

## Study of the influence of different packaging films on cauliflower color changes as a minimally processed product.

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### ABSTRACT

Among the films most widely used for the commercialization of minimally processed products, a study has been carried out to determine which one might be advisable for the 5 varieties of cauliflower under the Protected Geographical Indication (P.G.I.) “Cauliflower of Calahorra,” and which one might preserve hygiene-health conditions for the longest time possible. The results show that the P-Plus 120 film is the one that best preserves the chromatic characteristics and maintains adequate microbiological levels during a shelf-life period that is useful and sufficient for commercialization.

### 1. INTRODUCTION

The special characteristics of the cauliflower grown in the area of Calahorra (La Rioja, Spain) have lead to the establishment of the Protected Geographical Indication (P.G.I.) “Cauliflower of Calahorra”. This designation includes more than thirty heterogeneous varieties, both due to the planting season and harvest as well as the development time period. Thus, there are early varieties (which are grown during the winter and early spring months) and late varieties (which grow during the warm months). On the other hand, there are short-cycle varieties (30 development days) and long-cycle varieties (up to 120 development days). In addition, there are differences among the varieties in terms of appearance, color being one of the differential qualities.

The commercialization of minimally processed vegetables is an interesting alternative to the fresh produce market. For this kind of products, vegetables are subject to minimal processing, which does not reduce in anyway their freshness and facilitates their use by consumers while guaranteeing their quality.

Visual appearance is essential for this kind of products given that a variation in the original color could mean immediate rejection by consumers, even if health conditions are correct.

With the aim of promoting and facilitating the consumption of cauliflower, an adaptation of the minimally processed vegetables technology has been studied, namely, as a washed and packaged vegetable ready to be consumed, during its useful shelf-life, which preserves the characteristic of a fresh product and meets the hygiene-health standards in force.

Due to the differences among varieties, we have tried to find a film, among those most commonly used in the market, which might be appropriate for packaging most varieties.

### 2. MATERIALS AND METHODS

Five varieties of cauliflower grown in Calahorra and approved by the PGI have been studied: *50/90*, a short-term development variety harvested in March; *Serrano*, a short-term development variety harvested in May; *Casper*, a medium-term development variety harvested in October; *Nautilus*, a short-term development variety harvested in October, and *Dulix*, a medium-term development variety harvested in November.

The pieces were cut up and disinfected by being submerged in chlorinated water (50 ppm of free chlorine at 4° C for 5 minutes). Rinsing conditions were established based on techniques used for other vegetables<sup>1</sup> and the results obtained in previous tests on cauliflower. After rinsing, cauliflower was subject to spin-drying in order to eliminate excess water. Subsequently, it was packaged in trays

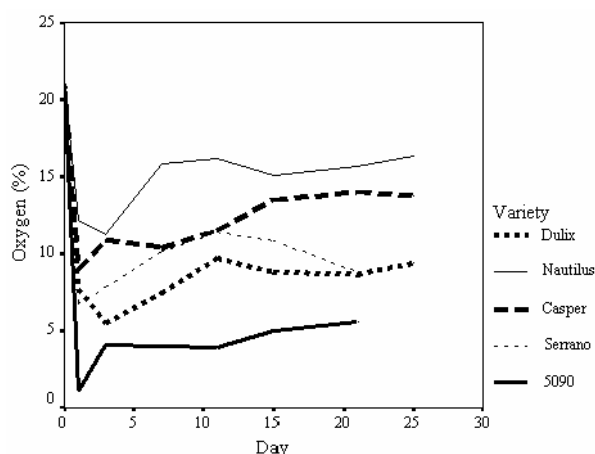
(batch A) and bags (batches B, C, and D), weighing 300 grams each one, using films with different types of permeability: batch A, placed in polystyrene trays covered in perforated PVC acting as a control batch; batch B, in P-Plus120 bags; batch C, in P-Plus 160 bags and batch D, in P-Plus 240 bags. Batches were stored at 4°C throughout the experiment. On days 0, 1, 3, 7, 11, 15, 21 and 25, two samples of each batch were analyzed to determine the inner atmosphere of the packages by estimating the percentage of O<sub>2</sub> and CO<sub>2</sub> with a Checkmate Dansensor analyzer; weight losses with respect to the initial weight and aerobic mesophyllic microorganism counts were determined by means of successive dilutions and plate sowing using the PCA<sup>2</sup> (Plate Count Agar), and incubation at 31 °C for 48 h. Likewise, on the sampling days, an evaluation of the sensory qualities (color, odour, texture, general appearance) was carried out by a panel of experienced tasters.

