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The Effect of Adding Ginger Powder on the Chemical and Sensory Properties of Beef Burger

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Abstract: *Incorporating ginger powder with veal meat was observed for Iraqi beefburger manufacturing, and its effect on the chemical and organoleptic characteristics was studied. The veal meat (thigh area) was purchased from the local markets of Baghdad for approximately 1.5 to 2 years. A typical burger mixture had been manufactured, consisting of minced meat, beef fat, water, flour, and salt. Then, the manufactured burger mixture was divided into five samples, each weighing 250 grams, and ginger powder was added to four samples in different proportions: 0.5%, 1%, 1.5%, and 2%, respectively. The fifth sample remained a control, with three triplicates for each sample prepared. After that, the prepared burger samples were kept in the refrigerator at 4°C for 3, 6, and 9 days until the chemical and sensory analyses were applied. The results showed the 2% and 4% samples caused a significant increase in the proportion of protein and fat compared with the control sample. As for oxidation indicators, a significant decrease was found in the percentage of free fatty acids and thiobarbituric acid for burger samples mixed with ginger compared to the control sample. It was also observed that there was a significant increase in tenderness and overall acceptability of the burger samples mixed with ginger compared to the control sample. As for the interaction between the treatments and storage periods, it was observed that there were significant differences between the treatments for each of the free fatty acids, thiobarbituric acid, and juiciness or tenderness of the beef burger samples. For that reason, the effect of adding ginger powder to beef burger samples led to interactions between the ingredients of these samples during their different storage stages through the significant differences in free fatty acids and thiobarbituric acid, as well as some differences in the juiciness and texture properties for those samples.*

Keywords: *The ginger powder, meat cold storage, veal meat, chemical analysis, sensory properties, beef burger.*

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INTRODUCTION

Fresh meat is considered a highly perishable food item if left in poor preservation conditions. Therefore, meat must be preserved when it is not consumed immediately (Eranda et al., 2024). One of the most commonly used methods for preserving meat is cold preservation at low temperatures (2-4°C); it is considered a short-term method of preserving meat and reducing its corruption. Meat is exposed to fat oxidation processes due to deterioration occurring during storage due to the chemical composition of meat and its products. Fat is the main factor affecting food quality, as the oxidation of meat fat alters taste, flavor, texture, and then a shortened storage life (Domínguez et al., 2019; Al-Shibli et al., 2023). The use of synthetic antioxidants such as BHA (Butylated Hydroxy Anisole) and BHT (Butylated Hydroxy Toluene) has caused many doubts and concerns due to their toxic and carcinogenic effects (Jalali Mousavi et al., 2015; Xu, 2021). For this reason, recent interest has been in using some plant sources suitable for human consumption, such as natural antioxidants, due to their availability in the market, their cheap price, and their containment of phenolic compounds, which were the most important antioxidants found in most plant parts, such as leaves, stems, and roots (Hussein et al., 2020). In addition, these natural antioxidants contain volatile oils that cause the desired flavor of the final product (Cai et al., 2004). Ginger is an important spice because it contains some substances with effective antioxidants, such as volatile oils. Ginger is an important spice because it contains some effective antioxidants, such as volatile oils, eugenol, gelatinous, and starchy substances (Ameh et al., 2015). On the other hand, the roots of the ginger plant are used as a spice in preparing foods, adding a distinctive taste and flavor. This study aimed to add ginger powder, one of the common medicinal plants in local markets, to identify the possibility of using it as an antioxidant in preserving meat, improving its qualities, and prolonging its shelf life. In the second month of the ginger, triglyceride, and LDL group, there was a significant increase in the ginger group when ginger was re-fed to experimental mice (Al-Jubouri, 2017).

MATERIALS AND METHODS

1) Plant of study

The ginger rhizomes are available in local markets. A quantity of them was peeled and dried at room temperature (25°C) for four weeks, then ground with an electric grinder, and the powder was stored in a glass bottle until use.

2) Meat and fat

Beef (thigh area) and the meat deposited around the kidneys and pelvic bones were cut in the local markets of Baghdad, meat aged between 1.5 and 2 years. Then, they were placed in sterile polyethylene bags and suitable plastic ice packs until they reached the laboratory and stored in freezing at a temperature of -18 °C until used.

3) Ginger:

The dried roots were bought from local markets and ground using a laboratory grinder, and the ginger powder was stored in a sealed container until use.

4) Table salt

The pure and impurity-free table salt (NaCl) is 1.5% of the manufactured product in one sample.

