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INFLUENCE OF CHEMICAL TREATMENT ON THE PHYSICAL PROPERTIES OF PEA PODS

INFLUENCIA DE TRATAMIENTOS QUÍMICOS SOBRE LAS PROPIEDADES FÍSICAS DE LA VAINA DE ARVEJA

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ABSTRACT

The husks or pods of peas are residues that are obtained once the seeds are removed from their envelope. This agro-industrial waste is rich in carbohydrates, proteins, vitamins, pigments and even phenolic compounds. In order to take advantage of this by-product, the object of the research was to study the influence of chemical treatments on the physical properties of the pea pod. Initially, the pea pod was treated with 0.5 % and 2% oily acid, with 2.5 % sodium bisulfite and an untreated control sample. Subsequently, the pods were analyzed by determining the color by colorimetry using the CieLab scale, hardness by texturometer, total chlorophyll content (TCh) and carotenoids (TCa) by visible spectrophotometry at 663 mm, 645 mm and 410 mm respectively. The pods treated with 0.5 % acetic acid presented the highest values of the parameter of b * of 19.17 and those treated with sodium bisulfite at 2.5 % presented significant differences (p ≤ 0.05) with respect to the other samples in the parameters of luminosity (L) and (b *). With respect to hardness the force required for the break was 28 to 32 N in a span of 16 to 18 seconds, indicating a correlation with moisture content, crude fiber and pectin content. The pigments contained in the pea pod can be used to enrich foods because it is a natural source of chlorophyll and carotenoids, providing a high nutritional value with attractive color and beneficial effects for human health.

Keywords: *peas, carotenoids, chlorophyll, physical properties, texture, sheath.*

RESUMEN

Las cáscaras o vainas de arvejas son residuos que se obtienen una vez se retira de su envoltura las semillas. Este residuo agroindustrial presenta alta riqueza de carbohidratos, proteínas, vitaminas, pigmentos e incluso compuestos fenólicos. Con el fin de aprovechar este subproducto el objeto de la investigación fue estudiar la influencia de tratamientos químicos sobre las propiedades físicas de la vaina de arveja. Inicialmente, se trató la vaina de arveja con ácido aceitico al 0,5 y 2 %, con bisulfito de sodio al 2,5 % y una muestra control sin tratamiento. Posteriormente, las vainas fueron analizadas determinando el color por colorimetría mediante la escala CieLab, dureza por texturómetro, contenido total de clorofila (TCh) y carotenoides (TCa) por espectrofotometría Visible a 663 mm, 645 mm y 410 mm respectivamente. Las vainas tratadas con ácido acético al 0.5 % presentaron los valores más alto del parámetro de b* de 19,17 y las tratadas con bisulfito de sodio al 2,5 % presentaron diferencias significativas (p≤0,05) con respecto a las otras muestras en los parámetros de luminosidad (L) y (b*). Con respeto a la dureza la fuerza requerida para que la ruptura fue de 28 a 32 N en un lapso de 16 a 18 segundos, indicando una correlación con el contenido de humedad, fibra cruda y contenido de pectina. Los pigmentos contenidos en la vaina de arveja pueden ser utilizado para enriquecer alimentos por ser fuente natural de clorofila y carotenoides, aportando un alto valor nutricional con color atractivo y efectos benéficos para la salud humana.

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Palabras clave: *arveja, carotenoides, clorofila, propiedades físicas, textura, vaina.*

INTRODUCTION

The pea pod, composition and properties.

Pea (Pisum sativum, L.) is a leguminous plant of the Fabaceae family, domesticated by man since ancient times, according to archaeological findings in Thailand, Iraq and Switzerland dating between 10,000- and 3,000-years BC (DANE, 2015). The waste production of green pea shells or pea pods is estimated at 35%-40% after extracting peas from their pods (Hanan et al., 2020). Pea pods or shells offer great health benefits, providing excellent nutritional properties due to their vitamin, mineral, pigment and dietary fiber content, as well as being low in calories, fat and cholesterol (Pathak et al., 2016).

Agricultural residues have great potential to be exploited as a potential source of natural pigments (chlorophyll, carotenes), phenolic compounds, vitamins, minerals and dietary fiber, etc., given their antioxidant and anti-inflammatory properties beneficial to health

(Ordoñez-Santos et al., 2020). These phytochemicals are widely exploited in the agri-food, pharmaceutical, chemical and textile industries, which are used for the elaboration of functional or enriched foods, in the production of medicines, paint and dye industry (Sagar et al., 2018; Villada et al., 2022).

