DOI 10.33045/fgr.v35.2019.16

PARAMETRII FIZICO-CHIMICI AI UNOR HIBRIZI ROMÂNEȘTI DE KIWI SUB INFLUENȚA CONDIȚIILOR DE PĂSTRARE FRIGORIFICĂ

FRUITS PHYSICO-CHEMICAL PARAMETERS OF SOME ROMANIAN KIWIFRUIT HYBRIDS INFLUENCED BY DIFFERENT COLD STORAGE TECHNOLOGIES

Iliescu Lavinia Mihaela[1,2], Stănică Florin[1,2], Stan Andreea[2], Bezdadea-Cătuneanu Ioana Laura[1,2], Mihai Cosmin Alexandru[1]

[1]Faculty of Horticulture, University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania

[2]Research Center for the Study of Quality Food Products, University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania

Abstract

Kiwifruit is recognized as highly nutritious having many biochemical characteristics that deliver a range of health benefits. In Romania, kiwi is a new fruit species and the creation, testing and introduction of winter hardy genotypes, adapted to the local harsh climate conditions is a priority. A common Italian-Romanian kiwifruit breeding program was initiated in 1993 and during the time, several hybrid genotypes were obtained and introduced to be tested. After more than two decades of research, it was demonstrated that *Actinidia deliciosa* and *Actinidia chinensis* can be grown in Romania in peach favourable areas, while *Actinidia arguta* (hardy kiwi, kiwiberry) can cover larger areas, suitable for plum cultivation. At the Faculty of Horticulture within the University of Agronomic Sciences and Veterinary Medicine of Bucharest, an experimental field with kiwifruit hybrid genotypes, was established in 1993. The plants were grown under an organic orchard management, on a T-bar trellis, being irrigated with micro sprayers. The fruits were harvested at beginning of November, in 2017 and 2018. Harvesting moment was established when the fruit flesh firmness was lower than 7.0 kg force cm^2. After harvesting, kiwifruits were stored in two different cold storage conditions: normal atmosphere (NA) at 3°C and 95% humidity and controlled atmosphere (CA) with 1.5% Oxygen, at 1-2°C and 95% humidity. The aim of this study was to analyse the fruit quality characteristics of some new kiwi hybrid genotypes at harvest and during storage with the final goal to select best elites. Fruit weight and shape index have been determined after harvest. Different fruit characteristics were measured and evaluated in dynamics: firmness, soluble solids, dry matter, titratable acidity and ascorbic acid. All the determinations and analyses were made at the Research Center for Studies of Food Quality and Agricultural Products laboratories. During the storage, observations showed that R1P9 kiwifruit hybrid presented better biochemical quality parameters and the lowest weight losses compared to the other studied hybrids – 4.69 % in CA and 5.22 % in NA. As expected, keeping kiwi fruits in controlled atmosphere with 1.5% Oxygen, at 1-2°C and 95% humidity, presented better physical and biochemical quality compared with those stored in normal atmosphere, at 3°C and 95% humidity. Using the results of the study regarding the fruits physicochemical characteristics after harvesting and during the storage, but also some other plant parameters, several kiwi hybrid elites were selected – R0P13 and R1P9. They will be propagated and planted for the production test.

Cuvinte cheie: fermitate pulpă, substanţă uscată solubilă, substanţă uscată totală, aciditate titrabilă, acid ascorbic.

Key words: fruit flesh firmness, soluble solids, dry matter, titratable acidity, ascorbic acid.

1. Introduction

Kiwifruit also known as 'China's miracle fruit', 'the horticultural wonder of New Zealand' and 'Chinese gooseberry (Nirmal et al., 2018) is a native of China (Ferguson, 1990; Young et al., 1995) and is an example of recent success in the domestication and commercialisation of a plant for food (Young et al., 1995). The major centre of diversity for *Actinidia* genus is the hilly region of south-western China (Litz 2005; Nirmal et al., 2018), but the fruit was first commercially grown in New Zealand (Ferguson and Bollard, 1990; Warrington 1990; Young et al., 1995) in 1950's (Barboni et al., 2010). From New Zealand it expended around the world (Biao et. al., 2018; Nirmal et al., 2018). This new fruit gained popularity quickly (Yang, 2010), due to its high vitamin C content, flavour and nutrients rich composition (Biao et. al., 2018).

 DOI 10.33045/fgr.v35.2019.16

According to the World Health Organization, fruit and vegetables are important components of a healthy diet, and their sufficient daily consumption could help prevent major diseases such as cardiovascular ones and certain cancers. Kiwi is proven to be one of the most nutrient fruit available, along with low caloric value according with Drummond (2013). It has a broad range of phytonutrients and bioactive compounds, including carbohydrates, vitamins A, C, E, and K, folate, polyphenols, fibber (Samadi-Maybodi and Shariat, 2003; Iwasawa et al. 2011; Testolin et al., 2016).

Due to its composition, sensory characteristics and stability during preservation, kiwi is an economically important fruit crop and has great potential for industrial exploitation (Cano Pilar, 1991; Soufleros et al., 2001; Tavarini et al., 2008).

A large number of studies are reported in the literature concerning the monitoring of kiwifruits during their developmental stages, maturation and ripening (Okuse and Ryugo, 1981; Matsumoto et al., 1983; Crisoto et al., 1984; Antognozzi et al., 1996; Manolopoulou and Papadopoulou, 1998; Nishiyama et al., 2004; Stănică et al., 2007; Stănică et al., 2009; Chiaramonti and Barboni, 2010). Kiwi is a climacteric fruit (De Vriesa et al., 1996; Sfakiotakis et al. 1997; Antunes 2007; Chiaramonti and Barboni, 2010; Meena et al., 2018) and its storage has a considerable impact on its quality, in particular, on its organoleptic flavour properties, determined mainly by the content of total soluble solids and total acids (Lallu et al., 1989; Huang et al. 2004; Nishiyama et al. 2008; Tavarini et al., 2008; Testolin, 2016). According with Antunes and Sfakiotakis (2002); Crisosto and Kader (1999), the storage period for the fresh kiwi fruit market is about 4–6 months and many physicochemical parameters change during this, because of the fruit respiration.

The objective of this paper is to compare some new Romanian kiwifruit hybrids quality as a result of two storage methods – normal atmosphere at 3°C and 95% humidity and controlled atmosphere (CA) with 1.5% Oxygen, at 1-2°C and 95% humidity. Various fruit physicochemical parameters: weight, firmness, soluble solids, dry matter, acidity and ascorbic acid content, were studied in dynamics.

2. Material and methods

At the University of Agronomic Sciences and Veterinary Medicine of Bucharest, in the Experimental Field of the Faculty of Horticulture, in 1993 an experimental plot with kiwifruit hybrid genotypes, besides other varieties of *Actinidia deliciosa*, *A. chinensis* and *A. arguta*, was established (Peticilă et al. 2002; Stănică, 2009). The plants were grown on a T - bar trellis system and a micro spray irrigation system was used. An organic orchard management was applied.

