

## Some Physical Properties of Olive

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### ABSTRACT

Physical properties of olive, a fruit of paradise, and of other agricultural products are important factors in the design of processing, grading, transporting and other agricultural machinery. As an initial step to help improve the design of the machinery, in this research physical characteristics of two varieties of local olives, "yellow olive" and "oily olive", were studied. Having been randomly collected during harvest season, for each olive sample three basic diameters, weight, and volume were measured and the following physical characteristics were estimated. For yellow olive and oily olive, the averages of geometric mean diameter were 20.04 mm and 18.28 mm respectively and their sphericities were 0.81 and 0.79 respectively. Application of regression analysis addressing the relationship between the volume and weight of each variety of olive yielded a significant relationship. Also, the volume of the olive samples was compared with that of an assumed ellipsoid shape, which again indicated a significant relationship. Finally, the correlation sought between olive flesh and the whole olive fruit was similarly found to be quite significant.

**Keywords:** Olive, physical properties, geometric mean diameter, sphericity, Iran

### 1. INTRODUCTION

In many countries around the world with proper weather, olive is cultivated as an important product. In my country, Iran, about 90 percent of vegetable oil is imported, which costs the country about millions of dollars. In order to decrease vegetable oil

import and related costs, our country started a project to expand olive gardens and total area under olive cultivation. In 1992 the area of olive gardens was about 5 thousand hectares and it is about 65 thousand hectares now (13 times as large as it used to be before) and it is going to be increased to 170 thousand hectares very soon.

Also, in 1992, the amount of production of olive was about 7-8 Kilo tons and at this time it is 35 Kilo tons (5 times as much as it used to be before), most of which is sent to olive oil factories for processing while a small quantity of it is consumed as fresh product.

It is clear that, with the increase in the total area under olive cultivation, greater attention should be paid to the processing of olive (Bakker et al, 1999). Determinations of physical and mechanical properties of agricultural products are very important factors in the design of processing, grading, transporting and other agricultural machinery (Altunatş et al, 2007). Moreover, the shape and the size of the product are the most important physical properties (Altunatş et al, 2005). Shape and size are inseparable in a physical object, and both are generally necessary if the object is to be satisfactorily described. Further, in defining the shape some dimensional parameters of the object must be measured. If both shape and size affect the process, the relationship can be shown by a two dimensional equations as follows:

$$I=F (SH, S) \quad (1)$$

Where: I is the index influenced by both shape (SH) and size (S). Most of the seeds, grains, fruits and vegetables are irregular in shape and from a theoretical standpoint; a complete specification of their size requires an infinite number of measurements. However, from a practical point of view, measurement of several mutually perpendicular axes is sufficient (Mohsenin, 1986).

Many researchers have identified the shape and size for agricultural products with different methods. For example, Mohsenin (1986) expressed the relationship between volume and dimensions of particle diameters as follows:

$$V = a_1^{b_1} a_2^{b_2} a_3^{b_3} \dots a_n^{b_n} \quad (2)$$

Where V is the volume of specimen and  $a_1, a_2, a_3, a_1 \dots, a_n$  are particle diameters and  $b_1, b_2, b_3, \dots b_n$  are experimental constants. Logarithm of both sides of the above equation yields the following linear expression.

$$\text{Log } v = b_1 \log a_1 + b_2 \log a_2 + b_3 \log a_3 + \dots + b_n \log a_n \quad (3)$$

Using multiple linear regression, volume was related to axial dimensions and the contribution of each axis to the volume was determined using the analysis of variance technique. Gupta and Dus (1997) reported correlation among various dimensions of sunflower seeds. Madamba et al. (1993) measured length, width and thickness of specimen by using vernier (or caliper). Tabil et al (1999) used an image processing program to determine size and shape characteristics of seeds including the length of the longest and shortest axis, total area, etc. Information about physical and mechanical properties of olive is not available in the literature. Since in my country, the total areas under olive cultivation are expanding now, this information is very important for designing and making olive processing machinery and the related equipment (Parenti et al, 2000). The objectives of this study were to determine physical attributes of olive such as shape, size, volume, sphericity (SP), and geometric mean diameter (GM) and to define the relationship between properties of two varieties of local olive, “ Yellow Olive ” and “ Oily Olive ” , which cover most of the area under olive cultivation in Iran.

