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Fruit washing influence on extra virgin olive oil quality: a sensory perspective

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ABSTRACT

In this work the washing operation applied to fruits of olive tree (Olea europaea) will be studied to verify its influence on the quality of the oils that can be obtained subsequently. For this purpose, 60 fruit samples (of 7.5 kg each) were taken from a rainfed farm, dedicated to Picual variety under organic crop production, and the corresponding oils were obtained by washing and by non-washing such samples. After carrying out diverse sensory analyses (in which were assessed sensory attributes as green fruity, bitter, pungent, sweet, green leaf, grass, apple, almond and tomato), it is worth noting that, under the conditions in which this study was conducted, it is observed that there are no relevant differences among the oils obtained by washing and by non-washing the olive fruits. This fact is relevant and it could be considered by the producers of this sector when making decisions about the unit operations more indicated to apply in order to get high-quality oils.

***Key words**: olive washing, olive oil, quality, sensory analysis.*

INTRODUCTION

Fruit washing operation (previous to others as milling, malaxation or centrifugation) seems to be a simple task within the overall process of olive oil production, but today this operation is not without some controversy because there exist the belief that, when fruits are washed, the elaboration process and the product quality can be both affected (Hermoso et al., 1996; Uceda, 2006). To perform the washing, usually the incoming raw materials (olives from the farm) are introduced into a washing machine designed for that purpose and the impurities adhered to the fruits are removed there (such as dust, mud, stones, etc.). Several authors agree on the need to wash ground-picked olives in order to remove the impurities aforementioned and to avoid the loss of quality (Hermoso et al., 1996; Cabellos et al., 2001; Uceda, 2006; Jimenez and Carpio, 2008; De Torres et al., 2013). By contrast, some of these researchers also show in their works that washing the tree-harvested fruits could influence the content of polyphenols, oxidative stability, sensory attributes and extractability of the oils produced (Hermoso et al., 1996; Uceda, 2006), therefore discouraging the fruit washing in that case (Jimenez and Carpio, 2008; De Torres et al., 2013).

Bearing in mind the former, the authors of this paper developed a preliminary study on this issue (Vallesquino et al., 2015) finding that fruit washing had not an important effect on the quality of the oils (according to diverse physicochemical parameters like the oxidative stability, free acidity, peroxide value and ultraviolet indices K_{232} and K_{270}) if such oils were produced from early and tree-harvested fruits. Proceeding with this work, the present study treats to complete the previous one from a sensory perspective, as the regulated quality of olive oils is both based on physicochemical and sensory parameters (Jimenez and Carpio, 2008; EU, 2013).

MATERIAL AND METHODS

Sampling and preparation of the raw material

Picual variety olives were taken in all the experiments. These fruits were harvested in a rainfed farm (under organic crop production) located in Alcaudete (Jaén, Spain). The plantation framework followed a traditional pattern (about 12 m × 12 m) and the fruits only were tree-harvested by using a vibration machine. Sampling was conducted following the collection schedule applied by the company that collaborated in this study. This meant, in practice, that olives were harvested very early for 32 days (with a ripening index, RI, that varied between 0.49 and 4.29 according to the method proposed by Ferreira (1979)), just when the fruit growth was over. It must be noted that samples were randomly taken in field (approximately every two days, on average) and also that two batches of fruits (of around 15 kg each) were collected in the sampling days selected. These batches were later homogenized in the laboratory and they were also split into two smaller samples (of 7.5 kg each) in order to have enough material to realize further tests. Altogether, in this work 60 samples were available to develop the treatments that are described next.

Olive washing

Considering the aim of this study, from the four samples which were available each day of sampling, two of them were washed and the other ones were left intact. The washing operation in the lab was made on a small scale by using a 50 liters drum, in which 20 liters of drinking water were poured together with the olives of a given sample. To simulate an industrial washing in each test, for 2 minutes compressed air, that came from a regulation tank maintained at 600 kPa, was introduced into the drum to promote the agitation of the olives within the water. The washing water was replaced every five days to resemble, as far as possible, the fluid that could exist in an industrial machine.

