PHYSICAL PROPERTIES OF COOKIES ENRICHED WITH NETTLE (*URTICA DIOICA* L.) SEEDS: COLOR, TEXTURAL AND SENSORY EVALUATION

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The assessment of color, texture, and sensory characteristics of cookies is essential as these factors significantly influence consumer acceptance and overall product appeal. Moreover, such evaluations provide invaluable insights into the synergies between ingredients and the potential market viability of the product. This research aims to investigate the impact of nettle seeds and nettle seed extract on the color, texture, and sensory attributes of wheat flour-based products, comparing these outcomes to a control (products without nettle seeds). Product color was evaluated using a MINOLTA Chroma Meter CR-00, while textural properties such as firmness and brittleness were measured using a TA-XTplus Texture Analyzer equipped with a 3-Point Bending Rig. Additionally, sensory evaluations were conducted 24 hours post-baking by a panel of seven experienced evaluators using a standardized scoring method. Color analysis revealed that products enriched with nettle seeds exhibited darker shades, whereas those with nettle seed extract showed enhanced red tones compared to the control. Instrumental texture analysis indicated that nettle seed products had softer textures, as evidenced by significantly lower values of firmness and brittleness, which in stark contrast to the firmer textures observed in products with nettle seed extract and the control. These findings were further corroborated by sensory evaluations, where panelists expressed a preference for the appearance, texture, smell, and taste of products containing nettle seeds. Overall, this research emphasizes the significant potential of nettle seeds as a functional ingredient, enhancing both the sensory appeal and overall quality of food products.

Keywords: cookies, nettle seeds, color, texture, sensory evaluation

Introduction

In recent years, there has been an increasing consumer demand for healthier food products that not only provide nutritional and functional benefits but also offer enhanced sensory qualities. The strategic enrichment of foods with essential vitamins, minerals, polyphenols, and fibers has emerged as a compelling approach to produce functional foods that enhance human health [1]. The sensory attributes of these products, including color, texture, aroma, and flavor, are pivotal in shaping consumer perception, acceptability, and overall satisfaction. Color plays a significant role in setting expectations and influencing how consumers perceive the quality of the product. Texture (crisp, tender, creamy, etc.) significantly influences consumer preference and enjoyment. Furthermore, the interaction of aroma and flavor is crucial, as these sensory elements profoundly impact a product's appeal and ultimate market success.

Bakery products, especially cookies, enjoy widespread popularity worldwide due to their high energy content, affordability, convenience, availability in various flavors, and extended shelf life [2]. Wheat flour serves as the primary ingredient in cookie production, albeit deficient in certain nutritional components, such as essential amino acids like lysine and tryptophan. To bolster their nutritional profile, cookies are often formulated with fortified or composite flours enriched with various plant powders such as flaxseed, date seeds, fig seeds, papaya pulp, chokeberry extract, grape marc extract etc.[3-9].

Nettle (Urtica spp.), a resilient perennial herb from the Urticaceae family, has captured considerable scientific attention owing to its nutritional richness and bioactive compounds found in its stem, leaves, roots, and notably, its seeds [10-13]. There are many studies that have underscored nettle's nutritional benefits, emphasizing its high content of bioactive substances, especially polyphenolic compounds, which contribute

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to its antioxidative, antimicrobial, and anti-inflammatory properties [10,12,14-16]. Nettle seeds, which are recognizable by their rich oil content and high levels of polyunsaturated fatty acids (such as linoleic acid), and substantial fiber content are of particular interest [17,18]. These attributes highlight the seeds' significant nutritional value, complementing nettle's already impressive profile as a protein-rich source with essential amino acids [19,20].

