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Identification of some spanish olive cultivars using image processing techniques

Abdullah Beyaz[a,*], Mücahit Taha Özkaya[b], Duygu İçen[c]

[a] Department of Agricultural Machinery and Technologies Engineering, Faculty of Agriculture, Ankara University, Ankara, Turkey
[b] Department of Horticulture, Faculty of Agriculture, Ankara University, Ankara, Turkey
[c] Department of Statistics, Faculty of Science, Hacettepe University, Ankara, Turkey

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ABSTRACT

The aim of this research was to identify some Spanish olive cultivars using image processing techniques. For this purpose, *Lechin De Granada, Arbequina, Picual, Verdial De V-M, Picudo, Hojiblanca and Empeltre* Olive cultivars were identified utilizing the image processing and analysis techniques. Therefore, images of olives taken as 300 dpi with the 2896 × 1944 pixels, were captured using a DSLR camera, and evaluations of pixels were used for considering the pixel distribution and dimension measurements. LabVIEW Vision Assistant v2013 (NI) and Image j (NIH) software were used for image analysis procedures. Artificial Neural Network analysis were used to assess information of the length, width and color data results obtained from the fruits and stones (olive stones). All cultivars were identified. In addition, different classification techniques were applied to the olive stone and fruit data with the help of SPSS v22. Clementine v12 was used as a data mining software package from SPSS. The cultivars were identified 90% from dimensions with Artificial Neural Networks.

1. Introduction

Olive is an important agricultural product for Turkey and the world. According to the FAO statistics, Turkey ranked as the 4th country in terms of olive production with an income of 2783 million US Dollars. It is known that there are 171,992 olive trees (TSI, 2015) in Turkey. In addition to this, Turkey has an olive production capacity of 1,700,000 tons in a year (TSI, 2015). Olive (*Olea europaea* L.) production is of a great economic importance for Turkey as it is located in olive production zone. The geographical positions of Turkey have been proved to be suitable in terms of olive production as the overall climate is dominated greatly by Mediterranean climate (i.e. Aegean, Marmara, Mediterranean, Southeast Anatolia, Black Sea regions). The remainders can be observed in olive cultivars due to elements such as widespread region, differences between the climate conditions of the regions and cross-pollination. Therefore, it is of significant importance to define the type of the surface patterns of olive cultivars that are widespread in vast parts of the world. In this respect, many studies and researches needs to be conducted for improving olive production. A common problem encountered in studies conducted is that the forms of obtained data are insufficient for the determination of olive cultivars. The reason for this is that the characteristics of olive cultivars depend on the ecological conditions. The phenotypic and genotypic origin, molecular marker researches cannot provide accurate olive cultivar determination data (Sakar Çakır, 2009) as the full genome sequences of all olive cultivars have not been defined yet. The cultivar determination process has started with the identification of cultivars pomological information. As a consequence of these reasons, a new study was conducted on some Spain cultivars after conducting some Turkish cultivars evaluations.

Many studies and researches were conducted on the identification of olive cultivars around the world. For example, Diaz et al. (2000) produced four different algorithms for a machine vision system and applied these algorithms for the identification of olives. In addition to this, they compared human selected olive cultivars with computer vision algorithms. Bari et al. (2003) concentrated on identifying the characteristics of the olives in their studies and they stated that structural characteristics are significant factors in the identification of olives.

Diaz et al. (2004) worked on the classification of olives based on the fruit surface defects in different quality categories.

Mendoza et al. (2006) worked on different color spaces like RGB, HSV, and L * a * b *, and they stated that the colors of fruits and vegetables were measured by a computerized imaging system that can be applied for the determination of product status.

Riquelme et al. (2008) conducted studies on the color defects and structural parameters of olive cultivars.

Al Ibrahem et al. (2008) conducted studies on different olive

* Corresponding author.
E-mail addresses: abeyaz@ankara.edu.tr, abdullahbeyaz@gmail.com (A. Beyaz).

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cultivars (19) using manual measurement and image analysis techniques.

Moreda et al. (2012) worked on the shape determination of horticultural products using computer vision technology. They also stated that the computer vision measurements have become a proven and reliable tool for describing the product shape.

Vanloot et al. (2014) emphasized that image analysis and metric evaluations of agricultural products like olive stones for determining the varietal origin require specialists, who cannot always conclude with certainty, due to the large number of cultivars identified.

Olive production is also significant for many industrial applications as olive identification methods will affect the output characteristics of the olives. In this regard, the aim of this study was to distinguish the characteristics of some olive cultivars in Spain's World Collection using image processing and analysis techniques. In addition to this, the efficiency of image analysis methods was also investigated in this study.

Olives are generally divided into two groups; olive oil and table olive. Olives have a highly variable chemical and physical composition, but these variabilities mostly depend on four major factors. These four factors are cultivars, ecology, cultural practices, and processing. For example, a cultivar which is called dual purpose can be used as both table olive and olive oil. Therefore, cultivar is one of the most important factors for determining the quality of these two products (Gurdeniz et al., 2007).

Mono variety is important and indispensable factor for table olive processing. In recent years, mono varietal olive oil has gained importance because of the health benefits and sensory qualities of each cultivar (Gurdeniz et al., 2007).

