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Sensory evaluation of different walnut cultivars (*Juglans regia* L.)

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ABSTRACT

Sensory characteristics of walnut fruits were tested by students and employees at the Biotechnical faculty, separately, to determine the differences among cultivars 'Chandler', 'Adams', 'Cisco', 'Fernette', 'Fernor', 'Franquette', 'Rasna', 'Alsószentiváni 117' ('A-117') and 'Elit'. First of all, visual properties of inshell walnuts (shell smoothness, shell colour and seam closeness) and appearance of kernel (pellicle colour, internal colour of a kernel, and kernel brightness) were evaluated, then the kernel was tasted to assess its flavour, bitterness, astringency, texture, crispness and oiliness. Visual appearance of inshell walnuts was evaluated similarly by both groups of assessors. 'Rasna' and 'Fernor' walnuts had the roughest shell. 'Rasna' also had the least brightness of the kernel, the darkest pellicle and it was one from among the least crispy cultivars. Shell colour of 'Fernette', as well as pellicle and internal colour of 'Fernor' were the lightest. However, each group of assessors had quite different perceptions for tasting internal traits of the kernels. In the present study useful data of sensory characteristics of walnut fruits were obtained. Some of 12 descriptors, which were evaluated in the research, could be used as a custom method for testing and introducing of new walnut varieties in Slovenia.

Key words: sensory evaluation, walnut fruits, *Juglans regia* L., fruit in shell, appearance of kernel, internal characteristics of a kernel

IZVLEČEK

SENZORIČNO OCENJEVANJE RAZLIČNIH SORT OREHA (*Juglans regia* L.)

Študentje in uslužbenci Biotehniške fakultete so ločeno ocenjevali senzorične lastnosti plodov oreha, da bi ugotovili razlike med sortami 'Chandler', 'Adams', 'Cisco', 'Fernette', 'Fernor', 'Franquette', 'Rasna', 'Alsószentiváni 117' ('A-117') in 'Elit'. Najprej so ocenjevali vidne lastnosti orehov v luščini (gladkost luščine, barva luščine, zaprtost šiva) in zunanji izgled jedrc (barva povrhnjice, notranja barva jedrc, lesk jedrc). Zatem so ocenjevalci jedrca okušali, da so določili njihov vonj, grenkost, trpkost, teksturo, hrustljavost in oljnatost. Plodovi sort 'Rasna' in 'Fernor ' so imeli najbolj razbrazdano luščino. Sorta 'Rasna' je bila ocenjena kot

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ena izmed najmanj hrustljavih sort. Njena jedrca so imela najšibkejši lesk in najtemnejšo povrhnjico. Luščina sorte 'Fernette' ter povrhnjica in notranjost jedrca sorte 'Fernor' so bile med najsvetlejšimi. Obe skupini ocenjevalcev sta dokaj podobno ocenili izgled neoluščenih orehov in izluščenih jedrc, pri zaznavanju notranjih lastnosti jedrc pa smo določili precejšnje razlike med skupinama. Pri raziskavi smo pridobili uporabne podatke o senzoričnih lastnostih različnih sort oreha. Nekatere izmed 12 uporabljenih deskriptorjev bi lahko vključili v veljavno metodo preizkušanja in uvajanja novih sort oreha v Sloveniji.

Ključne besede: senzorično ocenjevanje, plodovi, *Juglans regia* L., plod v luščini, izgled jedrca, notranje lastnosti jedrca

INTRODUCTION

A valuable edible nuts produced by walnut trees are well appreciated because they are enriched with unsaturated fat (linoleic, oleic acid). They also contain other beneficial components like plant protein (e.g. arginine, leucine), carbohydrates (e.g. dietary fibre), vitamins (e.g. vitamin A, E), pectic substances, minerals (magnesium, potassium, phosphorus, sulphur, copper, iron), plant sterols, phytochemicals (phenolic acids, flavonoids, etc.) (Kris-Etherton et al., 1999; Prasad, 2003). Especially pellicle - a thin cover that surrounds kernel, was found as the most important source of walnut phenolics, although it only represents 5% of the fruit weight (Colarič et al., 2005).

