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Sensory Characterization of Cookies with Chestnut Flour

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***Abstract*—**In this work sensory characteristics of cookies with different amount of chestnut flour were determined by sensory and instrumental methods. The wheat flour for cookies was substituted with chestnut flour in three different levels (20, 40 and 60%) and the dough moisture was 22%. The control sample was with 100% of wheat flour. Sensory quality of the cookies was described using quantity descriptive method (QDA) by six trained members of descriptive panel. Instrumental evaluation included texture characterization by texture analyzer, the color measurements (CIE L*a*b* system) and determination by videometer.

The samples with 20% of chestnut flour were with highest ponderated score for overall sensory impression (17.6), which is very close to score for control sample (18). Increase in amount of chestnut flour caused decrease in scores for all sensory properties, thus overall sensory score decreased also. Compared to control sample and with increase in amount of chestnut flour, instrumental determination of the samples confirmed the sensory analysis results. The hardness of the cookies increased, as well as the values of red a* and yellow (b*) component coordinate, but the values for lightness (L*) decreased. Also the values, evaluated by videometer at defined wavelength, were the highest for control cookies and decreased with increase in amount of chestnut flour.

***Keywords*—**Cookies, chestnut flour, sensory characteristics.

I. Introduction

FUNCTIONAL food is food, or food component, with a positive physiological effect on the human health, that contributes to reduced risk of disease. Positive effects of functional food are noticeable after long period of consuming [1]. Some of the functional products are products with added vitamins, minerals, fibers, antioxidants, with reduced amount of sugar and fat. A number of researches related to the replacement of wheat flour, in the flour based confectionery products, with other non–gluten flours indicated that rice and chestnut flour in adequate amount are suitable tailor made mixtures for production of gluten–free or gluten–reduced food products. The content of carbohydrates in the fruit of chestnut is approximately the same as in the grain of wheat and rice. The fruit of chestnut contain vitamin B, vitamin A and C, and minerals (K, Mg, Fe, Mn, P, Cu). It is important source of fibers and essential amino acids. Also, the content of antioxidants is high and amount of fat is low, without cholesterol, which contributes to increase in nutritional value and positive health effect [2]. Milled fruit of the chestnut is chestnut flour. The chemical composition of the chestnut flour is similar with corn flour in content of ash, lipids, fibers and starch, but the content of proteins is half of the content in corn flour. The dominant component of the chestnut flour is starch [3]. The content of protein in chestnut flour is similar with content of protein in rice flour. The most important characteristic of the chestnut flour is high content of proteins with essential amino acids and the absence of gluten, which is significant for application of chestnut flour for products aimed for consumers with celiac disease. Considering that many of gluten–free raw materials are poor with vitamin B, iron, folic acid and fibers, the addition of chestnut flour in gluten–free products increases their nutrition value [4].

However, the changes in composition of food product influence on sensory properties of the product that is most important for acceptability of the product. The chestnut flour is usually functional component of snack products. Sacchetti et al. concluded that the texture and sensory properties of extruded snack products with added chestnut flour were improved [5].

Sensory properties of food products are evaluated by a subjective method based on usage of human senses. Sensory analysis provides assessment of the product acceptability by the consumer. Different sensory properties are evaluated for different food products, but common sensory properties are appearance, color, structure, mastication, odor and taste. Some sensory properties of food products, like color and texture properties, can be instrumentally determined by texture analyzer or new kind of instrumental analysis by videometer. For overall sensory impression and in the aim of complete characterization of food products the high correlation between results of sensory analysis and results of instrumental determination is required.

The objective of this study was to characterize the sensory properties of cookies with different amount of chestnut flour. The wheat flour for cookies was substituted with chestnut flour in three different levels (20, 40 and 60%). Moisture of the dough was 22%. Obtained cookies were compared with control sample with 100% of wheat flour. Sensory properties of cookies were determined by quantity descriptive method (QDA). Color and texture of the samples were also

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instrumentally determined.

II. Material and Methods

A. Material

Materials used for experimental work were wheat flour for flour based confectionary products (Type 500), chestnut flour ("Molino Rosseto", Italy), sugar powder, vegetable fat, NH_4HCO_3, $NaHCO_3$, NaCl and water. The compositions of the flours are presented in Table I.

TABLE I
Composition of the Wheat and Chestnut Flour

Components of the flours	Wheat flour (%)	Chestnut flour (%)
Moisture	12.29	5.71
Starch	73.75	45.28
Proteins	9.70	5.54
Reducing sugars	1.83	21.10
Fats	0.84	3.19
Ash	0.45	2.06

