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Geometrical traits in bay laurel fruit as a function of moisture content and harvest season in Northern Morocco

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Abstract

Information about the physical properties of bay laurel fruit is important for designing the equipment for processing, transportation, sorting, separation, and storing. To our knowledge, no research was undertaken in northern Morocco to study the dimensional or geometrical traits of Bay laurel fruit, hence, the present research aims to determine some physical properties of bay laurel fruit as a function of moisture content and harvest season. In this research work the dimensional properties (length, width, thickness, arithmetic, geometric mean diameter, sphericity, volume of the fruit, surface area, and projected area) were investigated depending on moisture. Also, sphericity, volume, and surface area were determined by using different theoretical equations and the results of different equations were compared.

Keywords: Bay laurel, Geometrical traits, harvest season, moisture content, Northern Morocco.

1-Introduction

The Lauraceae family comprises of 52 genera and almost 3000 species **(Dahak *et al.*, 2014)**. Laurus is genus of evergreen shrubs belonging to the *Lauraceae*family, including three autochthons' species *Laurus nobilis L, Laurus azorica and Laurus novocanariensis*(**Confortiet *al.*, 2006; Ballabio et Goetz, 2010; Vinhaet *al.*, 2015)**.

Laurus nobilis L. (Lauraceae) commonly known as bay leaves, is one of the most well-known and most frequently used plants from this family; it's an evergreen shrub widespread in the Mediterranean region, including countries like Italy, France, Spain, Morocco and Portugal **(Dall'Acqua *et al.*, 2006; Juliantet *al.*, 2012; Ouchikhet *al.*, 2011)** with optimal conditions sunny and well-drained soils **(Marques *et al.*, 2016)**. The dried leaves are widely used as a spicy fragrance for cooking purposes and flavoring agent in culinary **(Gomez-coronado and barbas, 2003; Conforti *et al.*,2006; Santoyo *et al.*,2006; Ouchikh*et al.*,2011;Dias *et al.*,2014; Boulila*et al.*,2015)**. The plant morphology reveals hardy that is a dioecious (unisexual) plant with separate male and female trees, the pollination is entomophilous. The flowers are small and four lobed, the male has 8 to 12 stamens and female have 2 to 4 staminodes **(Pacini *et al.*, 2014)**,the lather produce ovoid berries similar to a small olive **(Takos, 2001; Marques *et al.*, 2016)**. The diameter of these berries measures about 2.0–2.5 cm long and 2.0 cm broad **(Bozan and Karakaplan, 2007; Konstantinidou*et al.*, 2008)**. Inside the fruit is a single large seed, which is a white kernel surrounded by a light brown shell. The seeds are mature when they are dark brown and the fruits are dark purple **(Beis *et al.*, 2006; Demirbas, 2010)**. The fruit from this plant contain fixed and volatile oils.The oil extracted from these berries contain fatty acid (lauric, 20.8 to 43.1 %; oleic, 32.5 to 42.0 %; linoleic, 11 to 18.2 %; and palmitic, 6.2 to 14.1 %) and volatile compounds such as 1.8 cineol **(Marzouki *et al.*, 2008; 2009)**.Both the volatile and non-volatile oil are used for cosmetic and food industry (**Yurtlu*et al.*, 2010)**.

It is reported that this plant is a rich source of bioactive molecules, such as phenolic compounds and essential oils **(Dias *et al.*, 2014)**. A Previous phytochemical investigations on *Laurus nobilis* leaves and fruits have resulted in the isolation of sesquiterpenes lactones **(De Marino *et al.*,2005; Dall'Acqua *et al.*,2006; Julianti*et al.*, 2012; Chen *et al.*,2014)**, Alkaloid **(Pech and Bruneton ,1982; Osmakov*et al.*,2018 ; Silva Teles *et al.*, 2019)**, monoterpene **(Hogg, Terhune and Lawrence, 1975; Novak,1985)**, terpenes **(Uchiyama *et al.*, 2002;Yahyaa *et al.*, 2015; Siddhartha *etal.*, 2017)**, tannin **(Sakar and Rolf ,1985; Stefanova *et al.*, 2017 ;Dhifi*etal.*,2018 ; Mansour*etal.*,2018)**, tocopherol content **(Gomez-coronado and barbas, 2003; Ouchikh*et al.*, 2011)**, fatty acids **(Marzouki *et al.*, 2008; 2009; ozcan*et al.*, 2010)** , proanthocynidins**(Skerget*et al.*, 2005; Ouchikh*et al.*, 2011 ; Dias *et al.*, 2014)**, anthocyanins**(Longo and Vasapollo, 2005)** and flavonoid such as Quercetin, luteolin, apigenin, kaempferol and myricetin derivatives as well as flavano-3-ol **(Kang *et al.*, 2002; Lida *et al.*, 2002; De Marino *et al.*, 2004; Ouchikh*et al.*, 2011; Papageorgiou *et al.*, 2008; Vadapetyan*et al.*, 2013; Boulila*etal.*, 2015; Vinha*et al.*, 2015; Kubincova*et al.*, 2016; Kivrak *etal.*, 2017; Siddhartha *etal.*, 2017)**.

