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Short communication

DEVELOPMENT AND APPLICATION OF DESCRIPTORS FOR ESTABLISHING SENSORY PROFILE OF GLUTEN-FREE COOKIES BY A MULTIDIMENSIONAL APPROACH

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ABSTRACT: The aim of this study was to create the list of descriptors for establishment the sensory profile of gluten-free cookie. The list of descriptors was created using six commercial cookies and a gluten-free cookie made in the pilot plan. The free choice profiling (FCP) method was used for generation of descriptors by panellists. PCA was performed to explore the relationships among the established descriptors and to estimate the relative importance and contribution of descriptors in distinguishing between products. Application of the multidimensional approach confirmed that this method can be useful tool for drawing up the sensory profile of the gluten-free cookie.

Key words: *descriptors, sensory profile, gluten-free cookie, multidimensional approach*

INTRODUCTION

Celiac disease is a gluten–sensitive entheropathy with genetic, immunologic and environmental basis (Torbica et al., 2008). This is nowadays the most common life-long dietary disorder worldwide, affecting around 1% of the European population (Miñarro et al., 2012). The only available treatment for celiac disease has been strict adherence to gluten–free diets (Turabi et al., 2010). Many commercially available gluten–free products are inferior in quality to their gluten–containing counterparts (Sakač et al, 2011). The gluten-free products possess poor protein structure forming ability which causes the decrease of sensory quality (Torbica et al., 2012, Laureati et al., 2012).

There are many studies about technological (Schober et al., 2010; Crockett et al., 2011; Arendt et al., 2008), but just few studies about the sensory properties of gluten–free products. To determine the sensory profile of any food products, it is necessary to select appropriate descriptors which represent the perceptible product's attributtes used for assessment on the intesity scale (Dolors Guŕrdia et al., 2010). The various methods for establishing the list of descriptors can be divided into several categories, i.e. those for arriving at a unanimous description of the product, reffered as the consensus method, those which do not require this consensus, reffered to as independent method (or FCP – free choice profilling), and the multidimensional method.

The multidimensional approach describes a method for identifying and selecting descriptors which can then be used for drawing up the sensory profile of a product. Also, it describes the different stages in the process for setting up test through which a complete description of the sensory attributes of a product can be obtainned: from a qualitative point of view by defining by means of descriptors all the perceptions for distinguishing one product from others of the same type; from a quantitative point of view, by evaluating the

intensity of each descriptor (ISO 6564 (2002); SRPS ISO 11035 (2002)).

The multidimensional method has been applying for sensory profiling of many food products, such as soft drinks (Chauhan and Harper, 1986), rye bread (Hellemann et al., 1987), French bread (Hayakawa et al., 2010), drinking water (Falahee and MacRae, 1995), yogurt (Uysal–Pala et al., 2006), extra–virgin olive oil (Aparicio et al., 1996), vinegar (Tesfaye et al., 2010), apple (Echeverria et al., 2008), as well as fat in a milk model system (Tepper and Kuang, 1996) and sensory profiling of pomegranate juices flavor (Koppel and Chambers, 2010).

Flour based confectionery products such as cookies and related products hold an important position in total production and consumption of confectionery products in Serbia (Šimurina et al., 2008). To provide good quality products for people with celiac disease and to create better quality gluten–free cookies, the present study is aimed at developing a comprehensive list of descriptors for gluten–free cookies. The descriptors were selected using the criteria that should have relevance to the product, be able to clearly determine the differences between products, be nonredundant, and have cognitive clarity to the assessors.

MATERIALS AND METHODS

Samples

Six similar composition cookies (P1 to P6) were purchased in a local food store while a gluten–free cookie sample (P7) was made in the pilot plant of the Institute of Food Technology, Novi Sad. The selected samples were provided the possibility to detect all observed quality differences in the products during the sensory evaluation.

Sensory methodology

In Figure 1 is presented the procedure for identification and selection of descriptors to determine a sensory profile of gluten–free cookie.

Establishing sensory profile of gluten-free cookie by a multidimensional approach was carried out by a panel of eight trained assessors (7 females and 1 male, 30 – 43 years old). The panellists were selected from previously trained academic staff of the Institute of Food Technology, Novi Sad, according to ISO 8586-1 (2002), and they were familiar with the sensory profiling methodology.

