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in

Melgarejo P. (ed.), Martínez-Nicolás J.J. (ed.), Martínez-Tomé J. (ed.).
Production, processing and marketing of pomegranate in the Mediterranean region: Advances in research and technology

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 42

2000
pages 211-217

Colorimetric properties and commercial opportunity of pomegranate kernels (*Punica granatum* L.) under a minimum processing

A. Coret*, D. Salazar*, E. García and P. Melgarejo****
*Escuela Técnica Superior de Ingenieros Agrónomos, Universidad Politécnica de Valencia, Camino de Vera s/n, Valencia, Spain
**Escuela Politécnica Superior de Orihuela, Universidad Miguel Hernández, Ctra. de Beniel km 3,2, 03312 Orihuela (Alicante), Spain

SUMMARY – In this work, the tasting and microbiological quality of a new product based on pomegranate kernels has been studied when packed in semi-permeable plastic packing. The role and influence of the packaging conditions in the colorimetric and physico-chemical properties has been studied in depth in order to determine its influence on the quality of the product. It is concluded that the use of a modified atmosphere (93% N_2, 5% CO_2 and 2% O_2) combined with the use of potassium sorbate in acid conditions, or natural lemon juice leads to the product with the best tasting and colorimetric properties. This product has a higher luminosity and a lower yellow colour than other products tested and controlled.

Key words: Pomegranate, colour, modified atmosphere, preservation.

RESUME – *"Propriétés colorimétriques et opportunité commerciale des graines de grenades (*Punica granatum *L.) pour une transformation de quatrième gamme". Dans ce travail, le goût et la qualité microbiologique d'un nouveau produit basé sur les graines de grenade ont été étudiés lorsqu'elles sont sous emballage plastique semi-perméable. Le rôle et l'influence du conditionnement sur les propriétés colorimétriques et physico-chimiques ont été étudiés en profondeur afin de déterminer leur influence sur la qualité du produit. On en a conclu que l'utilisation d'une atmosphère modifiée (93% N_2, 5% CO_2 et 2% O_2) combinée avec l'utilisation de sorbate de potassium en conditions acides, ou de jus naturel de citron, mène à obtenir un produit ayant le meilleur goût et les meilleures propriétés colorimétriques. Ce produit a une luminosité plus forte et une couleur jaune plus faible que les autres produits testés et contrôlés.*

Mots-clés : *Grenade, couleur, atmosphère modifiée, préservation.*

Introduction

The pomegranate is a shrub belonging to the Punicacea family. It is grown in very specific areas of the Mediterranean, in some parts of the USA and South America, as well as particular areas of the Near East (Pakistan, Afghanistan, Iran, Saudi Arabia and India) (Elyatem and Kader, 1984). Of the whole pomegranate-growing area in Spain, 88% of the Spanish pomegranate production is grown in the Valencian Community.

The means of prolonging the shelf life of pomegranates have been widely studied. Already in 1969, Nukerjee reported the viability of storing pomegranates for 7 months at 0 and 4.5°C with a relative humidity of between 80 and 85% (Kondav, 1969).

Later, in 1984, Elyatem and Kader, reported that at 2.2°C the pomegranates present their lowest level of respiration and endogenous ethylene production.

In 1987, Pota *et al*. studied the effect of packing materials on the quality and shelf life of 'Banluang' pomegranates in storage at different temperatures, reaching the conclusion that the best conservation takes place in polyethylene bags stored at 10°C.

However, only Juven *et al*. (1984) addressed the problem of inconvenience of peeling, and studied how viable it would be to develop a new product based on loose pomegranate kernels packed in sealed plastic bags with a modified atmosphere. He observed how this product, kept at 1°C, had a shorter shelf life due to the unpleasant taste from the microbial metabolism.

Material and methods

Elaboration conditions

For this study pomegranates of the 'Mollar' variety were used (harvested in Elche, Alicante, Spain). These pomegranates were peeled and selected, and then treated with preservatives. The pomegranates were then screened, selected, packed and stored.

Two possibilities were studied for peeling: hand peeling, and mechanical peeling using a machine set up by the Plant Production Department of the Polytechnical University of Valencia. The subsequent trials were carried out in order to determine which of the two methods was the most appropriate. In order to do so, the respiration index was chosen as a differentiating parameter for the quality of the pomegranate kernels obtained by each method. As a result of the trials, a higher respiration rate was observed for machine-peeled pomegranates than those peeled by hand. This was attributed to the presence of a greater number of broken or damaged kernels. These damaged kernels lost transparency leading to a more opaque product 3-4 hours after peeling and cool storage at 2.4°C. Therefore, hand peeling was finally chosen on this occasion.

