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Research Article

Physical, nutritional, textural and sensory qualities of Turkish noodles produced with siyez wheat (*Triticum monococcum*), kale (*Brassica oleracea* var. *acephala*) and chia seed (*Salvia hispanica* L.)

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ABSTRACT

In this study, physical (cooking time, water absorption, cooking loss and color), chemical (proximate composition, pH, total phenolic content, mineral matter (Ca, K, Fe, Mg and Zn)), textural (hardness and adhesiveness) and sensory (color, taste, flavor, appearance, hardness, adhesiveness and overall acceptability) attributes were determined in different types of noodles produced from siyez wheat flour, kale powder and chia seed mucilage. Results were statistically evaluated using SAS software. The optimal cooking time for the noodles were 20 min and cooking loss varied between 8.36-12.22%. Kale powder and chia mucilage addition decreased L* and a* values of the noodles. Ash, crude fiber, mineral matter and total phenolic contents of the noodles were higher and fat contents of the noodles were lower than the control sample. Hardness and adhesiveness of the noodles were decreased by addition of the kale powder at 10%. The noodles with higher hardness and lower adhesiveness were preferred by the panelists in sensory evaluation. Increasing the kale powder level in the noodle formulation from 5% to 10% resulted in higher color scores. However, the control sample was the most preferred sample in terms of taste.

Keywords: Einkorn, Freeze-dried powder, Mucilage, Turkish noodle

Introduction

Noodles have been produced in various contents and shapes and consumed widely in many Asian countries since ancient times. As become an internationally accepted food, worldwide consumption of noodle has been gradually increasing. Taste, nutritional content, easy and safe consumption, long shelf life and affordable prices of noodles have increased their popularity (Gulia *et al.*, 2014). Noodles have been also produced and consumed widely in Anatolia. Although industrial-based production of Turkish noodles (erişte) has been made in Turkey, they are made in rural areas and consumed locally. Noodles are usually prepared with three main ingredients; flour, water and salt. Noodle production steps are mixing, resting, dough rolling, thinning, cutting and drying, respectively (Bilgiçli, 2009; Levent, 2019). Noodle quality varies depending on the characteristics of the raw materials used in production. Important quality features used in the evaluation of noodle quality are color, flavor, texture and cooking quality. The structure of the cooked noodles should remain firm and not lose too much solid matter in cooking water. Additionally, they should not become sticky when standing after cooking (Khouryieh *et al.*, 2006). Wheat flour used as a raw material in noodle production is generally rich in starch; but the dietary fiber content of the flour is usually low. Thus, addition of fiber rich ingredients, especially fruit and vegetables, into baked products will improve their nutritional properties and also have positive effects on human health (Wani *et al.*, 2013). As a cold climate plant, kale is resistant to drought and has a wide production area in the world. It is the most typical winter vegetable grown and consumed in Turkey, especially in the Eastern Black Sea Region. Kale production of Turkey was 56 thousand tonnes in 2020 (TUIK, 2021). This vegetable is a very important source of phenolic compounds. It is beneficial for eyes, skin and respiratory system thanks to its β-carotene, provitamin A, lutein and zeaxanthin compounds. It is a good source of calcium (35-300 mg/100 g), magnesium (20-123 mg/100 g), iron (0.7-1.5 mg/100 g), copper (2-116 µg/100 g) and potassium (188-873 mg/100 g). In addition, it contains 2-5% protein, 0.5-4% fiber, 0.4-1.3% lipid, 1-10% carbohydrate and 1.55-2.18% ash depending on the environmental and growing factors (Acikgoz and Deveci, 2011; Pathirana *et al.,* 2017; Šamec *et al.*, 2019).