5) Flour:

Turkish flour, called "Fakher," is used in local markets.

6) Sterile water:

Cold, salt-free drinking water was used.

Manufacture of beef burgers

This study was conducted in the meat and fish technology laboratories at the College of Agricultural Engineering Sciences, University of Baghdad, from 5/9/2023 until 2/12/2023. The burger was manufactured in the following proportions: For every 100 g of burger (lean beef and boneless beef about 73 g, beef fat 10 g, water 125 g, table salt 1.5 g, flour 3 g). The thighs were physically separated to separate the meat from the fat and bones. The meat and fat were cut into small pieces to facilitate the subsequent mincing process. The meat and fat were minced in an electric mincer twice with a sieve hole (8 mm) for homogeneity. The fat and meat were distributed, and then water, salt, and flour were added according to the mentioned proportions. Then, ginger powder was added to every 100 grams of the burger mixture in (4) treatments, except for the control treatment (T1), and the ratios were 0.5%, 1%, 1.5%, and 2% as T2, T3, T4, and T5, respectively. The burger patties, weighing 50 grams, were manufactured according to the mentioned treatments. They were packed in polyethylene bags, emptied of air, sealed well, and stored in the refrigerator at 4 °C for 3, 6, and 9 days until chemical and sensory analyses were conducted (Douglas, 2024).

Sensory evaluation for beef burger

The burger patties were grilled in the oven for 40 minutes at 180 o C. The aspects such as flavor, tenderness, juiciness, and texture of the patties were assessed according to Lee et al. (1997) on a visual descriptive scale by 10 faculty members and postgraduate students. The evaluation was done on the degree of flavor, tenderness, juiciness, general acceptability, and texture based on the degree of 1 to 9 for flavor as Cross recommended, which meant that the existing flavor degree was negligible (completely nonexistent); a flavor degree of nine symbolized excellent flavor, and the same applied to other degrees.

CHEMICAL ANALYSIS

1) Determination of free fatty acids

Free fatty acids were determined in cold-storage burger samples as reported by Egan et al. (1988). Then, 3 g of the burger was well, and 50 ml of 98% ethyl alcohol was added. After that, drops of phenolphthalein indicator were added to the sample, and then the mixture was titrated with 0.1% sodium hydroxide solution until the solution turned light pink. The percentages of free fatty acids are calculated according to the following equation:

Free fatty acids (%) = titrate (A - B) x N x 2 8 2 x 100 / sample weight (g) x 1000

A = number of NaOH ml required to calibrate the fat or oil sample
B = number of NaOH needed to calibrate the control sample
282 = molecular weight of oleic acid

2)Measuring of thiobarbituric acid value (TBA)

The value of thiobarbituric acid was estimated according to Mehran (1976) and previously modified by Jalali-Mousavi (2015). Then, 5 g of meat was dissolved in 10 ml of chloroform and placed in a water bath at 60 °C for 5 minutes. After that, add 10 ml of 0.07% thiobarbituric acid solution (prepared with glacial acetic acid). Next, add 10 ml of 0.07% thiobarbituric acid solution (prepared with glacial acetic acid). Then, the mixture was centrifuged at 1000 rpm (for 5 min). After centrifugation, the filtrate was placed in a water bath for 30 minutes. Then, read the optical absorbance of the filtrate at laboratory temperature at a wavelength of 538 nm. The value of thiobarbituric acid is calculated as mg of Mallon aldehyde (MD)/kg of meat according to the following equation:

Mallon aldehyde Concentration (mg/kg meat) = Absorption × 7.8

3) Determination of peroxide value (P.V)

The method mentioned in AOAC (2005) adopted: take 5 g of the burger fat and 30 ml of a solution consisting of 3 parts glacial acetic acid, 2 parts chloroform, 0.5 ml of a potassium iodide solution, 30 ml of distilled water, and add 1 ml of the starch indicator at a concentration of 1%. Then, (0.01) N was titrated with sodium thiosulfate until the blue color disappeared, and the peroxide number was calculated according to the following equation:

Peroxide value (mill equivalent) = [number of milliliters of sodium thiosulfate X (0.01) / weight of the sample (g)] X 1000

4) Estimation of total volatile nitrogen (TVN)

