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*E-mail: stefanova_b@abv.bg

Characteristics of introduced plum cultivars under the conditions of Troyan region

Ivan Minev, Boryana Stefanova*, Georgi Popski

Research Institute of Mountain Stockbreeding and Agriculture, 281 Vasil Levski Str.,
5600Troyan, Bulgaria

SUMMARY

Pomological characteristics of the following plum cultivars were studied: ' a anska lepotica', ' a anska Najbolja', ' a anska Rodna', 'Katinka', 'Top first', 'Tegera', 'Hanita', 'Jojo', 'Stanley', under soil and climate conditions of Troyan region. Trees in the period of full fruit bearing were being observed. Flowering phases and fruit ripening periods were determined, as well as fruit and stone weight. The main biochemical composition of fresh fruits was examined.

The examined plum cultivars covered a harvesting period from the second decade of July to the second half of September. The fruits of 'Katinka' and 'Top first' ripened most early, and 'Elena' was the latest. The fruits of the control cultivar - 'Stanley', ripened in the period of 25.08-05.09, as in most cases in the end of August. The fruit sizes varied from 20,4 g, for 'Katinka' cultivar, to 47,4 g – ' a anska najbolja'. The fruit skin colouring was dark blue for most of the cultivars, as it was dark purple only for

25.08-05.09,
20,4
g 47,4 g

9,40% () 11,95% ().

' a anaska rodna' and 'Katinka'.

Total sugars in the fruits of the tested cultivars ranged from 9,40% (a anaska Najbolja) to 11,95% (a anaska Lepotica and Stanley). The content of invert sugar is significantly higher than that of sucrose and only in the control are similar values.

The susceptibility to plum pox virus was determined under the field conditions and damages on different cultivars. All of the studied cultivars, with the exception of 'Jojo', were vectors of the virus with symptoms on their leaves. There were no typical disease signs on fruits recorded.

Key words: pomologia, plum, cultivars, biological characteristics, sharka disease

al., 1977).

(Trifonov, 1977).

(Iliev et

INTRODUCTION

Plum is traditional for Bulgarian fruit growing (Iliev et al., 1977). In recent years, due to wide dissemination of viral disease of sharka (Plum pox virus), the main cultivar for plum production was 'Stanley' (Trifonov, 1977). When only one cultivar is used, there is tension during harvesting and processing of production and shortens the period of fresh fruit supplying for the market. On the other hand, the rapidly changing market demands and organic fruit production require the establishment of plantations with new varieties. Many of the newly created cultivars are derived under specific soil and climate conditions. Before introducing them on a large scale in the practice in other regions and habitats, it is necessary to test them and to determine their economic qualities.

(Dinkova et al., 2010; Stefanova et al., 2010)

In RIMSA-Troyan are grown and examined newly-introduced German and Serbian cultivars (Dinkova et al. 2010; Stefanova et al. 2010).

The aim was to determine the suitability of plum cultivars, such as

- ' a anaska lepotica', ' a anaska Najbolja',
- ' a anaska Rodna', 'Katinka', 'Top first',
- 'Tegera', 'Hanita', 'Jojo', 'Stanley' for
- growing in Troyan region and to study fruit
- quality and the behaviour towards viral
- disease of sharka (Plum pox virus).

MATERIAL AND METHODS

Pomological characteristics of the following plum cultivars were studied: ' a anaska lepotica', ' a anaska Najbolja', ' a anaska Rodna', 'Katinka', 'Top first', 'Tegera', 'Hanita', 'Jojo', 'Stanley', grown under soil and climate conditions of Troyan region. 'Tegera', 'Hanita', 'Jojo' and Elena were imported from Germany and planted in 2003 on FAMAD project, while 'Katinka' and 'Top first' were grown in 2006. Trees in the period of full fruit bearing were being observed.

Flowering phases and fruit ripening periods were determined, as well as fruit and stone weight, and fruit colouring. Chemical analysis of fresh fruits was performed. Trees were grown on light-grey forest soil, under non-irrigated conditions, with row tillage.

Field surveys were conducted in May and June in order to determine the health condition of cultivars towards sharka virus. Their susceptibility was determined according to the following scale of Methods for studying the plant resources in fruit plants (Nedev et al., 1979):

/ Degree of susceptibility	
/ Immune	/ They are not infected by the virus
Resistant	There are no typical disease signs on fruits and leaves
Tolerant	/ There are typical signs on leaves, slightly obvious on fruits, without affecting the quantity and quality of the harvest
Susceptible	/ There are clear signs on leaves and fruits and strong deterioration in fruit quality
Highly susceptible	There are severe signs on leaves and fruits, accompanied by prematurely dropping off of fruits

RESULTS AND DISCUSSION

The studied plum cultivars grow and develop well under the conditions of Troyan region. Trees and crowns are characteristics for the relevant cultivar with sizes that corresponded to their age. Only 'Hanita' cultivar turns to be susceptible to extreme abiotic factors.

Freely growing crown and too much fruit led to dying out of skeletal branches. In combination with drought in 2012 and high temperatures in that period, 60-70% of trees perished.

According to the period of flowering, plum cultivars under study fell into the group of mid-season flowering. In most cases during years, flowering occurred in April as in different cases it finished in the beginning of May. 'Jojo' is the earliest flowering cultivar, as during the years of study the beginning was recorded in the period 24.03-18.04, followed by 'Tegera' – 28. 03, ' a anaska Najbolja' – 29.03.

The latest flowering started for ' a anaska Lepotica' and 'Katinka'. For control cultivar of 'Stanley', the beginning of flowering was in the period of 28.03 – 25.04.

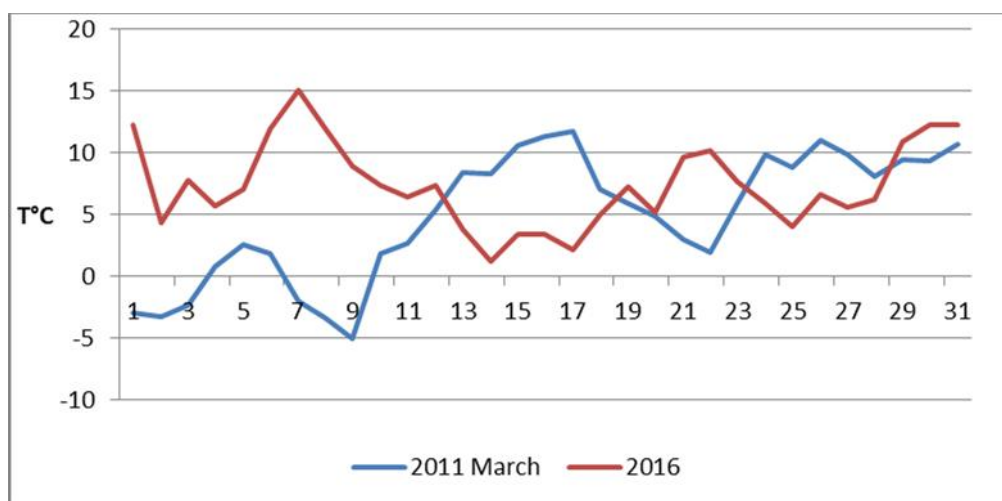
The flowering of 'Tegera', 'Hanita' and 'Jojo' cultivars was the latest – the first ten days of May.

' a anaska Lepotica', ' a anaska Najbolja', 'Tegera', 'Elena' had a huge blooming force. In most years, the duration of flowering for different cultivars was 5-8 days, as it was the longest for 'Stanley' and 'Jojo' (Table 1).

The earliest flowering for studied varieties was in 2016 - in the first half of April, and the latest in 2011. – third decade of April and first decade of May. The reason for that were the higher temperatures in March 2016, causing earlier development (Figure 1).

During the study period there were no spring frosts recorded.

		2012	
	60-70%		
28.03,	24.03-18.04,	29.03.	
		28.03-25.04.	
		5-8	
	(1).	
		2016	
2011	–		
		2016,	
		(1).



1. - 2011 2016 .
Fig. 1. Daily average temperatures for March – 2011 and 2016

(14.07.) (28.07.),
 - (16.09).
 ,
 6-8
 23.08-3.09,
 (1).

The examined plum cultivars covered a harvesting period from the second decade of July to the second decade of September. Fruits of 'Katinka' (14.07.) and 'Tegera' (28.07.) reached the earliest ripening stage, and 'Elena' cultivar was the latest. In relation to climate conditions during recent years, the beginning of fruit ripening for various cultivars varied with 6-8 days. The control cultivar of 'Stanley' became ripen in the period of 23.08-3.09, in most cases in the end of August (Table 1).

1. **2010-2016**
Table 1. Beginning and end of flowering and ripening of fruits average for 2010-2016

Cultivars	Beginning of flowering	End of flowering	Fruit ripening
a anaska Lepotica	2.04-20.04	12.04-30.04	12.08-18.08
a anaska Rodna	30.03-26.04	6.04-1.05	17.08-24.08
a anaska Najbolja	29.03-24.04	5.04-3.05	25.08-04.09
Katinka	3.04-15.04	9.04-22.04	14.07-22.07
Top First	1.04-12.04	10.04-24.04	11.08-17.08
Tegera	28.03-23.04	7.04-7.05	28.07-07.08
Hanita	1.04-22.04	9.04-5.05	17.08-24.08
Jojo	24.03-18.04	5.04-10.05	27.08-02.09
Elena	30.03-25.04	8.04-2.05	9.09-16.09
Stanley	28.03-25.04	8.04-3.05	25.08-03.09

The fruits of ' a anaska Lepotica', 'Tegera', 'Elena' and 'Jojo', which became

47,4 g, (2).
20,4 g
32,5 g.
0,9 g 2,1 g
1,2-1,4 g. -
5,9%,
4,1% 5,4 %.

ripen, remained on the tree for a long period without to drop off.

The plum cultivars, which are grown and studied in the region, allow to receive fruit with good economic qualities. All of them have blue coloring of the fruit skin, with purple nuance for 'a anaska Rodna', 'Katinka' and 'Top First'. Their size varied from 20,4 g to 47,4 g, which specified them in the groups of large-sized and very large-sized (Table 2). The fruit size was not large enough for 'Katinka' cultivar, but the harvest was good due to high fruitfulness. The fruit of 'a anaska Najbolja' had the largest size. The fruits of 'a anaska Lepotica', 'Top First' and 'Jojo' had the largest size, which exceeded the control cultivar of 'Stanley' with fruit weight (32,5 g). The stone weight for different cultivars varied from 0,9 g for 'Katinka' to 2,1 g for 'a anaska Najbolja', as for most of them it was 1,2 – 1,4 g. There was the highest relative share for control cultivar of 'Stanley' – 5,9%, and for rest of the cultivars it was from 4,1% to 5,4 %. It was from detached to semi-detached, but during the years there were differences in the extent of its detachment.