Olive oil extraction

Olive oil extraction was performed by using the Abencor system (Abengoa S.A., Sevilla, Spain) as it was described in (Vallesquino et al., 2015). The oil produced from each sample was stored at 4 ° C (into different bottles) waiting to be tested.

Determination of sensory attributes

This work has enjoyed the cooperation of the Tasting Panel of the "Priego de Cordoba" Designation of Origin to carry out the sensory analyses required. The attributes assessed in these analyses have been the following (based on usual methods proposed by the International Olive Council; IOC, 2005; 2017): *green fruity, bitter, pungent, sweet, green leaf, grass, apple, almond and tomato*.

Statistical analysis

The Shewhart's method (Montgomery, 2004; Box, et al., 2009) will be employed in the analysis of the results to distinguish the presence of trends or even any value that could be considered as an outlier. In each case, and in order to establish the limits of variation of such results, the upper (WL_U) and the lower (WL_L) warning lines will be computed by only using the data from non-washed samples (WL_U and WL_L, with a probability of occurrence between them of 95.4%). Together with the former lines, the upper and lower control lines (CL_U and CL_L, respectively, and with probability between them of 99.7%) and the ML line (with equal probability of occurrence on both sides of it) will also be estimated from the information of non-washed samples. Please note that in a normal distribution, with a large number of data, ML corresponds to the median or mean, and it is also fulfilled that: $WL_U = ML + 2\sigma$; $WL_L = ML - 2\sigma$; $CL_U = ML + 3\sigma$; $CL_L = ML - 3\sigma$; being σ the standard deviation of the population. To compute the former lines in those populations that have shown a non-normal distribution, the Johnson's method (Lagos and Vargas, 2003) will be applied to transform the original data into others normally distributed. For comparison purposes, the data from washed samples will be also projected over the 'Shewhart lines' obtained from the non-washed ones to bring out if there are differences between treatments. Tests of means (t tests) and variances (F tests) will be also developed (Montgomery, 2004) to contrast the similarity or difference between normal populations of washed and non-washed samples.

RESULTS AND DISCUSSION

In next paragraphs the results linked to the sensory parameters analyzed are commented. In general, regardless of the type of treatment applied ('washing' or 'non-washing'), the most significant sensory attribute has been *green fruity*, with a mean value (MV) equal to 5.2, followed by others like *bitter* (MV = 4.1), *pungent* (MV = 3.5) and *green leaf* (MV = 3.3). The rest of sensory characteristics have reached a mean punctuation lower than 3. In addition, it is notable that none of the samples analyzed showed sensory defects (probably due to the ripening state of the olives at sampling, which was very early: RI $\approx$ 0.49 – 4.29). In accordance with several authors (Rivas et al, 2013; Jimenez et al, 2012; Aparicio and Luna, 2002; Salvador et al, 2001; Jimenez et al, 2014) olive oil sensory quality is closely related to the harvesting time, usually being higher in fruits with low ripening index, what precisely happened in this study.

Green fruity

This attribute (together with other main descriptors as *bitter, pungent* or *sweet*) is presented in **Figure 1**. In this case, no particular trends are observed and it shows an intensity that can be considered as medium (according to the criteria of IOC, 2017). Taking into account the harvesting period was early, this characteristic has been tasted in all samples and no ripe fruitiness sensation has been perceived in any oil. Comparing the data of this parameter with those given by other studies, that work with the Picual variety and approximately at the same harvesting period (Jimenez et al., 2012; Pardo et al., 2015; Mena et al., 2015), it can be verified that the values here included are similar to those cited, in which this attribute was of the order of 5.3 – 6.2. With regard to the possible differences between treatments, in this descriptor there are no relevant differences between the oils produced from washed and non-washed samples, but the P value obtained in the test of means has been low ($P = 0.07 > 0.05$, see **Table 1**). The presence of a particular sample, which could be considered as an outlier, is probably the main reason that has led to that P value. In this respect, it could be referred that this sample was from the group of the washed ones and it was taken on the 15th day of sampling. The relevant point is that such sample has the lowest value of *green fruity* and also it scores very low on other attributes such as *bitter*, *pungent*, *green leaf*, *grass*, *apple or almond* (see as examples **Figures 1 and 2**).

