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Research Article

EFFECT OF STINGING NETTLE LEAF AND SEED POWDERS ON PHYSICAL, TEXTURAL AND SENSORY PROPERTIES OF COOKIES

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ABSTRACT. In this study, different parts (leaf and seed) of the stinging nettle (*Urtica dioica* L.) were used in cookie production, and their effects on some physical, textural, and sensory properties of the cookies were investigated. Stinging nettle leaf powder (SNLP) and stinging nettle seed powder (SNSP) were used in cookie production at different ratios (0, 2, 4, 6, 8, and 10%) and replaced with wheat flour. The *L*, b**, and SI color values of cookies decreased with the increasing usage ratios of SNLP and SNSP in cookie formulation The diameter, thickness, and spread ratio values of the cookies containing SNLP and SNSP varied between 53.93-55.90 mm, 6.06-6.59 mm and 8.45-9.19 and 55.85-59.02 mm, 5.52-6.62 mm and 8.44-10.70, respectively. Significant ($p<0.05$) diameter and spread ratio increases were determined using 4% or more SNSP in cookies. While the firmness value of cookies increased at all usage ratios of SNLP, it decreased with the use of SNSP above 4%. The cookies' taste, odor, appearance, color, and overall acceptability scores were reduced with the increasing ratios of SNLP. In general, the panelists did not like cookies containing 8-10% SNLP. Although there was a decrease in sensory scores of cookies at high SNSP ratios, scores remained within the panelists' liking limits for all SNSP ratios.

Keywords: *Stinging nettle, cookie, powder, functional food, physical properties*

INTRODUCTION

Stinging nettle (*Urtica dioica* L.) belongs to the family Urticaceae and is native to Europe, Asia, Northern Africa, and America [1]. Stinging nettle is generally consumed as a vegetable in dishes. It is also used as a medicinal plant because the different parts of the nettle contain bioactive components that significantly affect human health and nutrition. Bioactive components found in stinging nettle leaves and roots were reported as vitamins (vitamin A, C, K, and B vitamins), minerals (calcium, iron, magnesium, phosphorus, potassium, and sodium), fats (linoleic acid, linolenic acid, palmitic acid, stearic acid, and oleic acid), amino acids (all of the essential amino acids), polyphenols (kaempferol, quercetin, caffeic acid, coumarins, and other flavonoids), pigments (beta-carotene, lutein, luteoxanthin and other carotenoids). On the other hand, seeds of stinging nettle contain vitamins, minerals, beta-carotene, folic acid, and essential fatty acids as bioactive components [2-4]. Stinging nettle has antioxidant, antimicrobial, anti-ulcer, anti-diabetic, antimutagenic, and anti-inflammatory activities thanks to these bioactive components in its structure [1].

Stinging nettle has many uses in traditional medicine and is consumed daily as vegetables, tea, and juice. There have been many studies on using stinging nettle in different cereal products. These studies generally used various parts of stinging nettle in powder or extract form to prepare cereal products. Utilization of dried stinging nettle leaves in bread and egg pasta [5-7], stinging nettle flour in flatbread (kitta), noodles and cookies [8-10], stinging nettle extract in cake, chocolates, oat flake cookies, and shortbread cookies [11-14], frozen

stinging nettle leaves in bread [15], lyophilized stinging nettle in durum wheat pasta [16] were studied by different researchers.

In this study, powders obtained from stinging nettle leaves and seeds were used in different proportions to produce cookies. The aim was 1) to determine the effects of these powders on the cookie's physical, textural, and sensory properties, 2) to expand the usage area of stinging nettle leaves and seeds, and 3) to introduce new products to the functional food industry.

MATERIALS AND METHODS

Materials

Cookie ingredients (wheat flour, fine granulating sucrose, skimmed milk powder, sodium and ammonium bicarbonate, all-purpose shortening, and high fructose corn syrup) were obtained from a commercial biscuit factory in Karaman, Turkey. Stinging nettle and its seeds were obtained from a farmer from the Çumra district of Konya, Turkey. This local type has been commonly cultivated in fruit and vegetable plantations for many years for local consumption and commercial purposes.

Preparation of SNLP and SNSP powders

Fresh stinging nettle leaves were washed under running tap water and dried in a dryer at 60 ± 2 °C for 24 hours. After drying, stinging nettle leaves were ground by a lab-type grinder (Arçelik K3104, İstanbul, Turkey) and passed through a 500 μm sieve to obtain SNLP. Seeds of stinging nettle were directly ground to powder form via a grinder and passed through a 500 μm sieve to obtain SNSP.