As pharmacological properties of *Laurus nobilis* L., it has been previously reported to have antibacterial **(Dadalıogˇlu and Evrendilek, 2004; Toroglu*et al.*, 2006; Derwich *et al.*, 2009; El malti and Amarouch, 2009;Marzouki *et al.*, 2009; Ozcan *et al.*, 2010; Dahak *et al.*, 2014; Elharas*et al.*, 2013; Rafiq *et al.*, 2016; Caputo*et al.*, 2017 ; Fernández *et al.*, 2018 ; Fidan *et al.*, 2019)** , anti-inflammatory**(Sayyah *et al.*, 2003;Lee *et al.*, 2013; Lee *et al.*, 2018)**,anticonvulsant **(Sayyah *et al.*, 2002)**, antiviral **(Aurori*et al.*, 2016)**antidiabetic**(Khan *et al.*, 2009; Aljamal, 2010 and Aljamal et al., 2011)**, antiproliferative**(Al-Kalaldeh*et al.*, 2010; Abu-Dahab *et al.*, 2014),** neuroprotective **(Pacifico *et al.*, 2013; 2014)** and antioxidant activity **(Simic *et al.*, 2003; Skerget*et al.*, 2005; Elmastas*et al.*, 2006; Santoyo *et al.*, 2006; Bozan and Karakaplan, 2007; Papageorgiou*et al.*, 2008 ; Bouzouita*et al.*, 2009; Tchombé*et al.*,2013; Muniz-Marquez *et al.*, 2014; Ereifej *et al.*, 2016;Guenane*et al.*, 2016; Fernández *et al.*, 2018)**. Although several pharmacological and biological activity have been carried out on the leaves of *L. nobilis*, there has been very little work published on its fruits. For these reason, geometrical properties of *Laurus nobilis* L. fruit must be known.

The geometric and mechanical properties of bay laurel seed such as such as the length, width, thickness, arithmetic mean diameter, geometric mean diameter, sphericity, volume, unit mass, bulk density, true density, porosity, projected area are considered to be necessary for improving the technology of equipment for handing; conveying; separating; sorting; storing and processing. These mechanical properties are eventually depended on moisture content **(Yurtlu*et al.*, 2010)**. In recent years several study have studied the physical properties of some agricultural products and mechanical behavior **(Demchik*et al.*, 2016; Kabas and Vladut, 2016; Sakar*et al.*, 2018)**. In addition, the physical characteristics were used also for modelling geometrical properties **(Tinoco *et al.*, 2017)**.

The physical properties of *Laurus nobilis* L. growing in Northern Morocco are, however, unknown. The study presented here, therefore, evaluates various physical properties of *Laurus nobilis* L. and their dependence on fruit moisture content.

2-Materials and Methods

2-1-Study site

This study was carried out in site of northern Morocco (Figure1), namely Tazia (10 km from Moulay Abdeslam commune of Tangier-Tetouan, N 35°21.652’ W005°33.739’, altitude 731 m). This site was chosen mainly because of their important distribution of bay leaves as well as the availability of several commercial of leaves, oils crops and their traditional use in medicine.

Northern Morocco is characterized by a Mediterranean climate humid in winter and semi-arid in summer. The province of Tetouan is located in the western part of the Rif east of the Tingitane peninsula. It is located at an altitude of 65 m not far from the Mediterranean coast. It is bordered to the north by the provinces of M'diq-Fnideq and FahsAnjra, to the west by the Tangier wilaya and the province of Larache, to the south by the province of Chefchaouen and to the east by the Mediterranean Sea. From a bioclimatic point of view, it is a subhumid region with a warm winter **(Sauvage, 1963).**

Figure 1: Geographic localization of the studied site (Tazia).

2-2-Plan Material and sampling

Samples used in this study were bay laurel fruits (green and black) collected in different seasons in July 2016, September 2016, November 2016, July 2018, September 2018, and November 2018. Identification was performed in the Laboratory of Plants Biotechnologyby the Professor Lamarti Ahmed, a specialist in plant physiology, Faculty of Sciences, Abdelmalek Essaadi University Tetouan, Morocco. Determination of fruit maturity was based on pericarp color that turns dark black when ripe.

The fruits were immediately transported to the laboratory and a sample of 40 fruits from each group was considered for the determination of moisture content and geometrical measurement. Hand-harvestedBay laurel fruits were cleaned mainly to remove all foreign materials and broken fruits, as well as dust and dirt. The fruits were stored at 4 °C before the experiment. The sample mass was measured with precision balance (Presica, accuracy 0.01g).