To provide the necessary concentration for individual assessors, the work of assessors was performed in the boots and the prescribed environmental conditions according to SRPS ISO8589 (1998).

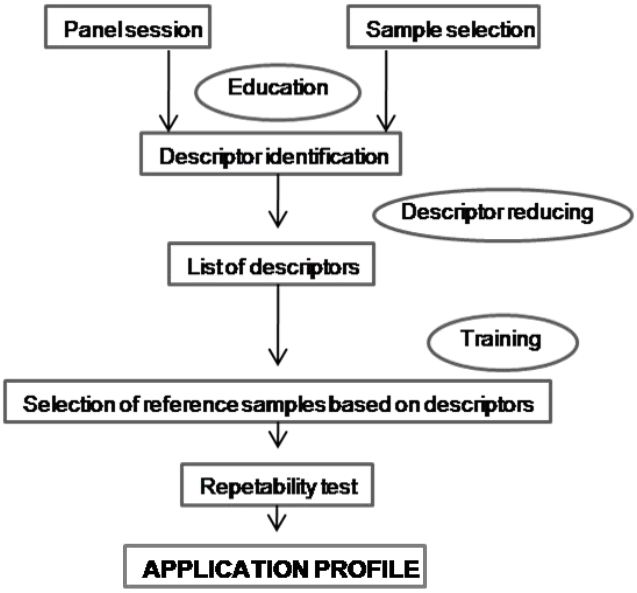

Figure 1. Schematic representation of descriptors' identification and selection (SRPS ISO 11036, 2002)

Table 1.
Explanation of Equation 1

Parameter	Definition	Calculation
F	F_d - Number of times the descriptor was mentioned; F_{max} – Number of times that the total may be mentioned.	$F = F_d / F_{max}$ F_{max} = number of samples x number of assessors F_{max} = 56 (i. e.: 7 samples x 8 assessors)
I	I_d - Sum of intensities given by the panel for one descriptor; I_{max} - Max intensity of the descriptor.	$I = I_d / I_{max}$ I_{max} = max intensity x number of samples x number of assessors I_{max} = 280 (i.e.: 5 x 7 samples x 8 assessors)

During the first four preparatory sessions the panellists were presented a series of six selected commercial cookies as well as the product needed to make profile.

The panellists were asked to note and record the largest number of descriptors which would describe all perceived properties of products using different sensory techniques (visual, olfactory, palpatory, and gustatory) (appendix A). Also, they were instructed to include only objective, associative or cognitive terms rather than hedonic, affective or quantitative terms, such as good, bad, intense aroma, etc.

To express intensity of each perceived descriptor was applied the intensity scale (from 0 – absence of perception to 5 – strong perception/max intensity) (SRPS ISO 11035, 2002; SRPS ISO 4121, 2002). After that, it was carried out the panel discussion, and the panellists were encouraged and inspired individually by the panel leader to analyze different components of products perceptions. Terms that were either too general or nondescriptive were eliminated from the further consideration. Since each assessors made his/her list of descriptors (FCP), including synonyms, the panel leader collected them and established the initial list of descriptors. Removal of the descriptor from the initial list is conducted on the basisof the criteria that they should be relevant to the products, clearly discriminating them, and be understood and easily perceived by each assessor.

Subsequent removal of the descriptors was achieved on the basis of geometric mean (*M*) which was calculated by:

$$M=(F*I)^{1/2} x\ 100\ (\%) \quad (1)$$

where *F* is the frequency and *I* is the relative intensity (Table 1).

The final list of the descriptors was established by multivariate statistical analyses. This technique enabled the estimation of importance and contribution of descriptors to differentiate between the samples. Also it gave the opportunity of visualisation the samples and correlation between the descriptors simultaneously.

Data analysis

In this study PCA was used to explore the relationships among the established sensory descriptors and to estimate the relative importance and contribution of descriptors in distinguishing between products. PCA analyses were carried out using the Software XLSTAT, version (2012.2.02) (http://www.xlstat.com/).

RESULTS AND DISCUSSION

The number of descriptive terms used by each panellist ranged from 12 to 42, so the initially list contained 188 descriptors. Similar descriptive terms were grouped together in order to simplify the obtained list by consensus method. During the session panel, leader together with panellists discussed any proposed descriptor and redundant, synonymous and vague terms were removed from the list that was included 34 descriptors. The reduced initial list with calculated M value for each included descriptor is shown in Table 2.