Chia is a seed originated from Mexico and Northern Guatemala. Chia seed contains 20-22% protein, 30-35% fat, 25-41% carbohydrate, 18-30% crude fiber (mainly cellulose, pentosans and lignin) and 4-6% ash. Chia seed is balanced in terms of essential amino acid composition and rich in polyunsaturated fatty acids mainly omega-3 (17.8-20.4%) and omega-6 (5.2-5.7%). Additionally, it is a good source in terms of total dietary fiber (35%) that contains high amount of insoluble dietary fiber (Muñoz *et al.*, 2013; Zettel and Hitzmann, 2018; Grancieri *et al.*, 2019). Besides its nutritional content, chia seed also has important technological functions in food industry. The seed can form a gel structure called mucilage that surrounds the seed coat when the seed is immersed in an aqueous medium. This structure is composed mainly of soluble fiber and used as fat replacer, stabilizer and thickener agent in food products (Zettel *et al.*, 2015; Chavan *et al.*, 2017; Fernandes and Salas-Mellado, 2017; Menga *et al.*, 2017). Einkorn (Siyez) is the oldest known diploid type of wheat which was first cultivated in Karacadağ region of Turkey approximately 10,000 years ago. Nowadays, it has been grown in Turkey, Balkan countries, Germany, Switzerland, France, Spain and Italy (Brandolini and Hidalgo, 2011). Einkorn has higher content of ash (2.1-2.8%) and significant advantages in terms of both protein (15-23%) and mineral content, especially manganese (34.4-68.2 mg/kg), zinc (42.7-71.1 mg/kg), iron (37.2-62.6 mg/kg), copper (4.9-8.3 mg/kg) and selenium (99-279 µg/kg), compared to other types of wheat. In addition, it contains more yellow pigments such as lutein and carotenoid than the other types of wheat. However, dietary fiber content (8.7%) is lower than the other cultivated wheats (12.5%) (Løje *et al.*, 2003; Brandolini and Hidalgo, 2011; Zaharieva and Monneveux, 2018). It has been reported that einkorn was used in noodle (Levent, 2019), bread (Brandolini and Hidalgo, 2011), pasta (Brandolini *et al.*, 2018) and cookie (Nakov *et al.*, 2018) production.

The object of this study was to promote consumption of einkorn wheat (siyez) and regional vegetable (kale) as an ingredient in Turkish noodle (erişte) and to improve the health benefits of noodles for consumers in terms of high fiber and mineral content. Further, using chia mucilage as an egg replacer in the noodle production was also aimed.

Materials and Methods

Materials

All chemicals were of high purity grade and supplied by Sigma-Aldrich (Steinheim, Germany). Siyez wheat flour, kale leaves, table salt and chia seeds were purchased from the local market in Trabzon, Turkey. Chia mucilage was extracted according to Coorey *et al.* (2014) with some modifications. Chia seeds were ground by a spice grinder and sieved through a 0.6 mm sieve. Then, 5 g of ground chia seeds were placed in a 1 L beaker and distilled water was added in 1:20 proportion (w:v). The seed-water mixture was stirred with a magnetic stirrer at 1000 rpm for 4 h. The extraction was performed at room temperature (26±1 ºC). After extraction, the mixture was centrifuged at 4500 rpm for 50 min at 26±1 ºC.

Chia seed and mucilage mixture (chia mucilage) was obtained by removing the water accumulated in the upper layer. Freeze-drying was carried out in a freeze dryer (Labconco FreeZone, USA) at Central Research Laboratory of Recep Tayyip Erdoğan University. Kale leaves were homogenized and frozen at -20 ºC for 24 hours and then placed on the trays of the freeze dryer. The homogenized leaves were dried to a water content of below 10% (9.47±0.06%). The freeze-dried (-80 ºC, $3x10^{-3}$ torr) leaves were ground by a spice grinder and sieved through a 0.6 mm sieve.