Bitter

The values of this attribute (with a mean around 4, see **Table 1** and **Figure 1**) are comparable to those obtained by other authors in similar conditions (Villegas-Peralta et al., 2015; Mena et al., 2015; Jimenez et al., 2012). For Pardo et al. (2015), the magnitude of this descriptor generally reaches higher values even with ripe fruits (of the order of or greater than 5). According to several authors (Rivas et al., 2013; Jimenez et al., 2012; Aparicio and Luna, 2002; Salvador et al., 2001), with increasing the fruit ripeness the *bitter* attribute tends to decrease, which could indicate that other factors (such as the soil type, the climate or the agronomic techniques) could have influenced the differences remarked between the study from Pardo et al. (2015) and the one here presented. In reference to the washing and non-washing treatments, it is notable that there are no relevant differences between them with regard to this attribute. The means and variances have high P values (well above 0.05, see **Table 1**) and all data are included between the control lines (see **Figure 1**). In addition, within the sampling period followed (early and very short) the *bitter* values fluctuate around the mean without a clear pattern.

Pungent

The original data of this attribute followed a non-normal distribution. Therefore, a Johnson's transformation (Lagos and Vargas, 2003) was applied to fit such data to the ones of a normal distribution. Making this, the Shewhart lines could be established and the tests of means and variances (t and F) could be developed. The function applied to carry out such transformation was in this case:

$$PU_J = -2.155+1.824*AHSIN((PU - 2.707)/0.506),$$

Where PU_J is the *pungent* value (PU) after the Johnson's transformation and AHSIN is the hyperbolic arc-sine function. In **Figure 1** the values of this attribute are displayed, in the original data space after undoing the Johnson's transformation, for the samples washed and non-washed. Again, one can say that there are no significant differences between both data populations (with an average value around 3.4). In addition, P values are clearly higher than 0.05 in the statistical tests applied (see **Table 1**). Furthermore, Shewhart lines cover all measured points except a washed sample (previously referred with the green fruity descriptor) which was taken on the 15th day of sampling. Besides these aspects, it is also worth noting a possible upward trend towards the end of the harvesting period. This pattern could be tentatively marked by the appearance of some points that are above the upper warning line in that time. If the values here presented are compared with those reported by other authors, it is remarkable that, as in previous cases, such values are similar to other found in the literature, in which the pungent attribute has ranged for Picual variety from 2.3 to 5, (Jimenez et al, 2012; Mena et al, 2015; Villegas-Peralta et al., 2015; Pardo et al, 2015). What is not common is to find a growing pattern at the end of the sampling period, since it is normally observed that this attribute decays with the harvesting time (Jimenez et al., 2012; Villegas-Peralta et al., 2015). A possible explanation for this may be related to the sampling period followed, that was very early and it was finished just when the ripening index was of the order of 4. According to Morales and Garcia-Ortiz (2003), close to that ripening index (and for the variety and area treated in the present work) it is probable to find in the fruits a maximum phenolic content, what can lead to oils with more intense sensory characteristics. In this study, and probably due to inherent factors related to the farm analyzed, it is observed at the end of the sampling period that the more intense attributes has been pungent, green leaf and tomato (which will be commented later). In the remaining attributes this pattern is not shown clearly, but it is also possible to find samples with high scores.

Sweet

Sensory data do not follow a clear pattern in sweet attribute (see **Figure 1**), marking an average value close to 2.15. As in previous cases, no significant differences between oils obtained from washed and non-washed olives are observed, and P values in the statistical tests performed are well above 0.05 (see **Table 1**). Also, all points are included within the limits of the control lines. If these results are compared with those ones reported by other authors (Jimenez et al., 2012), a similar mean is obtained for the collecting period applied in this work (with no apparent trends). For ripening indices higher than those ones treated here, it is found that the sweet attribute becomes more intense (Jimenez et al., 2012).