2-3-Determination of the (initial) moisture content of fruits

The fruits were taken to laboratory after collection. The initial and conditioned moisture content of laurel fruits were determined by using the standard hot air oven method, at 105°C for 24 h **(Yurtlu*et al.*, 2010; Oztekin*et al.*, 2010; 2011**). The determination was carried out in triplicate.

2-4-Geometrical properties

In order to determine the dimensions of the laurel bay fruit, 40 seeds were randomly selected from each group. For each single fruit, the three principal axial dimensions also called size dimensions namely length (L), width (W) and thickness (T) (figure 2) were measured by using a digital caliper with an accuracy of 0, 01 mm, their definition, abbreviation and units are listed in **Table 1**.

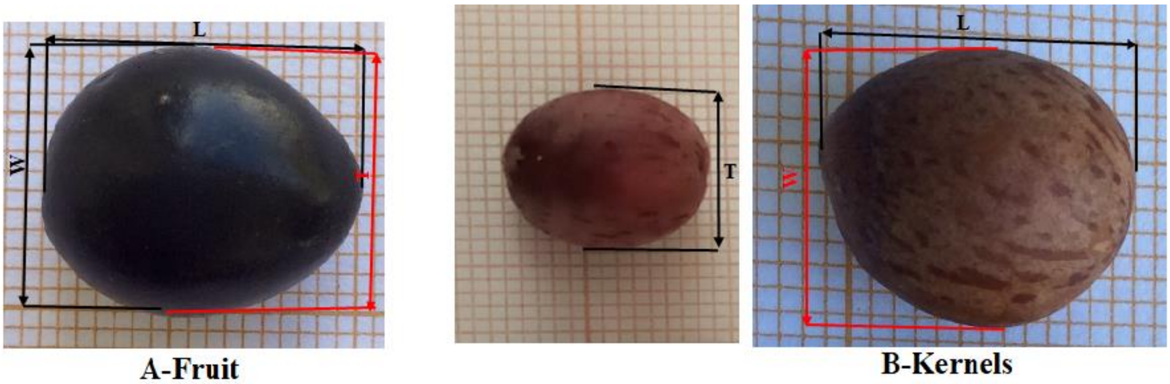

Figure 2: Illustrations of size parameters in of laurel berry fruits (B) and kernels (A); L, W and T are the length (major axis), width (intermediate axis) and thickness (minor axis); source: Oztekin*et al.*, 2010-2011, modified).

Figure 2: Illustrations of size parameters in of laurel berry fruits; L, W and T are the length (major axis), width (intermediate axis) and thickness (minor axis); **source: Oztekin*et al.*,2010-2011, modified).**

The arithmetic mean (D_a), the geometric mean diameter (D_g) of fruits were determined using the following Equation (1) and Equation (2) as reported by **Mohsenin, 1980; koochaki*et al.*,2007**.

$D_a = (L+W+T)/3$ (1)

$D_g = (L \times W \times T)^{1/3}$ (2)

The sphericity of the seed is an index of its roundness. For non-spherical particles, the sphericity is determined as ratio of the surface area equivalent sphere to the surface area of the seed **(Jain and Bal, 1997).**

The sphericity index (Ø) of fruits was calculated adopting the formula (3) proposed by **Mohsenin, 1980 and khazaei et *al.*, 2008**.

$Ø_1 = (L \times W \times T)^{1/3} \times 100/L$ (3)

The sphericity of seeds and fruits can also be calculated by using equation (4**) (Baryeh, 2002; kibar and Öztürk, 2008; Mirzabe*et al.*, 2013).** Also some research used Equation (5) (**Milani *et al.*, 2007; Mirzabe*et al.*, 2013**); in order to determine the sphericity of seeds or fruits.

$Ø_2 = \left[\frac{B(2L-B)}{L^2}\right]^{1/3} \times 100$ (4)

$Ø_3 = \left[\frac{B(2L-B)}{L}\right]^{1/3} \times 100$ (5)

Where, $B = (WT)^{0.5}$

The volume (V) and the surface area (S_a) of the fruit samples were calculated following the equations (6, 7) and (8, 9) respectively **(Baryeh , 2002; Tabarsa*et al.*,2011).**

$V_1 = (\pi \times Dg^3)/6$ (6)

$V_2 = \frac{\pi B^2 L^2}{6(2L-B)}$ (7)

$S_{a1} = \pi \times Dg^2$ (8)

$S_{a2} = \pi BL/2L - B$ (9)

The projected area is an important parameter, which is used for determining aerodynamic properties. This parameter was calculated by using the following equation (10) (11) as cited in **Khazaei *et al.*,2006, Burubai*et al.*,2007; Kabas *et al.*,2007**.

$P_{a1} = \pi \times LW/4$ (10)

$P_{a2} = 1.21V^{2/3}$ (11)

Table 1: Nomenclature of parameter traits, abbreviations and units.

