Original Article

Improvement of Physicochemical, Textural and Quality Attributes of Chicken Kebabs Using Infrared-dried Sprouted Wheat Flour

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ABSTRACT

Background and Objectives: Kebab is a food product containing at least 70% animal minced meat. Sprouted wheat flour is a valuable natural source for enhancing nutritional values and improving sensory attributes of food products such as chicken kebabs. Combining ultrasonic and infrared processes decreases drying time and improves product quality.

Materials and Methods: In this study, physicochemical characteristics (moisture, ash, acidity, pH, lightness, redness, yellowness and density), phenolic content, textural characteristics (puncture and texture profile analysis assays) and sensorial attributes of chicken kebabs containing various substitution levels of sonicated and infrared-dried sprouted wheat flour were investigated.

Results: Chicken kebabs with sprouted wheat flour included higher total phenolic contents than the control sample. Complete replacement of sprouted wheat flour with breadcrumbs increased acidity, redness index, density, firmness, cohesiveness, springiness and chewiness of baked chicken kebabs and decreased moisture content, ash content, pH and lightness index of kebabs. However, no statistically significant differences were seen between the kebabs for density, texture hardness, cohesiveness and springiness ($p > 0.05$). The average total phenolic contents of prepared kebabs containing 0, 50 and 100% of sprouted wheat flour were 439.98, 466.50 and 757.57 µg GA/g, respectively.

Conclusions: Based on the sensory assessment results, sprouted wheat flour is recommended for chicken kebab preparation due to its superior appearance, flavor, texture and overall acceptability scores.

Keywords: Phenolic content, Puncture test, Sensory assessment, Texture profile analysis

Highlights

- Infrared-dried sprouted wheat flour was used to preparation chicken kebabs.
- Chicken kebabs with sprouted wheat flour included higher total phenolic content than the control sample.
- Kebabs with sprouted wheat flour included higher firmness, cohesiveness, springiness and chewiness.
- Hardness, redness and density of kebabs increased with increasing sprouted wheat flour levels.
- Chicken kebabs containing sprouted wheat flour included appropriate texture and sensory characteristics.

Introduction

Currently, use of sprouted grains, including wheat, in people's diets is increasing due to the scientific reports on the nutritional values and phytochemical contents of sprouted grains (1,2). In addition, sprouted grain flour is addressed as an excellent source of nutrients for enhancing physicochemical and quality characteristics of foods, including noodles, pasta, chiffon cakes, bread and sausages (1,3-6). Joker (2019) used sprouted wheat flour (SWF) in production of sausages (5). Their results verified that adding SWF to the formulation improved the moisture retention capacity of sausage samples. An (2015) investigated the quality attributes of cookies produced with SWF (7). Moisture content and bulk density of the cookie dough containing SWF were higher than those of the control samples but pH was lower. Results of this study verified that 4% of SWF is appropriate for preparing cookies. In another study, Javaheripour et al. (2022) studied effects of the addition of quinoa flour and SWF on quality attributes of sponge cakes (8). Their results showed that increasing levels of quinoa flour and SWF significantly enhanced ash, protein and fat contents in the

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sponge cakes. Ozturk et al. (2014) studied effects of SWF addition on oxidation of lipids and physicochemical characteristics of beef patties (9). These researchers reported that addition of SWF improved product quality and decreased fat oxidation.

Kebab is a product containing at least 70% of animal minced meat (cattle, sheep and chicken) and contains breadcrumbs, grated onion and other edible vegetables, liquid oil, salt, pepper, spices, eggs and saffron (10). Maleki Azar, S and Fahim Danesh, M. (2018) investigated feasibility of making kababs fortified with oleaster kernel flour and phytosterol (11). Their results demonstrated that by increasing the level of oleaster kernel flour, yellowness of the product significantly increased and characteristics such as oil uptake, length decrease, texture firmness, lightness and redness indexes of the product significantly decreased.

Food dehydration is a complex procedure including simultaneous transfers of mass and heat. In this process, products demonstrate several changes in their physicochemical characteristics, structural and textural characteristics. It is important to select an appropriate method for drying sprouted grains (3,12,13). From various food dehydration techniques, infrared drying is one of the most widely used moisture decrease techniques. The major advantages of infrared drying method compared to hot-air drying are higher heat transfer rate, shorter drying time, higher quality dried fruit and vegetable products, high performance and energy saving in the process (14). In addition, ultrasonic pretreatment as a non-thermal food processing technique is a better pretreatment before dehydration procedure of fruits and vegetables due to its advantages such as saving energy, preserving original freshness and nutrient levels, retaining bioactive compounds and decreasing processing duration (15-17). Tavakoli et al. (2019) studied effects of sprout-derived extracts from three various wheat cultivars grown in Iran and ultrasound exposure on the oxidative stability of soybean oil (18). Results verified that ultrasound increased values of polyphenolic and tocopherol compounds and included greater effects on the extraction of polyphenolic compounds. Ultrasonic pretreatment and drying conditions can significantly affect physicochemical characteristics of SWF. The goal of the current study was to assess physicochemical characteristics (moisture, ash, acidity, pH, color indexes and density), phenolic content, textural characteristics [puncture and texture profile analysis (TPA) assays] and sensorial attributes of chicken kebabs containing various substitution levels of ultrasonic pretreated and infrared-dried SWF.