Preparation of Noodles

Noodles production was carried out according to a previous study applied by Bilgiçli *et al.* (2009) with some modifications. Noodles were prepared with the formulations given in Table 1. Siyez wheat flour (100 g) and salt (1 g) were kept at constant level for each treatment. The raw materials were mixed by using a mixer (Prochef Xl, Schafer, Germany) for 5 min at medium speed and then rested for 15 min. After resting, the dough was passed through a noodle machine (Atlas 150, Marcato, Italy) with the roller gap reduced gradually to get dough sheets 2 mm in thickness and 6 mm in width. Then, the dough sheet was cut into 4 cm in length. The cut product was dried for 17 hours at 40 ºC. After drying, the noodles were cooled to room temperature (26±1 ºC) in desiccator and analyzed for further analysis. Control sample was produced by the same preparation procedure with 100 g of siyez wheat flour, 20 g of whole liquid egg, 1 g of salt and 40 mL of water.

Cooking Properties

The cooking properties (cooking time, water absorption and cooking loss) were determined according to AACC method 66-50 (Anonymous, 2000). For the cooking time, approximately 25 g of noodles were cooked in 250 mL of boiling distilled water in a 400 mL beaker and the cooking times were determined by crushing cooked noodles between a pair of glass plates until the opaque core in the noodle strand disappeared during cooking (every 1 min). For the cooking loss, 25 g of noodles was weighted into 250 mL of boiling distilled water in a 400 mL beaker and cooked for 20 min. Cooking water was collected in a 500 mL graduated cylinder and made to volume 350 mL with distilled water. A liquid of 50 mL was dried in a conventional oven at 105 ºC until constant weight was obtained. The residue was weighted and the cooking loss was calculated as a percentage of the starting material. For the water absorption, the cooked samples were drained for 5 min until no dripping was observed and then the weights were recorded. The water absorption was expressed as the weight ratio of the cooked noodles to the uncooked noodles.

Color Measurement

The color of uncooked and cooked noodles were measured with a chroma meter (Konica Minolta CR400, Japan) using CIE L* (lightness), a* (redness-greenness), b* (yellowness-blueness) color measurement system. A standard white plate was used for calibration. After calibration, two noodle strands were stacked together and three readings were taken on each side of the both uncooked and cooked noodles (Niu *et al.*, 2014).

Chemical Analysis

The proximate composition of dried noodles was determined according to the ICC methods. Moisture and ash content were determined after drying in a conventional oven at 100 ºC (ICC, 1976) and combustion in a muffle furnace at 550 ºC, respectively (ICC, 1990) until constant weight was obtained. Protein and fat content were determined by Kjeldahl method (ICC, 1994) and Soxhlet method (ICC, 1984), respectively. Crude fiber content was determined by gravimetric method (ICC, 1972).

Table 1. Formulation of noodles with kale powder, chia mucilage and water

Sample code	Kale powder (g)	Chia mucilage (g)	Water (mL)
KL1	5	20	30
KL2	5	20	40
KL3	5	30	20
KL4	5	30	30
KL5	10	20	30
KL6	10	20	40
KL7	10	30	20
KL8	10	30	30

pH

After uncooked noodles were ground to a size that can pass through a sieve with a hole size of 1 mm, 10 g of sample was mixed with 100 mL distilled water and stirred using a magnetic stirrer. The pH value of the filtrate that filtered through a coarse filter paper was measured by a pH meter (Jenco 6173, USA) (Ho and Dahri, 2016).

Total Phenolic Content

Total phenolic content was determined according to the method applied by Menga *et al.* (2017). After grinding, 1 g of sample was extracted with 8 ml of a mixture contained methanol/distilled water/HCl (80:19:1 v/v/v) for 30 min with orbital shaker (GFL 3005, Germany). After that, the extract was centrifuged at 4000 rpm for 15 min. Then, 200 µL of the extract was added to the tubes containing 1.5 mL of 10-fold diluted Folin-Ciocalteu reagent. The tubes were mixed and kept for 5 min. Later, 1.5 mL of sodium carbonate solution (6%) was added to the mixture and the mixture was kept at room temperature (26±1 ºC) for 90 min. After incubation, the absorbance of the mixture was measured at 725 nm. The results were expressed as mg gallic acid/g dry matter.