In Slovenia, the Persian or common walnut (*Juglans regia* L.) is found as a widely spread species, consisted of natural, artificially created, partly naturally created and rural populations (Solar et al., 2002).

A wide range of walnut cultivars grown in Slovenia is mainly a consequence of a long-term project called 'Introduction and selection of fruit plants'. The main purpose of the project is to ensure the Slovenian fruit-growers quality plant material of tested varieties of local and foreign origin. The introduction and selection of fruit plants is led and co-ordinated by the researchers from the Agricultural Institute of Slovenia. In the field of nut crops it is carried out in cooperation with experts at the Biotechnical Faculty (Agronomy department, Chair for fruit-growing). The selection procedure is performed according to UPOV (Union internationale pour la protection des obtentions végétales, 1989) and IPGRI (International Plant Genetic Resources Institute, 1994) descriptors. Generally, in evaluating new cultivars or genotypes more commercially important tree and nut characteristics are emphasized. Nevertheless, among sensory properties of nuts only pellicle colour, shell strength, shell seam, easiness of kernel halves removal and taste used to be evaluated for selection purposes (Solar, 1996-2004). However, from the consumer's point of view (his satisfaction and further consumption) the sensory properties of fruit are among the most important, especially visual and taste properties, therefore sensory characterization is rather welcome.

The main purposes of this study are to describe and evaluate some sensory characteristics of nuts in different walnut cultivars by untrained consumers of different age (students and employees at the Biotechnical Faculty), and then to determine if the differences between studied cultivars could be found between both estimated groups.

MATERIAL AND METHODS

Material

Ripe and healthy nuts of ten different walnut cultivars, which were harvested in September 2005 at the experimental orchard of the Biotechnical Faculty (Maribor, Slovenia), were used in the research (Table 1).

Tabela 1. Sorte orehov, uporabljene pri senzoričnem ocenjevanju ter njihov izvor.
Table 1. Walnut cultivars used in sensory evaluation and their origin.

Cultivar	Origin
'Elit'	Slovenia
'Fernor'	France
'Chandler'	USA
'Adams'	USA
'Cisco'	USA
'Fernette'	France
'A-117' ('Alsószentiváni 117')	Hungary
'Lara'	France
'Franquette'	France
'Rasna'	Serbia and Montenegro

The inshelled nuts were immediately dried in forced-air dryers at 30-35 °C until 12% moisture content was achieved and kept in the storeroom at 4 °C until sensory evaluation.

Assessors

Two different age groups (which were also two different vocational groups) participated in the sensory evaluation: a younger age group, which consisted of students at the Biotechnical faculty and an older age group, which consisted of the employees at the same faculty. Each group consisted of twenty non-expert assessors.

Sensory evaluation

On the evaluation day the shell was cracked and kernel divided into fourths, then for each assessor 4 fourths derived from 4 different nuts (to represent one sample) were allotted. Evaluated cultivars were coded with a three-digit number. All testing was performed under the same conditions at room temperature. During the assessment of different samples water and bread were available for taste neutralization.

Sensory evaluation comprised estimation of external and internal properties of walnut fruit (Table 2). The sensory descriptors were rated on an anchored line scale, 'low intensity' and 'high intensity' being the anchor points. Line scale was 100 mm in length and divided in ten sections. The scale was converted on to 1 to 10 score range for data analysis purposes by template.

Table 2. Deskriptorji senzoričnih lastnosti plodov oreha.
Table 2. Descriptors of sensory characteristics of walnut fruit.