## 2. MATERIALS AND METHODS

The samples of olives (*Olea Europaea*) were obtained locally in the Roodbar region, Gilan, Iran. (Roodbar is the region where olives are most widely cultivated.)

The samples of olives (Oily and Yellow) were randomly collected from the south side of trees and from different gardens (Bravo, 1990).

An attempt was made to select the samples in a manner in which they could be comparable to the extent possible in terms of ripeness and environmental conditions of cultivation. To meet the latter condition, the gardens selected so that they could represent those in the area.

The samples were weighed with an accuracy of 0.01 gr and their main diameters were measured with an accuracy of 0.01 mm (for three main axes). Then the stones were removed from the olives and, the same measurements were repeated for them (olive stones) The geometric mean diameters (Mg) of the olives were calculated by using the following equation:

$$Mg = (L.W .T)^{\frac{1}{3}} \quad (4)$$

Where L is the length, W is the width and H is the height of olive fruit each two of which are mutually perpendicular.

The sphericities (SP) of the two varieties of olive were calculated by using the following equation:

$$SP = \frac{Mg}{L} \quad (5)$$

Through the experiment conducted, the above measurements were performed for the two varieties of olive 25 times in four consecutive years. The data obtained were analyzed by means of SAS, MSTAT, and EXCELL soft wares. Diameters of the three dimensions (L, W, and H) for the two varieties of olives were compared. By using F-test and T-test the difference between variance and mean for the dimensions was estimated.

By using multiple regressions, the relationship between volume and dimensions of olives was examined and the equation between them was specified. Also, different regression methods were applied.

The sphericities for the two varieties of the olive fruit were compared. To show the difference between the sphericities of them, the T-test and F-test were used.

Further, the volume of the olive fruit samples were compared with the volume of ellipsoid shape and the relationship between them was determined with the function “Y= f (X)”. Then their R<sup>2</sup> (the coefficient of multiple determination) were also calculated.

By applying linear regression analysis the relationship between real volume and weight and that between theoretical volume and weight were determined for each variety separately and also R<sup>2</sup> were calculated.

Further, the relationship between weight of the whole olive fruit and weight of olive flesh (or pomace) was considered by regression analysis.

### 3. RESULTS AND DISCUSSION

Tables 1 and 2 show the related data and information for the two varieties of olive, oily olive and yellow olive, respectively. Considering local oily olives, the mean, the variance, and the standard deviation for longer diameter (L) were found to be 23.29, 2.31, and 1.52 respectively and for intermediate diameter (W) those indices were found to be 16.61, 0.99, and 1.00 and for shorter diameter (H) they were found to be 16.00, 0.96, 0.98 respectively.

Also considering local yellow olives, the mean, the variance, and the standard deviation for longer diameter (L) were found 24.94, 4.45, and 2.11 respectively, for intermediate diameter (W) those indices were found to be 18.51, 2.29, 1.51 respectively, and for shorter diameter (H) they were found to be 17.56, 2.25, and 1.50 respectively.

The average of geometric mean diameter and sphericity for local oily olive were found to be 18.35 and 0.79 with standard deviation 1.03 and 0.03 respectively. Also the average of geometric mean diameter and sphericity for local yellow olive were found to be 20.08 and 0.81 with standard deviation 1.55 and 0.03 respectively.

The average of weight of the two varieties of local olives (Oily, Yellow) were 3.58gm and 4.73gm respectively with variance 0.30 and 0.70 and standard deviation 0.55 and 0.83 respectively.

By applying F test, the sphericities of the two varieties of local samples were compared.

The probability of F obtained was 0.43 ( $P=0.43$ ), which indicates no significant difference between the two varieties in terms of sphericity. Application of T-test indicated that the means of both varieties was equal.

The variance of the differences between the means equals to 0.7535 and standard deviation of differences were found to be 0.86. Probability of T was obtained to be 0.0786 ( $\alpha =0.01$ ) which indicated no significant difference between the varieties in terms of sphericity.

Volumes of the olive fruit samples were compared with that of ellipsoid shape. To this end, we assumed that the measured diameters (L, W, and H) belonged to the assumed ellipsoid shape. Then the volume of this shape was estimated and was regarded as the theoretical volume of the samples. The estimated volume ( $V_c$ ) and the

real volume ( $V_r$ ) were compared by using F-test. The F-test indicated that variances of both varieties were equal and no significant differences were observed between VC and  $V_r$ .

