

**THE STUDY OF POPULATIONS OF HAZELNUT *C. avelana* L. AND
TURKISH HAZELNUT *C. colurna* L. AND THEIR SELECTION**

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Properties of populations of hazelnut *C. avelana* L. and Turkish hazelnut *C. colurna* L. in different regions of Serbia were studied over 1998 – 2005. Round-fruit selections suitable for candy industry were concurrently singled out. Populations of hazelnut and Turkish hazelnut are characterized by small or medium large fruits with round shape index and kernel index ranging from 0.77 – 0.89 and 0.78 – 0.84 respectively.

Singled out selections of hazelnut and Turkish hazelnut have averagely medium large fruits and kernel. Round shape index of fruits and kernel of hazelnut amount to 0.98 (1.01 – 0.91) and 0.99 (1.00 – 0.96) respectively, whereas the same parameter in Turkish hazelnut amounts to 0.99 (0.99 – 0.97) and 0.98 (0.98 – 0.97). Average fruit weight of the singled out selections is 1.79 g (hazelnut) and 1.74 g (Turkish hazelnut). Average kernel mass is 0.75 – 0.70 g. i.e. kernel ratio in hazelnut and Turkish hazelnut amounts to 41% and 40.2% respectively. The mineral matter content in the kernel of the selections amounted to 2.4% and 2.3%

respectively. Raw proteins content ranged from 13.8% - 12.4% respectively, and oil content ranged from 47.7 – 50.2% respectively. The majority of indicators under *in situ* conditions suggest that all selections singled out from the population deserve attention with objective of more intensified propagation and wider introduction into commercial production. It particularly refers to the round shaped kernel which is the most suitable for the candy industry.

Key words: Population, hazelnut, Turkish hazelnut, fruit, round shape index.

INTRODUCTION

By its importance within the group of kernel fruits hazelnut ranks second. It has high quality fruits with good aroma, which recommends it for the candy industry. Current forms of hazelnut and Turkish hazelnut are spontaneously widespread in the nature, representing a very rich genetic pool, significant for the selection. Biodiversity, pomological and technical properties of hazelnut and Turkish hazelnut were studied under diverse agroecological conditions by MITRESKI et al., (1983), MANUŠEV (1988), MITROVIĆ et al., (1997) MILETIĆ et al., (1997) etc. These studies resulted in selections which were described by PEJKIĆ (1980), INIĆ-TODOROVIĆ (1987), KRSTIĆ-PAVLOVIĆ et al., (1990), MILETIĆ et al., (2005). The stated researchers highlight high quality and their dietary and dietary-therapeutic value of the fruits.

Being suitable for production of biologically high quality food, the fruits of hazelnut and Turkish hazelnut are outstanding raw material for this very purpose. The objectives of hazelnut selection are maintenance of the current germplasm, breeding and establishment of commercial plantings. New requirements of the hazelnut processing industry refer mainly to developing cultivars with somewhat smaller, roundish-shaped fruits. Special attention has been devoted to the selection of hazelnut and Turkish hazelnut, in compliance with the demands of the candy industry.

MATERIALS AND METHODS

The investigations were conducted on the wide territory of the central, eastern and east-southern Serbia where hazelnut and Turkish hazelnut are more widely spread. The paper presents major properties of the studied populations as well as the properties of the round shaped fruit selections singled out from the population. More vigorous, winter hardy, vital, high and regular cropping bushes and trees resistant to *Curculium nucum* were particularly studied. Furthermore, a special attention was devoted to fruit size, shape, fruit and kernel weight and chemical composition of the fruits.

Five hazelnut and Turkish hazelnut trees that gave the best results over 1998 – 2005 were singled out from a large number of bushes. The collected fruits

were analyzed. i.e. fruit and kernel size (length, width and thickness) were determined by a calliper, whereas fruit and kernel weight were measured on a technical precision balance. Round shape index of fruit and kernel was calculated by the formula $I = \frac{\text{width} + \text{thickness}}{2} : \text{length}$, SIMOSKI (1971). Oil content was determined by the nuclear magnetic resonance method, whereas raw proteins were assessed by Kjendal and mineral matter content by the burn method.