Preparation of cookie samples

The formulation of control cookies was 84 g fine granulating sucrose, 2 g skimmed milk powder, 2 g sodium bicarbonate, 80 g shortening, 3 g high-fructose corn syrup-42%, 1 g ammonium bicarbonate, 200 g wheat flour and water as required. In other cookie formulations, wheat flour was replaced with SNLP and SNSP at 0, 2, 4, 6, 8, and 10 % ratios. Cookie samples were prepared according to method AACC, 10-54 [17].

Laboratory analysis

The color of the cookie samples was measured using the Minolta CR-400 device (Minolta Chroma Meter CR-400, Osaka, Japan). L^* (lightness), a^* (red-green), and b^* (yellow-blue) values were determined; Hue angle value was calculated according to the formula arctan (b^*/a^*) for $a^*>0$ and $b^*>0$; and arctan [b^*/a^*] + 180° for $a^* < 0$ and $b^* > 0$. SI (saturation index) value was calculated according to the formula $(a^{*2}+b^{*2})^{1/2}$ [18].

The diameter and thickness of the cookie samples were measured using a digital micrometer (0.001 mm, Mitutoyo, Minoto-Ku, Tokyo, Japan). The diameter/thickness values were calculated to estimate the spread ratio.

A texture analyzer (model TA-XT2i, Stable Microsystems, Surrey, U.K.) was used to measure the firmness of the cookie samples using a 3-point bending test using a 3-point bending rig. The test conditions were: load cell: 5 kg, pre-test speed: 1.0 mm/s, post-test speed: 10.0 mm/s, distance: 3.0 mm, and trigger force: 50 g.

Sensory analysis was conducted by semi-trained panelists from the Food Engineering Department of Necmettin Erbakan University, Turkey. The samples were coded with letters and served to the panelists randomly to guard against bias. Taste, odor, appearance, color, crispness, and overall acceptability of samples were rated on a 1–9 scale (1 – dislike extremely,

2 – dislike very much, 3 – dislike moderately, 4 – dislike slightly, 5 – neither like nor dislike, 6 – like slightly, 7 – like moderately, 8 – like very much, 9 – like significantly).

Statistical analysis

All analyses were performed in duplicate. For statistical analysis, the JMP statistical program, version 10.0 (SAS Institute Inc., Cary, NC, USA) was used. Two different types of statistical evaluations were made. In the first one, a comparison was made based only on the SNSP or SNLP ratio. In the second one, the averages were compared with the Tukey HSD multiple comparison test using "nettle powder type" and "nettle powder ratio" variance sources.

RESULTS AND DISCUSSION

The color values of cookie samples prepared with the addition of different ratios of SNLP are given in Table 1. Increasing usage ratios of SNLP in cookie formulation significantly ($p<0.05$) decreased the *L** values of cookies. The *L** value, which was 66.32 in the control cookie, decreased to 41.41 by adding 10% SNLP. The *a** values of the cookies varied between -9.73 – (-1.15). The greenish color of the stinging nettle leaf caused a decrease in the *a** value even at the lowest (2%) SNLP addition ratio. The *cookie samples' b* and SI values* decreased significantly ($p<0.05$) in parallel with the increasing SNLP addition ratio. The Hue values of cookies increased with the usage of SNLP. *L**, *a**, and *b** values of wheat flour and SNLP used in this study were determined as 93.67, -5.65, and 15.18; 46.34, -13.24, and 18.02, respectively (data not shown). It is thought that the color characteristics of the raw material are partially reflected in the product.

Color values of cookies containing SNSP are presented in Table 2. *L** values of cookies decreased depending on the SNSP addition ratio, and the lowest value was obtained at 10% ratio. The fact that the *L** value of SNSP (36.69) used as raw material is lower than the *L** value of wheat flour (93.67) may have been effective in obtaining this result (data not shown). *a** values decreased with the use of SNSP in cookies. The lowest *a** values were determined at 4 and 8% SNSP addition ratios. Increasing the usage ratio of SNSP in cookie formulation decreased both *b** and SI values. Hue values of cookies were significantly ($p<0.05$) affected by using SNSP.

