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Investigation of the Possibilities for After Harvest Ripening the Fruits of Cape Gooseberry (*Physalis peruviana* L.) Depending on the Applied Agrotechnology

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Abstract

The main goal of the present study was to establish the possibilities for posy-harvest ripening of fruit of cape gooseberry (*Physalis peruviana* L.). Some part of the cape gooseberry fruit can not ripen until the end of the growing season. Therefore, it is necessary to be carried out the studies in relation with after harvest ripening. This results on an increase in overall productivity. The experiments were carried out with two genotypes of cape gooseberry – first Bulgarian variety Plovdiv and Columbian ecotype Obrazec 1. The plants were grown by different technological approaches and date of sowing: with pricked out and non-pricked out seedling, by direct sowing outside. In the end of vegetation normal development fruits, without damage and injuries, but unripe fruits were placed for after harvest ripening in ambient conditions. In a period of 7 days the quantity of ripening and damaged fruits, the content of dry matter and sugars and weight of the fruits were established. The highest percentage of after harvest ripe fruits for variety Plovdiv was found in variants with non pricked out of seedlings in sowing date on 15 and 30.03 and with direct sowing outside on 15.04 - 67.0, 52.56 and 57.34%, respectively. For Obrazec 1 these values was the highest for direct sowing outside on 1.04 and 15.04 – 72.67% and 67.56%, while for non-pricked out seedling it was observed at sowing on 15.03 - 62.67%. Dry matter and sugar content increased, while the fruit weight decreasesd. The periods for economic efficiency of after harvest ripening were 21 days for Obrazec 1 and 35 days for Plovdiv.

Keywords: cape gooseberry, after harvest ripening, chemical components, technology, fruit,

Introduction

Recently, growing of rare vegetables crops such as a cape gooseberry, broccoli, patissons etc. extends and therefore conducted and focused research efforts in breading and technological aspects is increasingly necessary (Panayotov, 2009; Antonova eta al., 2014, Haytova and Gergova, 2011). The flowering, fruit-set formation and maturity of cape gooseberry fruits are directly dependent on the applied agrotechnology and often can be delayed in case of a strong vegetative growth (Prasad, 1979). Similar reason for immature of part of fruit reported also Chernook (1997) and he pointed out that there is a very good opportunity for after harvest ripening of the green fruit and that they can be stored until spring. This crop is characterized by very good ability for after harvest ripening and for storage, and these two aspects are the main economic features that ofen used in practice. This contributes to increasing the marketed production and the income and consequently to increase also the efficiency of production (Christov, 2010).

Sarkar et al. (1993) found out that by means of additional ripening of green and semi-green fruits of cape goosberry the content of sugars and the total amount of the salts is changed. It is recommended for a long-term storage to be picked semi-green fruits and to be placed for ripening. In the process of ripening the fruit color changes from green to yellow or orange, which is associated with degradation of chlorophyll and an increase of carotenes, primarily of β-carotene. The hardness decreases, resulting on an increase of the enzymatic activity of pektilmetilesterase, α-galactosidase, α-and β-arabinofurinosidase, glucosidase, and at the same time with accumulation of sugars and increases the content of soluble pectin (Majumder and Mazumbar 2002; Trinchero et al. 1999; FAO 2001; Fischer et al. 2000).

During the ripening of fruits of cape goosberry, sugar content, total soluble salts, the relationship between soluble salts and acids, and ascorbic acid content increased while starch decreased, the ratio of sucrose: glucose: fructose

changed. In the early stages of ripening, acidity increases, but then gradually reduces until the fruit reaches full maturity (Fischer and Lüdders 1997; Fischer et al. 2000; Sarangi et al. 1989; Baumann and Meier, 1993; Majumder and Mazumbar 2001).

The main aim of the study was to determine the influence of different types of cultivation of cape goosberry, by planting or direct sowing and different terms of sowing on the possibility of after harvest ripening of its fruit.