B. Preparation of the Cookies

The cookies were prepared by baking test method. The dough for cookies was prepared in amount of 350g. Ingredients for the dough were flour (199.4g), sugar powder (69.8g), vegetable fat (41.9g), NaCl (1.1g), $NaHCO_3$ (0.6g), NH_4HCO_3 (0.4g) and water. The amount of water was added to achieve 22% of dough moisture. The control sample contained wheat flour. Wheat flour was substituted with chestnut flour in amounts 20, 40 and 60% for samples with chestnut flour. The ingredients were mixed in Z profiled mixer (Stephan–Werke Hamelin, ZD2245) for 15 minutes. Dough was pressed manually in a shape of a compact low cylinder. After 2min of the relaxation time dough stripe was developed by putting dough twice in either direction between two rollers of the laminator (Laminoir Marchand LA4-500). First lamination was with 10mm gap and second one was with 6mm gap. Dough relaxed for 0.5min after each lamination. To avoid an adhesion cloth stripe was floured by a small quantity of starch. After the relaxation time (2min) dough was shaped by impressing a round mould (50mm in diameter) on the surface of the dough stripe. Twelve pieces of shaped dough were moved to perforate sheet–metal for baking. Cookies baking time was 15min at 230±2°C. During baking the oven was closed and without the vapor connection. Cookies were cooled for 30min on the baking sheet under ambient conditions.

C. Sensory Evaluation

Sensory quality of cookies was described by quantity descriptive method (QDA) and by system of ponderated scores. Six–member trained panel participated in the evaluation. The sensory properties of cookies external appearance (upper and bottom surface), structure (snap), mastication and taste (odor and taste) were evaluated. The sensory attributes were rated on a scale in range of 1–5 where 1 was the lowest score and 5 were the highest score of each property. Obtained scores were multiplied by a predefined factor of importance (FI) to determine the ponderated scores (PS). The values of the FI for each quality parameters were: for external appearance 0.8, structure 0.8, mastication 0.8, odor 0.6, and for taste 1. Based on the sum of ponderated scores the category of quality was defined. The categories of quality were: excellent (sum of ponderated scores in the range from 19.1–20), very good (16.1–19.0), good (13.1–16.0), low (11.1–16.0) and not satisfactory (<11.1) [6]. The scores of 1–5 for each quality parameter were presented by polar coordinates in the aim to present the QDA diagram of the observed cookies samples.

D. Color Determination

The color of cookies was recorded by chromameter MINOLTA, type CR 400, Japan. The color was measured on the upper surface. Color characteristics were presented in CIE L*a*b* system. CIE L*a*b* system defines color by the parameters such as lightness, L^* (L*=0 (black) and L*=100 (white)), a* (coordinate of red and green color; -a*=greenness and +a*=redness), and b* (coordinate of yellow and blue color; -b*=blueness and +b*=yellowness). The total color difference (ΔE^*_{ab}) between the control cookies and the cookies with chestnut flour was calculated [7]. The values used to determine, if the total color difference was visually obvious, were the following: $\Delta E^*<1$ – color differences are not obvious for human eye, $1<\Delta E^*<3$ – color differences are not appreciative by the human eye, $\Delta E^*>3$ – color differences are obvious for the human eye.

E. Textural Properties

Texture property of the cookies, the hardness, was determined by method specified by device producer, Hardness measurement of biscuits by cutting, using the Texture Analyzer TA.HD Plus (Stable Micro Systems, Godalming, U.K.). The load cell of 250 kg and knife edge were used by following operating parameters: pre–test speed 1.5 mm/s, test speed 2 mm/s, post–test speed 10 mm/s.

F. Videometer

The surface and the color of the cookies were additionally determined by device of new generation of VideometerLab 3. This unit provides the scanning of sample surface with high resolution (from 2448x2048 pixels) and to 20 spectral groups with defined wavelength in the range from 360nm to 1050nm.

III. Results and Discussion

A. Sensory Evaluation

Results of sensory evaluation of control cookies described the control sample as sample with little deformed shape with less visible blend of the dough on the upper surface. The structure was uniform and very little dense in the middle, easily breakable and slightly crumbly. A weak gruel was formed by chewing. The smell and taste were suitable and characteristic for cookies. These characteristics of control sample were evaluated with 18 ponderated scores and the quality was defined as very good (Table II).

The addition of chestnut flour in the composition of the cookies caused the appearance of wrinkles and visible dough blends on the upper surface. The category "very good" was

maintained by addition of 20% of chestnut flour and the ponderated scores were slightly reduced (17.6). However, the addition of 40% and 60% of chestnut flour reduced the quality of cookies structure, and the structure was inconsistent with large pores to very dense and underdeveloped, due to the high amount of sucrose in the chestnut flour. By chewing the gruel was formed. Taste of cookies with chestnut flour was from low to extremely bitter, in proportion to amount of chestnut flour. The quality category for cookies with 40% (15.5 of ponderated scores) and 60% (13.1of ponderated scores) of chestnut flour were defined as good (Table II).

QDA diagram for observed cookies is presented in Fig. 1. In accordance with scores for sensory parameters, the cookies with the highest amount of chestnut flour were presented as samples with the worst quality. The cookies are presented on Fig. 2.