In order to accomplish the aim of this paper, five kiwifruit hybrids: R0P12, R0P13, R0P15, R1P9, R2P6 and Hayward variety (R2P3) – control, were used (Figure 1).

The fruits were harvested at the beginning of November (Table 1). Harvesting moment was established, when the fruit flesh firmness was less than 7 kgf/cm² and the soluble solids content was higher than 6.5 % Brix, after minimum maturity has been achieved (according to Crisosto and Kader, 1999; Dayang, 2019).

After picking, the fruits were stored in two different conditions: normal atmosphere (NA) at 3°C and 95% humidity and controlled atmosphere (CA) with 1.5% Oxygen, at 1-2°C and 95% humidity. The optimum storage conditions were determined according with Crisosto and Kader (1999), Zhixue (2002), Hennion (2003), Park (2015).

Fruit weight and shape index have been determined after harvest. Different fruit characteristics were measured and evaluated in dynamics (after harvest and then monthly, for five to eight months, respectively): firmness, soluble solids, dry matter, acidity and ascorbic acid. All the determinations and analyses were made at the Research Center for Studies of Food Quality and Agricultural Products laboratories, using the common laboratory techniques.

Fruit weight (g/fruit) was measured by a digital balance of accuracy of 0.001 g. Fruit shape index was determined by measuring length, longitudinal and transversal diameter, using a calliper with 0.1 mm accuracy. The peduncle length, was also measured and expressed in mm. Fruit weight (g) evolution during the storage, in 2018-2019, was determined in dynamics using the same fruits for each hybrid/variety, in every storage condition - normal atmosphere (NA) and controlled atmosphere (CA), respectively.

Fruit flesh firmness determined by measuring the penetration force, was determined in two opposite cheeks of a sliced fruit, using an electronic penetrometer, equipped with a cylinder of 8 mm diameter. The results were expressed in kgf/cm² (Fattahi, 2010; Hennion, 2003; Cipriani et al., 2018).

Soluble solids content (SSC) of the fruit juice was determined using a digital Krüss Refractometer DR301-95 (Fattahi, 2010; Hennion, 2003; Cipriani et al., 2018) and the results expressed in % Brix.

The samples dry matter and water content were determined by oven drying for 24 hours at 105º C using a UN110 Memmert oven. The method was used also by Delian et al. (2011), Corollaro et al. (2014), Cipriani et al. (2018).

The titratable acidity (TA) was determined according to the Polish Standard PN-EN 12147: 2000, Hennion (2003), Fattahi (2010), in water extract from an average sample of minced fruit. TA was determined using 5 ml of fruit puree from mixed fruits with 25 ml of distilled water, titrated with 0.1N NaOH to an endpoint pink – pH 8.2. The results were expressed as percent of anhydrous citric acid since it is the dominant acid in kiwifruit.

Ascorbic acid content from kiwifruit samples was determined with HPLC – Agilent Technologies 1200 Series equipment. A ZORBAX Eclipse XDB-C18 (4.6x50 mm, 1.8µm) column with Rapid Resolution HT and a detector UV-DAD detection wavelength 220/30 nm, reference wavelength 400/100 nm, was used.

Mobile phases were A= 99% (ultrapure water with H_3PO_4 up to 2,0 pH) and B= 1% (acetonitrile with 10% A). The samples were homogenized with IKA T25 equipment for a period of 45-50 seconds at 20 000 rpm speed. 1.5 g of fruit pulp was extracted in centrifuge tubes with 15 ml of water acidified with phosphoric acid to a pH of 2.0. Then the tubes were mixed with an orbital shaker for 15 minutes at 500 rpm, under dark conditions. After this operation, the tubes were centrifuged for 5 minute at 7000 rpm and 4°C, to sediment the coarse part of the preparation. The samples were filtered through a filter Agilent RC 0.45 µm. The injection volume was 2.0 µl, with 4 min post time, flow rate at 0.5 ml/min. The samples were analysed in triplicate and were expressed in mg/100g. In order to perform the samples quantitative analysis, a calibration curve through injection of known concentration standards (from 12.5 to 1000 µg/ml), was realised.

Statistical evaluation of the experimental data was performed by simple comparisons of mean values and standard deviation, calculated using incorporated function of Microsoft Excel.

3. Results and discussions

After fruits were harvested, average fruit weight (represented in Table 1) and shape index (represented in Table 2) have been determined. The size of green kiwifruits ranged from small (42.44 g at R0P12) to large size (106.86 g at R1P9), while the yellowish fruit of the interspecific hybrid R2P6 was rather small in size with only 8.02 g. R2P3 (Hayward) - control registered 85.60 g. Regarding shape index, it can be observed in Table 2, that most hybrids, as well as the control variety, were elongated. The hybrid R1P9 with nearly spherical shape and R2P6 with slightly flattened shape, were noticed.

Many physicochemical parameters changed during storage because of the fruit respiration: firmness, titratable acidity, soluble solids, ascorbic acid, dry matter and water content. These parameters are considered to be an important factor in terms of quality at the eating stage (Lallu et al., 1989; Tavarini et al., 2008; Chiaramonti and Barboni, 2010).

Fruit weight (g) evolution during the storage for each hybrid, is represented in Figure 2. After eight months of storage the highest weight losses was registered at R0P12 (26.38 % in CA), while the lowest at R1P9 (4.69 % in CA). For the control – R2P3 (Hayward) the weight losses were 7.3 % in controlled atmosphere (CA) and 9.86 % in normal atmosphere (NA).

After picking, during the post-harvest storage, the kiwifruits, continued the physiological development until they become suitable for consumption. For all genotypes throughout storage a noticeable decrease of fruits flesh firmness compared with the initial moment, can be observed in Figure 3 and Figure 4. The degree of flesh softening has influence on the storage life of kiwifruit in both conditions – NA and CA.

Firmness is the parameter of greatest concern in kiwifruit storage and marketing, because fresh softening is associated with senescence and fruit injuries (Chiaramonti and Barboni, 2010). Kiwifruits are ready to eat when the flesh firmness reached less than 1,00 kgf/cm² (Krupa, 2011). The fruits harvested in 2017 have reached the consumption maturity in mid-December, while the fruits harvested in 2018, in mid-January (Figure 3 and 4).

In the same time, soluble solids content increased during cold storage as found by Lloret et al. (1990), Manolopoulou and Papadopoulou (1998). After harvesting time, the soluble solids content was increase until they reached maturity of consumption for each kiwi hybrid (Figure 5 and Figure 6). And then, after maturity of consumption period, the soluble solids start to decrease and the fruits begin to overripe. The minimum sugar level recommended for kiwifruit at consumption maturity is between 12 % (Tavarini et al., 2008) and 14 % Brix (Lloret et al., 1990).