Mineral Content

Finely ground noodle samples (0.5 g) were digested with a mixture of HNO_3 (4 mL, 65%), H_2O_2 (1 mL, 30%) and deionized water (3 mL) in a microwave digestion system (Speedwave, Berghof, Germany). The mixture was mineralized at 170 ºC during 30 min. After digestion, the samples were cooled to room temperature (26±1 ºC) and diluted up to 25 mL with deionized water (Nascimento *et al.*, 2014). The elements including Ca, K, Fe, Mg and Zn were determined using ICP-OES (Optima 7000 DV, Pelkin Elmer, USA) at Central Research Laboratory of Recep Tayyip Erdoğan University. Measurements were performed at the following emission lines (nm): Ca (317.933), K (766.490), Fe (238.204), Mg (285.213) and Zn (206.200).

Textural Properties

The textural parameters (hardness and adhesiveness) of the cooked noodles were determined by using a texture analyzer (TA-XTPlus, UK) with 50 kg load cell at Central Research Laboratory of Ordu University. The method was applied according to Application Study NOO2/P35 with some modifications (SMS, 2000). The noodles (25 g) were cooked for the optimal cooking time and evaluated within 5 min after cooking. Superficial water layer on the noodle strands was soaked with filter paper. Two strands of cooked noodles were put on top of each other and were compressed by a cylindrical probe (3.6 cm dia) until to get 50% in strain. Pre-test speed, test speed and post-test speed were set as 1 mm/s and trigger force was set as 5 g.

Sensory Evaluation

Thirty semi-trained panelists from the Department of Food Engineering at Avrasya University participated in sensory analysis. The sensory evaluation of the cooked noodles was performed using five-point hedonic scale (1: very bad and 5: very good). Cooked noodles were evaluated for color, taste, flavor, appearance, hardness and adhesiveness. The samples were served on white plates and coded with different three-digit random numbers. Drinking water was served to panelists for rinsing during evaluation.

Statistical Analysis

All data obtained in this study were analyzed with SAS statistical software (SAS Institute Inc., Cary, NC, USA) using analysis of variance (ANOVA). Significance was defined at $P< 0.05$ by using Duncan's multiple range tests.

Results and Discussion

In this study, the optimum cooking times of the KL samples were not significantly affected by the evaluated treatments and were within the range of the control sample. The dry matter content of the uncooked control sample was the lowest (92.60%), whereas the dry matter content of the KL samples produced with the addition of 5% (KL1, 2, 3, 4) and 10% (KL5, 6, 7, 8) kale powder were between 93.47-93.80% and 94.33-94.64%, respectively (Table 2). Table 2 shows water absorption and cooking loss of the noodles. Generally, the quality of noodle can be evaluated by cooking parameters in terms of low cooking loss and high water absorption and by textural parameters in terms of high hardness and low adhesiveness (Piwińska *et al.*, 2016). As mentioned before, cooking losses indicated the amount of dry matter passed into the cooking water. Cooking loss values of the KL samples were between 9.41-12.22%, whereas the value of the control sample was 8.36%. There was no significant difference in terms of cooking loss values among themselves of KL1-2-3-4-5 or among themselves of KL6-7-8. Foshia *et al.* (2015) and Bouasla and Wójtowicz (2019) were explained that the starch-gluten network could be weakened because of higher fiber content; therefore the release of dry matter into the cooking water was increased. On the other hand, at constant chia mucilage level, it was observed that the water absorption was higher in the KL samples which had higher water level in the noodle formulation prepared with either 5% or 10% kale powder. Additionally, increasing chia mucilage amount from 20 g to 30 g resulted in higher water absorption at constant water level in the noodle formulation. When the interaction between chia mucilage and water amount was evaluated, the formulations with 20 g of chia mucilage and 40 mL of water (KL2 and KL6) showed the highest water absorption. Moreover, a slight increase in water absorption was observed by adding kale powder into the noodle formulation. For instance, the mean values in the water absorption of the KL samples produced with the addition of 5% (KL1, 2, 3, 4) and 10% (KL5, 6, 7, 8) kale powder were 155.91% and 157.41%, respectively (Table 2). Due to higher fiber content, the KL samples gained the ability of higher water absorption than the control sample. Similar results were reported by Foshia *et al.* (2015) and Bouasla and Wójtowicz (2019).