Trait	Unit	Abbreviation
Length	mm	L
Thickness	mm	T
Width	mm	W
Arithmetic mean diameter	mm	D_a
Geometric mean	mm	Dg
Sphericity	mm	$Ø_1$; $Ø_2$; $Ø_3$
Volume	mm^3	V_1; V_2
Surface area	mm^2	S_{a1}; S_{a2}
Projected area	mm^2	P_{a1};P_{a2}

2-5-Statistical Analysis

All measurements were run in triplicates (n =3); 40 samples were used for each replicate and the values were averaged and given along with standard error (±SE). Analyses were performed with SPSS.

3-Results and discussion

3-1-Moisture content of *L.nobilis* L. fruits

The proximate analysis revealed that *L.nobilis* L. fruits contain the moisture contents dependent harvesting time and the percentage ranging between 8.120±0.759-80.427±1.529%. The variability between values of moisture content from *L.nobilis* L. could be attributed to harvesting time and vegetative stage of *L.nobilis* L. fruits. The lowest value for fruits (together with the kernel and berry flesh) was obtained from black fruits collected in 06 November 2016 with 8.120±0.759% and the highest value was taken from green fruits harvested in 11 September 2018 with 80.427±1.529%. The average moisture content (MC) of laurel fruits measured in this study was more divergent than that of the values obtained by **Petkova *et al.*, (2019).** The difference on moisture contents (MC) of laurel fruits reported in previous study and this study may be to the collection site, growth conditions and finally expression results. However, **Yurtlu*et al.*, 2010** revealed that the moisture content of Turkish bay laurel *(L. nobilis* L.) was ranged from 6.09 to 36.70, which was lower than the values obtained in the recent study. Similar findings (6.8% and 7.5%, respectively) have been also reported by **Onay, 2014 and Beis *et al.*, (2006).**

Furthermore, **Konstantinidou *et al.*, (2008)** demonstrated that the moisture content (MC) varied according to dried methods (oven and open air), temperature (30°C and ambient) and drying times (slow and fast). The moisture contents (%) found in this research is of the order of 15-37% during (7 hours -15 days) for oven drying at 30°C. Similarly, the moisture content (%) for free-range drying is 28.7-12.8% for 15-180 days, respectively.

Additionally, the variations found in moisture contents (MC) of laurel fruits may be to the intervention of several parameters such as drying time, drying temperature and the choice of technique or equipment used during processing of preparation of vegetable materials. However, there is little information on moisture content (MC) of Laurel fruits so more research should be made for confirm these results.

For dry matter, the highest value was found in black fruits harvested at 6 November 2016 (91.880±0.759%) and the lowest value was measured with value (19.573±1.529%) from green fruits collected at 11 September 2018.

The dry matter obtained of laurel fruits varied considerably with the season, as well as the morphological and physiological structure of laurel fruits. **Ayanoglu*et al.*, (2018)** reported that the average of dry matter content of fruits genotypes collected in Turkey was between 44.89-69.44%. These results were also within the range of dry matter previously reported in present study but with different percentage.

Tableau 2: Moisture and dry matter content of laurel fruits (Green) harvested in 29 July 2016

Parameter	Max/mm	Min/mm	Mean ±SE	STD	CV %	Skewness	Kurtosis
Moisture content	62.751	57.984	59.961±1.435	2.485	6.176	1.314±1.225	0.000±0.000
Dry Matter (DM) content	42.016	37.249	40.039±1.435	2.485	6.176	-1.314±1.225	0.000±0.000

Results are mean values of 40 determinations of three individual procedures (n=40; 3) ± standard deviation (SD); CV (%): coefficient of variation

Tableau 3: Moisture and dry matter content of laurel fruits (Green) harvested in 24 September 2016

Parameter	Max/mm	Min/mm	Mean ±SE	STD	CV %	Skewness	Kurtosis
Moisture content	40.863	39.404	40.183±0.424	0.735	0.540	-0.595±1.225	0.000±0.000
Dry Matter (DM) content	60.596	59.137	59.817±0.424	0.735	0.540	0.595±1.225	0.000±0.000

*Results are mean values of 40 determinations of three individual procedures (n=40; 3) ± standard deviation (SD); CV (%): coefficient of variation

Tableau 4: Moisture and dry matter content of laurel fruits (Black) collected in 24 September 2016

Parameter	Max/mm	Min/mm	Mean ±SE	STD	CV %	Skewness	Kurtosis
Moisture content	75.079	69.923	72.406±1.491	2.583	6.673	0.328±1.225	0.000±0.000
Dry Matter (DM) content	30.077	24.921	27.594±1.491	2.583	6.673	-0.328±1.225	0.000±0.000

*Results are mean values of 40 determinations of three individual procedures (n=40; 3) ± standard deviation (SD); CV (%): coefficient of variation

