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Chemical composition of sugar beet, fodder beet and table beet depending on the harvest period

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Abstract

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The chemical composition of standard Bulgarian cultivars of sugar, fodder and table beet from the gene pool of the Agricultural Institute in Shumen was studied at two harvest periods.

On the first harvest date (9th August), Preslav (fodder beet) cultivar had the highest content of dry matter (951.70 g/kg) and crude fiber (113.70 g/kg). The highest level of crude fats (18.60 g/kg) and Ca (16.90 g/kg) were registered in dry matter of Tetra gold (fodder beet) Radost cultivar (table beet) registered the highest concentration of crude protein (220.50 g/kg), N (33.30 g/kg) and P (2.51 g/kg).

At the second harvest date (23 October), the highest content of crude protein (231.00 g/kg), crude fat (6.50 g/kg), minerals (136.80 g/kg), Ca (10.10 g/kg) and N (33.50 g/kg) were registered for Joy 3 (table beet) cultivar. Diex sugar beet cultivar registered a maximum amount of dry matter (951.80 g/kg), nitrogen-free extractable substances (780.00 g/kg) and phosphorus (2.90 g/kg). At a later harvest date, the crude fiber content was again the highest (81.50 g/kg) in dry matter composition of Preslav cultivar.

Keywords: chemical composition; sugar beet; fooder beet; table beet

Introduction

Table beet is a valuable technical and forage crop. The inclusion of fooder beet and sugar beet in the rations of ruminants is one of the ways to solve the problem of balanced nutrition. The controlled inclusion in the feed balance of sugar beet cultivars from the usual and yield trend has been proven to increase the productivity of ruminants without any side effects (Enchev et al., 2018).

High yields and concentrations of nutrients and vitamins and their good taste determine the use of fodder beet for succulent feed and their inclusion in the rations of cows, sheep, pigs, especially during the autumn-winter period (Badawi et al., 2002). The dry matter of rootbeet has a feed value around or above one, which is close to the effect of feeding on concentrated fooder (Todorov, 1997). There is a higher content of amino acids in the biomass of sugar beet due to the higher concentration of dry matter (Vladimirov, 1973). It has valuable qualities not only as food, but also to maintain normal metabolism in animals (Kikindonov et al., 2009)

The high sugar content, combined with high productivity, updates the significance of sugar beet for the production of organic sweet syrups. Sugar beet is the preferred source of raw material for bioethanol production in European countries (Hinkova & Bubnik, 2001; Oktay, 2004; Kikindonov & Kikindonov, 2012).

The taste qualities of table beet has long been known. That root crop and its leaves contain valuable nutrients, pigments and vitamins (Kikindonov & Kikindonov, 2010; En-

chev et al., 2020). During storage, the root crops do not lose their nutritional qualities (Uchkunov & Raikov, 2008)

The aim of the present study is to determine the chemical composition of dry matter in different types of sugar beet, fodder beet and table beet .

Material and Methods

In 2018, in the experimental field of the Agricultural Institute – Shumen, field experiments were carried out to assess the selection value of standard cultivars of sugar beet, fodder beet and table beet, and their pollinators. The researches optimize the developed technologies for growing beets with an emphasis on feed materials and determining the growth dynamics of pollinators and their hybrids from comparative attempts to establish the genotypic response.

Agroclimatic characteristics in the area of the experiment

The climatic characteristics of the area are an important factor for plant growth and development (Arechiga & Carlos, 2000, Hakansson et al., 2002; Albayrak & Çamaş, 2007). The intensity of light affects the accumulation of dry matter (Picken et al., 1986), and the soil microflora favors the absorption of nutrients, yield and quality of plant production (Markoski et al., 2015). The climatic conditions in 2018 in the area of the Agricultural Institute – Shumen were characterized as unfavorable. Uneven distribution of precipitation, drought with high temperatures during critical phases of beet development are observed (Table 1).

The field experiment is based on the method of long plots in 4 replications, with a plot size of 8.4 m^2 and includes determination of the chemical composition and energy value of root crop pulp (for standard cultivars). The following origins were used (Table 2):

Table 2. The origins, used in the experiment

Species	Standard cultivars	Pollinators
Sugar beet	Diex and Peshtera	5319R
Fodder beet	Sasha and Preslav, Tetragold	–
Table beet	Radost 1 and Radost 3	Radost

Sowing was done manually at a row spacing of 70 cm (10,000 plants per decare), in 6 replications, in two dates in August (09.08.) and October (23.10.). The chemical analysis of the root crops was performed after drying the ground pulp from the 2 harvest dates. The soil type is carbonate chernozem (black soil) with a slightly alkaline reaction of the soil solution.