2. – 2015
Table 2. Characteristics of plum cultivars – harvest 2015

Cultivars	Fruit weight (g)	Stone weight (g)	Share of the stone (%)	Stone detachment	Fruit skin colouring
a anaska Lepotica	33,8	1,4	4,1	/Yes	Dark blue
a anaska Rodna	26,7	1,2	4,4	/Yes	Dark purple
a anaska Najbolja	47,4	2,1	4,4	/Yes	Dark blue
Katinka	20,4	0,9	4,4	/Yes	Dark purple
Top First	38,9	2,0	5,1	Semi-detached	Dark purple
Tegera	30,5	1,4	4,5	/Yes	Dark blue
Hanita	26,7	1,4	5,2	Semi-detached	Dark blue
Jojo	35,4	1,9	5,4	Semi-detached	Dark blue
Elena	23,4	1,2	5,1	Semi-detached to detached	Dark blue
Stanley	32,5	1,9	5,9	Semi-detached	Dark blue
<i>LSD 0.05</i>	<i>3.94</i>	<i>0.22</i>			

3.

Table 3. Chemical composition of fruit

Cultivars	SS in R %	Total sugars %	Inverted sugars %	Sucrose %	Acids %	Tanning substances %	Anthocyanins mg%
a anska Lepotica	20,25	11,95	8,20	3,56	0,57	0,229	25,48
a anska Rodna	17,15	9,90	5,70	3,99	0,51	0,145	19,84
a anska Najbolja	17,00	9,40	5,50	3,71	0,64	0,145	20,48
Katinka	15,50	9,85	6,05	3,61	0,34	0,166	11,72
Tegera	15,50	9,55	8,05	1,43	0,57	0,166	7,90
Hanita	16,75	10,05	6,15	3,71	0,60	0,103	21,61
Jojo	21,12	9,55	7,59	1,52	0,45	0,160	4,19
Elena	21,00	10,95	6,92	3,82	0,45	0,220	8,39
Stanley	23,30	11,95	6,00	5,50	0,51	0,240	4,60

(3).
9,40% (
) 11,95% (
).
,
-
1,43% 1,42%.
0,34%
0,64%
-
,
23,3% 15,5%
-
0,103 0,240 %
0,140 % 0,160 %.

Plum cultivars have abundant biochemical composition (Table 3).

The total sugar content in fruits of studied cultivars varied from 9,40% (' a anska Najbolja') to 11,95% (' a anska Lepotica' and the control cultivar of 'Stanley'). The share of inverted sugar was relatively higher than sucrose, as only for the control they had close values

'Tegera' and 'Jojo' cultivars had the lowest content of sucrose, respectively 1,43% and 1,42%. The acid content varied from 0,34% in 'Katinka' to 0,64% in ' a anska Najbolja'.

The dry matter values determined by the refractometer range from 15,5% for Tiger to 23,3% for Stanley. For all varieties, the content is lower than the control.

The content of tanning substances ranges over a wide range from 0,103% at Hanit to 0,240% at Stanley. In most varieties it is from 140% to 160%.

As they were grown with high density of Plum pox virus, the rate of infection for various cultivars was different. The number of infected trees during years, for 'Tegera', 'Hanita', 'Elena' and ' a anska Lepotica' is presented on Figure 2. The virus spread fastest on

4.

Table 4. Susceptibility to sharka and symptoms on leaves and fruits

Cultivars	Degree of susceptibility	Symptoms on leaves	Symptoms on fruits
a anska Lepotica	/Resistant	Medium occurrence	Spots with different colouring
a anska Rodna	/Tolerant	High occurrence	Spots with different colouring
a anska Najbolja	/Resistant	Slight occurrence	/None
Katinka	/Resistant	High occurrence	/None
Top First	/Resistant	On single leaves	/None
Tegera	/Tolerant	High occurrence	/Spots with different colouring
Hanita	/Tolerant	High occurrence	/None
Jojo	/Immune	/None	/None
Elena	/Tolerant	High occurrence	/None
Stanley	/Tolerant	/Single leaves with symptoms	/None

CONCLUSIONS

The tested plum cultivars find favourable conditions for growth and development in Trojan region. There were no good results only for 'Hanita' cultivar due to the growing system and extreme conditions in 2011 and 2012.

The studied cultivars had average early flowering period. In most cases during years, it occurred in April.

The examined plum cultivars covered a harvesting period from the second decade of July to the second decade of September. Fruits of 'Katinka' (14.07) and 'Tegera' (28.07.) reached the earliest ripening stage, and 'Elena' cultivar was the latest (16.09.).

'Jojo' cultivar proved as immune to the viral disease. There were no symptoms on leaves and fruits. The rest of the cultivars were resistant and tolerant. Symptoms of sharka (Plum pox virus) on fruits occurred only in 'a anska Lepotica', 'a anska Rodna' and 'Tegera' in the shape of darker spots on the surface.

2011 2012 ,

(14.07.) (28.07.),
(16.09.).

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E-mail: marian_pashev@abv.bg

Influence of liquid organic fertilizer 'Aminobest' and 'Ecosist-Arbanasi' over some qualitative indicators of plum fruit of 'Stanley' cultivar

Marian Pashev

PhD student at Research Institute of Mountain Stockbreeding and Agriculture - Troyan, Dryanovo Branch, Bulgaria

SUMMARY

The results of a survey are presented on some quality indicators of 'Stanley' plum cultivar in three variants of foliar and soil treatment with the innovative organic fertilizers "Aminobest" and "Ecosist-Arbanasi", compared to the control.

Biochemical analysis was conducted for two consecutive years on 'Stanley' plum fruit as the content of dry matter, organic acids, tanning substances, glucose, fructose, sucrose and total sugars were determined.

The highest content of dry soluble solids, sugars and other nutrients was found in the stage of technological maturity of plum fruits.

Monosaccharides (glucose and fructose) are easily absorbed energy sources and do not cause high blood

18,70%	20,5%	0,80%
0,94%,		0,367%
0,651%		3,00%
4,57%,	2,8%	3,88%,
3,45%	7,08%	
10,21%	14,45%	
		:

sugar levels, unlike sucrose, which has a lower biological value.

The dry matter in fruit was from 18.70% to 20.5%. The content of organic acids was from 0.80% to 0.94%, of tanning substances from 0.367% to 0.651%, glucose from 3.00% to 4.57%, fructose from 2.8% to 3.88%, sucrose from 3.45% to 7.08% and total sugars from 10.21% to 14.45%.

Key words: plum fruit, 'Stanley', organic fertilizers, biochemical analysis, Aminobest, Ecosist-Arbanasi

INTRODUCTION

(*Prunus domestica* L.)
 (Vitanova et al., 2006).
 (Miši , 1996),
 (Lavinski, 2005).
 (Iliev et al., 1977).
 (Mondeshka et al., 2002).

Domestic plum (*Prunus domestica* L.) had been grown in Bulgarian lands since ancient times. It is a valuable fruit species, and its fruits are used for fresh consumption, for freezing, drying, sweet, jams, marmalades, compotes, juice, nectar, mousses and other derivatives (Vitanova et al., 2006). At the stage of technological maturity of fruits, the content of dry soluble substance, sugars, organic acids, tanning and colouring substances, pectin, vitamins and mineral salts is the highest. The fruits are very juicy, aromatic and delicious in general (Miši , 1996), and are a suitable dietary food for kidney disease and rheumatism, for the treatment of anemia as a tonic food, as well as for the fight against chronic diseases (Lavinski, 2005).

It has been found that the chemical composition of the fruit is influenced both by the load of the fruit tree and by the fact that the fruits are taken from the inside, from the periphery or from the top of the crown, as well as from the direction of the light (Iliev et al., 1977).

The chemical components in fruit species are primarily a varietal feature but are directly related to soil and climatic conditions and cultivation techniques (Mondeshka et al., 2002).

The use of biologically active

(Tanova and Kirilov, 2004).

(Alves et al., 2009).

(Yakimov, 2013).

- substances and biological preparations in contemporary agricultural production is an alternative to high doses of mineral fertilizers and pesticides that violate the ecological balance in agrobiocenosis (Tanova and Kirilov, 2004).

- The use of liquid bio-fertilizers is one of the organic farming practices that aims at achieving lower doses of application to achieve balanced plant nutrition by delivering many macro and microelements in digestible form, biologically active and building substances (Alves et al., 2009).

- Foliar organic fertilizer favors the absorption of nutrients from plants and increases the physiological activity of their root system.

- Fertilizing with liquid organic fertilizers improves soil fertility and increases yields of fruit trees. Their application in practice is related to the protection of the environment from pollution and is an indispensable part of organic farming. In order to protect human health, the organic production of fruit in the world and in Europe is constantly increasing, and more and more consumers are eager to consume fruit without pesticide residue. The application of liquid organic fertilizers contributes to a more delicious and healthy food and sustainable yields over time (Yakimov, 2013).

- Sugars are a basic ingredient of dry matter. Monosaccharides (glucose and fructose) do not cause high blood sugar levels. They are easily absorbed sources of energy, unlike sucrose, which has a lower biological value.

- The content of organic acids in plum fruit has a favorable effect on disorders of the intestinal tract. The presence of a large amount of mineral substances in the fruit contributes to their easier absorption by the human organism.

- The astringent taste of fruit is due to the presence of a significant amount of tanning substances. These substances, which belong to so-called protectors, bind

free radicals in case of radiation exposure. It is these actions that determine their biological and physiological significance.

The study is aimed at identifying the changes in the biochemical composition of plums of 'Stanley' variety, as a result of treatment with the liquid organic fertilizers 'Aminobest' and 'Ecosist-Arbanasi'.

MATERIAL AND METHODS

'Aminobest' is a liquid organic fertilizer based on amino acids and low molecular weight peptides in combination with soluble solutes of humic and fulvic acids. Amino acids are obtained by enzymatic hydrolysis of a protein-rich, plant component for nutritional purposes, GMO free.

Humic and fulvic acids are extracted from humus (compost) of Red California Worm.

Composition of 'Aminobest':

dry matter – 9.5-12.5%; PH 9.0-13; humic compounds – 1.65%; aminoacids – 4.02%; total nitrogen – 0.4-0.75%; micro and macro-elements: phosphorus – 0.1-0.25%; potassium – 0.55-0.7%; sodium – 0.2-0.37; calcium – 0.001-0.003; magnesium – 0.009-0.013; copper – 0.002-0.003%; zinc – 0.0003-0.0006%; manganese – 0.0005-0.0009%; iron – 0.001-0.003%; Heavy metals in%: Ni<0.0005; Cd <0.00003; Hg <0.000005; Cr <0.00003; B <0.0005.

'Ecosist-Arbanasi' is a microbial fertilizer that consists of several strains of *Bacillus subtilis* as well as bacteria, such as *Bacillus licheniformis*, *Azotobacter chroococum* and *Azotobacter vinelandii*. They are deeply cultivated as in the suspension were added molasses and high protein flour for nutritional purposes as nutrient medium.