Further, by using the regression analysis a relationship between the estimated volume and the real volume for both varieties were found:

$$\text{Yellow Olive: } V_r = 0.1557 VC^2 - 0.8079 VC + 5.3066 \quad R^2 = 0.89$$

$$\text{Oily Olive: } V_r = 1.0155 VC + 0.4241 \quad R^2 = 0.83$$

Where:  $V_r$  is the real volume of olive fruit ( $\text{mm}^3$ ), VC is the estimated volume of olive fruit ( $\text{mm}^3$ ) and R is the correlation coefficient. The graphs for the above equation are displayed in figures 1 and 2.

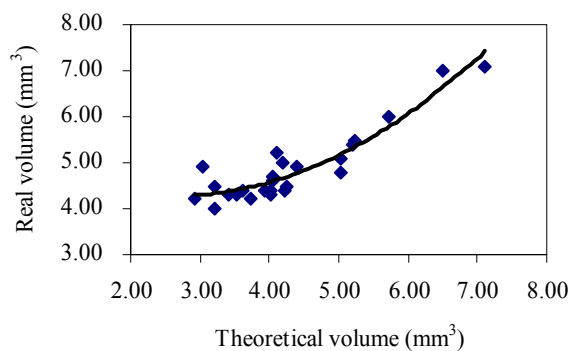


Fig.1: relationship between theoretical volume and real volume for yellow Olive

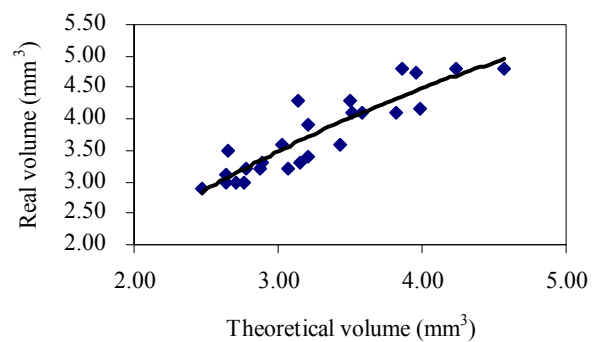


Fig.2: relationship between theoretical volume and real Volume for oily Olive

The relationship between unit volume and main dimensions for both varieties of olives were found by using multiple regressions:

Yellow olives:

$$\text{Log } V = 1.117 \text{ Log } L + 0.686 \text{ Log } W + 0.8 \text{ Log } H - 1.837 \quad R^2 = 0.80$$

Oily olives:

$$\text{Log } V = 0.638 \text{ Log } L + 1.774 \text{ Log } W + 0.335 \text{ Log } H - 2.872 \quad R^2 = 0.84$$

Where: V is the volume ( $\text{mm}^3$ ) and L, W, H are major, intermediate and minor dimensions (mm) and R is the correlation coefficient.

Having overlooked the measurements of minor dimension (H), we found the following equation:

Yellow olives:

$$\text{Log } V = 1.156 \text{ Log } L + 0.741 \text{ Log } W - 1.86 \quad R^2 = 0.80$$

Oily olives:

$$\text{Log } V = 0.677 \text{ Log } L + 2.051 \text{ Log } W - 2.86 \quad R^2 = 0.84$$

The relationship between real volume and weight for both varieties of local olives were found to be:

Yellow Olive:

$$V_r = 0.0678 w^2 + 0.1756 w + 2.5282 \quad R^2 = 0.89$$

Oily Olive:

$$V_r = 0.02207 w^2 + 2.6687 w - 2.8587 \quad R^2 = 0.87$$

Where:  $V_r$  is the real volume of olive fruit ( $\text{mm}^3$ ), and  $W$  is the weight of olive fruit (gr) and  $R$  is the correlation coefficient. The graphs for above equations are shown in figures 3 and 4.