Pigments such as chlorophyll and carotenes are found in chloroplasts and chromoplasts respectively. Chlorophyll a is responsible for the green color of vegetables and confers the blue-green color (intense green) while chlorophyll b is responsible for the yellow-green color (green), both present in a ratio of 2 or 3 to 1 (Lancaster et al., 1997). Carotenoids are responsible for the yellow, orange and red colors due to their high antioxidant potential (Guevara et al., 2020; Kumari & Deka, 2021). With respect to texture on hardness and firmness conditions, these depend on factors such as the degree of maturity at the time of harvest, type of harvest, turgor level, variety, etc. Factors that at the time of processing play a very important role in their quality (Jadán Piedra, 2017).

Use of pea pods in the agri-food industry.

Agro-industrial residues such as pea pods have been used in recent studies as protein supplements in foods targeted to obese populations (Ding et al., 2023). Also in the elaboration of plant milks (Xing et al., 2022), gel biofilms (Elsebaie et al., 2023), agricultural biostimulants (Szpunar-Krok, 2022), organic moisture retainers (Arunadevi et al., 2022), nutraceutical feed supplement (Castaldo et al., 2022), plant meals (González-Montemayor et al., 2021), biomasses (Krga et al., 2021) and even biofuels (Vasiljevic et al., 2021).

Given the current state of knowledge on the use of pea pods, their versatility of uses and applications, it is necessary to explore the physical properties of pea pods when subjected to chemical treatments to improve their intrinsic properties. The purpose of the study was to evaluate the influence of chemical treatments on the physical properties of pea pods.

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MATERIALS AND METHODS

The research was carried out at the Science and Technology Laboratory of the Faculty of Engineering of the University of Pamplona-Pamplona (Norte de Santander).

Obtaining and preparation of plant material: The starting point was 2 kg of pea pods, which were acquired at the Cúcuta (Norte de Santander) supply center in a single stage of maturation (green), and were divided into four equal lots to be processed. The seeds were removed from the pods manually. Each of the lots was disinfected with sodium hypochlorite at 50 ppm, and subsequently treated with a preservative alone and in combination (Table 1), in aqueous solutions at room temperature (20 ± 2 ºC), in order to retard the processes of chlorophyll degradation, color, loss of turgor.

Table 1. Treatments for application to the analysis samples.

Pretreatment	Component	Concentration %
1 (AA 0,5%)	Acetic acid	0,5
2 (AA 2%)	Acetic acid	2
3 (BS 2,5%)	Sodium bisulfite	2,5
4	Control	---

The samples were cut into 10 cm long pieces. Once the treatments had been carried out, the samples were previously drained and with the help of absorbent paper were dried and stored in plastic bags.

Color determination: For the determination of color in the samples, the four treated batches of plant material were analyzed. Measurements were performed in a colorimeter with the CieLab scale, using a D65 light source and a viewing angle of 10º. CIE Lab color parameters were used to describe the color of the samples, where L* indicates lightness, a* indicates chromaticity on a green (-) to red (+) axis and b* indicates chromaticity on a blue (-) to yellow (+) axis. Five shots were taken per sample.

Determination of chlorophyll and carotenes: For the extraction, 10 g of plant material were initially taken and crushed with the help of a mortar, a process that helped to destroy the plant cells and thus release the chlorophyll included in the chloroplasts. Two g of crushed material were introduced into an amber-colored flask, to which 10 mL of a 90%

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by volume acetone-water solution was added, taking it to an ultrasonic bath for 5 minutes at 25 ºC, each flask was shaken and left for 24 h at 4 ºC in total darkness. After 24 h, the supernatant was removed and centrifuged at 2700 x g at 4 ºC for 5 min (Rammuni et al., 2019).

Chlorophyll measurement and quantification.

With a syringe, 3 mL of the extract solution obtained were taken in triplicate and placed in a quartz cuvette for spectrophotometric reading (Genesys 10) of the concentrations of total chlorophyll a and b. (Official Methods of Analysis of AOAC) (AOAC, 1990). The wavelength used for pigment evaluation was 663 mm, 645 mm and 410 mm to measure chlorophyll a, chlorophyll b and carotenes, respectively (Pariasca et al., 2001).