Tableau 5: Moisture and dry matter content of laurel fruits (Black) collected in 6 November 2016

Parameter	Max/mm	Min/mm	Mean ±SE	STD	CV %	Skewness	Kurtosis
Moisture content	9.635	7.270	8.120±0.759	1.315	1.730	1.694±1.225	0.000±0.000
Dry Matter (DM) content	92.730	90.365	91.880±0.759	1.315	1.730	1.694±1.225	0.000±0.000

*Results are mean values of 40 determinations of three individual procedures (n=40; 3) ± standard deviation (SD); CV (%): coefficient of variation

Tableau 6: Moisture and dry matter content of laurel fruits (Green) harvested in 14 July 2018

Parameter	Max/mm	Min/mm	Mean ±SE	STD	CV %	Skewness	Kurtosis
Moisture content	40.146	1.435	26.895±12.734	22.055	486.435	-1.728±1.225	0.000±0.000
Dry Matter (DM) content	60.896	59.840	60.197±0.349	0.606	0.367	1.731±1.225	0.000±0.000

*Results are mean values of 40 determinations of three individual procedures (n=40; 3) ± standard deviation (SD); CV (%): coefficient of variation

Tableau 7: Moisture and dry matter content of laurel fruits (Green) collected in 11 September 2018

Parameter	Max/mm	Min/mm	Mean ±SE	STD	CV %	Skewness	Kurtosis
Moisture content	83.040	77.746	80.427±1.529	2.648	7.010	-0.115±1.225	0.000±0.000
Dry Matter (DM) content	22.254	16.960	19.573±1.529	2.648	7.010	0.115±1.225	0.000±0.000

*Results are mean values of 40 determinations of three individual procedures (n=40; 3) ± standard deviation (SD); CV (%): coefficient of variation

Tableau 8: Moisture and dry matter content of laurel seed (Green) harvested in 15 November 2018

Parameter	Max/mm	Min/mm	Mean ±SE	STD	CV %	Skewness	Kurtosis
Moisture content	44.137	43.192	43.683±0.273	0.474	0.224	-0.356±1.225	0.000±0.000
Dry Matter (DM) content	56.808	55.863	56.317±0.273	0.474	0.224	0.356±1.225	0.000±0.000

*Results are mean values of 40 determinations of three individual procedures (n=40; 3) ± standard deviation (SD); CV (%): coefficient of variation

3-2-Agro-morphological properties of *L.nobilis* L. fruits

Results of agromorphological properties of *L.nobilis* L. fruitscollected from different seasons are given below in **Table 9-14**. The values corresponding to geometrical properties including length, width, and thickness are 10.4408±1.05677-15.2710±0.9073mm, 6.9788±0.75429-11.9014±0.02340 mm, and 5.5708±0.62114-11.7648±0.05542 mm, respectively. Then, the others morphological data such as arithmetic mean, geometric mean diameter, sphericity, volume, surface area and projected area obtained on the fruit from L. *nobilis* L. collected in different seasons are also determined.

In fact, the arithmetic mean **(Da)**, the average was ranging from 7.663±0.811 to 13.075±0.035 mm for green fruits collected in different seasons. The geometric mean diameter **(Dg)** was varied from 7.389±0.789 to 12.938±0.033 mm for green fruits harvested in diverse seasons.

The sphericity of fruits **($Ø_1$)** was ranging from 58.362±23.434 to 90.839±0.190% in black and green fruits collected at 8 September 2018 and 06 November 2016, respectively. Also, the sphericity index of fruits **($Ø_2$)** was presented with the percentages between 91.67756±2.426 and 99.425±0.023% for green and black fruits collected in 14 July 2018 and 06 November 2016.

Furthermore, the average of sphericity of fruits **($Ø_3$)** calculated showed the highest percentage with interval ranging from 199.493±5.374 to 244.366±0.272% in green fruits harvested in different periods; 14 July 2018 and 24 September 2016, respectively. Whereas, the volume **(V_1 and V_2)** means of laurel fruits were found to be 225.337±63.877 and 1134.100±8.701 mm^3 and 115.598±30.712 and 928.114±6.309 mm^3, respectively. In addition, the surface areas **(S_{a1} and S_{a2})** were measured as 175.433±35.362 and 525.912±2.692 mm^2, respectively. Finally, the projected areas **(P_{a1} and P_{a2})** were found to be 58.478±11.537 and 145.687±0.968 mm^2, respectively for green fruits collected in 14 July 2018 and 24 September 2016, as well as 39.144±13.242 and 130.972±0.669 mm^2, respectively from green fruits harvested also in 14 July 2018 and 24 September 2016.

Therefore, the results in this study showed that the measured morphological characteristics are different and these characteristics are dependent to the harvesting time and vegetative stage. However, more research must be carried out in this fields to indicated these finding research.

