COMPARATIVE TRIALS ON KAPIJA TYPE PEPPER CULTIVARS

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Abstract

The experiment was carried out on two locations in the region of Strumica – Boriovo village and Dobrejci village. Four pepper cultivars of the kapija type have been examined: *kaloca*, KP2, KP3 and KP4. All four were compared to the referent variety, well known on the market as *slonovo uvo*. The following traits and characteristics were recorded: duration of different phases of vegetation [days], plant height [cm], number of fruits per plant (percentage of pollination) [%], fruit weight [g], pericarp thickness [mm], consumable fruit portion [%], total yield [t/ha] and chemical composition of the fruit. In general, among the examined cultivars grown in the region of Strumica in comparison to the reference cultivar *slonovo uvo,* the best results were registered in the cultivars *kaloca* and KP2. As a result of the excellent plant structure, good uniformity, the shape and the color of the fruit, these two cultivars can be well established on the markets in the Republic of Macedonia. Both cultivars exhibited better results in comparison with the reference variety regarding the number of fruits per quality class, better characteristics of the fruit, and as the most significant nutritional value, vitamin C content was also higher. The cultivar *κaloca* obtained total yield 75 t/ha, with statistical difference on the level 0,05 in comparison to reference cultivar while KP2 obtained 68,37 t/ha with no statistical differences in comparison to the reference cultivar. It can be concluded that these two cultivars meet all the criteria for a high quality final product. Their placement on the market will result with relevant income for the growers on one hand, but it will also fulfill the expectations of the fresh product consumers and processing industry on the other.

Keywords: varieties, greenhouse production, yield, fruit quality.

Introduction

The Capsicum pepper (*Capsicum annuum* L.) is one of the most widely grown crops in the Republic of Macedonia. The soil and climate conditions for growing peppers in the country are very favorable. According to production area and usage, the pepper dominates among vegetables. Major pepper varieties grown for processing industry are *kurtovska kapija*, amphora, slonovo uvo and others. Pepper variety *kurtovska kapija* is the leading variety, especially in the Strumica region. The pepper production has steady growth, both in terms of area and in terms of total yield. Average yield per hectare is around 16 tones for the period of last ten years 2002-2012. Pepper type kapija produced in the Republic of Macedonia is of high quality and that is why it is needed both on the domestic and foreign market as raw material for processing (Jankulovski, 1997). According to the Macedonian Association of Processors peppers - type kapija accounted for most of the purchased fruits and vegetables, as it is used in preparation of many traditional Macedonian dishes: ajvar, lutenica, djuvec etc. In 2012, this type of pepper accounted for approximately 60% of purchased fruits and vegetables, or around 42000 tons. Sudden climate changes in the recent years which affected the territory of Macedonia lead to the abandonment of the cultivation of pepper in the open field and the growth of obsolete varieties and hybrids of pepper (Tanaskovic et al, 2007). A major factor in abandoning outdoor cultivation is the strong temperature fluctuations during the day and night, which represent a great shock for continued normal function of plants (Bar-Yosef, 1995). The goal is to use high quality seeds of varieties / hybrids that will be able to meet all the needs of the farmer, market and industry (Ivanovska and Popsimonova, 2006). The objective of this research is to place a

variety/ hybrid on the market that will be more tolerant of drastic climate change (such as high temperatures in the summer period and high solar insolation), particularly in the Strumica region, where most of the vegetable production in Macedonia is located.

Material and methods

The experiment was conducted in greenhouses at two locations in the Strumica region: Borievo village and village Dobrejci. Four varieties and hybrids of the pepper type kapija were tested: *kaloca*, KP2, KP3 and KP4. All varieties/hybrids were compared with existing varieties on the market – "*slonovo uvo*". Identical agriculture techniques and operations were applied to all varieties in order to assure high quality production. A drip irrigation system was used, which enabled precise irrigation with simultaneous application of fertilizers, or in other words fertigation was applied in both locations. Experimental plots included 50 plants in four repetitions in a randomized block system. Fruit traits were done in technological maturity of 10 fruits from each repetition.