Color measurements were performed with a Minolta CM2600d spectrophotometer, which measured reflectance spectra between 400 and 700 nm every 10 nm, on the exterior part of the cauliflower (6 points) and on the cut area (6 points). Color coordinates were also calculated with the CIE Standard Illuminant D65 and the CIE 1964 Standard Observer, given that these are the most critical areas for observing color variations. Of the six measurements made, both the average deviation and typical deviation were calculated.

### 3. RESULTS

The use of films with a different permeability and the differences in the respiratory activity of the varieties used resulted in different atmospheres inside packages, which conditioned both the microbiological and sensory evolution of packaged cauliflower. On the one hand, all the varieties packaged with PVC presented O<sub>2</sub> and CO<sub>2</sub> percentages similar to atmospheric ones (21% O<sub>2</sub> and 0% CO<sub>2</sub>). However, the influence of the respiratory rate of each variety was obvious in batches B, C, and D, where the packaging films used presented a limited permeability of gases. In fact, in batch B, which was packaged with a film of lesser permeability, the atmosphere composition inside the packages ranged from 16% O<sub>2</sub> and 5.5% CO<sub>2</sub> for the Nautilus variety to 4% O<sub>2</sub> and 19% CO<sub>2</sub> for the 50/90 variety. In Figure 1, the evolution of oxygen content for the different varieties packaged with film B (P-Plus 120) is shown.

From a microbiological point of view, the largest counts at the end of the studied period were found in those packages where the atmosphere had greater oxygen percentages and lesser CO<sub>2</sub> percentages. Therefore, samples packaged with film A presented greater aerobic mesophyllic microorganism counts for all varieties (greater than 4 logarithmic units per gram with respect to the initial counts for some varieties). On the contrary, the samples of batch B showed, at the end of the period studied, microbiological counts slightly higher than the initial counts (hardly +1.2-2.7 logarithmic units per gram, depending on the variety). Despite these differences, the counts were below the 7 logarithmic units established by the current Spanish legislation<sup>3</sup>.



**Figure 1.-** Evolution of oxygen percentage for the different varieties packaged with film B (P-Plus 120)

However, this did not happen in the sensory evaluation, where the varieties in which the inner atmosphere of the packages presented lower levels of O<sub>2</sub> and higher levels of CO<sub>2</sub>, and obtained the least score, mainly due to the development of unpleasant odors.

In terms of weight losses during the storage period studied, only batch A suffered losses greater than 4% with respect to the initial weight, regardless of the variety. None of the batches packaged with P-Plus film presented substantial losses given that they were below 0.05% in every case.

Changes in color coordinates among different batches indicated different patterns of behavior for the coordinates.

Coordinate a\* presented a very small variation (below 1.5 CIELAB units) for all the varieties and all the films, both in terms of exterior color of cauliflower and for cut areas.

Coordinate b\* presented variations between 2 and 8 CIELAB units, which depended on the type of film used.

The behavior of coordinate L\* varied depending on the variety and the point where measurements were made, and so variations could be below 1 CIELAB unit in the case of the Casper variety when cut areas were measured, or greater than 3 units for the Nautilus variety when the external area was measured.

In Table 1, the values obtained for coordinate b\* and coordinate L\* from the measurements carried out in the cut area are shown.

