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Contribution for the Physical-Chemical Characterization of Portuguese Crowberry (*Corema album*)

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Abstract

The present work was undertaken to study some physic-chemical characteristics of Portuguese crowberry, namely: sizeable properties (dimension and weigh), chemical components (water, crude fiber, total and reducing sugars, total soluble solids and acidity), and finally physical characteristics (color and texture). The determination of the chemical components followed standard procedures, for color a colorimeter was used and texture was evaluated by a texturometer. The results obtained indicated that the Portuguese crowberries showed a mean diameter of about 9 mm, and a mass of ~0.7 g. Relating to the chemical analyses, the moisture content was 88% (expressed in fresh weight), the crude fiber was 37% (dry basis), the total and reducing sugars were 63% and 41% (dry basis), respectively. The total soluble solids were ~6 ºBrix and total acidity was 11% (expressed in citric acid). Hence, the work undertaken permitted concluding that the white crowberries at study constitute an important source of fibers and sugars.

keywords: ***Corema album; Portuguese crowberry; Physical characteristics; Chemical properties; Color; Texture***

Introduction

The white crowberry or Portuguese crowberry (*Corema album*) is known in Portugal by the name Camarinha. This berry has been used by people in the Iberian Peninsula since ancient times, for eating raw and for using in culinary preparations. The native people still obtain the fruit from the bushes that grow in sand dunes by the coast [1]. This fruit shows countless possibilities for commercialization in the world trade of berries due to the novelty and freshness that comes with a certain touch of acid [2].

The genus *Corema* fits into the family *Ericaceae* of the order *Ericales*. It includes two species, one being *Corema conradii*, which is native to the Northwest coast of the USA, and the other being *Corema album* (L.) D. Don, native from the Iberian

Peninsula, particularly on the coastal areas facing the Atlantic Ocean. The C. *album* inncludes wto subspecies, one being *C. album subsp. azoricum* Pinto da Silva, native from the Azores (the islans in the atlantic Ocean) and the other being the mainland subspecies, which is named *C. album ssp album* [3]. The plants produce the flowers in early spring, staring in February and going until April, and the fruits ripen in the early summer (June and July) when the plants are located further south or a little later (August to September) when the plants are in the northern areas. The berries persist in the bushes till October-December dependent from the geographic position [4].

The Portuguese crowberries correspond to small berries, possessing a rounded shape, and the coloration is primarily white or alternatively with some pink coloration or translucent if fully ripe [5]. The developed fruit is typically fully white. Nevertheless, discrimination between genotypes can be observed between the fruits which present a pearl white color and other fruits which turn into translucent. The berries belonging to the genotypes that become transparent develop a pinkish tinged surface [4]. The *C. album* presents a pleasant and quite revitalizing taste, despite being a little acidic. Its sugar contents is high and contains mostly water, as many other fruits and berries. Its economic and social relevance comes from the fact that it is an alternative food product providing an extra source of income for the coastal populations, besides being also available for wild animals to eat. The Portuguese crowberry typical properties are a steady peel, interesting taste and aroma as well as a characteristic balance between sweet and acid [4]. Due to the still undiscovered potential of the *C. album* berries to be used in the raw state or as food ingredients, the objectives of the present study were to contribute for the physico-chemical characterization of those berries, since there is still some lack of information in the literature about this particular berry.

Materials and Methods

Samples

The fruits utilized in the present study were Portuguese crowberries, collected from bushes in the Northern-Central part of Portugal (FIG. 1), grown wildly over the sand dunes near the Mira beach, situated in the Coimbra district, Central region of Portugal. The *C. album* fruits were harvested corresponding to two different stages: berries showing a totally white coloration and berries white/pink or already translucent. The samples were authenticated by the Department of Ecology and Sustainable Agriculture of the Agrarian School of Viseu. To undertake this work were used around 250 g of berries, taken at random from various bushes situated in diverse locations inside the area referred previously for collection [6].

FIG. 1. ***Corema album* berries (a) and bushes (b).**

Handling and conservation

Subsequently to harvest, all samples were carried to the laboratory, conditioned in proper cuvettes, made of plastic material, and safe from sunlit as well as heat. When they reached the laboratory, the crowberries were separated and cleaned and were analyzed for the size/shape measurements, the physical properties and the chemical components.

