

'Bhagwa', respectively.

Furthermore, to access an extensive view on the metabolic shift that exit during fruit advancement, the whole info set was subjected to Principal Component Analysis. The overall variability is interpreted by four factors (F1 - F4), with the first two factors of PCA showing correlation of 97.88 % (Fig. 2). The first factor (F1) was responsible for 93.47 % total variations, however the second factor (F2) elucidated only 4.41 % of total variations, indicating that the maximum variations in fruit maturity indices was interpreted by F1 (Fig. 3A). A general view of the PCA showed that young fruits had higher titratable acid and total phenolics, while fully mature fruits have higher SSC which is correlated with SSC/TA, pH, Vitamin C and sugars of fruits juice. Negative scores along F1 corresponded to late immature fruits at 80 DAFB. Full mature fruits had high positive scores along F1, while low negative scores were half mature at 110 DAFB (Fig. 3B). In the present study, decrease in acidity and TP in immature fruits was also characterized by the shift from right to left, reflecting the beginning of maturity process between 110 DAFB to 130 DAFB. The beginning of ripening process in the cultivar could well ascribed to fruit at 110 DAFB, where consolidation of fruit biochemical indices seemed to be at equilibrium (Fig. 3A and Fig. 3B). These results are similar to those reported by Fawole and Opara (2013b) where maturity of 'Bhagwa' pomegranate fruit could be fixed around 165 DAFB where fruit were characterize by intense chemical changes in fruit juice.

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References

- Al-Maiman, S.A. and D. Ahmad: Changes in physical and chemical properties during pomegranate (*Punica granatum* L.) fruit maturation. *Food Chem.*, **76**, 437-441(2002).
- Al-Said, F.A., L.U. Opara and R.A. Al-Yahyali: Physico-chemical and textural quality attributes of pomegranate cultivars (*Punica granatum* L.) grown in the Sultanate of Oman. *J. Food Eng.*, **90**, 129-134 (2009).
- A.O.A.C.: Official Methods of Analysis. Association of Official Analytical Chemist, Benjamin Franklin Station, 15th Edn., Washington DC, USA(2000).
- A.O.A.C.: Official Methods of Analysis. Association of Official Analytical Chemist, Benjamin Franklin Station, 15th Edn., Washington DC, USA(2005).
- Borochoy-Neori, H., S. Judeinstein, E. Tripler, M. Harari, A. Greenberg, I. Shomer and D. Holland: Seasonal and cultivar variations in antioxidant and sensory quality of pomegranate (*Punica granatum* L.) fruit. *J. Food Compos. Anal.*, **22**, 189-195 (2009).
- Fawole, O.A. and U.L. Opara: Changes in physical properties, chemical and elemental composition and antioxidant capacity of pomegranate (cv. Ruby) fruit at five maturity stages. *Sci. Hort.*, **150**, 37-46 (2013a).
- Fawole, O.A. and U.L. Opara: Effects of maturity status on biochemical content, polyphenol composition and antioxidant capacity of pomegranate fruit arils (cv. Bhagwa). *S. Afr. J. Bot.*, **85**, 23-31 (2013b).
- Fawole, O.A. and U.L. Opara: Influence of fruit developmental and maturity stages on chemical, phytochemical and antioxidant properties of pomegranate juice. *Acta Hort.*, **1007**, 461-470 (2013c).
- Gil, M.I., A.T. Berberan, B.H. Pierce, D.M. Holcroft and A.A. Kader: Antioxidant activity of pomegranate juice and its relationship with phenolic composition and processing. *J. Agr. Food Chem.*, **48**, 4581-4589 (2000).
- Labbe, M., A. Pena and C. Saenz: Antioxidant capacity and phenolic composition of juice from pomegranate stored in refrigeration. *Inter. Conf. Food*, **48**, 88-95(2010).
- Legua, P., P. Melgarejo, M. Martinez and F. Hernandez: Evolution of sugars and organic acid content in three pomegranate cultivars (*Punica granatum* L.). *Option Mediterran.*, **42**, 99-104 (2000).
- Kulkarni, A.P. and S.M. Aradhya: Chemical changes and antioxidant activity in pomegranate arils during fruit development. *Food Chem.*, **93**, 319-324 (2005).
- Makkar, H.P.S.: Quantification of tannins in tree foliage. A laboratory manual for the FAO/IAEA Coordinated Research Project on 'use of nuclear and related techniques to develop simple tannin assay for predicting and improving the safety and efficiency of feeding ruminants on the tanniferous tree foliage'. Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Vienna, Austria (2000).
- Melgarejo, P., D.M. Salaze and F. Artes: Organic acids and sugars composition of harvested pomegranate fruits. *Eur. Food Res. Technol.*, **211**, 185-190 (2000).
- Prasad, R.N., G.J. Banker and B.B. Vashishtha: Assessment of maturity in pomegranate on the basis of physico-chemical characteristic in arid regions. *Hary. J. Hort. Sci.*, **28**, 69-70 (1999).
- Seeram, N.P., L.S. Adams, S.M. Henning, Y. Nilu, Y. Zhang, M.G. Nair and D. Heber: *In vitro*, antiproliferative, apoptotic and antioxidant activities of punicalagin, ellagic acid and total pomegranate tannin extract are enhanced in the combination with other polyphenols as found in pomegranate juice. *J. Nut. Biochem.*, **16**, 360-367 (2005).
- Shulman, Y., L. Fainberstein and S. Lavee: Pomegranate fruit development and maturation. *J. Horticult. Sci.*, **59**, 265-74(1984).
- Shwartz, E., I. Glazer, I. Bar-Ya'akov, F. Matityahu, I. Bar-ilan, D. Holland and R. Amir: Changes in chemical constituents during the maturation and ripening of two commercially important pomegranate accessions. *Food Chem.*, **115**, 965-973 (2009).
- Weerakkody, P., J.I. Jobling, M.V. Maria and G. Rogers: The effect of maturity, sunburn and the application of sunscreens on the internal and external qualities of pomegranate fruit grown in Australia. *Sci Hort.*, **124**, 57-61 (2010).
- Zarei, M., M. Azizi and Z. Bashir-Sadr: Evaluation of physico-chemical characteristics of pomegranate (*Punica granatum* L.) fruit during ripening. *Fruits*, **66**, 121-29(2011).