After harvest, the fruit content in soluble solids varied from 9.30 % Brix (for R0P12) to 18.43 % Brix (for R2P6), while the control R2P3 registered 9.34 % Brix. During NA storage, the soluble solids content highest value (18.53%) was measured in the fruits of R2P6 selection, fallow by R0P13 with 17.53 % Brix.

According with Fisk et al. (2006), total soluble solids content of fruits during storage is considered an index of fruit ripening and an increase in TSS corresponds to a conversion of starch to soluble sugars.

Regarding dry matter and the water content, in Figure 7, can be observed the evolution of this parameters in the both storage condition – normal atmosphere (NA) and controlled atmosphere (CA). For all studied kiwifruit hybrids, and also for control variety, it can be observed that the total dry matter quantity increases to a certain point, after which it begins to decrease dramatically, with the beginning of the process of over-ripening the fruits.

Before storage, the highest total dry matter content (21.38 % ± 1.52) was registered in the fruits of R0P12 selection, fallow by R0P13 hybrid with 20.25 % ± 1.33. At R2P3 (control) 17.77 % ± 1.05 was measured. During the storage in normal atmosphere (NA), the highest total dry matter content was determinate at R0P13 – 52.75 %, while Hayward reached 40.70 %. In controlled atmosphere (CA), the highest total dry matter content was determinate at R0P12 – 46.0 %, while R2P3 reached 31.82 %.

The pH increased during both cold storage conditions. This value is one of the important factors influencing fruit flavour (Chen et al., 2009) and they accumulate at the early stages of fruit development (Zhao et al., 2007).

The anhydrous citric acid percent decreases from the moment of harvest to the final moment, in both variants of storage. The highest anhydrous citric acid percent after harvest was recorded at R1P9 hybrid - 1.91 % ± 0.04 and the lowest in R0P12 - 1.55 % ± 0.02. The control, Hayward variety (R2P3), recorded after harvesting 1.61 % ± 0.01 anhydrous citric acid. After eight months of storage, the R1P9 hybrid recorded 1.62 % ± 0.01, R0P12 0.92 % ± 0.05, and the control 1.36 % ± 0.02 in normal atmosphere (NA) (Table 3). In controlled atmosphere (CA) at the end of the storage period, R1P9 hybrid recorded 1.65 % ± 0.01, R0P12 - 1.06 % ± 0.03, and the control R2P3 - 0.89 % ± 0.66 (Table 4).

Significant reductions in vitamin C concentrations during cold storage have recorded in normal atmosphere (NA) and also in controlled atmosphere (CA), according with a large number of authors (Adorisio et al., 1990; Lombardi-Boccia et al., 1986; Manolopoulou and Papadopoulou, 1998; Selman, 1983; Barboni et al., 2010). In a study conducted by Tavarini et al. (2008), the vitamin C concentration of the Hayward variety changed from 200 to 37 mg/100 g fresh weight after 6 months of cold storage.

The ascorbic acid content at the consumption maturity moment, expressed in mg/100g fresh matter, had the values scaled between 11.61 ± 2.03 mg/100g (for R2P6, in NA) and 166.90 ± 11.06 mg/100g (for R1P9 in CA) – Figure 8. The control (R2P3) recorded 60.46 ± 3.79 mg/100g in NA, and 70.05 ± 9.06 mg/100g in CA.

4. Conclusions

The aim of this study was to analyse the fruit quality characteristics of some new kiwifruit hybrids – R0P12, R0P13, R0P15, R1P9, R2P6 compared with Hayward variety (R2P3) – control, at harvest and during storage with the final goal to select best elites.

It can be noted that keeping kiwi fruits in controlled atmosphere with 1.5% Oxygen, at 1-2°C and 95% humidity, presented better physical and biochemical quality compared with those stored in normal atmosphere, at 3°C and 95% humidity. During the storage, flesh firmness, titratable acidity and ascorbic acid were decrease compared to the initial moment and soluble solids, respectively total dry matter quantity were increases until they reached maturity of consumption.

R1P9 hybrid seems to be a very promising selection - with 106,86 g average fruit weight, spherical shape and the weight losses between 4.69 % in CA and 5.22 % in NA. During the storage, observations showed that R1P9 kiwifruit hybrid presented better biochemical quality parameters compared to the other studied hybrids.

Also R0P13 hybrid it was noticed for the highest value of soluble solids at maturity of consumption (17.53 % Brix) and a high value of total dry matter content (20.25 % ± 1.33).

The highest amount of ascorbic acid content at the consumption maturity moment, was determined for R1P9 – 166.90 ± 11.06 mg/100g.

References

1. Adorisio S., Cappelloni M., Lintas C., Monastra, F., 1990. Caratteristiche nutrizionali di frutti di actinidia prodotti in Italia. Frutticoltura, 52, 61–65.
2. Antognozzi E., Battistelli A., Famiani F., Moscatello S., Stanica F., Tombesi A., 1996. Influence of CPPU on carbohydrate accumulation and metabolism in fruits of *Actinidia deliciosa* (A Chev.). Sci. Hortic., 65 (1996), pp. 37-47, 10.1016/0304-4238(95)00852-7
3. Antunes M. D. C., Sfakiotakis E. M., 2002. Chilling induced ethylene biosynthesis in 'Hayward' kiwifruit following storage. Scientia Horticulturae, 92(1), 29–39.
4. Antunes M. D. C., 2007. The role of ethylene in kiwifruit ripening and senescence. Stewart Postharvest Review, 3(2), 1–8.
5. Barboni T., Cannac M., Chiaramonti N., 2010. Effect of cold storage and ozone treatment on physicochemical parameters, soluble sugars and organic acids in *Actinidia deliciosa*. Food