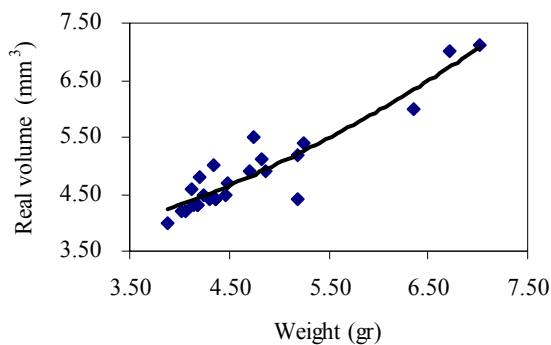


Fig3: relationship between weight and real volume for yellow Olive

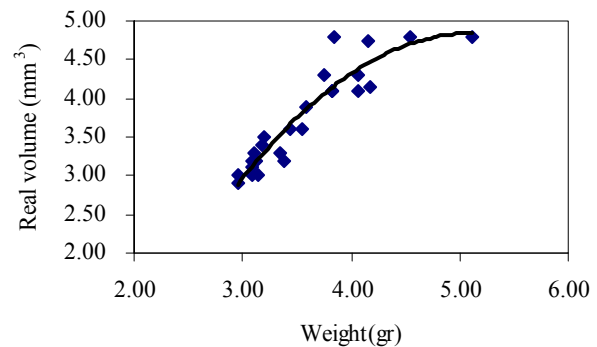


Fig4: relationship between weight and real volume for oily Olive

Further, relationships between estimated volume and weight for the two varieties of local olives were found to be:

Yellow olives:

$$VC = 0.1285 w^2 - 0.3383w + 2.9474 \quad R^2 = 0.71$$

Oily olives:

$$VC = -0.1349 w^2 + 1.9861w - 2.0796 \quad R^2 = 0.86$$

Where:  $VC$  is the estimated volume ( $\text{mm}^3$ ) and  $W$  is the weight of olive fruit (gr) and  $R$  is the correlation coefficient. The graphs for the above equations are shown in figures 5 and 6.

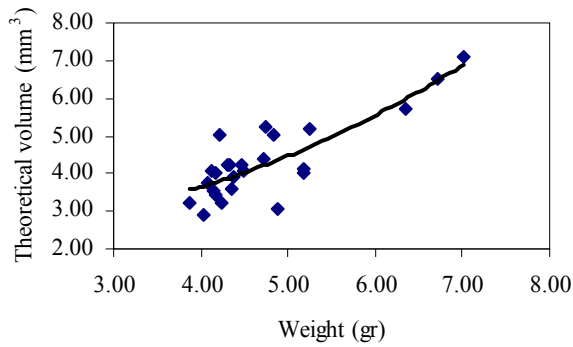


Fig5: relationship between weight and theoretical Volume for yellow Olive

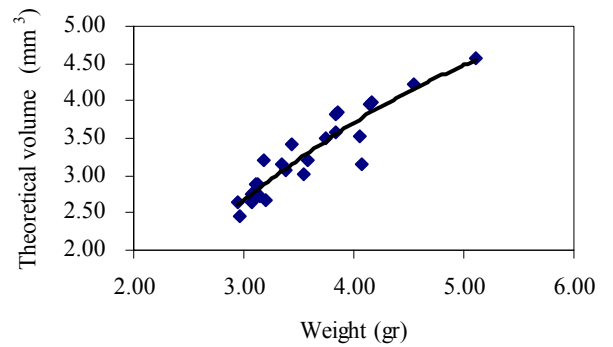


Fig6: relationship between weight and theoretical Volume for oily Olive

Finally, the relationship between weight of olive core and whole olive fruit was found to be:

Yellow Olive:

$$w = 0.0264 Wc^2 + 0.7789 Wc + 1.0798 \quad R^2 = 0.99$$

Oily Olive:

$$w = 0.0375 Wc^2 + 0.7182 Wc + 1.0705 \quad R^2 = 0.97$$

Where:  $W$  is the weight of olive fruit (gr),  $Wc$  is the weight of olive core (gr) and  $R$  is the correlation coefficient. The graphs for the above equations are shown in figures 7 and 8.