	Scale anchors	
Descriptor	1	10
A. External appearance		
Shell smoothness	very rough	very smooth
Shell colour	light brown	very dark
Seam closeness	open	tightly closed
Pellicle colour	extra light	very dark brown
Internal colour	whitish	dark brown
Kernel brightness	none	emphasized
B. Tasted kernel properties		
Flavour	weak	typically walnut flavoured
Bitterness	absent	strong
Astringency	very weak	strong
Texture	fragile	firm
Crispness	weak	crisp
Oiliness	little	high

Data evaluation

The results were evaluated using the Statgraphics Plus 4.0 program (Manugistics, Inc.; Rockville, Maryland, USA). A one-way analysis of variance was used for testing differences in the data of sensory evaluation between cultivars. The mean values of assessors for each sensory descriptor were compared between cultivars to look for grouping (Duncan, $P < 0.05$). Data in Tables 3–6 are presented as means of 20 assessors (separately for employees and students). Spearman rank correlations were done for measuring the relation between astringency and bitterness for each cultivar (Table 7).

RESULTS AND DISCUSSION

Each assessor evaluated twelve properties in ten coded cultivars. Many statistically significant differences were found (Tables 3-6).

External appearance

Shell smoothness, shell colour and seam closeness were evaluated on inshelled walnuts; then pellicle colour, internal colour and kernel brightness were evaluated on shelled walnuts on a scale ranging from 1 to 10. All abovementioned sensory properties were estimated visually by appearance, which is a vital attribute and involves analysis of both geometric attributes and colour attributes (Shepherd et al., 1993). The results are summarized in Table 3 and Table 4; significant differences among cultivars are also presented. In our previous work that was conducted in the frame of the national project ‘Introduction and selection of walnuts’ among external traits of the inshell nuts shell texture and shell seam used to be estimated visually on a scale from 1 to 9. The same scale was used when evaluating kernel properties like pellicle colour, taste and easiness of kernel halves removal (Solar, 1996-2004). During the investigation of the largest collection of local walnut genotypes with a great phenotypic variability of quantitative and qualitative traits, shell strength

(hardness) was also estimated. 5 scores were used for very strong (‘koščak’) and 6 scores for weak and thin shell (Solar et al., 2002).

Table 3. Povprečne ocene za zunanje lastnosti orehov v luščini in jedrc - zaposleni na Biotehniški fakulteti.
Table 3. Mean estimations for visual properties of inshell walnuts and kernels - employees at the Biotechnical Faculty.

	Inshell fruit			Kernel		
Property	Shell smoothness	Shell colour	Seam closeness	Pellicle colour	Internal colour	Brightness
Cultivar	(1 – 10)	(1 – 10)	(1 – 10)	(1 – 10)	(1 – 10)	(1 – 10)
‘Elit’	7.3 d	6.0 bc	9.2 e	4.4 bcd	3.9 a	6.4 b
‘Fernor’	3.1 a	6.2 c	9.3 e	2.3 a	3.7 a	6.7 b
‘Chandler’	5.2 bc	6.0 bc	7.3 bc	3.6 b	4.3 ab	6.0 b
‘Adams’	4.8 b	6.3 c	8.8 cde	4.7 cde	4.9 bc	6.4 b
‘Cisco’	6.0 c	6.0 bc	5.9 ab	4.7 cde	5.0 bc	5.6 b
‘Fernette’	7.7 d	4.1 a	9.0 de	2.7 a	5.8 c	6.0 b
‘A-117’	4.4 b	7.5 d	7.4 bcd	5.7 ef	5.2 bc	6.0 b
‘Lara’	5.0 b	5.1 b	6.2 ab	5.1 de	4.9 bc	6.0 b
‘Franquette’	4.7 b	5.7 bc	7.4 bcd	4.0 bc	5.0 bc	6.0 b
‘Rasna’	3.1 a	7.4 d	5.4 a	6.3 f	5.3 bc	3.9 a

Different letters within each column show significant differences in sensory descriptor among cultivars (Duncan, $P < 0.05$).

Table 4. Povprečne ocene za zunanje lastnosti orehov v luščini in jedrc - študenti Biotehniške fakultete.
Table 4. Mean estimations for visual properties of inshell walnuts and kernels - students at the Biotechnical Faculty.

