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Antimicrobial Activity of Dill Seeds and Celery Seeds on Beef Burger

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Medicinal plants possess compounds that can replace the conventional chemical preservatives utilized to preserve meat, which have adverse health effects on consumers. Many biochemical properties of dill and celery seeds as antimicrobial agents have been stated; thus, the present research aimed to determine the effect of employing dill and celery seed extracts as antimicrobial agents in beef burgers. In this study, dill and celery seed were extracted with methanol, ethanol, and acetone. Results showed that maximum yield was obtained from dill and celery seed extracts using methanol (58.4% and 55%). Total phenolic compound (TPC), total flavonoid (TF), total tannin contents (TTC), antioxidant activity, and the fraction of phenolic substances were identified in different extracts. Results showed that dill seed extract has the highest scores of TPC (8.22 mg/GAE/g), TFC (4.99 mgQE/g), and TTC (0.91%). The scavenging effects of dill and celery seed extracts on DPPH radicals were recorded (91.84%) in dill seed extract and (84.12%) in celery seed extracts. Additionally, antibacterial results showed that dill and celery seed extracts inhibited all

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tested microorganisms (*Staphylococcus aureus*, *E. coli* O157:H7, *Salmonella typhimurium*, *Pseudomonas aeruginosa*, and *Listeria monocytogenes*). At concentrations of 0.5%, 1.0%, and 1.5%, dill, and celery seed extracts were individually added to beef burgers as antimicrobials. Furthermore, by reducing the growth of bacteria throughout the preservation period, the treated burger had a substantially longer shelf life than the control sample. However, (TVN) Total volatile nitrogen, (TBA) Thiobarbituric acid, and total plate count in each sample containing dill and celery seed extracts were smaller than the control at zero time and rose over time in every specimen. However, beef burger samples containing extracts of dill and celery revealed a slower rate of increase relative to the control. All the parameters of sensory evaluation of cooked beef burger samples prepared by adding 0.5, 1, and 1.5 % of dill and celery seed extracts were acceptable. Results showed a slightly decreasing taste and flavor value obtained by 1.5 dill and celery seed extracts. Finally, extracts of dill and celery seed could be used as functional ingredients in meat-based foods.

Keywords: Phytochemical compounds; antioxidant activity; antimicrobial; anethum graveolens; apium graveolens; plant seed extracts; beef burger.

1. INTRODUCTION

Antimicrobial compounds in culinary products are intended to enhance consumer health and regulate herd immunity. As a source of antibacterial chemicals, plant seed is a relatively novel option. Numerous industries have benefited monetarily from using plant seed, which is typically discarded [1].

Southern Europe is the natural habitat of the *Umbellifer* family member *Anethum graveolens*. *Anethum graveolens* is a yearly crop native to the Mediterranean and Asia (central and southern). It is now grown extensively across the globe [2]. It possesses an extensive history of utilization, extending back more than 5,000 years, as a popular aromatic herb and spice. It was utilized as a treatment for dyspepsia and flatulence, as well as a milk production booster. In addition, it serves as an anti-emetic, anti-convulsant, anti-cramping agent (in infants), appetite stimulant, wound healer, and stomach strengthener [3]. *Anethum graveolens Linn.* is extensively utilized in traditional herbal remedies for the treatment of a *var*iety of illnesses. To offer an empirical basis for traditional applications of such vegetation, the antimicrobial capacity of their organic and aqueous seed extracts and isolated phytoconstituents was evaluated. To set up an empirical foundation for these conventional treatments, the present investigation aimed to evaluate their antibacterial properties utilizing extracts (organic and aqueous) toward some clinically significant bacteria. Major biologically active phytoconstituents were determined by phytochemical screening [4].