The additives and ingredients used in the cookie dough, baking temperature and time, and browning reactions (such as Maillard and caramelization) can effectively form the surface color properties of cookies [19]. The fact that stinging nettle leaves and seeds have much higher protein content than wheat flour may have effectively decreased the *L** values of both SNLP and SNSP-added cookies by promoting the Maillard reaction. In a study conducted by Zbikowska et al. [13], the utilization of nettle extract in oat flake cookies was investigated. An increase of nettle extract in the oat flake cookies decreased their brightness and redness but increased their yellowness.

Multiple comparison tests were also applied to the color results based on the variation sources of "nettle powder type" and "nettle powder ratio." It was determined that cookies with SNSP had higher *L**, *a**, *b**, and SI color values than those containing SNLP (Table 3 and Fig. 1). As can be seen from the cookie pictures in Fig. 2, cookies with SNLP addition had a dark and greenish color due to the natural color pigmentation of nettle leaf. According to the nettle powder variation source, the increasing usage ratio of nettle powder decreased the cookies' L*, b*, and SI values and increased the Hue value.

Table 1. *Color values of cookie samples containing SNLP*

SNLP ratio (%)	*L**	*a**	*b**	SI	Hue
0	66.32±0.10a	-1.15±0.07a	25.82±0.03a	25.85±0.06a	92.55±0.11f
2	53.87±0.14b	-9.35±0.14d	21.60±0.10b	23.54±0.05b	113.41±0.29e
4	49.34±0.06c	-9.73±0.04e	17.83±0.03c	20.31±0.05c	118.62±0.08d
6	46.57±0.14d	-9.35±0.07d	15.79±0.06d	18.35±0.14d	120.63±0.26c
8	43.52±0.03e	-8.60±0.08c	13.35±0.14e	15.88±0.23e	122.79±0.15b
10	41.41±0.14f	-8.16±0.06b	11.21±0.06f	13.86±0.05f	126.05±0.14a

Means with the same letter within a column are not significantly different (p > 0.05). Hue: Hue angle, SI: Saturation index. SNLP: Stinging nettle leaf powder

Table 2. *Color values of cookie samples containing SNSP*

SNSP ratio (%)	*L**	*a**	*b**	SI	Hue
0	66.93±0.18a	-1.136±0.05a	26.01±0.01a	26.03±0.13a	92.50±0.07d
2	65.70±0.07b	-1.674±0.03b	25.43±0.11b	25.49±0.09b	93.77±0.07c
4	63.58±0.11c	-2.164±0.09d	23.52±0.14c	23.62±0.14c	95.26±0.15ab
6	60.87±0.10d	-1.826±0.10bc	21.33±0.04d	21.41±0.12d	94.89±0.24b
8	59.39±0.06e	-2.022±0.11cd	20.49±0.06e	20.59±0.14e	95.64±0.05a
10	57.51±0.13f	-1.806±0.06bc	18.96±0.08f	19.05±0.05f	95.44±0.14ab

Means with the same letter within a column are not significantly different (p > 0.05). Hue: Hue angle, SI: Saturation index. SNSP: Stinging nettle seed powder

Table 3. *Multiple comparison test results of cookie color values*

Variance source	n	*L**	*a**	*b**	SI	hue
Nettle powder type						
SNLP	12	50.17±8,63b	-7.72±3.12b	17.60±5.15b	19.63±4.33b	115.68±11.53a
SNSP	12	62.33±3.52a	-1.77±0.34a	22.62±2.62a	22.70±2.67a	94.58±1.16b
Nettle powder ratio (%)						
0	4	66.63±0.37a	-1.14±0.05a	25.92±0.11a	25.94±0.14a	92.53±0.08f
2	4	59.79±6.83b	-5.51±4.43d	23.52±2.21b	24.51±1.13b	103.59±11.34e
4	4	56.46±8.22c	-5.95±4.37e	20.68±3.29c	21.97±1.91c	106.94±13.49d
6	4	53.72±8.26d	-5.59±4.34d	18.56±3.20d	19.88±1.77d	107.76±14.86c
8	4	51.46±9.16e	-5.31±3.80c	16.92±4.12e	18.23±2.72e	109.21±15.68b
10	4	49.46±9.30f	-4.98±3.67b	15.09±4.47f	16.46±2.99f	110.75±17.67a

Means with the same letter within a column are not significantly different (p > 0.05). SNLP: Stinging nettle leaf powder SNSP: Stinging nettle seed powder