Table 2. Equations for pigment quantification.

Pigment	Equation
Total chlorophyll (µg·cm-2)	7,05·A663 + 18,09·A645
chlorophyll a (µg·cm-2)	11,24·A663 – 2,04·A645
chlorophyll b (µg·cm-2)	20,13·A645- 4,19·A663
Total carotenes (µg·cm-2)	(1000·A470 - 1,90· chlorophyll a - 63,14· chlorophyll b)/214

Source: (Lichtenthaler, 1987).

Finally, the values obtained were replaced in the equations as expressed in Table 2 for extract quantification (µgL-1).

Shear strength analysis. The pods were arranged longitudinally avoiding the central rib in a double perforated plate. The tests were performed 8 times for each treatment. A 5 N load cell was used, pre-test and post-test speed 5 mm/s, test speed 1 mm/s advance. The results were expressed as Fmax per unit mass (N/g) according to Rubinstein et al. (2013).

Statistical analysis. The results obtained were treated statistically through normal analysis of variance (ANOVA) and in order to better discern the results of the ANOVA, the post hoc test of Minimum Significant Differences (MSD) was used. The experiments were performed in triplicate and were carried out using the SPSS version 26.0 statistical software package.

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RESULTS AND DISCUSSION

Colorimetric characteristics

Table 3 shows the results of the color analysis of the pea pod samples studied, where the samples treated with 0.5% acetic acid and 2.5% sodium bisulfite showed significant differences (p≤0.05) with respect to the other samples in the parameters of lightness (L) and (b*) with a tendency between green and yellow tones.

Table 3. Effect of the chemical treatments on the color of the pods

Pea Pod Sample	L Media ± SD	a Media ± SD	b Media ± SD
Control	44,55±2.06[a]	-7.97±1.12[a]	16,45±1.29[a]
AA 2%	45,21±2.23[a]	-8.18±1.89[a]	17,64±1.82[a]
AA 0.5%	46,51±2.29[ab]	-8.44±1.31[a]	19,17±0.54[ab]
BS 2.5%	42,87±2.19[ab]	-7.50±1.34[a]	17,45±0.85[ab]

L.: black to white (0-100); a.: green to red (-60, +60);
*Different letters between columns indicate significant differences (p<0.05), ± SD: standard deviation.

Figure 1 shows the results of the values of the pea pods samples represented in the CIELab graph, where it is observed that the pods present a coloration that goes from a light green to a light yellow tone, this is due to the changes that the chlorophyll suffers during post-harvest due to the effects of ethylene accelerates on the pods that degrade the chlorophyll and induces the synthesis of carotenoids. The pods treated with acetic acid at 0.5% presented the highest values of the b* parameter of 19.17 with significant differences (p<0.05) with respect to the other samples, which is associated with the yellow colors (Mono, p<0.05). associated with yellow colors (Montalvo-González, 2009). Schmalko et al., (2003) reported that color changes in foods depend on the degradation of chlorophyll and carotenes present in them and by the significant influence of temperature and water activity.

Determination of total chlorophylls and carotenoids by spectrophotometry.

Table 4 shows that the samples treated with AA 2%, AA 0.5% and BS 2.5% did not show

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significant differences ($p<0.05$) in relation to the control sample.

