 22.75 min (Figure 3).

References
CIE (1986). Colorimetry (2nd Edition). Commision International de l'Eclairage. Publication CIE 15.2. Vienna. CIE. Cochran, W.G., Cox, G.M. (1957). In: Experimental Designs. John Wiley and Sons, New York, pp. 122-217. Derringer, G. & Suich, R. (1980). *Journal of Quality Technology*, **12**, 214. Salih, A.M., Smith, D.M., Price, J.F. and Dawson, L.E. (1987). *Poultry Science*, **66**: 1483.

***Table 1.** Pressure and time of treatment as suggested by the model design.*

Batch	Pressure (bar)	Time (min.)
1	240	17.5
2	800	10
3	800	25
4	2150	7
5	2150	17.5
6	2150	28
7	3500	10
8	3500	25
9	4059	17.5

***Table 2.** Evolution of CIE a*-values and TBA-Rs of vacuum packaged dry-cured loins treated with high hydrostatic pressure treatment.*

	Redness (Cie a*-value)				Lipid oxidation (TBA-Rs)			
Days	0	30	45	60	0	30	45	60
Batch #1	19.26	28.01	30.76	30.47	0.55	0.38	0.42	0.43
Batch #2	24.41	23.58	25.49	24.62	1.32	0.28	0.38	0.46
Batch #3	25.17	29.55	30.13	31.49	0.49	0.37	0.44	0.46
Batch #4	26.79	22.19	23.25	22.61	0.47	0.26	0.34	0.41
Batch #5	25.03	30.44	30.32	30.99	0.41	0.23	0.38	0.35
Batch #6	23.05	23.51	21.71	22.85	0.46	0.21	0.33	0.46
Batch #7	25.23	30.59	30.22	26.96	0.61	0.26	0.43	0.39
Batch #8	24.33	26.39	26.27	26.11	0.39	0.22	0.27	0.32
Batch #9	25.13	25.59	25.50	26.63	0.30	0.21	0.35	0.39

***Figure 1.** Effects of pressure and time of pressurization on CIE-a* (left) and TBA-Rs (right) after treatment (day 0).*

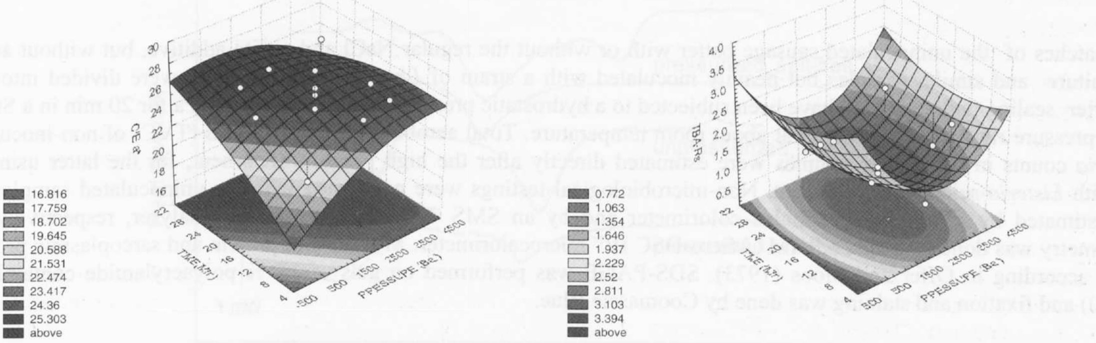

***Figure 2.** Effects of pressure and time of pressurization on CIE-a* (left) and TBA-Rs (right) at the end of experiment (day 60).*

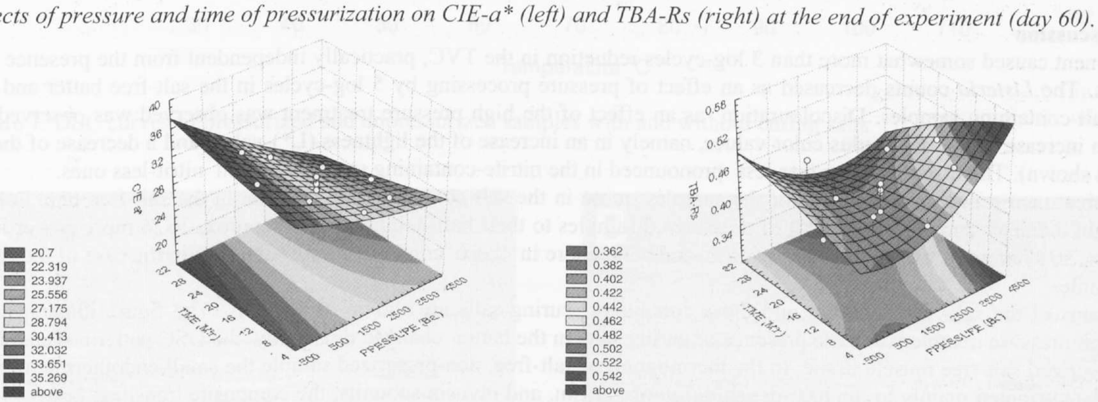

***Figure 3.** Desirability surface/contour for the highest redness (CIE a*-value) and the lowest lipid oxidation (TBA-Rs number) (left) and profile for predicted value and desirability (right up: pressure, right down: time).*