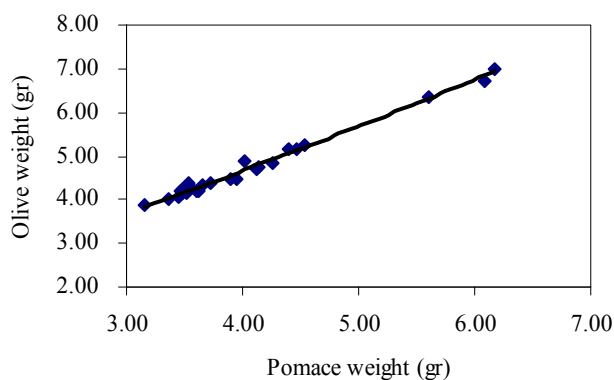


Fig7: relationship between olive weight and pomace weight for yellow Olive

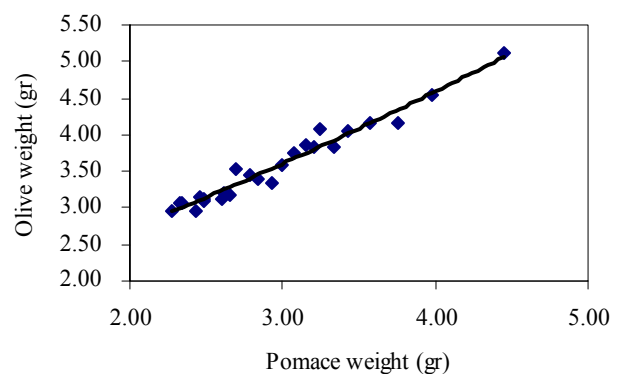


Fig8: the relationship between olive weight and pomace weight for oily Olive



#### 4. CONCLUSION

In this study an attempt was made to determine the physical properties of two varieties of local olives, "yellow olive" and "oily olive". To that end, the means of the basic dimensions, including those of the longer, intermediate, and shorter diameters, were estimated together with the associated variance and standard deviations for the two varieties of the olives. The results obtained were as follows.

Concerning the local oily olives, the means of basic dimensions, including those of the longer, intermediate, and shorter diameters were found to be 23.29, 16.61 and 16.00 respectively with variances 2.31, 0.99 and 0.96 and with standard deviations (Std) 1.52, 1.00 and 0.98

Regarding the local yellow olives, the means of basic dimensions, including those of the longer, intermediate, and shorter diameters were 24.94, 18.51, 17.56 respectively with variances 4.45, 2.29, 2.25 and with standard deviations (Std) 2.11, 1.51, 1.50.

The above results indicated that the size of the two varieties were intermediate.

The relationship between unit volume and main dimensions for both types of olive were found to be:

Yellow olives:

$$\text{Log } V = 1.117 \text{ Log } L + 0.686 \text{ Log } W + 0.8 \text{ Log } H - 1.837 \quad R^2 = 0.80$$

Oily olives:

$$\text{Log } V = 0.638 \text{ Log } L + 1.774 \text{ Log } W + 0.335 \text{ Log } H - 2.872 \quad R^2 = 0.84$$

Where: V is the volume (mm<sup>3</sup>) and L, W, H are major, intermediate and minor dimensions (mm) of olive fruit and R is the correlation coefficient.

Having disregarded the measurements of minor dimensions (H), this researcher found the following equations:

Yellow olives:

$$\text{Log } V = 1.156 \text{ Log } L + 0.741 \text{ Log } W - 1.86 \quad R^2 = 0.80$$

Oily olives:

$$\text{Log } V = 0.677 \text{ Log } L + 2.051 \text{ Log } W - 2.861 \quad R^2 = 0.84$$

Considering the above equations, unit volume and two basic diameters (L, W) had a correlation about 80 percent for both types of local olives (without taking account of minor dimensions)

The averages of sphericity for the two varieties of the olive were 81 and 79 percent with standard deviation 3 for both of them. No significant difference was observed between them. Therefore, yellow olives sphericity is the same as that of oily olives. And both varieties of local olive were ellipsoid.

Comparison of the volume of the two varieties of the olive samples with that of assumed ellipsoid shape indicated that there was no significant difference between the two volumes. The  $H_0$  was thus accepted.

This result is very important because it is possible to obtain other physical properties with well-known mathematical methods by considering the relation between them.

The averages of weight for two varieties of local olive were 3.58 and 4.73. By using F test no significant differences were observed between them. So the weights of both varieties were intermediate.