Apium graveolens (of the family *Apiaceae*) is a plant frequently known as 'Celery' that has been widely farmed for over three thousand years, primarily in Egypt, Shinnawy NA [5]. The epithet 'celeriac' describes a variety of this species called *Apium graveolens* var. *rapacious*. Despite the stem becoming the most widely utilized part of the crop as an ordinary vegetable, the seeds of celery are seen to have been utilized for therapeutic reasons (in Egypt and China) for treating asthma, bronchitis, liver, and spleen diseases; however, they have a hepatoprotective activity against many hepatotoxins [3]. Celery (*Apium graveolens*; *Apiaceae*) is a medicinal plant used in Unani and Ayurvedic medicine. Extracts of celery roots, leaves, seeds, and stems have remarkable medicinal properties, according to scientific evidence.

Additionally, the abundance of fatty acids, proteins, phytochemicals, and micronutrients in seeds makes them essential to human nutrition. Celery seeds contain various medicinally active compounds, including phenols, alkaloids, phthalides, coumarins, glycosides, limonene, myrcene, flavonoids, and steroids. Celery seeds possess antihyperlipidemic, anticancer, antidiabetic, antibacterial, antioxidant, and anti-inflammatory properties [6]. Vegetation seed was recognized as one of the main antimicrobial substance sources. Antibacterial substances derived from plant seeds have been discovered to inhibit or reduce pathogenic and decaying microbes effectively and offer remedies for antibiotic resistance [7]. Recently, researchers in the food business have sought alternative sources of antibacterial and chemical preservatives to combat bacterial and lipid oxidation invasions [8]. Meat and its derivatives, like beef burgers, are ingested extensively worldwide. However, these products' shelf life is

diminished during storage. Organoleptic agent breakdown and lipid oxidation alter the meat products' texture, flavor, and color. Additionally, food loss and pathogenic microbes might pollute meat products, posing public health risks and causing financial losses [9].

This work is intended to identify the phytochemical composition, antioxidant capacity, and antimicrobial capacity of *Apium graveolens* and *Anethum graveolens* seed. Additionally, to improve the burgers keeping quality and prolong the shelf life through the use of dill and celery seed extracts at varying concentrations and their potential use as natural food additives.

2. MATERIALS AND METHODS

2.1 Materials

Celery (*Apium graveolens*) and dill *(Anethum graveolens)* seeds were sourced from a local private farm, EL-Mansoura, AL-Dakahlya Government.

Frozen beef meat and fat were purchased from the local butcher store. The meat was refrigerated overnight at 5±1ºC prior to the experiment. Other ingredients, including garlic, seasonings, onion, salt, starch, and refined sunflower oil, were sourced from market.

Microbial strains included three gram-negative pathogen bacteria, *Salmonella Typhimurium* (ATCC 14028), *Pseudomonas aeruginosa,* and *E. coli* O157:H7. Additionally, microbial strains included two gram-positive pathogens strains, *Listeria monocytogenes* (ATCC 7644) and *Staphylococcus aureus* (25923). Microorganism strains were obtained from The National Research Center, Food Industry and Nutrition Division and kept at -20°.

2.2 Methods

2.2.1 Sample preparation of seed powder

The seeds were washed and kept at room temperature in a laboratory until usage. Prior to extraction, the seeds had been ground with a laboratory grinder.

10 g of each seed powder was weighed and incubated for 24 hours in a Soxhlet apparatus containing 150 mL of methanol, acetone, and ethanol. Subsequently, the mixture was filtered. Next, the filtrate was collected. Then, the solvents were extracted by evaporation. Before proceeding with the analysis, the extract was chilled in a desiccator [10].

2.2.2 Burger preparation formulas

The Special Food and Nutrition Department, Food Technology Research Institute, Agricultural Research Center prepared seven varieties of formulations. Individually tested samples were prepared with 0% (control), 0.5, 1, and 1.5% dill seed and celery seed extracts. Using the method outlined by Dreeling et al. [11], beef burger were prepared. The burger formulation ingredient percentages are displayed in Table 1. Each burger's ingredients were homogenized in a Braun Cutter Machine (CombiMax 700, USA). Subsequently, the mixture was formed into approximately 45-55 gram weight patties with an 8 cm diameter and 1 cm thickness.