	Inshell fruit			Kernel		
Property	Shell smoothness	Shell colour	Seam closeness	Pellicle colour	Internal colour	Brightness
Cultivar	(1 – 10)	(1 – 10)	(1 – 10)	(1 – 10)	(1 – 10)	(1 – 10)
‘Elit’	6.9 c	6.8 bc	7.7 ab	4.3 bc	5.4 ab	4.7 c
‘Fernor’	3.1 a	7.4 c	7.3 ab	2.8 a	4.4 a	5.1 c
‘Chandler’	5.3 b	7.4 c	6.9 ab	4.0 bc	5.1 ab	5.8 c
‘Adams’	5.0 b	7.2 c	7.3 ab	5.7 e	5.3 ab	4.8 c
‘Cisco’	6.7 c	7.0 c	6.5 a	5.6 de	6.0 b	4.9 c
‘Fernette’	6.9 c	4.3 a	6.8 ab	5.0 cde	6.2 b	7.3 d
‘A-117’	7.0 c	7.7 c	8.3 b	5.8 e	4.9 ab	3.4 b
‘Lara’	4.1 ab	6.0 b	6.3 a	4.4 bcd	5.4 ab	5.9 c
‘Franquette’	4.9 b	7.2 c	7.1 ab	3.4 ab	5.2 ab	5.6 c
‘Rasna’	3.4 a	7.5 c	7.6 ab	7.0 f	4.4 a	2.1 a

Different letters within each column show significant differences in sensory descriptor among cultivars (Duncan, $P < 0.05$).

‘Rasna’ and ‘Fernor’ had the roughest shell among evaluated cultivars, not only for the employee (Table 3) but also for the student group (Table 4). ‘Elit’ and ‘Fernette’ had the smoothest shell for both groups, besides ‘A-117’ and ‘Cisco’ in the student group. According to the students’ opinion, there are three cultivars (‘Chandler’, ‘Cisco’ and ‘Lara’) with medium to smooth shell (5 to 7 points) (Table 3) in comparison to the employees who estimated the shell texture less critically. Seven out of ten cultivars were allotted between 5 and 7 points by the employee group (Table 4). When comparing the results with those obtained through the research of 840 genotypes from domestic population, we can see that in the trees of unknown origin

there were only 9 % with rough to very rough shell. 5% of the trees had very smooth shell, whereas almost two thirds had a smooth shell (Solar et al., 2002).

Shell colour of 'Fernette' was evaluated as the lightest by both groups of assessors. On the other hand, the nuts of 'A-117' and 'Rasna' had the darkest shell among all cultivars. The most open seam had 'Rasna' (according to the employee group) and 'Lara' and 'Cisco' (according to the student group). For employees, the closest seam was found in 'Elit' and 'Fernor' and 'A-117' by the student group.

Both groups evaluated 'Fernor' nuts with the lightest pellicle. According to the students, 'Fernette' had light pellicle, too. By French assessors, 'Fernor' was also characterized as a cultivar with light pellicle colour (Rouvès et al., 2003; Petit-Rouvès et al., 2004). When compared, external colour of the kernel in 'Lara', it is a little bit darker than 'Fernor' in both, Slovene and French production areas.

In the case of 'Franquette', the pellicle colour was estimated as light by students and as middle light by the group of older assessors. These estimations are in agreement with those obtained for 'Franquette' grown in two French areas, Périgord and Isère, while the 'Franquette' fruits from north-eastern Spain had a much darker pellicle (Charlot et al., 1996). Similar relationship could be seen in the fruits of 'Chandler' (Charlot et al., 1996; Rouvès et al., 2003; Petit-Rouvès et al., 2004).

Our results show that 'Rasna' walnuts had the darkest pellicle among evaluated cultivars according to the both groups.

According to the employee group, 'Fernor' and 'Elit' had the lightest internal colour of kernel, whereas students assessed as such 'Fernor' and 'Rasna'. 'Fernette' had the darkest kernel, besides 'Cisco' in the student group. As reported by Charlot et al. (1996), 'Fernor' had lighter internal colour than 'Franquette' and 'Fernette' in France, too.

Both groups evaluated 'Rasna' as the least bright. According to statistical analyses all other cultivars were classified into only one group (all were more bright than 'Rasna') by the employees. According to the student evaluation, 'Fernette' had the most emphasised kernel brightness. This is not in agreement with French experiences, which show that 'Fernette' had less bright kernels than 'Fernor' and 'Franquette' (Charlot et al., 1996).