The next preliminary operation was selection in order to discard the kernels that had been damaged during peeling or that had physiological problems.

All kernels classified as optimum and which went on to the selection process, were divided into six groups, each of which were treated with different preservatives by immersing the seeds in the solutions shown in Table 1 for 10 minutes.

Table 1. Solutions used for each of the six groups of samples

Sample T	Sample CA	Sample SP3	Sample SP5	Sample SCA	Sample L
Solution 1: No treatment (Reference)	*Solution 2:* Citric acid 2% + ascorbic acid 0.5%	*Solution 3:* Potassium sorbate 0.3%	*Solution 4:* Potassium sorbate 0.5%	*Solution 5:* Potassium sorbate 0.3% + citric acid 1% + ascorbic acid 0.5%	*Solution 6:* Natural lemon juice in distilled water (30%)

The seeds were then filtered and selected, after which each group was separated into two batches and each was packed at two different atmospheres. The bags used were plastic, and semi-impermeable to gas, made of 80% polyethelene and 20% polyamide. This had been shown in previous tests to be the most appropriate type of plastic for the trials. Different types of packing were used for each batch. In the first, a natural method was used, obtaining a product packed in a non-modified atmosphere (AN). However, for the second, a sealing machine was used (a Tecnotrip Model EV-7) that allowed a modified atmosphere (AM) to be applied in doses, made up of a mixture of gases (93% N_2, 5% CO_2 and 2% O_2). In this way, a total of 12 different samples were obtained.

All the bags were kept in cool storage at 2-4°C and a humidity of 80%.

Analysis

In order to determine the ripening of the product, the maturity index was analysed, expressed as: "*Maturity index = Soluble solid content/Acidity*".

The soluble solid content was measured with a refractometer, making three replications per sample analysed.

The acidity was measured from 1 ml of juice, using a solution of 0.1 N of previously titrated soda, and taking phenolphthalein as an indicator. The results are expressed in "grams of citric acid/100 ml of juice" as this is the principle organic acid.

The evolution of colour over time was analysed with a Minolta CM 1000 R colorimeter. This colorimeter allowed the coordinates of the colour CIEL*a*b*, to be measured where: L* (luminosity), a* (red/green), b* (yellow/blue). From these determinations, the variation of the sensation of colour (AE) was measured using the formula: $AE = (Aa^2 + Ab^2 + AL^2)^{1/2}$. The reflectance was measured using a sight at 10° and D-65 illuminant.

As the orientation of the seeds at the time of measurement produced variability in the parameters L*, a*, and b*, an apparatus was designed in order to guarantee that this orientation was the same for the different samples at different times. The values obtained could thus be compared with each other.

The basic microbiological conditions were controlled by limiting total anaerobic germs. For this purpose, 1 gram of each sample was sown in Agar Schaedler Anaerobia, making various dilutions. The incubation conditions were 48 hours at 37°C. The results were expressed in *"Colony-forming units/gram".*

In turn, a sensorial analysis of the product was made up to the previously determined organoleptic and microbiological expiry date.

The analyses were made 6 times consecutively for 29 days, taking samples on days: 0, 5, 8, 15, 22 and 29. All measurements were taken three times. Furthermore, the trials were repeated for three consecutive years under the same conditions in order to guarantee the reliability of results.

Results

The evolution of the product maturity index is reflected in Table 2.

Table 2. Maturity index of the product

Treatment	Non-modified atmosphere						Modified atmosphere					
	Time (days)						Time (days)					
	0	5	8	15	22	29	0	5	8	15	22	29
T	55.22	74.68	65.50	64.73	71.48	71.33	60.93	67.42	60.23	75.30	73.13	80.91
CA	46.68	56.59	52.48	53.71	61.59	64.31	49.34	58.90	50.29	59.64	59.24	56.31
SP3	63.58	70.92	62.92	69.58	75.78	78.24	68.88	75.68	71.13	76.05	71.67	88.79
SP5	62.85	65.46	65.50	64.23	65.30	80.91	65.27	75.50	70.67	79.91	82.77	76.00
SCA	52.81	66.23	64.62	59.61	63.43	70.92	54.52	40.93	47.43	46.80	52.25	52.87
L	49.80	62.83	51.97	51.41	58.24	59.11	51.27	60.28	59.90	66.19	61.24	59.59

If an increase in the maturity index was observed in all samples, it was also noticed that the samples subjected to SCA and CA treatment, under the action of a modified atmosphere, were those that maintained the most stable maturity index throughout the experiments.