Materials and Methods

Sprouting process

Grains of wheat cultivar Pishgam (*Triticum aestivum* L.) were harvested from the agricultural fields, Hamedan, Iran. Grains were manually cleaned to remove dust and stored in dry and cool places until use. Samples were washed and soaked in water (1:4 grain-to-water ratio) for 24 h at 25 °C ±1 (1). The soaked grains were stored in polyethylene containers covered with clean kitchen towels and allowed to germinate at 25 °C ±1 for 72 h.

Sprouted wheat flour

Using ultrasonic water bath (Backer, vCLEAN1-L2, Iran), sonication was used for the germinated grains of 15 × 14 × 15 cm with water capacity of 2 L at 40 kHz and 100 W. Germinated grains were directly transferred into the water bath at 25 °C for 5 min. After sonication, infrared dryer (L = 440 mm, W = 200 mm and H = 400 mm) equipped with an infrared radiation source [250 W, near-infrared (NIR)] (Noor Lamp, Iran) was used to dry germinated wheat grains. Distance from the radiation lamp to the sprouted grains was 5 cm. Then, industrial electric grinder was used at 1600 W and 25000 rpm (Best, China) to grind the infrared-dried sprouted grains (Figure 1). Prepared SWF was poured into a polyethylene bag (moisture-proof), sealed and stored at -18 °C.

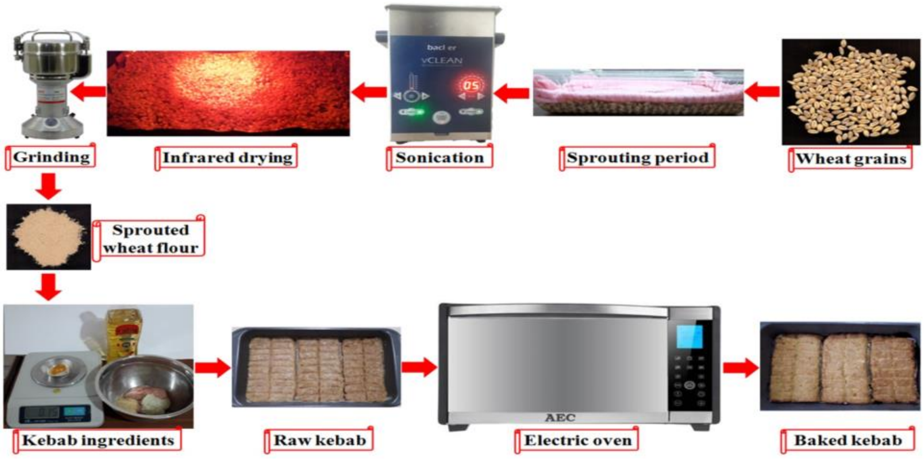

Figure 1. Schematic of chicken kebab preparation with infrared-dried sprouted wheat flour

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Chicken kebab production

The chicken kebab recipe included minced chicken breast (72%), grated onion (15%), breadcrumbs (6%), liquid oil (5.40%), salt (1.48%), black pepper (0.06%) and turmeric powder (0.06%). In this study, SWF was substituted by breadcrumbs with proportions of 0, 50 and 100%. Moreover, liquid oil was purchased from Oila, Iran, breadcrumbs from Tordak, Iran, salt from Sepiddaneh, Iran, and black pepper and turmeric powders from local stores in Hamedan, Iran. After the raw materials (ingredients) were weighed using laboratory balance with sensitivity of ±0.01 g (Lutron GM-300p, Taiwan) and mixed thoroughly by hands, prepared mixture was evenly distributed in the mold, transferred into electric oven (AEC, model H5000, Iran) and baked at 180 °C for 40 min. Then, baked kebabs were removed from the electric oven, cooled down and stored in polyethylene bags.

Moisture and ash contents

Moisture contents of SWF and baked chicken kebabs were assessed at 105 °C for 5 h using laboratory oven (Fan Azma Gostar, Iran). The sample's mass was recorded using laboratory balance (±0.01 g; AND, model EK-410i, Japan). Ash contents of SWF, breadcrumbs and baked chicken kebabs were assessed at 600 °C for 8 h using laboratory electric furnace (Shimifan, Iran). The sample's mass was recorded using laboratory balance (Sartorius, model TE-124S, Switzerland) with a sensitivity of ±0.0001 g.