Material and Methods

Experiments were carried out with first Bulgarian variety cape gooseberry Plovdiv and Columbian ecotype, named Obrazec 1 in Experimental field and scientific laboratories of Department of Horticulture at the Agricultural University-Plovdiv, Bulgaria during the period 2008-2010. The plants were grown by three ways: through pricking seedlings, non-pricking seedlings and by direct sowing outside. The seeds for pricked out seedlings were sown in enriched peat mixture in heated glasshouse in three times during an interval of 15 days - 1.02, 15.02 and 2.03 at 1.8 $g.m^{-2}$, and the sowing rate for decare was 8 g. In the phase of first pair of true leaves seedlings were pricked in pots № 10 in the same enriched peat mixture in plastic house. After running the risk of last spring frost, and development of 10-12 true leaf, the plants were planted in rows by the distances 70 × 50 cm.

Non pricked out seedlings were produced in non-heated plastic green house on the bed with terms of sowing 1.03, 15.03 and 30.03 with the same rates of sowing for decare, while for square meter it was 1.2 g and the seeds were covered with enriched peat mixture. Planting was done in the middle of May when the plants was with 7-8 true leaves.

The direct sowing outside implemented in following terms: 1.04, 15.04 and 30.04 with sowing rate from 15 $g.da^{-1}$ and with 4-5 seeds in a cluster by the scheme 110 + 50 × 50 cm and the plants were thinned in the phase of two true leaves.

The experimental plot was 8 m^2 and the experiments carried out in four replications. During vegetation each agro-technological practice that are necessary were applied. At maturity regularly harvests are carried out.

At the end of the growing season, before the first autumn frost, well-formed fruit with normal size, but unripe, undamaged and illnesses were harvested and placed for after harvest ripening. It carried out in four replications, in ambient conditions in storage house with temperature 20-22^{0}C and 60-65% air humidity. The fruits in quantity of 500 g were placed in plastic, very good disinfected boxes with depth of layer of 7-8 cm. Through periods of 7 days until depletion of healthy fruit, the ripe fruits were taken and their weight was measured, while the rotting and damaged ones were removed. The weight per fruit, content of dry matter (refractometrically) and sugar (by the methods of Hagedorn – Yensen, described by Stambolova et al., 1978) were established in four replications on the day of placing for after harvest maturation and every seventh day of the trial is conducted. Data of the study were subjected to analysis of variance, and least significant differences between means were calculated by the Fisher test at p = 0.05(described by Fowel and Cohen, 1992). The presented data are mean values from the three years of the investigation periods, because the trends were similar.

Results and Discussion

Cape gooseberry is a vegetable crop in which not all fruits under Bulgarian condition can mature by the end of the growing season. Formation and ripening of fruits have a direct relationship with the applied technology and it is decisive for the ripening process (Sahoo et al., 2002). Production of cape gooseberry with different means of growing substantially affect to the amount of unripe fruits (Table 1). At least they were in the variants with pricking out of seedlings, and their portion was highest in direct sowing outside. This could be due, on one hand on the fact that the growing season in the cultivation with pricking out of seedlings is longer, the majority of fruits can ripen, and on other hand by direct sowing outside the plants are phenologicaly younger and they set most fruits at the end of the growing season and therefore the number of harvests are less. Differences between the two genotypes are almost nonexistent, but the quantity of unriped fruits is more in variety Plovdiv. At least they were in plants of pricked out seedlings, sown on 02.03 - 26.98 $kg.da^{-1}$ and 22.88 $kg.da^{-1}$ and most they were in direct sowing of 30.04 - 68.09 $kg.da^{-1}$ and 51.14 $kg.da^{-1}$ for Plovdiv and Obrazec 1, respectively. The differences between most of the variants have statistical significance. The proportion of unripe fruits, to all formed was higher for Plovdiv, except when the seedlings has been picked out. In variants with non-pricked out seedlings it was between 12.3% (01.03) to 17.35% (30.03), direct sowing outside occupies an intermediate position with approximately 15% unripe fruit. In non-pricked out seedlings of Obrazec 1 sown on, 30.3 and 15.03 this proportion was between 12.6% and 9.96%, respectively. These

not small amounts suggest that after harvest ripening of fruit it is required practice in cape gooseberry.

As a result of conducting the after harvest ripening the percentage of riped fruits for variety Plovdiv was higher in non-pricked out plants and in direct sowing outside, while for Obrazec 1 it was observed from direct sowing outside. The quantity was highest for first variety in variants with non-pricked out seedlings sowing on 15.03 - 67.0%, while for the other variety in direct sowing outside of 1.04. - 72.67%. It can be emphasized that as a consequence of after harvest ripening of fruit, the proportion of ripened fruits were significantly greater, of approximately more than twice for those that are from non pricked out and by direct sowing outside plants, as compared with those of the pricked out seedlings. This concerns for both genotypes.

