Physicochemical, nutritional, and sensory quality and storage stability of cookies: effect of clove powder

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ABSTRACT
This study aimed to investigate the effect of different concentrations (0, 0.5, 1, 1.5, and 2%) of clove powder on the physicochemical, nutritional, and sensorial quality and storage stability of cookies. The results showed significantly (P ≤ .05) increases in the peak viscosity, breakdown, final viscosity, setback, hardness, cohesiveness, springiness, adhesiveness, chewiness, water holding capacity, and oil holding capacity, and reduction of pasting temperature of cookie flour containing clove powder compared to control. In cookies, the incorporation of clove powder significantly (p ≤ .05) increased diameter, thickness, hardness, factorability, redness (a*), and moisture. The significant increasing significantly (p ≤ .05) in cookies content was: macro-nutrients (Protein (10.65 ± 0.03 to 10.62 ± 0.07), Fat (14.52 ± 0.15 to 15.48 ± 0.07), Ash (1.08 ± 0.05 to 1.35 ± 0.00%), minerals (K (12.04 ± 0.78 to 35.16 ± 0.76), Mg (12.62 ± 0.45 to 17.63 ± 0.04), Fe (8.14 ± 0.06 to 8.61 ± 0.02), P (10.51 ± 0.94 to 13.52 ± 0.12), Zn (0.31 ± 0.01 to 0.53 ± 0.00), Ca (56.89 ± 0.31 to 66.97 ± 0.43) (mg/kg)), also, TPC (12.93 ± 1.8 to 34.07 ± 1.9 (mg GAE/g)), and DPPH (% inhibition) was increased from (15.73 ± 1.4 to 28.51 ± 1.7) in control and 2% clove cookies respectively. However, it reduced the spread ratio, water activity, lightness (L*), and yellowness (b*) of cookies (p ≤ .05). Clove powder also improves the storage stability of cookies. Overall, incorporating clove powder into cookies enhanced the physicochemical, nutritional, bioactive properties, and storability without a major effect on the sensorial acceptability of the developed product.

Introduction

Cookies are the most important bakery snakes produced and consumed in large quantities all over the globe due to their palatability, affordability, storability, diverse tastes, and ready-to-eat nature.\cite{1} Cookies are considered an energy source because they are generally prepared from wheat flour, fat, and sugar.\cite{2} However, the traditional cookies are deficient in various nutrients, phytochemicals, and fiber, hence considered unhealthy.\cite{3} To overcome such limitations, recent research is directed toward fortifying cookies with different food ingredients or plant materials that are considered good sources of nutrients and phytochemicals.\cite{4} Recently, increased consumer demands for foods with higher health benefits than general nutrition have been increased. Consequently, the fortification of foods or formulations of new food products with health-promoting effects such as antidiabetic, anti-inflammatory, anticancer, and antioxidants properties is on the rise.\cite{5} In this regard, various studies have shown enhanced nutritional values and health potentials of cookies by incorporation of Guduchi (\textit{Tinospora cordifolia}) leaf powder,\cite{6} barley flour, carrot pomace powder,\cite{7} tomato powder, and crude lycopene,\cite{8} \textit{Tinospora cordifolia} stem powder,\cite{8} Chiku (\textit{Manilkara zapota} L.) fiber powder,\cite{9} and \textit{Zizyphus lotus} powder.\cite{10}

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Clove (Syzygium aromaticum L.) is an important spice that is used in food as a flavoring agent as well as a preservative because it is rich in bioactive compounds, namely eugenol at its derivatives. In addition, it possessed antioxidant, antimicrobial, antidiabetic, anti-inflammatory, insecticidal, anticancer, antithrombotic, antipyretic, and chemoprotective properties. Clove and its oil have been used as antimicrobial agents in foods and found to control foodborne microorganisms. Recently, clove also has been found to improve the nutritional quality and bioactive properties of dairy products, bakery products, namely cake, and meat products. The application of clove in the development of food products is progressing. In this regard, the current study was carried out to investigate the effect of different concentrations of clove powder on cookies’ physicochemical, nutritional, sensory, and bioactive properties.