The main chemical composition of dry feed mass was analyzed at the analytical laboratory of the Research Institute of Mountain Stockbreeding and Agriculture – Troyan, using Weende analysis: crude protein (CP, g/kg) according to Kjeldahl (according to BDS/ISO-5983); crude fibers (CFr, g/kg); crude fats (CF, g/kg) (according to BDS/ISO-6492) – by extraction in an extractor type Soxhlet; ash – mineral substances (g/kg) – (according to BDS/ISO-5984) decomposition of organic matter by gradual combustion of the sample in a muffle furnace at 550°C; dry matter (DM, g/kg) – empirically calculated from % of moisture; nitrogen-free extracts (NFE, %) = 100 – (CP, % + ,% + CFr, % + CF, % + ash,% + moisture, %) converted to g kg; calcium (Ca, g/kg) – complexometrically and phosphorus (P, g/kg) – with vanadate-molybdate reagent by the method of Guericke and Curmis with a spectrophotometer (Agilent 8453 UV – visible Spectroscopy System), measuring in the region of 425 ηm.

The experimental data were statistically processed by analysis of variance (ANOVA) and the program Statistica for Windows 10.

Table 1. Average air temperature (T°C) and annual amount of precipitation, mm

Month	Precipitation					Air Temperature			
	Decades			Amount	Rate	Decades			Average
	I	II	III			I	II	III	
January	0.6	23.4	22.5	46.5	35.0	5.2	1.2	0.1	2.2
February	23.6	40.6	51.0	115.2	28.0	5.8	2.4	-2.1	2.0
March	20.2	45.4	33.3	98.9	31.0	4.5	8.4	3.4	5.4
April	11.4	2.5	-	13.9	41.0	12.9	24.5	17.1	18.2
May	26.6	41.6	2.8	71.0	64.0	17.5	17.3	18.6	17.8
June	12.0	1.0	55.4	68.4	75.0	20.7	22.5	19.2	20.8
July	12.3	27.8	100.5	140.6	60.0	21.8	25.0	22.3	23.0
August	3.6	0.4	0.3	4.3	42.0	23.1	21.6	22.9	25.5
September	18.3	3.8	2.2	24.3	28.0	21.2	18.4	13.8	17.8
October	10.4	0.8	0.2	11.4	53.0	12.5	13.9	12.4	12.9
Annual amount					559.0				

Results and Discussion

Main chemical composition of dry matter of *Beta vulgaris*, on the first (09.08.) and second (23.10.) date of harvest.

The chemical composition of beets gives a real idea of its nutritional value. In August, fodder beet (Preslav cultivar) had the highest values (951.70 g/kg) in terms of dry matter. Table beet (Radost cultivar) registered the highest content of crude protein (220.50 g/kg), nitrogen (33.30 g/kg) and phosphorus (2.51 g/kg) (Table 3). Dry matter of table beet (pollinator Radost) also had the highest concentration of carbohydrates (756.20 g/kg). The values of the indicator are 1.5 and 13.4% higher than the maximum content of dry matter of sugar beet (Diex – 745.30 g/kg) and fodder beet (Sasha – 666.80 g/kg). The mineral substances (130.60 g/kg) in the composition of Radost 3 cultivar prevail by 25.8 and 82.9% compared to the maximum values in other types of beets.

The highest concentration of crude fiber (113.70 g/kg) was found in dry matter of fodder beet (Preslav cultivar). In contrast, Diex sugar beet cultivar recorded the lowest fiber content (53.10 g/kg) compared to the other experimental cultivars.

On the first harvest date, fodder beet (Tetra Gold) registered the least amount of dry matter (901.20 g/kg) but the highest in crude fat (18.60 g/kg) and calcium (16.90 g/kg). The highest crude protein content (170.30 g/kg) was alo registered in Tetra gold cultivar compared to other fodder beet cultivars.

For sugar beet cultivars, the dry matter content varied from 929.60 g/kg (5319R cultivar) to 949.70 g/kg (Peshtera cultivar). Compared to other sugar beet cultivars, 5319R had the lowest content of nitrogen-free extracts (687.90 g/kg) and phosphorus (1.10 g/kg) and the highest amount of crude protein (101.10 g/kg), minerals (71.40 g/kg), calcium (9.90 g/kg) and nitrogen (15.00 g/kg).