Other descriptors

Along with the previous attributes, the tasting panel that conducted these tests provided scores of other sensory descriptors which are less frequent in the literature. Specifically, in **Figures 2 and 3** are shown the values of the following attributes: green leaf (GL), grass (GR), apple (AP), almond (AL) and tomato (TO). As in the former cases, those data which did not fit a normal distribution were transformed by applying the Johnson's method. This time, from the original data from green leaf, grass and apple, the next transformations were implemented using the hyperbolic arc-sine function AHSIN (subscript J designs the data transformed):

$$GL_J = -0.359+0.936 * AHSIN((GL - 3.161)/0.289)$$

$$GA_J = 0.38+1.766 * AHSIN((GA - 2.579)/0.907)$$

$$AP_J = 0.477+0.863 * AHSIN((AP - 2.332)/0.359)$$

As in preceding cases, the attributes that are discussed in this section have not shown significant differences related to the washing operation. Statistically, all P values (calculated in t and F tests, see **Table 1**) are clearly greater than 0.05, and the points represented in **Figures 2 and 3** are included within the Shewhart lines. However, it is relevant in this case (unlike the other attributes studied in this work) that in some of the sensory evaluations performed the scores obtained have been zero (such in the cases of apple, almond, tomato and grass).

At this point, it should be noted that according to the methodology of the IOC (2005), the assessment of a given attribute is obtained through the median of the results provided by the tasters of the panel. In addition, to score a given attribute over zero it is needed, at least, that such attribute is detected by 50% of the panel members. Using this methodology it is not possible to assess a sample with a score between 0 and 1 (both values non-included) because, even if a part of the tasters of the panel identifies a descriptor, such attribute will have a zero score if that part of the panel is less than 50% (and it will have a score equal or greater than 1 if more than 50% of the panel tasters identify such descriptor). That is why the aforementioned attributes have samples with zero scores and the minimum punctuation (greater than zero) is always 1. In this context, the lower warning and control lines have been omitted in some cases to avoid indicating negative values never achievable.

Except in the tomato descriptor (and probably in the green leaf one), no trends are observed in the data of this section of the work. As it was commented with the pungent attribute, and probably due to the harvest schedule followed, it is possible that the fruits taken at the end of the sampling period could have higher phenols content (Morales and Garcia-Ortiz, 2003), what may accentuate the intensity of certain attributes (in this case tomato and green leaf). It is also notable, as well, that the values here presented are somewhat distinct to those reported by Jimenez et al. (2012), (showing differences of the order of 1 – 2 points in each descriptor). Probably, these less intense attributes are strongly dependent of each farm or crop area, being also very sensitive to agronomic factors and even to the production process applied. For this reason, this could be an open issue that may deserve attention in further studies.

Sensory profile

To summarize, the mean value of each sensory descriptor is below displayed through a ‘spider chart’ for washed and non-washed samples (see **Figure 3**, on the right). For comparison purposes, Shewhart control lines are also included to verify the magnitude of the differences. In practice, the sensory profiles from both washed and non-washed samples are very similar, which supports the fact that, under the conditions in which this study was conducted, there are not significant differences between oils from washed and non-washed fruits.

CONCLUSIONS

Olive oil quality can depend on many factors related to the production process, so in this work it has been studied whether the fruit washing operation could be a determining factor when extra virgin olive oils (from organic farming) are produced. According to the sensory parameters considered, it is important to note that, under the conditions in which this study was conducted (early sampling of tree-harvested fruits), no relevant differences have been found between the oils obtained from washed olives and those ones which were prepared without washing the fruits.

