Original article

Quality of packed baby kiwi cultivar 'Hortgem Tahi®' and 'Hortgem Rua®'

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Summary. Baby kiwi fruits (*Actinidia arguta*) represents a relatively new product in the fresh italian market and the crop is grown in recent years. They are similar to berries and their storage period is different from other kiwi. The aim of this work is to evaluate the evolution of some quality parameters of packaged fruits of two cultivar actually marketed under the Nergi® brand (Hortgem Tahi®and Hortgem Rua®). We monitored weight loss, colour, total soluble solid content, titratable acidity, dry matter, firmness, textural parameters and total polyphenol content of fruits stored at low temperature (1±1°C) up to 60 daysWe can state that baby kiwi are very susceptible to pulp firmness decrease. Generally samples of cv Hortgem Tahi® andHortgem Rua® packed with the lid have maintained an higher pulp if compared with the control values. The stability of the peel colour and the limiting of the weight losses during the whole storage period are successfully preserved in this preliminary study.

Key words: *Actinidia arguta*, post-harvest, storage, quality, punnet

Introduction

Fruits of *Actinidia arguta* (Siebold et Zucc), also known as baby kiwi, kiwi berries, mini kiwi, hairless kiwi and hardy kiwifruit, are the smaller version of the renowned green-fleshed (*Actinidia deliciosa*) and yellow-fleshed (*Actinidia chinensis*) kiwifruit. The region of origin of this species includes Russian Siberia, Northern China, Japan and Korea (1, 2) and different varieties and cultivars are cultivated in the word. Cultivars Issai, Weiki, Geneva, Hortgem Tahi®, Hortgem Rua®, Hortgem Toru®, Hortgem Wha®, Jumbo and Ananasnaya are the most important in Europe. The production of *Actinidia arguta* has increased in the last few years, as a result of a growth in consumer demand.

Due the rich content of bioactive compounds (3, 4) the sweet and aromatic taste and the high vitamin C content (5), they are known as healthy fruits. They are marked as berries because the small size and the nakedness makes their management during the post-harvest chain similar to those of the other soft fruits such as blueberries or raspberries (6).

Fruits of Actinidia arguta show a short shelf life (1-2 months) (7,8) if compared to other kiwi (9) and the quality at the harvesting time is fundamental to influence the storage process (10). In fact the green kiwifruit (Actinidia deliciosa) have an indicative shelf-life of 6 to 8 months and the gold kiwifruit (Actinidia chinensis Planch.) of 4 to 6 mouths (7,11). The rapid dehydration and softening process (12,13) cause important economic losses during the during the commercialisation because the consumer rejection (14,15) so, their management after harvest is crucial. The baby kiwi softening can be limited by low temperature but limited studies about the evolution of the quality parameters during the post-harvest are reported. Edible coating solutions maintaining fruits under cold temperature could be improve the shelf life of cv. Ananasnaya of three weeks (16) while Latocha et al. (9) studied the post-harvest life of *A. arguta* and various hybrids, under air and controlled atmosphere for 2 months. From field to fresh market sector the importance of packaging solution is well known. Considering the baby kiwi edibility with peel it's necessary to minimize the treatments. In this context the use of good packaging solutions is fundamental. Rigid containers such as plastic basket or ventiled clamshell are able to protect berries from damage and plastic overwrape are usefull to resist environmental contaminants. On the contrary, unsuitable packaging can cause an accumulation of moisture inside the package and a possible development of spoilage by microorganisms (17). Considering the limited knowledge about the quality of these fruits during post-harvest period the aim of this work is to evaluate the quality and the storability of the baby kiwi of two cultivar (Hortgem Rua® and Hortgem Tahi®) actually marketed under the Nergi® brand in the italian market.

Materials and methods

Fruit source and experimental field location

The baby kiwi orchard was localised at Revello (Cuneo, Piedmont, Italy). Two different cultivars Hortgem Rua® and Hortgem Tahi® (marketed under the Nergi® brand) of *A. arguta* (Siebold et Zucc.) were used for the work. Both cultivars are new patented varieties and come from New Zealand (18,19). Fruits of each cultivar were collected at the harvesting maturity stage, placed inside a plastic fruit box and transported to the Agrifrutta Cooperative warehouse (Peveragno, Cuneo, Piedmont, Italy) for the storage process at 1±1°C in normal atmosphere.