RESULTS

Hazelnut (*C. avelana* L.) and Turkish hazelnut (*C. colurna* L.) are widely spread in the region of Serbia. Both are mainly grown in phytocenoses with different wood plants as well as in homogenous surroundings. Forms of *C. avelana* L. and *C. colurna* L. developed spontaneously in nature are of generative origin and they are very important genetic pool.

Studied populations of hazelnut have either small or medium large fruits. Average dimensions (length x width x thickness) are as follows: 17.2 (21.0-13.4) x 13.8 (16.1-10.7) x 12.8 (16.7-9.2) mm. Kernel dimensions: 12.1 (13.5-10.7) x 8.8 (12.5-6.7) x 7.7 (12.9-7.3) mm. Fruit dimensions of *C. colurna* L.: 14.7 (17.5-12.0) x 14.1 (16.5-11.5) x 12.1 (16.0-9.3) mm. Kernel dimensions of *C. colurna* L.: 11.5 (13.0-10.2) x 10.2 (12.6-7.2) x 9.2 (12.5-5.0) mm (Table 1).

Average values of fruit and kernel shape index of hazelnut amount to 0.77 (1.03-0.58) and 0.78 (1.00-0.46) respectively. As for *C. avelana* L. these values are 0.89 (1.04-0.66), i.e. 0.84 (1.02-0.53). The fruits of the *C. avelana* L. are mainly elongated. It is similar with the *C. colurna* L. population. However, as the fruits of Turkish hazelnut are larger and their round shape index is higher, fruit shape tends to be roundish. Typically roundish fruits as well as their kernel ($I=1.00$) are rarely found in the stated populations.

Average fruit weight of *C. avelana* L. is 1.02 g (1.40 – 0.42), kernel weight 0.34 (0.51 – 0.09 g) and kernel ratio amounts to 33.3% (37-12.8%). As for *C. avelana* L., the values are as follows: 1.15 g (1.55-0.94 g); 0.32 g (0.56-0.22 g); 27.8% (39.2-22.2%). Hollow fruits as well as the incidence of damage caused by *Curculium nucum* is more frequent in the population of *C. colurna* L. and it ranges from 10.6% (17.7-0.0%), i.e. 3.9% (13.8-0.0%). As regards the populations of *C. avelana* L., these values are more pronounced amounting to 1.9% (4.4-0.0), i.e. 0.37% (1.5-0.0%).

In respect of the contents of mineral matters and raw proteins, the kernel of *C. avelana* L. are more rich in comparison with *C. colurna* L. - 2.02% (2.4-1.1%) and 12.8% (15.5-9.6%) respectively (for *C. avelana* L.); 1.9% (2.3-1.6%) and 12.6% (14.4-10.6%) respectively (for *C. colurna* L.). In contrast to that, the kernel of *C. colurna* L. has higher oil content 52.3% (65.5-48.6%) compared to *C. avelana* L. (51.4-36.0%, 41.5% on average), table 2.

Table 1. Fruit size and shape in yx and yy in respective populations

Species	No.	Fruit (mm)				Kernel (mm)			
		Length mm	Width mm	Thickness mm	Shape index	Length mm	Width mm	Thickness mm	Shape index
<i>Corylus avelana</i> L.	1	15.0	10.7	9.2	0.66	11.5	7.0	6.5	0.59
	2	16.0	14.4	13.3	0.86	10.8	8.5	6.2	0.68
	3	18.3	12.1	12.5	0.67	12.7	8.5	7.5	0.63
	4	18.2	15.1	14.0	0.80	13.5	7.5	5.9	0.50
	5	19.1	14.2	12.3	0.70	13.4	9.1	7.6	0.62
	6	13.4	13.8	13.2	1.00	10.7	10.3	10.5	0.97
	7	21.0	13.1	11.1	0.58	12.4	6.7	4.7	0.46
	8	19.3	15.1	13.7	0.75	11.9	8.8	7.9	0.70
	9	16.0	13.4	11.7	0.78	11.7	8.4	7.3	0.62
	10	15.9	16.1	16.7	1.03	1.26	12.5	12.9	1.00
Mx	17.2	13.8	12.8	0.77	12.1	8.8	7.7	0.68	
<i>Corylus colurna</i> L.	1	12.0	12.0	9.6	0.90	10.5	8.2	8.3	0.78
	2	15.5	16.5	12.4	0.93	12.4	11.9	11.0	0.92
	3	16.2	16.5	12.0	0.89	13.0	12.5	10.6	0.89
	4	17.5	13.0	10.0	0.66	11.5	7.2	5.0	0.53
	5	15.1	14.4	13.5	0.94	12.5	10.1	9.9	0.80
	6	11.8	11.5	9.3	0.88	10.2	9.7	6.0	0.68
	7	14.3	14.3	11.7	0.91	10.2	9.4	9.4	0.92
	8	15.0	15.4	15.7	1.04	10.9	10.6	10.3	0.96
	9	13.7	11.8	11.0	0.83	11.3	9.9	9.2	0.94
	10	15.6	16.0	16.0	1.02	12.3	12.6	12.5	1.02
Mx	14.7	14.1	12.1	0.89	11.5	10.2	9.2	0.84	