Materials and methods

Materials
Wheat flour, sucrose, shortening, baking powder, cloves buds (Cultivated locally in Saudi Arabia), salt, and eggs were purchased from local markets in Riyadh, Saudi Arabia. Clean clove buds were ground for almost 3 min at low speed in a coffee grinder. Powdered was sieve through a 60 mesh sieve before being stored in the refrigerator. Wheat flour and clove powder blends (CP) were prepared by replacing the wheat flour with CP at 0.5 g, 1 g, 1.5 g, and 2 g /100 g wheat flour.

Water and oil holding capacity
The water and oil holding capacity (WHC, WOH) for flour samples were measured according to Berton et al. with slight modification. In brief, 1.0 g from flour samples were suspended in 5 ml of distilled water/sunflower oil and vortexed for 10s. The sample was left at room temperature (25 ± 2°C) for 30 min, then centrifuged at 2000 x g for 10 min, and the sediment was weighed. WHC/ WOH was expressed as a percentage of water absorbed by 1.0 g flour samples.

Pasting properties of composite flour dispersions
The pasting properties of flour blends were measured by using the Rapid Visco Analyzer (Newport Scientific, Sydney, Australia). All samples (3.5 g at 14% moisture basis) were weighed into aluminum canisters, and the distilled water was used to adjust the total weight to 28 g by. The flour-water slurry obtained in the aluminum pan was loaded in RVA, held for 50s at 50 C, heated at 13.15 C/min to 95 C in 3.42 min, and held at 95 C for 3.30 min. It was then finally cooled to 50 C in 3.48 min (at 12.93 C/ min) and held at 50 C for 2 min. The samples were measured in triplicate, and the data were processed by using Thermocline window software.

Gel texture
A Brookfield CT3 Texture Analyzer (Brookfield Engineering Laboratories, Inc., Middleboro, USA) was used to gel firmness analysis in two penetration cycles at a speed of 0.5 mm/s to a distance of 10 mm using a 12.7 mm wide and 35 mm long cylindrical probe.

Cookies preparation
Cookies were made according to the AACC method no 10–50 with few modifications. Briefly, all the ingredients shown in Table 1 were added to the mixing bowl in a particular order. Sugar, egg, and shortening were mixed for 2 minutes at a low speed. Flour samples were mixed, baking powder and salt were added and mixed for 1 minute at a low speed. In the end, dextrose and distilled water were
Table 1. Cookie's recipe.

| Ingredients          | Control  | 0.5%  | 1%    | 1.5%   | 2%    |
|----------------------|----------|-------|-------|--------|-------|
| Wheat flour (g)      | 200      | 199   | 198   | 197    | 196   |
| Clove powder (g)     | 0        | 1     | 2     | 3      | 4     |
| Shortening (g)       | 55       | 55    | 55    | 55     | 55    |
| Baking powder (g)    | 2        | 2     | 2     | 2      | 2     |
| Salt (g)             | 2        | 2     | 2     | 2      | 2     |
| Sugar (g)            | 110      | 110   | 110   | 110    | 110   |
| Egg (g)              | 50       | 50    | 50    | 50     | 50    |
| Dextrose 6% (ml)     | 30       | 30    | 30    | 30     | 30    |
| Distilled Water (ml) | 14       | 14    | 14    | 14     | 14    |

added and mixed until homogenized. Cookies dough was a sheet to 5-mm thickness with the help of rolling pins. Cookies were cut, placed on baking trays, and baked at 225°C for 8 minutes. Baked cookies were cooled at room temperature and sealed in plastic bags for further analysis.

**Cookie physical analysis**

Cookies diameter, thickness, and spread ratio were assessed according to Kaur et al.\[18\] Six cookies were stacked to get an average thickness in mm with the help of a digital Vernier caliper. The same for diameter, six cookies were lined edge to edge, and the average width in mm was calculated by rotating the cookies at 90°. Calculating the spread factor is the ratio between the diameter and the thickness.