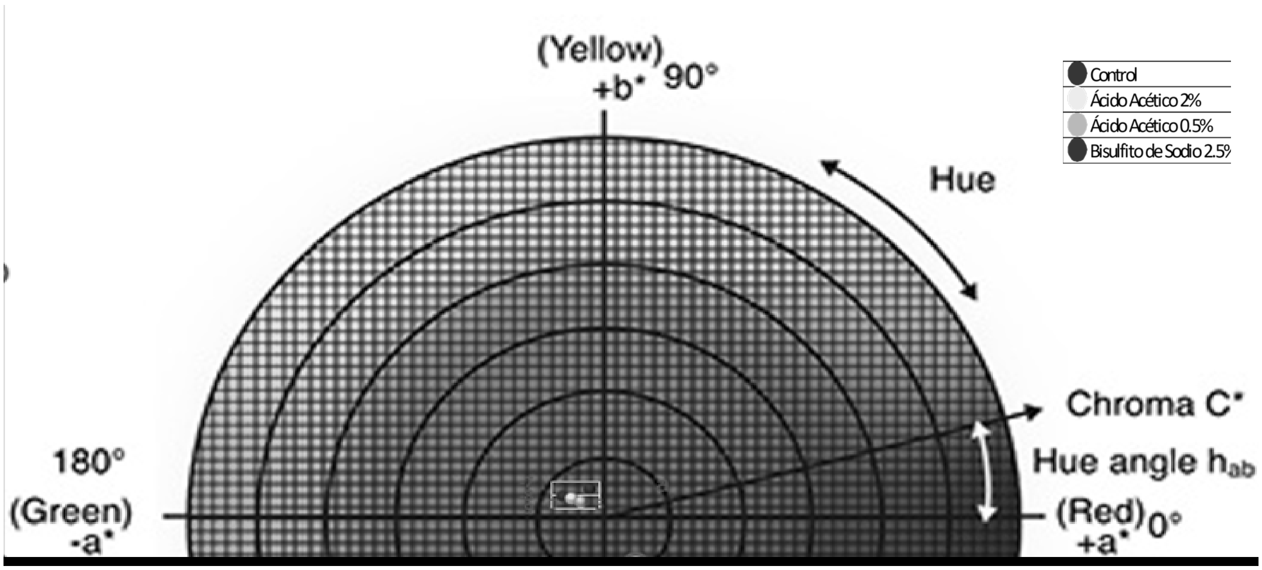


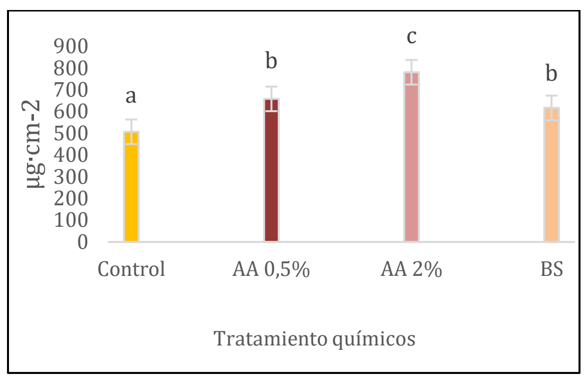
Figure 1. Chromatic space of the samples analyzed according to the treatment applied.

Table 4. Chlorophyll quantification of the treatments

Sample	Total Chlorophyll	Chlorophyll a	Chlorophyll b
Control	8,02±2.69[a]	5.90±1.88[a]	2,11±0.81[a]
AA 2%	10,25±0.37[a]	7.46±0.23[a]	2,79±0.15[a]
AA 0.5%	11,97±0.56[a]	8,00±0.58[a]	3,96±0.99[a]
BS 2.5%	8,69±0.63[a]	6.44±0.40[a]	2,24±0.24[a]

Different letters present differences at the 0.05 level.

Figure 2 shows the results obtained in the determination of carotenoids. The samples with chemical treatments presented significant differences ($p<0.05$) with the control sample, the one treated with AA 2% showed higher carotenoid content of 781.11 μg·cm-2 compared to the others.



Different letters present differences at the 0.05 level.

Figure 2. Quantification of carotenoids from treatments.

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The content of carotenoids and chlorophyll pigments present in fruits and vegetables is highly dependent on the quality of raw materials and climatic conditions during growth and ripening. Suggesting that during ripening the amount of chlorophyll in fruit and vegetable tissues decreases rapidly and the amount of carotenoids increases (Ayour et al., 2016). Las clorofilas y carotenoides son sintetizados y acumulados en organelos especializados (cloroplastos y cromoplastos, respectivamente) (Delgado-Pelayo *et al.,* 2014). El cambio causado por la síntesis de carotenoides y la degradación de clorofilas es el primer signo observable de maduración (Ayour *et al.,* 2016).

Texture análisis

Figure 3 shows the results obtained from the respective analysis. The hardness is the maximum force occurring at any time during the first compression cycle (Bourne, 1978)It is expressed in units of force, N ò (Kg m s-2) (Rosenthal, 1999).