The results of the textural characteristics of cooked noodles are presented in Table 2. The hardness and adhesiveness were influenced significantly (P<0.05) by the level of kale powder and water in the noodle formulation. Formation of gluten matrix plays a major role in texture development of pasta and also noodle products. Further, water is another important factor for defining the stability and quality of these products through interaction of water with other molecules existed in the structure (Carini *et al.*, 2012). It was observed that increasing the level of kale powder in the noodle formulation resulted in decreased hardness and adhesiveness values of the noodles, whereas increasing the level of chia mucilage had no significant effect on the textural parameters. It could be associated with fiber content of the kale that caused weaker gluten network. Also, increasing the level of water in the noodle formulation decreased the hardness and increased the adhesiveness of the cooked noodles. As reported similarly by Park and Baik (2002), hardness was significantly affected by water absorption parameter and a reduction in water absorption was resulted in harder noodles.

It was observed that pH of the control sample (6.31±0.02) was the highest and that of the KL samples was decreased depending on increased level of kale powder. The noodles made with 5% kale powder exhibited significantly (P<0.05) higher pH (5.88±0.02) than those made with 10% (5.67±0.02). There was no significant difference in terms of pH values among themselves of KL1-2-3-4 and among themselves of KL5-6-7-8 (Table 2). However, increasing amount of chia mucilage in the noodle formulation from 20 g to 30 g did not have a significant effect on pH value of the KL samples. The color values of the samples before and after cooking are presented in Table 3 and Table 4, respectively. The results indicate that addition of kale powder and chia mucilage had a significant effect (P<0.05) on the color values of the KL samples. It was determined that addition of the kale powder into the noodle formulation decreased L* and a* values of both uncooked and cooked samples significantly (P<0.05) in comparison with control sample. That means the KL samples were darker and greener because of natural pigment color of the kale powder. Additionally, increasing the amount of chia mucilage from 20 g to 30 g resulted in also decreased L* and a* values. After cooking, L* value of the control sample was increased, however there was no significant difference in terms of a* and b* values. On the other side, all cooked KL samples had increased L* values and also a* values as a consequence of passing the natural coloring compounds into the cooking water. The results obtained from the present study were similar with the studies regarding the noodles made by green tea powder and spinach puree reported by Li *et al.* (2012) and Shere *et al.* (2018), respectively.

Table 2. Cooking properties and textural parameters of noodles

Sample	pH	Cooking times (min)	Dry matter* (%)	Cooking loss (%)	Water absorption (%)	Hardness (g)	Adhesiveness (g.sec)
Control	6.31±0.04^{a}	20.50±0.71	92.60±0.30^{d}	8.36±0.12^{c}	152.73±3.22^{ab}	3969.64±148.51^{abc}	-62.47±4.46^{a}
KL1	5.90±0.08^{b}	20.50±0.71	93.47±0.27^{c}	9.52±0.13^{b}	150.32±0.58^{b}	4267.24±289.55^{ab}	-111.72±5.40^{bcd}
KL2	5.90±0.08^{b}	20.50±0.71	93.54±0.04^{c}	9.42±0.03^{b}	162.47±0.90^{a}	4071.88±231.95^{abc}	-147.63±11.10^{e}
KL3	5.86±0.09^{bc}	20.50±0.71	93.62±0.24^{c}	9.41±0.19^{b}	153.62±1.15^{ab}	4337.94±110.30^{a}	-120.19±7.32^{cde}
KL4	5.88±0.01^{b}	20.50±0.71	93.80±0.28^{bc}	9.96±0.03^{b}	157.24±0.23^{ab}	4256.29±49.97^{ab}	-125.04±4.74^{de}
KL5	5.70±0.01^{bc}	20.00±0.00	94.52±0.19^{a}	10.26±0.54^{b}	154.19±1.94^{ab}	3536.76±49.29^{c}	-80.67±10.18^{ab}
KL6	5.67±0.02^{c}	20.00±0.00	94.64±0.06^{a}	11.38±0.55^{a}	161.58±4.14^{a}	3486.50±72.29^{c}	-103.10±21.25^{bcd}
KL7	5.67±0.02^{c}	20.00±0.00	94.57±0.05^{a}	11.55±0.53^{a}	153.94±0.46^{ab}	3738.51±128.24^{bc}	-62.77±3.40^{a}
KL8	5.67±0.02^{c}	20.00±0.00	94.33±0.01^{ab}	12.22±0.16^{a}	159.94±1.15^{ab}	3444.68±111.06^{c}	-87.04±5.66^{abc}