Total volatile nitrogen (mg/100 g) estimated in the burger samples based on the method described by Egan Dal (1981). A 100-gram sterilized burger sample was placed in a 5% trichloroacetic acid solution, and then the mixture was obtained to obtain a clear extract. 5 ml of the clear extract was transferred to a distillation flask (Kjeldahl method), and 5 ml of 2 M sodium hydroxide solution was added. The Kjeldahl distillation apparatus was connected to the mixture. The distilled liquid was heated and received in a receiving cycle containing 15 ml of 4% boric acid with added drops of methyl red and bromocresol green pigment. The mixture was titrated using 0.01 M hydrochloric acid, and the amount of total volatile nitrogen was calculated according to the following equation:

Amount of Volatile Nitrogen (mg nitrogen/100g meat) = V X (300+ Mo) X 14/500
V = ml of hydrochloric acid in 0.01 M

Mo = moisture content of the meat sample

Statistical analysis

The statistical program applied the SAS-statistical analysis system (2012) to analyze the data to study the effect of treatment, time, and their interaction on the studied traits. A completely randomized design (CRD) was applied, and the significant differences between the averages were compared using the Duncan (1955) multi-range test. The following adopted mathematical model:

Yijk = m + Ti + Pj + TP (ij) + eijk
Yijk: Observation values for each trait
m: General average for the trait
Ti: Effect of treatment
PJ: Effect of period
Tp (ij): Effect of interaction between treatment and period
eijk: Standard error

Results and Discussion

Chemical composition of ginger powder solution

Preliminary tests showed a different response to the ginger powder solution. A good test for each compound resulted in various colours: discoloration by carbohydrates, yellow by flavonoids, red-brown by alkaloids, and brown by phenols, which did not produce a blue-green colour in the terpenes test. However, the tannin test gave the expected white liquid, indicating a negative result (Deshpande et al., 1986). These data are summarized in Table 1.

Chemical analysis of beef burger samples during storage period

1) Free fatty acid (FFA)

Table 2 shows the effect of using different concentrations of ginger powder and storage unit increasing the percentage of free fatty acids in the cold storage beef burger at 4 °C ± 2 (mean - standard error). Table 2 shows the effect of using different concentrations of ginger powder and the storage unit on the increase in the percentage of free fatty acids in beef burgers stored in ± error (average) in the refrigerator. This table shows the effect of different concentrations of tocopherol powder on the percentage of free fatty acid (FFA) formation under storage conditions. The results indicate significant differences between the various concentrations at a confidence level of P<0.05.

Free fatty acids (FFA) across the different tocopherol treatments compared to the control sample. The lowest value was recorded in the sample containing 2% tocopherol (0.07 ± 0.01), while the highest percentage was observed in the control sample (0.16 ± 0.02). The reduction in FFA values can be attributed to the ability of tocopherol to inhibit the oxidation process by capturing free radicals, which leads to the stability of unsaturated fatty acids in the samples treated with tocopherol. This observation aligns with the findings of Ashie (2002). In addition, differences between tocopherol concentrations were evident, as the proportion of free fatty acids decreased as tocopherol concentrations increased. These results emphasize the role of antioxidants, especially tocopherols, in maintaining the quality and stability of stored oils, because the FFA includes long-chain fatty acids free of triglycerides; these fatty acids are found in large quantities in crude oil, but if the oil is refined, the amount decreases to a certain level, as mentioned by Ponnampalam et al. (2022) and Abed and Khairy (2023) findings.

2) Estimation of thiobarbituric acid value (TBA)

The thiobarbituric acid values (TBA) in Table 3 for the different burger treatments were recorded. Significant differences were recorded between the treatment rates. It was noted that the control sample (1.04 mg malondialdehyde/kg meat) outperformed the rest of the samples, to which different proportions of ginger powder were added, such as the second, third, fourth, and fifth samples as (0.90, 0.82, 0.86, and 0.62) mg malondialdehyde/kg meat, respectively. These results are consistent with the findings of Abdel-Moneim et al. (2015) because ginger contains effective compounds and antioxidants, such as Nigel lone and its compounds, which protect meat products from the dangers of free radicals, peroxide compounds, and harmful bacteria (Mahmmod et al., 2014).

The results did not agree with Rincón-Gamboa et al. (2021), who made mistakes and did not compare the values of the meat discs to the refineries. The reason for increasing in values of the thiobarbiturate (TBA) in the first treatment (control) may be due to the increase in malonaldehyde concentration with the continuation of the storage process, which is one of the secondary products of the fat oxidation in meat and its products due to the breakdown of peroxides (Domínguez et al., 2019). In addition, it was also found that ginger extract was more effective than rosemary extract in reducing TBA values, while their effectiveness was similar in influencing the number of bacteria (Baker and Alkass, 2020).