Internal properties

In our research, kernel properties were tasted, and flavour, bitterness, astringency, texture, crispness and oiliness were evaluated in the mouth on a scale from 1 to 10 (Table 5 and Table 6). Tasted perception (internal properties of kernel) of both consumer groups was rather different, nevertheless external or visual properties of walnuts were estimated more similarly. For Slovenian selection purposes of walnuts only the taste of nuts is evaluated among internal properties on a scale from 1 (bad taste) to 9 (excellent taste) (Solar, 1996-2004). However, taste and flavour are two different attributes that are frequently wrongly equated, which can be found even in

the scientific literature. However, the peripheral taste and smell systems are completely separate and distinct. Water-soluble compounds contribute to taste when interact with specialized cells in the oral cavity and certain volatile compounds to flavour via the olfactory organ situated in the nasal cavity. The taste is limited to mixtures of four basic qualities – sweet, sour, salty, and bitter. If we oversimplify, bitter taste is perceived in the back of the tongue, although most taste buds, regardless to location, appear to be receptive to multiple taste qualities (Shepherd et al., 1993).

Table 5. Povprečne ocene za notranje lastnosti jedrca - zaposleni na Biotehniški fakulteti.
Table 5. Mean estimations for internal properties of the kernels - employees at the Biotechnical Faculty.

	Internal properties of a kernel											
Property	Flavour		Bitterness		Astringency		Texture		Crispness		Oiliness	
Cultivar	(1 – 10)		(1 – 10)		(1 – 10)		(1 – 10)		(1 – 10)		(1 – 10)	
'Elit'	6.8	ab	3.8	abc	4.1	ab	5.9	ab	6.6	ab	5.8	Not significant
'Fernor'	6.9	ab	3.7	abc	3.4	a	6.0	ab	6.1	ab	5.9	
'Chandler'	6.0	a	3.5	ab	4.1	ab	5.9	ab	6.6	ab	5.6	
'Adams'	6.1	a	4.9	bc	5.3	b	5.7	ab	7.3	b	5.2	
'Cisco'	6.8	ab	4.4	abc	4.7	ab	5.5	ab	5.9	a	5.8	
'Fernette'	7.1	ab	3.1	a	3.2	a	6.0	ab	6.5	ab	5.4	
'A-117'	6.2	a	3.9	abc	3.9	ab	6.6	b	6.8	ab	5.1	
'Lara'	6.3	a	3.0	a	3.2	a	5.3	a	5.8	a	6.0	
'Franquette'	7.8	b	5.1	c	5.0	b	5.2	a	6.3	ab	5.2	
'Rasna'	5.9	a	4.3	abc	3.8	ab	5.2	a	5.8	a	5.3	

Different letters within each column show significant differences in sensory descriptor among cultivars (Duncan, $P < 0.05$).

Table 6. Povprečne ocene za notranje lastnosti jedrca - študenti Biotehniške fakultete.
Table 6. Mean estimations for internal properties of the kernels – students at the Biotechnical Faculty.

Property	Internal properties of a kernel											
Cultivar	Flavour		Bitterness		Astringency		Texture		Crispness		Oiliness	
	(1 – 10)		(1 – 10)		(1 – 10)		(1 – 10)		(1 – 10)		(1 – 10)	
'Elit'	2.6	a	6.2	e	7.0	d	5.4	Not significant	5.4	bc	6.4	abc
'Fernor'	5.0	bcd	3.1	ab	4.2	abc	5.8		5.0	bc	7.6	c
'Chandler'	4.6	bcd	2.4	a	3.6	a	4.9		4.6	b	5.7	a
'Adams'	5.6	cd	4.6	bcd	5.1	abc	5.3		5.5	bc	7.1	bc
'Cisco'	4.7	bcd	5.7	de	5.6	bcd	4.6		5.4	bc	6.9	abc
'Fernette'	4.1	bc	3.5	abc	3.9	a	5.2		4.9	b	5.8	a
'A-117'	3.8	ab	4.8	cde	5.8	cd	5.3		5.3	bc	5.7	a
'Lara'	3.9	ab	3.1	ab	4.1	ab	5.8		6.3	c	7.1	bc
'Franquette'	5.6	cd	4.6	bcd	4.9	abc	5.8		5.6	bc	6.1	ab
'Rasna'	6.1	d	2.6	a	5.2	abc	6.0		3.2	a	6.0	ab

Different letters within each column show significant differences in sensory descriptor among cultivars (Duncan, $P < 0.05$).