The following characteristics were examined:

1. Stages of growth [days]
2. The height to the first branching and plant height [cm]
3. Number of fruits per plant
4. Fruit set (percentage of pollination) [%]
5. Fruit weight [g]
6. Pericarp thickness [mm]
7. Consumable fruit portion [%]
8. Total yield [t/ha]
9. The chemical composition of the fruit

Measurement of the fruit weight, as well as determining the consumable fruit portion was made using a precision electronic balance to the second decimal and pericarp thickness was measured by caliper tool. The description of the shape and color of the fruit was made by IPGRI descriptor for pepper. The number of marketable fruits per plant and their classification in quality classes was done according to the Rules for the quality of fresh fruit and vegetables for processing according the Law on Quality of Agricultural Products. Prior to descriptive statistics of the investigated traits of varieties/hybrids a t-test was done in order to detect any difference between the results obtained in both experimental locations. Such differences were statistically insignificant and therefore the results presented in the paper are the result of analysis of variance in eight repetitions for each tested property while for total yield an analysis of variance (ANOVA) for one factor (variety/hybrid) was done. Chemical analysis of the fruits was done in the Laboratory of Fruit and Vegetables processing at the Faculty of Agricultural Sciences and Food in Skopje. The following parameters were examined:

a) Percentage of dry matter and water – via the gravimetric method
b) Ash - dry mineralization,
c) Percentage of total acids - by volumetric method and
d) Vitamin C content - method according Tillmans.

Results and discussion

Technological and botanical fruit maturity in different varieties of peppers has a different duration, depending on agro-ecological conditions and agricultural technical practices applicable to their cultivation. Different authors give various lengths of the vegetation period of the peppers. Thus, according Aladzajkov (1966) the vegetation period of pepper to technological maturity is 95-115 days, and the botanical maturity 119-143 days. On the other hand, Jankulovski (1983) states that according to the length of the duration of the vegetation period from sprouting to botanical maturity varieties, peppers can be divided in early varieties with vegetation period from germination to botanical maturity not exceeding 120 days, middle varieties from 121 to 140 days and late varieties with vegetation period with more than 140 days.

Table 1. Length of vegetation period in tested varieties / hybrids

Variety/Hybrid	Transplanting	Flowering	Fruit set	Botanical maturity	Total days
KP 2	17.07.2012	10.08.2012	01.09.2012	20.10.2012	94
KP 3	17.07.2012	12.08.2012	04.09.2012	25.10.2012	99
KP 4	17.07.2012	07.08.2012	28.08.2012	17.10.2012	91
slonovo uvo	17.07.2012	12.08.2012	04.09.2012	27.10.2012	101
caloca	17.07.2012	10.08.2012	02.09.2012	20.10.2012	94

The vegetation period is a time expressed in days from sprouting to first fruits in the botanical maturity. But in production, depending on the type of purpose the pepper is grown for, the term 'earliness' is used to describe the technological and botanical maturity of fruit. Taking into account that pepper-type kapija is used for industrial processing and the fact that examined varieties were grown in protected areas, observation was done on stages of growth from planting to botanical or physiological maturity. For all varieties/hybrids, sowing was carried out on 03.06.2012 and transplanting on 17.07.2012. According to the observed stages of development in the examined varieties/hybrids, shown in Table 1, the earliest flowering and fruit set was observed in KP 4. This hybrid gave the most flowers and fruits set, however, the development of the whole plant and marketable fruits were of lesser quality in comparison to other varieties and hybrids that had longer vegetation periods. According to the height of the plant, Popov (1940) and Jankulovski (1983) grouped pepper varieties in: low (30-40 cm), medium high (46-65 cm), high (66-90 cm) and very high (over 90 cm).

Table 2. Plant high [cm]

Variety	Repetition in location 1 and 2								Mean
	I		II		III		IV		
	1	2	1	2	1	2	1	2	
KP 2	84,60	82,70	89,80	90,20	101,90	103,70	97,70	93,70	93,03
KP 3	81,30	76,30	82,50	81,60	96,30	89,50	95,00	86,80	88,70
KP 4	93,00	76,30	90,00	81,60	88,50	89,30	86,00	85,20	89,30
slonovo uvo	86,00	81,00	91,50	88,50	83,00	98,50	77,50	88,20	84,50
kaloca	97,00	96,00	105,00	104,00	98,00	101,00	101,00	99,70	100,25

Location 1 Borievo
Location 2 Dobrejci

Table 2 shows the values for plant height in both locations. The highest value was observed in hybrid *kaloca* (100,25 cm), followed by the variety/hybrid KP 2 (93,03 cm). According to the categorization of Popov (1940) and Jankulovski (1983), these two genotypes belong to the very high varieties, while other observed varieties/hybrids belong to the group high varieties.