Experimental design and sampling procedure

The selected baby kiwi fruits, of each cultivar, were packed inside plastic polyethylene terephthalate punnets (5 × 10 × 3.7 cm) each one contained 0.125 kg of fruit. The fruits were packaged in the punnets without a lid (control) and in the punnets with lid.. The *A. arguta* were stored in a cold room (1±1°C), for up to 60 days. For each cultivar and for each type (control and lids) a total of 72 punnets were prepared at the start beginning. The quality parameters of the samples were analysed the day of packing the fruit (day 0) and after 20, 40 and 60 days of storage. For each sample and for each analysis of quality, six punnets were randomly selected and analysed regarding the weight losses, the quality parameters (total soluble solids (TSS), titratable acidity (TA), and dry matter (DM)), colour parameters (luminosity, chroma and hue angle), firmness, texture profile analysis (TPA) (hardness, cohesiveness, gumminess and springiness) and the total phenolic content (TPC). All analysis were performed according with the responsible of the warehouse integrating to the analysis on kiwi (13) the most important analysis that are usually performed on berry fruits in the post-harvest (20-22).

Weight loss

Weight loss (%) was determined using an electronic balance (model SE622, VWR Science Education, Radnor, Pennsylvania, USA), with a 10^{-2}g accuracy. Weight was monitored during the whole storage period and it was calculated as difference between initial and final punnet weights.

Quality parametres

Total soluble solids (TSS) were evaluated with a digital refractometer Atago® Pal-1 (Atago Co. Ltd., Tokyo, Japan) and expressed as °Brix. For each quality control the instrument was calibrated with distillate water. The titratable acidity (TA) was measured using an automatic titrator (Titritino 702, Methrom, Herisav, Switzerland) and it was determined potentiometrically using 0.1N NaOH to the end point of 8.1 in 5 mL of juice diluted in 25 mL of distilled water.

Dry matter (DR) was measured on 10 whole fruits. The fruits were placed in an oven at 70 ± 2 °C for 24 h. Initial and final weights were measured using an electronic balance and the value were expressed as %, according to Mc Glone et al. (23).

Colour parameters

For each cultivar and sample the colour measurement was performed on the middle of peel of 20 fruits, using a tristimulus CR-400 chromameter (Konica Minolta, Langenhagen, Germany), according to the Commission International d'Eclairage (CIE) L*a*b* system. L^* refers to the lightness and ranged from L^* = 0 (black) to L^* = 100 (white). A negative and positive values of a^* indicates green and red color, respectively while positive and negative b^* indicate yellow and blue color, respectively (24). These values were used to calculate the chroma ($C^* = (a^{*2} + b^{*2})^{1/2}$), which denotes the intensity or colour saturation, and the hue angle ($h^\circ = \text{arctangent}(b^*/a^*)$), where 0° = red to purple, 90° = yellow, 180° = bluish to green and 270° = blue (25).

Firmness and Textural parameters

The firmness and the texture profyle analysis (TPA) were performed with the Texture Analyser TA.XT.PLUS (Stable Micro Systems USA) (30 Kilo Load Cell). For the firmness measurement a compression test on 20 whole fruits for each sample and cultivar was performed with a 30-mm aluminium flat tipped probe (P/3) to an 10% strain, with a pre test speed of 1 mm/s; test speed 1 mm/s; post test speed 5 mm/s and 5 g trigger force. For the TPA analysis, the instrument was equipped with a 75-mm aluminium compression plate (P/75) and the instrument settings were as follows: setting strain 25%, pre-test speed of 1 mm/s, test-speed 5 mm/s and trigger force 5 g. The parameters analysed were the hardness, the cohesiveness, the gumminess and the springiness.

Total phenolic content (TPC)

For each cultivar an extract of the baby kiwi fruits was obtained using 10 g of sample added to 25 ml of extraction buffer (500 ml methanol, 23.8 ml deionised water and 1.4 ml of 37% hydrochloric acid). After 1 hour in the dark at room temperature, the samples were thoroughly homogenised for few minutes, with an Ultra-Turrax (IKA, Staufen, Germany) and then centrifuged at 3000rpm for 15 minutes. The supernatant obtained by centrifugation, was collected and transferred into glass test tubes and stored at −20°C, until analysis. The TPC was measured using the Folin–Ciocalteu reagent with gallic acid as a standard, at 765 nm, based on Slinkard and Singleton (26). The results were expressed as mg of gallic acid equivalents per 100 g of fresh weight (mgGAE/100g).