The employees estimated kernel flavour very homogenous (Table 5) compared to the students (Table 6) who were more critical. They arranged cultivars from the ones with the weakest flavour ('Elit') to those with a more typical walnut flavour ('Adams', 'Franquette' and 'Rasna'). Our results are comparable with the French results where the group of 12 adults evaluated the internal quality of walnut kernels. Nine out of 11

studied cultivars had rather equal flavour (4 to 5 scores), and only in two cultivars ('Parisienne' and 'Fernor') the walnut flavour was more expressed (Rouvès et al., 2003; Petit-Rouvès et al., 2004). Nonsignificant differences among kernel flavour were also reported by American authors after the comparison between very spread Californian cultivar 'Hartley' and four other cultivars (Ingels et al., 1990).

Prasad (2003) reported that the black walnut (*Juglans nigra* L.) had a richer flavour than the English walnut (*J. regia* L.); nevertheless it is not as popular, because its shell is much thicker and harder to remove without breaking the kernels.

Among evaluated cultivars 'Lara' and 'Fernette' for the employee group and 'Chandler' and 'Rasna' for the student group were the least bitter. 'Lara' is less bitter than other cultivars also when grown and evaluated in France (Rouvès et al., 2003; Petit-Rouvès et al., 2004). This characteristic could be a consequence of a very low level of bitterness, which used to have its kernels at the stage of physiological maturity (Germain et al., 1999). This character makes 'Lara' kernels very interesting and marketable as the so-called 'fresh walnut', and thus very appreciated by the French consumers.

'Franquette' had the bitterest taste for the employee group and 'Elit' was the bitterest and the most astringent for the students. 'Franquette' was estimated as more bitter than 'Fernor' and 'Fernette' in France, too (Charlot et al., 1996). The same authors also report that the kernels of 'Franquette' grown in colder areas (Isère, France) is less bitter than those grown in warmer areas like Tarragona, Spain.

Astringency was estimated with 3.2 to 5.0 scores among the students and with 3.6 to 7.0 scores among the employees. According to students 'Chandler', 'Fernette', 'Lara', and 'Fernor' had the least astringency compared to 'Elit' with the strongest expression of astringency. According to the employee group, French cultivars 'Lara', 'Fernette' and 'Fernor' were among the least astringent, whereas 'Franquette' and 'Adams' had the strongest astringency. Some of these results confirm those obtained by French assessors (Rouvès et al., 2003; Petit-Rouvès et al., 2004). They reported that 'Lara' and 'Fernor' were almost equally astringent and also less than 'Franquette'. In 'Franquette', the influence of climate conditions in the production area on the astringency was proved like in the case of bitterness. As reported by Charlot et al. (1996), 'Franquette' from warm north-eastern Spain was much more astringent than the one from colder south-eastern France. On the other hand, American investigators found no significant differences in astringency between five Californian cultivars (Ingels et al., 1990).

Although the firmness of the kernel was estimated in a narrow rank (between 5.2 and 6.0 scores by the employee group and between 4.6 and 6.0 scores by the student group), 'Franquette', 'Rasna' and 'Lara' were found to be less firm than other cultivars and 'A-117' was the firmest of all by older assessors, while by the students none of the cultivars significantly differed in kernel texture. Small differences in firmness were reported also for the six cultivars grown in France as well as for 'Franquette' grown in different climatic areas. Larger differences were proved in cultivar 'Hartley', which had firmer texture when grown in north-eastern Spain compared to Californian production area (Charlot et al., 1996). In California,

'Hartley' was significantly less firm than four other American cultivars (Ingels et al., 1990).

