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# Introduction of determination of optimum harvest date in Afghanistan. Sweet cherry: a case study

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*Key words:* harvest date, maturity index, sweet cherry.

**Abstract: In the last decade, Afghanistan has been under the political attention by several Institution and Organizations whose invested millions of dollars for the reconstruction of the country. Part of such efforts were focused on the agricultural sector, as the principal source of income of Afghanistan. Mainly, perennial horticulture represents the one of the most challenging opportunity for the developing economies of Afghanistan, and the high contribute of EU in such direction, shown significant results. However, the level of the export is still neglected and the reputation of Afghan' products has lost the ancient brittleness. The generic low hygienic conditions and poor quality of the products are the primary cause of such situation. In this scenario, PHDP (Perennial Horticulture Development Project) first and ANHDO (Afghanistan National Horticulture Organization) then, tried to improve the quality of perennial horticulture crops. PHDP has, for the first time created a certification scheme for the production of certified perennial plants, ANHDO has the main goal of improving the quality of the fruit value chain of the principal crops in Afghanistan. In this study the first protocol for the determination of the Optimum Harvest Date (OHD) for Cherry var. Burlat is given, as a case study of the new course of Horticulture in Afghanistan.**

## 1. Introduction

During the last decades, after over ten years of reconstruction projects, Afghanistan horticulture has grown to the pre-war level. In 2014, the estimated horticulture crops extended over 340,000 ha that represents the 14% of the total irrigated land. The overall contribution of horticulture is valued at 1.4 billion (6.7%, to the total GDP) and the 34% of the agriculture GDP contribution with a crops employment generated estimated in 2 million people involved to various degrees. Principal crops are grapes ($330m), almonds ($120m), pomegranates ($100m), all of which are largely exported to the neighbour countries. By comparison, illicit crops (opium poppy, cannabis) in the same period are grown on 220,000 ha with an estimated value of about $1 billion. Many important fruit and vegetables are origin from Afghanistan (e.g. pistachio, walnut and pomegranate) and Afghanistan has favourable climate condition suitable for high quality horticulture. The hypothetically development of the horticulture sector is huge as well as the potential international interest for their quality (pomegranates, apricots, almonds, raisins). Despite the improvements, especially the road network, the horticulture sector claims a lack of massive interventions. As a consequence, the overall quality is still low due to a well-known list of constraints: small land holdings, small commercial orchards, lack of standardized product, poor orchard management, lack of infrastructure and substandard storage, sorting, packaging, marketing, transport facilities.

*Afghan quality control system*

In general, the quality of the agriculture products is the final result of a long list of interventions, controls and standards adopted by a nation, generically define as quality control system.

The quality control system has the primary function of protecting its citizen by selecting active controls of the imported commodities at the borders and promote the safety of the exported goods. The lack

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of an efficient quality control system, affects the horticulture sector in many ways. The general situation in Afghanistan is critical in both the import/export directions: international requirements (rules and consumers education) on food are extremely rigid and difficult to overcome for Afghan traders. From the import side, the situation is without control. The absence of an explicit laws with a specific phytosanitary standards regulation, allows to the neighbour countries to freely provide goods and services without any reliable control. The consequence is a risk for the food safety and human health aspects (e.g. OGM) and besides that also the religious point of view is involved. The respect of Halal rules is in fact often not certified and the customs authority has technical difficulties to check the provided certificates.

For the above mentioned reasons, the national quality control system of Afghanistan is now under a deep revision: Afghanistan has started the World Trade Organization (WTO) membership path.

