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# Physical properties of *Physalis peruviana* L.

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**Abstract:** *Physalis* (*Physalis peruviana* L.), also known as cape gooseberry or ground-cherry, plays an important role in nutrition as an excellent base for dietetic products. Highly valued for its unique flavour, texture and colour, recent research has shown that physalis fruit is rich in many beneficial compounds.

In this study, the diameter and mass of physalis fruits were measured, which can be used to calculate other biometric characteristics of the fruit, such as: surface area, volume or density. Other physical properties were measured, namely the colour coordinates, by means of a Chroma meter, whilst the textural parameters firmness and elasticity were measured with a texturometer.

The following values were calculated for the physalis fruits analysed in the present work: 1.69 cm for average diameter; 8.98 cm<sup>2</sup> for surface area, 2.51 cm<sup>3</sup> for volume; 2.77 g for mass was, and 1.10 g/cm<sup>3</sup> for density. The colour coordinates were 56.72 for lightness, 16.69 for redness, and 58.11 for yellowness. Skin firmness and elasticity were evaluated for texture attributes, and their average values were 2.40 N and 2.94 mm, respectively. The results of this work are in accordance with data reported by other authors in the literature.

**Keywords:** *Physalis peruviana* L., gooseberry, diameter, mass, colour, texture

## 1 Introduction

Exotic fruits play an important role in nutrition and are an excellent base for dietetic products due to their beneficial bioactive compounds and low energetic value. Highly valued for its unique flavour, texture and colour, recent research has shown *Physalis peruviana* L. fruit to be rich in many beneficial compounds [1, 2]. For instance, the physalis fruit is rich in pro-vitamin A, ascorbic acid, and in some vitamins of the B complex (thiamine, niacin, and vitamin B<sub>12</sub>). Additionally, the fruit is rich in crude protein, phosphorous and iron, although calcium content is low [3]. Some of the health benefits of physalis include: blood purification, reduction of the albumin in the kidneys, reconstruction and strengthening of the optic nerve, alleviation of throat infections, elimination of intestinal parasites, and treatment of prostate problems [3].

The *Physalis* genus includes approximately 100 species originally from the Andes, although its modern distribution includes tropical regions and areas with a more moderate climate, such as Portugal. The majority of the species is wild, but some species are cultivated in Colombia, Mexico, China, Japan, and more recently in Brazil and in Portugal. The main consumer market of these countries is Europe, where fresh fruits are used as food and in the pharmaceutical industry. Only recently has the plant become an important crop and widely introduced in cultivation in tropical, subtropical and even temperate areas. *Physalis peruviana* has numerous common names depending on the country and/or region where it is found [4, 5]. Some of the common names are: cape gooseberry (South Africa, UK), Inca berry, Aztec berry, golden berry, giant ground cherry, African ground cherry, Peruvian groundcherry, Peruvian cherry, “amour en cage” (France), and sometimes simply physalis (United Kingdom).

*Physalis* has a short shelf life cycle. It can be planted any time of the year. The species is capable of adapting to any warm climate and expresses tolerance to cold. However, it does not like excess moisture or frost. The flowers are hermaphrodite, solitary, and bell-shaped. Its most distinctive feature is the fruiting calyx which enlarges to cover the fruit and hangs downwards similar to a lantern. *Physalis* forms a domed shrub that can

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grow up to 1 m tall. The flowers, produced in winter, are yellow with purple blotches. *Physalis* is an upright, herbaceous, semi-shrub, and perennial in subtropical zones. Its ovoid-shaped fruit can weight approximately 4–5 g, is protected by an accrescent calyx or fruit basket covered by a brilliant yellow peel [1, 3] that completely surrounds the fruit during its development and ripening, and protects it against insects, birds, diseases and adverse climatic conditions [6].

The fruit is a juicy berry that can reach 1.25 to 2.50 cm in diameter, can contain around 100 to 200 small seeds. The lifetime of the plant production goes from nine to eleven months from the time of the first harvest; thereafter, both the productivity and fruit quality decrease. Shelf life of the fruit is one month with the calyx, and four to five days without the calyx [1].

This crop represents an alternative for the production sector in many countries, creating a positive economic impact due to the good perspectives and interest of the worldwide trade for fruits and berries, and the demand from consumers for fruits that have nutritional and medicinal properties [7]. The principal growers of *physalis* are Colombia, Kenya, Zimbabwe, Australia, New Zealand, India and Ecuador. Other less expressive growers include the United States, Brazil, Venezuela, Bolivia, Peru, Chile, Central-America, Mexico, Belize, Guatemala, El Salvador, Nicaragua, Costa Rica, Panama, Jamaica, South Africa, Gabon, Egypt, China, Japan, Malaysia, Indonesia, Philippines, Samoa, Tonga, New Caledonia, Guam, United Kingdom and Israel [7].

Although there are some studies about *physalis*, the information on this berry is still scarce. Therefore, this study was undertaken to analyse some biometric and physical properties of *physalis* fruit grown in Portugal as an attempt to compliment the information presently available in the scientific literature.