Chemistry 121 (2010) 946–951, www.elsevier.com/locate/foodchem, DOI: 10.1016/j.foodchem.2010.01.024.
6. Biao Y., Wenchuan G., Weiqiang L., Qianqian L., Dayang L., Xinhua Z., 2018. Portable, visual, and nondestructive detector integrating Vis/NIR spectrometer for sugar content of kiwifruits. Wiley Periodicals, Journal of food Process Engineering, DOI: 10.1111/jfpe.12982.
7. Cano Pilar M., 1991. HPLC separation of chlorophyll and carotenoid pigments of four kiwi fruit cultivars. Journal of Agricultural and Food Chemistry, 40, 594–598.
8. Chen F. X., Liu X.-L., Chen L.-S., 2009. Developmental changes in pulp organic acid concentration and activities of acid-metabolising enzymes during the fruit development of two loquat (*Eriobotrya japonica* Lindl.) cultivars differing in fruit acidity. Food Chemistry, 114, 657–664.
9. Chiaramonti N., Barboni T., 2010. Relationship between the physicochemical parameters and the ethylene emission during cold storage of kiwifruits. International Journal of Food Science & Technology, 45(7), 1513–1516, DOI: 10.1111/j.1365-2621.2010.02297.x.
10. Cipriani G., Messina R., Vizzotto G., Testolin R., 2018. Harvest time and storage of ‘Soreli’ kiwifruit (*Actinidia chinensis* Planch.). Acta Hortic. 1218. ISHS 2018, Proc. IX International Symposium on Kiwifruit, Eds.: M.D. Antunes and P.P. Gallego, DOI: 10.17660/ActaHortic.2018.1218.63.
11. Corollaro M. L., Aprea E., Endrizzi I., Betta E., Demattè M. L., Charles M., Bergamaschi M., Costa F., Biasioli F., Grappadelli L. C., Gasperi F., 2014. A combined sensory-instrumental tool for apple quality evaluation. Postharvest Biology and Technology 96: 135-144
12. Crisoto G.U., Mitchell F.G., Arpaia M.L., Mayer G., 1984. The effect of growing location and harvest maturity on the storage performance and quality of ‘‘Hayward’’ kiwifruit. Journal of American Society and Horticultural Science, 109, 584–587.
13. Crisosto C. H., Kader A. A., 1999. Kiwifruit postharvest quality maintenance guidelines. Department of Pomology, University of California - Davis, http://postharvest.ucdavis.edu/produce/producefacts/.
14. Dayang L., Wenchuan G., Qianqian L., Dandan X., 2019. Relationship of the bulk optical properties in 950 - 1650 nm wavelength range with internal quality and microstructure of kiwifruit during maturation. Elsevier, https://doi.org/10.1016/j.biosystemseng.2019.05.005
15. De Vriesa H.S.M., Wasonob M.A.J., Harren F.J.M., Woltering E.J., Van Der Valk H.C.P.M., Reuss J., 1996. Ethylene and CO2 emission rates and pathways in harvested fruits investigated, in situ, by laser photo thermal deflection and photo acoustic techniques. Postharvest Biology and Technology, 8, l–10.
16. Delian E., Petre V., Burzo I., Bădulescu L., Hoza D., 2011. Total phenols and nutrients composition aspects of some apple cultivars and new studied breeding creations lines grown in Voineşti area – Romania. Romanian Biotechnological Letters vol. 16, no. 6.
17. Drummond L., 2013. The composition and nutritional value of kiwifruit. Advances in Food and Nutrition Research, 68, 33–57.
18. Fattahi J., Fifaii R., Babri M., 2010. Postharvest quality of kiwifruit (*Actinidia deliciosa* cv. Hayward) affected by pre-storage application of salicylic acid. South Western Journal of Horticulture, Biology and Environment, Vol. 1, No. 2, 2010, pp. 175-186, http://anucraiova.3x.ro/swjhbe/index.html.
19. Ferguson A. R., 1990. The kiwifruit in China. In I. J. Warrington & G. C. Weston (Eds.), Kiwifruit: Science and management (pp. 155–164). Auckland: Ray Richards in Association with the New Zealand Society of Horticultural Science.
20. Ferguson A. R., Bollard E., 1990. Domestication of the kiwifruit. In I. J. Warrington & G. C. Weston (Eds.), Kiwifruit: Science and management (pp. 165–246). Auckland: Ray Richards in Association with the New Zealand Society of Horticultural Science.
21. Fisk C.L., 2006. Investigation of postharvest quality and storability of Hardy kiwifruit (*Actinidia arguta* ‘Ananasnaya’). A thesis submitted to Oregon State University.
22. Hennion B. et al., 2003. Le kiwi. Ctifl.
23. Huang H. W., Wang Y., Zhang Z. H., 2004. *Actinidia* germplasm resources and kiwifruit industry in China. HortScience 39:1165–1172.
24. Iwasawa H., Morita E., Yui S., Yamazaki M., 2011. Anti-oxidant effects of kiwi fruit *in vitro* and *in vivo*. Biological and Pharmaceutical Bulletin, 34(1), 128–134.
25. Krupa T., Latocha P., Liwińska A., 2011. Changes of physicochemical quality, phenolics and vitamin C content in hardy kiwifruit (*Actinidia arguta* and its hybrid) during storage. Sci. Hortic. 130: 410.
26. Lallu N., Searle N.A., MacRae A.E., 1989. An investigation of ripening and handling strategies for early season kiwifruit (*Actinidia deliciosa* cv Hayward). Journal of Science and Food Agricultural, 47, 387–400.
27. Litz, R. E., 2005. Biotechnology of fruit and nut crops. Vol. 29, CABI.
28. Lloret, J., Alavoine, J., Mornas, F., Crochon, M., Morin, D., 1990. The Kiwi Taste Quality. Antony, France: Agriculture, Plant and Veterinary Sciences.