This is a very important step forward for the quality control of the country, especially for the agricultural commodities: join the WTO will allow to Afghanistan to implement non-tariff barriers useful to protect his local market from the massive import from neighbours countries i.e China, Pakistan and India on top (WTO, 1995 a). Beyond WTO, the gap between the Afghan food industries and the international competitors, is consistent. Afghan industries may require large investment to make them efficient and competitive in a reasonable period of time. Applying a protection policy is probably, the best way for Afghanistan to fill the gap with its competitors. Protection would act as incentive for such industries, the introduction of Technical Barriers agreements (TBT) may establish a more transparent trade with the neighbour countries and allow to Afghanistan a better control of the imported commodities based on harmonised rules. Application of TBT required the WTO membership and the main obstacle to this is the lack of a Food Law that will clarify the different responsibilities among the Ministries and will produce the conditions to the creation of the National Quality Control System. The responsibilities on the food safety are now divided between the Ministry of Public Health (MoPH) and the Ministry of Agriculture Irrigation and Livestock (MAIL) but such division is not clear, with the consequence of an inefficient Sanitary and Phytosanitary System, with respect to the requested SPS agreement (WTO, 1995 b).

At the best of our knowledge, the Food Law is still stuck in the Parliament and Afghanistan doesn't adopts any procedures and a clear set of harmonized standards. Such a law represents a necessary milestone for the future of agriculture sectors, but it is not sufficient to promote a real food quality control in Afghanistan. The first goal of such law must be the protection of human health from risks created by uncontrolled trading, tools as quarantine measures, certification, borders checks, inspections network and laboratory tests are the pillars of the quality control. In the last ten years, the PHDP has successfully developed a certification scheme for the horticulture crops and keep the horticulture to an upper level of quality in the whole Afghanistan. Moreover, PHDP developed the national collection orchards (NC) where the local and international varieties were tested for their adaptive level in the specific Afghanistan climate. Within its activities, PHDP has also set-up six pomology laboratories where, for the first time, local and introduced horticulture varieties were characterized under many aspects (e.g. UPOV, grafting, etc.). The PHDP project ends up with a great numbers of varieties, however, not all these varieties were fully characterized and some basic information are still missing. Specifically, the harvesting date and maturity index were not included as tested parameters because out of the scope of the project. Horticulture Private Sector Development Project (HPS) has, in one specific subjective (SO3), as primary goal, the evaluation and the promotion of the fruit commercial varieties. ANHDO is the implementing partner of HPS and in close collaboration with MAIL (that has inherited the ownership of the Pomology laboratories) has succeeded to the PHDP cultural heritage and is developing the missing horticulture parameters: in the next two years at least 60 varieties of the major commercial horticulture crops will be fully characterized and studied for the pomology basic tests, including post-harvest tests, maturity indexes and harvesting date by HPS specific sub objective (SO2 - Adaptive research).

ANHDO/HPS ambitions are high and even if the pomology laboratories are well equipped and the technical staff has been trained, the overall technical level is still critical due to the general environmental situations and only basic tests are possible.

*Fruit quality in Afghanistan: Cherries*

As least development country, Afghanistan has a total potential catchment not depending on the quality of the products and the domestic market has the peculiarity of accepting every type of fruits. The wide range of the existing social classes creates consumers with different tolerance and allow traders to sell all the product without any formal losses. The well-known effect of the extended cherry shelf-life over the 7-10 days (loss of firmness, color and flavour, stem discoloration, desiccation and mould growth) will not affect the trade. However, such condition is changing with the increase of the consumer awareness. Soon, farmers and traders will face, for the first time, the necessity of an improvement in the cherries quality. To be prepared, for the very first time in Afghanistan, HPS has set-up a formal protocol to start the characterization of the main commercial fruit varieties, with the final aim of helping farmers to harvest the crops in the optimum period for domestic consumption or international export.

*Aim of the work*

The aim of the study is to provide a simple and pragmatic in-field tool for the ANHDO/HPS beneficiaries farmers, to identify the appropriate harvesting date and suitable maturity index for cherry cv. Burlat. The proposed approach is a compromise between scientific research (that requires at least twenty single observations) and the real condition of Afghanistan that forced to reduce such observations to five. PHDPII project provided initial data on the harvesting period of many varieties, based on visual observations. This study will confirm the hypothetical harvesting date and will provide (among different existing parameters) one or two easy and quick maturity indexes for the Afghan farmers.