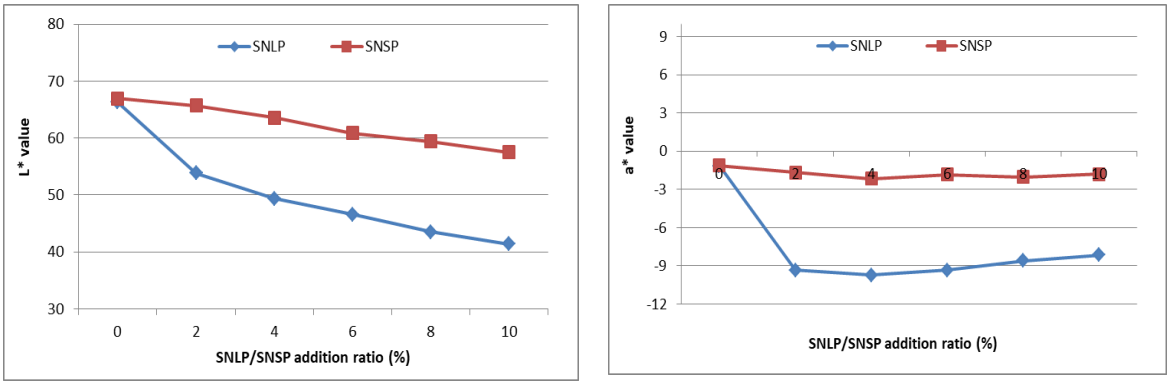

***Fig 1**. Interaction between "nettle powder type" and "nettle powder ratio" factors affecting L* and a* color values.*

***Fig. 2.** Images of cookies containing SNLP and SNSP (from left to right, cookies with 0, 2, 4, 6, 8 10% SNLP and 0, 2, 4, 6, 8 10% SNSP).*

The diameter, thickness, and spread ratio values of the cookie samples prepared with the addition of SNLP varied between 53.93-55.90 mm, 6.06-6.59 mm, and 8.45-9.19, respectively (Table 4). Compared to the diameter value of the control cookie sample, the diameters of the cookies produced with the addition of 2, 8, and 10% SNLP decreased. The lowest diameter value was determined at the highest SNLP addition ratio (10%). On the other hand, the lowest thickness values were determined in cookies containing 2-6% SNLP. While the spread ratio of cookies containing 8 and 10% SNLP was similar to the control, cookies containing 2-6% SNLP had a higher spread ratio than the control. The spread ratio is an important quality characteristic of cookies. All SNLP usage ratios yielded spread ratio values equal to or higher than the control.

Firmness values of cookies containing 0, 2, 4, 6, 8, and 10% SNLP were found as 3770, 4625, 4530, 4652, 4675, and 4785 g, respectively (Table 4). All additional ratios of SNLP increased the firmness value of the cookies, and the firmness of cookies containing 10% SNLP reached up to 4785 g. The high fiber content of SNLP may have effectively increased the firmness value of cookies. Adhikari et al. [20] reported that nettle powder contains 9.08% crude fiber, approximately 9 times more than wheat flour fiber content.

Physical properties and firmness values of cookie samples containing SNSP are given in Table 5. The addition of SNSP (4% and above) improved the diameter of cookies, which

increased from 55.85 mm up to 59.02 mm with the addition of 10% SNSP. Despite this increase in diameter value, thickness values decreased by 6% and above SNSP. Using 8-10% SNSP in cookie formulation yielded the lowest thickness values. This expected increase in spread ratio was achieved due to the increase in diameter and decrease in thickness. SNSP usage ratios of 4% and above significantly ($p<0.05$) increased the spread ratios of cookies. Guil-Guerreroa et al. [21] reported the unsaponifiable oil content of stinging nettle leaf, seed, and root as 3.3%, 15.1%, and 0.1%, respectively. While the high-fat content of SNSP promoted spreading, it caused a decrease in thickness. Maache-Rezzoug et al. [22] reported that fat contributes to cookie spread and general product appearance; it enhances aeration for leavening and volume and makes the cookies more easily breakable.

Firmness values of cookies containing SNSP varied between 3265 and 4156 g. While the use of 2-4% SNSP increased the firmness value of the cookies, the use of higher amounts (6-10%) of SNSP caused a significant ($p<0.05$) decrease in the firmness (Table 5). As mentioned before, stinging nettle seed has a high fat content, affecting the cookies' physical properties and texture [22].