Being aware of the competitiveness which is usually associated to any production area, the results of this work could be an element to consider in the production of olive oil (linked to the harvesting procedure to follow and also to the washing operation to apply). In this regard, if the absence of stones (or other hard impurities) could be guaranteed in early-harvested fruits, the ‘non-washing’ alternative would be an adequate solution (by the cost savings that could be achieved without thereby causing any loss of quality). On the other hand, if the absence of hard impurities could not be guaranteed during the harvesting process, the ‘washing’ treatment could be an adequate option (if no alternative procedure is disposed to remove such impurities) to avoid further damages in the machinery (like in mills or centrifuges).

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Table 1: Relevant statistics associated to sensory attributes obtained from washed and non-washed samples (green fruity (GF), bitter (BI), pungent (PU), sweet (SW), green leaf (GL), grass (GR), apple (AP), almond (AL) and tomato (TO)). Subscript J designs results linked to data transformed by Johnson's method.

	GF	BI	PU	SW	GL	GR	AP	AL	TO
Mean 'Washed'	5.116	4.051	3.369	2.186	3.201	2.413	2.048	0.930	1.836
Mean 'Non-Washed'	5.289	4.110	3.428	2.157	3.278	2.380	2.146	1.262	1.663
P value	0.072	0.740	0.656	0.744	0.368	0.805	0.411	0.175	0.442
	GF	**BI**	**PU_J**	**SW**	**GL_J**	**GR_J**	**AP_J**	**AL**	**TO**
Variance 'Washed'	0.124	0.406	1.471	0.099	1.095	0.755	0.685	0.820	0.775
Variance 'Non-Washed'	0.144	0.520	0.905	0.136	1.016	1.176	1.024	0.939	0.715
P value	0.697	0.511	0.196	0.398	0.843	0.239	0.285	0.718	0.830