Tabela 2. Fruit weight and chemical composition of yx and yy in respective populations.

Species	No.	Fruit weight (g)	Kernel weight (g)	Kernel ratio (%)	Hollow nuts (%)	C. <i>Nucum</i> (%)	Mineral matters (%)	Raw proteins (%)	Oil content (%)
<i>Corylus avelana</i> L.	1	0.42	0.10g	23.8	3.3	0.0	2.3	15.5	36.8
	2	0.94	0.29	30.8	0.0	0.0	2.2	11.3	51.4
	3	0.95	0.30	31.6	4.40	1.0	1.1	9.6	47.4
	4	1.19	0.39	32.8	3.2	0.0	2.7	12.8	40.3
	5	1.21	0.42	34.7	0.0	1.5	1.9	11.9	41.1
	6	1.03	0.32	31.1	1.0	0.0	2.44	15.2	37.7
	7	0.70	0.09	12.8	0.0	0.5	2.0	14.9	36.2
	8	1.40	0.51	36.4	0.0	0.1	1.6	13.3	36.0
	9	1.31	0.49	37.4	2.2	0.0	2.2	12.0	48.8
	10	1.07	0.35	32.7	4.7	0.6	1.8	11.3	39.6
Mx	1.02	0.34	33.3	1.9	0.37	2.02	12.8	41.5	
<i>Corylus colurna</i> L.	1	0.95	0.22	23.1	0.0	2.4	1.7	13.3	51.7
	2	1.39	0.44	28.8	0.0	0.0	2.0	13.7	52.9
	3	1.43	0.56	39.2	3.6	3.6	1.6	13.3	53.8
	4	0.94	0.24	25.5	17.7	7.5	2.0	10.6	65.5
	5	1.26	0.35	27.8	2.2	0.0	2.1	14.4	52.6
	6	0.90	0.20	22.2	0.0	0.0	1.7	13.9	62.6
	7	1.04	0.24	23.1	34.5	12.2	2.2	13.0	48.6
	8	1.55	0.40	25.8	41.1	0.0	2.3	12.6	55.2
	9	0.68	0.26	38.3	2.4	0.0	1.7	11.0	58.5
	10	1.41	0.32	28.1	10.3	13.8	1.9	13.0	61.8
Mx	1.15	0.32	27.8	10.6	3.9	1.9	12.6	52.3	

Selections of *C. avelana* L. singled out from the population that meet basic criteria related to fruit shape have averagely medium large fruits (16.5 (17.6-12.0) x 16.4 (18.3-12.2) x 15.9 (18.0-11.6) mm) and kernel 12.4 (13.0-10.5) x 12.4 (13.2-10.5) x 12.1 (13.0-10.0) mm. On the other hand, fruits of *C. colurna* L. are somewhat larger – 18.1 (19.6-16.9) x 17.9 (19.1-16.8) x 17.8 (19.4-16.4), kernel amounting averagely to 12.2 (13.0-11.5) x 12.0 (12.8-11.3) x 11.9 (12.5-11.3) mm. Round shape index for fruits and kernel of *C. avelana* L. amounts averagely to 0.98 (1.01-0.91) and 0.99 (1.00-0.96) respectively, whereas for *C. colurna* L. the values are 0.99 (0.99-0.97) and 0.98 (0.98-0.97) respectively. As for this parameter the fruits of the selections are approximately or typically roundish, table 3.