**Approximate analysis of cookies**

The moisture, crude fat, crude protein, and ash content of cookies were measured by using the AOAC\[19\] method. The difference approach was used to calculate total carbohydrates.

**Cookie instrumental texture analysis**

Cookie texture was measured using a texture analyzer (TA-XT plus Stable MicroSystems, Haslemere, UK) fitted with a 50 kg load cell, a 3-point bending rig, and a heavy-duty platform. The pretest speed was adjusted to 1 mm/s; the test speed was 3 mm/s, while the posttest speed was 10 mm/s; the distance to the bend was adjusted to 5 mm. The data were recorded as hardness (force required to break) and tractability (distance to break).\[20\]

**Color and water activity measurement**

The color was measured in terms of L* (lightness), a* (redness), and b* (yellowness) values by using a portable colorimeter (Konica Minolta, CR-400-Japan) as previously described.\[21\] The determination of water activity (aw) by using an Aqua Lab Series 3 Water activity meter (Decagon Devices, Pullman, USA) at 25°C.\[22\]

**Mineral composition**

In a Teflon tube, 0.5 g of samples were weighed, then added 1.6 mL of HCl 37% w w\(^{-1}\) and 1.7 mL of HNO\(_3\) 65% w w\(^{-1}\), and the tubes were left for 30 minutes, then add 1.7% of H\(_2\)O\(_2\) 30% v v\(^{-1}\). The digestion proceeds with heating in a microwave, a temperature ramp-up to 170°C for 20 minutes, and the temperature was maintained at 170°C for 15 minutes. Finally, cool to room temperature, the solution was transferred to 25.0 ml conical tubes and filled with ultrapure water. The concentration of the elements was determined by the ICP OES (Inductively Coupled Plasma Optical Emission Spectrometry),
a Perkin Elmer Optima 7300DV (Waltham, USA) was used, under the following conditions: measuring power 1,300 W; integration time of signal 1 s; plasma gas flow 15 L min⁻¹; auxiliary gas flow 1.5 L min⁻¹; nebulization gas flow 0.70 L min⁻¹; pumping rate of sample 0.70 mL min⁻¹.

**Total phenols and radical scavenging activity determination**

One gram of cookie samples were extracted by 25 mL ethanol for 24 h in a shaker and then centrifuged for 15 min at 10,000 × g. The mixture was filtered using filter paper (Whatman #41) and the supernatant was separated. The collected volume of the supernatant was adjusted to 25 mL and kept at 4°C for estimation of phenolics and radical scavenging activity. The total phenolic contents were assessed according to Wu et al.[23] with minor modifications. A gallic acid standard curve was prepared for comparison, and results were presented as equivalents of gallic acid per unit weight (g) of cookies. The antioxidant activity was determined using scavenge 2,2-diphenyl-1-picrylhydrazyl (DPPH) radicals activity method, as described by Akillioglu and Karakaya.[24] In brief, a 950 μL of DPPH stock solution (0.08 mM DPPH methanol solution) was added to 50 μL extract and incubated for 5 min. Exactly 5 min later, the absorbance readings were performed at 515 nm. Antioxidant activity (AA) was expressed as percentage inhibition of DPPH radical by using the following equation:

\[
AA = 100 - \left\{100 \times \frac{(A_{\text{sample}} - A_{\text{control}})}{A_{\text{control}}}\right\}
\]

Where A sample is the absorbance of the sample at t = 5 min, and A control is the absorbance of control.