**Table 1.** Initial and final values of coordinates b\* and L\* for the different varieties and different films.

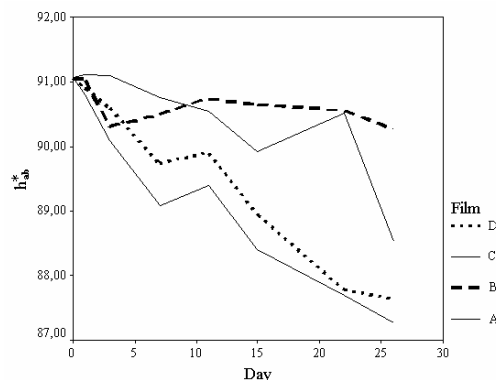
Variety	Film	b* ini	b* final	$\Delta b^*$	L* in	L* final	$\Delta L^*$
5090	A	13.25	18.57	5.32	86.0	82.6	-3.4
	B	13.25	17.77	4.52	86.0	85.0	-1.0
	C	13.25	18.16	4.91	86.0	80.9	-5.1
	D	13.25	21.68	8.43	86.0	77.8	-8.2
Serrano	A	14.05	17.06	3.01	84.8	82.6	-2.2
	B	14.05	15.47	1.42	84.8	83.0	-1.8
	C	14.05	15.41	1.36	84.8	84.4	-0.4
	D	14.05	17.58	3.53	84.8	81.1	-3.7
Casper	A	9.91	13.98	4.07	86.6	85.9	-0.7
	B	9.91	10.68	0.77	86.6	86.9	0.3
	C	9.91	11.98	2.07	86.6	86.6	0.0
	D	9.91	11.64	1.73	86.6	85.7	-0.9
Nautilus	A	10.15	12.28	2.23	87.2	80.6	-6.6
	B	10.15	13.46	3.31	87.2	82.7	-4.5
	C	10.15	15.03	4.88	87.2	81.9	-5.3
	D	10.15	16.24	6.09	87.2	81.1	-6.1
Dulix	A	9.04	14.58	5.54	87.8	87.5	-0.3
	B	9.04	11.36	2.32	87.8	87.1	-0.7
	C	9.04	11.87	2.83	87.8	84.7	-3.1
	D	9.04	12.53	3.49	87.8	86.8	-1.0

We can see that film B (P-Plus 120) presents a better response for all the varieties, since coordinate variations are lower for most of them. On the other hand, film A (perforated PVC) presents the worst results for coordinate b\* and film D (P-Plus 240) provides the worst results for coordinate L\*.

Given the minimal variation of coordinate a\*, the behavior of coordinate C<sub>ab</sub><sup>\*</sup> is similar that of coordinate b\*.

Coordinate  $h_{ab}^*$  presents a very normal behavior in all the varieties, for example figure 2 shows the behavior of the variety Dulix when the outside of the piece is measured.

The study of all the varieties verifies that film B presents a lesser variation of coordinate  $h_{ab}^*$  for all the varieties.



**Figure 2.** Variation of coordinate  $h_{ab}^*$ , when the exterior area of the variety Dulix, packaged in the different films, is measured

#### 4. CONCLUSIONS

Despite the agronomic heterogeneousness of the different varieties of cauliflower grown under the I.G.P. “Cauliflower of Calahorra”, the selection of one film is possible, which allows for maintaining the sensory qualities and adequate microbiological levels during a shelf-life period that is useful and sufficient for commercialization.

The maintenance of adequate microbiological levels for long periods of time makes variations in chromatic characteristics mark the useful lifespan of the product. Colorimetric measurements indicate that the P-Plus 120 film best preserves the chromatic characteristics of the five varieties studied, in terms of color of the external area and color of the cut area.

Variations in color coordinates are below those of other types of films, although these variations depend on the variety value. These variations are between 0.5 and 6.5 CIELAB units.

#### Acknowledgements

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