The shaded low *M* values and *M* values which did not contribute to good differrentiation of the cookie samples were removed from further processing. PCA was performed on the correlation matrix of 26 retained descriptors (variables). It was per-

formed to study the relationship between these variables and to explore their relative importance in distinguishing between cookies through the variable loading plot (Figure 2).

The first two dimensions explained 50.66% of the total variance. The first principal component (F1) accounted for 32.57% of the total variation in the data. In general, a high magnitude (near to +1 or −1) for loading means that the descriptor is highly correlated to that factor, but >0.5 can be enough for importance (Bower, 2009). Based on the fact that the preconditions for the application of PCA are more conceptual than statistical, in this research PCA was performed on the correlation matrix of more convenient descriptors (Pestorić, 2011).

The descriptors with small contribution to the components F1 (Desc1, Desc10, Desc11, Desc21, Desc29, Desc34) and F2 (Desc7, Desc8, Desc9, Desc14 and Desc15) were removed from the further processing and the sequential PCA1 was performed on the 13 variables (descriptors).

Table 2.
The initial list of descriptor by FCP

Descriptor	Product						
	P1	P2	P3	P4	P5	P6	P7
	M – values, %						
Whole cookie							
(1) Shape	82.35	96.18	89.44	79.65	96.18	81.01	90.83
(2) Colour uniformity	0.00	12.50	0.00	0.00	11.18	0.00	12.50
(3) Surface uniformity	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(4) Shiny	11.18	11.18	11.18	11.18	11.18	11.18	23.72
Upper surface							
(5) Colour	53.03	46.10	53.03	41.83	48.73	46.10	48.73
(6) Colour uniformity	72.46	68.47	67.08	76.85	71.15	78.26	72.46
(7) Brightness	11.18	44.72	30.62	19.36	25.00	23.72	22.36
(8)Gravure	33.54	46.10	44.72	44.72	12.50	12.50	23.72
(9) Surface texture	0.00	23.72	9.68	0.00	0.00	22.36	22.36
Bottom surface							
(10) Colour	50.00	40.31	43.30	43.30	44.72	34.91	46.10
(11) Colour uniformity	40.31	40.31	22.36	33.54	58.63	47.43	32.11
(12) Smoothness	0.00	12.50	0.00	0.00	0.00	0.00	0.00
(13) Gravure	46.10	48.73	47.43	46.10	48.73	48.73	48.73
Cross - section							
(14) Colour uniformity	11.18	0.00	7.91	0.00	7.91	20.92	11.18
(15) Structure	81.01	69.82	67.08	78.26	92.20	67.08	89.44
(16) Crumbliness	11.18	11.18	22.36	11.18	17.68	15.81	7.91
(17) Sharpness	12.50	12.50	12.50	11.18	9.60	9.60	9.60
Texture palpatory							
(18) Hardness	86.60	86.60	71.15	76.85	72.46	73.74	100.00
(19) Fatness	7.91	7.91	7.91	9.68	7.91	7.91	43.30
(20) Moisture	23.72	25.00	23.72	11.18	23.72	12.50	9.68
(21) Surface texture	33.54	33.54	20.92	30.62	34.91	33.54	23.72
Texture in mouth							
(22) Fracturability	58.63	58.63	59.95	68.47	58.63	57.28	50.00
(23) Particle size and shape	19.36	20.92	19.36	20.92	20.92	22.36	46.10
(24) Adhesiveness	32.11	32.11	29.05	30.62	23.72	43.30	44.72
(25) Chewiness	23.72	23.72	9.68	23.72	22.36	22.36	23.72
(26) Melting	11.18	12.50	11.18	12.50	22.36	20.92	34.91
(27) Fat content	0.00	0.00	0.00	0.00	0.00	0.00	7.91
(28) Moisture	12.50	12.50	12.50	12.50	12.50	12.50	12.50
(29) Covering of oral cavity	9.68	19.36	11.18	19.36	9.68	7.91	9.68
Odor and taste							
(30) Odour	84.96	81.01	70.93	40.31	48.41	59.69	54.49
(31) Off-odour	0.00	22.36	0.00	7.91	9.68	19.36	29.05
(32) Taste	55.90	57.28	43.30	36.23	32.11	44.72	34.91
(33) Off-taste	0.00	0.00	0.00	23.72	0.00	12.50	34.91
(34) Flavor	22.36	36.23	33.54	46.10	34.91	32.11	34.91

Although Desc34 (flavor) expressed high correlation with F2 component, it was excluded from further PCA analysis because Desc30 (odour) and Desc32 (taste) were more convenient for individual assessment by panellists. Desc26 (melting) and Desc20 (moisture) were eliminated for the same reason from the list of descriptors, although they expressed high correlation with F1 component.