3) Estimation of peroxide value (PV)

It is noted in Table (4) that the different burger treatments recorded differences ($P<0.05$) between the treatment rates, as the first treatment, the control (1.06) ml Eq/kg fat, outperformed the rest of the treatments, which recorded (0.92, 0.64, 0.88, and 0.84), respectively. The peroxide values were decreasing due to the effect of the natural additives on the treatments in inhibiting fat oxidation, as indicated by Kim et al. (2015), who noticed a significant decrease in peroxide samples of meat to which natural extracts were added compared to samples free from additives during the periods of cold storage. The permissible peroxide value should not exceed 10 ml Eq/kg fat (Shobha and Badigannavar, 2024). Those results were less than noted by Al-Zaid et al., (2023), as the peroxide values were 4.20 for the control sample and less than 3 for the samples treated with essential oils.

4) Total volatile nitrogen (TVN)

Table 5 shows no significant differences between the total volatile nitrogen amounts in the burger samples made with ginger powder. These results disagree with the results of Al-Rubaie (2006), who found a significant increase in total volatile nitrogen when beef was cooled at 4°C for 3, 6, and 9 days, respectively.

As for the effect of the different storage periods on the average total volatile nitrogen in the burger samples treated with ginger powder, there was a significant increase for the third storage period, which recorded 0.34 mg nitrogen/g meat, despite comparing it with the first storage period (3 days), which amounted to 0.15 mg nitrogen/kilogram of beef. This is because cold storage does not stop the activity of chitin enzymes in the meat, which does not lead to the decomposition of protein materials but works to slow them down. With the increase in the storage period in refrigeration, the number of decompositions increases, which contributes to free nitrogen groups, and their separation from the protein leads to an increase in the total volatile nitrogen amount (Senturk Parreidt et al., 2018). These results were consistent with the results of Al-Rubaie and others (2008), who observed that TVN was an increased advancement of the storage period for beef preserved in refrigeration at 4 °C for different periods.

Sensory evaluation of beef burger samples

1) Freshness

The sensory evaluation of the freshness characteristic is shown in Table 6. The results of the statistical analysis showed that the third treatment (3.91) differed significantly ($p<0.05$) from the first and fourth treatments (3.97 and 3.91), respectively. The table also showed a significant effect ($p<0.05$) of the storage period on the freshness characteristic if it increased with the increase in the storage period, as the third storage period was significantly more (3.83) than the first and second storage periods (3.29 and 3.79), respectively. These results were observed by Ajhani et al. (2022) when the soil was flooded with fruits during rainfall at a concentration of 5%. The wine storage period extended from 65 to 105 days, which led to a significant increase in the percentage of total soluble solids in the fruits, and a decrease in weight, total sugar percentage, and carotene content in the ridge.

2) ***Juiciness***

The sensory evaluation of the juiciness characteristic is shown in Table 7. The statistical analysis results showed no significant differences between the treatment rate of the burger samples treated with ginger powder and the control treatment. The same table also showed a significant effect ($P<0.05$) of the storage period on the degree of juiciness if it increased with the increase in the storage period, as the third storage period was significantly superior (3.50) compared to the first and second partial periods (3.07 and 3.27), respectively. The increase in juiciness values with the increase in the storage period is due to the increase in pH values and their distance from the electrical neutrality point, thus increasing the ability of the meat to hold water. When estimating the fate in the samples treated with aromatic oils, the juiciness values were recorded as less than those found by AL. Zaid et al., (2023). The increase in juiciness is also because ginger contains phenolic compounds, has high antioxidant activity, inhibits free radicals, and protects cell membranes. This results in a decrease in the exudate and maintains the nutritional value of meat and its products (Jebur & Almaaeny, 2018). This was confirmed by Holze et al. (2023) in their study. It is noted in the same table that there are significant differences ($P<0.05$) regarding the interaction between the different treatments for the mentioned periods.

3) Overall acceptable

The general acceptability trait in Table 8 shows that rates from the second, third, and fifth treatments are significantly varied. As for the different storage periods, it is noted in the same table that there were no significant differences between storage times. Adding ginger powder improves the juiciness and tenderness, and it has an antioxidant effect, thus preserving the flavour of the burger, preventing the appearance of rancidity in the taste, and preserving the moisture of the meat, which was reflected in the general acceptability trait (Cai et al. 2015).