*Determination of optimum harvest date of sweet cherry cv. Burlat grown in kabul*

Optimum Harvest Date (OHD) is defined as the date in which harvesting results in optimum fruit quality of the produce after long-term storage (Baumann, 1998). Typically, OHD is predicted using calculation models or through direct measurement of certain physiological fruit parameters and quality characteristics during a given period until harvest (Çalhan *et al.*, 2014). The first method required historical series of meteorological and phenological data that are not available in Afghanistan. On the contrary, direct measurements of fruit characteristics, in specific intervals before the estimated harvest date, are more reliable for specific cultivars and applicable in Afghanistan. This study was conducted to evaluate OHD through physical and chemical measurements of fruit quality as a maturity index for estimating proper harvest time of Burlat cherries, in Kabul. Among the exiting maturity indexes, sugar content (SSC), titratable acidity (TA), SSC/TA ratio, skin color, and firmness have all been used as indices of cherry fruit maturity. However, skin color has long been accepted as the best indicator for the appropriate harvest maturity of sweet cherries (Drake and Elfving, 2002).

## 2. Materials and Methods

Cherry cv. Burlat has leaves sawed, average green, slightly lengthy and pointed. Burlat fruit has a dark red or purple skin, slightly flat and mean sized. The flesh is dark red, with sweet taste, juicy and firm. It is defined as early ripening, it is self-incompatible and it needs a pollinizer.

Fruit from the sweet cherry cv. Burlat was harvested during 5 different dates (between 18.05.2015 and 27.05.2015) from the National Collection in Badam Bagh, Kabul, Afghanistan. Full bloom date of Burlat was at 19.04.2015. The harvesting period was concentrated in 10 days due to existing data obtained from previous tests on the same station. In the National Collection each varieties is replied 6 times in a row. Fruits were collected early in the morning from branches with the same orientation (South-East) and all the fruit from the selected branches were immediately transferred to the pomology laboratory. In the laboratory, samples with defects (split, diseased or damaged fruit) were annotated and then rejected. The collected cherries were then divided into 5 maturity class according to their visual skin color:

a) Yellowish - immature;
b) Light red - nearly mature;
c) Red - mature;
d) Dark red - ripe;
e) Overripe.

The number of cherries for each class was annotated. In this study only Red and Dark groups were considered. Fruits parameters were collected by 24 fruits per class for a total of 48 samples. Weight was measured by an electronic balance (Kern EMB-200) to an accuracy of 0.01 g; results were expressed as gram (g). Fruit width and length was measured using manual calliper (Verinier caliper 0-150 mm). Results were expressed as millimeter (mm). Total soluble solids concentration (TSS) was determined with a temperature compensated digital refractometer (ATAGO Pal-1) previously calibrated with distilled water and results expressed as °Brix. Titratable acidity (TA), was estimated by juice titration with 0.1 N NaOH to the titration end point of pH 8.1, monitored with a pH meter (HANNA Instruments HI3221) and expressed as malic acid content (mg/100 mL). Flesh firmness was defined as the maximum load required to push the 6 mm diameter probe into the fruit firmness one side of each fruit, to a depth of 6mm with fruit texture analyser (Fruit Pressure Tester FT 327). The results were expressed in Newton (N). Skin color was measured on 24 fruits per class using a Minolta Chromometer Model CR 400 and average readings at six pre-determined points on the circumference of the fruits were recorded. The instrument was calibrated against a standard white color Plate (Y=93,9, x=0,313, y=0,321) (Konika Minolta, 2013), Color space (XYZ) (Batu, 2004; Žnidarčič and Požrl *et al.*, 2006).

All the above mentioned parameters were measured between 18.05.2015 and 27.05.2015. The final dataset was statistically analysed by Pearson correlation test, ANOVA test and PCA using Systat 12 software and Minitab 17.