It is noteworthy that the sugar beet and fodder beet cultivars, which have the least amount of dry matter, are characterized by the highest concentration of crude protein. The values of this quality indicator prevail by 13.7 and 71.5% compared to the minimum content of the respective species.

On the second harvest date, the trend: low dry matter combined with high levels of crude protein was observed in the dry matter of table beet and fodder beet cultivars. Indicative in this respect is Radost 3 (Radost 3 table beet cultivar). The cultivar had the lowest amount of dry matter (907.20 g/kg) and the highest content of crude protein (231.00 g/kg), crude fat (6.50 g/kg), minerals (136.80 g/kg), calcium (10.10 g/kg) and nitrogen (33.50 g/kg). In the second harvest period, Diex sugar beet cultivar accumulated a maximum amount of dry matter (951.80 g/kg), richest in nitrogen-free extracts (780.00 g/kg) and phosphorus (2.90 g/kg) compared to other types and cultivars of beets.

Regardless of the harvest period, Preslav cultivar again recorded a maximum (81.50 g/kg) fiber content of dry matter. The lowest values of the indicator (40.30 g/kg) were reg-

Table 3. Main chemical composition of dry matter of *Beta vulgaris*, by cultivars and harvest periods, g/kg DM

Species	Cultivar	DM	CP	CF	CFr	Ash	NEF	Ca	P	N
09.08.2018										
Sugar beet	Peshtera	949.70	88.90	5.40	75.50	54.30	725.60	9.70	1.23	13.50
	5319R	929.60	101.10	3.30	65.90	71.40	687.90	9.90	1.10	15.00
	Diex	940.90	90.40	2.80	53.10	49.30	745.30	7.70	1.13	13.60
Table beet	Radost	933.40	61.70	1.70	63.70	50.10	756.20	7.70	1.06	9.20
	Radost 3	933.10	211.00	12.20	69.80	130.60	509.50	7.70	2.34	31.50
	Radost 1	943.80	220.50	6.30	64.40	115.20	537.40	14.00	2.51	33.30
Fodder beet	Preslav	951.70	99.30	2.20	113.70	103.80	632.70	13.90	2.14	15.10
	Tetra gold	901.20	170.30	18.60	66.90	82.20	563.00	16.90	2.13	24.60
	Sasha	946.10	119.80	4.10	77.60	77.80	666.80	7.60	2.03	18.10
23.10.2018										
Sugar beet	Peshtera	948.90	90.20	2.10	47.10	33.10	776.40	7.70	0.91	13.70
	5319R	938.40	84.90	3.30	44.50	30.50	775.20	9.80	0.85	12.70
	Diex	951.80	85.10	2.10	49.00	35.60	780.00	9.70	2.90	13.00
Table beet	Radost	949.70	102.70	1.40	40.30	34.90	770.40	7.60	0.92	15.70
	Radost 3	907.20	231.00	6.50	66.70	136.80	466.20	10.10	2.59	33.50
	Radost 1	914.80	186.30	3.10	60.00	96.90	568.50	7.90	2.28	27.30
Fodder beet	Preslav	931.70	131.70	1.80	81.50	75.60	641.10	7.70	2.62	19.60
	Tetra gold	916.80	167.20	5.50	52.90	90.40	600.80	7.70	1.62	24.50
	Sasha	923.00	134.20	6.30	50.10	81.00	651.40	5.60	1.25	19.80

istered in table beet (Radost cultivar) compared to the types and cultivars included in the experiment.

Comparative analysis of basic chemical indicators in the composition of sugar beet, table beet and fodder beet.

Table beet had the highest values of crude protein content (229.14-229.88 g/kg DM), minerals (128.36-131.01 g/kg DM) and nitrogen (32.40-30.40 g/kg DM) compared to the other types of beets, at both harvest dates – Table 3. It is proven (P <0.05) that the values of the indicators exceeded the values of the group (All Grps) by 63.5-66.3% (for CP), by 50.3-73.5%, respectively) and by 52.2-67.6% (for N). For both harvest periods, sugar beet had the highest concentration of nitrogen-free extracts (776.57-818.75 g/kg DM). The excess over All Grps varied from 12.4 to 14.1% (for both harvest dates).