**Sensory evaluation of cookies**

All cookies sample got a cod and, in random order were presented to 20 semi-trained panelists. Samples were evaluated for their sensory attributes such as appearance, color, texture, aroma, taste, aftertaste, and overall acceptability, according to Gat & Ananthanarayan.[25] Sensory characteristic scales were calculated by using a 9-point hedonic scale, with 1 for “dislike extremely,” 5 for “neither dislike nor like,” and 9 for “like extremely.”[26]

**Cookies shelf life and microbial analysis**

Cookies were stored in air-tight polyester pouches (120mmX200mm (250 gm), Thickness: 50 microns) at room temperature 28 ± 2°C. The storability was studied for (0, 7, 14, 21, and 28) days and the peroxide value (PV), and microbiological analyses including (total plate count and total yeast and mold count) were determined by using FDA/CFSAN standard methods. Total aerobic plate counts were determined using nutrient agar, while yeasts and molds were counted using potato dextrose agar.

**Statistical analysis**

The collected data were done in three replicates and analyzed by using analysis of variance (ANOVA). To compare means were used the Duncan’s Multiple Range (DMR) test at sig ≤0.05, SPSS (IBM Statistical Analysis Version 21).
Results and discussion

Functional properties of wheat flour fortified with clove powder

The results of the pasting properties, texture, water holding capacity, and oil holding capacity of wheat flour fortified with different concentrations (0, 0.5, 1, 1.5, and 2%) of clove powder are shown in Table 2. The results showed significant (p ≤ .05) differences in the pasting and textural properties and water and oil holding capacities between control cookies and those fortified with different concentrations of clove powder. Compared to control, the pasting properties, namely peak viscosity, breakdown, final viscosity, and setback, were increased, whereas pasting temperature was reduced following the incorporation of clove powder into the cookie mixture formulation. Improving pasting properties following the addition of clove powder could be attributed to the interaction of polyphenols and essential oils components in the clove with wheat flour starch. The factors such as starch granule size, amylose contents, amylopectin structure, protein, polyphenol, fiber, and lipid contents significantly affected the flour pasting properties. Previous reports indicated that the incorporation of mushroom powder, amaranth flour, and carrot pomace powder affected the pasting properties of cookies in various manners. These findings indicate that incorporating clove powder into the cookie mixture improved its pasting properties. The texture properties (hardness, cohesiveness, springiness, adhesiveness, and chewiness) of flour gel were greatly increased following clove to wheat flour compared to control (wheat flour only). The highest levels of hardness and cohesiveness were seen in 0.5% clove containing flour mixture and slightly reduced as the concentration of cloves in the mixture increased (p ≤ .05). Incorporation of clove powder at ≥ 1% slightly increased the levels of adhesiveness and chewiness compared to that with 0.5% clove and control. These findings indicate that incorporation of clove powder into cookie mixture improved its texture properties. Similarly, improvement in the texture of the cake was achieved following the incorporation of potato peel flour and green tea powder in the formulations. The water holding capacity and oil holding capacity were slightly increased by incorporating 1.5% powder in the mixture. The increase in water holding capacity and oil holding capacity is likely due to the increased hydroxyl group in the fiber and polyphenols of clove powder which allows the binding of more water and oil. Similarly, increased water and oil holding capacity was reported in cookie flour incorporated with carrot pomace powder and sesame peel flour. Generally, the findings of our study indicate that the incorporation of clove powder into the cookie mixture improved the functional properties of the mixture.

Table 2. Functional and physical properties of wheat flour with different levels of clove powder.