Acidity of baked chicken kebabs

To assess acidity of the baked chicken kebabs, 10 g of the sample were poured into a conical (Erlenmeyer) flask. Then, 50 ml of 67% ethyl alcohol were added to the sample and the mixture was covered and stirred for 5 min using electric stirrer. This was filtered using filter papers. Then, 25 ml of the filtered solution were transferred into an Erlenmeyer flask and three drops of phenolphthalein reagent (3% w/v) (Merck, Germany) were added to the flask and titrated with 0.1 N NaOH solution (Kian Kaveh Azma, Iran). Acidity of the baked chicken kebabs was calculated based on the lactic acid using Equation 1 (19).

$$\text{Acidity}\,(\%) = \frac{2 \times V \times 0.9}{M} \tag{1}$$

Where, V was the volume of NaOH solution consumed (ml) and M was the mass of sample (10 g).

pH of the baked chicken kebabs

To assess pH of the baked chicken kebabs, 10 g of homogenized sample were mixed with 100 ml of freshly boiled distilled water (DW) and set to stand for 20 min. Then, pH of the mixture was recorded using laboratory pH meter (Denver, Ultrabasic, USA).

Surface and core color

Kebab photos (from surface and core) were captured using scanner (HP, model Scanjet-300, USA). Kebab photos were converted from RGB to L^*(lightness), a^*(greenness-redness) and b^* (blueness-yellowness) indices using Image J software v.1.42e, USA, and its color space conversion plug-in (20).

Density of chicken kebabs

Density of the baked chicken kebabs was calculated using Equation 2.

$$\rho\,(\text{kg/m}^3) = \frac{M}{V} \tag{2}$$

Where, ρ was density of the baked chicken kebab (kg/m^3), M was weight of the kebabs (kg) and V was volume of the kebabs (m^3). Volume of the baked chicken kebabs was estimated using canola displacement technique (21). Kebab weight was recorded using laboratory balance (±0.01 g) (Lutron, model GM-300p, Taiwan).

Total phenolic content

To prepare SWF or baked chicken kebab extract, 10 ml of 80% methanol were added to 1 g of the sample and mixed for 30 min using magnetic stirrer (Alpha, model HS-860, Iran). Then, mixture was transferred to conical tubes. Conical tubes were centrifuged at 4000 rpm for 5 min using desktop centrifuge (Fartest, Iran). Supernatant of the mixture was used as the sample extract. To measure total phenolic content of the samples, 0.5 ml of the extract was transferred into a laboratory test tube. Then, 0.5 ml of Folin-Ciocalteu reagent (Merck, Germany) was added to the tube. After 5 min, 2 ml of Na_2CO_3 (20% w/v) (Ghatran Shimi T, Iran) were added and agitated for 30 s. After incubation for 15 min at room temperature (RT) (25 °C ±1), 10 ml of DW were added to the mixture and the precipitate was separated at 4000 rpm for 5 min using desktop centrifuge (Fartest, Iran). Absorbance of the supernatant was recorded at 725 nm using spectrophotometer (Thermo Spectronic, model Helios α, UK) and then compared with that of Gallic acid (GA) standard curve. Results were presented in μg GA/g dry matter (22). To generate the standard curve, DW was first used to prepare GA solutions (Merck, Germany) with concentrations of 0.04, 0.02, 0.01, 0.005 and 0 g/100 ml. Instead of the extract, 0.5 ml of the GA solutions was used, following steps in the previous section. Equation 3 was used to calculate total phenolic of the samples based on micrograms of GA per gram of dry matter (μg GA/g).

$$\text{Total phenols} = 0.5 \times (0.0185\text{ABS} - 0.0007)/100 \times 20 \times 10^6 \tag{3}$$

Where, ABS was absorbance value of the sample at 725 nm and GA was Gallic acid.

Textural characteristics

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A texture analyzer (Santam, model STM-5, Iran) was used for assessing surface hardness (puncture test) of the baked chicken kebabs. Puncture assay was carried out using cylindrical probe with diameter of 0.5 cm at speed of 1 mm/s and penetration depth of 10 mm. The TPA of baked chicken kebabs (2 × 2 × 2 cm) was carried out using texture analyzer equipped with a 5-cm diameter cylindrical probe, 50% deformation and test speed of 1 mm/s.

Sensory assessment

Sensory assessment of the baked chicken kebabs containing SWF at various levels and control was carried out by 18 panelists (20–50 years old).

Statistical analysis

In this study, all experiments were carried out with three repetitions. The mean values of responses were compared with each other using Duncan's multiple range test at $p < 0.05$ using SPSS software v.21 (IBM, USA).