Statistical analysis

All the pooled data were analysed using SPSS Statistics 24 (2017, IBM, Milan, Italy) for MAC. Analysis of variance (ANOVA) was performed, followed by Tukey's post-hoc test, when the differences were significant. Also, multivariate analysis was carried out, to verify a possible interaction between the packaging and the storage days and, also, a possible single effect between the packaging and the storage day.

Results and Discussion

Weight loss

The weight loss (figure 1) is correlated to the water loss and to the dehydration process during the post-harvest storage, consequently, the evolution of this parameter directly affects the marketability of the product (27). Although a rapid pre-cooling was performed before the packaging process to reduce the respiration rate (28) weight losses occurred for both the cultivars considered up to the end of storage but all the samples fruits maintained with the lid showed lower

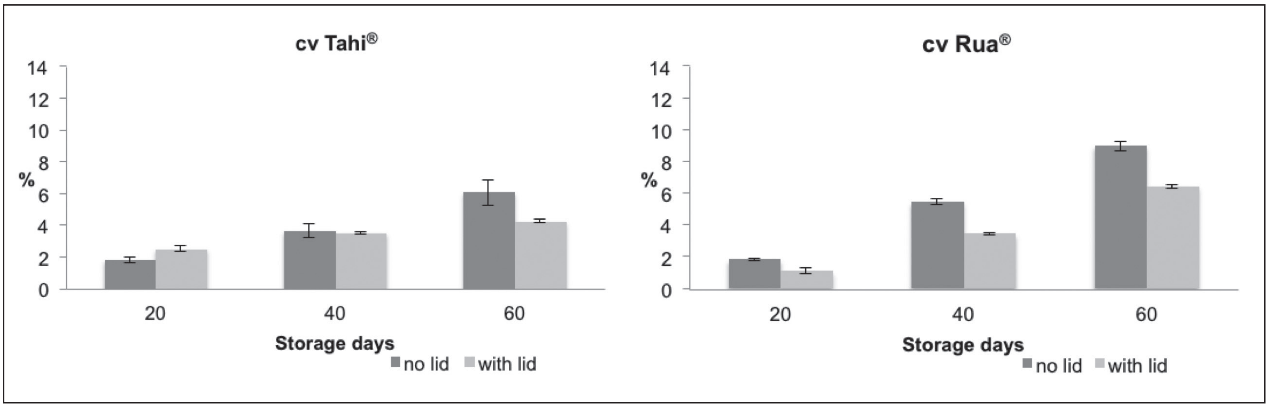

Figure 1. Weight loss (%) for the cv Horgem Tahi® and cv Hortgem Rua during storage

water losses. In fact the lids by retaining moisture and reducing pathological deterioration and consequently metabolic activities of the fruits have maintained an higher hydratation of fruits. Considering the cv Hortgem Tahi® is possible to observe a stabilization of the weight losses between 40 and 60 days of storage (respectively in a range of 5.08±0.32% and 5.11±0.19% for the control and 3.29±0.12% and 3.59±0.14% for packaging with lid). The cv Hortgem Rua® generally showed an increase of the weight losses reaching the maximum at the end of the storage with more than 6% for the control and around 4 % for fruits packed with lid.

Quality parameters

Quality parameters reported in this study included total soluble content (TSS), titratable acidity (TA) and dry matter content (DM) of the fruits. The TSS of *A. arguta* has proved to be to be predominantly represented by sucrose, with small contents of glucose and fructose (29). Regarding the TA, the citric and malic acids are reported to be the more representative but in a lower concentration respect to *A. deliciosa* and *A. chinensis* (30). About the dry matter (DM), *A. arguta* has a lower content than other species of Actinidia because *A. arguta* is richer in non-structural carbohydrates (31). All the quality parameters monitored are reported in Table 1. The TSS content at the packaging day (0 days) was

Table 1. Averages and multivariate analysis (single effects and interactions) of the evolution of the quality parameters (total solid soluble, titratable acidity and dry matter) for the cv Hortgem Tahi® and cv Hortgem Rua®.