29.Lombardi-Boccia G., Cappelloni M., Lintas C., 1986. Vitamin C contents of kiwi fruits: Effect of ripening and post-harvest storage. Rivista della Societa Italiana di Scienza dell'informazione.
30.Manolopoulou H., Papadopoulou P.A., 1998. Study of respiratory and physico-chemical changes of four kiwi fruit cultivars during cool-storage. Food Chemistry, 63, 529–534.
31.Matsumoto S., Obara T., Luh B.S., 1983. Changes in chemical constituents of kiwifruit during post-harvest ripening. Journal of Food Science, 48, 607–611.
32.Meena N. K., Baghel M., Jain S. K., Asrey R., 2018. Postharvest biology and technology of kiwifruit. S. A. Mir et al. (eds.), Postharvest Biology and Technology of Temperate Fruits, Springer International Publishing AG, part of Springer Nature 2018, https://doi.org/10.1007/978-3-319-76843-4_13.
33.Nishiyama I., Yamashita Y., Yamanaka M., Shimohashi A., Fukuda T., Oota, T., 2004. Varietal difference in vitamin C content in the fruit of kiwifruit and other *Actnidia* species. Journal of Agricultural and Food Chemistry, 52, 5472–5475.
34.Nishiyama I., Fukuda T., Shimohashi A., 2008. Sugar and organic acid composition in the fruit juice of different *Actinidia* varieties. Food Sci. Technol. Res. 14:67–73.
35.Okuse I., Ryugo K., 1981. Compositional changes in the developing ''Hayward kiwi fruit in California. Journal of American Society and Horticultural Science, 106, 73–76.
36.Park Y. S., 2015. The postharvest performance of kiwi fruit after long cold storage. Springer, https://link.springer.com/article/10.1007/s00217-015-2487-x
37.Peticilă A. Stănică F., Cepoiu N., 2002. Synthesis of researches regarding the kiwifruit (*Actinidia* sp.) propagation. Sesiunea Ştiinţifică 150 de ani de învăţământ superior agricol, UŞAMV, Facultatea de Horticultură, pp. 127-132.
38.Samadi-Maybodi A., Shariat M. R., 2003. Characterization of elemental composition in kiwifruit grown in Northern Iran. J Agric Food Chem 51:3108–3110.
39.Selman, T. D. (1983). The vitamine content of some kiwi fruits (*Actinidia chinensis* Planch), variety Huywards. Food Chemistry, 11, 63–75.
40.Sfakiotakis E., Antunes M. D., Stavroulakis G., Niklis N., Ververidis P., Gerasopoulos D., 1997. Ethylene biosynthesis and its regulation in ripening "Hayward" kiwifruit. InBiology and biotechnology of the plant hormone ethylene (pp. 47–56). Dordecht: Springer.
41.Soufleros E. H., Pissa I., Petridis D., Lygerakis M., Mermelas K., Boukouvalas G., 2001. Instrumental analysis of volatile and other compounds of Greek kiwi wine; sensory evaluation and optimisation of its composition. Food Chemistry, 75, 487–500.
42.Stănică F., Zuccherelli G. 2007. New selections of *Actinidia arguta* from the Romanian breeding program. Acta Hortic. 753:263–267. DOI: 10.17660/ActaHortic.2007.753.32.
43.Stănică F., 2009. Kiwifruit, the fruit of XXth Century. Lucrări ştiinţifice USAMVB, Seria B 53, 15–28.
44.Stănică F. and Zuccherelli G., 2009. Nuove selezioni di *Actinidia arguta* dal programma di miglioramento genetico italo-romeno. Societa Orticola Italiana, Italus Hortus Journal, Vol. 16, pp 262-265.
45.Tavarini S., Degl'Innocenti E., Remorini D., Massai R., Guidi L., 2008. Antioxidant capacity, ascorbic acid, total phenols and carotenoids changes during harvest and after storage of Hayward kiwifruit. Food Chemistry, 107(1), 282–288.
46.Testolin R., Huang H. W., Ferguson A. R., 2016. The Kiwifruit Genome, Compendium of Plant Genomes Springer International Publishing Switzerland, DOI 10.1007/978-3-319-32274-2.
47.Warrington I. J., 1990. Areas and trends of kiwifruit production in New Zealand and around the world. In I. J. Warrington & G. C. Weston (Eds.), Kiwifruit: Science and management (pp. 511–525). Auckland: Ray Richards in Association with the New Zealand Society of Horticultural Science.
48.World Health Organization, 2012. Global strategy on diet, physical activity and health: Promoting fruit and vegetable consumption around the world. http://www.who.int/dietphysicalactivity/fruit/en/.
49.Yang E., Zhao Y., Qian M. C., 2010. Effect of edible coating on volatile compounds of hardy kiwifruit during storage. Downloaded by PURDUE UNIV on May 28, 2016, http://pubs.acs.org, DOI: 10.1021/bk-2010-1035.ch006.
50.Young H., Stec M., Paterson V. J., McMath K., Ball R., 1995. Volatile compounds affecting kiwifruit flavor. http://pubs.acs.org, 2016, DOI: 10.1021/bk-1995-0596.ch006.
51.Zhao Y.H., Li X.L., Jiang Z.S., Wang C.J., Yang F.L., 2007. Organic acid metabolism in nectarine fruit development under protected cultivation. Chinese Journal of Eco-Agricultural, 15, 87–89.
52.Zhixue C., Hongwen H., Xingguo X., 2002. Actinidia in China, China Agricultural Science and Technology Press.

Tables and Figures

Table 1. Kiwi harvesting time and average fruit weight

Sample	Harvesting time		Average fruit weight (g)		
	2017	2018	2017	2018	2017-2018 average
R0P12	Nov. 3rd	Nov. 7th	45.44	39.44	42.44 ± 2.243
R0P13	Nov. 3rd	Nov. 7th	65.76	65.78	65.77 ± 0.014
R0P15	Nov. 3rd	Nov. 7th	70.51	60.46	65.49 ± 7.106
R1P9	Nov. 3rd	Nov. 7th	102.18	111.57	106.86 ± 6.640
R2P6	Nov. 3rd	Nov. 7th	11.22	4.81	8.02 ± 4.533
R2P3 - Control (Hayward)	Nov. 3rd	Nov. 7th	88.66	82.54	85.60 ± 4.327

Table 2. Kiwifruit shape index

Sample	Peduncle length (mm)		Fruit length (mm)		Fruit diameter (mm)				Shape index	
					Longitudinal		Transversal			
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
R0P12	32.38	33.13	58.43	61.70	35.34	40.29	32.38	33.13	1.73	1.68
R0P13	41.53	42.82	55.53	54.38	46.39	47.26	41.53	42.82	1.26	1.21
R0P15	41.38	40.10	63.42	56.94	45.83	41.36	41.38	40.10	1.45	1.40
R1P9	49.03	56.79	55.47	58.23	58.24	59.38	49.03	56.79	1.03	1.00
R2P6	23.90	28.03	23.64	26.19	27.05	33.81	23.90	28.03	0.93	0.85
R2P3 (Hayward)	43.95	43.66	64.08	58.32	53.48	46.69	43.95	43.66	1.32	1.29

Table 3. Variation of titratable acidity expressed as anhydrous citric acid (%) during kiwifruit storage in normal atmosphere (NA) – 2018-2019

Sample	19.11.2018	18.12.2018	15.01.2019	26.07.2019	29.08.2019
R0P12	1.55 ± 0.02*	1.36 ± 0.01	1.34 ± 0.01	1.21 ± 0.01	0.92 ± 0.05
R0P13	1.59 ± 0.03	1.47 ± 0.03	1.46 ± 0.05	1.36 ± 0.01	1.39 ± 0.01
R0P15	1.75 ± 0.01	1.65 ± 0.03	1.68 ± 0.03	1.48 ± 0.01	1.57 ± 0.03
R1P9	1.91 ± 0.04	1.67 ± 0.03	1.65 ± 0.04	1.63 ± 0.01	1.62 ± 0.01
R2P3 (Hayward)	1.61 ± 0.01	1.39 ± 0.04	1.53 ± 0.10	1.33 ± 0.01	1.36 ± 0.02
R2P6	1.66 ± 0.06	1.58 ± 0.04	1.76 ± 0.07	-	-

*Standard deviation

Table 4. Variation of titratable acidity expressed as anhydrous citric acid (%) during kiwifruit storage in controlled atmosphere (CA) – 2018-2019