Mean±standard deviation. Different letters in the same column presented significant differences P<0.05.
*Dry matter values of uncooked samples

Table 3. Color parameters of uncooked noodles

Sample	L*	a*	b*
Control	44.88±0.52^{a}	4.56±0.19^{a}	14.34±0.51^{ab}
KL1	40.79±0.47^{b}	-0.75±0.04^{e}	14.55±0.29^{ab}
KL2	37.31±0.05^{e}	0.53±0.04^{b}	13.97±0.13^{b}
KL3	38.94±0.03^{cd}	-0.42±0.02^{d}	13.19±0.01^{c}
KL4	38.32±0.02^{d}	0.20±0.02^{c}	14.13±0.05^{ab}
KL5	41.04±0.08^{b}	-2.70±0.03^{h}	14.79±0.01^{a}
KL6	37.36±0.06^{e}	-2.01±0.01^{g}	14.10±0.02^{ab}
KL7	39.74±0.42^{c}	-1.97±0.04^{g}	14.19±0.25^{ab}
KL8	33.75±0.29^{f}	-1.53±0.02^{f}	12.01±0.24^{d}

Mean±standard deviation. Different letters in the same column presented significant differences P<0.05.

Table 4. Color parameters of cooked noodles

Sample	L*	a*	b*
Control	50.32±0.52^{a}	4.39±0.19^{a}	14.28±0.51^{ab}
KL1	42.27±0.54^{c}	-0.61±0.03^{cd}	13.94±0.34^{abc}
KL2	44.24±0.39^{b}	-0.75±0.04^{d}	14.85±0.41^{a}
KL3	41.73±0.23^{c}	-0.28±0.01^{b}	13.41±0.11^{bc}
KL4	40.44±0.11^{d}	-0.40±0.01^{bc}	13.05±0.03^{c}
KL5	38.54±0.31^{e}	-1.07±0.03^{f}	14.01±0.28^{abc}
KL6	39.13±0.34^{e}	-1.09±0.04^{f}	14.74±0.25^{a}
KL7	39.28±0.42^{e}	-1.04±0.11^{ef}	13.46±0.29^{bc}
KL8	36.40±0.11^{f}	-0.79±0.09^{de}	13.20±0.08^{c}

Mean±standard deviation. Different letters in the same column presented significant differences P<0.05.

Color is one of the most essential quality attributes that directly has an impact on perception of consumers. Therefore, colored products that produced by using natural compounds have gained much attention day by day (Vimercati *et al.*, 2020). Results in Table 5 indicated that greener color occurred within the noodles by the increased level of kale powder influenced the color scores of the panelists positively. There was no significant difference among the samples in terms of appearance. The flavor scores were also affected positively by adding kale powder, whereas the control sample was the most preferred sample in terms of taste. Texture was an important criterion that affected the final acceptance of the consumers. In general, the samples with higher hardness and lower adhesiveness according to textural analysis received higher scores in sensory analysis in terms of hardness and adhesiveness attributes. After the overall sensory appreciation score of the control sample, KL1 and KL5 samples received the highest scores among all samples.