The major strain used— *Bacillus subtilis* TS 01, was registered with No NBIMCC 8718 in the National Bank for Industrial

()

– 9,5-12,5%; 9,0-13;
– 1,65%;
– 4,02%; –
0,4-0,75%; :
– 0,1-0,25%; – 0,55-0,7%;
– 0,2-0,37; –
0,001-0,003%; – 0,009-0,013%;
– 0,002-0,003%; –
0,0003-0,0006%; – 0,0005-
0,0009%; – 0,001-0,003%;
%: Ni<0.0005; Cd<0.00003;
Hg<0.000005; Cr<0.00003; b<0.0005.
e

Bacillus subtilis,
Bacillus licheniformis,
Azotobacter chroococum *Azotobacter*
vinelandii.

– *Bacillus subtilis* TS 01,
NBIMCC 8718

(Todorova, 2009).

(Yakimov et al., 2016).

2008 .

300 m

5 4 m – 50 /da.
2015-2016 .

(150 ml/da), (250 ml/da)
0,5% 0,3%.

ml) 50 l (250 ml + 150
) 12

Microorganisms for patent procedures. The strain has stronger effect against plant pathogens than other strains of the same bacterium (Todorova, 2009).

The microbial product contains other plant and animal-friendly bacteria and organic substances (Yakimov et al., 2016).

Liquid organic fertilizer 'Carbo Activ' is a product based on molasses. Its main purpose is to activate the microbial flora in joint application with microbial fertilizers as well as to affect the soil symbiotic microorganisms and fungi present in the soil. Carbo Active serves to activate the microorganisms in 'Ecosist-Arbanasi' liquid organic fertilizer.

The experimental plantation of 'Stanley' plum, established in 2008 in the area of the branch of RIMSA in the town of Dryanovo, is in the phase of full fruitfulness. Trees are grown at 300 m altitude and the soil in the experimental plot is pseudopodzolic, gray forest. The soil surface in the plantation is maintained as black fallow, and the planting distance of the individual trees is 5 x 4 m – 50 trees/da.

In the period 2015-2016 was carried out soil and leaf treatment of 'Stanley' variety with the organic fertilizers 'Aminobest' and 'Ecosist-Arbanasi'. A sprayer is used to treat each variant with organic fertilizers.

The experiment was set in four variants, each of which includes ten trees.

I. Soil nutrition - a combination of organic fertilizers 'Ecosist-Arbanasi' (250 ml/da) and 'Carbo Active' (150 ml/da), with a 50 l working solution - 0.5% and 0.3%, respectively. Carbo Activ is applied for the activation and propagation of microorganisms from Ecosist-Arbanassi. For the activation process, fertilizer concentrate (250 ml + 150 ml) is introduced into 50 l of water (working solution) and left for 12 hours in aerobic conditions without exposure to direct

20-22 °C.

II. ml/da, 45 l - 0,8%
III. 400 ml/da, 45 l - 0,9%
0,8 % 0,9 %
IV.

sunlight and at an optimum temperature of 20-22 °C. Soil treatment is performed at irrigated conditions.

Treatments are performed according to the following scheme:

- first soil treatment – beginning of vegetation – white button phenological phase;

- second soil treatment – after June /physiological/ falling of fruit set /second ten days of June/;

- third soil treatment - after harvest /first ten days of September/;

The working solution is introduced into the crown projection by 8 liters of water per tree.

II. Foliar fertilizing with organic fertilizer 'Ecosist-Arbanasi' - 360 ml/da with a working solution of 45 l - 0.8% compared to the working solution.

III. Foliar fertilizing with organic fertilizer 'Aminobest' - 400 ml/da, with a working solution of 45 l - 0.9% compared to the working solution.

In both variants of foliar fertilizing with liquid organic fertilizers 'Ecosist-Arbanasi' 0.8% and 'Aminobest' 0.9% was applied identical treatment three times at an interval of twenty days:

- first foliar treatment – after full leaf development of trees /third ten days of April, first ten days of May/;

- second leaf treatment – second, third ten days of May;

- third leaf treatment – second ten days of June;

IV. variant: organic and mineral fertilizers were not used in the control.

Average fruit samples were gathered from all the four cardinal points of each variant of the experiment.

A biochemical analysis of fresh plum fruits was carried out at the chemical laboratory of RIMSA, branch of Dryanovo in two consecutive years. The following indicators were determined: dry matter content,% – refractometric; total sugar amount,% – by Bertrand and Kolthoff; content of organic acids,% – titrimetric with 0.1 n NaOH; tanning substances,% –

,% – 0,1 n NaOH;
 ,% –
 (Frayman et al., 1969).

according to Neubauer and Lovental. The biochemical analysis of fruits was carried out according to the method of Frayman (Frayman et al., 1969).

RESULTS AND DISCUSSION

Pashova (2006)
 -
 „ ” – 18%.
 1
 -
 -
 - 18,70%.
 0,2%
 -
 -
 0,3%.
 1.

Pashova (2006) presents data according to which the highest dry matter was found in "Stanley" plum cultivars - 18%.

It is evident from data in Table 1 that during the first year of the research there were no significant differences in dry matter content. The highest values were observed in fruit of the control variant - 18.70%. It was lower in the other studied fruits by 0.2% for both treatment variants with 'Ecosist-Arbanasi' soil and 'Aminobest' leaf application. In case of 'Ecosist-Arbanasi' the difference in leaf treatment comparing to the control was 0.3%.

2015

Table 1 Biochemical composition of fresh fruit of 'Stanlay' plum cultivar – 2015

/Variant	Dry matter %	Organic acids %	Tanning substances %	Glucose %	Fructose %	Sucrose %	Total sugars %
/Control	18,70	0,80	0,651	3,00	3,88	4,50	11,38
/Ecosist-Arbanasi soil 0,8 %	18,50	0,83	0,651	3,45	3,31	3,45	10,21
/Ecosist Arbanasi leaf 0,8 %	18,40	0,81	0,651	4,11	3,03	4,50	11,64
Aminobest leaf 0,9 %	18,50	0,84	0,651	3,00	3,31	4,33	10,64

-
 - 0,80%,
 0,84%.
 0,83%,
 -
 - 0,81%.

The organic acid content for the control in fruits of the four studied variants was the lowest – 0.80%, while it was 0.84% for the variant of treatment with 'Aminobest'. For the soil treatment with 'Ecosist-Arbanasi', the organic acid content was 0.83%, and in case of a leaf treatment with the same organic fertilizer – 0.81%.

(Minev and Stoyanova, 2005).

0,104-0,105% (Pangelova, 1977), 0,206-0,278% (Minev, 2002), 0,050% 0,358% (Bespechalnaya, 1973).

(Anzin et al., 1956).

4,11%.

0,66%

- 1,11%

- 3,88%.

0,57%

0,85%.

- 4,50%.

0,17%

1,05%

Tanning substances are one of the major chemical components of plum fruits of all varieties. They give their astringent taste. With fruit ripening and their storage, their amount decreases (Minev and Stoyanova, 2005).

It is evident from the results obtained during the first year of the experiment that for the four investigated variants the amount of tanning substances is absolutely equal - 0.651%.

According to published research data, the tanning substances content in plum varies from 0.104-0.105% (Pangelova, 1977), 0.206-0.278% (Minev, 2002), 0.050% to 0.358% (Bespechalnaya, 1973).

Sucrose and glucose are dominant in plum, and the amount of fructose is significantly lower (Anzin et al., 1956). The reported glucose content was the highest in a leaf treatment variant with 'Ecosist-Arbanasi' - 4.11%.

In the other variants it was lower with 0.66% in soil treatment with 'Ecosist-Arbanassi', and the values obtained for control variants and the foliar application with 'Aminobest' were identical - 1.11% lower compared to the foliar treatment variant 'Ecosist-Arbanasi'.

In the first year of the experiment, the fructose content of the control was the highest, 3.88%. For 'Ecosist-Arbanassi' soil and 'Aminobest' foliar application, it was lower by 0.57% and for the variant with the foliar application with 'Ecosist-Arbanasi' with 0.85%.

The content of sucrose was the highest in two of the variants in the research - control and leaf treatment with the organic fertilizer 'Ecosist-Arbanasi' - 4.50%. It was lower in the other variants by 0.17% for leaf treatment with 'Aminobest' and by 1.05% for the soil treatment with 'Ecosist-Arbanasi'.

(Minev and Stoyanova, 2005).



An important indicator of fruit quality and their suitability is the content of total sugars (Minev and Stoyanova, 2005).

In the variant of foliar treatment with the organic fertilizer 'Ecosist-Arbanasi' had the highest content of total sugars - 11.64%. In the other variants it was lower - by 0.26% in the control, by 1% in 'Aminobest' leaf application and by 1.43% in the variant with soil application with 'Ecosist-Arbanasi'.

Table 2 presents the results of the study conducted in the second year of the experiment. It was found that the dry matter content did not differ significantly from the previous year.

Here is the trend of increasing the treated soil and leaf variants with the organic fertilizers 'Ecosist-Arbanasi' and 'Aminobest' compared to the control. Dry matter in the variant of soil treatment with 'Ecosist-Arbanasi' had the highest content - 20.5%. In the other variants, it was lower by 1.2% in the foliar treatment with 'Aminobest', with 1.5% in the control and 1.9% in the variant with leaf treatment Ecosist-Arbanasi.

The highest content of organic acids was recorded in the soil treatment with 'Ecosist-Arbanasi' - 0.99%. For the other three variants, the organic acid content was found to be lower, respectively with 0.4% for the leaf treatment with 'Ecosist-Arbanasi', 0.5% for the leaf treatment with 'Aminobest' with 0.5% and for the control with 0.14%.

In the previous year the content of organic acids was lower and varied insignificantly from 0.80-0.84%. The organic acid content in the second year of the trial had higher values of 0.85-0.99%.

Concerning the amount of tanning substances, the results in Table 2 report the highest values for the control - 0.440%, while for the other three variants of foliar and soil treatment with 'Ecosist-

0,367%.
-
-
-
- 4,57%.
- 0,23%.
0,81%
-
-
3,76-4,57%.
2,8%,
- 3,07%.
- 3,03-3,31%,
-3,88%,
2,8-3,07%
2,8%.
- 7,08%,
- 3,7%.
4,50%.
- 3,45-4,50%.

'Arbanasi' and 'Aminobest' they are absolutely equal - 0,367%.

When comparing data obtained during both years it was found that in the second year of the research, the content of tanning substances was almost twice as low.

Biochemical analysis in the second year showed that the glucose content in the control was the highest - 4.57%. In the soil and foliar treatment variants with 'Ecosist-Arbanasi' the values are identically lower by 0.23%. For the variant of leaf treatment with 'Aminobest', the glucose content was lower by 0.81% compared to the control.

When comparing data obtained from both years of the experiment, it is evident that in the second year the glucose content was higher in all experimental variants, and in the four variants it varied between 3.76-4.57%.

For all the three variants – control, soil and leaf treatment with 'Ecosist-Arbanasi', the fructose content was 2.8%, while for the fourth experimental variant of leaf-treatment with 'Aminobest fertilizer', it was the highest - 3.07%.

The fructose content in the first year of experiment for the three variants of soil and foliar fertilization was lower, with values of 3.03-3.31%, compared to the control-3.88%, but in the second year there was an evident tendency to increase the fructose content to 2.8-3.07% for the three fertilization variants while in the control it was 2.8%

In the second year of experiment the sucrose content was highest - 7.08%, while in the other three variants it was 3.7% lower.