Table 1. Beef burger formulation

Mean ingredient%	Control	Dill seed extract			Celery seed extract		
		0.5%	1%	1.5%	0.5%	1%	1.5%
Beef meat	65	65	65	65	65	65	65
Beef fat	15	15	15	15	15	15	15
Iced water	10	10	10	10	10	10	10
Dried onion	3	3	3	3	3	3	3
Dried garlic	3	3	3	3	3	3	3
Salt	2	2	2	2	2	2	2
Spices	2	2	2	2	2	2	2
Total	100	100	100	100	100	100	100
Additives (%)							
Dill seed extract		0.5	1	1.5	0.5	1	1.5
Celery seed extract		0.5	1	1.5	0.5	1	1.5

2.2.3 Determination of extraction yield

The yield extraction was determined using the following equation in accordance with Kumar et al. [12].

> Yield% = (weight of dried extract)/ (weight of plant sample) x100

2.2.4 Phytochemical analysis of extracts

According to Singleton and Rossi [13], total phenolic compounds were measured colorimetrically.

2.2.5 Fraction of phenolic compounds

According to Goupy et al. [14], phenolic compounds were determined using HPLC. Five grams of the specimen were combined with methanol and centrifuged for 10 min at 1000 rpm. Subsequently, the supernatant filtered through a 0.2 Mm Millipore membrane filter then 1-3 ml was collected in a vial for injection into HPLC Agilant. (Series 1100) equipped with outo-sampling injector, solvent degasser, ultraviolet (UV) detector set at 280 nm and quaternary HP pump (series 110). The column temperature was kept at 35º. The graduated separation was carried out with acetonitrile and methanol as the mobile phases at a 1 ml/min flow rate. Sigma Company standards of phenolic acid have been dispersed in a mobile phase. Agilent software was used to determine the phenolic substance level using retention time and peak area.

2.2.6 Total flavonoid determination

Using a colorimetric assay, the total flavonoid level was determined [15]. The calibration curve utilized catechin as the standard. The overall amounts of flavonoids were determined as (mgCE/g of the sample).

2.2.7 Total tannin determination

Ten milliliters of standard Tannic acid solution were diluted with one hundred milliliters of distilled water. Aliquots (1-10 ml) have been collected in clear test tubes. Each test tube was filled with Folin-Denis solution (0.5 ml) and sodium carbonate buffer (1 ml). Each container contained 10 ml of distilled water. According to Saxena et al. [16], all solutions in each vial were mixed well and left undisturbed for 30 minutes before being read at 760 nm against the reagent blank.

2.2.8 Antioxidant activity determination

According to the methodology of Park et al. [17], plant extract's free radical scavenging effect was evaluated. Briefly, the reaction mixture comprising 2 ml of DPPH and 2 ml of extract was violently agitated and maintained for 30 minutes at room temperature in the dark. When the DPPH reached with an antioxidant compound in an extract that can donate hydrogen, it was reduced and resulting decrease in absorbance at 517 nm using UV-visible spectrophotometer, and the mean values were obtained from triplicate experiments. The percentage of remaining DPPH was plotted against the sample concentration. A lower value indicated greater antioxidant activity. The following equation was utilized to calculate the radical scavenging activity as a percentage of inhibition.

> % DPPH = [Abs. of Control – Abs. of sample/ Abs. of control] × 100.