The total quantity of ripe fruits by means of after harvest ripening practice increased. The least this increase was in variants with pricked out seedlings from 1.90% (1.02. Obrazec 1) to 3.33% (15.02. Plovdiv). The proportion of after harvest ripe fruits was more significant for non pricked out seedlings and it was 9.93% in sowing date of Plovdiv on 30.03 and 6.48% for the other variety at the previous date. Similar trend was observed for direct sowing outside, where as a result of the after harvest ripening the amount of suitable for consumption fruits has increased by 9.30% and 8.02% at sowing on 15.04 for Plovdiv and for Obrazecl 1, respectively. Growing the cape gooseberry by direct sowing outside or by non pricked out seedlings, i. e. in case of a shorter vegetation period, on one hand it is characterized by a higher proportion of unripe fruit to all developed one, but on other hand it is with a higher percentage of after harvest ripe. Therefore more appropriate and economically efficient is the application of his practice in the above mentioned two types of cultivation.

The dynamic of after harvest ripening is shown on Figure 1. Special differences between the two genotypes were not observed. The most fruits ripe on the seven days and were obtained from variant with non-pricked out seedlings, sown on 15.03 - 37.56% for Plovdiv and 35.0% for Obrazec 1. Secondly for the first variety were the fruits from the same type of seedlings, but sown on 1.03 - 34.0%, while for the other one was from direct sowing outside on 15.04 - 34.33%. After that day, the percentage of after harvest riped fruits began to decrease gradually. After harvest ripening, even in insignificant amount detected until 35 days in Obrazec 1 in sowing date 30.03 and in all terms of direct outside sowing , while for Plovdiv observed on 42 day, but in extremely low quantity - 0.89% and 0.67% in two variants with pricked out seedling with sowing dated of 15.02 and 2.03. The earliest after harvest ripening completed in sowing of 15.03 for non pricking out seedlings of Plovdiv still 28 days, while for Obrazec 1 on the same days for fruits from pricked out seedlings and for first date of non-pricked out. The highest decrease was observed between 7 and 14 days for date 1.03 - with 18.88%, followed by 15.04 - with 16.0% of Plovdiv and for Obrazec 1 - of 15.03 and 15.04 with 23.33% and 17.78%, respectively.

Table 1. Quantity on non maturity fruits and ratios between maturity and after harvest ripping fruits of cape gooseberry

Varieties	Non maturity fruits (kg.da^{-1})		Portion of the unripe to all formed fruits (%)		After harvest riped fruits (%)		Portion of after harvest riped to whole quantity of maturity fruits(%)	
	Plovdiv	Obra-zec 1	Plovdiv	Obrazec 1	Plovdiv	Obra-zec 1	Plovdiv	Obrazec 1
Pricked out seedlings								
01.02	38.89	29.93	9.97	11.74	26.78	14.67	2.88	1.90
15.02	35.88	25.65	9.72	12.06	33.00	23.00	3.33	3.05
02.03	26.98	22.88	8.70	11.05	31.83	20.33	2.91	2.46
Non-pricked out seedlings								
01.03	50.65	34.36	12.30	10.65	61.12	20.67	7.88	2.40
15.03	52.54	36.87	12.40	9.96	67.00	62.67	8.66	6.48
30.03	57.73	41.41	17.35	12.60	52.56	44.67	9.93	6.05
Direct sowing outside								
01.04	54.00	36.30	16.11	10.63	51.78	72.67	7.70	7.95
15.04	61.01	42.47	15.17	11.43	57.34	67.56	9.30	8.02
30.04	68.09	51.14	14.96	13.04	43.66	54.67	7.13	7.57
LSDp=0.05	2.60	2.65						

Appropriate period for after harvest ripening was up to 21 days, when for Plovdiv obtained additional ripen fruit within 4.56% (1.02) to 9.56% (30.03), and for Obrazec 1 between 2.45% (1.02) to 11.33% (1.04).