Sample	19.11.2018	25.02.2019	17.04.2019	26.07.2019	29.08.2019
R0P12	1.55 ± 0.02*	1.40 ± 0.06	1.37 ± 0.01	1.16 ± 0.01	1.06 ± 0.03
R0P13	1.59 ± 0.03	1.46 ± 0.10	1.49 ± 0.01	1.40 ± 0.01	1.27 ± 0.01
R0P15	1.75 ± 0.01	1.62 ± 0.05	1.60 ± 0.01	1.47 ± 0.01	1.31 ± 0.01
R1P9	1.91 ± 0.04	1.76 ± 0.01	1.70 ± 0.01	1.64 ± 0.02	1.65 ± 0.01
R2P3 (Hayward)	1.61 ± 0.01	1.58 ± 0.02	-	1.40 ± 0.01	0.89 ± 0.66
R2P6	1.66 ± 0.06	1.20 ± 0.05	-	-	-

*Standard deviation

DOI 10.33045/fgr.v35.2019.16

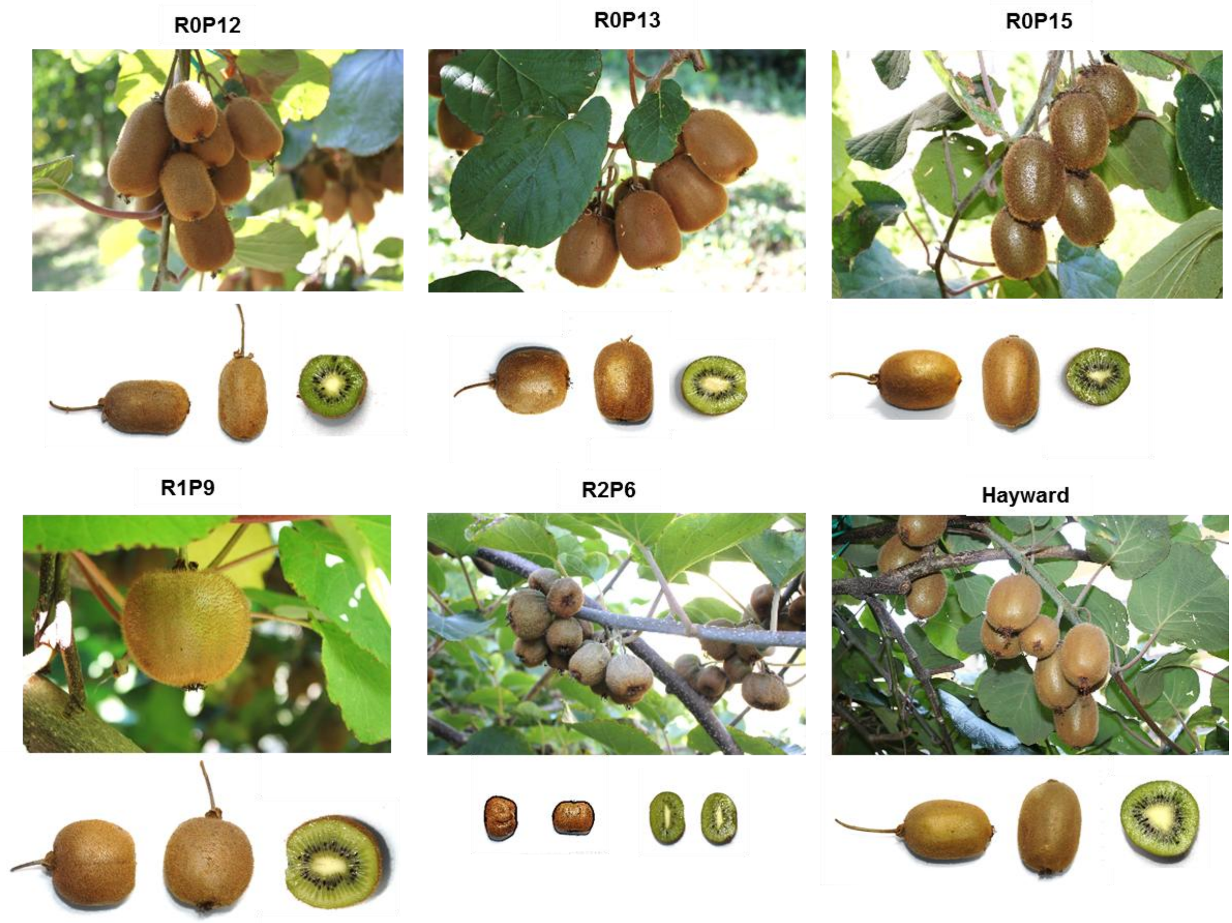

Fig. 1. Studied Romanian kiwifruits hybrids

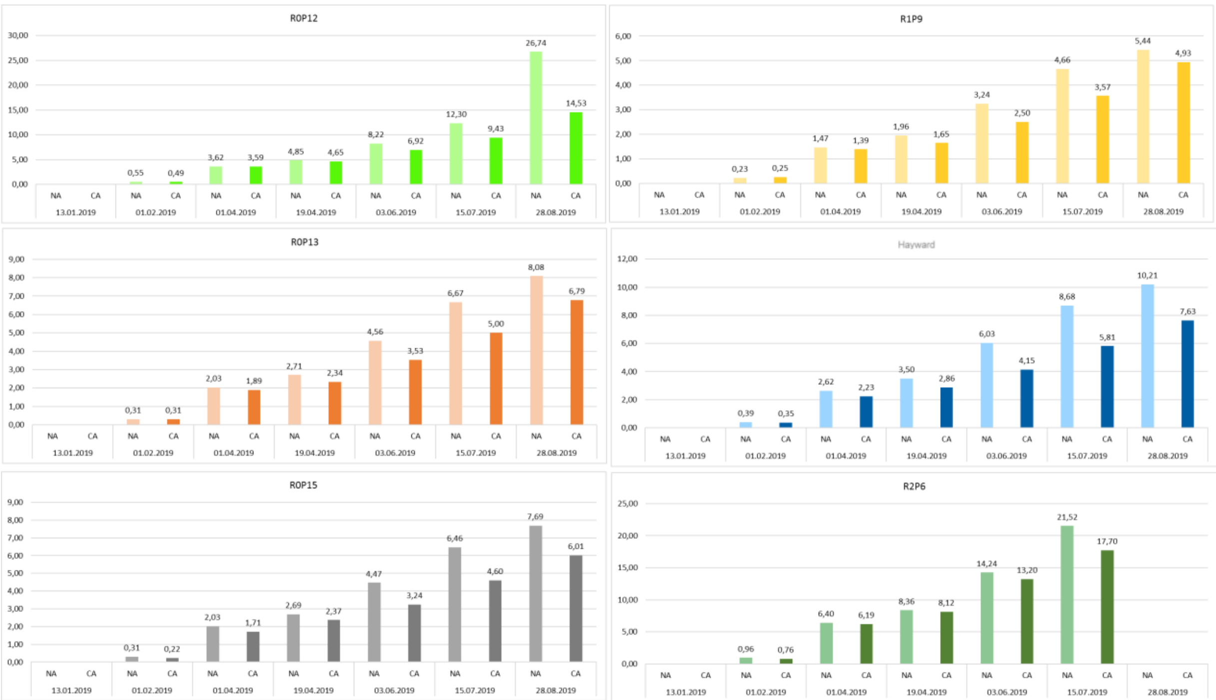

Fig. 2. Kiwifruit weight losses (g) during the storage in NA and CA – 2018-2019

 DOI 10.33045/fgr.v35.2019.16

Fig. 3. Kiwifruit flesh firmness (kgf/cm²) dynamics during the storage in NA and CA – 2017-2018