The sucrose content of the studied fruits during the first year varied insignificantly, having a higher value for the control – 4.50%. In the other three fertilization variants, sucrose had a lower value of 3.45-4.50%. In the second year of the experiment, the difference in

– 7,08%,
– 4,01-4,04%,
– 14,45%.
– 3,3%,
– 3,58%
10,21-11,38%,
10,87-14,45%.

control values are evident – 7.08%, as well as those in the other three variants – 4.01-4.04%, where the sucrose content decreased almost twice.

The total sugar content in the control had the highest values – 14.45%. In the soil and foliar applications of 'Ecosistst-Arbanasi, they were lower with 3.3% and for 'Aminobest' foliar application the total sugars content is 3.58% less than the control.

The total amount of total sugars in fruits during the first year of the studies was less 10.21-11.38%, compared to the amount in the next year, which ranges from 10.87-14.45%.

2.

2016

Table 2. Biochemical composition of fresh fruit of "Stanley" plum - 2016

/Variant	Dry matter %	Organic acids %	Tanning substances %	Glucose %	Fructose %	Sucrose %	Total sugars %
/Control	19,0	0,85	0,440	4,57	2,8	7,08	14,45
/Ecosist Arbanasi soil 0,8%	20,5	0,99	0,367	4,34	2,8	4,01	11,15
/Ecosist Arbanasi leaf 0,8%	18,6	0,95	0,367	4,34	2,8	4,01	11,15
/Aminobest leaf 0,9%	19,3	0,94	0,367	3,76	3,07	4,04	10,87

CONCLUSIONS

It was found that treatment with the organic fertilizers 'Aminobest' and 'Ecosist-Arbanasi' resulted in an increase in dry matter content of plum fruit.

In terms of fructose content, it was found that 'Aminobest' had the best influence in the treatment.

The research carried out has shown a tendency to increase the values of dry matter, fructose and organic acids

in fruit of 'Stanley' plum, which are one of the main determinants of fruit quality.

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*E-mail: vbozkova@abv.bg

Investigation of the rootstocks ‘Docera 6’, ‘Garnem’ and ‘Greenpac’ in nursery

Valentina Bozhkova* and Marieta Nesheva

Fruit Growing Institute, 12 Ostromila Str., 4004 Plovdiv, Bulgaria

SUMMARY

In our country the most used rootstock for plum cultivars is the vigorous seedling *P.cerasifera* Ehrh. For peaches the most common rootstock is ‘GF677’.

For intensification of the plum production it is necessary to be found a suitable low-vigorous rootstock, and for peaches tests with new rootstocks except ‘GF677’ are needed.

In the spring of 2014 *in vitro* produced rootstocks ‘Docera 6’ used for plums, ‘Garnem’ and ‘Greenpack’ used for peaches and almonds were planted in nursery. In a previous study all the tree rootstocks showed a good tolerance to the *Plum Pox Virus* in a natural background of contamination. Before the grafting season a biometric analysis were done. Total height and stem diameter in the area of budding were measured and the percentage of standard rootstocks was calculated. In August 2014 the rootstocks were budded. A year later the percentage of the obtained trees to the grafted rootstocks was calculated.

It was found that all rootstocks were

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- suitable for grafting in the same year when they were planted. The peach rootstock 'Greenpack' overgrew.

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- 'Docera 6' showed very good compatibility with the grafted cultivars but it is necessary to be clarified it's behavior after infection with PPV of the grafts. 'Garnem' rootstock provides a high percentage produced trees to the number of grafted rootstocks. 'Greenpack' should be investigated further.

Key words: rootstock, 'Docera 6', 'Garnem', 'Greenpack', plum, peach

INTRODUCTION

Ehrh.) (*P.cerasifera*)

Myrobalan 29C

(Olson et al., 1990; Stefanova et al., 2009; Yordanov et al., 2015).

GF677,

(Hudina et al., 2015; Remorini et al., 2015; Xiloyannis et al., 2007).

GF677.

6 (Milusheva and Bozhkova, 2015).

- In our country the most commonly used rootstock for plums is the vigorous seedling *P.cerasifera* Ehrh. There are orchards planted with purchased from abroad plant material. The cultivars are grafted on the clone rootstock 'Myrobalan 29C' or 'Wavit'. These rootstocks show a good compatibility with the grafted cultivars and induce different vigour (Olson et al. 1990, Stefanova et al.2009, Yordanov et al. 2015). For producing peach propagation material the most used rootstock is 'GF 677', because of its good compatibility with almost all peach cultivars and its tolerance to tired soils. Moreover new rootstocks for this fruit species are tested (Hudina et al. 2015, Remorini et al. 2015, Xiloyannis et al.2007). For intensification of the plum production it is necessary to be found a suitable low-vigorous rootstock, and peach cultivars should be tested with new rootstocks except 'GF 677'.

- In a previous study concerning resistance of some rootstocks to the *Plum Pox Virus* conducted in the region of Plovdiv, were obtained very good results for 'Docera 6', 'Garnem' and 'Greenpack' (Milusheva and Bozhkova, 2015). Since there is data only for their vegetative growth in nursery (Bozhkova; 2009), it was set a new trial

(Bozhkova, 2009)

- for a detail evaluation of their suitability as rootstocks.

2014 .

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[*Prunus persica* (L.) Batsch x *P. davidiana* (L.) Batsch] x [*P. dulcis* (Mill.) D.A.Webb x *P. persica*]

(Pinochet, 2010).

Prunus amigdalus x *Prunus persica* (Nemared peach).

6 – 269 ., 99 .
45 .

30

5

6

2015 .

(Steele and Torrie, 1980).

MATERIAL AND METHODS

In March 2014 the *in vitro* produced rootstocks for plum – ‘Docera 6’ and for peach and almond ‘Garnem’ and ‘Greenpack’ were planted in a nursery in the Fruit Growing Institute - Plovdiv. ‘Docera 6’ is a hybrid of plum and myrobalan plum and is recommended as a rootstock for plum. ‘Greenpack’ [*Prunus persica* x *P. davidiana*] x [*P. dulcis* x *P. persica*] is a complex hybrid included the types of peach and almond and it is suitable for these two species and apricot (Pinochet, 2010).

‘Garnem’ also is a hybrid from a cross between almond and peach – *Prunus amigdalus* x *Prunus persica* (Nemared peach). It is used as a rootstock for peach, almond and even certain plum cultivars.

The number of planted rootstocks was: ‘Docera 6’ – 269, ‘Garnem’– 99 and ‘Greenpack’– 45 pcs. The date of leaf occurrence was observed. Before the grafting season biometric analysis of 30 randomly selected rootstocks along the entire row in groups of 5 was done.

Total height and stem diameter in the area of budding were measured and the percentage of standard rootstocks was calculated. In August, all planted rootstocks were budded as follows: ‘Docera 6’ with cultivar ‘Jojo’, ‘Topgigant plus’ and ‘Stanley’, ‘Garnem’ with the peach cultivars ‘Redhaven’, ‘Glohaven’ and ‘Suncrest’ and ‘Greenpack’ was budded with the cultivar ‘Redhaven’. In 2015 the number of the produced trees to the grafted rootstocks was calculated. Data were statistically processed by Duncan’s test (Steele and Torrie, 1980).

RESULTS AND DISCUSSION

According to phenological observations the appearance of the leaves on 'Garnem' and 'Greenpack' was on March 24th, while leaves on 'Docera 6' appeared 28th of March. The rootstocks were grown under conventional agricultural practices. For a period of 5 months from the planting to the measurement time, all of them were different according to their height and stem diameter (Table 1). Lowest average height was measured for the 'Docera 6' plants – 70 cm. The shortest plant was 48 cm high, and the highest - 102 cm, but 73% of them were between 60 and 80 cm high. The mean calculated height for 'Garnem' is 85.2 cm, the plant with the lowest height is 37 cm, while the biggest measured height is 103 cm. Seventy percent of this rootstock plants were high 80-90 cm. Between these two rootstocks and 'Greenpack' the differences are statistically proven. For 'Greenpack' the mean plant height was 125 cm, the shortest plant was 50 cm and the highest - 152 cm. In general, all three rootstocks have reached the desired high before the grafting season. The stem diameter in the grafting area is more important for their assessment.

The best rootstocks are with diameter 8-10 mm, the ones with diameter above 12 mm are reported as overgrown. The best results were obtained with 'Docera 6' and 'Garnem' – resp. 3% and 10% overgrown rootstocks. All 100% of the 'Greenpack' plants were overgrown. Their mean diameter was 13 mm, obviously the greatest in comparison with the other two tested rootstocks. The stem diameter of 30% of the 'Greenpack' plants was 14 to 16 mm. Definitely this rootstock has a high vigor.

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1.

Table 1. Biometric analysis of plum and peach rootstocks

Rootstock	Height (cm)	Stem diameter (mm)	() Percent of nonstandard (overgrown) rootstocks
Docera 6	70bc*	8.4c	3
Garnem	85.2b	9.3b	10
Greenpack	124a	13.1a	100

*Different letters in the same row/column indicated significant difference (p<0.05)

38 (), 37 () 2).
60.4%
- 18.4%
- 92.7%,
22.5%
()

With the plum cultivar 'Stanley' (as a standard) were grafted 38 plants of the 'Docera 6' rootstock, with 'Topgigant plus' - 37 and with 'Jojo' - 194 plants (table 2). The mean percent of successful grafted rootstocks is 60.4% and is due to the extremely low percentage of the trees produced with the 'Stanley' cultivar - 18.4%. Moreover, two of the produced trees are nonstandard. There are two possible reasons for this: technical and the presence of the *Plum Pox Virus* in the budsticks. The technical reasons may be bad storage of the budsticks or budding in a very hot weather conditions which has prevented of callus formation. A very probable cause is the presence of the PPV in some of the budsticks and thus the scion cannot develop on 'Docera 6' According to the breeders, this rootstock reacts that way when the grafted bud is infected. The highest percentage of produced trees was with 'Jojo' - 92.7%, indicating that the rootstock is suitable for this cultivar, but it should be take in mind that only this cultivar is known as resistant to PPV. A good result was also obtained with 'Topgigant plus', although the difference compared to 'Jojo' is quite large - 22.5%. Apparently this new rootstock should be tested with other cultivars and the impact of the virus on the produced trees should be reported, too. On the one hand the produced trees will be free from PPV but on the other when the scion gets infected (by budsticks, in nursery or in a new orchard) the whole tree could be possible to die. This would be a very big problem for the

2016
6,

plum fruit production. As a result the rootstock may subsequently be used only with resistant cultivars. The only one known so far is 'Jojo'. In the spring of 2016 in an orchard are planted the rootstock/cultivar combinations 'Topgigant plus' on 'Docera 6' and 'Jojo'/'Docera 6' which would give us an opportunity to track the development of the trees and to clarify questions regarding the use of the rootstock.

2.