2.2.9 Microbiological analysis

An assessment of the antimicrobial efficacy of different extracts was determined. However, according to Kaur et al. [3], the antimicrobial capacity of tested extracts toward bacterial strains was determined using the disc diffusion technique as a screening procedure. Sterilized filter paper disc (6mm) were soaked in 10 µl of different contraction (10, 20 and 30 mg/ml) of methanol. The medium without any plant extract in petri plates served as negative control and medium with ciprofloxacin served as positive control. The soaked discs were put in the plates which were contained 0.1 ml bacterial inoculums and the plates were incubated at 37 C for (staph. Aureus, E.coli , salmonella typhimurium and listeria monocytogenes). All strains incubated for 24h. The diameter of zone of inhabitation around each of discs (disc diameter included) was taken as measured of antimicrobial activity all tests were performed in triplicates.

2.2.10 Total microbial count in the prepared beef burger

The procedure outlined by Abdulla et al. [18] was utilized to analyze the contamination and proliferation of microorganisms in the beef burger via the total plate count (TPC). Using a lap mixer, beef burger specimens (10 g) were thoroughly incorporated with sterilized peptone water (90 ml) at 0, 1, 2, and 3 months during the storage period. Subsequently, 100 ml of each serial

dilution was moved onto a prepared count agar plate (Difco Laboratories, Detroit, MI, USA). After 48 hours of incubation at 35°C, the colonies were recorded as log10 CFU/g [18].

2.2.11 Determination of TBA and TVN beef burger

Thibarbituric Acid method (TBA) [18] determined the TBARS number in triplicate. In brief, ten grams of beef burger specimens were homogenized for two minutes with 25 milliliters of distilled water and 25 milliliters of 10% trichloroacetic acid (TCA). The specimen was filtered (utilizing No. 1 Whatman filter paper). Subsequently, 1 ml of 0.06 M thiobarbituric acid in acetic acid (TBA reagent, 90%) was transferred to filtrate (4 ml) in a vial and thoroughly mixed. To develop the chromogen, vials were sealed and heated for 10 minutes in a boiling water bath before being chilled to room temperature. Using a spectrophotometer, the absorbance at 538 nm was detected relative to a blank consisting of 1 ml of TBA-reagent and 4 ml of distilled water. The TBA values were determined as milligrams of malondialdehyde per kilogram of the specimen, utilizing the following formula.

TBARS number (kg) = Absorbance × 7.8

Total volatile nitrogen (TVN) was calculated using the procedure outlined by Malle and Poumeyrol [19]. In a blender, 200 milliliters of trichloroacetic acid (TCA) (7.5%) and the beef burger specimen (100 grams) were combined, and the mixture was filtered through filter paper. Twenty-five filtrates were added to the macro-Kjeldahl apparatus distillation unit, primed with 5 mL of 10% NaOH, and the distillate was obtained in 15 ml of 4% boric acid. The distillate was then titrated with H2SO4 (0.05 N), and the endpoint was determined using methylene red–bromocresol green. 25 mL of 7.5% trichloroacetic acid was employed as a blank instead of the sample. TVN was determined to be mg/100g using a formula as follows.

TNV (mg N/100gm) = [0.05 H_2SO_4 x 14 x (200 + Moisture content/100-100)] / [25 x 100]

2.2.12 Sensory evaluation

Ten panelists from the sensory evaluation team at the Department of Special Food and Nutrition, Food Technology Research Institute, Agriculture Research Center, Giza, Egypt, assessed the cooked burgers from each treatment. Male and female panelists of varying ages were instructed to evaluate each sample individually, without comparing it to other specimens. The panelists were acquainted with the questionnaire format that was utilized. Using a 9-hedonic scale test as described by LARMOND [20], the samples were assessed for their appearance, color, tenderness, flavor, and overall acceptability. The scale ranged from 9 (like extremely) to 1 (dislike extremely). To neutralize the flavor between samples, water, and bread were utilized.

2.2.13 Statistical analysis

A one-way analysis of variance (ANOVA) was carried out to compare the means of the categories. Duncan's multiple range test identified significant differences between the means, and < 0.05 was considered significant [21].