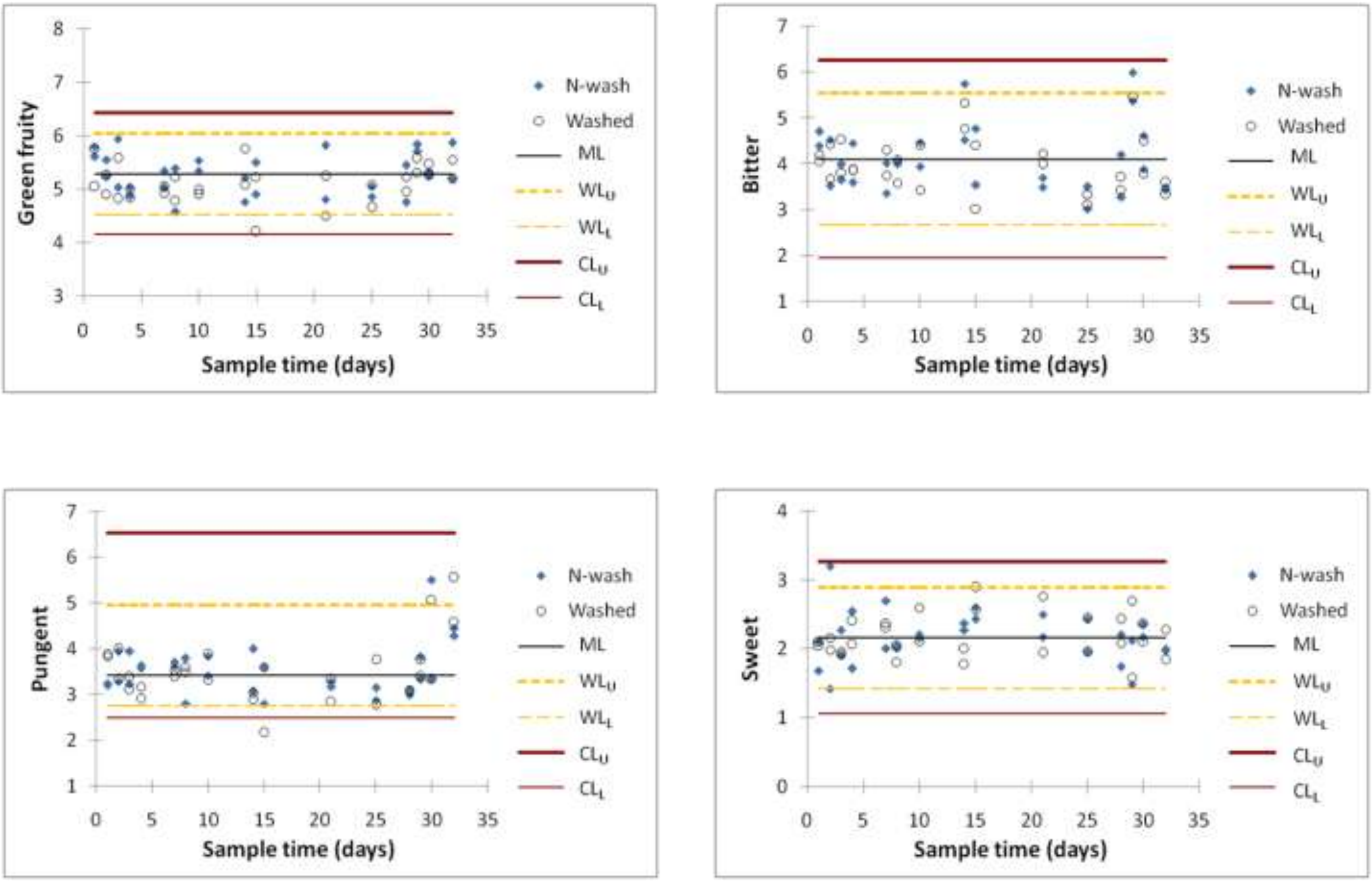

Figure 1: Main descriptors from washed and non-washed samples (green fruity, bitter, pungent and sweet).