Table olive and olive oil produced from olives of just one cultivar (mono varietal) obtained form one geographical region are becoming increasingly important in the market (Gurdeniz et al., 2007).

The documentation of the geographical source of table olive and olive oil is becoming increasingly important as the authenticity and quality issues can be linked with a special region and cultivar. The Denomination of Origin (Protected Denomination of Origin (PDO) and Protected Geographical Indication (PGI)) is a certification program established in Europe for the protection of high-quality agricultural products (Babcock and Clemens, 2004).

There are many analytical methods used to determine the varietal origin of olive. Olive stone (pit) is one of the fingerprinting organ used for varietal identification (Ozen et al., 2005).

The aim of this study was to identify olive cultivars from their characteristics using image processing and analysis techniques. In this study, the methods of International Olive Council (IOC) and European Union (EU) were adopted for determining olive cultivar and,then, stone, fruit, and leaf data were used for identifying olive cultivars. Moreover, image processing and analysis techniques were employed to accomplish this aim.

2. Material and method

2.1. Harvest of fruit samples

In this study, *Lechin De Granada, Arbequina, Picual, Verdial De V-M, Picudo, Hojiblanca* and *Empeltre* olive cultivars were used for the experiments (Fig. 1). All cultivars were obtained from Instituto Andaluz de Investigación y Formación Agroalimentaria y Pesquera de Andalucía (IFAPA), Cordoba, Spain (37°51′42.7″N, 4°45′56.7″W). Olive samples were harvested from 5 different trees randomly for each olive cultivars in November 2015. A total of 100 olive fruit samples were harvested from each cultivar. During the period of the experimentations, olive cultivars placed in cold storage (+4C°, 80% humidity) in The Faculty of Agriculture, Department of Horticulture in Ankara University, Turkey.

2.2. Imaging system

After the harvest, 100 samples were taken randomly from each olive cultivar. These samples were photographed from 4 different views − from the front, handle hole, left and tip sides (Fig. 2). These imaging sides are also employed as standard classification views by Kemalpaşa Olive Research Institute for the identification of national collection of Turkey's olive cultivars. In aggregate, 4400 digital images were captured from 1100 olive fruits for evaluations. A macro capture tripod was set at a distance of 40 centimeter away from the olives to obtain these digital pictures.

A Nikon D300 s body with an 18–140 mm zoom lens was used for general purpose imaging and a Nikon D800 with a 105 mm macro lens was used for macro captures. The captured images were stored as JPEG files. All images were captured in 2896 × 1944 pixel dimension and at 300 dpi resolution. Olive fruit and stone images were captured one by one for evaluations. 5 × 5 mm calibration plate was used with a white backdrop for making precision calibration (Fig. 3). First, the primary image capturing problems such as shaded regions and image focus clarity were worked out. Different lenses and flashes were employed for working out the problems encountered during experimentation. The problem of shaded regions was worked out by using a ring flash. Image focus problem was also worked out by using a 105 mm macro lens. After overcoming these problems related to digital imaging, olive cultivars were harvested from the national collection. Then, each olive fruit was photographed, put in numbered plastic bags (5 × 5 cm) and prepared for the following step (olive stone removal step).

After completing the picture capturing process, olive stones were removed from fruits. The olive stones were removed from the fruits with an extractor and, then, the olive stone pattern structures were determined. After cleaning the olive stones with the help of a knife, the stones were washed. Then, the stones were stored in plastic containers holding in a 10% bleach solution for 15 h. As a final step, olive stones were stored at − 4 °C to prevent cracking because of physiological activity.

Removed olive stones were put in numbered plastic bags (5 × 5 cm). The processes applied to olives are demonstrated in Fig. 4.

2.3. Image processing and determination of sample proportions

Image J (NIH) and LabVIEW Vision Assistant v2013 (NI) software were used for evaluations. Segmentation process was not applied to the images of olives during the image analysis of the fruit and stones as location as LabVIEW Vision Assistant v2013 software gave us a chance for precision measurement without the need for any segmentation process. After completing all surface segmentation processes, LabVIEW Vision Assistant v2013 (NI) software was used for measuring the dimensions of olives. The length and width data were collected from the digital pictures of olive stones (Fig. 5).

LabVIEW Vision Assistant v2013 (NI) was used for measuring the length and width dimensions of olive stones and fruits (Fig. 6). Image J (NIH) software was used for determining pixel counts.

The monochrome pixel values were counted from the images. Therefore, these counts were changed into '%' values for evaluating the olive cultivars. The aim of converting counts into '%' was the standardization of pixel counts for comparison of each picture. In this study, the IOC and EU determination methods were used for the experimentations. Özilbey, 2011 provided information on manual olive identification methods in his book and outlined the characterstics of Turkey's olive cultivars. These methods are based on morphological and pomological measurements methods, i.e. olive tree measurements, leaf measurements, flower measurements, fruit dimension and olive stone evaluations. In addition to this, other studies in literature were found and analyzed. For the stones' monochrome pixel distributions, the length and width of stones were investigated (Özilbey, 2011).