3. RESULTS AND DISCUSSION

3.1 Yield Extracts of Dill and Celery Seeds

A significant consideration for separating specific elements from plants is the choice of an extraction solvent [22]. The extract yields obtained from dill and celery seed powder by various extraction techniques are displayed in Table 2. The methanol extract shows that the maximum yield value was obtained from dill and celery seed extracts. The maximum yield was obtained from dill and celery seed extracts using methanol (58.4% and 55%), followed by dill and celery seed extracts using acetone. On the other hand, the yield from ethanol extract was the lowest, either in dill or celery seed extracts (Table 2). The final product of extracts depends on a variety of factors, like the vegetative part, the season and maturity of the part plant, and the agro-climatic conditions from which that part is collected. These findings agree with those of Nour et al. [23], who displayed that the antioxidant amount of the methanolic preparations of the chosen aromatic species was extremely high.

Regarding the sampling procedure, it was determined that methanol was an effective solvent for extracting the compounds, consistent with prior studies utilizing methanol for obtaining organic antioxidants from other kinds of vegetation [24].

Table 2. Yield extract of dill and celery seed solvents

Extract methods	Yield, %
Dill seeds methanol extract	58.4
Dill seeds ethanol extract	46.01
Dill seeds acetone extract	52.06
Celery seeds methanolextract	55.0
Celery seeds ethanol extract	48.9
Celery seeds acetone extract	54.6

3.2 Phytochemical Analysis and Antioxidant Capacity of Dill and Celery Extracts

The total flavonoid compound (TFC), total phenol compound (TPC), and total tannin content (TTC) of dill seed extract were greater than those of celery seed extract, as shown in Table 3. However, the crop's quality and nutritional value are enhanced by these phenolic substances. It was found that dill seed extract has the highest TPC (8.22 mg/GAE/g), TFC (4.99 mgQE/g), and TC (0.91%) compared to celery seed extract. Additionally, the greatest antioxidant capacity was identified in dill seed extracts (91.84%), followed by celery seed extracts (84.1%), in a similar order as for total phenolic composition. Phenolics are being identified as potent antioxidants that inhibit the effects of free radicals and reactive oxygen species (ROS), which are at the root of several chronic infections among people [25].

These findings align with those of Nour et al. [23], who stated that celery and dill plants exhibited the greatest antioxidant capacity. In addition, there was a significant association between antioxidant activity and total phenolic content in the four aromatic botanicals investigated.

Tannins are naturally occurring polyphenols in various vegetative parts, including seeds, fruits, and vegetables. However, the amount of this chemical is essential for the seeds' antioxidative characteristics to be justified. These substances are essential in avoiding disease and maintaining health [26]. TTC was greater in dill seed extract (0.91%) than in celery seed extract (0.78%) (Table 3).

The half-maximum inhibitory concentration IC50 Where: (TTC) Total tannin content; (TFC) Total flavonoids content; (TPC) Total phenolic compound.

According to Isbilir and Sagiroglu [27], dill may also be utilized as an easily accessible supply of natural antioxidants and as a potential dietary supplement.

3.3 Phenolic Compounds in Dill and Celery Seed Extracts

An analysis of the phenolic compounds in dill and celery seed extracts is shown in (Table 4). Ellagic acid and rutin were the main phenolic substances in dill and celery seed extracts. Ellagic acid in dill and celery seed extracts ranged from 245.42 mg/100g in dill seed extract to 199.6 mg/100g in celery seed extract of the identified polyphenolic compounds. Rutin in celery seed extract (194.01 mg/100g) was higher than in dill seed extract (155.21mg/100g). On the other hand, sinapic acid, caffeic acid, chlorogenic acid, epicatechin, coumaric acid, ferulic acid, trans-cinnamic acid, salicylic acid, and quercetin in dill seed extract were higher than celery seed extract. Myricetin has a favorable impact on renal functions and is an intriguing option for the chemoprevention of skin cancer [28,29].