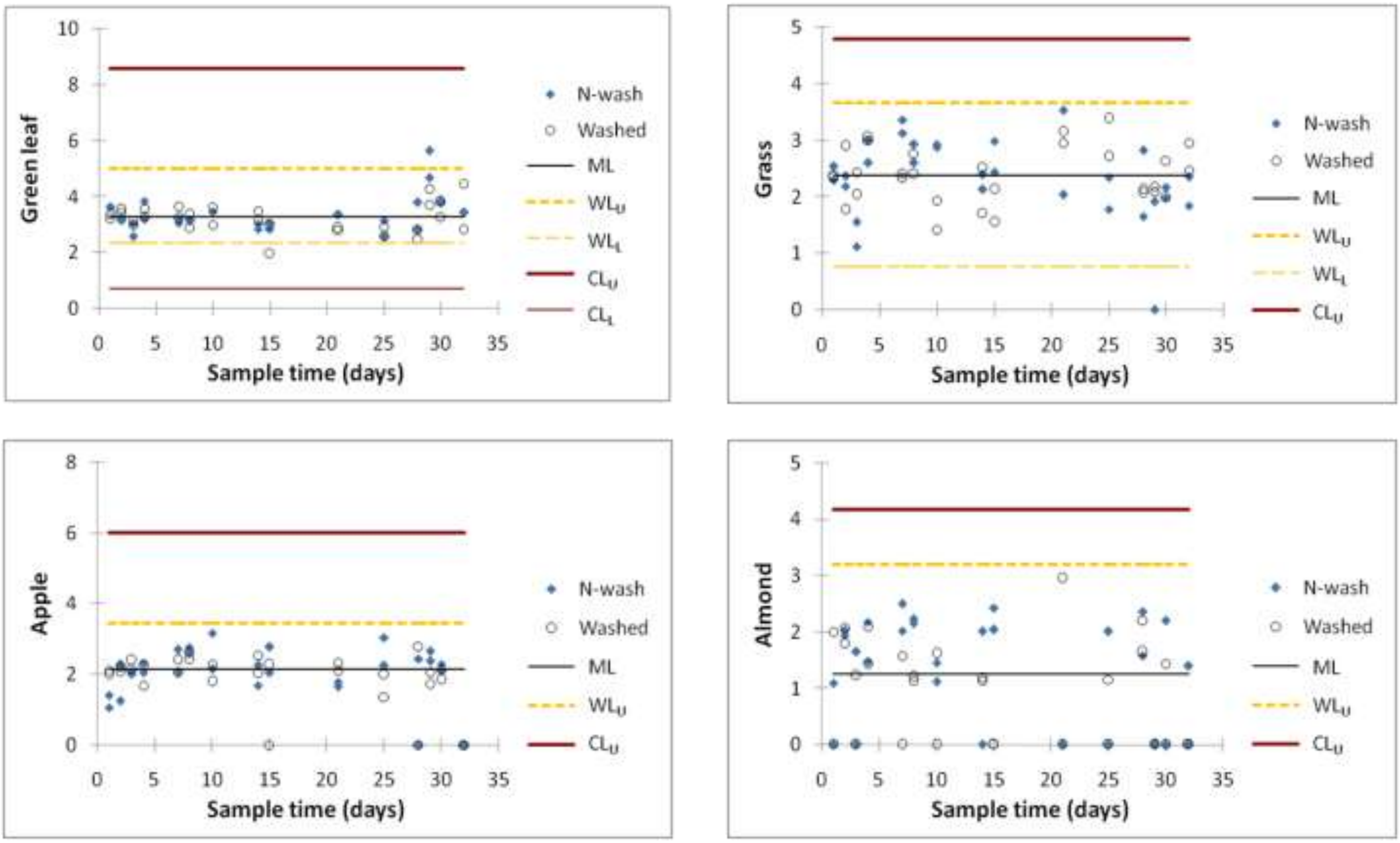

Figure 2: Other descriptors from washed and non-washed samples (green leaf, grass, Apple and almond).

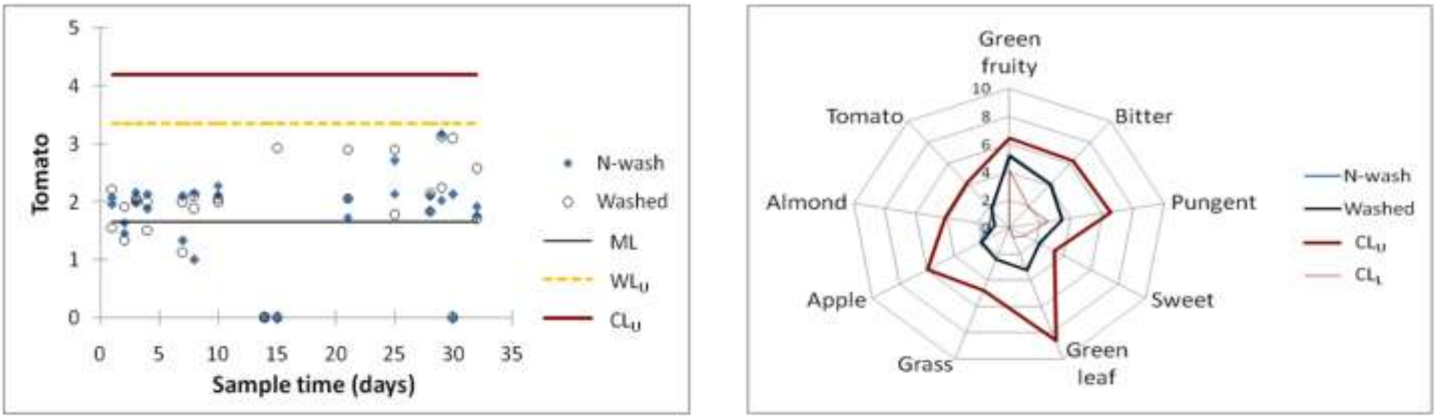

Figure 3: Tomato descriptor (on the left) and sensory profile (on the right) for washed and non-washed samples.