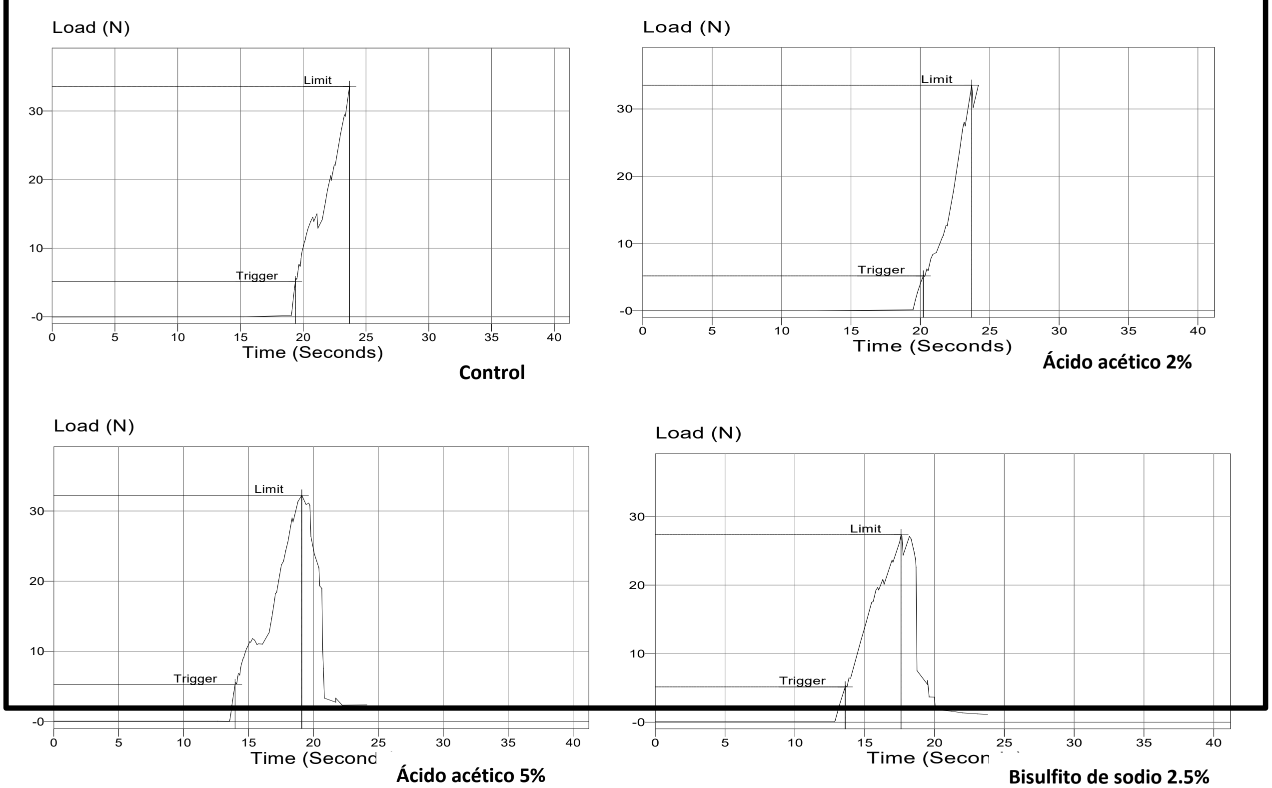

Figure 3. Texture test of the analyzed treatments.

Figure 3 shows the results of the instrumental measurements of the hardness attribute for the four samples. The results show that the force required for the rupture to occur is between 28 to 32 N in a time span of 16 to 18 seconds, possibly given by the degree of maturity of the peel, level of turgor (Knee et al., 2008), quantity and nature of the polysaccharides present in the cell wall of the plant cells (Andrade et al., 2010). The results indicated that hardness correlated with moisture content, crude fiber and pectin content.

CONCLUSIONS

The color of pea pods showed differences among them. The treatments increased the brightness and green tones in expression of the treatment with sodium bisulfite. This indicates that the chemical treatments favored the presence of chlorophyll in this by-product. These results correlate with chlorophyll quantification, where the highest content was found in the 0.5% acetic acid treatment, being the most effective means for obtaining and quantifying total chlorophyll and its variants a and b. However, as for carotenoid content, the treatment with the highest content was the 2% acetic acid treatment. Finally, texture was not significantly influenced by the treatments, being between 28 and 32 Newtons. Among the treatments, the influence of acetic acid was relevant with respect to the others, being the chemical treatment that best indicates positive effects on pea variation, increasing its availability of compounds such as chlorophyll and carotenes..

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