Size and shape properties

To do the evaluation of the biometric properties, namely weight and diameter, fifty fruits were used at random trying to be illustrative of each of the samples evaluated (white and translucent crowberries). Diameter of all berries was assessed by using a caliper rule (automatic) and for the determination of mass a precision scale was utilized [6]. Having in mind the values of height and diameter, measured as indicated in FIG. 2, is possible to calculate some related characteristics as shown in the following equations:

$$Caliber\left(average\,radius\right)=\frac{\left(Height+Diameter\right)}{2} \qquad (1)$$

$$Volume=\pi\frac{4}{3}\left(caliber\right)^{3} \qquad (2)$$

$$Specific\,mass=\frac{Mass}{Volume} \qquad (3)$$

FIG. 2. **Schematic representation of the measurement of the dimensions in the *C. album* berries.**

Evaluation of the chemical characteristics

Moisture, as g water per g of whole sample, was evaluated using a Halogen Moisture Analyzer (model HG53 from Mettler Toledo, Columbus, OH-EUA), considering the operating conditions as described: the heating was provided by a halogen lamp; the temperature used for drying the samples was 120°C; the drying rate considered was three, in a scale from 1 to 5, corresponding respectively to very fast and very slow, hence the value 3 corresponds to a midway drying rate [6]. Three replicates were made for both samples analyzed, being those evaluations all independent.

The acidity was evaluated over the samples that had to be previously prepared following the Portuguese Standard NP-783 (NP-783, 1985) [7]. For the determinations of acidity was used the Portuguese standard NP-1421 (NP-1421, 1977) [8], which evaluates the volume of normal alkaline solution, in milliliters, need to neutralize 100 cm^3 of the sample when in a liquid form. The measurements of acidity comprised 2 independent assays, with autonomous titrations, for each of the samples studied. The evaluation of the crude fiber content followed the method of Weende and was made using a cellulose extractor apparatus (Dosi-Fiber; model 4000623, from Selecta). For that 1 g of each sample was treated with 150 mL of an acidic solution (H_2SO_4 1.25%) and then washed trice with 150 mL of distilled water. Next, the process was repeated with a basic solution (NaOH 1.25%), and washed with 5 mL of acetone, for 3 times. Finally, samples went to muffle and were weighed. The evaluation of crude fiber was based on 3 independent replicates for each sample.

The total sugars and the reducing sugars, was made by following the Portuguese Standard NP-1420 (NP-1420, 1987) [9], allowing the quantification of reducing sugars and total sugars, by means of the Luff-Schoorl protocol. A sample of 10 g was used and then 12.5 mL of Carrez I and 12.5 mL of Carrez II solutions were added to the sample, together with distilled water, causing the precipitation (base solution). This solution was then used for the different determinations. For reducing sugars, 25 mL of Luff-Schrool solution, 10 mL of base solution and water were used in a total volume of 50 mL, which was boiled for 8 minutes with a condenser to avoid evaporation. Later, it was added 9 mL of potassium iodide (1 M), 20 m of H_2SO_4 (1 part acid + 6 parts water), and also 2 mL of starch paste solution, and then it was titrated using a sodium thiosulfate solution (0.1 N). For total sugars it was used 50 mL of base solution and 3.5 mL of HCl (37%) left on a bath at around 70 ºC for 5 minutes. Then the solution was cooled and later was neutralized with NaOH (40 g/100). The titration was like in the reducing sugars, but instead of using 10 mL of the base solution it was used 10 mL of the solution that was obtained from the determination of total sugars. The blank trial was done with the same procedure but just with 25 mL of Luff-Schrool solution and 25 mL of distilled water. The evaluation of sugars was made by repeating the measurements twice for each sample. This study further assessed the contents of total soluble solids by measuring the degrees Brix in a laboratory refractometer (model 3T from Atago, Tokyo, Japan). The ºBrix corresponds to approximately the number of grams of sucrose per 100 g of solution. The sample preparation for this determination was the same as for acidity. For this measurement 3 repetitions were made for both samples.

Determination of color coordinates

The color coordinates of the crowberries were assessed using a colorimeter (Chroma Meter - CR-400, Konica Minolta, Tokyo, Japan) and were registered in the color space named CIE Lab, from the "Commission Internationale de l´Eclairage - CIE" (International Commission on Illumination) (FIG. 2a). For that the Cartesian coordinates were used, which correspond to L^*, a^* and b^*. The axis for L^* corresponds to brightness and varies from 0 (signifying absence of light, i.e., total black), until 100, which corresponds to maximum lightness (i.e. absolute white). The other two axes correspond to the coordinates a^* and b^*, and they stand at right angles from one another. Coordinate a^* ranges from green at one end (represented by negative values) to red at the other end (represented by positive values). The other coordinate, b^* ranges from blue (negative) to yellow (positive). Theoretically the range of values for a^* and b^* does not have extremes, but it is commonly accepted that they can vary from -128 to +127. All color measurements were made in a set of twenty fruits.