| Parameters               | Control         | 0.5% CP         | 1% CP           | 1.5% CP         | 2% CP         |
|--------------------------|-----------------|-----------------|-----------------|-----------------|----------------|
| Pasting properties       |                 |                 |                 |                 |                |
| Peak Viscosity (cP*)     | 1285.0 ± 0.50e  | 1868.0 ± 0.24a  | 1739.0 ± 0.18d  | 1802.0 ± 0.65c  | 1817.0 ± 0.31b |
| Breakdown(CP)            | 523.0 ± 0.64d   | 729.0 ± 0.50a   | 725.0 ± 0.74b   | 731.0 ± 0.32a   | 675.0 ± 0.24c  |
| Final Viscosity (cP)     | 1524.0 ± 0.34d  | 2054.0 ± 0.37ab | 1934.0 ± 0.51c  | 1959.0 ± 0.14bc | 2035.0 ± 0.60a |
| Setback (cP)             | 786.0 ± 0.60e   | 825.0 ± 0.19d   | 925.0 ± 0.11a   | 864.0 ± 0.88c   | 876.0 ± 0.55b  |
| Pasting Temp. (°C)       | 86.0 ± 0.34a    | 85.0 ± 0.15b    | 83 ± 0.35c      | 83.0 ± 0.38c    | 84.0 ± 0.42c   |
| Gel texture              |                 |                 |                 |                 |                |
| Hardness (g)             | 42.00 ± 0.9c    | 61.00 ± 1.00a   | 47.33 ± 0.33b   | 47.67 ± 0.58b   | 47.00 ± 0.53b  |
| Cohesiveness (mm)        | 0.42 ± 0.03c    | 1.82 ± 0.38a    | 0.49 ± 0.1b     | 0.49 ± 0.1b     | 0.49 ± 0.1b    |
| Springiness (mm)         | 8.53 ± 0.32b    | 10.03 ± 0.06a   | 10.13 ± 0.06a   | 10.20 ± 0.1a    | 10.10 ± 0.1a   |
| Adhesiveness (mm)        | 0.53 ± 0.01c    | 0.70 ± 0.01a    | 0.71 ± 0.03a    | 0.60 ± 0.01b    | 0.71 ± 0.01a   |
| Chewiness (g)            | 152.0 ± 1.38b   | 110.0 ± 3.58c   | 237.0 ± 3.58a   | 237 ± 2a        | 234.0 ± 1.24a  |
| Water Holding Capacity   | 1.88 ± 0.04a    | 1.86 ± 0.04ab   | 1.87 ± 0.01ab   | 1.90 ± 0.01a    | 1.84 ± 0.03b   |
| Oil Holding Capacity     | 1.76 ± 0.04a    | 1.70 ± 0.04b    | 1.77 ± 0.02a    | 1.78 ± 0.01a    | 1.78 ± 0.01a   |

Values followed by different letters within each column significantly different (p ≤ 0.05); CP: Clove Powder.
**Physical, texture, color, and water activity properties of clove containing cookies**

The results of the physical (diameter, thickness, and spread ratio), textural (hardness and fracturability), water activity, and color (L*, a*, and b*) properties of cookies with and without clove powder are shown in Table 3. Incorporation of clove powder into the cookies formulation concomitantly (p ≤ .05) increased the diameter and thickness to maximum values 1% and 1.5%, respectively. The spread ratio showed concomitant reduction following the addition of different concentrations of clove powder. The highest value was observed in control cookies and the lowest values in the cookies with 1.5% clove powder. The reduction in the spread ratio and increment in thickness and diameter of cookies following the addition of clove powder is probably due to the dilution of gluten and less water available for its rehydration.[33,34] In agreement with our findings, previous reports indicate the increased thickness and reduced spread ratio following the incorporation of blueberry powder[35] and orange-fleshed sweet potato flour[34] into the cookie formulations. The hardness and fracturability were increased following the incorporation of clove powder into the cookies formulation to the maximum values of 2% and 1.5%, respectively. The increase in hardness and fracturability of cookies following the addition of clove powder could be attributed to the dilution of gluten and fiber influence on the development of protein matrix and starch granule network.[36,37] In addition, a similar increase in the hardness and fracturability was reported following the incorporation of Tunisian Ziziphus lotus L. fruits[10] and roasted flaxseed flour[4] into cookie formulations. The highest water activity was observed in control cookies, whereas the least value was seen in cookies containing 1.5% clove powder. The reduced water activity of cookies containing high levels of clove powder could be due to the high fiber and polyphenols contents of the cloves, which can absorb more water and hence reduce the water activity of cookies.[34] Similar observations on the reduced water activity of cookies with increased levels of orange-fleshed sweet potato flour.[34] The range of water activity in this study (0.36–0.46) was greatly less than 0.6, which is the minimum water activity for the growth of microorganisms,[38] indicating more storage stability of clove-containing cookies.