Tabela 3. Fruit and kernel size and shape of the selections singled out from the respective populations

Species	No.	Fruit (mm)				Kernel (mm)			
		Length	Width	Thickness	Shape	Length	Width	Thickness	Shape
		mm	mm	mm	index	mm	mm	mm	index
	30/96	17.8	16.2	16.1	0.91	13.0	12.7	12.3	0.96
<i>Corylus</i>	12/96	17.4	17.3	16.3	0.96	12.8	13.0	12.6	1.00
<i>avelana</i> L.	33/02	12.0	12.2	11.6	0.99	10.5	10.5	10.0	0.98
	24/03	17.9	18.3	18.0	1.01	12.6	12.8	12.5	1.00
	50/03	17.6	17.8	17.4	1.00	13.0	13.2	13.0	1.00
	Mx	16.5	16.4	15.9	0.98	12.4	12.4	12.1	0.99
	7/01	18.4	18.2	17.6	0.97	12.6	12.4	12.2	0.98
	9/02	17.9	17.7	17.8	0.99	12.0	11.8	11.8	0.98
<i>Corylus</i>	14/02	17.8	17.5	17.6	0.98	11.8	11.6	11.6	0.98
<i>colurna</i> L.	22/03	19.6	19.1	19.4	0.98	13.0	12.8	12.5	0.97
	18/04	16.9	16.8	16.4	0.98	11.5	11.3	11.3	0.98
	Mx	18.1	17.9	17.8	0.99	12.2	12.0	11.9	0.98

Fruit and kernel weight of the selections is different, though averagely approximate in values. Thus, average fruit weight of *C. avelana* L. and *C. colurna* L. amounts to 1.79 g (2.21-0.95 g) and 1.74 g (2.29-1.28 g) respectively. The kernel weight from *C. avelana* L. and *C. colurna* L. amount to 0.75 g (0.93-0.32 g) and 0.70 g (0.85-0.56 g) respectively, with the kernel ratio ranging from 46.2-33.7%, 41.0% on average, and 43.9-36.7%, 40.2% respectively. Hollow fruits amount to 0.5% (1.4-0.0) and 0.56% (1.2-0.0) respectively. *Curculium nucum* was recorded only in one selection of *C. avelana* L. and in two selections of *C. colurna*

L.. Mineral matter content in the kernel of the selections ranges from 2.7-2.0%, 2.4% on average (*C. avelana* L.) and 2.7-1.9%, 2.3% (*C. colurna* L.). Soluble proteins content amounts to 13.8% (16.3-11.0%) and 12.4% (14.4-10.9) respectively, whereas oil content is 47.7% (51.7-43.9%) and 50.2% (53.1-47.7%) respectively (Table 4).

Tabela 4. Fruit weight and chemical composition of kernel of the selections singled out from the respective populations

Species	No.	Fruit weight (g)	Kernel weight (g)	Flesh ratio (%)	Hollow nuts (%)	C. <i>mucum</i> (%)	Mineral matters (%)	Raw proteins (%)	Oil content (%)
	30/96	2.21	0.90	40.7	0.1	0.0	2.4	11.0	47.7
<i>Corylus</i>	12/96	2.11	0.93	44.1	0.6	0.2	2.6	13.4	46.8
<i>avelana</i> L.	33/02	0.95	0.32	33.7	0.0	0.0	2.0	16.3	51.7
	24/03	1.99	0.79	39.7	0.5	0.0	2.7	15.3	48.2
	50/03	1.71	0.79	46.2	1.4	0.0	2.4	13.2	43.9
	Mx	1.79	0.75	41.9	0.5	0.04	2.4	13.8	47.7
	7/01	1.28	0.56	43.8	0.6	0.5	2.7	11.4	49.4
	9/02	1.85	0.78	42.2	0.7	0.0	1.9	11.6	52.0
<i>Corylus</i>	14/02	1.96	0.72	36.7	1.2	0.0	2.0	10.9	53.1
<i>colurna</i> L.	22/03	2.29	0.85	37.1	0.0	0.4	2.4	14.4	47.7
	18/04	1.32	0.58	43.9	0.3	0.0	2.5	13.8	48.6
	Mx	17.4	0.70	40.2	0.56	0.16	2.3	12.4	50.2

DISCUSSION

There are many bushes and trees with different pomological, biological and productive properties owing to the generative method of propagation within the populations of *C. avelana* L. and *C. colurna* L..