The weight of the fruit during after harvest ripening decreased relatively slowly from the first to the last day (Figure 2). It could be assumed that this is due to natural processes of transpiration and loss of water from the fruit during after harvest ripening, which affects on their weight. More sharply this process is observed in Plovdiv on 21 day in variants with pricked out seedlings – decrease with 39.557% to 52.91%, while for the others ones was established on 28 day, on 35 day the reduction toward the initial weight was with 37.33% and 38.09% for 1.03 and 1.04 dates. Weaker fluctuations, but also in a trend for a smaller fruit weight that were riped later observed for Obrazec 1, except only for variant 1.02 which fruits at the time of placement have already been with smaller weight. The decrease on 35 day towards the initial weight was most significantly for the second sowing term in non-pricked out seedlings 15.03 with 46.81%, followed by the date 15.04 in direct sowing outside - 44.6%. It can be assumed that these fruits in the moment of placement also have already been with smaller weight, a comparatively less developed, which delayed the further maturation processes and it reflected on their weight at the time of occurrence of orange color. Discoloration of fruit during after harvest ripening is an indication for reaching the suitable for consumption maturity and according to Fischer et al., 2000, as it was above mentioned, it is in the result of degradation of chlorophyll and increasing of the carotens.

Some differences between the two tested genotypes observed for the content of dry matter (figure 3). In fruits of Obrazec 1 the dry matter content increased in the period of after harvest ripening in each variants with exception of that of sowing 1.02 for pricking out of the seedling, where in at 28 days there were decrease. The highest increase was observed between 1 and 7 days. In cultivar Plovdiv the increase up to 21 days, except for dates of 15.02 and 2.03 in pricking out of the seedlings, and then on day 28 decreased sharply and remained almost unchanged on 35 days. It can be assumed that the reason which was mentioned about weight decrease, i. e. normal water loss is also associated with the increase of dry matter in the fruit.

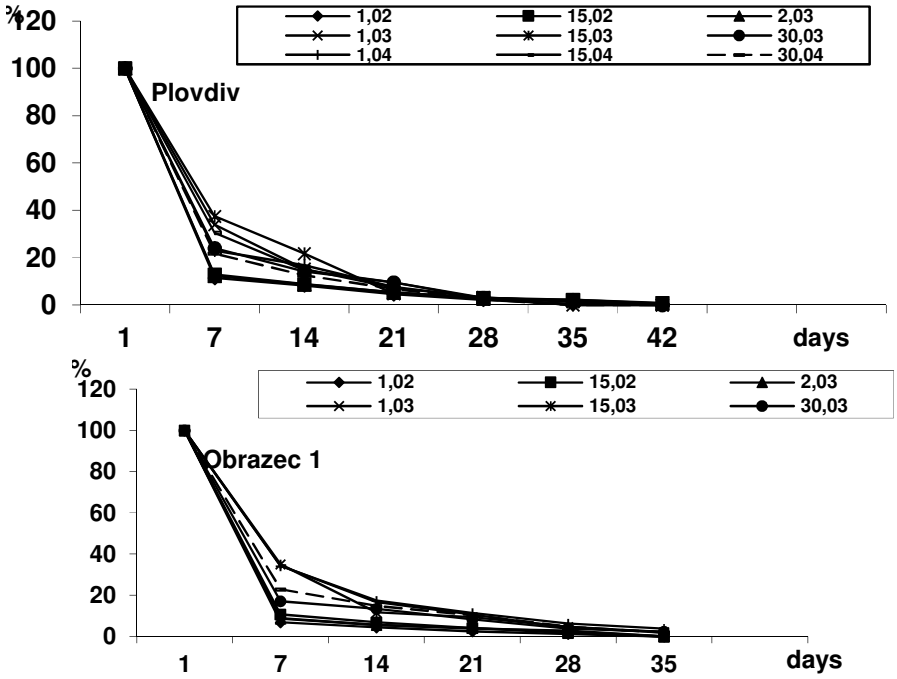

Figure 1. Dynamic of maturation of cape gooseberry fruits during the period of after harvest ripening

The processes of after harvest ripening are associated with convert of nutrients into the fruits. Similar dynamic, such as in the dry mater, has been established also for sugar content, (Figure 4). In Obrazec 1 in almost all variants increased with a slow rate to 28 days, with

exception of sowing on 1.02, 2.03 and 1.03. On 35 day sharp decrease was observed in the last two periods of direct sowing outside as decrease was with 34.53% and 25.0%. In Plovdiv, however sugar content increased in fruit from pricked out seedlings to 14 days, while those of non-pricked ones and of direct sowing outside to 21 days and only for date 15.03 until 28 days. Subsequent after harvest riped fruits were with lower sugar content. Sarkar et al. (1993) in an investigation of the chemical composition of the cape gooseberry fruits, with different stage of maturity, placed for additionall after harvest ripening, also established that the sugar content decrease but, the total quantity of salts increase.