The color properties were also influenced by incorporating clove powder in the cookies formulation (Table 3, Figure 1). The lightness (L*) and yellowness (b*) values were reduced, whereas the redness (a*) increased following the addition of clove powder. The highest L* and b* values were seen in cookies without clove powder, and the least values of these attributes were found in cookies containing 1% clove powder. The highest redness value was observed in cookies containing 1.5% clove powder. The reduction of L* and b* values following the addition of clove powder could be due to the dark brown color of clove powder as well as high polyphenols, and their oxidizing enzymes in clove powder could also lead to enzymatic browning and hence increased a* value and reduced L* and b* values of cookies.

| Table 3. Physicochemical quality properties of cookies fortified with different levels of clove powder. |
|---------------------------------------------------------------|
| **Parameters** | **Control** | **0.5% CP** | **1% CP** | **1.5% CP** | **2% CP** |
| Diameter (mm) | 51.78 ± 0.37d | 52.45 ± 0.57c | 56.28 ± 0.24a | 53.75 ± 0.97b | 53.38 ± 0.74b |
| Thickness (mm) | 8.45 ± 0.46d | 9.33 ± 0.10c | 10.83 ± 0.73b | 12.65 ± 0.96a | 11.90 ± 0.48a |
| Spread ratio | 6.13 ± 0.20a | 5.68 ± 0.04b | 5.22 ± 0.41b | 4.25 ± 0.08d | 4.49 ± 0.16c |
| Texture | 56.23 ± 0.15b | 55.55 ± 0.67c | 48.01 ± 0.12d | 54.60 ± 0.04c | 60.75 ± 0.30a |
| Hardness (N) | 4.75 ± 0.42c | 4.89 ± 0.17b | 4.10 ± 0.34d | 5.03 ± 0.12a | 4.93 ± 0.07a |
| Fracturability (mm) | 0.46 ± 0.02a | 0.39 ± 0.01b | 0.45 ± 0.01a | 0.36 ± 0.01c | 0.45 ± 0.01a |
| Water activity (a*) | 70.55 ± 0.89a | 66.71 ± 0.10b | 53.97 ± 0.69e | 59.56 ± 0.09d | 60.65 ± 0.54c |
| Color | 1.12 ± 0.13d | 1.19 ± 0.72d | 1.82 ± 0.68c | 3.65 ± 0.17a | 2.92 ± 0.03b |
| b* | 23.86 ± 0.29a | 21.95 ± 0.24c | 20.33 ± 0.01d | 22.81 ± 0.09b | 21.78 ± 0.42c |

Values followed by different letters within each column significantly different (p ≤ 0.05); CP: clove powder
Similarly, a report showed that incorporating mango peel powder into biscuits formulations reduced L* and b* values and increased the value of the product.\[1\] In addition, reduction of L* and b* values and increase of a* values were found in cookies fortified with Tunisian Zizyphus lotus L. fruits compared to control.\[10\] Overall, the fortification of cookies with clove powder enhanced the physical and textural properties of the product.