In our recent research [16], the incorporation of nettle seeds and extracts into wheat flour-based food products was investigated, focusing on their functional properties (specifically, the content and antioxidant activity of polyphenolic compounds) and technological attributes (volume, mass, and "holding" value). Our findings demonstrated a statistically significant enhancement in polyphenolic content and antioxidant properties upon incorporating nettle seeds. Moreover, products enriched with nettle seed flour had increased volume, a highly desirable attribute in food products. It is noteworthy that the presence of phenolics in food products is known to influence sensory attributes such as color, flavor, and astringency [21-23]. While significant progress has been made in understanding the functional properties of these novel food formulations, there remains a critical gap concerning their sensory impact. As consumer preferences increasingly favor foods that not only promote health benefits but also provide superior sensory quality, our current study aims to address this aspect comprehensively. The primary objective of our present work is to provide a detailed evaluation of the physical properties of wheat flour-based products containing nettle seeds and nettle seed extract, including color, texture, and sensory attributes. By exploring these incorporative components comprehensively, we not only contribute to satisfying the growing demand for healthier food options but also open avenues for innovative formulations that merge nutritional excellence with sensory delight.

Material and Methods

Materials

The Urtica dioica L. seeds were purchased from “Jeligor”, Svrljig in Serbia, milled in an electric mill (Bosh, MKM 600, Germany) and sieved through a 0.40 mm riddle to get nettle seed flour.

The wheat flour, type 500, produced by ‘DON-DON’, Novi Beograd New Belgrade Serbia, was purchased from a retail market in Leskovac, Serbia. Other cookie ingredients including margarine (Vital, Vrbas, Serbia), baking powder (Centroproizvod, Surčin, Serbia), sugar (Centroproizvod, Surčin, Serbia) were all purchased from a local market in Leskovac, Serbia.

The nettle seed extract

The extract was obtained by the extraction of bioactive compounds from nettle seeds by using water at a ratio of 1:10 w/v, at room temperature for 24 h, with occasional stirring.

Cookies preparation

In order to obtain the control cookie (CC), 500 g of wheat flour, 5 g of baking powder, 50 g of margarine, 150 g of sugar and 200 mL of water were manually mixed. The obtained dough was rolled out into disks (4.5 cm in diameter and 1 cm in height) and was processed in an oven (Candy FPP403 Plan Light Fan Oven, Brugherio, Italy) at 180 °C for 25 min and cooled to ambient temperature.

The cookie enriched by nettle seeds (CWS) was obtained following the same recipe used for the control cookie, with the exception that 150 g of nettle seed flour was used to partially replace the wheat flour. Baked samples were obtained in the same manner as the control cookie.

The cookie containing nettle seed extract (CWE) was prepared following the same recipe used for the control cookie, with the exception that nettle seed extract was used instead of water.

Determining the color of the products

The color of the product is determined by the use of a MINOLTA chromometer, Chroma Meter CR-00 (Minolta Co., Ltd., Osaka, Japan) with D-65 illumination, a 2° standard viewing angle and an 8-mm hole in the measuring head. The results are expressed as lightness (L*), the proportion of red/green (a*) and yellow/blue (b*) color, according to the CIE L*a*b* system [24]. The color of the product is measured on the surface of each product sample. The color measurement was carried out in 5 repetitions.

Determination of the textural characteristics of the products

The texture characteristics of the product were determined using the TA-XTplus Texture Analyzer (Stable Micro Systems, Surrey, Great Britain), using a three-point bending rig (HDP/3PB). This device is used to measure the firmness and brittleness of the product.

Firmness is defined as the maximum force achieved during the fracture of the sample and is expressed in Newtons (N). Brittleness is defined as the distance at the moment of fracture of the sample, i.e. the resistance that the sample provides to the bending force and is expressed in mm. Brittleness expressed in this way shows that if the sample breaks at a short distance, it is categorized as more brittle. The parameters of the instrument adjustment during the test were as follows: module – measurement of force during compression; speed before test – 1.0 $mm \cdot s^{-1}$; speed during test – 3.0 $mm \cdot s^{-1}$; speed after test – 10.0 $mm \cdot s^{-1}$; distance – 5.0 mm; trigger force – 50 g. Texture measurement was performed in 15 repetitions.