Part of the graphs do not shown Red group values at the latest observation. This happened because during the division in maturity classes - immediately done after the harvest - in the last part of the maturity process, the Red group was without samples. Such a situation is obviously due to the ripening of cherries and the lack of non-mature fruits.

## 3. Results

As reported in figure 1, Red groups weight increase at maximum rate to 24/05 and then starting decreasing. On the contrary, the Dark group results do not shown significant variation of weight. This suggest that the maturity weight was reached before the start of the observations, and is confirmed by the red group trend that increases as confirmation of the maturity development. As reported in figure 2, height increase during the observation period. However, as expected, the height/diameter ratio is not changing (Table 1). The difference between the first and the last observations reports an increase of 7.56%. This result is clearly explained by the shorter observation period where the contiguous observations are not significant.

Firmness (Fig. 3), as expected, decrease during the observations period and drastically dropped between 24/05 and 26/05. Considering the Dark red and Red Groups separately (Fig. 3), the decrease is 31.89% and 50.23% respectively. Sugar content (Fig. 4) is constantly increasing for both Dark and Red groups.

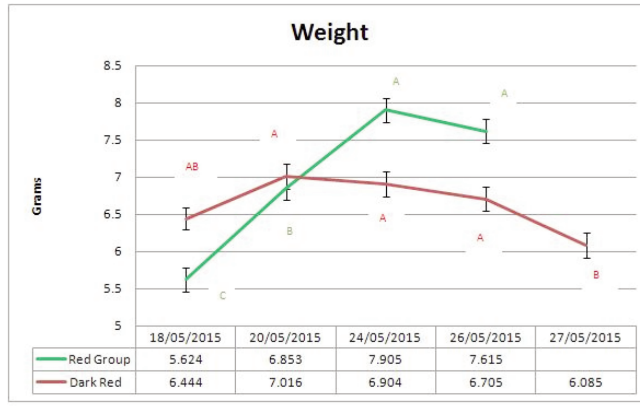


Fig. 1 - Effects of different picked dates on 48 fruit weight (g) of sweet cherry cv. Burlat fruits. Vertical bars represent standard error. Means with different letter are significant different (Tukeys's HSD p<0.05).

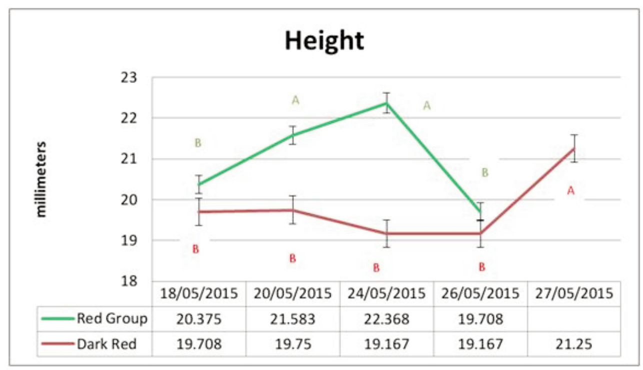


Fig. 2 - Effects of different picked dates on 48 fruit height (mm) of sweet cherry cv. Burlat. Vertical bars represent standard error. Means with different letter are significant different (Tukeys's HSD p<0.05).

Table 1 - Effects of different picked date of ratio between height and diameters (H/D) on 48 fruits of sweet cherry cv. Burlat

| Date | Height-diameter ratio | | | | | |
|---|---|---|---|---|---|---|
| | Dark red group | | Red group | | Error D.R. | Error R. |
| 5/18/15 | 0.852 | A | 0.893 | A | 0.017 | 0.018 |
| 5/20/15 | 0.859 | A | 0.879 | A | 0.018 | 0.018 |
| 5/24/15 | 0.833 | A | 0.839 | A | 0.018 | 0.019 |
| 5/26/15 | 0.834 | A | 0.861 | A | 0.018 | 0.018 |
| 5/27/15 | 0.984 | B | | | 0.018 | |

Means with different letter are significant different (Tukey's HSD p<0.05).