Table 4. *Physical properties and firmness values of cookie samples containing SNLP*

SNLP ratio (%)	Diameter (mm)	Thickness (mm)	Spread ratio	Firmness (g)
0	55.90±0.14a	6.59±0.06a	8.48±0.11d	3770±7.07d
2	55.38±0.11bc	6.27±0.03bc	8.83±0.04bc	4625±21.21b
4	55.78±0.04a	6.23±0.04bc	8.95±0.07ab	4530±12.73c
6	55.68±0.11ab	6.06±0.08c	9.19±0.13a	4652±2.83b
8	55.12±0.03c	6.41±0.06ab	8.60±0.04cd	4675±19.80b
10	53.93±0.10d	6.38±0.11ab	8.45±0.07d	4785±7.07a

Means with the same letter within a column are not significantly different ($p > 0.05$). SNLP: Stinging nettle leaf powder

Table 5. *Physical properties and firmness values of cookie samples containing SNSP*

SNSP ratio (%)	Diameter (mm)	Thickness (mm)	Spread ratio	Firmness (g)
0	55.85±0,07e	6.62±0.03a	8.44±0.06e	3745±2.83c
2	56.13±0.18e	6.50±0.06a	8.64±0.11de	4156±8.49a
4	56.67±0.04d	6.42±0.03a	8.83±0.04d	3870±21.21b
6	57.93±0.04c	6.15±0.07b	9.42±0.03c	3520±7.07e
8	58.51±0.13b	5.74±0.06c	10.20±0.14b	3635±4.24d
10	59.02±0.03a	5.52±0.11c	10.70±0.07a	3265±5.66f

Means with the same letter within a column are not significantly different ($p > 0.05$). SNSP: Stinging nettle seed powder

When multiple comparison test results were examined according to the nettle powder type variation source, it was determined that cookies containing SNSP had higher diameter, spread ratio, and lower thickness and firmness values (Table 6). Fig. 3 shows that the changes in the spread ratio of cookies are in different directions at 8-10% SNLP/SNSP usage ratios. While the spread ratios of cookies continued to increase linearly at high SNSP usage ratios, a slight decrease occurred in cookie spread ratio with %8-10 SNLP addition. The fact that SNSP has a much higher fat content than SNLP effectively achieved those results. Cookie firmness values were also affected differently by the increasing usage ratios of SNLP/SNSP. With nettle powders above 4%, the firmness increased in cookies containing SNLP and decreased in cookies with SNSP.

Table 6. *Multiple comparison test results of some physical properties and firmness values of cookie samples*

Variance source	n	Diameter (mm)	Thickness (mm)	Spread ratio	Firmness (g)
Nettle powder type					
SNLP	12	55.30±0.70b	6,32±0.18a	8.75±0.28b	4506±352a
SNSP	12	57.35±1.26a	6.16±0.43b	9.37±0.87a	3699±290b
Nettle powder ratio (%)					
0	4	55.88±0.10d	6.61±0.04a	8.46±0.08d	3758±15.09f
2	4	55.76±0.45d	6.39±0.14b	8.74±0.13c	43901±271.10a
4	4	56.23±0.52c	6.33±0.11b	8.89±0.08c	4200±381.32b
6	4	56.81±1.30a	6.11±0.08c	9.31±0.15b	4086±653.58d
8	4	56.82±1.96a	6.08±0.39c	9.40±0.93ab	4155±600.56c
10	4	56.48±2.94b	5.95±0.51c	9.58±1.30a	4025±877.59e

Means with the same letter within a column are not significantly different ($p > 0.05$). SNLP: Stinging nettle leaf powder SNSP: Stinging nettle seed powder