Table 1. Sensory characteristics and significance factors of products enriched with nettle seeds and nettle seed extract

Sensory characteristics	Assessment	Significance factor	Description of the characteristics assessed
APPEARANCE Shape, homogeneity, surface	5	1.0	Proper shape, no damage; upper surface slightly cracked, with slight unevenness; the upper and lower surfaces visible ingredients of the dough (particles of ground nettle seeds); the lower surface of a uniform color.
	4		Slight deformation of the shape with a slightly uneven height; upper surface slightly rough and cracked; the upper and lower surfaces visible ingredients of the dough (particles of ground nettle seeds); the lower surface of a uniform color.
	3		Weakly deformed form; upper surface very rough and cracked; on the upper and lower surfaces visible ingredients of the dough (particles of ground nettle seeds); lower surface weaker or harder baked.
	2		Deformed form, uneven height of the product; the upper and lower surfaces are extremely cracked, under- or over-baked.
	1		Completely deformed form, markedly damaged edges; uneven color of the upper and lower surfaces.
TEXTURE Structure, firmness, crispiness	5	1.2	Slightly layered and uniform structure with dense uneven oval cavities; dry texture and inherent firmness; weakly uneven, brittle fracture; on the fracture visible ingredients (particles of ground nettle seeds).
	4		Slightly uneven layered structure with dense and uneven cavities; dry texture and inherent firmness; uneven, brittle fracture with visible components (particles of ground nettle seeds).
	3		Structure compact, too dense and firm, coarser texture; A rough and a crumbly break.
	2		Very compact structure or split layers; coarse texture; It's a hard break.
	1		Very compact and dense structure or split layers, with an extremely rough texture; Hard break.
TEXTURE Chewiness	5	1.0	Firm, dry, with adequate chewiness, slightly scratches the palate and softens slowly in the mouth.
	4		Firm, dry, with adequate chewiness, scratches the palate and softens slowly in the mouth.
	3		Too firm, mediocre chewiness, scratches the palate, softens very slowly in the mouth.
	2		Too firm, harder to chew, scratches the palate, softens very slowly in the mouth.
	1		Hard, tough, scratches the palate very much, does not soften for a long period in the mouth.
SMELL	5	0.6	Inherent smell to the fatty component, rounded, aromatic to the ingredients (nettle seeds), constant for a long time.
	4		Slightly pronounced smell, characteristic of the fatty component, rounded, aromatic to the ingredients (nettle seeds), constant over a long time.
	3		Pronounced smell to the fatty component, weakly aromatic to the ingredients (nettle seeds), constant for a long time.
	2		Very pronounced smell of the fatty component, very weakly aromatic to the ingredients (nettle seeds), admixture of foreign odor.
	1		The presence of a foreign odor, an unpleasant odor.
TASTE	5	1.2	Inherent taste to the fatty component, rounded, aromatic to the ingredients (nettle seeds), constant for a long time.
	4		Slightly pronounced taste, inherent in the fatty component, rounded, aromatic to the ingredients (nettle seeds), constant for a long time.
	3		Very pronounced taste to the fatty component, very weakly aromatic to the ingredients (nettle seeds).
	2		Very pronounced taste to the fatty component, very weakly aromatic to the ingredients (nettle seeds), admixture of foreign odor.
	1		The presence of a foreign taste, an unpleasant taste.

Determination of sensory characteristics of cookies using the scoring method

Sensory evaluation of the product using the scoring method was carried out 24 hours after baking by a seven-member panel of experienced evaluators for this product group. Prior to the sensory evaluation, the representative sensory attributes of the product were determined and taken as a quality factor. Each quality factor was rated on a 5-point scale, with criteria defined for each point (Table 1) [25, 26]. The panelists also defined significance factors (FS) for each quality factor, the sum of which was 5: FS = 1.0 for appearance (shape, homogeneity and surface); FS = 1.2 for structure, strength, brittleness; FS = 1.0 for chewiness; FS = 0.6 for smell and FS = 1.2 for taste. The average score of each attribute, multiplied by the significance factor, were used to obtain the final score of the product, which is expressed as a quality number (QN):

$$\mathrm{QN} = \frac{\sum_{i=1}^{n} X_i * F\ S_i}{5} \qquad (1)$$

where is:

X_i - the average score of quality factor

FS_i - the significance factor assigned to quality factor

n - number of evaluated quality factors

The quality category is determined based on the range of quality number values presented in Table 2. All samples were labeled with randomly selected three-digit numbers, which allowed unbiased and objective assessment of sensory attributes to be achieved. The samples are presented at the same time, in the same order and dynamics, in order to avoid undesirable psychological effects. Samples of the product are evaluated in two repetitions. The sensory analysis was conducted in testing cabinets under normal lighting conditions, at a temperature of 22 °C and approximately 65% humidity, designed according to the ISO 8589 standard [27].