Results

Moisture and ash contents

The moisture content (wet basis) of SWF was 6.93%. Figure 2(a) shows effects of replacing SWF with breadcrumbs on changing moisture content of the chicken kebab samples. Regarding moisture content, no significant differences were seen in kebabs ($p > 0.05$). Moisture contents of the samples containing 0, 50 and 100% of SWF were 54.67, 54.27 and 53.20%, respectively. In this study, the ash contents of SWF and breadcrumbs were 1.57 and 4.78%, respectively. As seen in Figure 2(b), ash content of the kebabs prepared with SWF was lower than that of kebabs prepared with breadcrumbs. Ash contents for kebabs containing 0, 50 and 100% of SWF were 3.60, 3.07 and 3.22%, respectively.

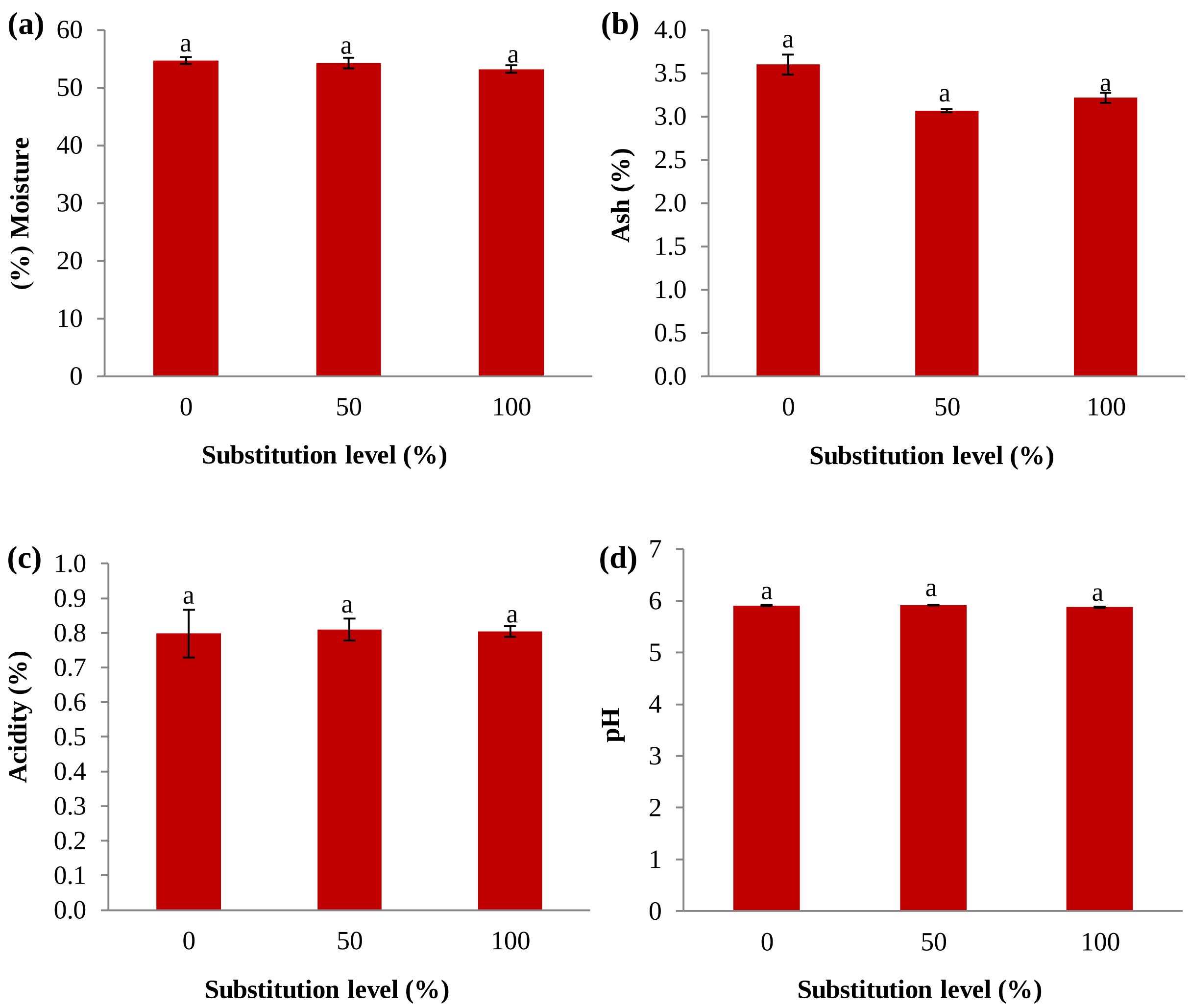

Figure 2. Moisture content (a), ash content (b), acidity (c) and pH (d) of the chicken kebabs containing various substitution levels of sprouted wheat flour