MITRESKI et al.. (1983) state that fruit dimensions of the types singled out from the populations of *C. avelana* L. are 17.0-23.4x16.0-19.6x12.7-16.0 mm, fruit weight .45-2.08 g, kernel weight 0.48-1.15 g and kernel ratio 1.0-53.0%. On the Pešter plateau, PEJKIĆ (1980) made a selection of forms of *C. avelana* L. with fruit length ranging from 14.4 – 22.1, fruit width 14.1 – 16.9 mm and fruit weight 1.13 – 1.51 g. It is similar with the fruits of *C. colurna* L. - NINIĆ-TODORVIĆ (1987) reports biotypes with fruit size 16.4-18.6x14.4-17.8x11.0-15.8 mm, fruit weight 1.17-2.54 g and kernel weight 0.52 - 0.71 g. Within the studies of

biodiversity of *C. colurna* L. in Serbia MITROVIĆ et al. (1997, 2001) reported properties for 11 and 7 genotypes of *C. avelana* L. and *C. colurna* L. respectively singled out from the selections of the central and the eastern Serbia. The authors state the following values of fruit size, kernel size and fruit weight, kernel weight and kernel ratio: 13.8-19.1x11.6-19.1x9.0-16.7 mm, 11.3-15.4x8.0-13.4x5.7-10.2 mm, 0.63 - 2.86 g, 0.24 - 0.86 g and 25.9 - 38.1% respectively. In their studies MILETIĆ et al., (2005) presented eight selections of *C. colurna* L. and *C. avelana* L. each that attract attention. Kernel content in *C. avelana* L. ranges from 27.9% to 46.2% and in *C. colurna* L. from 30.7 to 40.8%.

All stated selections have typically elongated fruits, which corresponds with our results which suggest that elongated fruits dominate populations of *C. avelana* L. and *C. colurna* L. with the exception of the selection "Dučalovići" singled out by MITROVIĆ et al. (1997). By its properties, this selection is close to the demands of the candy industry and high quality fruits. It also confirms the statement that genotypes with roundish fruits that are suitable for the chocolate industry may be found in the populations. HLIŠČ (1971) reports that round shape index in such fruits amounts to 1.0, whereas SIMOSKI (1971) reports the value 0.94 for the parameter. According to these criteria, the stated selections are highly suitable for the candy industry. Hollow fruits, irrespective of the incidence of parasites, are caused by various factors, MANUŠEV (1988). The incidence of *Curculium nucum* is certainly negative and a limiting factor for more intensive growing of such selections.

Fresh hazelnut fruits are complex and high calorific value food with high dietary value, which is confirmed by the presented results of the selections of *C. colurna* L. and *C. avelana* L. singled out from the respective populations. These correspond to the reports of KRSTIĆ-PAVLOVIĆ (1990), MILETIĆ et al., (1997, 2005), NINIĆ-TODOROVIĆ (1987), MITROVIĆ et al., (1997), etc.

As for the chemical composition of kernel of *C. colurna* L. and *C. avelana* L. it is not in correlation with the standard found in widely grown cultivars, MILETIĆ (1994), which does not affect their value and potential for both for fresh use and processing. Besides, populations of hazelnut are largely found in ecologically favorable environment and consequently hazelnut fruits may be described as biologically valuable food. Additionally, both *C. avelana* L. and *C. colurna* L. grow and produce fruits spontaneously in natural surroundings without a special cultivation and pest management. These facts speak in favour of beneficial values of fruits of hazelnut that recommend them for nutrition, which is certainly a special advantage of fruits of the *Corylus* genus. There are favorable conditions in our country for the establishment of collection plantings with the aforementioned selections in high altitude and high humidity regions, at the foot of big mountains, near mountain streams and in river valleys. The advantage of such regions are longer winter and snow periods along with relatively late snow melting which provide water for the optimal growth of fruits and kernel as well as for the regular cropping.

CONCLUSION

Within the studies of *C. avelana* L. and *C. colurna* L. over 1998 – 2005 some selections with outstanding properties were singled out.