Table 2. Qualitative categories of products enriched with nettle seeds and nettle seed extract

Point range	Quality category
< 2.5 points	Unsatisfactory sensory quality
2.5 to 3.5	Good sensory quality
3.5 to 4.5	Very good sensory quality
4.5 to 5.0	Excellent sensory quality

Statistical analysis

Analytical data were subjected to an analysis of variance (ANOVA) to compare mean values, and significant differences were calculated according to Tukey's post-hoc HSD ("honestly significant differences") test at $p < 0.05$, 95% confidence level. Analyses were carried out in the program StatSoFT Statistica software v. 14 (TIBCO® Data Science/STATISTICA™, StatSoft, Hamburg, Germany).

Results and Discussion

Color analysis of the cookies with nettle seeds and nettle seed extract

Color is widely recognized as a crucial physical characteristic of food, closely associated with its overall quality in terms of how it is perceived sensorially and accepted by consumers [28]. The color parameters L*, a*, and b*, determined by a photocolorimeter, were used to describe the lightness (L*), redness (a*), and yellowness (b*) of the products: cookies with nettle seeds (CWS), cookies with nettle seed extract (CWE), and control cookies (CC). The results are shown in the Table 3. It is noticeable, that CC has significantly higher L* values compared to both CWS and CWE. This suggests that the control product is lighter in color. Both CWS and CWE products show higher a* values compared to the CC, indicating a slightly more reddish hue. On the other hand, CWE and CC products exhibit higher b* values compared to CWS, indicating that the products containing nettle seed extract and the control product have a more pronounced yellow tone compared to the products with nettle seeds.

Table 3. Color characteristics of products enriched with nettle seeds (CWS) and nettle seed extract (CWE), and the control product (CC)

	CWS	CWE	CC
L*	40.65 ± 1.35^{a}	72.94 ± 1.27^{b}	77.34 ± 1.97^{c}
a*	2.13 ± 0.43^{a}	3.27 ± 0.30^{b}	1.05 ± 0.31^{c}
b*	15.45 ± 1.65^{a}	25.59 ± 1.21^{b}	25.15 ± 1.73^{b}

L - lightness; a* - red tone; b* - yellow tone; Within the rows, values marked by the same letters in the superscript do not differ statistically significantly, p > 0.05*

These findings align with recent research by Najjar et al. [4], who investigated the incorporation of date seeds into wheat flour-based cookies. Their study demonstrated that increasing the proportion of date seeds resulted in darker-colored cookies, highlighting the significant influence of seed incorporation on product coloration. Similarly, Gómez and Martinez [29], Aksoylu et al. [30], and Ashoush and Gadallah [31] have also observed color changes in cookies when seeds were added, attributing these changes to natural pigments present in the seeds. Moreover, the interactions between ingredients during mixing and baking processes play a crucial role in determining the final quality of baked goods, including their color development [32]. According to Kaur et al. [3], color development in cookies during late baking stages is influenced by surface evaporation and chemical reactions like Maillard browning (Maillard reaction products, MRPs). While nettle seed powder might have potentially masked color changes in the product samples containing seeds, differences in flour samples with nettle seed extract and the control product could cause more noticeable non-enzymatic browning reactions which arise as consequence of variations in amino acid and sugar profiles. These factors could ultimately impact the final color outcomes of the products. Therefore, understanding the chemical interactions and compositions involved in the baking processes is crucial for interpreting the observed color variations in products containing nettle seeds and extracts. In addition to color, Maillard reaction products can contribute to the antioxidant capacity of the products. In our previous study on the effect of thermal processing (baking at 180 °C for 25 min) on the antioxidant capacity of these products, rich in nettle seed and nettle seed extract, was documented that these products also show statistically significantly better antioxidant properties compared to the control sample. The observed increase in the antioxidant capacity of the product during baking is attributed, among other things, to MRPs with a high molecular weight that are formed in the advanced stages of the reaction [16, 33]. It can be expected that MRPs affect the extended shelf life and stability of the resulting cookies, and additional testing appears warranted. These results were also supported by Nooshkam et al. (2019) [34].