Table3.Percentage of fruit set in examined varieties/hybrids [%]

	KP 2	KP 3	KP 4	*slonovo uvo*	*kaloca*
Number of flower per plant	18,00	18,25	20,00	17,25	17,50
Number of fruit set	13,30	12,45	16,50	14,25	12,00
Percentage of pollination	73,89	68,22	82,50	82,61	68,57
Marketable fruits	9,10	11,00	7,80	9,10	8,80

Tested varieties/hybrids formed relatively uniform flowers high in number (Table 3). Although cultivation in protected areas can disrupt pollination due to high temperatures, the number of fruit

set as a percentage of pollination was extremely high - 68, 57% in *kaloca* to 82.50% in KP 4. These values are somewhat higher than those in the examinations of Trajkovska (2013) where she discovered that androgenic types of *kurtovska kapija* reached approximately 60% pollination. The same table also shows the average number of marketable fruits, where the variety/hybrid KP 4 has the lowest number of marketable fruits in spite of having the highest percentage of pollination. This disadvantage can be interpreted as the weaker habitus of the plant which can't feed all fruit sets.
Regular harvesting of fruits in technological maturity results in the formation of more generative organs or fruits providing reliable reproduction. If the fruits are left to reach botanical maturity, the plant uses assimilates for maturation of fruits, due to the number of fruits per plant which is smaller (Jankulovski, 1983).

Table 4. Number of fruits in quality classes for plant and percentage of proportional representation of quality classes

	I-class		II-class		III-class		Total	
	Number of fruits	%	Number of fruits	%	Number of fruits	%	Number of fruits	%
KP 2	6,00	66	1,60	18	1,50	16	9,10	100
KP 3	4,70	43	3,30	30	3,00	27	11,0	100
KP 4	5,50	71	1,80	23	0,50	6	7,80	100
slonovo uvo	5,30	58	2,00	22	1,80	20	9,10	100
Kaloca	7,30	83	1,00	11	0,50	6	8,80	100

The number of formed fruits per plant is an important economic feature of the pepper, but more important is the percentage of fruit formation which is first class. The difference in purchase price between first and second class is 100%, which determines the profitability of production. According to the results presented in table 4 the highest average number of fruits per plant is found the variety/hybrid KP 3 but only 43% of those fruits are first class quality. As shown in table 4, the highest percentage of first class fruit was registered in *kaloca* (83%), followed by the variety/hybrid KP 4 with a 71% share in first class. Pericarp is a useful part of the pepper fruit. Thickness of pericarp is a variety characteristic, conditioned by the technology of cultivation and agro-ecological conditions. Gvozdenović (2010) and Jankulovski (1997) classified peppers according the thickness of the pericarp as such:
- Very thin (0,5 mm), poorly fleshy peppers
- Thin (1-2 mm), slightly thin peppers
- Mean (2-4 mm), intermediate fleshy peppers
- Thick (4-6 mm), fleshy peppers
- Very thick (6-10 mm), very fleshy peppers.

This characteristic is related to the size of the fruit. Most often, small size peppers have thinner pericarp and large size peppers have thicker pericarp. Varieties with thinner pericarp are characterized by a smaller percentage of usable parts of the total weight of the fruit, but when used for processing in the dry state, such as red pepper powder, usable value is higher in varieties with thinner pericarp. The purpose of the production of certain pepper varieties depends on the thickness of the pericarp (Jankulovski, 1983). The thickness of the pericarp was relatively uniform within studied varieties/ hybrids, and there were no big difference among the tested varieties as shown in Table 5. The highest value for the thickness of the pericarp was determined in the variety/hybrid KP 2 (6, 24mm) which is slightly higher than the control variant *slonovo uvo* (6,16mm). The dimensions of the fruit, shape and weight of the fruit of the pepper by Andrews (1995) are highly variable and mainly determined by genetic and environmental factors. Less data has been acquired for the pepper regarding the genetic causes of these fluctuations compared with the findings on the tomato as a representative of the family Solanaceae (Russo, 2012). The formation of the fruit and its shape is determined by several external factors, especially temperature. More authors (Rylski, 1973, Rylski and Spigelman, 1982, Olareweju, 1988, Aloni et al., 1999) stated that if the temperature in the phase

of fruit formation is lower than 16°C, fruits are deformed, atypical for the variety and damaged. According to Gvozdenović (2010), the size of the fruit of the pepper can be: very large (weighing over 150 g), large (weighing 40-150 g), medium large (weighing 10-40 g), small (with weight of 4-10 g), very small (less than 4 g). According to the values of fruit mass, shown in Table 6, the largest mass of the fruit was achieved by the hybrid *kaloca* (120,43g). In comparison to the referent variety *slonovo uvo* (103,35g), KP 2 (108,05g) and *kaloca* (120,43g) had higher values of fruit mass.