The most significant increase is visible between 24/05 and 27/05, in which the sugar content passes from 20.27 °Brix to 24.73 °Brix for the Dark group. In the last day of observation (27/05), none of the sampled cherries was classified as red group, as consequence of the ripening process. The pH values, in this study, do not provide a reliable maturity index, as the variation observed during the experimental period were significant but ranged within the instrument

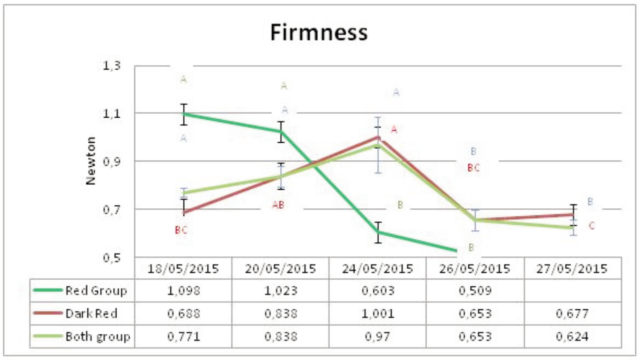


Fig. 3 - Effects of different picked dates on 48 fruit firmness of sweet cherry cv. Burlat compared with Red and dark red group. Vertical bars represent standard error. Means with different letter are significant different (Tukeys's HSD p<0.05).

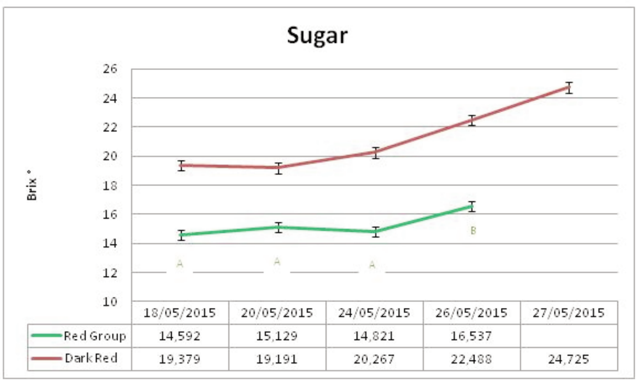


Fig. 4 - Effects of different picked dates on 48 fruit sugar content (Brix°) of sweet cherry cv. Burlat for both Dark and Red groups. Vertical bars represent standard error. Means with different letter are significant different (Tukeys's HSD p<0.05).

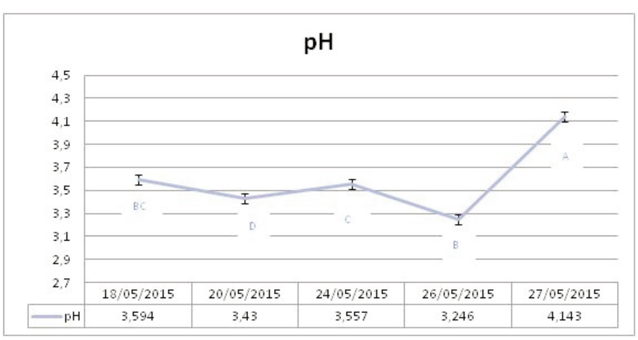


Fig. 5 - Effects of different picked dates on 48 fruit pH of sweet cherry cv. Burlat. Vertical bars represent standard error. Means with different letter are significant different (Tukeys's HSD p<0.05).

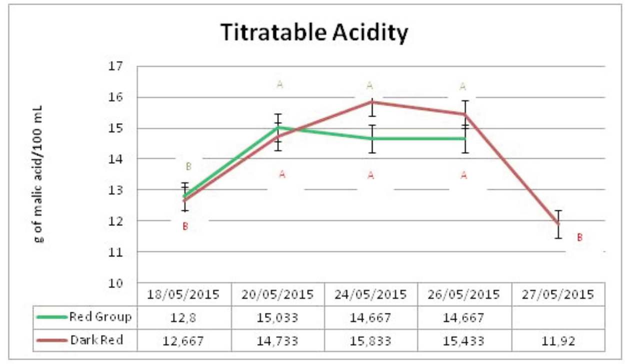


Fig. 6 - Effects of different picked dates on 48 fruit sugar content and tritatable acidity (TA) of sweet cherry cv. Burlat fruits for both Dark and Red groups. Vertical bars represent standard error. Means with different letter are significant different (Tukeys's HSD p<0.05).