'Rasna', 'Lara' and 'Cisco' (employee group) and only 'Rasna' by the student group were evaluated as the least crispy. In France, 'Fernor' and 'Franquette' had the crispest kernels (Rouvès et al., 2003; Petit-Rouvès et al., 2004), which was not confirmed in our experiment. According to the same authors, another crispy cultivar was 'Lara' which was one among the crispiest also for our students. As reported by Charlot et al. (1996), the production area could influence crispness, since 'Hartley' from California had less crisp kernels compared to the one from north-eastern Spain. In the case of oiliness of kernels, an opposite impact was determined by the same investigators: 'Hartley' from California was found to be much more oily than the same cultivar grown in north-eastern Spain. Here, a negative correlation between oiliness and crispness was proved. In our study, according to the student group 'Chandler', 'A-117' and 'Fernette' were the least oily, whereas in 'Fernor' the most emphasized oiliness was perceived. The results for 'Fernette' confirmed the results obtained by Charlot et al. (1996), while 'Fernor' was estimated as one of the least oily cultivars by French adult assessors (Rouvès et al., 2003; Petit-Rouvès et al., 2004). Both employees and students at the Biotechnical faculty considered 'Lara' as the oily cultivar, which was also mentioned by Rouvès et al. (2003) and Petit-Rouvès et al. (2004).

Sinesio and Moneta (1997) reported that among walnut sensory descriptors, bitterness and astringency appeared to be positively correlated, which can be important in walnut quality perception by consumers. Similarly, in our study strong positive correlation between bitterness and astringency was found by the employee group, however there was no strong correlation found by the students group (Table 7). Peleg et al. (1999) stated that the major factor, which influenced the sensory properties of bitterness and astringency, was molecular size of volatile flavonoids: as molecular size increased, bitterness decreased and astringency increased.

Tabela 7. Povezava med trpkostjo in grenkostjo za zaposlene in študente, ločeno po sortah.
Table 7. Correlation between astringency and bitterness as assessed by the employees and student group.

	Correlation	
Cultivar	Employees	Students
'Elit'	0.93	0.53
'Fernor'	0.91	0.54
'Chandler'	0.82	*0.41*
'Adams'	0.87	0.68
'Cisco'	0.80	0.67
'Fernette'	0.88	*0.35*
'A-117'	0.86	0.63
'Lara'	0.80	0.55
'Franquette'	0.81	0.56
'Rasna'	0.87	*0.41*

As could be seen in Table 7, the correlation between astringency and bitterness was very closed in the employee group in comparison to the student group, where these

two traits were not so highly correlated. It is possible that sensory perception of specific properties like astringency and bitterness becomes much more expressed with human age.

CONCLUSION

Sensory characteristics of walnut fruits were evaluated by visual and taste descriptors, and differences among studied cultivars were perceived by those descriptors within each assessor group. Both groups (employees and students) similarly evaluated visual appearance; whereas taste perception was assessed rather differently. Both groups agreed that 'Rasna' and 'Fernor ' nuts had the roughest shell among evaluated cultivars. In addition, 'Rasna' also had the least brightness, the darkest pellicle and was one of the least crispy cultivars. Moreover, shell colour of 'Fernette', and pellicle colour and internal colour of 'Fernor' were the lightest among all. With regard to other descriptors, there were different perceptions by the two groups.

This study provides useful data regarding sensory properties of evaluated cultivars, which are grown and sold in Slovenia. Based on this study, although both groups of assessors had different perceptions, it can be suggested that consumer preferences should be considered for the selection purposes before the final decision is made. With regard to sensory characteristics of nuts, it depends not only on cultivar, but also on growing conditions of the production area; some other sensory analyses have to be conducted. First of all, walnut fruits of the same cultivars grown in different Slovenian geographical areas should be included in further research. After two or three years' investigation the most distinguishing sensory characteristics would be selected, which should be used when evaluating new cultivars or germplasm.

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