## 2 Experimental procedure

### 2.1 Sampling

The fruits of one variety of *physalis* (*Physalis peruviana* L.) were harvested from one farm in North-Central Portugal and analysed for this work. The *physalis* fruits originated from conventional production methods.

The fruits were harvested at maturity. Approximately 750g of berries were randomly selected and collected from

several plants growing in different parts of the same plantation area.

### 2.2 Handling and conservation

After harvesting, the samples were transported to the laboratory in appropriate plastic cuvettes to protect the fruits from light, then refrigerated.

The refrigerated fresh samples, at 4 °C and 85 to 90% relative humidity (RH), were then analysed for their biometric and physical properties.

### 2.3 Biometric characteristics

Around 100 berries were randomly selected as representative of the sample for biometric characteristic analysis, weight and size. The size of each berry was measured with the aid of an automated calliper rule, and the weight was determined with a precision scale.

In order to calculate the volume and surface area of the berries, it was assumed that the fruit were sphere-shaped. Specific mass was subsequently calculated by dividing the mass by the volume.

### 2.4 Colour measurement

The skin colour of the *physalis* can be used as a maturity index; therefore, harvesting should start when the calyx begins to turn yellow, as to avoid over-maturity [2].

The colour of the *physalis* fruits was determined with a colorimeter (Chroma Meter - CR-400, Konica Minolta) in the CIE Lab colour space, by assessing the  $L^*$ ,  $a^*$  and  $b^*$  Cartesian coordinates, and using the illuminant D65. The  $L^*$  axis represents Lightness and varies from 0 (corresponding to no lightness, i.e., absolute black) to 100, or maximum lightness (i.e. absolute white). The other axes



Figure 1: *Physalis peruviana* bush and fruit (Oliveira S.)

are represented by  $a^*$  and  $b^*$  and they are at right angles to each other. The  $a^*$  axis varies from green at one extremity (represented by  $-a$ ) to red at the other ( $+a$ ), whereas the  $b^*$  axis varies from blue at one end ( $-b$ ), to yellow ( $+b$ ) at the other. Although in theory there are no extreme values of  $a^*$  and  $b^*$ , in practice, they can be numbered from  $-128$  to  $+127$ .

The chroma is the ratio between the values of  $a^*$  and  $b^*$  (2). Hue angle is the angle between the  $a^*$  and  $b^*$  axes, indicating the colour saturation of the subject [8].

The coordinates for value, colour intensity (Chroma) and hue angle were calculated using the following Equations [9]:

$$\text{Value} = \frac{L^*}{10} \tag{1}$$

$$\text{Chroma} = \sqrt{a^{*2} + b^{*2}} \tag{2}$$

$$\text{Hue angle} = \tan^{-1} \left( \frac{b^*}{a^*} \right) \tag{3}$$

One hundred berries were analysed to determine the colour.

### 2.5 Texture analysis

One hundred berries were randomly selected as representative of the sample to determine skin strength and elasticity as texture attributes. The analyzes were performed with a TA.XT Plus texturometer from Stable Micro Systems using a 2 mm probe (P/2) and the following test conditions: pre-test speed = 1.50 mm/s, test-speed = 1.00 mm/s, post-test speed = 10.00 mm/s, distance = 6 mm, trigger force = 0.05 mm and a load cell of 50 kg. The results were treated with Exponent software TEE (Stable Micro Systems) and the obtained texture profile (Figure 2) was used to determine firmness (strength on the highest peak) and elasticity (distance to the highest point). One hundred samples were used for the texture analysis.

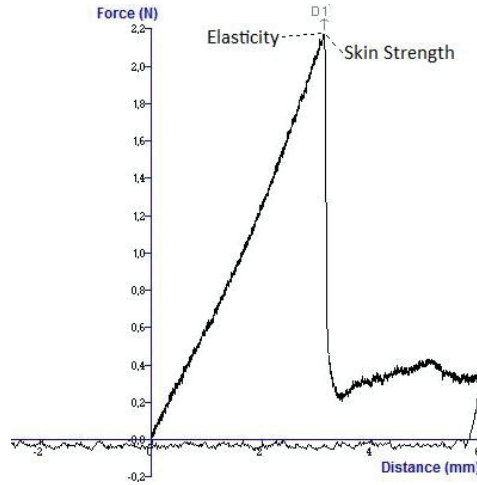


Figure 2: Texture profile analysis for physalis

## 3 Results and Discussion

### 3.1 Biometric characteristics

Mean values and corresponding standard deviations for diameter, volume, mass, and specific mass are presented in Table 1.

The average diameter of the analysed physalis fruits was  $1.67 \pm 0.14$  cm. This result was within the standard values obtained by Fischer et al. [2], Lucchese et al. [4] and Puente et al. [6], who found that the diameter of the physalis berries can vary between 1.25 and 2.50 cm.

The average mass of the berries was  $2.77 \pm 0.67$  g. The values found in the present work were lower than (however close to) the lowest limit of the 4 to 10 g interval estimated by Fischer et al. [2], Lucchese et al. [4] and Puente et al. [6]. Variations may be due to the state of maturity in which the berries were collected or to the specific climate and soil conditions of the region where the berries were grown.