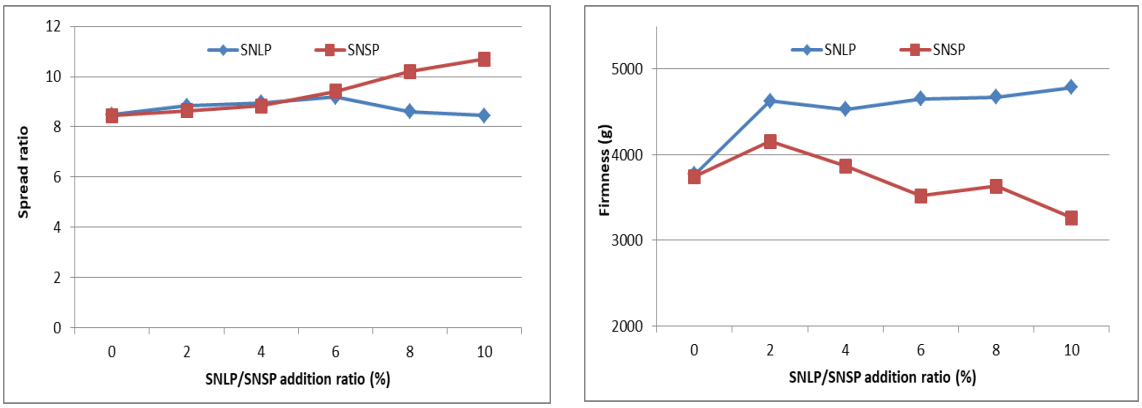

Fig. 3*. Interaction between "nettle powder type" and "nettle powder ratio" factors affecting spread ratio and firmness values.*

The use of SNLP in cookie production reduced taste and odor scores (Fig. 4). Taste and odor scores were below acceptable values at 8-10% and 6-10% SNLP usage ratios, respectively (4 represents "dislike slightly" and 3 represents "dislike moderately" on the rating scale used for sensory analysis). The herbaceous taste and odor of SNLP were felt by the panelists at high usage ratios and were evaluated in lower scores. Increasing ratios of SNLP in cookie formulation also caused a significant ($p<0.05$) decrease in appearance scores. At high SNLP usage ratios (8-10%), panelists did not like the appearance of cookies. The color scores of the cookies were also significantly ($p<0.05$) affected by the use of SNLP, and 2-8% SNLP usage ratios remained within the limits of appreciation in color evaluation. The crispness scores of cookies containing SNLP at all addition ratios were equivalent to the control cookies. Increasing usage ratio of SNLP in cookies caused a significant ($p<0.05$) decrease in overall acceptability scores, and cookies containing 8-10% SNLP remained below the liking limits. It is thought that SNLP has a high fiber content compared to wheat flour and does not contain gluten and starch, which are very effective on cookie properties, and that it also affects the sensory properties of the cookie by changing its physical and textural properties. In addition to the herbaceous odor and taste of SNLP, its dark color negatively affected the sensory scores, especially at high SNLP usage ratios.

Sensory analysis results of cookie samples containing SNSP are given in Fig. 5. Compared to the control sample, the taste and odor scores of the cookies decreased with 10% SNSP usage.

While an appearance score of a cookie with 2% SNSP was equivalent to the control, cookies containing other utilization ratios of SNSP were evaluated with lower appearance scores. The color and crispness scores were negatively affected by the use of 8-10% SNSP. Overall acceptability scores of cookies with 2-8% SNSP were similar to the control; only %10 utilization rates of SNSP decreased the overall acceptability. Boeștean et al. [23] used nettle root powder at different ratios in bread preparation. They reported that utilization of 1-5% nettle root powder in bread gave acceptable sensory properties, but a 7% usage ratio had a strange flavor and a darker color on bread samples. In another study, durum wheat semolina was partially replaced by a different amount (0–5%) of the freeze-dried nettle to produce nettle-enriched durum wheat pasta [16]. The appearance, color, odor, taste, hardness, adhesiveness, and springiness properties of the enriched pasta were comparable to those of the control commercial counterpart. In the study conducted by Alemayehu et al. [9], nettle flour was used in noodle production at 0, 5, 10, 15, and 20%. Nettle flour-enriched samples had lower consumer acceptance in terms of color, aroma, texture, taste, and overall acceptability compared to the noodles produced with 100% wheat flour.