**Table 1: Oily Olive Information.**

|            | <i>L</i>     | <i>W</i>     | <i>H</i>     | <i>Vr.</i>   | <i>W.</i>    | <i>GM</i>    | <i>Vc.</i>   | <i>SP</i>    |
|------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| 1          | 23.04        | 15.20        | 14.80        | 3.00         | 3.14         | 17.31        | 2.71         | 0.75         |
| 2          | 22.44        | 15.54        | 15.12        | 3.00         | 3.08         | 17.41        | 2.76         | 0.78         |
| 3          | 23.00        | 15.60        | 15.32        | 3.20         | 3.13         | 17.65        | 2.88         | 0.77         |
| 4          | 25.62        | 18.48        | 18.44        | 4.80         | 5.11         | 20.59        | 4.57         | 0.80         |
| 5          | 20.76        | 15.70        | 15.58        | 3.50         | 3.20         | 17.19        | 2.66         | 0.83         |
| 6          | 23.10        | 16.20        | 16.10        | 3.30         | 3.35         | 18.20        | 3.15         | 0.79         |
| 7          | 23.66        | 17.30        | 16.72        | 4.10         | 3.83         | 18.99        | 3.58         | 0.80         |
| 8          | 23.26        | 16.76        | 15.72        | 3.90         | 3.58         | 18.30        | 3.21         | 0.79         |
| 9          | 22.20        | 16.00        | 14.92        | 3.20         | 3.09         | 17.43        | 2.77         | 0.79         |
| 10         | 25.10        | 18.00        | 17.90        | 4.80         | 4.55         | 20.07        | 4.23         | 0.80         |
| 11         | 22.60        | 16.88        | 15.72        | 4.30         | 4.07         | 18.17        | 3.14         | 0.80         |
| 12         | 23.34        | 15.38        | 15.36        | 3.30         | 3.11         | 17.67        | 2.89         | 0.76         |
| 13         | 23.60        | 15.78        | 15.74        | 3.20         | 3.39         | 18.03        | 3.07         | 0.76         |
| 14         | 22.76        | 16.58        | 16.22        | 3.40         | 3.18         | 18.29        | 3.20         | 0.80         |
| 15         | 22.00        | 14.90        | 14.38        | 2.90         | 2.96         | 16.77        | 2.47         | 0.76         |
| 16         | 25.00        | 16.68        | 15.72        | 3.60         | 3.44         | 18.72        | 3.43         | 0.75         |
| 17         | 23.24        | 16.28        | 15.30        | 3.60         | 3.54         | 17.96        | 3.03         | 0.77         |
| 18         | 20.48        | 16.38        | 15.00        | 3.00         | 2.95         | 17.14        | 2.63         | 0.84         |
| 19         | 24.68        | 17.98        | 16.46        | 4.10         | 3.83         | 19.40        | 3.82         | 0.79         |
| 20         | 24.42        | 18.00        | 17.30        | 4.15         | 4.17         | 19.66        | 3.98         | 0.81         |
| 21         | 24.40        | 17.00        | 16.10        | 4.30         | 3.75         | 18.83        | 3.49         | 0.77         |
| 22         | 20.20        | 16.00        | 15.60        | 3.10         | 3.08         | 17.15        | 2.64         | 0.85         |
| 23         | 24.66        | 17.80        | 16.80        | 4.80         | 3.85         | 19.46        | 3.86         | 0.79         |
| 24         | 22.60        | 17.48        | 17.00        | 4.10         | 4.06         | 18.87        | 3.51         | 0.83         |
| 25         | 26.20        | 17.30        | 16.68        | 4.75         | 4.15         | 19.63        | 3.96         | 0.75         |
|            |              |              |              |              |              |              |              |              |
| <b>AVG</b> | <b>23.29</b> | <b>16.61</b> | <b>16.00</b> | <b>3.74</b>  | <b>3.58</b>  | <b>18.35</b> | <b>3.27</b>  | <b>0.79</b>  |
| <b>STD</b> | <b>1.52</b>  | <b>1.00</b>  | <b>0.98</b>  | <b>0.64</b>  | <b>0.55</b>  | <b>1.03</b>  | <b>0.56</b>  | <b>0.03</b>  |
| <b>VAR</b> | <b>2.312</b> | <b>0.992</b> | <b>0.965</b> | <b>0.410</b> | <b>0.300</b> | <b>1.067</b> | <b>0.315</b> | <b>0.001</b> |