Table 2. Results of the study of the three rootstocks planted in nursery

Rootstock	Grafted cultivar	Number of grafted plants	Number of produced trees	Percent of produced trees
Garnem	Redhaven	26	23	88.4
Garnem	Glohaven	26	21	80.7
Garnem	Suncrest	47	44	93.6
		<i>/ Mean for Garnem</i>		87.5
Greenpack	Redhaven	25	17	68.0
Docera 6	Stanley	38	7	18.4
Docera 6	Topgigant plus	37	26	70.2
Docera 6	Jojo	194	180	92.7
		<i>/ Mean for Docera 6</i>		60.4

87.5%.

7.7%.

25

5.2%

68.0%

For the three grafted cultivars on the 'Garnem' rootstock the average rate of produced standard trees was 87.5%. This shows a good compatibility of the rootstock with the grafted cultivars. The highest percentage produced trees were the budded with 'Suncrest' ones – 5, 2% more than the control 'Redhaven'. The trees produced with the cultivar 'Glohaven' were 7.7 % less than the control. Twenty five plants of the 'Greenpack' rootstock were grafted with the peach cultivar 'Redhaven'. The percentage of produced trees compared to the grafted ones was 68 % which is much lower percentage than the trees produced on the 'Garnem' rootstock. Obviously, this percentage is not high

- enough to assess definitely the compatibility of the rootstock with the grafted cultivar and the studies with it should continue.

CONCLUSIONS

Spring planted *in vitro* produced rootstocks 'Docera 6', 'Garnem' and 'Greenpack' produce standard plants which are suitable for grafting in the same year.

The 'Greenpack' rootstock overgrows and this reduces the rate of produced trees, so a new scheme should be developed.

The rootstock 'Docera 6' shows good compatibility with the grafted cultivars, but its behavior when the graft gets infected should be clarified.

'Garnem' rootstock provides a high percentage produced trees to the number of the grafted rootstocks.

It is necessary to be conducted additional tests with the rootstock 'Greenpack' because the percentage of the produced trees with the standard cultivar 'Redhaven' is 20% lower than the ones on 'Garnem' rootstock.

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(*Ribes nidigrolaria*)

13-23/3

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*E-mail: nedyalka_stoyanova@abv.bg

**Study on main characteristics
of jostaberry (*Ribes nidigrolaria*) hybrid B 13-23/3**

Nedyalka Stoyanova^{1*}, Diyan Georgiev²

¹Institute of Agriculture, 2500 Kyustendil, Bulgaria

²Research Institute of Mountain Stockbreeding and Agriculture, 5600 Troyan, Bulgaria

SUMMARY

2010-2014	The investigation of jostaberry was carried out in the period 2010-2014. The English hybrid josta B 13-23/3 was studied. It is included in the black currant plantation. The parameters of the main characteristics describing the vegetative and reproductive qualities of plants were found out – bush height and width, number of one-year young shoots, number of main shoots (stems), shoots diameter, fruit weight and yield.
13-23/3,	
(),	
13-23/3 ,	The average values for the main characteristics give a real characterization of josta B 13-23/3 plants grown under the certain climate conditions of our region. It ensures strong growth of sound and thick shoots but insufficient shoot-forming abilities.
162,24 cm.	The average bush height is 162.24 cm.
122,06 cm	The width of row-spacing and rows of bushes is 122.06 cm and 136.00 cm. The shoot-producing ability of plants is slight.
136,00 cm.	The number of fruit-bearing shoots per a bush is 5.00. The raceme is a short to
5,00.	

2 4 .
e 1,48 g.

0,656 kg.

13-23/3

(*Ribes nidigrolaria*)

(*Ribes nigrum* L.)

(*Ribes grossularia*)

Ribes divaricatum.

(

1883 . W.Culverwell

(Buchenkov, 2015; Tikhonova, et al. 2015).

mid-long cluster which has around 2 to 4 blossoms. The average berry weight is 1.48 g. The small number of blossoms and fruits per a cluster shows the low fertility potential of the hybrid. The actual average yield per a bush is 0.656 kg.

Under the climate conditions of Kostinbrod region, josta can successfully be grown but the fertility of hybrid B 13-23/3 is lower than the fertility of black currant and gooseberry.

Key words: biological characteristics, parameters, average values, plant characteristics

INTRODUCTION

Jostaberry (*Ribes nidigrolaria*) is a relatively new berry species. It was obtained as a result of the crossing of black currant (*Ribes nigrum* L.) and gooseberry (thorny, German) (*Ribes grossularia*) and a subsequent crossing with *Ribes divaricatum*. This hybrid became famous in the fruit growing under the name josta (an abbreviation of the German names of blackcurrant and gooseberry).

The idea of selectionists is to obtain valuable hybrids combining the best qualities of the parental forms. Black currant is characterized by its thornless plants and high-vitamin fruits, and gooseberry by its large berries and resistance to diseases and pests, especially to big bud mite. The application of the interspecies (remote) hybridization is a difficult process due to the inability of species to cross among one another resulting in sterile hybrid plants.

The first crossings between blackcurrant and gooseberry were made in 1883 by W.Culverwell, a selectionist in England. Later the hybridization between these species was repeated, but the plants again proved to be infertile (Buchenkov, 2015; Tikhonova, et al., 2015). An intensive selection activity was also carried out by I. V. Micurin in Russia, who crossed 'Shtamovai' gooseberry

(*Ribes odoratum* Wendal.).

(Buchenkov, 2015, Kuzmin, 1960, Ogoltsova, 1992, Tikhonova, et al. 2015).

(Knight, et al. 1974).

R. Bauer 70- (Max Planck), Muravski - Jochina

Jochelina. 1987 . R. Bauer A. Bauer Jostaki (*Shwarze traub* Gooseberry – *Ribes divaricatum*) (Bauer, 1978, Bauer, 1986).

Porpacsy Kroma. A. Rico. - Jostagranda (Barney, Humer 2005).

13-23/3

(2010-2014

1323/3 2.50m 0.80m.

(5,5-6,5) - 560 m.

cultivar with 'Seyanets Krandal' blackcurrant cultivar (*Ribes odoratum* Wendal.). The resulting seedlings are practically unfruitful. The research work on the introduction of valuable hybrids between blackcurrant and thorny German gooseberry was continued by a number of scientists (Buchenkov, 2015, Kuzmin, 1960, Ogoltsova, 1992, Tikhonova et al., 2015). By using various selection methods (polyploidy, becross, selection of infection background), English researchers succeeded in isolating the gene "Se" of gooseberry that controls the resistance to big bud mite (Knight, et al., 1974).

The first fruit-bearing hybrid between blackcurrant and gooseberry was created by R. Bauer in the 1970s in Germany (Max Planck), called josta. At the same time, the researcher Muravski in Dresden - Pillznits introduced the new varieties josta – Jochina and Jochelina. In 1987, R. Bauer and A. Bauer created Jostaki (*Shwarze traub* x Gooseberry – *Ribes divaricatum*) (Bauer, 1978, Bauer, 1986). As a result of interbreeding crossings in Sweden, Kroma was selected. In Hungary, A. Porpacsy introduces 'Rico' variety. In the United States and Canada, 'Jostagranda' is available for distribution (Barney, Humer 2005).

The aim of the research is to study some of the basic features and properties of the English hybrid josta B 13-23/3 and the possibility of its cultivation in the Kostinbrod region.

MATERIAL AND METHODS

The study was conducted in the experimental base in Kostinbrod of the Institute of Agriculture in Kyustendil (2010-2014). The plants of the English hybrid josta B 1323/3 were planted in a collection plantation according to the scheme of 2.50m x 0.80m. The soil type is haplic chernozem smolnitza, with a slightly acidic soil reaction (pH 5.5-6.5)

2012 .

(Nedev, et al. 1979)

(Boicheva, et al. 2003).

(Genchev, Marinkov 1973).
(M),
(VC %),
(P%) (m).

1323 /3

1,2-1,6 cm

3-5

- and an altitude of 560 m. The plantation is grown on a non-irrigated area according to the adopted black currant technology. In 2012, at the end of May, hail fell in the area of the experimental field, there for data were not included in the survey for this year. Methodology for the Study of Plant Resources in Orchard Plants (Nedev, et al., 1979) and Methodology for Variety Testing with Biological and Economic Qualities (Boicheva, et al., 2003) were used in order to take into account the indicators. Data for the surveyed indicators were developed by a variation-statistical method (Genchev, Marinkov 1973). Average values (M), variance coefficient (VC%), reliability (P%) and error (m) were calculated.

RESULTS AND DISCUSSION

The plants of hybrid B1323 / 3 are perennial shrubs with strong, thick, straight and thornless stems. Shoot producing ability is slighter than parental forms. The hybrid is significantly superior to blackcurrant and the thorny German gooseberry. The leaves are five-pointed, shiny, and look like those of gooseberry, but are larger in size.

Unlike blackcurrant, they do not have its typical flavor because it lacks the characteristic oil glands that determine the specific flavor. The upper side of the leaves has a darker green color compared to the bottom. The buds are ovoid-shaped, small, with tightly-laid scales slightly diverted from the twigs. The blossoms are large with a diameter of 1.2-1.6 cm in the form of a bell. The perianth is united at the base and resembles a tube. The sepals have an elongated ovate shape with arched curved peaks and red violet colour. Petals are green-white, small, upright and with a rounded point. The stamens are just below the stigma level. The style is single, divided at the top with two stigmas.

The inflorescence is a short cluster, arch-shaped with 3-5 blossoms. According to

	1323 /3		
()		
		17	8
		15	
20			29
		14	
5		18	
		20	
	1323/3		
()		
(1).		
	162,24 cm,		
%.		4,23	
cm	180,0 cm.	145,0	
	122,06 cm,	136,00	
cm.		110,0	
cm	132,8 cm		
	122,5 cm	150,5	
cm			
	-	3,08 %	
3,77 %.			

its type of fruit-bearing, hybrid B 1323/3 is closer to blackcurrant, but it differs in size and weight of the fruit. In terms of fruit shape, it is closer to the gooseberry, but it is significantly smaller. Fruits are dark-colored (dark wine-red) with rounded or ellipsoid shape. Fruit flesh is greenish with inferior taste.

Data on flowering and ripening of fruits show that, although genetically justified, they are largely dependent on the climate conditions of the area. For the region of Kostinbrod the beginning of the vegetation starts on 8th March, and the appearance of the leaves is on 17th March. Flowering occurs on 15th April, as it is massive on 20th April, and the end is on 29th April. Its duration is 14 days. The fruit starts ripening from 5th July, as it is massive on 18th July. Leaf fall starts about the end of 20th October.

If we compare the beginning of the period of the main phaeological phases of hybrid B 1323/3 with those of blackcurrant and gooseberry, we will find that the beginning of the vegetation and the flowering are almost the same as those of the parental forms. The ripening of fruits, however, takes place a little later, and is approaching some late varieties of thorny German gooseberry.

The vegetative indicators show the growth power: height of plants, width of the bushes in the row-spacing and row, number of annual shoots, number of the main (fruit-bearing) shoots and their thickness (Table 1).