error (Fig. 5). The graph reported in figure 6, perfectly, explain and reflects the Burlat maturity pattern of TA: the total acidity starts decreasing from the 26/05 in the Dark Group. Such a result, compared with sugar content clearly states that cherry acidity is decreasing, while the sugar content is still growing (Fig. 4). Considering the path of the sugar content and the TA result, is possible to set the maturity days between 26/05 and 27/05. The same conclusion is obtained by looking the color XYZ-CIE results (Fig. 7), in which the variation of color is stable in the same period. The identification of the most suitable parameter used as easy maturity index, passed through a first analysis of the data set using a PCA analysis. However, the interpretation of a PCA with more than 8 factors and at least three principal components, is not easy. To overcome such problem the Pearson correlation matrix was used to reduce the number of parameters analysed with PCA. The main correlations among X, Y, Z parameters are reported in Table 2. The color components are very well correlated, and such strong correlations justify to use only one of the

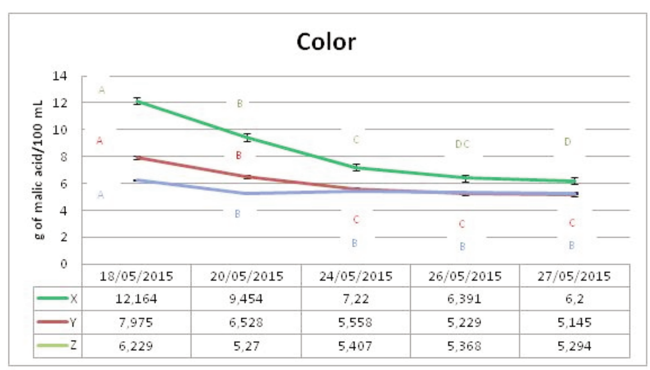


Fig. 7 - Effects of different picked dates on 48 fruit XYZ CIE color of sweet cherry cv. Burlat for both Dark and Red groups. Vertical bars represent standard error. Means with different letter are significant different (Tukeys's HSD p<0.05).

Table 2 - Pearson correlation for the XYZ-CIE parameters

| | X | Y | Z |
|---|---|---|---|
| X | 1.000 | | |
| Y | 0.993 | 1.000 | |
| Z | 0.834 | 0.883 | 1.000 |

three components in the PCA (Tabachnick and Fidell, 2006). Therefore, only X factor has been considered in the simplified PCA test, because from the statistical analysis (Fig. 7) such variable appears more sensible to the ripening process compared to Y and Z. Table 3 reported all the other correlations. Between diameter and weight the correlation is sufficient to justify the usage of the height and diameter ratio (H/D) to get an unique shape factor that will reduce the variability in the data set (Tabachnick and Fidell, 2006). Sugar content and pH are well positively correlated (0.694), as expected. Applying the above mentioned consideration, the simplified PCA is reported in figure 8. The first three components explain 71.8% of the variability. Table 4 reports loadings values for the first three components. SSC and pH have the highest loadings values and are positively correlated, thus able to explain almost all the variance of the dataset. Also color has a high loading value (Table 3) that suggests it as one of the possibly maturity index suitable for the Afghan farmers. The parameter weight explains the remaining variance. Weight, as very easy and cheap measure can be used as additional maturity index with sugar content, pH and color.