Fig. 4. Kiwifruit flesh firmness (kgf/cm²) dynamics during the storage in NA and CA – 2018-2019

DOI 10.33045/fgr.v35.2019.16

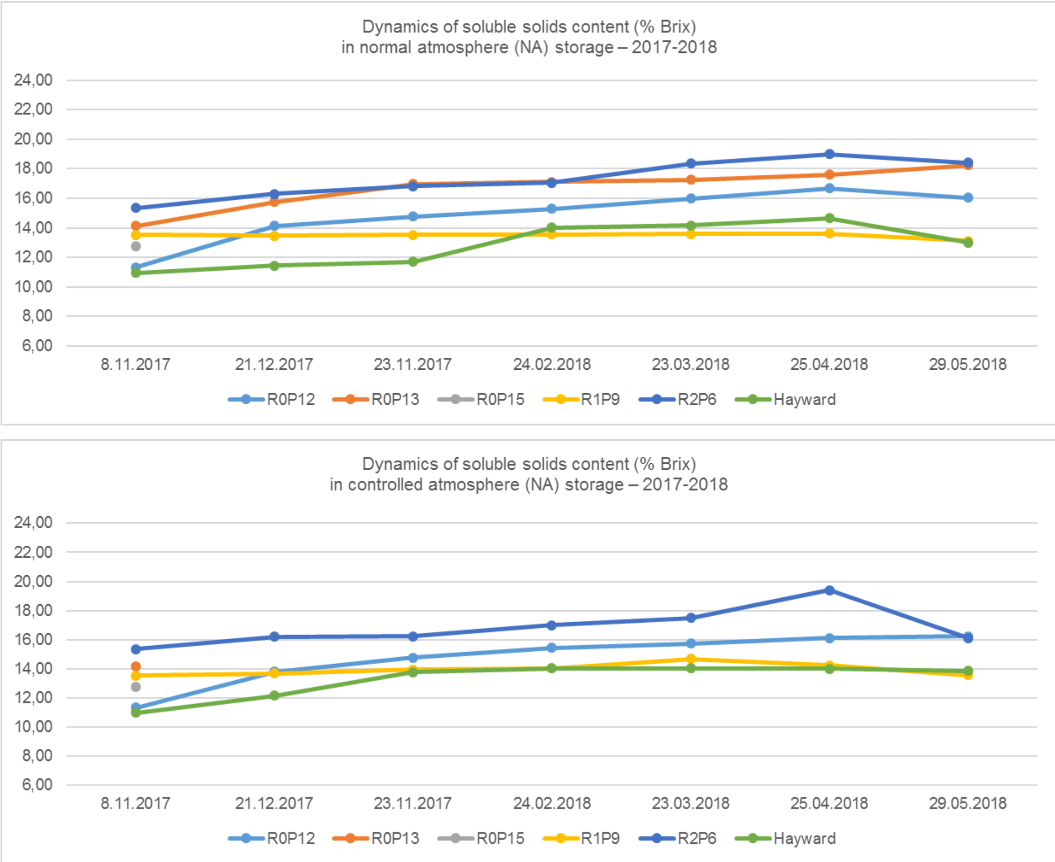

Fig. 5. Fruit soluble solids content (% Brix) dynamics during the storage in NA and CA – 2017-2018

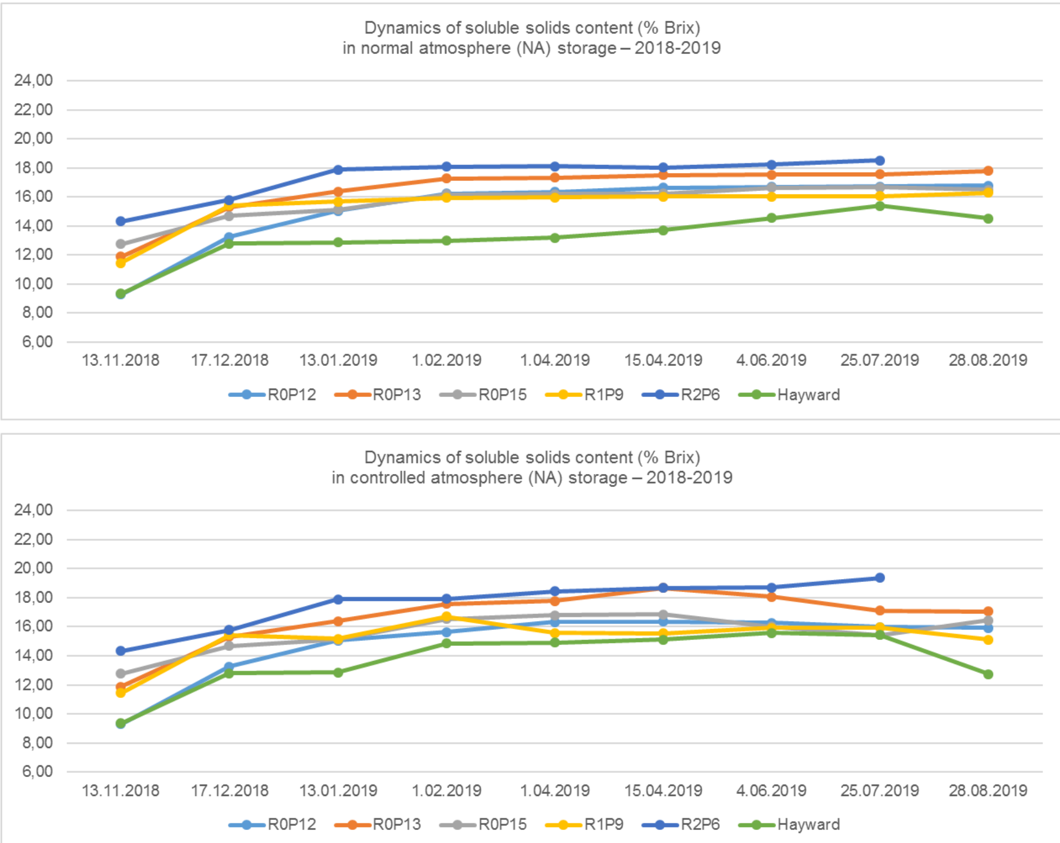

Fig. 6. Fruit soluble solids content (% Brix) dynamics during the storage in NA and CA – 2018-2019