**Table 2: Yellow Olive Information.**

|             | <b>L</b>     | <b>W</b>     | <b>H</b>     | <b>Vr.</b>  | <b>W.</b>   | <b>GM</b>    | <b>Vc.</b>  | <b>SP</b>   |
|-------------|--------------|--------------|--------------|-------------|-------------|--------------|-------------|-------------|
| 1           | 26.60        | 20.28        | 20.28        | 6.00        | 6.36        | 22.20        | 5.73        | 0.83        |
| 2           | 26.08        | 19.88        | 19.32        | 5.50        | 4.75        | 21.56        | 5.24        | 0.83        |
| 3           | 31.60        | 20.78        | 20.68        | 7.10        | 7.01        | 23.86        | 7.11        | 0.75        |
| 4           | 24.00        | 18.30        | 17.46        | 4.30        | 4.18        | 19.72        | 4.01        | 0.82        |
| 5           | 27.06        | 19.48        | 18.18        | 5.10        | 4.83        | 21.24        | 5.02        | 0.78        |
| 6           | 27.08        | 20.20        | 18.20        | 5.40        | 5.24        | 21.51        | 5.21        | 0.79        |
| 7           | 23.78        | 19.14        | 17.76        | 4.40        | 4.31        | 20.07        | 4.23        | 0.84        |
| 8           | 23.16        | 16.74        | 15.76        | 4.00        | 3.88        | 18.28        | 3.20        | 0.79        |
| 9           | 28.12        | 22.08        | 20.00        | 7.00        | 6.72        | 23.16        | 6.50        | 0.82        |
| 10          | 23.82        | 19.30        | 17.66        | 4.50        | 4.47        | 20.10        | 4.25        | 0.84        |
| 11          | 23.46        | 18.34        | 18.00        | 4.60        | 4.13        | 19.78        | 4.05        | 0.84        |
| 12          | 25.00        | 20.08        | 19.12        | 4.80        | 4.21        | 21.25        | 5.02        | 0.85        |
| 13          | 25.68        | 17.82        | 17.56        | 5.00        | 4.34        | 20.03        | 4.21        | 0.78        |
| 14          | 26.88        | 18.10        | 15.78        | 4.40        | 5.18        | 19.73        | 4.02        | 0.73        |
| 15          | 23.62        | 17.30        | 16.00        | 4.30        | 4.18        | 18.70        | 3.42        | 0.79        |
| 16          | 24.92        | 18.10        | 16.60        | 4.40        | 4.37        | 19.56        | 3.92        | 0.79        |
| 17          | 23.78        | 17.32        | 17.30        | 4.20        | 4.07        | 19.24        | 3.73        | 0.81        |
| 18          | 23.84        | 18.70        | 17.38        | 4.70        | 4.49        | 19.79        | 4.05        | 0.83        |
| 19          | 23.34        | 17.06        | 17.00        | 4.30        | 4.14        | 18.92        | 3.54        | 0.81        |
| 20          | 24.82        | 18.18        | 17.40        | 5.20        | 5.18        | 19.88        | 4.11        | 0.80        |
| 21          | 24.52        | 18.60        | 18.38        | 4.90        | 4.71        | 20.31        | 4.39        | 0.83        |
| 22          | 24.50        | 15.42        | 15.40        | 4.90        | 4.87        | 17.99        | 3.04        | 0.73        |
| 23          | 21.40        | 16.46        | 15.88        | 4.20        | 4.03        | 17.75        | 2.93        | 0.83        |
| 24          | 23.20        | 18.00        | 16.48        | 4.40        | 4.36        | 19.02        | 3.60        | 0.82        |
| 25          | 23.14        | 17.20        | 15.36        | 4.50        | 4.24        | 18.28        | 3.20        | 0.79        |
|             |              |              |              |             |             |              |             |             |
| <b>AVG=</b> | <b>24.94</b> | <b>18.51</b> | <b>17.56</b> | <b>4.88</b> | <b>4.73</b> | <b>20.08</b> | <b>4.31</b> | <b>0.81</b> |
| <b>STD=</b> | <b>2.11</b>  | <b>1.51</b>  | <b>1.50</b>  | <b>0.80</b> | <b>0.83</b> | <b>1.55</b>  | <b>1.04</b> | <b>0.03</b> |
| <b>VAR=</b> | <b>4.45</b>  | <b>2.29</b>  | <b>2.25</b>  | <b>0.65</b> | <b>0.70</b> | <b>2.39</b>  | <b>1.08</b> | <b>0.00</b> |

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