The color can be further converted into the cylindrical coordinates, which comprise the value, hue angle (h^0) and Chroma (C) or color saturation. For the conversion the equations described below can be used (Barros in 2012):

$$Value = \frac{L}{10} \quad (4)$$

$$h^o = \tan^{-1}\left(\frac{b}{a}\right) \quad (5)$$

$$C = \sqrt{a^2 + b^2} \quad (6)$$

The hue angle (h^o) differentiates between green, blue, yellow or red. This perception of color outcomes from alterations in the absorption of radiation according to the wavelength. The coordinate chroma, also designated as saturation or purity, shows how much the color is different from gray, and hence it differentiates the bright from the dim colors.

Evaluation of textural attributes

The textural parameters (skin strength and elasticity) were evaluated in a set of forty berries, selected at random to represent the whole sample, being this procedure adopted for both samples at study. All evaluation were made by using a texturometer (model TA.XT Plus, from Stable Micro Systems, Godaming, Surrey, UK): For the tests, the conditions used were a pre-test rate of 1.5 mm/sec, a test rate of 1.0 mm/sec and a post-test rate of 10.0 mm/sec. The compression distance was 6 mm, the trigger point was set to 0.05 mm and a the load cell used was of 50 kg. For the treatment of the results was used the program Exponent TEE (from Stable Micro Systems) which, from each of the graphs of texture profile (FIG. 3) allowed calculating firmness (corresponding to the strength at the highest peak) and elasticity (corresponding to the distance at the highest peak) [6].

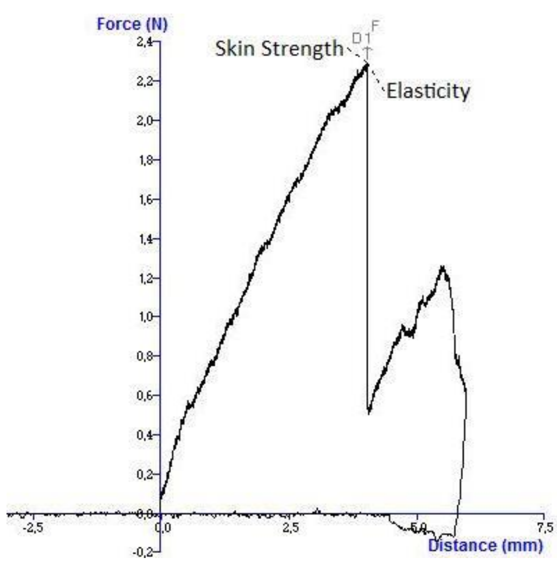

FIG. 3. **Texture profile analysis for a sample of Portuguese crowberry.**

Results and Discussion

Biometric characteristics

The biometric characteristics of Portuguese crowberry are presented in TABLE 1. The results obtained for the measurement of height showed on average a value of 8.63 ± 0.84 mm. Regarding the diameter, the mean value was calculated as 9.43 ± 0.74 mm (TABLE 1), being slightly over that of height because the berries tend to be flat on the top (FIG. 4).

TABLE 1. **Biometric characteristics of Portuguese crowberry and other berries.**

Fruit (reference)	Height (mm)	Diameter (mm)	Calibre (cm)	Volume (cm^3)	Mass (g)	Specific mass (g/cm^3)
Corema album (This work)	8.63 ± 0.84	9.43 ± 0.74	0.90 ± 0.06	0.39 ± 0.09	0.66 ± 0.11	1.70 ± 0.18
Corema album (Oliveira and dale [4])	n.a.	5 - 8	n.a.	n.a.	0.40 ± 0.06	n.a.
Corema album (Clavijo et al. [10])	n.a.	n.a.	n.a.	n.a.	0.31 ± 0.03 to 0.42 ± 0.04	n.a.
Corema album (Calviño-Cancela [3])	n.a.	9.0 ± 0.1	n.a.	n.a.	n.a.	n.a.
n.a. = not available						

(a) (b)