CONCLUSIONS

The current study concludes that many important developments have emerged when mixing minced meat with ginger powder to manufacture beef burger patties, including important improvements in chemical and sensory aspects. Adding ginger powder played an effective role in increasing the percentage of both protein and fat when compared to the control sample, which in turn improves the nutritional value of the final product. On the other hand, both free fatty acids and thiobarbituric acid (TBA) in the samples to which ginger powder was added were significantly lower when compared to the control sample, which confirms the importance of added ginger powder during the beef burger manufacturing process by increasing the stability of the product during storage for long periods. In addition, the juiciness and softness of the burger samples mixed with ginger appeared to be greater than the control sample, which led to increased interest in consuming these samples due to the increased palatability of consumers. This confirms that adding ginger powder has helped reduce the negative changes that may occur to the Birker discs during cold storage. As a result, it is recommended that ginger can be used as a natural anti-oxidant powder for fats, as it improves the sensory, chemical, and storage properties, making it a suitable natural alternative to unnatural preservatives during food manufacturing processes.

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Supplementary data

Table 1. Specifications for ginger powder solution

Sample	Carbohydrates	Flavonoids	Alkaloids	Phenols	Terpenes	Tannins
Ginger powder solution	+	+	+	+	—	—

Table 2. Influence of varying levels of tocopherol powder on the free fatty acid content.

Storage Duration	Control	1% Tocopherol	1.5% Tocopherol	2% Tocopherol	Date Powder
3 Days	0.20 ± 0.08 [a]	0.06 ± 0.02 [fg]	0.08 ± 0.02 [de]	0.10 ± 0.05 [cd]	0.09 ± 0.03 [b]
6 Days	0.15 ± 0.09[bc]	0.04 ± 0.01 [g]	0.07 ± 0.02 [defg]	0.08 ± 0.02 [def]	0.07 ± 0.02 [b]
9 Days	0.16 ± 0.05 [b]	0.04 ± 0.01 [fg]	0.07 ± 0.02 [defg]	0.08 ± 0.02 [def]	0.07 ± 0.02 [b]
12 Days	0.09 ± 0.05 [b]	0.03 ± 0.01 [fg]	0.07 ± 0.02 [defg]	0.08 ± 0.02 [def]	0.07 ± 0.02 [b]
14 Days	0.12 ± 0.09 [bc]	0.04 ± 0.01 [g]	0.07 ± 0.02 [defg]	0.10 ± 0.05 [cd]	0.09 ± 0.03 [b]

The results indicate significant differences between the various concentrations based on the confidence level P<0.05.

Table 3. Standard TBA values for beef burgers fortified with different concentrations of ginger powder at 4±2°C for different periods

Beef burger / **Storage duration**	Control sample	**0.5% Ginger powder sample**	**1% Ginger powder sample**	**1.5% Ginger powder sample**	**2% Ginger powder sample**	**Average rate**
3 Days	0.78±0.28[bcd]	0.76±0.28[abc]	0.92±0.50 [ab]	1.02±0.49[abc]	1.01±0.50[abc]	0.90±0.16 [a]
6 Days	0.62±0.15 [cd]	1.17±0.46 [ab]	0.99±0.44[abc]	0.92±0.22[abc]	0.38±0.17 [ab]	0.96±0.15 [a]
9 Days	1.29±0.17 [a]	0.77±0.29 [bed]	0.56±0.20 [b]	0.65±0.21 [cd]	0.91±0.48 [d]	0.75±0.10 [a]
Average transaction	1.04 ± 0.19 [a]	0.90 ± 0.19[ba]	0.82 ± 0.21 [b]	0.86±0.18 [b]	0.62 ± 0.11 [b]	—

*Different letters within the same row and column indicate significant differences at the significance level (P<0.05).

Table 4. Peroxide values for beef burgers fortified with different concentrations of ginger powder at 4±2°C for different periods

Beef burger / Storage duration	Control sample	**0.5% Ginger powder sample**	**1% Ginger powder sample**	**1.5% Ginger powder sample**	**2% Ginger powder sample**	**Average rate**
3 Days	0.80±0.30[bcd]	0.78±0.30[abc]	0.94±0.52 [ab]	1.04 ±0.51[abc]	1.03 ±0.52[abc]	0.92±0.18 [a]
6 Days	0.64±0.17 [cd]	1.19±0.48 [ab]	1.01 ±0.46[abc]	0.94±0.24[abc]	0.40±0.15 [ab]	0.98±0.17 [a]
9 Days	0.31±0.19 [a]	0.79 ± 0.31[bcd]	0.58±0.22 [b]	0.67±0.23 [cd]	0.50±0.39 [d]	0.77±0.12 [a]

Average transaction	0.21 ±0.06 [a]	0.92 ± 0.21 [b]	0.84±0.23 [b]	0.88±0.20 [b]	0.64 ±0.13 [b]	_

* Significant differences at (P<0.05) level are indicated by different letters within the same row and column.