The luminosity (L*) value presents significant differences between treatments; between the modified atmosphere and the non-modified atmosphere, and in the interaction between the type of atmosphere and the time.

As for the different treatments, the potassium sorbate 0.3% (SP3) treatment maintained a better luminosity in the final product.

Comparing the effect of the different atmospheres, the product kept at modified atmosphere presented a more stable luminosity (L*) for all treatments, as shown in Fig. 1.

The red component of the colour (a*) presented significant differences over time and in the treatment-atmosphere interaction. Table 3 shows the average values of "a*" for different treatments and atmospheres.

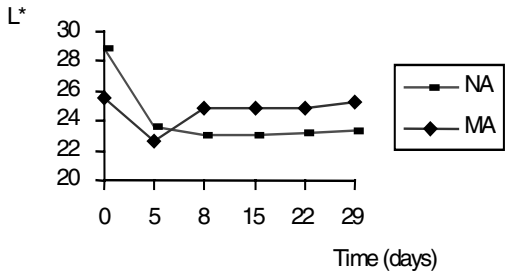

Fig. 1. Effect of the atmosphere used in the packing on the luminosity of the product.
NA = non-modified atmosphere; MA = modified atmosphere.

Table 3. Average values of a* (red component of colour)

Treatment	Non-modified atmosphere						Modified atmosphere					
	Time (days)						Time (days)					
	0	5	8	15	22	29	0	5	8	15	22	29
T	18.43	21.49	18.81	20.30	17.45	19.33	20.51	20.22	18.19	16.97	15.70	17.05
CA	18.43	21.38	18.35	19.88	17.31	18.71	20.51	20.85	22.12	18.60	18.23	16.62
SP3	18.43	20.70	20.41	20.11	19.09	17.47	20.51	22.45	18.05	16.07	15.90	15.89
SP5	18.43	20.86	22.61	17.95	19.14	16.17	20.51	18.63	19.95	16.73	15.33	17.51

A decrease in the red colour (a*) is observed over time as can be seen in Fig. 2.

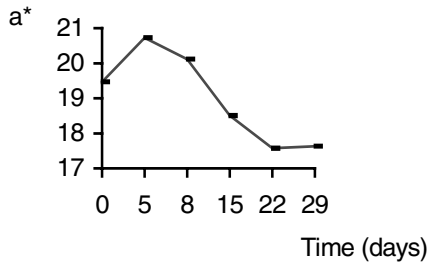

Fig. 2. Evolution over time of the red component of the colour.

As for the difference between batches for given treatments and atmospheres, the following can be observed: (i) treatments SCA and L – there were practically no differences between both atmospheres; and (ii) the rest of the treatments keep the red colour better in the non-modified atmosphere.

In the yellow component of the colour (b*), the significant differences occurred in time and between the different treatments. In Table 4, the average values of the yellow component of the colour can be appreciated for different treatments and atmospheres.

Fig. 3 shows how the batches packed with natural lemon juice (L) present a lower value in the yellow component of the colour in comparison to the other treatments used.

The variation of the sensation of colour (AE) for both batches shows the following differences: (i) batches packed in non-modified atmosphere – the AE oscillates between 6 and 7.5; and (ii) batches packed in modified atmosphere – the AE oscillates between 2 and 4 as shown in Table 5.

Table 4. Average values of b* (yellow component of the colour)

Treatment	Non-modified atmosphere						Modified atmosphere					
	Time (days)						Time (days)					
	0	5	8	15	22	29	0	5	8	15	22	29
T	4.85	8.36	6.78	7.85	5.48	8.09	6.87	7.63	6.88	7.72	5.92	6.23
CA	4.85	8.20	6.53	7.87	7.04	7.24	6.87	7.96	9.31	7.60	7.14	6.23
SP3	4.85	8.55	7.26	7.89	7.86	7.32	6.87	9.47	8.35	8.62	7.85	8.39
SP5	4.85	8.66	9.18	7.57	7.69	7.39	6.87	8.24	10.10	8.92	7.50	7.34
SCA	4.85	7.22	7.00	5.85	7.47	6.89	6.87	7.85	8.73	8.88	7.45	6.89
L	4.85	7.54	7.49	7.02	6.27	6.82	6.87	7.02	7.29	6.78	6.23	6.48