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Acidity and pH

In this study, acidity values of SWF and breadcrumbs were 1.32 and 0.36%, respectively. Figure 2(c) shows effects of replacing SWF with breadcrumbs on the acidity of chicken kebab samples. No significant differences were reported for acidity of the chicken kebabs ($p > 0.05$). The average acidity rates of kebabs containing 0, 50 and 100% of SWF were 0.80, 0.81 and 0.80%, respectively. The SWF and breadcrumbs included pH values of 6.64 and 5.25, respectively. Figure 2(d) shows effects of substitution SWF with breadcrumbs on pH of the chicken kebabs. As seen in this figure, no significant differences were observed in samples concerning pH ($p > 0.05$). Furthermore, pH of breadcrumbs was lower than that of SWF with no effects on pH of the kebabs. In general, pH values of kebabs prepared with 0, 50 and 100% of SWF were 5.91, 5.92 and 5.88, respectively.

Color parameters

- Lightness

The lightness index or L^* ranges from 0 to 100. The lighter the color of the sample, the higher the value of this index, closer to 100. Figure 3(a) shows effects of substituting SWF with breadcrumbs on surface lightness of the chicken kebabs. As seen in this figure, significant differences were reported in surface lightness between the 100% sample and the 0 and 50% samples ($p < 0.05$).