The average bush height is 162.24 cm, with a very low annual variability of 4.23%. The amplitude of the variation is from 145.0 cm to 180.0 cm.

The bush width in the row-spacing is 122.06 cm and in the row is 136.00 cm. Their width values range from 110.0 cm to 132.8 cm in the row-spacing and from 122.5 cm to 150.5 cm in the row. Variation coefficients are low – 3.08% and 3.77%, respectively.

1.

1323 /3

Table 1. Characteristics of main traits of a josta hybrid B1323 /3

Traits	Measure	Average values standard errors (M ± m)	Coefficient of variation (VC %)	Amplitude min-max	Index of accuracy (P %)
Height of the bushes	cm	162,24±3,04	4,23	145,0-180,2	1,89
	cm	122,06±1,67	3,08	110,0-132,8	1,37
Width of the bushes in the row spacing	cm	136,0± 2,28	3,77	122,5-150,5	1,68
Width of the bushes in the row ()	.	5,0 ± 0,28	12,60	3,0-7,0	5,62
Shoots per bush	mm	19,64 ± 0,64	7,33	16,5-24,2	3,27
Diameter of the shoots	.	4,6 ± 0,41	20,16	3,0-8,0	9,00
One-years old shoots	mm	11,4±0,01	1,75	11,0-12,0	0,78
Diameter of the one-years old shoots	g	1,48 ± 0,04	6,41	1,20-1,80	2,86
Weight of the fruit	kg	0,656± 0,14	46,26	0,350-0,920	20,83
Average yield per bush	cm	3,5± 0,11	7,17	2,7-4,2	3,20
Length of clusters	.	2,4± 0,11	10,2	2,0-3,0	4,25
Number of berries per cluster	.	3,2± 0,09	6,25	3,0-4,0	2,79
Number of blossoms per cluster					

20,16 %).
5,0
(VC % – 12,60).
3,00
7,00
()
19,64 mm
(7,33 %).
16,50
mm 24,20 mm.

- Shoot-producing ability is weak.
- The number of young shoots is between
- four and five with a relative variation of
(VC – 20.16%). The average
- number of stems is also small 5.0 at low
- variability (VC% – 12.60). The amplitude
- of shoot variation ranges from 3.00 to
- 7.00 per a bush.
- The diameter of the main (fruit-
- bearing) stems is 19.64 mm with a slight
- variation in years (7.33%). The amplitude
- range is from 16.50 mm to 24.20 mm.
- The diameter of one-year shoots is 11.4

11,4 mm	-	mm and the variation amplitude is very small. Hybrid B 1323/3 differs substantially from blackcurrant and gooseberry with its thick shoots.
1323 /3		
1,48 g	-	The main factors determining the yield are fruit weight, number of fruit-bearing stems and number of fruit per cluster.
(6,41 %).	-	The average fruit weight is 1.48 g and the hybrid is characterized by average-sized fruit. The variation coefficient is relatively low (6.41%). The amplitude of fruit weight over the years has ranged from 1.20 g to 1.80 g. Data shows that the fruits of the hybrid are larger than those of the blackcurrant, but smaller than the gooseberry.
1,20 g	-	
1,80 g.	-	
-	-	
- 0,656 kg,	-	The actual yield per bush of 0.656 kg provides little opportunity for manifestation of that species. The variation range of the average yield is relatively broad - 0.350 kg/bush to 0.920 kg/bush and shows differences in years. It is obvious that the hybrid's fertility is lower than that of blackcurrant and gooseberry.
0,920 kg/	-	
-	-	
3,5 cm,	-	The average length of the cluster is 3.5 cm, with a slight variance of 7.17%. The number of fruit per cluster is small - 2.4. The amplitude of the variation of fruit on the cluster is from 2 to 3 berries. The average number of blossoms on the cluster is also small 3.2, and the variation range is very small in number from 3 to 4 blossoms. The small number of blossoms and berries per cluster shows the low yield potential of hybrid B 13-23/3. Productive abilities of josta are smaller than those of blackcurrant and thorny German gooseberry.
7,17 %.	-	
- 2,4.	-	
2	3	
3,2,	-	
3	4	
13-23/3.	-	
-	-	
		During the years of cultivation, there have been no attacks of big bud mite and American powdery mildew. Josta can be grown successfully in our climate conditions.

CONCLUSIONS

The average values of the main features give a reliable characteristic of the hybrid B1323/3, growing under specific climate conditions. It provides a vigorous growth of strong and thick shoots, but a weak shoot producing ability. Inflorescence is a short to medium cluster, where are arranged from 2 to 4 blossoms. The small number of blossoms and the berries per cluster shows the low potential for fruitfulness of hybrid B 13-23/3.

The average plant height is 162.24 cm. The width of bushes in the row-spacing and within the row is 122.06 cm and 136.00 cm respectively. Shoot producing ability is low (4.6 pieces). The number of fruit bearing shoots per a bush is also small - 5.00. The length of the cluster is 3.5 cm, forming 3.2 blossoms and 2.4 fruit respectively. The average weight of one fruit is 1.48g. The bush provides an average yield of 0.656 kg.

Under our climate conditions, josta can be grown successfully, but the hybrid's fertility is lower than that of blackcurrant and gooseberry.

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70 rpm.

150 160° .
3:1.

:

- Feed screw speed was fixed at 70 rpm.

Feed zone temperature was kept constant at 150°C. Kneading zone temperature was kept constant at 160°C. Screw compression ratio was 3:1.

- **Key words:** extrusion, specific mechanical energy, brewers' spent grain

INTRODUCTION

- Waste products from the food industry not only represent a big problem for food factories, but also they are a good source of functional ingredients.

- Brewers' spent grains (BSG) form 85% of the total amount of waste products in the brewing industry. They represent a lignocellulosic material comprising of 17% cellulose; 28% noncellulosic polysaccharides (mainly arabinoxylans) and 28% lignin (Muthusamy, 2014). They are easily available materials, but their main application is limited on animal feed.

- Despite all, brewers' spent grains are rich in fibers and proteins with potential application in the biotechnology industry (Mussatto et al., 2006). An important characteristic of BSG is their composition, making them products with proven prebiotic effect. In combination with certain bacteria they provide a symbiotic effect which makes them useful in the prevention of gastrointestinal tract diseases (F rca et al., 2014).

- The right use of waste products from the food industry is directed towards the development of effective processing methods. In this respect, extrusion is an innovative and an especially suitable method.

- Food products with new quality and lower price can be obtained by extrusion, thus solving a lot of ecological and economic problems (, 2014).

17%

28%

(Muthusamy, 2014).

85%

(Mussatto et al., 2006).

(F rca et al., 2014).

(Ruskova, 2014).

19,8% (0% 4.8% 30%) (F rca et al., 2014).

Carafa, Munich

Corona

0.5 mm.

(1), 24 h 5°

The addition of BSG in extruded snacks increases the fiber content of the product from 4.8% in the control sample to 19.8% in the samples containing 30% brewers' spent grains (F rca et al., 2014).

The aim of the present examination was to study the influence of some extrusion parameters of extruded BSG mixture with wheat semolina on the specific mechanical energy consumption.

MATERIAL AND METHODS

Brewers' spent grains

Three malt sorts were used in the present research: Munich, Carafa, and light barley malt. The malt seeds were ground using a Corona hand mill and were passed through standard sieves. The prepared particle size of BSG was about 0.5 mm.

Preparation of the samples for extrusion

BSG and wheat semolina were mixed with distilled water to obtain various moisture contents (Table 1). The wet materials were homogenized and kept in sealed plastic bags for 24 h in a refrigerator at 5°C. The samples were tempered for 2 h at room temperature prior to extrusion.

1.

Table 1. Independent variable values and corresponding levels

Independent variables	/ Levels				
	-2	-1	0	+1	+2
Blend ratio (Malt bran content) (C), % - X ₁	10	20	30	40	50
Feed moisture (W), % - X ₂	17	20	23	26	29
Screw speed (n), rpm - X ₃	120	150	180	210	240
Final cooking zone temperature (T _m), °C - X ₄	130	140	150	160	170

Extrusion

The BSG mixture was extruded in a laboratory single screw extruder

„Brabender 20 DN“ () . -
 70 rpm.
 150 160° .
 (1).
 3:1.
 3 mm.

(Brabender 20DN, Germany). The feed screw speed was fixed at 70 rpm. The temperatures of the feed and kneading zone were 150 and 160°C, respectively. The final cooking zone temperature and the screw speed were varied according to the experimental design (Table 1). The screw compression ratio was 3:1. The die diameter was 3 mm.

(SME, kJ/kg)

Specific mechanical energy consumption

The specific mechanical energy consumption was calculated using the equation (Chuang et al., 2004):

(Chuang et al., 2004):

$$SME = \frac{2f \cdot Mn \cdot n}{60 \cdot Q} \times 3.6 \tag{1}$$

: Mn –
 , N.m; n –
 , rpm; Q –
 , kg/h.

where, Mn - corrected torque (N.m), n - screw speed (rpm), Q - feed rate (kg/h).

Experimental design and data analysis

Response surface methodology was applied to determinate the influence of the BSG content – X₁, the moisture content – X₂, the screw speed – X₃, and the final cooking zone temperature – X₄ on the specific mechanical energy consumption (response, y). A central composite rotatable design was used: 2^k+2.k+n , where k is the number of the independent variables, n_o – the replicates of the central point (n_o=3).

The regression model was the following:

$$Y = b_o + \sum_{i=1}^n b_i x_i + \sum_{i=1}^n b_{ii} x_i^2 + \sum_{i=1}^n \sum_{j=1}^n b_{ij} x_i x_j \tag{2}$$

b_o, b_i, b_{ii} b_{ij}

where, b_o, b_i, b_{ii} and b_{ij} are equation coefficients.

RESULTS AND DISCUSSION

The specific mechanical energy consumption values of the extruded products are shown in Table 2. The results of the statistical analysis of variance (ANOVA) for the specific mechanical energy consumption are shown in Table 3. In this case, 8 effects had P-values less than 0.05, indicating that they are significantly different from zero at the 95.0% confidence level. The R-squared statistic was 0.92. The standard error of the estimate was 19.63 while the mean absolute error was 9.95.

2
,
(ANOVA-).
8
(P<0.05) 95 %
0.92.
19.63,
9.95.

2.

Table 2. Specific mechanical energy

	SME, kJ/kg		SME, kJ/kg		SME, kJ/kg
1	205.56	10	212.37	19	180.44
2	203.97	11	144.22	20	137.75
3	163.75	12	110.94	21	215.55
4	160.14	13	165.08	22	305.39
5	216.91	14	187.21	23	185.81
6	268.62	15	187.08	24	168.81
7	223.63	16	258.23	25	271.41
8	242.74	17	180.61	26	271.79
9	200.09	18	174.35	27	271.54

3.