In general, the color of products with incorporated nettle seeds or nettle seed extract varies significantly from control samples, which can influence their sensory appeal and consumer perception. Future studies could further explore the correlation between these color attributes and the chemical composition or bioactive compounds present which contribute to the color of the products.

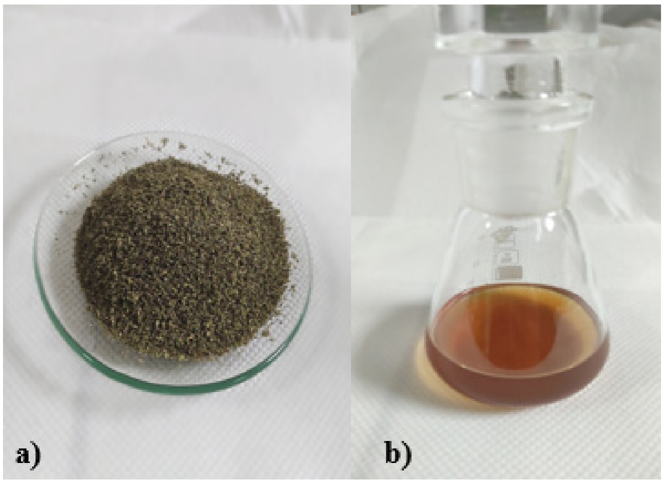

Figure 1. Appearance of nettle seeds (a) and aqueous extract of nettle seeds (b)

Textural characteristics of the cookies

Texture is also a critical quality parameter in food products, significantly influencing consumer perception and overall acceptability of products. In this study, texture analysis was conducted using a texture meter with the "three-point bending" technique to evaluate firmness and brittleness of products containing nettle seeds and nettle seed extract, as well as a control product. The appearance of typical curves for products obtained on the TA-XTplus Texture Analyzer is shown in Figure 2.

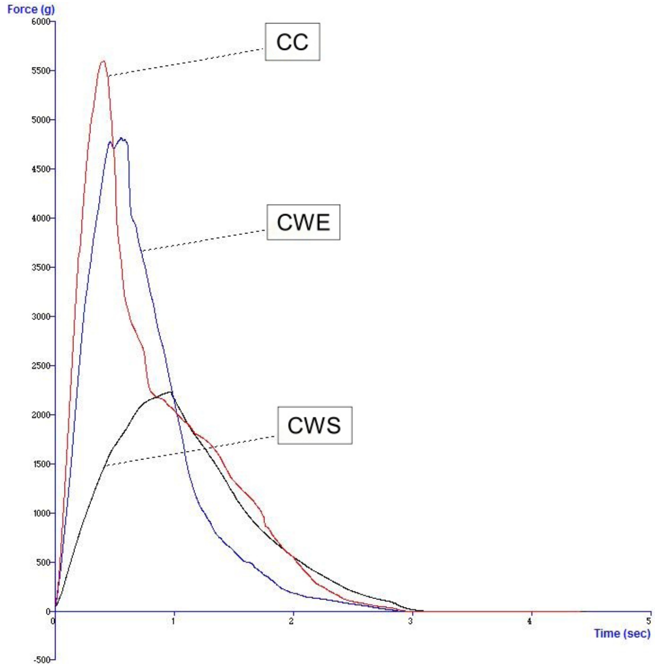

Figure 2. Appearance of typical curves for products enriched with nettle seeds (CWS), products enriched with nettle seed extract (CWE) and control products (CC) obtained on the TA-XTplus Texture Analyzer

The firmness of the samples, defined as the maximum force required for product breakage, exhibited statistically significant differences ($p < 0.05$) among all three product types (Table 4). The CWS demonstrated a significantly lower firmness compared to both the CWE and the CC. The firmness of a product, assessed using a texture meter, is affected by factors such as the product's thickness and shape [35], along with type and fat content [36]. Since the product samples were formulated with same type and quantity of fat, and generally exhibited similar thicknesses and shapes, any variance in firmness is likely attributable to differences in the added raw materials. In fact, the obtained results indicate that the incorporation of nettle seeds led to a softer texture, and this finding was supported by the previous studies on seed incorporation in baked goods [37,38]. Literature data suggest that the reduction in firmness may be attributed to decreased gluten content when seed flour replaces wheat flour, affecting dough structure and resulting in softer final products.