Average surface area was  $8.98 \pm 1.28$  cm<sup>2</sup>. Average volume of the berries was  $2.51 \pm 0.59$  cm<sup>3</sup> and specific mass was  $1.10 \pm 0.04$  g/cm<sup>3</sup>. These values are similar to, although slightly higher than, those obtained by Puente et al. [4] ( $1.038 \pm 0.0054$  g/cm<sup>3</sup>).

Table 1: Biometric characteristics of physalis

Diameter (cm)	Surface area (cm <sup>2</sup> )	Volume (cm <sup>3</sup> )	Mass (g)	Specific mass (g/cm <sup>3</sup> )
$1.69 \pm 0.16$	$8.98 \pm 1.28$	$2.51 \pm 0.59$	$2.77 \pm 0.67$	$1.10 \pm 0.04$

### 3.2 Colour

Table 2 shows the values for chromatic coordinates: the Cartesian coordinates ( $L^*$ ,  $a^*$  and  $b^*$ ) as well as the cylindrical coordinates ( $V$ ,  $H^\circ$  and  $C$ ).

The  $L^*$  coordinate corresponded to  $65.72 \pm 3.13$ , a value closer to 100 (white) than to 0 (black), thus leading to the conclusion that the berries were clear. The berries analysed in the present work were slightly clearer than those analysed by Puente *et al.* [6], who determined an  $L^*$  coordinate range between  $70.31 \pm 0.39$  and  $71.37 \pm 1.10$ .

The value of the  $a^*$  coordinate was  $16.69 \pm 2.70$ . A positive value for this coordinate, as in the present case, corresponds to the red colour, and redness intensity increases as values increase. Puente *et al.* [6] found values obtained for this coordinate ranging between  $14.31 \pm 1.28$  and  $15.20 \pm 0.48$ . Hence, the berries evaluated in this work had a slightly more intense red coloration. The value of the  $b^*$  coordinate was  $57.94 \pm 3.60$ . A positive value for this parameter showed that the colour of the berries was within the yellow spectrum. Puente *et al.* [6] reported values for this coordinate varying from  $60.84 \pm 3.10$  to  $61.76 \pm 1.34$ ; hence, the berries analysed in the present work were marginally less yellow. The slight differences found in the colour coordinates may naturally occur due to different maturity stages, cultivar or cultivation procedures.

Chroma value was  $60.64 \pm 3.19$ , and slightly lower than those described by Puente *et al.* [6], who found Chroma values ranging from  $63.61 \pm 1.40$  to  $62.50 \pm 3.26$ . Hue angle was  $73.95 \pm 2.57$ , which can be considered a slightly lower value for such parameter when compared to the range value of  $76.77 \pm 0.57$  to  $76.20 \pm 0.26$  found by Puente *et al.* [6].

### 3.3 Texture

Texture may be affected during post-harvest storage and handling. Therefore, assessing texture is crucial for consumer's acceptance, but also to avoid skin injuries and, consequently, fruit waste. Some of the factors that can affect fruit texture are respiration of the fruit and ethylene production. Ethylene promotes fruit softening as a

**Table 2:** Chromatic coordinates in physalis

Cartesian coordinates			Cylindrical coordinates		
Lightness $L^*$	Redness $a^*$	Yellowness $b^*$	Value $V$	Chroma $C^*$	Hue Angle $H^\circ$
$65.72 \pm 3.13$	$16.69 \pm 2.70$	$58.11 \pm 3.21$	$6.57 \pm 0.31$	$60.64 \pm 3.19$	$73.95 \pm 2.57$

consequence of the weakening of the cell wall caused by hydrolases [2].

Table 3 presents the values for the analysed textural attributes: firmness and elasticity. Firmness reflects the integrity of the pericarp tissue Berry firmness was  $2.40 \pm 0.53$  N. This value was lower than what Trinchero *et al.* [10] found for the physalis berries they analysed ( $3.42 \pm 0.32$  N). As for elasticity, the value obtained was  $2.94 \pm 0.54$  mm. The differences observed in this study may be linked to the state of maturity of when the berries were harvested, among other factors.

## 4 Conclusions

The results of the present work showed that the analysed physalis berries had an average diameter of 1.69 cm, a surface area of 8.98 cm<sup>2</sup>, a volume of 2.51 cm<sup>3</sup>, a mass of 2.77 g and a density of 1.10 g/cm<sup>3</sup>. The biometric characteristics were relatively similar to those reported in the literature for the same product.

The colour coordinates obtained for the analysed berries were similar to those reported in the literature. Skin firmness and elasticity, the two attributes related to texture, were also in accordance with data published by other authors.

The results of this work presented a better understanding of the characteristics of the physalis berries, some of which up to the present time had not been evaluated yet. However, the present study could be complemented by researches on the effects of time on post-harvested physalis berries to help understand the effects of conservation conditions on the biometric and physical properties of this fruit.

**Table 3:** Texture characteristics of physalis

Firmness (N)	Elasticity (mm)
$2.40 \pm 0.53$	$2.94 \pm 0.54$

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