Table 5. The thickness of the pericarp in tested cultivars / hybrids [mm]

	KP 2	KP 3	KP 4	*slonovo uvo*	*κaloca*
I	5,86	6,36	6,00	6,14	5,86
II	6,87	5,14	5,54	6,14	5,00
III	6,14	5,14	6,00	6,14	6,04
IV	6,14	6,00	5,80	7,01	5,14
V	6,73	5,20	6,00	6,00	5,39
VI	6,14	6,00	6,87	6,00	5,88
VII	6,14	5,86	5,60	5,86	5,12
VIII	5,88	5,14	4,90	6,00	6,36
Mean	6,24	5,61	5,84	6,16	5,60
Standard error	0,13	0,18	0,20	0,13	0,18
Standard deviation	0,37	0,50	0,56	0,36	0,50
Variance Width	1,01	1,22	1,97	1,15	1,36

Table 6. Fruit mass in tested varieties / hybrids[g]

	KP 2	KP 3	KP 4	*slonovo uvo*	*kaloca*
I	112,00	87,00	73,20	94,00	111,00
II	97,50	92,70	90,70	97,20	109,50
III	114,70	72,20	64,50	114,20	125,70
IV	96,00	116,00	68,90	106,40	130,60
V	114,70	102,60	80,10	111,00	113,20
VI	102,30	104,50	85,00	107,00	110,20
VII	126,50	84,50	83,50	96,00	130,80
VIII	100,70	104,50	97,20	101,00	132,40
Mean	108,05	95,50	80,39	103,35	120,43
Standard error	3,75	4,96	3,91	2,62	3,65
Standard deviation	10,61	14,02	11,06	7,40	10,33
Variance Width	30,50	43,80	32,70	20,20	22,90

Consumable fruit portions are calculated as the ratio of fruit mass without seeds and placenta and whole fruit mass. In large pepper types, such as type *kurtovska kapija*, stem and seeds placenta and seeds amounting to 40% of the total weight of the fruit (Gvozdenović, 2010).

Consumable fruit portions for tested varieties/hybrids varied from 84.13% in the variety/hybrid KP 4 to 90.29% in the variety *slonovo uvo* which is a slightly higher percentage than the results of Gvozdenović (2010) who reports 82.6% consumable fruit portion in the variety *kurtovska kapija*. The yield per unit area of pepper depends on the variety type and producers are interested in varieties that will ensure high and quality yield. The yield is determined by several characteristics of peppers that are in particular dependence and correlation. The yield of pepper is positively correlated to the

number of fruits per plant and the weight of the fruit, which means that plants with more and larger fruits will have a higher yield per plant (Gvozdenović and Cvejić, 2009).

Table 7. Consumable fruit portionin tested varieties/ hybrids [%]

Variety/ Hybrid	Repetition per location 1 and 2								Mean
	I		II		III		IV		
	1	2	1	2	1	2	1	2	
KP 2	87,50	86,70	89,80	88,70	85,60	84,20	90,30	89,40	87,78
KP 3	86,70	83,00	85,20	78,10	85,30	82,40	88,30	84,00	84,13
KP 4	88,50	86,20	89,30	83,10	88,80	82,50	90,40	84,30	86,64
slonovo uvo	91,30	87,90	90,60	90,60	92,40	88,60	91,20	89,70	90,29
Kaloca	85,00	87,20	86,00	85,10	92,00	90,20	87,00	86,00	87,31

Location 1 Borievo
Location 2 Dobrejci

For high yield of pepper with good quality of the fruits, it is important to fulfill certain external conditions, such as an average temperature of 21-23^{o}C during vegetative growth and 21°C during fruit growth (Bakker and van Uffelen, 1988). The yield is higher when daily ambient temperature during flowering is 18-31^{o}C (Aloni et al., 1999). The yield is limited by the adverse impact of high temperatures during flowering and harmful effects of low temperatures on the shape of the fruit (Rylski and Spiglman, 1982).