	Storage days	TSS (°Brix)			TA (meq L^{-1})			DM (%)		
		Average	S.E.		Average	S.E.		Average	S.E.	
					control					
cv Hortgem Tahi®	20	13.93	0.28	ns	14.92	0.03	ns	19.35	0.48	a
	40	15.53	0.15		14.74	0.48		17.77	0.57	a
	60	14.23	0.75		14.15	0.21		15.77	0.11	b
					with lid					
	20	14.87	0.15	ns	14.76	0.04	ns	18.11	0.49	ns
	40	14.23	0.01		14.56	0.76		15.92	0.36	
	60	14.80	0.56		14.90	0.11		15.74	1.33	
	Single effects/interaction	Sig.			Sig.			Sig.		
	Packaging	0.001			0.020			0.270		
	Storage days	0.001			0.001			0.010		
	Packaging*Storage days	0.001			0.060			0.200		
					control					
cv Hortgem Rua®	20	14.73	0.34	a	10.75	0.15	a	18.21	0.26	a
	40	14.53	0.20	a	8.13	0.69	b	16.32	0.05	b
	60	12.60	0.42	b	9.37	0.21	ab	17.92	0.34	a
					with lid					
	20	13.90	0.38	ns	9.27	0.30	ab	17.78	0.25	a
	40	13.73	0.03		8.98	0.15	b	15.58	0.27	b
	60	14.83	0.54		9.98	0.13	a	17.07	0.11	a
	Single effects/interaction	Sig.			Sig.			Sig.		
	Packaging	0.050			0.010			0.250		
	Storage days	0.020			0.010			0.001		
	Packaging* Storage days	0.930			0.050			0.710		

All data are expressed as average value and the standard error of 15 different fruits. Different letters within the same column indicate significant differences among every harvesting time (Tukey test; p< 0.05).

respectively of 7.31 °Brix and 6.25 °Brix for the cultivar Hortgem Tahi® and Hortgem Rua® (data not showed). In both cultivars onsidered and all samples (control and packaging with lid) is possible to observe an increase in the TSS content if compared with the starting values. According with previous studies of Krupa et al. (32) this happens because the starch in the baby kiwi is used for the fruit respiration (33). In fact the increase in the TSS content would be correlated with the glycolytic enzyme activity that would cause the starch degradation and its conversion in sucrose. Cultivars of *A. deliciosa* and *A. chinensis* contain similar amounts of glucose and fructose, with lower levels of sucrose, whereas *A. arguta* species are particularly high in sucrose with lower glucose and fructose contents (34). Choudhury et al. (35) identified a different activity of the glycolytic enzyme based on the cultivar but, in this current study no important differences were found between the cultivars considered. If compared with *A. deliciosa* and *A. chinensis* cultivars the levels of organic acid in fruits of *A. arguta* are reported to be lower due the lower levels of the quinic acid (30). The ratios of the acids vary as the fruit matures and the total concentration is important for the sugar-acid balance and its influence on the organoleptic qualities. About the titratable acidity (TA) 16.61 meq L^{-1} and 14.66 meq L^{-1} values were observed respectively for Hortgem Tahi® and Hortgem Rua® as initial values (data not showed). All samples of both cultivars show a general decrease during the storage period and the multivariate analysis reported the interaction of the packaging and the storage factors in affecting the TA content ($p<0.05$). About the dry matter (DM) is well known that its value is correlated with a good flavour (36) and fruit with an higher content should be more acceptable to the consumer. Considering that the initial DM content by the two cultivar was of 19.2% and 18.9 % (data not showed) it's possible to assert that in all samples the content was maintained at high levels until the end of storage. The multivariate analysis shows as the packaging and its interaction with the storage time didn't affect statistically the DM values in any cultivar.

Colour parameters

Colour is an important attribute of fruits and influences the consumer's choice and preferences. The parameters describing this attribute evolve during growth, maturation and post-harvest handling of fruit (25). All the colour parameters observed during the storage are reported in table 2. The external colour of *A. arguta* varies according to the genotype of the fruit (3). Based on the current experiment, however, no important differences were found between the cultivars, regarding the luminosity, chroma and hue angle at the starting time (data not showed) and during the storage period. For the cultivar Hortgem Tahi® the initial L*, *C** and hue angle values were of 67.99, 36.61 and -1.04 (data not showed) while for the cultivar Hortgem Rua®, the parameters observed were of 65.88 (L*), 37.58 (*C**) and -1.10° for the hue angle. Only the single effect of the storage days affects statistically the L and chroma values for both the cultivars ($p<0.05$).

Firmness and Textural parametres

Changes in firmness and texture properties are largely attributed to alterations in the composition and structure of cell wall polysaccharides and they have a great commercial importance because these modifications shall not be accepted by consumers. The firmness and the texture parameters were monitored during the post-harvest storage because softening is one of the main issues for the *A. arguta* and models of softening decay are suggested for these fruits (13). The firmness value is the most important parameter for the control of *A. arguta* quality and the decrease of this attribute is due to the polygalacturonase activity (32). All the values measured at the harvesting time (data not showed) are within the range documented by Firsk et al. (16) and as expected for both the cultivars is possible to observe a statistical decrease of the pulp firmness and hardness during the storage period (table 3). Generally samples of cv Hortgem Tahi® and Hortgem Rua® packed with the lid have maintained an higher pulp if compared with the control values. Considering all the parameters with the exclusion of the gumminess for the Hortgem Rua® is possible to confirm that the storage duration influences statistically the TPA values.