Although, several studies have been carried out on *Laurus nobilis* L., revealed the most important use and application of different vegetative organs of this aromatic species, especially fruits and its components**(Demirbas, 2010; Saab *et al.*, 2015;Uluataand Özdemir, 2012)**, there has been a very little work on its geometrical traits of laurel fruits. **Oztekin et al, 2010 and Yurtlu*et al.*, 2010** investigated the morphological characteristics and geometrical traits of *Laurus nobilis* L. fruits from different regions of Turkey. However, in Morocco no work has been carried out about determination of physicals and geometrical properties of fruit *L.nobilis* L.

In fact, **Öztekin *et al.*, 2010** reported the mean geometrical traits and some physicals properties of Turkish bay such as length (14.26 mm), width (12.22 mm), thickness (10.86 mm), geometric mean diameter (12.36 mm), arithmetic mean diameter (12.44 mm), sphericity (0.86 mm) , volume (1.38 cm^3) and projected area (149.31 mm). These findings were in divergence with those reported in our study. These findings were in accordance with those reported in our study.

Furthermore, **Yurtlu*et al.*, (2010)** determined also the physical properties of bay laurel seeds at different moisture levels. Results obtained declare that the sphericity and surface area varied from 0.775 to 0.802 and 410.9 to 441.4 mm^2, respectively. However, it`s very difficult to compare the result of this literature study with our study because researcher can set different way to express.

Tableau 9: Agro-morphological characteristics of laurel fruits (Green) collected in 24 September 2016

Parameter	Unit	Max/mm	Min/mm	Mean ±SE	STD	CV %	Skewness	Kurtosis
Da	mm	13.124 13.020	13.006 12.928	13.075±0.035 12.979±0.027	0.061 0.047	0.004 0.002	-1.292±1.225 -0.932±1.225	0.000±0.000 0.000
Dg	mm	12.988 12.880	12.876 12.799	12.938±0.033 12.849±0.025	0.0576 0.044	0.003 0.002	-0.870±1.225 -1.650±1.225	0.000±0.000 0.000
Φ_1	%	84.041 84.947	83.255 83.370	83.692±0.231 84.150±0.455	0.400 0.789	0.160 0.622	-0.942±1.225 0.090±1.225	0.000±0.000 0.000
Φ_2	%	98.260 98.430	98.086 98.112	98.183±0.051 98.281±0.098	0.089 0.169	0.008 0.029	-0.983±1.225 0.015±1.225	0.000±0.000 0.000
Φ_3	%	244.643 244.133	243.822 243.298	244.266±0.272 243.608±0.264	0.471 0.457	0.222 0.209	-1.731±1.225 1.649±1.225	0.000±0.000 0.000
V_1	mm^3	1147.164 1118.723	1117.612 1097.857	1134.100± 8.701 1110.979± 6.597	15.071 11.426	227.123 130.560	-0.870±1.225 -1.649±1.225	0.000±0.000 0.000
V_2	mm^3	939.811	918.164	928.114±6.309	10.929	119.446	0.701±1.225	0.000±0.000
Sa_1	mm^2	529.949	520.809	525.912±2.692	4.663	21.739	-0.974±1.225	0.000±0.000
Sa_2	mm^2	472.488	464.936	468.652±2.181	3.777	14.269	0.144±1.225	0.000±0.000
Pa_1	mm^2	146.750	143.755	145.687±0.968	1.676	2.809	-1.706±1.225	0.000±0.000
Pa_2	mm^2	131.976	129.702	130.972±0.669	1.16	1.346	-0.975±1.225	0.000±0.000

*Results are mean values of 40 determinations of three individual procedures (n=40; 3) ± standard deviation (SD); CV (%): coefficient of variation

Tableau 10: Agro-morphological characteristics of laurel seed (Black) collected in 24 September 2016

V_2	mm^3	926.603	902.878	913.893±6.901	11.953	142.876	0.625±1.225	0.000
Sa_1	mm^2	521.154	514.653	518.742±2.055	3.560	12.675	-1.650±1.225	0.000
Sa_2	mm^2	466.881	459.670	463.390±2.085	3.611	13.039	-0.284±1.225	0.000
Pa_1	mm^2	144.002	142.057	142.741±0.631	1.093	1.196	1.714±1.225	0.000
Pa_2	mm^2	129.788	128.171	129.188±0.511	0.885	0.784	-1.649±1.225	0.000

*Results are mean values of 40 determinations of three individual procedures (n=40; 3) ± standard deviation (SD); CV (%): coefficient of variation