TABLE II
THE PONDERATED SCORES OF COOKIES SAMPLES AND QUALITY CATEGORY

Sensory property	Control sample		20% of chestnut flour		40% of chestnut flour		60% of chestnut flour	
	Score	PS	Score	PS	Score	PS	Score	PS
Appearance (uniformity of size, upper and bottom surface)	4	3.2	4	3.2	4	3.2	3.5	2.8
Structure	4	3.2	4	3.2	3.5	2.8	2.5	2
Mastication	4.5	3.6	4	3.2	3.5	2.8	3	2.4
Odor	5	3	5	3	4.5	2.7	4	2.4
Taste	5	5	5	5	4	4	3.5	3.5
Sum of the scores	22.5	18	22	17.6	19.5	15.5	16.5	13.1
Quality category	Very good		Very good		Good		Good	

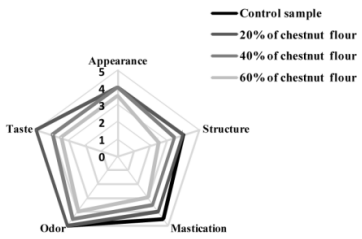

Fig. 1 QDA diagram of sensory evaluation of the cookies

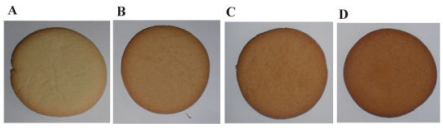

Fig. 2 A) control sample; B) 20%; C) 40%; D) 60% of chestnut flour

B. Color of the Cookies

Color of the cookies is one of the important quality factors that affects to the acceptability of the final product by the consumer. Technological processes, such as parameters of baking phase, are usually observed by this sensory property. The results of instrumental determination of cookies color by Minolta are presented in Table III.

TABLE III
COLOR PARAMETERS OF THE COOKIES

Sample	Trichromatic values			CIE L*a*b* system			
	X	Y	Z	a*	b*	L^*_{ab}	ΔE^*_{ab}
Control sample	45.20	46.17	26.87	3.83	29.15	73.68	36.27
20% of chestnut flour	27.45	25.66	15.70	12.44	31.22	59.21	44.14
40% of chestnut flour	21.78	20.87	12.56	15.55	35.87	55.61	58.77
60% of chestnut flour	14.45	18.91	5.36	18.98	36.54	45.36	62.54

Based on the values of parameters for CIE L*a*b* system the increase in parameter a^* with increase in amount of chestnut flour was noticed. Thus, the red tone of the color was increased. Also, the yellow tone of color was increased, because the values of parameter b^* for control sample was lower than for samples with chestnut flour. Chestnut flour influenced on lightness of the samples. The lightness (L^*_{ab}) decreased with increase in amount of the chestnut flour. Golden–brown color of the cookies with chestnut flour was partially due to Maillard reactions between reducing sugars and amino acids. The Maillard reactions were more intensive with higher amounts of sucrose in composition of the cookies, thus higher amounts of chestnut flour caused more darkness of the color.

C. Textural Properties

The values of hardness for the cookies are presented in Table IV.

TABLE IV
HARDNESS OF THE COOKIES

Sample	Hardness ±SD (kg)
Control sample	13.1±2.5
20% of chestnut flour	12.9 ± 2.3
40% of chestnut flour	13.4 ± 3.0
60% of chestnut flour	14.6 ± 1.7

Based on results, the hardness of the cookies increased with addition of chestnut flour compared to control sample. The hardness increased with increase in amount of chestnut flour, also, that was in accordance with literature data [8]. High amount of sucrose in chestnut flour that inhibited the starch gelatinization could be reason for increase in hardness of the cookies.

D. Videometer

Videometer provided additional comparison of the color of the samples. The samples of the cookies with 60% of chestnut

flour were omitted from this determination, because they were described by previous methods as samples with worst quality (the sum of ponderated scores were 13.1, the values of CIE L*a*b* systems were lowest and the hardness was the highest). The samples with 20 and 40% were compared with control sample. Graphically presented results from videometer determination pointed that samples with 40% of chestnut flour were with darkest color (Fig. 3). The values scanned by Videometer on defined wavelengths were the lowest for sample with 40% of chestnut flour and the highest for control sample. The sample is lighter if the values on defined wavelengths are higher.

The comparison can be also observed by values on the lowest wavelengths. The lowest value of wavelengths for these three samples was 435nm. On this wavelength the lowest value was for sample with the highest amount of the chestnut flour.

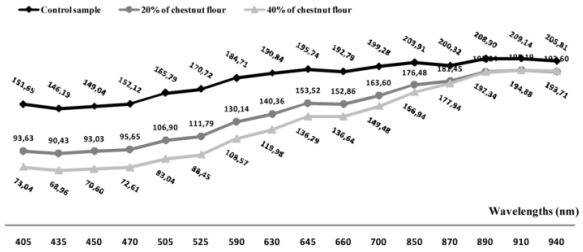

Fig. 3 Results of determination with Videometer

IV. Conclusion

Sensory determination of cookies with partially replacement of wheat flour with chestnut flour pointed that samples with 20% of chestnut flour were highly sensory evaluated. Quality descriptive analysis described the cookies with 20% of chestnut flour as cookies with very good quality. Same quality category was for control sample. Instrumentally determination of texture and color of cookies samples confirmed the results obtained by descriptive method. A good accordance between descriptive and instrumental applied methods was noticed. Thus complete sensory characterization of the samples was achieved.

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