**Nutritional quality and bioactive properties of cookies**

The results on the proximate composition, mineral contents, and bioactive properties of cookies containing different concentrations of clove powder are shown in Table 4. The incorporation of clove powder in cookie formulations significantly increased the cookies’ moisture, protein, fat, ash, and carbohydrate contents (P ≤ .05). The highest values of moisture and protein were observed in cookies fortified with 1.5% clove powder, and the highest levels of fat and ash were found in cookies with 2% clove powder suggesting that incorporation of ≥1.5% clove powder in the cookies enhanced these properties. The highest carbohydrate content was seen in cookies with 0.5% clove powder. The improvement of proximate composition cookies following the addition of clove powder is likely attributed to the richness of clove with these substances. Similarly, previous reports showed an increase in moisture, ash, protein, fat, and carbohydrate of cookies following the addition of Tunisian Zizyphus lotus L. fruits,\[10\] roasted flaxseed flour,\[4\] and Tinospora cordifolia stem powder.\[8\] Incorporation of different levels (0, 0.5, 1.0, 1.5, and 2.0%) of clove powder concomitantly improved the contents of potassium, sodium, magnesium, iron, phosphorous, zinc, and calcium. The maximum values of minerals were found in cookies fortified with 2% clove powder. The increment of minerals in cookies following the incorporation of clove powder could be attributed to the rich mineral profile of clove.\[12\] In agreement with our findings, increases in mineral contents of cookies following the addition of spinach powder,\[39\] Tinospora cordifolia stem powder (8). The addition of different concentrations of clove powder concurrently increased the total phenolic contents and DPPH scavenging activity to the maximum values in cookies containing 2% clove powder, whereas the lowest values were observed in
Table 4. Nutritional quality and bioactive properties of cookies containing different levels of clove powder.

| Parameters            | Control     | 0.5% CP | 1% CP  | 1.5% CP | 2% CP  |
|-----------------------|-------------|---------|--------|---------|--------|
| Proximate composition (%) |             |         |        |         |        |
| Moisture              | 4.73 ± 0.22d | 5.16 ± 0.23c | 5.86 ± 0.83c | 6.55 ± 0.02a | 6.26 ± 0.18b |
| Protein               | 10.65 ± 0.03c | 9.98 ± 0.05d | 10.80 ± 0.05b | 10.96 ± 0.08a | 10.62 ± 0.07c |
| Fat                   | 14.52 ± 0.15b | 13.90 ± 0.95c | 13.21 ± 0.36c | 14.87 ± 0.63b | 15.48 ± 0.07a |
| Ash                   | 1.08 ± 0.05d | 1.11 ± 0.07c | 1.15 ± 0.01c | 1.24 ± 0.03b | 1.35 ± 0.00a |
| Carbohydrate          | 69.02 ± 0.25b | 69.85 ± 0.01a | 68.98 ± 0.88b | 66.38 ± 0.90c | 65.31 ± 0.41c |
| Minerals (mg/Kg)      |             |         |        |         |        |
| K                     | 12.04 ± 0.78e | 17.82 ± 0.43d | 23.60 ± 0.80c | 29.38 ± 0.33b | 35.16 ± 0.76a |
| Na                    | 91.13 ± 0.07d | 91.25 ± 0.08d | 91.37 ± 0.04c | 91.49 ± 0.02b | 91.62 ± 0.01a |
| Mg                    | 12.62 ± 0.45e | 13.87 ± 0.12d | 15.12 ± 0.02c | 16.38 ± 0.72b | 17.63 ± 0.04a |
| Fe                    | 8.14 ± 0.06d | 8.26 ± 0.04c | 8.38 ± 0.08c | 8.50 ± 0.03b | 8.61 ± 0.02a |
| P                     | 10.51 ± 0.94c | 11.26 ± 0.26c | 12.02 ± 0.58b | 12.77 ± 0.63b | 13.52 ± 0.12a |
| Zn                    | 0.31 ± 0.01d | 0.48 ± 0.01c | 0.51 ± 0.00b | 0.51 ± 0.01b | 0.53 ± 0.00a |
| Ca                    | 56.89 ± 0.31d | 59.41 ± 0.68 cd | 61.93 ± 0.12c | 64.45 ± 0.74b | 66.97 ± 0.43a |
| Bioactive properties  |             |         |        |         |        |
| TPC (mg GAE/g)        | 12.93 ± 1.8e | 17.09 ± 3.1d | 22.54 ± 2.4c | 27.56 ± 3.8b | 34.07 ± 1.9a |
| DPPH (% inhibition)  | 15.73 ± 1.4e | 18.45 ± 1.1d | 21.15 ± 0.3c | 26.93 ± 1.5b | 28.51 ± 1.7a |

Values followed by different letters within each column significantly different (p ≤ 0.05); CP: Clove Powder.