Table 8. Total yield in tested varieties/hybrids [t/ha]

	KP 2	KP 3	KP 4	*slonovo uvo*	*kaloca*
I	62,37	55,04	50,65	67,42	69,79
II	64,90	62,78	56,43	71,67	73,70
III	68,42	50,58	57,78	74,76	79,94
IV	64,24	70,30	58,90	61,51	78,33
V	77,64	72,93	60,20	66,85	64,44
VI	68,53	64,02	64,75	65,32	79,07
VII	70,60	64,42	63,77	72,80	74,32
VIII	70,28	63,97	60,57	63,35	81,20
Mean	68,37	63,01	59,13**	67,96	75,10*
Diference	+0,41	-4,96	-8,83	0,00	+7,14
LDS 0,05	5,55				
LSD 0,01	7,43				

Jankulovski (1983) pointed out that, depending on the variety, purpose for which the variety is grown, agro-technical measures and climate conditions, the yield of pepper can be: for early production of 40 to 50 t/ha, for later production of 20 to 25 t/ha and production of pepper varieties for red powder of 12 to 20 t/ha. The same author groups pepper varieties for early, middle and late production according to yield per hectare as the following:

1. Varieties with low yield - 20 t/ha;
2. Middle yield varieties - from 21 to 35 t/ha;
3. High yield varieties - from 36 to 50 t/ha and
4. Very high yield varieties - with over 50 t/ha.

According to the above categorization, all tested hybrids/varieties belong to the group of very high yield varieties, due to the intensive nature of farming. The highest yield was observed in the *kaloca*

hybrid with 75,10 t/ha and in comparison to the control variety *slonovo uvo* the difference in yield was statistically significant at the level of probability of 0.05. The lowest yield gave variety/hybrid KP 4 (59,13 t/ha) with statistically high significant difference at level of 0.01 (Table 8).
Results of chemical composition of pepper fruits of different tested varieties/hybrids are described in table 9. The highest value of water content was observed in the variety/hybrid *kaloca* (91,928 %) while the lowest in the variety/hybrid KP2 (90,691%). The rest of the varieties/hybrids had lower water content in comparison to the control variety *slonovo uvo* (91,652%).

Table 9. Chemical composition of pepper fruits in tested varieties/hybrids

Variety/Hybrid	Water (%)	Dry matter (%)	Ash (%)	Total acids (%)	Vitamin C (mg/100g)
slonovo uvo	91,652	8,348	0,301	0,292	125, 004
kaloca	91, 928	8, 072	0,328	0,284	147, 548
KP 2	90,691	9,309	0,273	0,289	140,466
KP 3	91,126	8,874	0,294	0,273	149,443
KP 4	90,882	9,051	0,374	0,225	133,397

In terms of dry matter content, the control variety/hybrid contained 8,348% dry matter while the least dry matter content was in the *kaloca* (8,072%). The variety/hybrid KP2 had the highest percentage of dry matter (9,309%). In the research of Babamovska-Milenkovska et al. (2016) the dry-matter content in the variety *kurtovska kapija* (9,58%) was similar within the varieties/hybrids KP2 (9,309%) and KP4 (9,051). The largest deviation in ash content occurred in the variety/hybrid KP4, where the ash content was highest and amounted to 0.374%, while the lowest percentage of ash content occurred in the variety/hybrid KP2. The content of total acids in all tested varieties/hybrids was lower than referent variety/hybrid *slonovo uvo* (0,292%). The variety/hybrid KP4 had the lowest percentage of total acids (0,225%). According to the results of Babamovska-Milenkovska et al. (2016), the content of total acids in fresh fruits of *kurtovska kapija* variety was 0,333% which is higher in comparison to tested varieties/hybrids. The content of vitamin C was lowest in the control variety/hybrid *slonovo uvo* (125,004 mg/100g) while the highest content of vitamin C was found in the variety/hybrid KP3 (149,443 mg/100 g).

Conclusions

In general, all tested varieties/hybrids of pepper grown in the Strumica region exhibited good results. The best results in comparison with the control variety/hybrid *slonovo uvo* were achieved in *kaloca* and KP 2. Because of the excellent vigorous plants, uniformity in shape and color of fruits and their nutritional value, varieties/hybrids KP 2 and *kaloca* can reach a high status on the market in The Republic of Macedonia. Both mentioned varieties/hybrids compared with the control variety/hybrid showed a higher number of fruits per plant in all three classes, better and more typical form of the fruit, and as a significant trait in terms of nutritional value, these two varieties/hybrids had higher vitamin C content compared to the control variety/hybrid. Their placement on the market will result in relevant income for the growers, on one hand, but it will also fulfill the expectations of the fresh product consumers and processing industry, on the other.

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