Harvest dates significantly affected the phosphorus content. At the first harvest date (09.08.), the difference in the amount of the element among the groups of beets was statistically proven. Fodder beet and table beet cultivars are characterized by 20.6 to 39.7% higher concentration of the macronutrient compared to All Grps (1.74 g/kg DM). In contrast, at the second harvest date, there was no statistically proven difference in its content in the individual groups of beets. A similar trend was observed in crude protein. The percentage difference in the quantity of this quality indicator among the three types of beets was statistically proven and varied from 46.5 to 139.3%, at a later date of harvest (23.10.).

Unlike harvest dates, the type of crop had an impact on the content of crude fat, crude fiber, NEF, minerals, Ca and N in the dry matter of beets. Significant differences in the values of some indicators (nitrogen-free extract substances, ash and nitrogen) were found among the varieties in the group.

The interesting thing in this case is that according to the results of statistical data processing, the fiber content

Table 4. Chemical composition of sugar beet, fodder beet and table beet by types and harvest periods, g/kg DM

Beet types	CP	CF	CFr	NFE	Ash	Ca	P	N
09.08.								
Sugar beet	91.14a	3.51a	68.77a	776.57***	60.01**	8.75a	1.13***	12.83**
Table beet	229.88*	9.87a	71.52a	557.71**	131.01***	10.85a	2.43**	32.40***
Fodder beet	139.99a	9.10a	91.91a	664.82**	94.18*	12.80a	2.1**	19.27**
All Grps	138.25	6.79	77.09	690.69	87.18	10.57	1.74	19.32
Std.Dev.	61.77	6.21	17.54	95.66	31.35	3.49	0.60	8.50
Variance	3816.03	38.56	307.65	9151.10	982.88	12.21	0.36	72.33
Std.Err.	20.59	2.07	5.85	31.89	10.45	1.16	0.20	2.83
Minimum	66.10	1.82	56.44	546.03	52.40	7.6	1.06	9.20
Maximum	233.63	20.64	119.47	810.16	139.96	16.9	2.51	33.30
23.10.								
Sugar beet	95.77**	2.35a	47.74a	818.75***	35.38**	8.7a	1.40a	13.78**
Table beet	229.14***	5.28a	69.56a	567.67**	128.36***	9.0a	2.40a	30.40***
Fodder beet	156.37**	4.92a	66.48a	683.05**	89.17**	7.0a	1.83a	21.30**
All Grps	145.61	3.86	58.84	717.72	73.97	8.2	1.77	19.98
Std.Dev.	57.86	2.22	14.32	109.93	41.44	1.43	0.83	7.22
Variance	3347.74	4.94	205.19	12083.75	1717.67	2.05	0.69	52.06
Std.Err.	19.29	0.74	4.77	36.64	13.81	0.48	0.28	2.41
Minimum	89.41	1.47	42.43	513.89	32.50	5.6	0.85	12.70
Maximum	254.63	7.16	87.47	826.09	150.79	10.1	2.90	33.50
Harvest period	Average (09.08.-23.10.)							
09.08.	138.25a	6.79a	77.09*	690.69a	87.18a	10.57a	1.74a	19.32a
23.10.	145.61a	3.86a	58.84*	717.72a	73.97a	8.20a	1.77a	19.98a
All Grps	141.93	5.32	67.97	704.20	80.58	9.38	1.76	19.65
Std.Dev.	58.19	4.77	18.15	100.93	36.29	2.86	0.70	7.66
Variance	3385.51	22.74	329.57	10186.34	1317.01	8.19	0.49	58.65
Std.Err.	13.71	1.12	4.28	23.79	8.55	0.67	0.17	1.81
Minimum	66.10	1.47	42.43	513.89	32.50	5.60	0.85	9.20
Maximum	254.63	20.64	119.47	826.09	150.79	16.90	2.90	33.50

* P < 0.05

in dry matter of the studied beets was not significantly affected from the date of harvest. The average results for 09.08-23.10. however, showed a proven difference only in the amount of crude fiber in sugar beet, fodder beet and table beet. During the first harvest date, the fiber fraction concentration predominated. Its values significantly exceeded (P <0.05) by 31.0% and 13.4% respectively the amount at the second date of harvest (58.84 g/kg DM) and that of All Grps (67.97 g/kg DM) (Table 4).

The studied factors had a significant effect (P < 0.05) on dry matter composition (Table 5).

The type of the studied crop (sugar beet, fodder beet and table beet) had a great impact on the content of: crude protein (99.22%), nitrogen-free extracts (98.01%), minerals (95.22%), phosphorus , 25%) and nitrogen (98.80%).