the control cookies without clove powder. Compared to the other analyzed doughs, the antioxidant activity of the dough and cookies prepared from oat and buckwheat flour and several spices found that the highest value was noticed for the dough with clove (137.01 µmol Trolox/g DM).[40]

A concomitant increase in total phenolic content and antioxidant activity of cookies following the increased concentration of clove powder is likely due to the high bioactive properties of clove.[11] Similarly, previous reports revealed that the total phenolic content TPC in ten selected spices or herbs and oat-buckwheat doughs and cookies were increased, the highest TPC value was determined in the samples of clove (221.91 ± 9.85 of gallic acid (GAE)/g on a dry matter basis (DM)).[40] The study of Assefa et al. was likewise confirmed the higher total phenolic content in clove.[41] Another study indicated the improvement of total phenolic content and antioxidant activity of cookies fortified with various levels of mango peel powder,[11] tomato powder, crude lycopene,[5] Tinospora cordifolia stem powder,[6] Tunisian Zizyphus lotus L. fruits.[16] Overall, the incorporation of clove powder into cookie formulations greatly enhanced the product’s nutritional quality and bioactive properties.

**Sensory attributes of cookies**

The sensory quality attributes (color, aroma, mouthfeel, sweetness, hardness, crunchiness, shape, and overall acceptance) of cookies fortified with different levels of clove powder are shown. Differences in the sensory attributes were observed among the cookie samples depending on the level of added clove powder. The control cookies and those fortified with 0.5% clove powder showed the highest levels of most sensory attributes, except for the sweetness of control cookies and the color of cookies with 0.5% clove powder. Cookies fortified with 1.5% clove powder showed high scores of sweetness, mouthfeel, and hardness, whereas they showed low scores of shape, crunchiness, and overall acceptability Figure 2. The high overall acceptance scores were found in control cookies and those with 0.5% clove powder, followed by those fortified with 1% and then 1.5% clove powder. Similarly, a previous report showed the incorporation of 5% spinach powder,[39] 10% mango peel powder,[11] and 8% Tinospora cordifolia stem powder,[8] into cookie formulations resulted in acceptable products without adverse effects on the sensory attributes of cookies.
Storage of cookies

The developed cookies’ shelf-life was assessed during storage for 28 days at room temperature (28°C), and the results are shown in Table 5. The peroxide value, total plate count, and total yeast and mold count have differed between the cookies, with the generally highest values being observed in control cookies and the incorporation of clove powder concomitantly reduced the levels of these attributes. During storage, the peroxide value was greatly increased to the maximum at the end of storage, and the highest value was observed in the control sample at day 28 of storage. Interestingly, the incorporation of 2% clove powder in the cookies significantly improved the storage stability, and at 28 days of storage, the peroxide value of cookies with 2% clove powder was only half that of the control sample (52 meq O2/kg vs. 104 meq O2/kg) indicating improving the storability of cookies by clove powder. The enhancement of the oxidative stability of cookies following the addition of clove powder could be attributed to the high antioxidant activity of clove powder. The total bacterial, yeast and mold counts were also affected by incorporating clove powder in the cookies. The lowest counts of these microbes are observed in cookies containing higher levels of clove powder. During the storage,
bacterial counts and yeast and mold counts were increased to the maximum levels at the end of storage; however, the least increase was seen in cookies with higher levels of clove powder. These findings indicate the potential antimicrobial activities of clove powder, which is in accordance with previous reports.\textsuperscript{[11,13]}

**Conclusion**

This study investigated the effect of different levels of clove powder on the physicochemical, nutritional, bioactive properties, and sensory quality of cookies. The incorporation of clove powder into cookie formulations with concentrations ≤ 2.0\% improved the pasting properties, texture, and water and oil holding capacities of cookie flour. In addition, clove powder enhanced cookies’ nutritional, physical, textural, and bioactive properties without adverse effects on the product’s sensory attributes. Overall, incorporating clove powder into cookie formulations can increase the nutritional and health quality attributes of cookies.

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