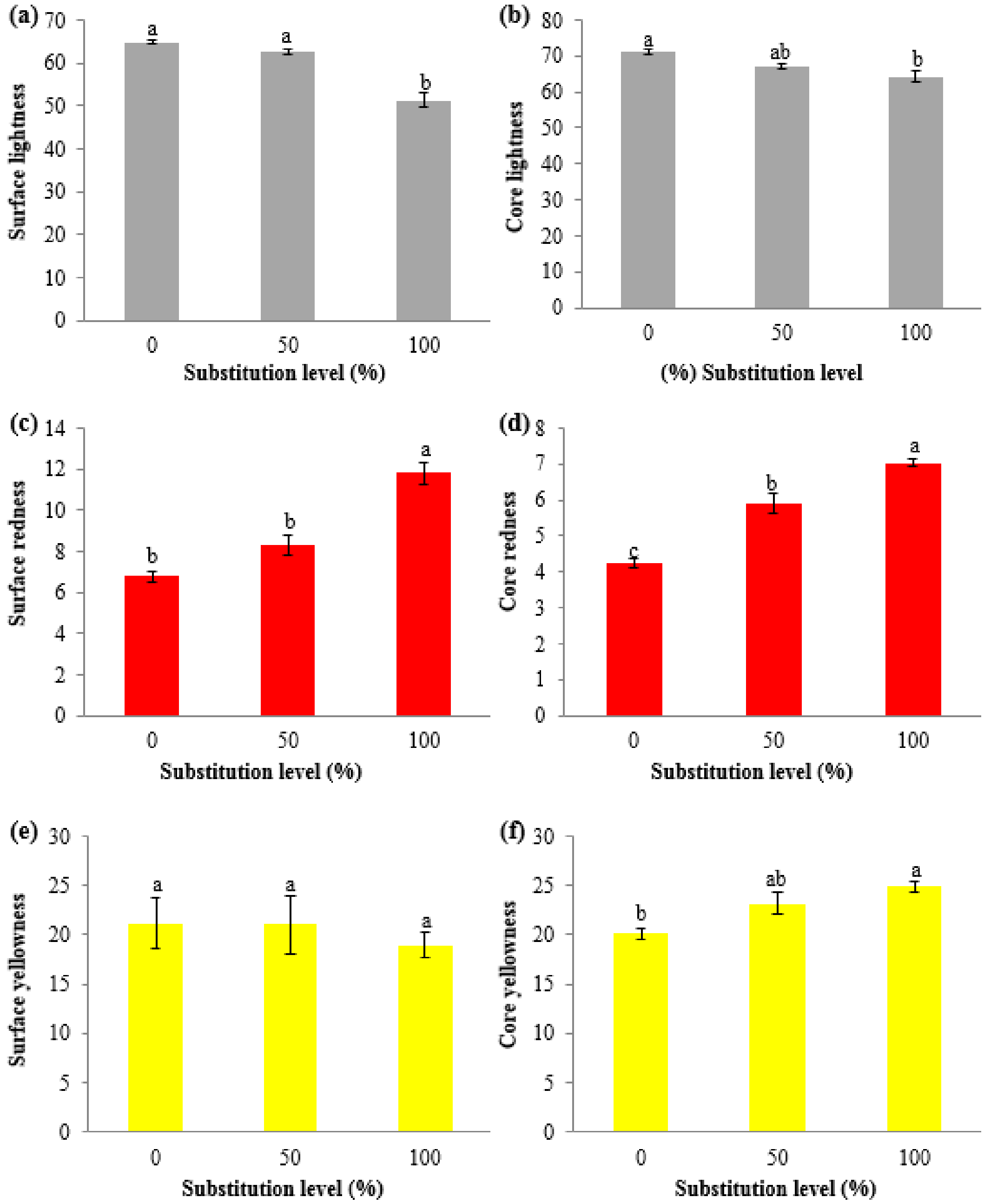

Figure 3. Lightness [surface (a) and core (b)], redness [surface (c) and core (d)] and yellowness [surface (e) and core (f)] indices of the chicken kebabs with various levels of sprouted wheat flour substitution

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Increasing level of SWF substitution in the formulation of the chicken kebabs, surface color of the baked kebabs darkened and significantly decreased the lightness index. Figure 3(b) shows effects of replacing SWF with breadcrumbs on the core lightness of chicken kebabs. As seen in this figure, significant differences were recorded between 0 and 100 samples for internal lightness ($p < 0.05$). Similar to the surface color, interior color of the baked products darkened as the substitution level of SWF in kebab formulation increased.

- Redness

The redness index or a^* ranges from -120 to +120. A negative range of this index indicates that the sample is green and a positive range indicates that the sample is red. The redder the color of the sample, the more positive this index and the higher the value. Figure 3(c) demonstrates effects of substituting SWF with breadcrumbs on surface redness of the chicken kebabs. As seen in this figure, significant differences were reported in surface redness between the 100% sample and the 0 and 50% samples ($p < 0.05$). Figure 3(d) shows effects of substituting SWF with breadcrumbs on internal redness of the chicken kebabs. As seen in this figure, significant differences were reported in kebabs regarding internal redness ($p < 0.05$).

- Yellowness

The yellowness index or b^* ranges from -120 to +120. A negative range of this index indicates that the sample is blue and a positive range indicates that the sample is yellow. The more yellow the color of the sample, the more positive this index and the higher the value. As seen in Figure 3(e), as the substitution proportion of SWF in kebab formulation increased, yellowness index of the sample decreased. However, no statistically significant differences were observed between the kebabs ($p < 0.05$). Figure 3(f) shows effects of replacing SWF with breadcrumbs on internal yellowness of the chicken kebabs. As observed in this figure, significant differences were recorded in kebabs regarding internal yellowing ($p < 0.05$).

Density

Figure 4(a) demonstrates effects of replacing SWF with breadcrumbs on density of the chicken kebab samples. Increasing the replacement proportion of SWF by breadcrumbs increased the density values, which was likely due to decreases in kebab volumes. However, no statistically significant differences were reported in kebabs for density ($p > 0.05$). The average densities of kebabs prepared with 0, 50 and 100% of SWF were 922.51, 941.86 and 978.47 kg/m^3, respectively.

Total phenolics

In this study, total phenolic contents of wheat flour, breadcrumbs and SWF were 470.20, 320.35 and 2010.63 µgGA/g, respectively. Figure 4(b) shows effects of substituting SWF with breadcrumbs on total phenolic content of the chicken kebabs. The average total phenolic contents of prepared kebabs containing 0, 50 and 100% of SWF were 439.98, 466.50 and 757.57 µg GA/g, respectively.