The second PCA explained 71.65% of the total variance. The first component (F1) was characterized by the fatness (Desc19), particle size and shape (Desc23), adhesiveness (Desc24), off-odour (Desc31) and off–taste (Desc33) with positive loadings. These descriptors were well separated from odour (Desc30), taste (Desc32), and colour (Desc5) that were highly correlated with component F2. The similar trend of separation was expressed by colour uniformity (Des6) and Desc33 (off–taste) in comparison with crumbliness (Desc16) and fracturability (Desc22) (Figure 3).

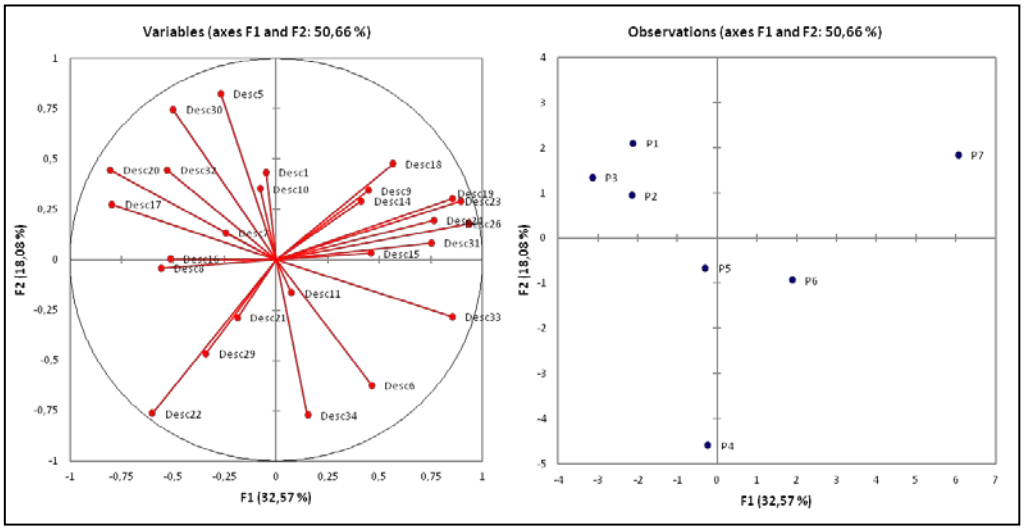

Figure 2. PCA plot of relationship between the descriptors and differentiation between the samples after the first reduction

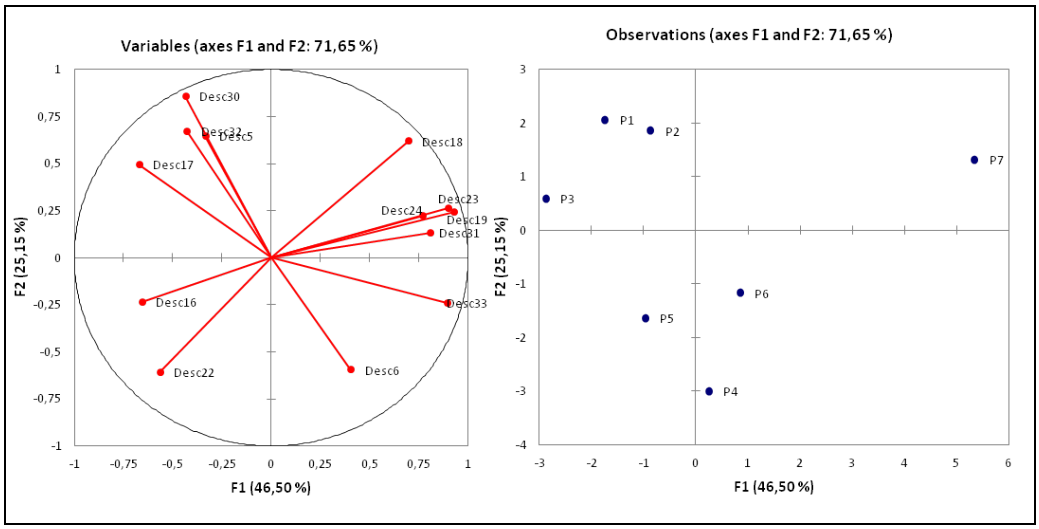

Figure 3. PCA1 plot of relationship between the descriptors and differentiation between the samples after the final reduction