Table 4. Textural characteristics of products enriched with nettle seeds and nettle seed extract, and the control product

Textural properties	CWS	CWE	CC
Firmness, N	23.36^{a}	55.66^{bc}	52.93^{b}
Brittleness, mm	2.60^{c}	1.61^{b}	1.20^{a}
Strength required for breakage, N·mm^{-1}	0.39^{a}	1.08^{c}	0.96^{b}

Within the rows, values marked by the same letters in the superscript do not differ statistically significantly, p > 0.05

The brittleness of the products, quantified as the distance at breakage (i.e., the resistance to bending force expressed in mm), indicates that shorter distances at breakage correspond to higher brittleness. The CC exhibited the highest brittleness (1.20), indicating it broke at a shorter distance compared to the CWE (1.61) and the CWS (2.60), as evidenced by statistically significant differences ($p < 0.05$) reported in Table 4. This suggests that while the control cookie was more brittle, the nettle seed cookie was more resilient to bending forces, possibly due to its unique composition and fiber content.

In general, the observed texture differences can be attributed to various factors, such as moisture content, sugar crystallization, starch gelatinization, and protein interactions during the baking process. In cookies, the development of texture is a dynamic process influenced by the interplay of factors (ingredients and formulation, baking conditions, and cooling process). Scientific studies [35,39-41] have explored these dynamics, highlighting how variations in these parameters influence the texture of cookies.

These instrumental findings align well with the sensory evaluation results, where panelists scored the nettle seed product higher in texture attributes compared to the other samples (Table 5). This consistency between instrumental measurements and sensory evaluation by the panelists underscores the reliability of both methodologies in assessing textural qualities of baked goods.

Sensory evaluation of the cookies

The sensory evaluation of cookies revealed significant differences across various attributes including appearance, texture, smell, taste, and overall quality (Table 5). The CWS received the highest score for appearance, indicating superior ratings in terms of shape, homogeneity, and surface characteristics. In contrast, the CWE scored lower, which suggests that the incorporation of nettle seeds enhances visual appeal more than the extract alone.

Table 5. Sensory evaluation of products enriched with nettle seeds and nettle seed extract, and the control product

Sensory properties	CWS	CWE	CC
Appearance (shape, homogeneity, surface)	$4.48±0.38^{a}$	$3.55±0.38^{bc}$	$3.82±0.24^{b}$
Texture (structure, firmness, crispiness)	$4.75±0.65^{a}$	$3.68±0.28^{b}$	$3.54±0.42^{b}$
Texture (chewiness)	$4.12±0.65^{a}$	$3.57±0.28^{b}$	$3.34±0.79^{c}$
Smell	$4.15±0.62^{a}$	$3.25±0.58^{b}$	$3.18±0.67^{b}$
Taste	$4.42±0.93^{a}$	$4.15±1.34^{b}$	$4.12±1.42^{b}$
Quality number	4.45	3.65	3.58

Ratings are the median of seven evaluations by seven panelists±SD
Values in the same rows marked by different letters in the superscript differ statistically significantly (p<0.05)

The CWS scored significantly higher compared to the CWE and the CC in terms of textural attributes such as structure, firmness and crispiness. Similarly, in terms of chewiness, smell and taste, product with nettle seeds outperformed both the extract and the control. This suggests that incorporating nettle seeds contributes to a more desirable texture profile in the final product and that affects the better taste of the product, potentially enhancing sensory appeal and consumer satisfaction.

The overall quality rating further supports these findings, with the product containing nettle seeds receiving the highest score (4.45), followed by the nettle seed extract (3.65) and the control product (3.58). This comprehensive evaluation underscores that nettle seeds positively contribute to enhancing the overall sensory quality of the product, while the sensory quality of the control product and the product with nettle seed extract are largely identical.

The observed differences in sensory attributes can be attributed to the unique composition of nettle seeds, which may initiate specific flavors, textures, and aromas that resonate positively with sensory panels.