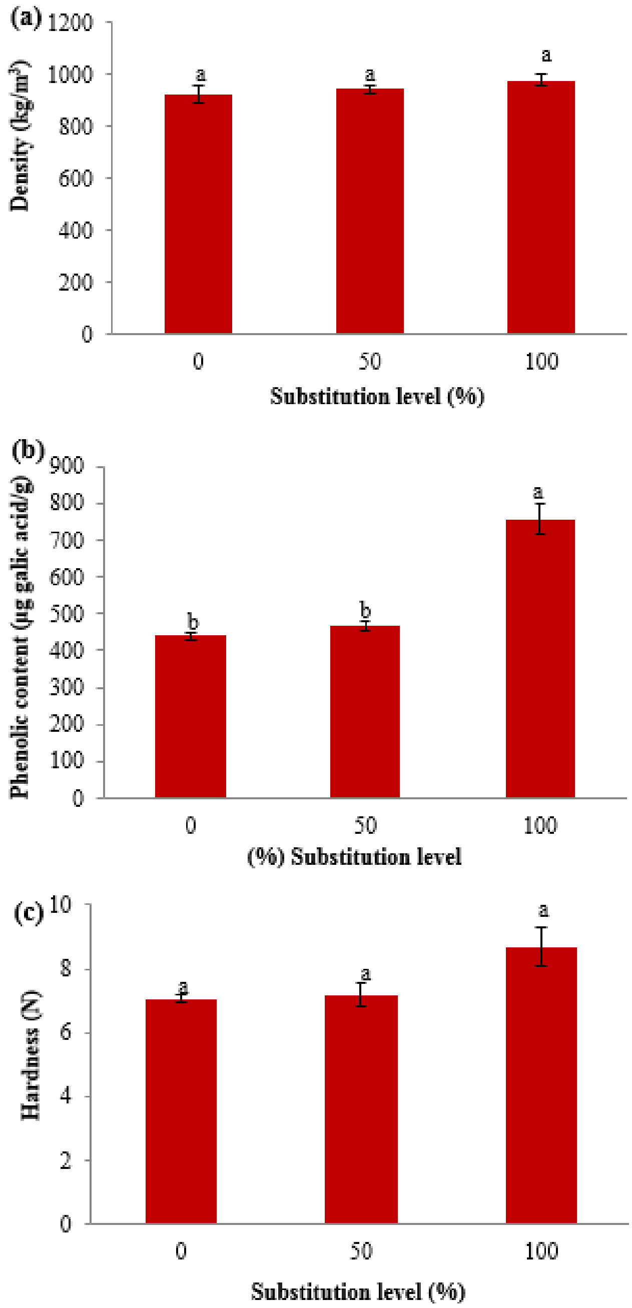

Figure 4. Density (a), phenolic content (b) and texture hardness (c) of the chicken kebabs with various levels of sprouted wheat flour substitution

Textural characteristics

- Puncture test

Figure 4(c) shows effects of using SWF instead of breadcrumbs on texture hardness of the baked chicken kebabs. Based on the puncture assay, kebab hardness increased as the proportion of SWF replaced with breadcrumbs increased. However, no statistically

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significant differences were seen between the samples for texture hardness ($p > 0.05$). Adding SWF to the kebab formulation increased stickiness and consistency of the raw products, which was associated to texture hardness of the kebab after baking. Moreover, volume of the SWF-containing kebabs decreased after baking (higher density) and the texture hardness further increased. The maximum forces needed to penetrate the prepared kebabs containing 0, 50 and 100% of SWF with the texture probe were 7.04, 7.18 and 8.69 N, respectively.

- Texture profile analysis (TPA)

Compared to the control kebab (100% of breadcrumbs), firmness of the kebabs with SWF increased (Table 1). Results of this study indicated no significant differences between the kebab samples for texture cohesiveness ($p > 0.05$). However, substituting the SWF increased texture cohesiveness of the kebabs, compared to the control. Results showed no significant differences between the kebab samples regarding springiness parameter ($p > 0.05$). However, substituting the SWF increased springiness of the kebabs, compared to the control. Adding SWF to the chicken kebab formulation increased firmness and cohesiveness of the texture, as well as increasing energy needed for chewing kebabs. Results shown in the table also verify that sample containing breadcrumbs needed less energy for chewing and this sample was statistically significantly different from the samples containing SWF ($p < 0.05$).

Sensory assessment

Table 2 demonstrates sensory assessment results of the chicken kebabs with various substitution levels of SWF. Regarding surface and core color parameters of the kebab samples, samples containing 100% of SWF were darker with statistically significant differences from the samples containing 0% of SWF prepared with 100% breadcrumbs ($p < 0.05$). These results were similar to image processing results. Image processing results indicated that the samples darkened as the proportion of SWF substitution increased. Based on the sensory assessment results, no significant differences were reported between the three chicken kebabs regarding parameters of appearance, odor and flavor acceptance ($p > 0.05$). However, the 50% sample for appearance acceptance, the 0% sample for odor acceptance and the 100% sample for flavor acceptance received the maximum values.

Firmness parameter addresses desirability of the kebab texture firmness and samples that were further favorable for chewing received higher scores from the panelists. Regarding the firmness parameter, the 100% sample scored higher with significant differences with the other two samples, meaning that samples containing SWF were more desirable and easier to chew. For texture acceptance, this sample received the highest score, showing significant differences with the 0% sample and the panelists preferred kebabs with these texture attributes ($p < 0.05$).

Table 1. Textural characteristics of the chicken kebabs with various levels of sprouted wheat flour substitution (assessed using TPA assay)

Substitution level	Firmness (N)	Cohesiveness	Springiness	Chewiness (N)
0%	52.29 ± 13.50^{a}	0.22 ± 0.10^{a}	0.51 ± 0.08^{a}	5.19 ± 1.36^{b}
50%	57.54 ± 1.53^{a}	0.38 ± 0.01^{a}	0.71 ± 0.05^{a}	15.47 ± 0.68^{a}
100%	55.16 ± 6.43^{a}	0.42 ± 0.10^{a}	0.62 ± 0.09^{a}	14.11 ± 3.93^{a}