The interaction between both factors as well as the independent impact of the harvest date caused the highest factor dispersion in the amount of Ca (46.05% and 43.93%, respectively) The type of crop had the least impact (10.02%) on the values of the studied trait compared to the other analyzed indicators.

According to the data analysis, the concentration of crude fiber was significantly affected both by the type (51.65%) and the reporting date (36.33%).

Table 5. Impact of the factors (type and date of reporting) of reporting on the chemical composition and energy nutritional value of dry matter of *Beta vulgaris*

Indicators	SS	Degree of Freedom	MS	F	p	Partial eta-squared	Observed power (alpha = 0.05)	Impact degree
CP. g/kg DM								
Type (A)	49715.50	2	24857.70	40.35	0.00	0.87	1.00	99.22
Harvest period (B)	189.80	1	189.80	0.31	0.59	0.03	0.08	0.38
A*B	202.60	2	101.30	0.16	0.85	0.03	0.07	0.40
CF. g/kg DM								
Type (A)	83.13	2	41.56	1.97	0.18	0.25	0.33	59.35
Harvest period (B)	45.52	1	45.52	2.16	0.17	0.15	0.27	32.50
A*Б	11.41	2	5.71	0.27	0.77	0.04	0.08	8.15
CFr. g/kg DM								
Type (A)	1537.96	2	768.98	4.18	0.04	0.41	0.62	51.65
Harvest period (B)	1081.96	1	1081.96	5.88	0.03	0.33	0.61	36.33
A*B	357.93	2	178.97	0.97	0.41	0.14	0.18	12.02
Ash. g/kg DM								
Type (A)	19033.00	2	9516.50	54.43	0.00	0.90	1.00	95.22
Harvest period (B)	481.30	1	481.30	2.75	0.12	0.19	0.33	2.41
A*B	473.10	2	236.60	1.35	0.30	0.18	0.24	2.37
NEF. g/kg DM								
Type (A)	155475.00	2	77738.00	68.91	0.00	0.92	1.00	98.01
Harvest period (B)	2285.00	1	2285.00	2.03	0.18	0.14	0.26	1.44
A*B	866.00	2	433.00	0.38	0.69	0.06	0.10	0.55
Ca. g/kg DM								
Type (A)	6.24	2	3.12	0.47	0.63	0.07	0.11	10.02
Harvest period (B)	27.37	1	27.37	4.15	0.06	0.26	0.47	43.93
A*B	28.68	2	14.34	2.18	0.16	0.27	0.36	46.05
P. g/kg DM								
Type (A)	4.03	2	2.01	5.88	0.02	0.50	0.77	94.25
Harvest period (B)	0.00	1	0.00	0.00	0.99	0.00	0.05	0.00
A*B	0.25	2	0.12	0.36	0.71	0.05	0.09	5.75
N. g/kg DM								
Type (A)	877.24	2	438.62	48.83	0.00	0.89	1.00	98.80
Harvest period (B)	0.45	1	0.45	0.05	0.83	0.00	0.06	0.10
A*B	10.07	2	5.04	0.56	0.59	0.09	0.12	1.10

Regardless of the type of beet, the harvest date had the least impact on the content of phosphorus (0.00%) and nitrogen (0.10%), crude protein (0.38%), NEF (1.44%) and ash (2.41%).

The interaction (A*B) of the studied factors had a slight impact on the amount of CP (0.40%), NEF (0.55%), N (1.10%), ash (2.37%), P (5.75%), CF (8.15%). and CFr (12.02%)

Conclusions

On the first harvest date (09. August), for fodder beet: Preslav cultivar registered the highest content of dry matter (951.70 g/kg) and crude fiber (113.70 g/kg), and Tetra Gold showed the highest amount in crude fat (18.60 g/kg) and Ca (16.90 g/kg). Radost 1 table beet cultivar had the highest concentration of crude protein (220.50 g/kg), N (33.30 g/kg) and P (2.51 g/kg).

On the second harvest date (October 23), Radost 3 table beet cultivar had the highest content of crude protein (231.00 g/kg), crude fat (6.50 g/kg), minerals (136.80 g/kg), Ca (10.10 g/kg) and N (33.50 g/kg), and Diex sugar beet had a maximum amount of dry matter (951.80 g/kg), nitrogen-free extracts (780.00 g/kg) and phosphorus. (2.90 g/kg). At a later harvest date, the crude fiber content was again the highest (81.50 g/kg) in dry matter composition of Preslav cultivar.

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