Table 5. Sensory evaluation of cooked noodles

Sample	Color	Taste	Flavor	Appearance	Hardness	Adhesiveness	Overall acceptability
Control	3.40±0.41^{a}	3.70±0.36^{a}	2.50±0.39^{b}	3.50±0.39^{a}	3.10±0.38^{ab}	3.05±0.40^{ab}	3.75±0.29^{a}
KL1	3.55±0.26^{a}	2.95±0.26^{ab}	2.45±0.27^{b}	3.30±0.29^{ab}	3.40±0.23^{ab}	3.00±0.28^{ab}	3.35±0.20^{ab}
KL2	2.65±0.25^{abc}	2.60±0.26^{b}	2.50±0.31^{b}	2.70±0.25^{ab}	2.65±0.27^{ab}	2.75±0.30^{ab}	2.70±0.26^{b}
KL3	2.25±0.25^{bc}	3.00±0.35^{ab}	2.40±0.32^{b}	2.45±0.31^{b}	3.05±0.36^{ab}	2.75±0.30^{ab}	2.80±0.27^{b}
KL4	2.10±0.31^{c}	2.95±0.32^{ab}	2.75±0.30^{ab}	2.45±0.29^{b}	2.55±0.26^{b}	2.50±0.27^{b}	2.70±0.30^{b}
KL5	3.40±0.31^{a}	3.20±0.34^{ab}	3.75±0.27^{a}	3.35±0.33^{ab}	3.60±0.29^{a}	3.60±0.30^{a}	3.45±0.32^{ab}
KL6	3.10±0.34^{ab}	2.75±0.34^{ab}	3.30±0.37^{ab}	3.25±0.32^{ab}	3.05±0.34^{ab}	3.35±0.33^{ab}	3.15±0.24^{ab}
KL7	3.05±0.34^{abc}	2.90±0.33^{ab}	3.05±0.37^{ab}	3.00±0.35^{ab}	2.85±0.33^{ab}	2.90±0.32^{ab}	2.95±0.32^{ab}
KL8	3.55±0.31^{a}	2.70±0.33^{ab}	3.05±0.34^{ab}	3.35±0.32^{ab}	2.95±0.33^{ab}	3.00±0.29^{ab}	3.00±0.32^{ab}

Mean±standard deviation. Different letters in the same column presented significant differences P<0.05.

Table 6. Chemical composition (dry basis) of uncooked noodles

	Control	KL1	KL5
Ash (g/100 g)	2.81±0.01^{c}	3.33±0.01^{b}	4.06±0.02^{a}
Crude fiber (g/100 g)	2.08±0.02^{c}	2.74±0.03^{b}	3.05±0.02^{a}
Crude protein (g/100 g)	14.97±0.09^{a}	14.14±0.10^{b}	14.91±0.13^{a}
Crude fat (g/100 g)	6.17±0.06^{a}	4.45±0.05^{c}	4.88±0.04^{b}
Ca (mg/100 g)	50.00±0.26^{c}	249.52±1.54^{b}	438.97±6.24^{a}
K (mg/100 g)	367.5±5.05^{c}	564.37±2.02^{b}	672.37±7.15^{a}
Mg (mg/100 g)	111.42±2.31^{c}	161.67±1.73^{b}	177.63±3.24^{a}
Fe (mg/100 g)	4.00±0.02^{b}	6.49±0.10^{a}	6.58±0.09^{a}
Zn (mg/100 g)	4.23±0.02^{b}	5.61±0.05^{b}	5.91±0.07^{a}
Total phenolic content (mg gallic acid/g)	1.06±0.07^{c}	1.61±0.02^{b}	1.97±0.10^{a}

Mean±standard deviation. Different letters in the same column presented significant differences P<0.05.