Table 3. Regression coefficients and analysis of variance for specific mechanical energy

	Regression coefficients	Sum of squares	F – F –ratio	P – P –value
constant	-5829.16			
A:C	8.038	655.006	1.70	0.2169
B:W	87.054	2697.91	7.00	0.0214*
C:n	-1.861	11622.2	30.15	0.0001*
D:Tm	69.236	2690.28	6.98	0.0215*
AA	-0.230	11257.5	29.20	0.0002*
AB	-0.065	60.6841	0.16	0.6985
AC	0.040	2263.38	5.87	0.0321*
AD	0.004	2.77222	0.01	0.9338
BB	-3.063	16213.1	42.06	0.0000*
BC	0.220	6272.64	16.27	0.0017*
BD	0.084	102.617	0.27	0.6153
CC	-0.002	105.534	0.27	0.6103
CD	-0.018	489.516	1.27	0.2818
DD	-0.230	11299.2	29.31	0.0002*

* < 0.05

* Significant at < 0.05

Based on the results from the ANOVA after removing the insignificant effects, the following regression equation has been obtained:

$$SME = - 5829.16 + 87.05W - 1.86n + 69.24T_m - 0.23C^2 + 0.04Cn - 3.06W^2 + 0.22Wn - 0.23T_m^2 \quad (3)$$

The main linear, quadratic and combined factor effects are summarized and their evaluations are presented in a standardized chart (Figure 1). The greatest influence on the specific mechanical energy consumption had the quadratic effect of moisture content in the extrusion mixture, followed by the linear effect of the screw speed.

Standardized Pareto Chart for SME

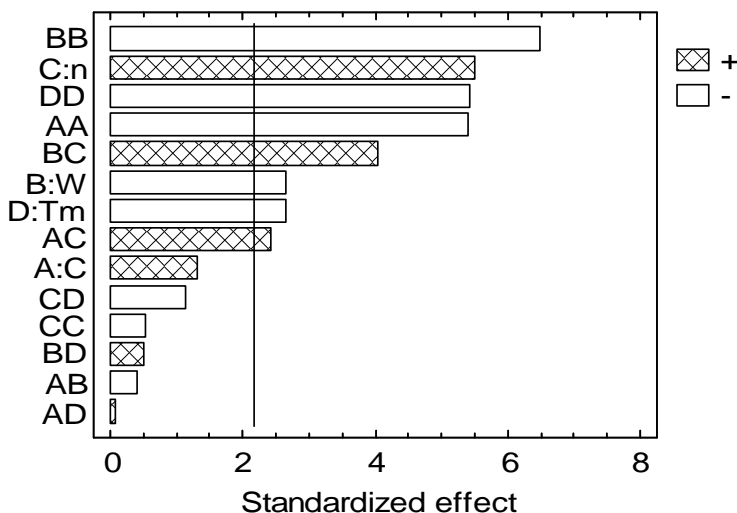
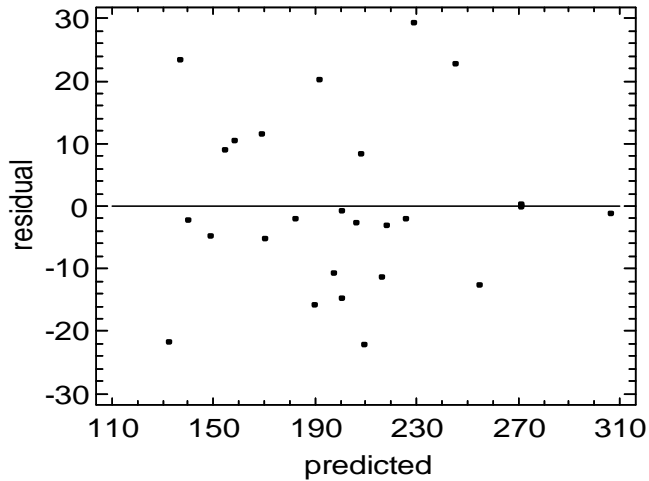


Fig. 1. Estimated effects of regression model coefficients on the specific mechanical energy

Figure 2 is a diagram of the distribution of the residual parameters of the regression model of the specific mechanical energy consumption, which shows that it is uniformly distributed around zero and there are no values to exceed two times the standard error.

Residual Plot for SME



. 2.

Fig. 2. Residual distribution diagram for the regression model of the specific mechanical energy

(2). 110.94 305.39 kJ/kg

29%

1.3

(3). 130 170° 1.1

” ”,

(Lei et al., 2005;

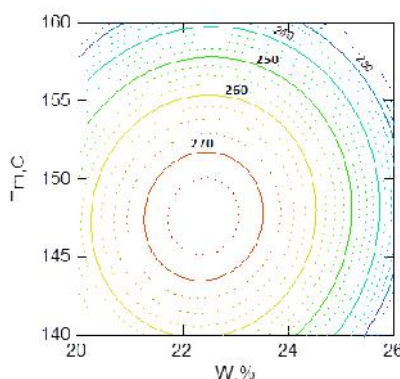
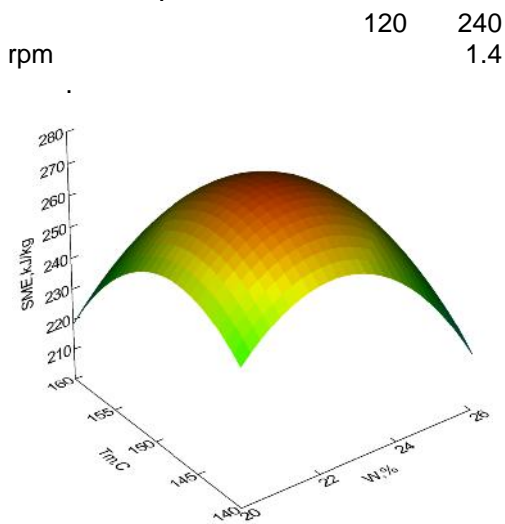
The specific mechanical energy consumption values in the extrusion of a mixture of malt spent grains and wheat semolina ranged from 110.94 to 305.39 kJ/kg (Table 2).

The mechanical energy consumption values tended to decrease when the temperature and the moisture content increased. When increasing the material moisture content from 17 to 29% as well as the values of the other parameters in the middle of the experiment, the specific mechanical energy consumption decreased 1.3 times. The increased moisture content of the material reduced the rubbing forces in the extruder, thus reducing the need for mechanical energy input (Figure 3). By increasing the temperature at the die from 130 to 170°C, the energy consumption decreased 1.1 times. This was probably due to the fact that high temperatures increase the plastification of the "dough", which reduces the material viscosity and friction. These trends have been identified by other researchers (Lei

Nwabueze, 2006; Ruiz-Ruiz et al., 2008).

et al., 2005; Nwabueze, 2006; Ruiz-Ruiz et al., 2008).

However, the specific mechanical energy consumption in the extrusion of a mixture of malt spent grains and wheat semolina increased in proportion to the screw speed, which could be explained by the occurrence of larger shear tension and hence a larger amount of energy imported into the system. When increasing the screw speed from 120 to 240 rpm, the energy consumption increased 1.4 times.



3. (Tm, °) 180 rpm (W, %) (SME, kJ/kg) 30%

Fig. 3. Specific mechanical energy changes (SME, kJ/kg) depending on moisture content (W, %) and final cooking zone temperature (Tm, °) at malt bran content 30% and extruder screw speed 180 rpm

CONCLUSIONS

The influence of some extrusion parameters of a mixture of malt spent grains and wheat semolina on the specific mechanical energy consumption was studied. The greatest impact on energy consumption had the quadratic effect of moisture content in the extrusion mixture, followed by the linear effect of the screw speed. The specific energy consumption values in the extrusion of a mixture of malt spent grains and wheat semolina ranged from 110.94 to 305.39 kJ/kg.

110.94 305.39 kJ/kg.

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*E-mail: kriss_k@abv.bg

Influence of extrusion conditions on sectional expansion index of brewers' spent grains

Kristina Ivanova^{1*}, Todorka Petrova¹, Ivan Bakalov¹,
Nikolay Penov², Milena Ruskova¹, Apostol Simitchiev²,
Georgi Kostov², Rositza Denkova²

¹Food Research and Development Institute, 4000 Plovdiv, Bulgaria

²University of Food Technologies, 4020 Plovdiv, Bulgaria

SUMMARY

(
Munich, Carafa
)
„Brabender 20 DN“ ()
19 mm
3 mm.
,
,
,
.
:
(10, 20, 30, 40, 50%),
(17, 20, 23, 26, 29%),
(120, 150, 180,
210, 240 rpm)
(130, 140, 150, 160, 170°).

Mixtures of brewers' spent grains (Munich, Carafa, and Light barley malt) and wheat semolina were extruded in a laboratory single screw extruder (Brabender 20DN, Germany) with screw diameter of 19 mm and die diameter of 3 mm. The influence of the brewers' spent grain content, feed moisture content, screw speed, and final cooking zone temperature on the sectional expansion index was studied.

Response surface methodology with combination of brewers' spent grain content (10, 20, 30, 40, 50%), moisture content (17, 20, 23, 26, 29%), screw speed (120, 150, 180, 210, 240 rpm), and final cooking zone temperature (130, 140, 150, 160, 170°C) was applied.

Feed screw speed was fixed at 70 rpm.

70 rpm.

150 160° .
3:1.

: ,
,

(Mercier et al., 1989).

(Harper, 1981; Kokini, 1993).

(Hwang et al. 1994).

(Fulger
and Bradbury, 1985; Ralet et al., 1990).

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Feed zone temperature was kept constant at 150°C. Kneading zone temperature was kept constant at 160°C. Screw compression ratio was 3:1.

Key words: extrusion, sectional expansion index, brewers' spent grain

INTRODUCTION

Extrusion cooking technology, high temperature-short time processing is widely used in the food and feed industries (Mercier et al., 1989). Extrusion combines high pressure, high shear and heat (Harper, 1981; Kokini, 1993). Extrusion is applied to modify the structure of the rigid cell wall (Hwang et al., 1994). Fibrous materials can be modified by extrusion in order to increase the soluble dietary fiber content and also improve the textural and sensory properties (Fulger and Bradbury, 1985; Ralet et al., 1990).

Extrusion cooking has advantages, including energy efficiency, high productivity, low operating costs, versatility, and shorter cooking times.

The extrusion cooking process can be analysed in terms of operational parameters and product characteristics.

Extrudate expansion is a complex phenomenon which occurs usually during high-temperature, low-moisture extrusion cooking. It is the consequence of several events such as biopolymer structural transformations and phase transitions, nucleation, extrudate swell, bubble growth, and bubble collapse (Moraru and Kokini, 2003).

The aim of the present investigation was to study the influence of extrusion conditions on sectional expansion index of mixtures of brewers' spent grains and wheat semolina.

MATERIAL AND METHODS

Brewers' spent grains

Three malt sorts were used in the present research: Munich, Carafa, and light barley malt. The malt seeds were

Carafa. , Munich

Corona

0.5 mm.

ground using a Corona hand mill and were passed through standard sieves. The prepared particle size of brewers' spent grain (BSG) was about 0.5 mm.

Preparation of the samples for extrusion

BSG and wheat semolina were mixed with distilled water to obtain various moisture contents (Table 1). The wet materials were homogenized and kept in sealed plastic bags for 24 h in a refrigerator at 5°C. The samples were tempered for 2 h at room temperature prior to extrusion.