Table 3.
The final list of descriptors and definitions

Descriptor	Technique	Definition
Appearance		
Colour	visual	Intensity of typical cookie colour
Colour uniformity	visual	Areas different from typical cookie colour
Appearance/texture of cross-section		
Crumbliness	visual	The amount of crumbs segregated during the breaking of cookie
Sharpness	visual or palpatory	Severity of the fracture edges
Texture		
Hardness	palpatory or in the mouth	The force required to achieve a given deformation or penetration of a cookie.
Fatness	palpatory or gustatory	Surface textural attributes relating to the perception of the quantity or quality of fat in a cookie
Fracturability	in the mouth	The force necessary to break a cookie into crumbs or pieces.
Particle size or shape	in the mouth	Geometrical texture attributes relating to the perception of the size and shape of particle in the cookie sample.
Adhesiveness	in the mouth	The force required to remove cookie that adheres to the mouth or to a substrate
Odour		
Odour	olfactory	Aromatic notes associated with flour, butter, etc., typical of gluten-free cookie
Off-odour	olfactory	Non typical aromatic notes
Taste		
Taste	gustatory	Aromatic notes associated with flour, butter, sugar, etc., typical of gluten-free cookie
Off-taste	gustatory	Non typical aromatic notes

Elimination of descriptors after the first and second list reduction as well as the performed sequential PCA on these data did not significantly change positions of products on the PCA plot (Figure 2 and 3). The obtained results showed that product P7 expressed the unique sensory profile. It was distinguished from the other samples by Desc18- hardness, Desc19– fatness, Desc23– particle size and shape, Desc24– adhesiveness, and Desc31– off–odour.

The obtained final list of descriptors encopassed the appearance (2 descriptors), appearance/texture of cross–section (2 descriptors), texture (5 descriptors), odour (2 descriptors) and taste (2 descriptors) of cookie is presented in Table 3.

CONCLUSION

This study confirmed that the application of the multidimensional approach can be suitable tool for identifying and selecting descriptors which can be used for drawing up the sensory profile of the gluten–ree cookie. Its utilization may contribute to the improvement of gluten–free cookie quality during the process of production, to determining of shelf–life, and to monitoring of changes that might occur during storage. From a qualitative point of view, application of descriptors can be a useful tool for distinguishing one product from others of the same type.

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РАЗВОЈ И ПРИМЕНА ДЕСКРИПТОРА ЗА УТВРЂИВАЊЕ СЕНЗОРСКОГ ПРОФИЛА БЕЗГЛУТЕНСКОГ КЕКСА МУЛТИДИМЕНЗИОНАЛНИМ ПРИСТУПОМ

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Сажетак: За процену сложених сензорских величина потребна је методологија која се заснива на идентификацији одговарајућих дескриптора. Стога је састављена листа дескриптора за утврђивање сензорског профила безглутенског кекса. За израду листе коришћено је шест комерцијалних узорака кекса и безглутенски кекс направљен у пилот постројењу. При избору дескриптора оцењивачи су користили метод слободног избора (FCP– free choice profiling). Обрада анализе главних компоненти (ПЦА) омогућила је испитивање корелација између одабраних дескриптора као и процену релативне важности и доприноса дескриптора у прављењу разлике између производа. Примена мултидимензионалне анализе потврдила је да овај метод може бити корисно средство за састављање сензорског профила безглутенског кекса.

Кључне речи: *дескриптори, сензорски профил, безглутенски кекс, мултидимензионална анализа*

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APPENDIX A

QUESTIONNAIRE FOR THE DEVELOPMENT OF A COMPREHENSIVE LIST OF DESCRIPTORS

LAST NAME: .....

FIRST NAME: .....

Sample code: .....

DATE: .....

Describe feelings caused by this (these) product (products) according to following properties, using your own vocabulary.

	Before evaluation	*During the evaluation*	*After evaluation*
Appearance			
Odour			
Tastefulness (taste and aroma)			
Texture (mouth)			
Texture (by fingers or by spoon)			