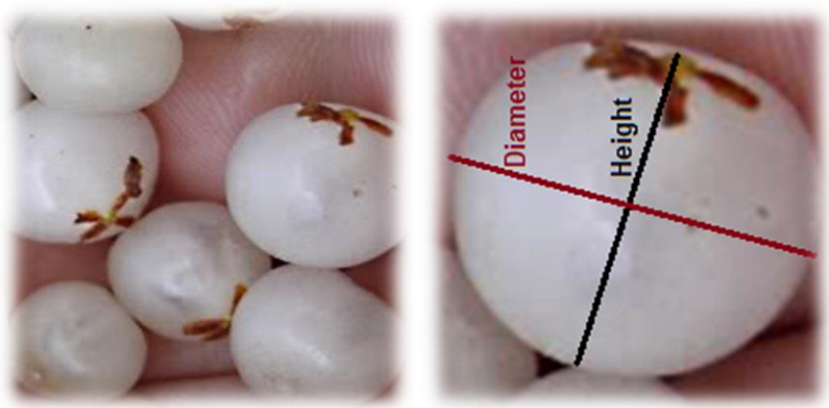

FIG. 4. **(a) Aspect of Portuguese crowberries, (b) Measurement of dimensions.**

The value obtained for diameter was considerably higher than those reported by Oliveira and Dale [4], which varied between 5 mm and 8 mm, for crowberries also collected in the same part of Portugal. Nevertheless, in another work conducted by Calviño-Cancela [3] with berries also from the same region, the crowberries presented a diameter of 9.0 ± 0.1 mm, being thus very similar to the one obtained in the present work. Considering the height and diameter, the caliber was calculated according to Equation (1), being obtained a value of 0.90 ± 0.06 cm, from which the volume was calculated according to

Equation (2) being equal to 0.39 ± 0.09 cm^3. These values were never previously reported in literature and hence it's not possible to compare with published data for these berries. In relation to weight (values presented in TABLE 1) the mean value calculated was equal to 0.66 ± 0.11 g. Oliveira and Dale [4] and Clavijo et al. [10] published scientific work where they reported a mass of 0.40 g and between 0.31 and 0.42 g, respectively, for the same type of crowberries. As a consequence of this, we can conclude that the fruits studied in this work were bigger than the reported values, which is beneficial for possible commercial applications.

The specific mass was calculated from the weigh and the volume and is shown also in TABLE 1 being 1.70 ± 0.18 g/cm^3. In general the fruits studied showed higher mass and dimensions when compared to those reported by other authors in scientific works. The observed differences might be due to the state of ripeness, as well as with the soil properties, namely its nutrients, and finally the edaphoclimatic circumstances of the particular areas from where the berries were harvested.

Chemical components

FIG. 5 presents the values of the chemical components evaluated in the Portuguese crowberries. Moisture showed an average value equal to 87.89 ± 1.04% (expressed in fresh weigh). According to the studies published by Clavijo et al. [10] and by Santos et al. [11] the moisture content of Portuguese crowberries in the fresh state were 75% and 83.41%, respectively. Hence, the berries analyzed in this work showed more moisture when compared to the reported values, and this divergence could be associated with the species or the plant characteristics as well as the environmental factors such as soil properties or climatic circumstances of the year in which the fruits were analyzed.

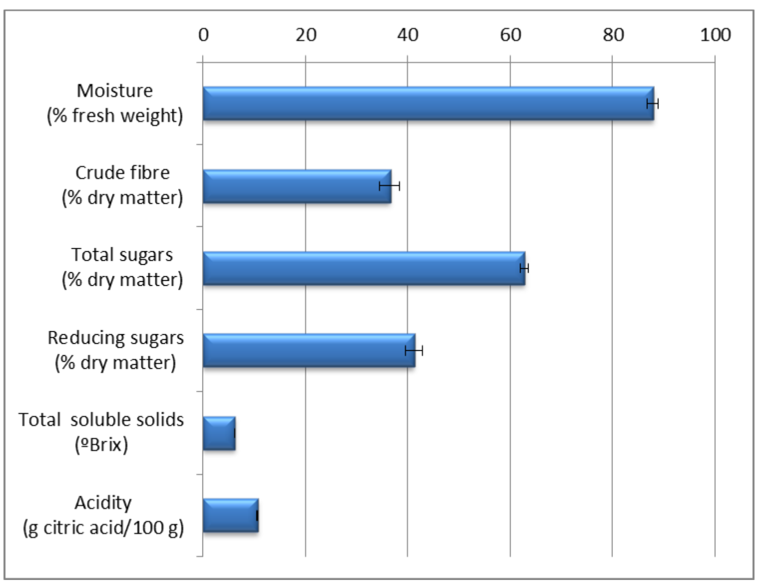

FIG. 5. **Results of the analyses to the chemical components in Portuguese crowberry.**

The results further show that these fruits are quite rich in crude fiber, with a mean value of 36.52 ± 1.96% dry basis (FIG. 5). According to Calviño-Cancela [3] these berries are much rich in fiber, owing to the fact that they possess 2-4 elongated seeds, which are eaten with the fruit.