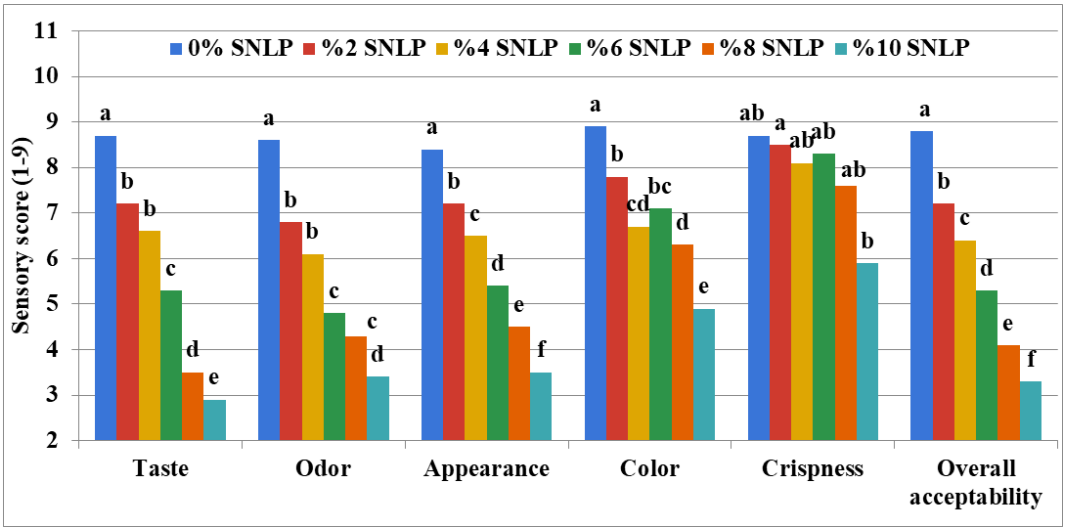

Fig. 4. *Sensory properties of cookie samples containing SNLP (Stinging nettle leaf powder)*

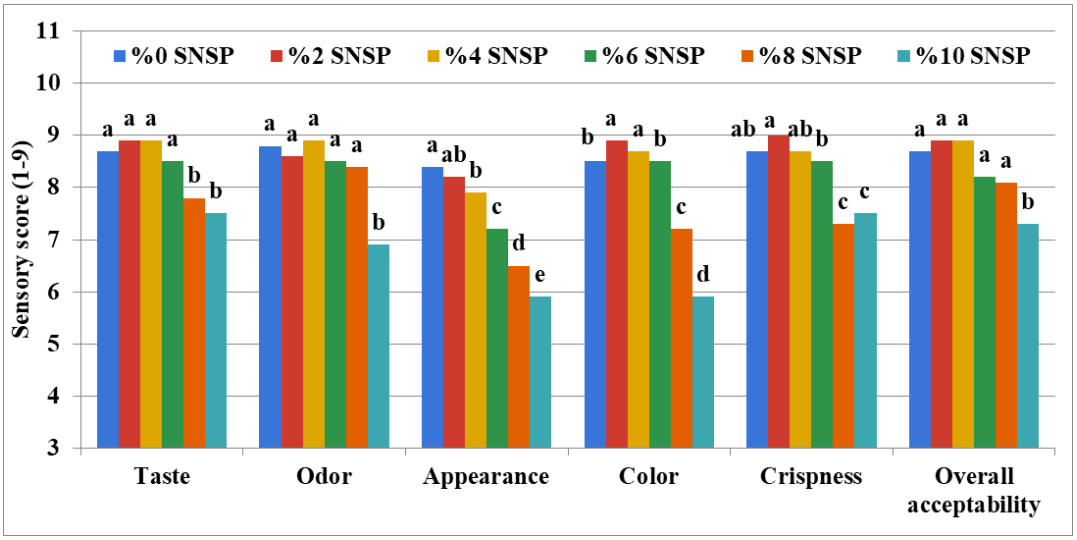

Fig. 5. *Sensory properties of cookie samples containing SNSP (Stinging nettle seed powder)*

CONCLUSION

In this study, the effects of different ratios of SNLP and SNSP on some physical, textural and sensory properties of cookies were investigated. Both nettle powders reduced the lightness and yellowness of the cookies. The use of SNLP in cookie production has resulted in firmer texture. On the other hand, cookies containing 6-10% SNSP were found to have lower firmness than the control. Compared to control cookie, the use of 4-10% SNSP significantly ($p<0.05$) increased the diameter and spread ratios of cookies, and this increase was realized as 5.7 and 26.8%, respectively, with the addition of 10% SNSP. Sensory scores of cookies containing SNLP was found lower than control. Overall acceptability scores of cookies containing 2-8% SNSP were found equivalent to control, but 10% SNSP addition ratio resulted in a lower overall acceptability value than the control. All parts of the nettle plant are rich in nutritional and functional components, and also can be potential ingredients in the fortification of cereal products. In future studies, the effect of SNLP and SNSP use in cookie formulation on nutritional and functional properties will be revealed.

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