Conclusions

Applied technology of growing of cape gooseberry affects on the amount of unripe fruit during the vegetation season. This quantity was more when the production has been accomplished by direct sowing outside and by non pricked out seedlings.

A higher percentage of fruits after harvest ripe in Plovdiv was in non pricked out plants, while for Obraets 1 it was the same in direct sowing outside. The least it was observed for fruit produced by pricking out of the seedlings.

After harvest ripening is economically efficient when done with fruits from plants that grown by direct sowing outside or by non pricked out seedlings, where unripe fruits were more, and increase of the total amount of riped fruit as a result of this practice were higher. The dynamics of the after harvest ripening of cape gooseberry fruits indicates that it is appropriate to continue to 21 days.

The weight of the fruit during after harvest ripening decreases, the dry mater increases, such as also the sugar content especially in the fruits of the Obrazec 1.

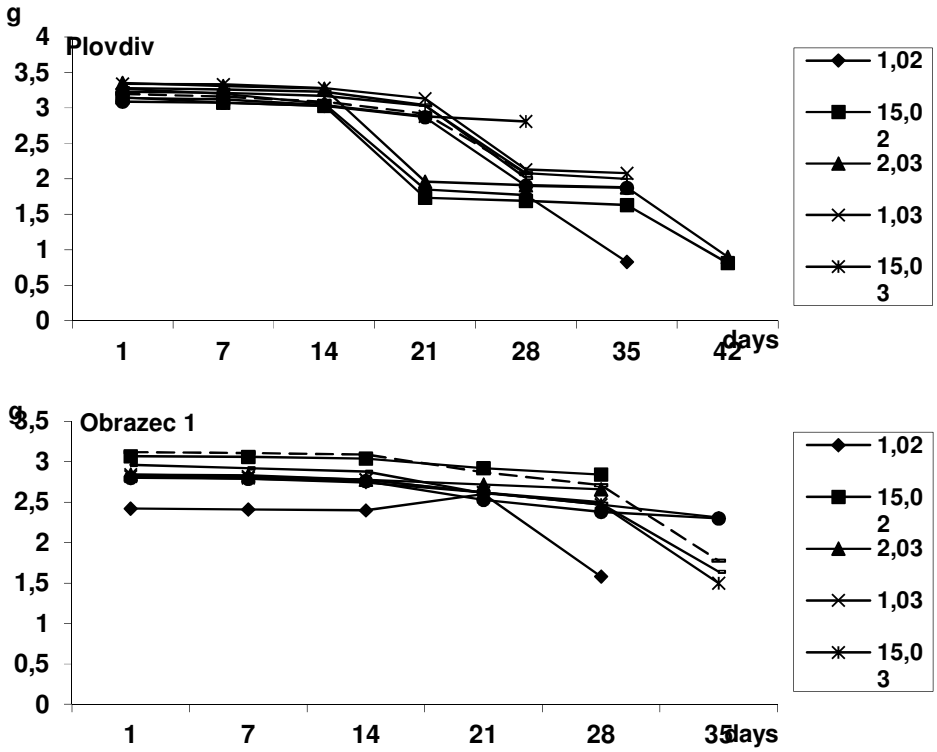

Figure 2. Weight of one fruit during the period of after harvest ripening

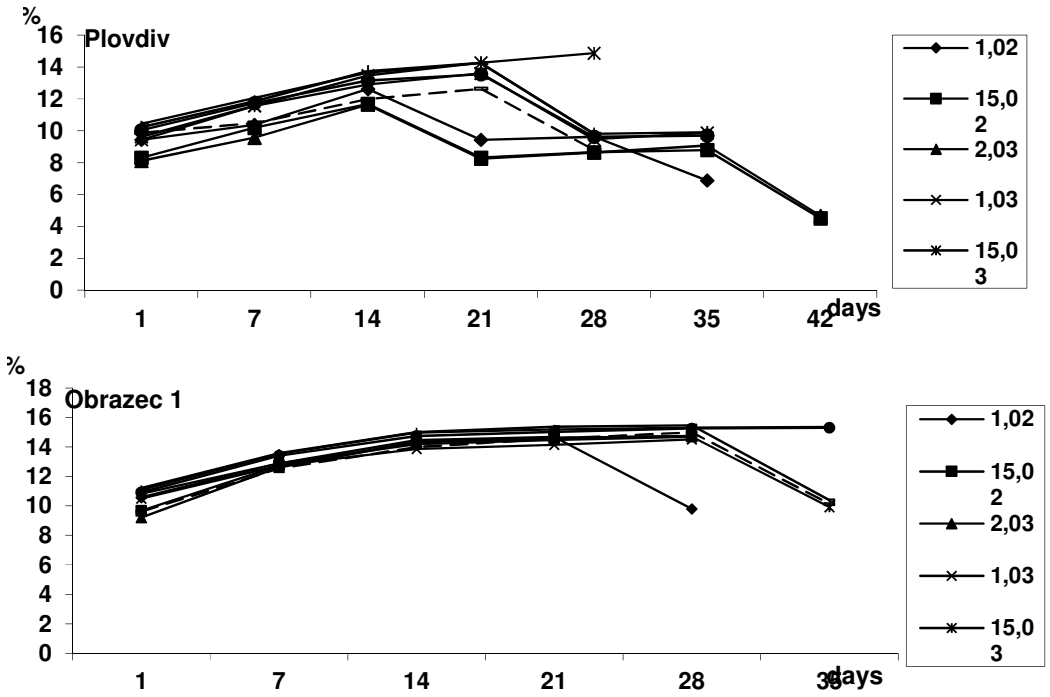

Figure 3. Content of dry mater of cape gooseberry fruits during the period of after harvest ripening

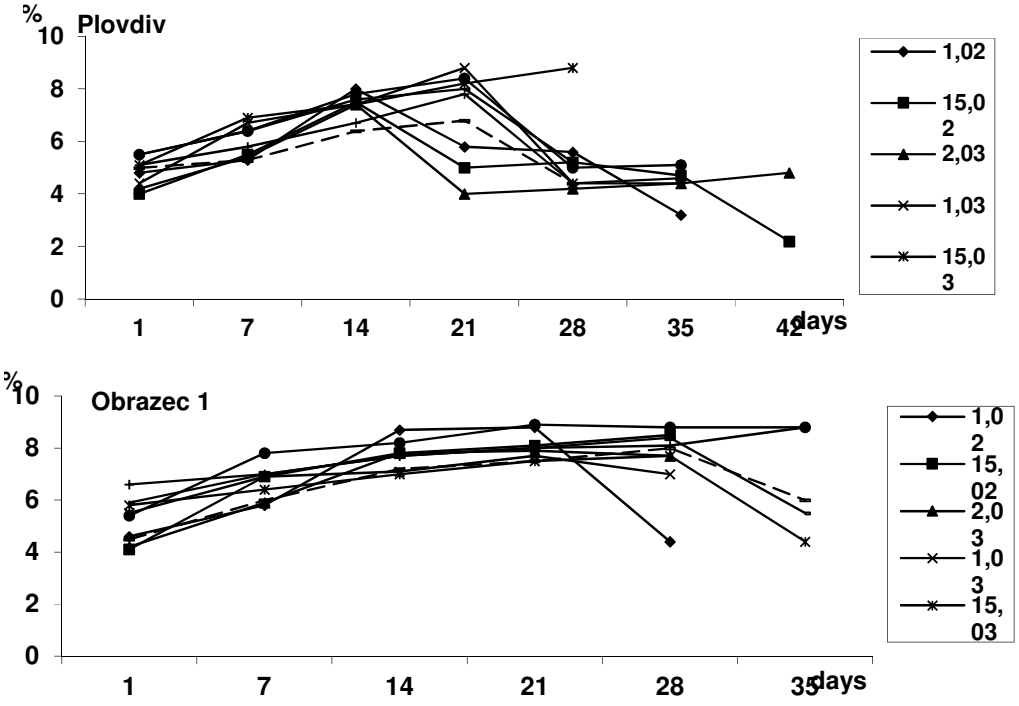

Figure 4. Content of sugar of cape gooseberry fruits during the period of after harvest ripening

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