Total phenolic content (TPC)

The content of phenolic compounds (figure 2) including phenolic acids, anthocyanins, and flavonoids in the fruits depends on the species and cultivars of Actinidia (32) and the *A. arguta* is a rich source of these bio-

Table 2. Averages and multivariate analysis (single effects and interactions) of the evolution of the color parameters (luminosity, chromacity and hue angle) for the cv Hortgem Tahi® and cv Hortgem Rua® for the 2016 season.

	Storage days	Luminosity (L)			Chroma (C*)			Hue angle (h°)		
		Average	S.E.		Average	S.E.		Average	S.E.	
	control									
cv Hortgem Tahi®	20	57.06	0.86	ns	32.53	0.53		-1.05	0.01	ns
	40	58.24	1.22		28.39	0.38		-1.05	0.01	
	60	58.41	1.04		25.09	1.84		-1.07	0.01	
	with lid									
	20	55.49	0.77	ns	32.06	0.56	a	-1.05	0.01	ns
	40	57.07	0.62		27.73	0.42	b	-1.04	0.01	
	60	58.55	3.96		23.84	2.36	b	-1.05	0.01	
	Single effects/interaction		Sig.			Sig.			Sig.	
	Packaging		0.89			0.71			0.98	
	Storage days		0.06			0.00			0.78	
	Packaging*Storage days		0.32			0.76			0.81	
	control									
cv Hortgem Rua®	20	57.75	0.98	ns	31.45	0.54	a	-1.07	0.01	ns
	40	57.67	0.54		24.42	1.13	b	-1.12	0.03	
	60	56.24	1.59		26.78	0.68	b	-1.10	0.01	
	with lid									
	20	57.75	0.98	ns	30.99	0.58	a	-1.08	0.01	ns
	40	57.67	0.54		26.32	0.59	b	-1.08	0.01	
	60	56.24	1.59		25.20	0.83	b	-1.11	0.02	
	Single effects/interaction		Sig.			Sig.			Sig.	
	Packaging		0.19			0.82			0.54	
	Storage days		0.04			0.04			0.09	
	Packaging*Storage days		0.05			0.96			0.69	

All data are expressed as average value and the standard error of 15 different fruits. Different letters within the same column indicate significant differences among every harvesting time (Tukey test; p< 0.05).

actives. These compounds are considered to be among the best antioxidants in helping the human organism and their function is similar to vitamins effect (4). Due to the unstable structure, phenolic compounds are strongly affected by environmental condition such as light, pH, oxygen, storage temperature and time (37). Due the varietal difference the TPC content of Hortgem Tahi® is greater than those of Hortgem Rua®. Hortgem Tahi® samples packaged with lid maintained highest values if compared with control samples respectively of 12%, 14% and 20% after 20 , 40 and 60 days of storage. On the contrary no differences were observed among samples of Hortgem Rua® wich TPC content was mantained stable in the range of 1346,67 and 1969,14 mq GAE 100 kg^{-1}

Conclusions

The baby kiwi represents a new product in the italian fruit marke. The consumer demand is due to the high quality properties of fruit and to his edibility unpeeled, like a berry fruit and the edibility of the whole fruit with the peel like a berry fruit.

The extension of the conservation in terms of time, the containment of the product losses, the shelf life, improvement, the maintenance of quality and nutritional aspects are key elements for the success of their supply chain. The post-harvest management of *A. arguta* is crucial to maintain the quality of the fruits and the use of packaging with lid can be suggested to

Table 3. Average and multivariate analysis (single effects and interactions) of the evolution of the mechanical property firmness, hardness, cohesivness, gumminess, springness) for the cv Hortgem Tahi® and cv Hortgem Rua®