The total and reducing sugars were found to be 62.80 ± 0.77 and 41.24 ± 1.74% dry basis (FIG. 6), respectively. By comparing with the value obtained by Clavijo et al. [10] for total sugars content (77.1% also expressed as dry solids), those obtained by us were slightly lower.

FIG. 6 also reveals the concentration of total soluble solids as approximately 6 g sucrose/100 g, corresponding to 6.20 ± 0.03 ºBrix, as well as acidity, which was 10.7 ± 0.1, expressed in g citric acid/100 g. when determining the total soluble solids in fruits of *C. album* species, Pimpão et al. [1] reported a value of 6.8 ± 0 Brixº, being thus comparable to that obtained in this work. The Portuguese crowberry is less sweet when compared to blueberry, which shows 12.3% to 15.5% soluble solids according to Souza et al. [12] or 12.6% to 13.8% according to Pasa et al. [13]. Also blackberry is reported as more sweet with 9.25 to 9.6% soluble solids [14]. As regarding acidity, Portuguese crowberry is more acid when compared to blueberry, which shows 0.7% to 0.8% citric acid [15] or with gooseberry, with 1.3% citric acid [16]. Some bioactivities of *C. album* berries might be related to its antioxidant activity and content in phenolic compounds or carotenoids. Hence these bioactive compounds could be evaluated in future studies, along with *in vitro* essays of the bioaccessibility along the gastrointestinal system.

Color coordinates

The color parameters in the Cartesian and cylindrical systems for the Portuguese crowberry are presented in FIG. 6.