According to the sensory evaluation, KL1 and KL5 were selected for further analyses to determine nutritional composition of the noodles. It was determined that the compositions of the KL samples were significantly (P<0.05) affected by the increased level of kale powder (Table 6). Control sample showed higher moisture and crude fat content than KL1 and KL5. As expected, significant increases in the ash and crude fiber contents were obtained in the noodles with the addition of kale powder. The ash content increased from 2.81% to 3.33% and 4.06% with the addition of kale powder at 5% and 10%, respectively. In addition, crude fiber contents increased from 2.08% to 2.74% and 3.05% with the addition of kale powder at 5% and 10%, respectively. However, there was no significant difference between the control sample and KL5 in terms of crude protein content. Moreover, higher level of kale powder addition into the noodle formulation increased the protein content of the KL samples. Besides its high fiber content, kale has significant concentration of essential minerals and medium level of protein (Acikgoz and Deveci, 2011; Vimercati *et al.*, 2020). Further, chia is also a rich source of valuable proteins (Muñoz *et al.*, 2013). Therefore, the protein contents of the KL1 and KL5 samples were at the same level with that of the control sample which produced with egg. Crude fat content was the highest in the control sample possibly due to egg content and there was a decrease in crude fat content approximately 28% and 21% in KL1 and KL5 samples, respectively, compared to the control sample. Low-fat products were produced by using chia mucilage as a fat substitute in pound cake (Ferrari Felisberto *et al.*, 2015) and cookie (Punia and Dhull, 2019) formulation.

Results showed that addition of kale powder and chia mucilage into the noodle formulation enhanced the nutritional quality of the noodles by increasing the mineral content. As reported by Jahangir *et al*. (2009), kale was a good source of mineral matters among the green leafy vegetables. There was a significant increase in mineral content of KL samples with the addition of kale powder into the noodle formulation. The mineral content of the KL samples produced with 10% of kale powder had the highest values in terms of K, followed by Ca and Mg. This result could be attributed to the high K, Ca and Mg content of kale (Jahangir *et al.*, 2009; Acikgoz and Deveci, 2011; Vimercati *et al.*, 2020). Among the minerals, the most increment (76%) was observed in Ca content by increasing the kale powder level in the noodle formulation from 5% to 10%. Similar to previous study (Morais *et al.*, 2020), kale flour provided a significant increase in Ca content in cookie production. Besides macro nutrients, content of Fe and Zn as micro nutrients in the KL samples (KL1 and KL5) were also higher than those of the control sample. However, there was no significant difference in terms of Fe content between KL1 and KL5. According to recommended daily intake values of the mineral matters, per 100 g of KL1 and KL5 could be a good source in terms of nutrients (Anonymous, 2016). Ferioli *et al.* (2013) reported that geographic origin and growing environment had a major effect on phenolic content of fresh kale. The kale used in our study collected from Maçka district of Trabzon in Turkey and the total phenolic content was 4.56 ± 0.07 mg gallic acid/g dry matters. As seen in Table 6, the addition of kale powder increased the content of total phenolic in the KL samples. Compared to the control sample, total phenolic content of the KL samples increased 55% and 84% with addition of kale powder at 5% and 10%, respectively. There was no significant difference in terms of total phenolic content values among themselves of KL1-2-3-4 or among themselves of KL5-6-7-8.

Conclusion

The physical qualities of the noodles in terms of cooking properties (cooking loss and water absorption) showed significant differences between the treatments. Cooking loss of the control sample was the lowest and the water absorption of the KL samples produced with 20 g of chia mucilage and 40 mL of water was the highest. The textural properties were affected by both the water content in the formulations and the water absorption values of the samples. Although the control sample showed the highest score in taste, increasing level of kale powder positively affected the appreciation of the panelists in terms of color and also flavor. Higher content of ash, crude fiber and also mineral matter (especially in Ca and K) was obtained with the addition of kale powder and chia mucilage into the noodle formulation. Further, decreased content of crude fat resulted in lower calorie in the samples. Additionally, increasing level of kale powder had a positive effect on the functional properties of the noodles in terms of total phenolic content. Consequently, the noodle produced with 10 % of kale powder, 20 g of chia mucilage and 30 mL of water was the most preferred by the panelists in terms of sensory attributes and its nutritional value was the highest.

Compliance with Ethical Standard

Conflict of interests: The author declares that for this article they have no actual, potential or perceived conflict of interests.

Ethics committee approval: Author declare that this study does not include any experiments with human or animal subjects.

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Disclosure: -

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