Table 2. Sensorial attributes of the chicken kebabs with various levels of sprouted wheat flour substitution

Substitution level	Surface lightness	Core lightness	Appearance acceptance	Odor acceptance	Flavor acceptance	Firmness	Texture acceptance	Overall acceptance
0%	6.89 ± 1.29^{a}	7.50 ± 1.50^{a}	6.78 ± 1.62^{a}	7.28 ± 1.37^{a}	6.56 ± 1.89^{a}	5.67 ± 1.89^{b}	6.17 ± 1.77^{b}	6.44 ± 1.74^{b}
50%	6.06 ± 1.68^{ab}	6.67 ± 1.60^{ab}	7.61 ± 1.16^{a}	7.11 ± 1.41^{a}	7.11 ± 1.15^{a}	5.78 ± 1.47^{b}	6.72 ± 1.48^{ab}	7.11 ± 1.29^{ab}
100%	5.61 ± 2.16^{b}	5.56 ± 1.83^{b}	7.17 ± 1.38^{a}	6.61 ± 2.00^{a}	7.39 ± 1.30^{a}	6.94 ± 1.51^{a}	7.44 ± 1.74^{a}	7.83 ± 1.46^{a}

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Discussion

Due to addition of salt during the bread preparation, proportion of salt and hence quantity of ash increased in breadcrumbs. Increasing proportion of SWF in the chicken kebab formulation to 50% decreased ash content in the samples. When the substitution rate increased to 100%, ash content increased mildly due to decreases in water content of the sample. However, no significant differences were reported between the ash contents of kebabs ($p > 0.05$). In all kebab formulations, kebab surface color was darker than the core color, showing further surface color changes in the samples as kebabs were toasted. In a study, An (2015) investigated quality attributes of the cookies produced using SWF. Their results showed that lightness and redness values of the cookies decreased significantly with the addition of SWF (7).

Increasing the level of SWF substitution in formulation of the kebab samples, surface color of the baked kebabs was reddened that significantly increased the redness index. Ozturk et al. (2014) reported that addition of SWF to beef patty formulations decreased lightness index of the product and enhanced the redness and yellowness indices (9). With increases in the replacement level of breadcrumbs with the SWF in the kebab recipe, redness of the inner part of the samples increased. Similarly, Javaheripour et al. (2022) reported significant increases in the redness index with the addition of SWF to sponge cake formulations (8).

Compared to the yellowness index calculated for the kebab surface, yellowness of the inner part of the sample increased with increasing substitution level of SWF in the formulation. It might be due to less color changes inside the kebabs during baking. Javaheripour et al. (2022) also reported that the addition of SWF to sponge cakes significantly enhanced the yellowness index (8). Total phenolic content of the chicken kebabs increased as the substitution rate of SWF and breadcrumbs increased. This was likely due to a higher content of phenolic compounds in this powder. As seen in this figure, statistically significant differences were recorded in total phenolic contents between the sample containing 100% of SWF and the other two samples ($p < 0.05$).

Based on the TPA assay results, Javaheripour et al. (2022) reported that the addition of SWF to sponge cakes significantly increased texture firmness of the samples (8). Based on the sensory assessment results, chicken kebabs prepared with 100% of SWF (100% substitution for breadcrumbs) included the highest score for overall acceptance and was recognized as the best formulation. This sample included a statistically significant difference ($p < 0.05$) from the 0% sample (prepared with 100% breadcrumbs). In addition, the 100% sample received the highest scores for flavor and texture acceptance parameters. Similarly, Ozturk et al. (2014) recommended addition of 4% of SWF to improve sensory characteristics of beef patties (9).

Conclusions

Sprouting is a simple technique for the improvement of nutritional and quality characteristics of cereal grains. In this study, physicochemical characteristics, phenolic content, textural characteristics and sensorial attributes of chicken kebabs containing various substitution levels of sonicated and infrared-dried SWF were investigated. Complete substitution of SWF significantly increased total phenolic content of the chicken kebabs. Results showed that the complete replacement of SWF with breadcrumbs increased acidity, density, texture firmness, cohesiveness, springiness and chewiness parameters as well as decreasing moisture content, ash and pH of the chicken kebabs. Chicken kebabs with SWF included higher redness and lower lightness index values, compared to the control sample. Based on the sensory assessment results and due to the highest scores for flavor, texture and overall acceptance, use of SWF in formulation of the chicken kebab is recommended. Addition of SWF to the chicken kebab formulation made the products darker (lightness index decreased) and redder (redness index increased) and panelists preferred this color and appearance of the kebabs and dedicated them higher scores. It is recommended to use other novel drying methods to dry wheat sprouts to produce products with higher qualities. Furthermore, it is recommended to investigate use of SWF in other meat products.

Financial disclosure

The authors declared no financial interest.

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