DOI 10.33045/fgr.v35.2019.16

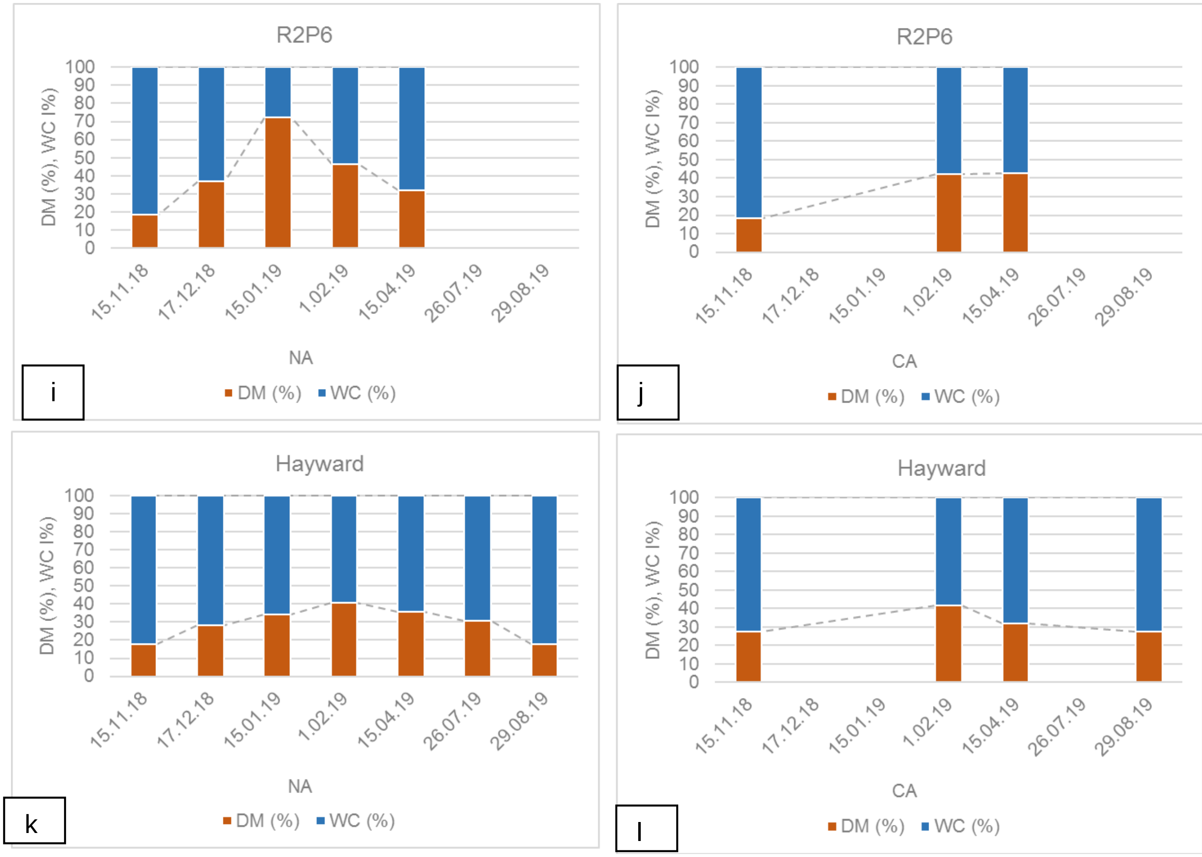

Fig. 7. Kiwifruit dry matter (DM) and water content (WC) evolution during the storage in normal (NA) and controlled (CA) atmosphere – 2018-2019: a. R0P12 – NA; b. R0P12 – CA; c. R0P13 – NA; d. R0P13 – CA; e. R0P15– NA; f. R0P15 – CA; g. R1P9 – NA; h. R1P9 – CA; i. R2P6 – NA; j. R2P6 – CA; k. R2P3 (Hayward) – NA; l. R2P3 (Hayward) – CA.

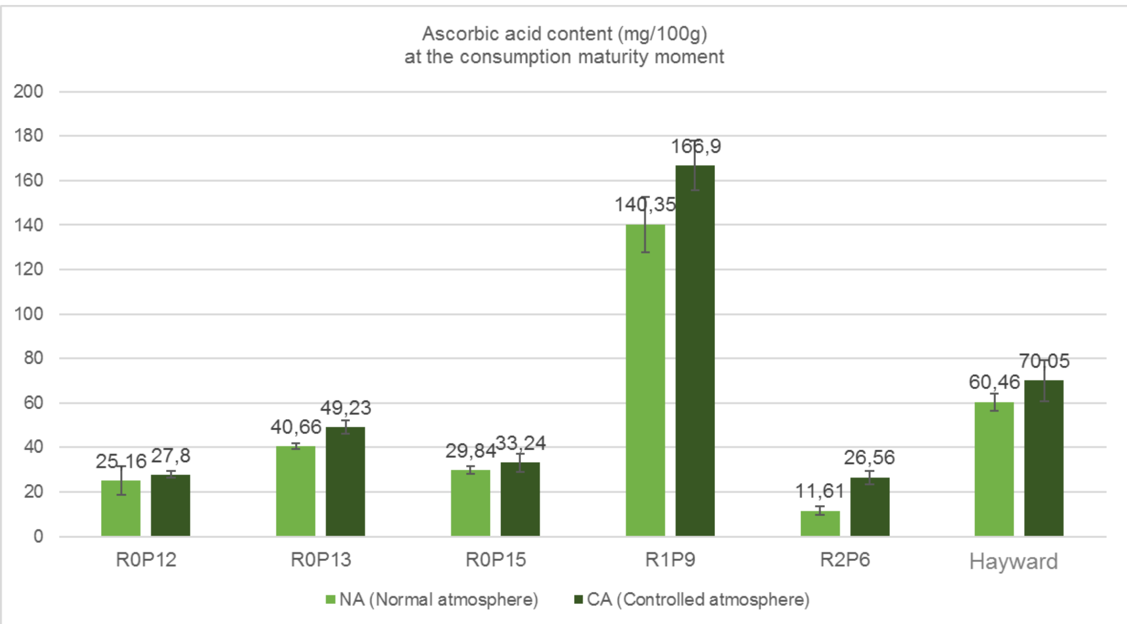

Fig. 8. Kiwifruit ascorbic acid content (mg/100g) at the consumption maturity moment in normal (NA) and controlled (CA) atmosphere – 2018-2019