Future research aims to deepen our understanding of the specific chemical components responsible for enhancing sensory attributes in food products. This involves identifying key compounds in nettle seeds. By elucidating these chemical constituents, formulation techniques could be refined to maximize sensory quality of products. Moreover, future studies should explore optimal processing conditions and formulation ratios tailored to the incorporation of nettle seeds. This approach ensures that these beneficial compounds are preserved and optimized during food processing, leading to consistent quality, enhanced sensory appeal, and improved nutritional value in the final products.

Conclusion

This study has provided valuable insights into the influence of incorporating nettle seeds and nettle seed extract on the color, texture, and sensory attributes of baked goods. The color analysis revealed distinct differences among the products. The products containing nettle seeds exhibited darker hues, whereas those with nettle seed extract showed varied color tones, particularly heightened red tones compared to the control. These findings underscore the potential of nettle seeds and extracts to influence product appearance, catering to consumer preferences for visually appealing food products. Texture analysis using instrumental method demonstrated significant variations in firmness and brittleness across the product samples. Incorporating nettle seeds resulted in softer textures compared to both the control and nettle seed extract products. This was supported by sensory evaluations where panelists rated the nettle seed product favorably for its texture attributes, including firmness and brittleness. These results suggest that nettle seeds contribute to desirable textural properties in baked goods, potentially enhancing consumer satisfaction. The sensory evaluation further corroborated instrumental findings, indicating that products with nettle seeds were preferred for their appearance, texture, smell, and taste compared to those with nettle seed extract and the control. Panelists noted the unique sensory characteristics imparted by nettle seeds, highlighting their potential as functional ingredients in enhancing overall product quality. This research not only expands our understanding of the sensory properties of nettle seeds and extracts in baked goods but also suggests promising avenues for their utilization in developing nutritious and appealing food products.

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Izvod

FIZIČKE OSOBINE PROIZVODA OBOGAĆENIH SEMENOM KOPRIVE (*URTICA DIOICA* L.): BOJA, TEKSTURA I SENZORSKE KARAKTERISTIKE

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Procena boje, teksture i senzorskih karakteristika keksa je od suštinskog značaja, jer ovi faktori imaju značajan uticaj na prihvatljivost od strane potrošača i ukupnu privlačnost proizvoda. Štaviše, takve procene pružaju neprocenjiv uvid u sinergiju između sastojaka i potencijalnu tržišnu održivost proizvoda. Ovo istraživanje ima za cilj da ispita uticaj semena koprive i ekstrakta semena koprive na boju, teksturu i senzorske karakteristike proizvoda na bazi pšeničnog brašna, poredeći ove rezultate sa kontrolnim uzorkom (proizvod bez semena koprive). Boja proizvoda je procenjena korišćenjem MINOLTA Chroma Meter CR-00, dok su teksturne osobine poput čvrstoće i krhkosti određene pomoću TA-XTplus analizatora teksture opremljenog 3-Point Bending Rig-om. Pored toga, sprovedena je i senzorska ocena proizvoda metodom bodovanja, 24 sata nakon pečenja, od strane sedmočlanog panela, iskusnih ocenjivača za ovu grupu proizvoda. Analiza boje je pokazala da su proizvodi obogaćeni semenom koprive tamniji, dok su oni sa ekstraktom semena koprive imali veći udeo crvene boje u odnosu na kontrolni uzorak. Instrumentalna analiza teksture je pokazala da proizvodi sa semenom koprive imaju mekšu teksturu, što je potvrđeno znatno nižim vrednostima čvrstoće i krhkosti, a što je u suprotnosti sa čvršćom teksturom kod proizvoda sa ekstraktom semena koprive i kontrolnog proizvoda. Ovi nalazi su dodatno potvrđeni senzorskom analizom, gde su ocenjivači pozitivno ocenili izgled, teksturu, miris i ukus proizvoda koji sadrži seme koprive. Istraživanje ističe značajan potencijal semena koprive kao funkcionalnog sastojka, čiji dodatak može poboljšati senzorsku prihvatljivost i ukupan kvalitet keksa.

Ključne reči: kolačići, seme koprive, boja, tekstura, senzorska evaluacija

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