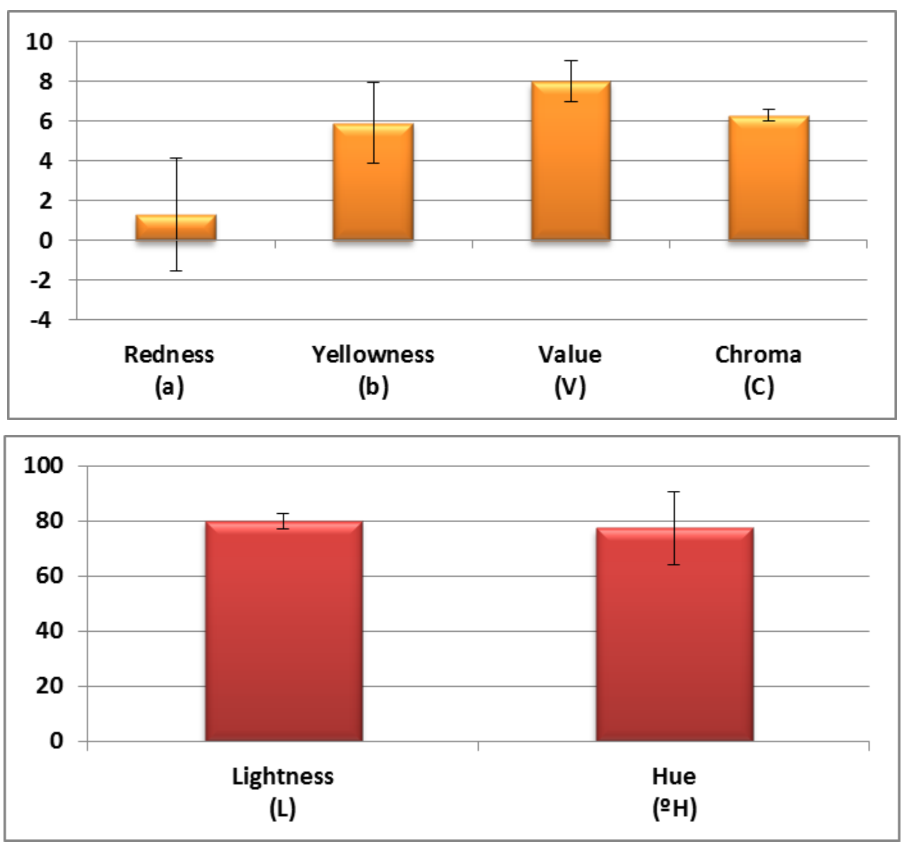

FIG. 6. **Results of the color coordinates in Portuguese crowberry.**

The values found revealed that the *C. album* fruits area clear due to the high value of lightness (L^*) obtained (79.82 ± 2.82), being thus closer to the value +100 (which represents white) and not so much to 0 (which corresponds to black). Regarding the value of redness, a^*, it was found to be 1.27 ± 2.05, which is almost zero, although on the positive region. This reveals that the fruits tend more to red, although slightly, instead of to green (in which case the value of a^* would be negative). In relation to the coordinate b^* (5.88 ± 2.1), because it corresponds to positive values, it stays in the yellow domain, although the value is not very high again. Hence, and considering the values obtained it could be inferred that both samples under study presented a light white-yellowish-pinkish color. The hue angle (hº) was calculated as 77.29 ± 13.36º, thus corresponding to the zone between yellow and green, but predominantly yellow (pure yellow would correspond to 60º and green to 120º).

Textural attributes

The results found for the different textural attributes evaluated in the Portuguese crowberry are shown in FIG. 7. The mean value of hardness was 1.93 ± 0.36 N, and this property corresponds to the force registered during the 1st compression cycle. It corresponds to the force necessary to compress the food product between the teeth or between the mouth and the tongue and mouth, i.e. is equal to the force necessary to originate a deformation [17]. This property is associated with the force necessary to break the material [18]. Hence, it is possible to conclude that the peel of the fruits had a small resistance to the compressive forces, and thus may easily suffer rupture. This indicates that the fruits are fragile and, therefore, must be handled carefully not to be damaged during transportation and storage.

The hardness of Portuguese crowberry is similar to that of other berries of the same size, namely blueberry reported to be 1.6-1.7 N by Moggia et al. [15]. However, Joo et al. [14] Reported that blackberry is considerable harder, with 14 N.

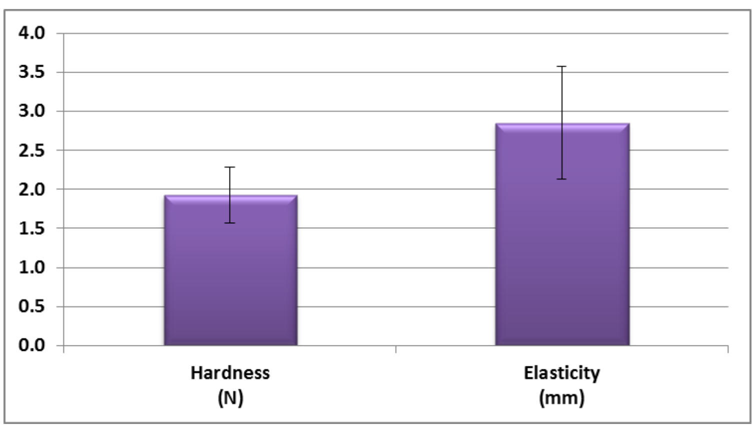

FIG. 7. **Results for the textural attributes in Portuguese crowberry.**

The elasticity mean value was calculated as 2.85 ± 0.72 mm, and this textural property means the ability to recover the shape after the compression has stopped, and therefore measures the rate in which the sample returns to the initial state after the force which caused the deformation has been removed [17]. Hence, it represents the resilience of the material [18]. Having this in mind, it is possible to conclude that the fruits did not show a very meaningful elasticity. So, in general terms, the *C. album* berries presented themselves quite soft and with low elasticity.

Conclusion

The present study allowed concluding that the Portuguese crowberry under evaluation showed values of dimensions and weight slightly higher when compared to the ones reported in the bibliography, but in the same order of magnitude. Considering the chemical analyzes made to the berries it was also possible to confirm that they constitute an important source of water, fibers, and total sugars. With regard to the assessment of color, it was possible to conclude that the berries have a light color, very approximate to white. In relation to texture the results showed that both the hardness and elasticity were low. Finally, and in view of the results obtained from this study, it is possible to depict an interest in these berries for the market of commercial berries. Still, some more studies would be necessary about the post-harvest and conservation of the fruits. Also, because berries in general tend to be rich in phenolic compounds with antioxidant activity, this aspect should also be studied in future works. Nonetheless, its interest as a food ingredient might depict its inclusion in jams, beverages or cakes, among others.

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