(), 24 h 5°

1.

Table 1. Independent variable values and corresponding levels

Independent variables	/ Levels				
	-2	-1	0	+1	+2
Brewers' spent grain content (C), % - X ₁	10	20	30	40	50
Moisture content (W), % - X ₂	17	20	23	26	29
Screw speed (n), rpm - X ₃	120	150	180	210	240
Final cooking zone temperature (T _m), °C - X ₄	130	140	150	160	170

„Brabender 20 DN“ ().

70 rpm.

150 160° .

Extrusion

The BSG mixture was extruded in a laboratory single screw extruder (Brabender 20DN, Germany). The feed screw speed was fixed at 70 rpm. The temperatures of the feed and kneading zone were 150 and 160°C, respectively.

The final cooking zone temperature and the screw speed were varied according to the experimental design (Table 1). The screw compression ratio was 3:1. The die diameter was 3 mm.

(1).
3:1.

3 mm.

Sectional expansion index (SEI, %)

Sectional expansion index is calculated using the ratio between the diameter of the extruded products (average value from 10 measures via caliper-gauge) and the diameter of the neck of the die nozzle:

(SEI, %)

10

(0,01 mm)

:

$$SEI = \frac{D_e}{D_o} \cdot 100 \quad (1)$$

D_e – average diameter of the extruded products (mm), D_o – diameter of the neck of the die nozzle (mm).

Experimental design and data analysis

Response surface methodology was applied to determinate the influence of the BSG content – X_1 , the moisture content – X_2 , the screw speed – X_3 , and the final cooking zone temperature – X_4 on the sectional expansion index (response, y). A central composite rotatable design was used: $2^k+2.k+n$, where k is the number of the independent variables, n_o – the replicates of the central point ($n_o=3$).

The regression model was the following:

$$Y = b_o + \sum_{i=1}^n b_i x_i + \sum_{i=1}^n b_{ii} x_i^2 + \sum_{i=1}^n \sum_{j=1}^n b_{ij} x_i x_j \quad (2)$$

b_o, b_i, b_{ii}, b_{ij} are equation coefficients.

RESULTS AND DISCUSSION

The sectional expansion index values of the extruded products are shown in Table 2. The results of the statistical analysis of variance (ANOVA) for the sectional expansion index are shown in Table 3. In this case, 4 effects had P-values less than 0.05, indicating that they are significantly different from zero at the 95.0% confidence level. The R-squared statistic was 0.85. The standard error of the estimate was 28.22 while the mean absolute error was 14.28.

where, D_e – average diameter of the extruded products (mm), D_o – diameter of the neck of the die nozzle (mm).

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2.

Table 2. Sectional expansion index

	<i>SEI</i> , %		<i>SEI</i> , %		<i>SEI</i> , %
1	223	10	130	19	246
2	150	11	133	20	109
3	203	12	93	21	110
4	113	13	190	22	146
5	200	14	176	23	220
6	146	15	133	24	100
7	183	16	116	25	113
8	96	17	240	26	115
9	206	18	223	27	113

3.

Table 3. Regression coefficients and analysis of variance for sectional expansion index

	Regression coefficients	Sum of squares	F – F – ratio	P – P – value
constant	3921.97			
A:C	-35.756	9801.04	12.31	0.0043*
B:W	-39.058	16276.0	20.43	0.0007*
C:n	-4.165	155.042	0.19	0.6669
D:T _m	-29.435	5922.04	7.44	0.0184*
AA	0.264	14828.6	18.62	0.0010*
AB	-0.035	18.0625	0.02	0.8828
AC	0.022	715.563	0.90	0.3619
AD	0.098	1540.56	1.93	0.1895
BB	1.429	3530.61	4.43	0.0570
BC	-0.0118	18.0625	0.02	0.8828
BD	-0.215	663.063	0.83	0.3795
CC	0.0005	5.11343	0.01	0.9375
CD	0.0244	855.563	1.07	0.3204
DD	0.0849	1537.56	1.93	0.1900

* < 0.05

* Significant at < 0.05

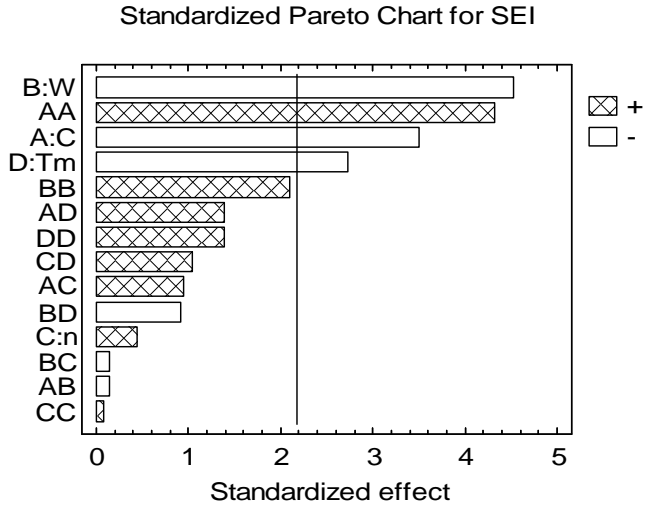
- Based on the results from the ANOVA after removing the insignificant effects, the following regression equation has been obtained:

$$SEI = 3921.97 - 35.76C - 39.06W - 29.44T_m + 0.26C^2 \quad (3)$$

- The main linear, quadratic, and combined factor effects are summarized and their evaluations are presented in a standardized Pareto chart (Figure 1). The greatest influence on the sectional expansion index had the linear effect of the mixture moisture content, followed by the quadratic effect of the brewers' spent

(1).

grain content in the mixture.

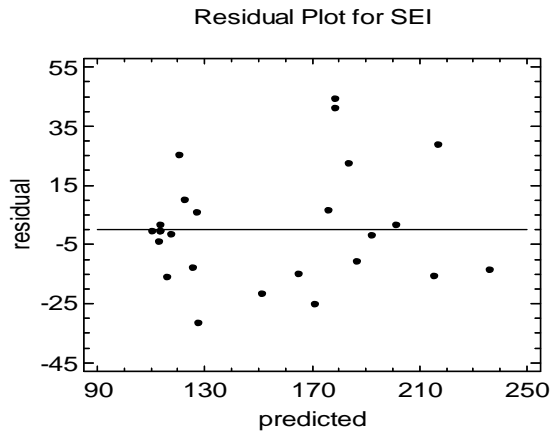


. 1.

Fig. 1. Estimated effects of regression model coefficients on the sectional expansion index

2

Figure 2 is a diagram of the distribution of the residual parameters of the regression model for the sectional expansion index of the extrudates, which shows that it is uniformly distributed around zero and there are no values to exceed two times the standard error.



. 2.

Fig. 2. Residual distribution diagram for the regression model of the sectional expansion index

93 246% (2).
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 .
 ” “
 ,
 (Ding et al., 2006).
 ,
 2.3
 17 29%
 150°C,
 180 rpm
 30%.
 (1).
 Altan
 et al. (2008), Dehghan-Shoar et al. (2010).
 ,
 (3).
 Balandran-Quintana et al. (1998)
 (140, 160 180°C),
 (18, 20 22%) (150,
 200 250 rpm).
 ,
 18 20%
 22%
 140 160°C
 160 180°C.

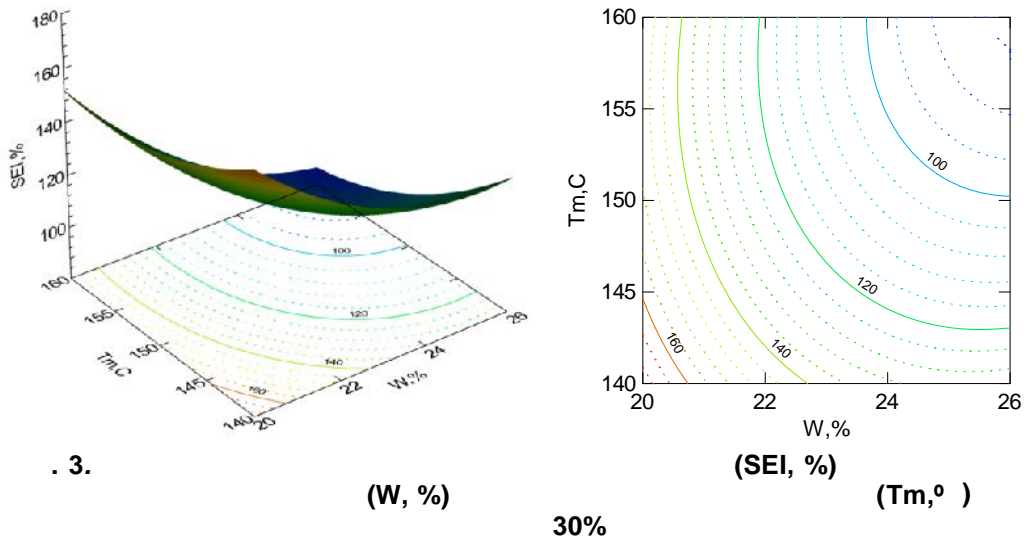
The sectional expansion index values of the extrudates ranged from 93 to 246% (Table 2).

Feed moisture has been found to be the main factor affecting extrudate expansion. Increased feed moisture content during extrusion may reduce the elasticity of the dough through plasticization of the melt, resulting in reduced the specific mechanical energy and therefore reduced gelatinization, decreasing the expansion of extrudates (Ding et al., 2006).

Our results show that the sectional expansion index of the extrudates decreases about 2.3 times with raising the moisture content from 17 to 29% at final cooking zone temperature 150°C, screw speed 180 rpm, and brewers' spent grain content 30%.

Raising the brewers' spent grain in the mixtures results in a reduction in the sectional expansion index of the extrudates (Figure 1). Similar results are observed by Altan et al. (2008), Dehghan-Shoar et al. (2010).

Our results show that as the temperature increases, the expansion decreases (Figure 3). Balandran-Quintana et al. (1998) have extruded pinto bean flours at three different die temperatures (140, 160, and 180°C), feed moisture content (18, 20, and 22%), and screw speeds (150, 200, and 250 rpm). They have reported that the expansion was influenced by moisture and temperature and it increased with increasing temperature for 18 and 20% moisture feed. For 22% moisture the expansion increased between 140 and 160°C and decreased abruptly between 160 and 180°C.



180 rpm

Fig. 3. Sectional expansion index (SEI, %) depending on moisture content (W, %) and final cooking zone temperature ($T_m, ^\circ$) at brewers' spent grain content 30% and extruder screw speed 180 rpm

CONCLUSIONS

- The changes in the sectional expansion index upon extrusion of a mixture of brewers' spent grains and wheat semolina were examined. The greatest influence on the sectional expansion index of the extrudates had the linear effect of the mixture moisture content, followed by the quadratic effect of the brewers' spent grain content in the mixture. The sectional expansion index values of the extrudates obtained from brewers' spent grains and wheat semolina ranged from 93 to 246%.

246%.

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