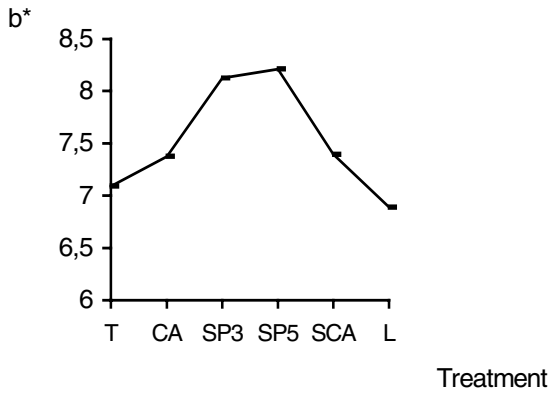

Fig. 3. Yellow component of the colour with different treatments.

Table 5. Variation in sensation of colour

	T	CA	SP3	SP5	SCA	L
Non-modified atmosphere	6.685	7.591	5.535	7.432	6.482	6.265
Modified atmosphere	4.072	3.059	3.471	4.159	2.423	2.523

Figure 4 shows how the combination of modified atmosphere and SCA or L treatments give rise to a product with a lower variation of sensation of colour.

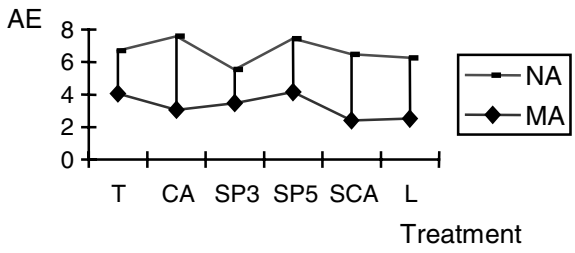

Fig. 4. Variation of the sensation of colour (AE).
NA = non-modified atmosphere; MA = modified atmosphere.

As for microbiological analysis, the results are reflected in Table 6.

Table 6. Total count of anaerobia

Treatment	u.f.c./g (sample of 12 days)	u.f.c./g (sample of 34 days)
T	3.5×10^2	3.2×10^4
CA	6×10^2	1.1×10^3
SP3	4	7.1×10^5
SP5	2	3.1×10^5
SCA	0	2.4×10^2
L	5	3.1×10^2

It was observed that in all the samples, the prevalent colonies were two species of yeast (Hanseniaspora and Debaryomices), coinciding with studies carried out by Juven *et al*. (1984).

The SCA and L treatments, presented the lowest microbial load, placing treatment CA in third place.

Conclusions

(i) The modified atmosphere used, together with the SCA treatments (potassium sorbate with citric acid and ascorbic acid) and CA (citric acid with ascorbic acid), are the elaboration conditions that have led to the obtention of the most stable maturity index throughout the period of study.

(ii) The modified atmosphere has allowed the luminosity of the product during the period of conservation to be studied, unlike what happened when a non-modified atmosphere was used.

(iii) Furthermore, and in relation with the luminosity, the SP3 treatment (potassium sorbate 0.3%) gave the best result.

(iv) In the SCA treatments (potassium sorbate with citric acid and ascorbic acid) and L (natural lemon juice), the atmosphere used in the conservation did not present an additional advantage for the maintenance of the red colour throughout the period of study. However, for the other treatments, the non-modified atmosphere is better than the modified atmosphere.

(v) The batch treated with natural lemon juice (L), presented the smallest yellow component of colour (b*).

(vi) The modified atmosphere used meant that the final product had a lesser variation of the sensation of colour in comparison with the use of non-modified atmosphere. The treatments SCA (potassium sorbate with citric acid and ascorbic acid) and L (natural lemon juice), where modified atmosphere has been used, are those which have a lesser variation in the sensation of colour, and therefore the most apt colorimetric properties.

(vii) From the microbiological analyses it can be deduced that the SCA treatments (potassium sorbate with citric acid and ascorbic acid) and L (natural lemon juice) are those which maintain the lowest anaerobia counts. Likewise, the tasting sessions that were held with the different samples reveal that the tasters liked both treatments (SCA and L), mainly for their more attractive colour.

(viii) As a final conclusion, the product obtained with the combination of treatment with potassium sorbate in acid medium, or natural lemon juice and a modified atmosphere, has offered the best physico-chemical, microbiological and organoleptic properties.

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