Table 5. Total volatile nitrogen for beef burgers fortified with different concentrations of ginger powder at 4±2°C for different periods

Beef burger / **Storage duration**	Control sample	**0.5% ginger powder sample**	1% **ginger powder sample**	**1.5% ginger powder sample**	2% **ginger powder sample**	**Average rate**
3 Days	0.23±0.11 [a]	0.14±0.04 [a]	0.14±0.04 [a]	0.12±0.02 [a]	0.14 ±0.03 [a]	0.15±0.03 [b]
6 Days	0.25±0.10 [a]	0.25±0.09 [a]	0.18±0.06 [a]	0.17±0.09 [a]	0.17±0.08 [a]	0.20±0.04 [ab]
9 Days	0.25±0.11 [a]	0.46±0.23 [a]	0.16±0.05 [a]	0.42±0.25 [a]	0.43±0.25 [a]	0.34±0.08 [a]
Average transaction	0.24±0.05 [a]	0.28±0.09 [a]	0.16±0.03 [a]	0.23±0.09 [a]	0.25±0.09 [a]	_

* Significant differences at (P<0.05) level are indicated by different letters within the same row and column.

Table 6. Freshness value of beef burger samples during cold storage at 4±2 °C for different days

Burger sample / **Storage (Days)**	**Control sample**	**0.5% Ginger powder**	**1% Ginger powder**	**1.5% Ginger powder**	**2% Ginger powder**	**Average rate**
3	4.19±0.08 [a]	3.03±0.15 [a]	2.86±0.04 [a]	3.36±0.14 [a]	2.69 ±0.17 [a]	3.29±0.13 [a]
6	4.03±0.09 [a]	3.86±0.14 [a]	3.36±0.19 [a]	4.03±0.31 [a]	3.69±0.42 [a]	3.79±0.12 [a]
9	3.69±0.18 [a]	3.69±0.14 [a]	3.36±0.19 [a]	4.36±0.32 [a]	4.03±0.43 [a]	3.83±0.12 [a]
Average period	3.97±0.04 [a]	3.53±0.09 [a]	3.19±0.01[ab]	3.91±0.17 [a]	3.47±0.23 [ab]	_

* Significant differences at e level (P<0.05) level are indicated by different letters within the same row and column.

Table 7. Juiciness value of beef burger samples during cold storage at 4±2 °C for different days

Burger sample / Storage (Days)	**Control sample**	**0.5% Ginger powder**	**1% Ginger powder**	**1.5% Ginger powder**	**2% Ginger powder**	**Average rate**

3	3.70±0.28 ab	3.37±0.18 a	3.04±0.07bc	2.87±0.19bc	2.69 ±0.17 a	3.07±0.08 b
6	3.37±0.26abc	3.20±0.14abc	3.04±0.07bc	3.37±0.32abc	3.69±0.42 a	3.27±0.14 ab
9	3.04±0.23bc	3.70±0.20 ab	3.20±0.09 ab	3.87±0.23 a	4.03±0.43 a	3.50±0.07 a
Average period	3.37±0.16 a	3.42±0.012 a	3.09±0.06a	3.37±0.18 a	3.47±0.23 ab	_

* Significant differences at (P<0.05) level are indicated by different letters within the same row and column.

Table 8. Overall acceptable value of beef burger samples during cold storage at 4±2 °C for different days

Burger sample / Storage (Days)	Control sample	0.5% Ginger powder	1% Ginger powder	1.5% Ginger powder	2% Ginger powder	Average rate
3	4.20±0.09 a	3.87±0.18 a	3.37±0.06a	3.87±0.14a	3.04 ±0.24 a	3.67±0.13 a
6	4.04±0.05 a	3.70±0.15a	3.54±0.09a	4.04±0.18a	3.70±0.31 a	3.80±0.13 a
9	4.04±0.05 a	4.20±0.18 a	3.54±0.09 a	4.37±0.18 a	4.70±0.30 a	3.97±0.13 a
Average period	4.03±0.06 a	3.92±0.12 ab	3.48±0.06b	4.09±0.11 a	3.48±0.30 b	_

* Significant differences at (P<0.05) level are indicated by different letters within the same row and column.

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