Populations of *C. avelana* L. and *C. colurna* L. are characterized by small to medium large fruits. Round shape index and kernel shape index of *C. avelana* L. amount to 0.77 and 0.78 respectively, and, in *C. colurna* L., 0.89 and 0.84 respectively. Average fruit weight, kernel weight and kernel ratio of *C. avelana* L. fruits are 1.02 g, 0.34 g and 33.3% respectively. As for, *C. colurna* L. these parameters are as follows: 1.15 g, 0.32 g and 27.8% respectively. Hollow fruits as well as damage caused by *Curculium nucum* in the *C. colurna* L. population are 10.6%, i.e. 3.9% on average, whereas in *C. avelana* L. the corresponding value is 1.9% (4.4-0.0) and 0.37%. Average mineral matters, raw proteins and oil contents in the kernel of *C. avelana* L. are as follows: 2.4%, 13.8% and 47.7% respectively. The same parameters in *C. colurna* L. are as follows: 2.3%, 12.4% and 50.2%, 0%, respectively.

Fruits and kernel of the selections of *C. avelana* L. and *C. colurna* L. singled out from the respective populations are mainly medium large. Round shape index of the fruits and kernel of *C. avelana* L. amounts to 0.98 (1.01-0.91) and 0.99 (1.00-0.96) respectively, whereas for *C. colurna* L. the values are 0.99 (0.99-0.97) and 0.98 (0.98-0.97) respectively. Average fruit weight in *C. avelana* L. is 1.79 g (2.21-0.95 g) and 1.74 g (2.29-1.28 g) in *C. colurna* L.. Kernel weight - 0.75 g (0.93-0.32 g) and 0.70 g (0.85-0.56 g) respectively, with kernel ratio 41.0% (46.2-33.7%) and 40.2% (43.9-36.7%) respectively. Hollow fruits are 0.5% (1.4-0.0) and 0.56% (1.2-0.0) on average, respectively. *Curculium nucum* was recorded only in one selection of *C. avelana* L. and in two selections of *C. colurna* L.. Mineral matter content in the kernel of the selections of *C. avelana* L. and *C. colurna* L. amounts averagely to 2.4% (2.7-2.0%) and 2.3% (2.7-1.9%) respectively.

Raw proteins content in *C. avelana* L. and *C. colurna* L. amount to 13.8% (16.3-11.0%) and 12.4% (14.4-10.9) respectively and oil content is 47.7% (51.7-43.9%) and 50.2% (53.1-47.7%) respectively.

The majority of indicators under *in situ* conditions suggest that all selections singled out from the population deserve attention with objective of more intensified propagation and wider introduction into commercial production. It particularly refers to the round shaped kernel which is most suitable for the candy industry.

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PROUČAVANJE POPULACIJA I KLONSKA SELEKCIJA ŠUMSKE I MEČJE LESKE

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I z v o d

Izučavane su karakteristike populacija šumske i mečje leske u različitim područjima Srbije u periodu od 1998 do 2005. godine. Istovremeno su izdvojene selekcije sa okruglastim plodovima pogodnim za konditorsku industriju. Populacije šumske i mečje leske karakterišu plodovi sitne ili srednje krupnoće sa indeksom okruglosti plodova od 0,77 i 0,89 i jezgre od 0,78, odnosno 0,84.

Odabrane selekcije šumske i mečje leske, su u proseku sa srednje krupnim plodovima jezgrom Indeks okruglosti za plodove i jezgru šumske leske je 0,98 (1,01-0,91) i 0,99 (1,00-0,96), a za mečju lesku 0,99 (0,99-0,97), odnosno i 0,98 (0,98-0,97). Prosečna masa plodova odabranih selekcija šumske leske je 1,79 g, a mečje 1,74 g, jezgre 0,75 g i 0,70 g te je sadržaj jezgre 41,0%, odnosno 40,2%. U jezgri odabranih selekcija, sadržaj mineralnih materija je u proseku 2,4% za šumsku i 2,3% za mečju lesku. Sadržaj sirovih proteina je 13,8% i 12,4%, a sadržaj ulja 47,7%, odnosno 50,2%. Prema većini pokazatelja u *in situ* uslovima sve navedene selekcije zaslužuju pažnju da se kolekcionisanjem i razmnožavanjem šire u komercijalnu proizvodnju. To se posebno odnosi na okruglast oblik jezgre koji je i najpogodniji u industriji čokolade.

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