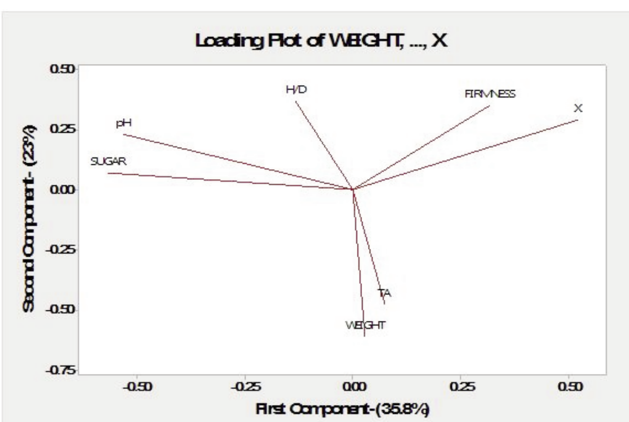


Fig. 8 - Simplified PCA using the following parameters: Weight, SSC, TA, pH, H/D, Firmness, X.

Table 4 - Variance explained by components

| Variable | PC1 | PC2 | PC3 |
|---|---|---|---|
| Weight | 0.027 | -0.609 | 0.166 |
| H/D | -0.133 | 0.367 | -0.724 |
| Firmness | 0.317 | 0:35 | -0.001 |
| SSC | -0.568 | 0.069 | 0.003 |
| pH | -0.532 | 0.733 | 0.166 |
| TA | 0.072 | -0.477 | -0.645 |
| X | 0.520 | 0.291 | 0.070 |

## 4. Conclusions

The Cherry cv. Burlat OHD is set for the year 2015 at 26th of May. Such result must be verified in the next coming years and correlated with the meteorological situation. Based on the whole results dataset, the suggested 'Burlat' characteristic at the OHD are: height: 19.167±0.254 mm, weight: 6.705±0.126 mm, pH: 3.246±0.009, sugar content: 22.488±0.5°Brix, TA: 15.433±0.450 g/ml, firmness 0.653±0.037 N, X: 6.391, Y: 5.229, Z: 5.368 (RGB=6B3540 HTML color).

As explained, the aim of the study was providing a simple tool applicable in the field as maturity index to the Afghan farmers. As reported, sugar content, pH, color and weight have very good chances to be used as maturity indexes. However, for the color determination, the required instrument is very expensive and not suitable for the Afghan condition, in which the gross national income per capita is 640 USD (World Bank, 2004). A similar conclusion is valid for the pH. Sugar content is, thus, the suggested solution for farmers. It is relatively cheap and extremely easy to use. However, based on the laboratory results, HPS may provide color gauge specific for each single varieties to the HPS beneficiaries and confirm with SSC, weight, pH and color tests the validity of sugar content as maturity index.

The same methodology applied for 'Burlat', and explained in this study, was used with four other

Table 3 - Pearson correlation for all paramenters

| | Weight | Height | Diameter | Grade | Firmness | SSC | X | pH | TA |
|---|---|---|---|---|---|---|---|---|---|
| Weight | 1 | | | | | | | | |
| Height | 0.274 | 1 | | | | | | | |
| Diameter | 0.599 | 0.485 | 1 | | | | | | |
| Grade | 0.540 | 0.121 | 0.423 | 1 | | | | | |
| Firmness | -0.207 | 0.053 | 0.119 | -0.098 | 1 | | | | |
| SSC | -0.134 | -0.259 | -0.339 | 0.035 | -0.251 | 1 | | | |
| X | -0.302 | 0.073 | 0.023 | -0.382 | 0.417 | -0.704 | 1 | | |
| pH | -0.199 | -0.207 | -0.315 | -0.037 | -0.260 | 0.694 | -0.481 | 1 | |
| TA | 0.129 | 0.045 | 0.153 | 0.262 | -0.193 | 0.152 | -0.306 | -0.126 | 1 |

cherry cultivars: Balck Star, Cherry Pie, Santina and Stella Compact, following the estimated OHD:
'Black Star': 6 June, 'Cherry Pie': 30 May-6 June, 'Santina': 4 June, 'Stella Compact': 6-11 June.

**Acknowledgements**

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