	Storage days	Fimness (N)			Hardness (N)			Cohesivness			Gumminess			Springness		
		Average	S.E.		Average	S.E.		Average	S.E.		Average	S.E.		Average	S.E.	
								control								
cv Hortgem Tahi®	20	0.33	0.03	a	17.70	22.83	a	0.39	0.01	b	696.19	81.24	a	0.67	0.01	ns
	40	0.17	0.02	b	12.35	89.77	a	0.40	0.02	b	503.09	38.88	a	0.63	0.02	
	60	0.21	0.02	b	4.30	32.66	b	0.53	0.00	a	234.36	17.16	b	0.70	0.01	
								with lid								
	20	2.91	0.27	ns	17.89	21.76	a	0.38	0.01	b	691.52	86.56	a	0.67	0.02	a
	40	2.10	0.11		11.28	88.15	b	0.38	0.01	b	432.85	31.92	b	0.62	0.01	b
	60	2.13	0.46		3.57	68.56	c	0.55	0.02	a	193.33	33.52	b	0.71	0.02	a
	Single effects/ interaction	Sig.			Sig.			Sig.			Sig.			Sig.		
	Packaging	0.180			0.280			0.600			0.120			0.200		
	Storage days	0.100			0.002			0.000			0.003			0.030		
	Packaging* Storage days	0.810			0.860			0.380			0.750			0.080		
								control								
cv Hortgem Rua®	20	0.24	0.03	a	20.91	16.74	a	0.41	0.01	b	867.45	58.58	a	0.69	0.01	ns
	40	0.11	0.02	b	12.52	11.37	b	0.37	0.02	b	479.09	44.08	b	0.65	0.02	
	60	0.17	0.02	b	3.90	35.28	c	0.53	0.01	a	210.13	18.81	c	0.69	0.01	
								with lid								
	20	0.24	0.04	a	23.41	21.77	a	0.25	0.05	b	612.14	14.26	ns	0.55	0.04	b
	40	0.23	0.02	b	15.99	11.15	b	0.35	0.01	b	565.61	41.16		0.64	0.01	ab
	60	0.33	0.02	b	5.21	49.51	c	0.54	0.01	a	283.56	24.14		0.70	0.01	b
	Single effects/ interaction	Sig.			Sig.			Sig.			Sig.			Sig.		
	Packaging	0.080			0.240			0.002			0.100			0.002		
	Storage days	0.010			0.010			0.003			0.420			0.003		
	Packaging* Storage days	0.860			0.830			0.001			0.070			0.003		

All data are expressed as average value and the standard error of 15 different fruits. Different letters within the same column indicate significants differences among every harvesting time (Tukey test; p< 0.05).

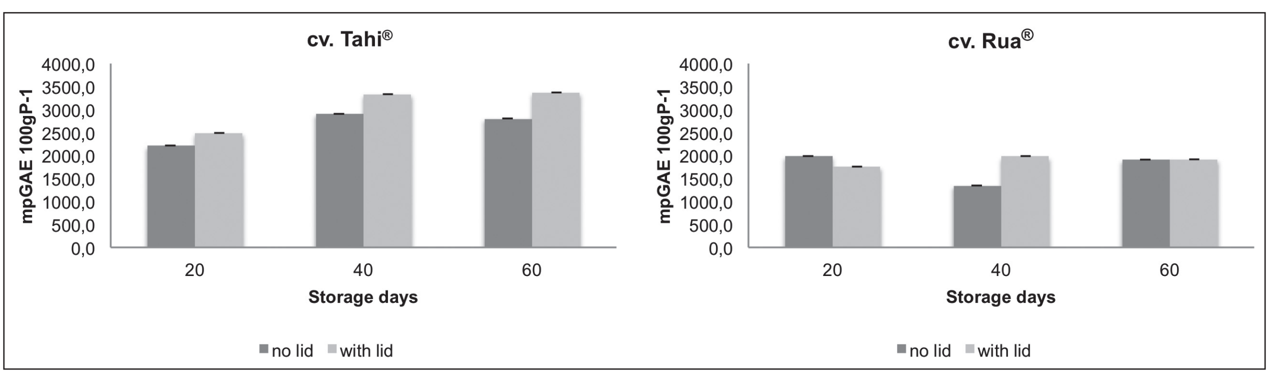

Figure 2. Total phenol content (TPC) for the cv Horgem Tahi® and cv Hortgem Rua® during storage

store fruits at low temperature (1±1°C) over long periods such as 60 days. The marketability of Hortgem Tahi® and Hortgem Rua® depends on different quality index such as the stability of peel colour during the storage period, the maintenance of the firmness pulp and the limiting of the weight losses and all these parameters are successfully preserved in this preliminary study. Considering the emergent market for these fruits the potential of the research in post-harvest sector to support the supply chain process is necessary to improve the knowledge on some post-harvest technology treatment such as the use of MAP, of controlled atmosphere, of ozone and the use of edible coating considering also the safety issues.

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Founding Source

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