Parameter	Unit	Max/mm	Min/mm	Mean ±SE	STD	CV %	Skewness	Kurtosis
Da	mm	11.692	11.293	11.487±0.115	0.199	0.040	0.251±1.225	0.000
Dg	mm	11.635	11.241	11.433±0.114	0.197	0.039	0.237±1.225	0.000
Φ_1	%	91.092	90.466	90.839±0.190	0.329	0.109	-1.429±1.225	0.000
Φ_2	%	99.456	99.380	99.425±0.023	0.040	0.002	-1.414±1.225	0.000
Φ_3	%	232.626	229.713	231.069±0.847	1.467	2.151	0.606±1.225	0.000
V_1	mm^3	824.758	743.791	782.972± 23.409	40.547	1644.020	0.288±1.225	0.000
V_2	mm^3	731.345	663.417	697.338±19.609	33.964	1153.545	0.011±1.225	0.000
Sa_1	mm^2	425.306	396.995	410.736±8.183	14.174	200.905	0.262±1.225	0.000
Sa_2	mm^2	395.003	369.916	382.421±7.242	12.544	157.344	0.028±1.225	0.000
Pa_1	mm^2	111.948	103.875	107.734±2.337	4.048	16.388	0.392±1.225	0.000
Pa_2	mm^2	105.940	98.890	102.312±2.038	3.529	12.457	0.261±1.225	0.000

Tableau 11: Agro-morphological characteristics of laurel fruits (Black) collected in 06 November 2016

*Results are mean values of 40 determinations of three individual procedures (n=40; 3) ± standard deviation (SD); CV (%): coefficient of variation

Tableau 12: Agro-morphological characteristics of laurel fruits (Green) harvested in 14 July 2018

*Results are mean values of 40 determinations of three individual procedures (n=40; 3) ± standard deviation (SD); CV (%): coefficient of variation

Parameter	Unit	Max/mm	Min/mm	Mean ±SE	STD	CV %	Skewness	Kurtosis
Da	mm	8.828	6.104	7.663±0.811	1.404	1.971	-1.164±1.225	0.000±0.000
Dg	mm	8.528	5.874	7.389±0.789	1.366	1.867	-1.146±1.225	0.000±0.000
Φ_1	%	71.372	69.892	70.684±0.430	0.745	0.556	-0.619±1.225	0.000±0.000
Φ_2	%	94.282	86.829	91.67756±2.426	4.203	17.661	-1.718±1.225	0.000±0.000
Φ_3	%	209.325	190.817	199.493±5.374	9.308	86.637	0.550±1.225	0.000±0.000
V_1	mm^3	324.688	106.107	225.337± 63.877	110.638	12240.819	-0.782±1.225	0.000±0.000
V_2	mm^3	175.912	75.376	115.598±30.712	53.194	2829.594	1.457±1.225	0.000±0.000
Sa_1	mm^2	228.452	108.388	175.433±35.362	61.249	3751.417	-0.976±1.225	0.000±0.000
Sa_2	mm^2	194.442	91.938	149.142±30.183	52.278	2733.035	-0.971±1.225	0.000±0.000
Pa_1	mm^2	75.337	36.405	58.478±11.537	19.983	399.318	-1.094±1.225	0.000±0.000
Pa_2	mm^2	56.941	13.260	39.144±13.242	22.936	526.057	-1.389±1.225	0.000±0.000

Parameter	Unit	Max/mm	Min/mm	Mean ±SE	STD	CV %	Skewness	Kurtosis
L	mm	14.48	14.16	14.2928	0.16477	0.027	1.367±1.225	0.000±0.000
W	mm	11.63	11.22	11.3673	0.22892	0.052	1.707±1.225	0.000±0.000
T	mm	11.07	10.82	10.9098	0.14149	0.020	1.688±1.225	0.000±0.000
Da	mm	11.871	11.642	11.724±0.074	0.128	0.016	1.698±1.225	0.000±0.000
Dg	mm	11.714	11.507	11.576±0.069	0.119	0.014	1.732±1.225	0.000±0.000
Φ_1	%	81.876	11.496	58.363±23.434	40.588	1647.426	-1.732±1.225	0.000±0.000
Φ_2	%	94.282	97.722	97.854±0.096	0.166	0.028	1.335±1.225	0.000±0.000
Φ_3	%	237.178	235.577	236.380±0.462	0.800	0.641	-0.031±1.225	0.000±0.000
V_1	mm^3	841.667	795.408	811.607± 15.045	26.059	679.055	1.716±1.225	0.000±0.000
V_2	mm^3	673.717	638.805	650.711±11.505	19.928	397.115	1.729±1.225	0.000±0.000
Sa_1	mm^2	431.100	415.155	420.741±5.184	8.979	80.636	1.716±1.225	0.000±0.000

Tableau 13: Agro-morphological characteristics of laurel seed (Green) collected in 8 September 2018

Sa_2	mm^2	380.344	366.800	371.454±4.446	7.702	59.314	1.726±1.225	0.000±0.000
Pa_1	mm^2	124.938	118.982	121.541±1.769	3.065	9.395	1.138±1.225	0.000±0.000
Pa_2	mm^2	107.381	103.413	104.805±1.289	2.234	4.989	1.715±1.225	0.000±0.000

*Results are mean values of 40 determinations of three individual procedures (n=40; 3) ± standard deviation (SD); CV (%): coefficient of variation

Parameter	Unit	Max/mm	Min/mm	Mean ±SE	STD	CV %	Skewness	Kurtosis
L	mm	14.22	12.01	13.4241±0.71071	0.515	1.515	-1.690±1.225	0.000±0.000
W	mm	11.82	10.35	11.2311±0.44710	0.600	0.600	-1.429±1.225	0.000±0.000
T	mm	11.82	10.48	11.3245±0.42502	0.542	0.542	-1.649±1.225	0.000±0.000
Da	mm	12.394	11.642	12.190±0.102	0.177	0.031	1.701±1.225	0.000±0.000
Dg	mm	12.278	11.960	12.072±0.103	0.178	0.032	1.710±1.225	0.000±0.000
Φ_1	%	84.798	84.144	84.460±0.189	0.328	0.108	0.301±1.225	0.000±0.000
Φ_2	%	98.419	98.281	98.348±0.039	0.069	0.005	0.282±1.225	0.000±0.000
Φ_3	%	239.662	237.733	238.459±0.606	1.049	1.100	1.622±1.225	0.000±0.000
V_1	mm^3	969.022	895.715	921.568± 23.758	41.151	1693.387	1.711±1.225	0.000±0.000
V_2	mm^3	802.799	738.957	760.587±21.108	36.561	1336.679	1.730±1.225	0.000±0.000
Sa_1	mm^2	473.558	449.363	457.902±7.839	13.577	184.341	1.711±1.225	0.000±0.000
Sa_2	mm^2	424.540	401.950	409.687±7.429	12.867	165.562	1.728±1.225	0.000±0.000
Pa_1	mm^2	132.263	125.130	127.624±2.322	4.022	16.175	1.717±1.225	0.000±0.000
Pa_2	mm^2	117.950	111.930	114.053±1.951	3.379	11.419	1.711±1.225	0.000±0.000

Tableau 14: Agro-morphological characteristics of laurel seed (Black) harvested in 11 September 2018

*Results are mean values of 40 determinations of three individual procedures (n=40; 3) ± standard deviation (SD); CV (%): coefficient of variation

4-Conclusion

Laurus nobilis L. is the most important medicinal and aromatic plant of Mediterranean region and also the main income source for local people including Northern Morocco which growing this plant.

The present study reported the physical proprieties of bay laurel fruit (*Laurus nobilis* L.) growing in Northern Morocco and their dependence on fruits moisture content. The results that we obtained indicated that *L.nobilis* L. fruits contain the moisture contents dependent harvesting time and the percentage ranging between 8.120±0.759-80.427±1.529%. Then, the variability between values of moisture content from *L.nobilis* L. could be attributed to harvesting time and vegetative stage of *L.nobilis* L. fruits. Furthermore, the conclusion were found from this study about the geometrical traits such as length of fruits collected from different seasons are length, width, and thickness are 10.4408±1.05677-15.2710±0.9073mm, 6.9788±0.75429-11.9014±0.02340 mm, and 5.5708±0.62114-11.7648±0.05542 mm, respectively. Besides, the others morphological data such as arithmetic mean, geometric mean diameter, sphericity, volume, surface area and projected area investigated on the fruit from L. *nobilis* L. collected in different seasons are also determined. The mean values of arithmetic **(Da)** andgeometric diameter were ranged from 7.663±0.811 to 13.075±0.035 mm and 7.389±0.789 to 12.938±0.033 mm for green fruits harvested in diverse seasons. For the sphericity of fruits (**$Ø_1$,$Ø_2$ and $Ø_1$, respectively**), the highest values were found for green fruits harvested in different seasons (July 2018 and September 2016), whereas the lowest valueswere observed for black fruits collected in various times (September 2018 and November 2016).

In addition, the mean values of volume (**V1 and V2, respectively** of laurel fruits were ranging from 225.337±63.877 and 1134.100±8.701 mm^3 and 115.598±30.712 and 928.114±6.309 mm^3, respectively. The surface areas **(S_{a1} and S_{a2})**were found to be175.433±35.362 and 525.912±2.692 mm^2, respectively.The means projected areas **(P_{a1} and P_{a2})** were varied from 58.478±11.537 to 145.687±0.968 mm^2 and 39.144±13.242 and 130.972±0.669 mm^2 for green fruits harvested in different seasons.

The studied characteristics of Moroccan bay laurel fruits can be recognized as an important for designing processing, transportation, sorting, separation and storing as well as the great pool to valorize the fatty acids composition.Furthermore, the studied and determination of physical properties of *L.nobilis* L. is very important in the design of post-harvest technologies.

More research must be conducted in this context to understanding the influence effect of proximate analysis (moisture content), and geometrical traits (such as length, width and thickness) in quality of fatty acids compositions of fruits of *L. nobilis* L.

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