These findings agree with those of Paven et al. [30] on the extracts of *Anethum graveolens* (fresh leaves and seeds). However, high antioxidant capacity and the profile of individual polyphenols were exhibited by the total phenolic content of these components of plants. Meanwhile, caffeic acid, protocatechuic acid, coumaric acid, rosmarinic acid, ferulic acid, resveratrol, rutin, quercetin, epicatechin, kaempferol, and gallic acid were the most common polyphenols found. Additionally, Atalar et al. [31] found that the phenolic compound analysis of the celery seeds extracted was performed using the HPLC method. Gallic acid, trans-ferulic acid, caffeic acid, and o-coumaric acid were among the phenolic substances identified in the seeds of the *Apium graveolens* plant.

3.4 Antibacterial Activity of Dill and Celery Seed Extract Against Tested Pathogenic Bacteria

Table 5 shows the dill and celery seed extracts' activity against pathogenic bacteria. Results indicated that the celery and dill seed extracts had powerful antimicrobial activity against all tested microbes, including *Staph aureus*,

Pseudomonas aeruginosa, *Salmonella typhimurium*, *Listeria monocytogenes*, and *E. coli* O157:H7. Maximum antibacterial activity of dill seed extract was observed against *Staph aureus* with a 36 mm inhibition zone diameter, followed by *E. coli* with a 34 mm inhibition zone since the extract inhibited the growth of bacteria. Additionally, the celery seed extract was also evaluated as an antimicrobial toward similar microbes, but it displayed a slightly less potential impact than the dill seed extract. Extracts of celery and dill seed were highly antimicrobial against all microorganisms tested. Antibacterial activity has also been attributed to flavonoids due to their capacity to form complexes with bacterial cell walls as well as soluble and extracellular proteins [32]. Tannins, a further category of polyphenolic substances, exert their antimicrobial activity by precipitating microbial proteins; their antimicrobial potency is proportional to their levels in vegetation [33].

According to Varga et al. [34], a seedling of dill (*Anethum graveolens*) had an increased fatal impact on E. coli living cells. This report indicates that dill seed extract may be utilized to preserve junk food as well as in pharmacological and natural remedies for infectious illnesses in both people and vegetation. In addition, Monica and Diana [6] stated that celery (*Apium graveolens*) seeds are essential to diets due to their high phytochemical content. Numerous *in vivo* (animal model) and *in vitro* studies have demonstrated that celery seeds have antioxidant, anticancer, antidiabetic, antihyperlipidemic, antimicrobial, antihypertensive, and anti-inflammatory properties.

3.5 Effect of Storage Period on TBA and TVN Values of Burger

Table 6 shows the impact of the storage period on the TBA and TVN mean values (mg/100g) of the control and the treated burger with dill and celery seed extraction. The variation of TBA and TVN mean values between the third month of the storage period and zero time for all samples was significant. The TBA assay provides a direct assessment of lipid oxidation in meat-based goods, and its correlation with the sensory assessment is strong. The sensitivity of the TBA test to detect the breakdown of unsaturated fatty acids allows it to assess oxidation more accurately than peroxide levels [35].

Table 3. Phytochemical analysis and antioxidant activity of dill and celery extracts

Seeds extracts	Total phenolic, mg GAE/g	Total flavonoids, mgQE/g	Total tannins, %	DPPH, %
Dill seed extract	8.22	4.99	0.91	91.84
Celery seed extract	6.81	3.6	0.78	84.12

Table 4. Phenolic compounds in dill and celery extract, mg/100g

Compounds	Seed extract	
	Dill	Celery
Gallic acid	24.09	12.09
Catechin hydrate	4.8	5.03
Vanillic acid	3.11	4.98
Chlorogenic acid	6.91	1.73
Caffeic acid	21.01	01.31
Syringic acid	1.82	3.24
Epicatechin	33.44	12.01
Coumaric acid	13.41	1.22
Ferulic acid	25.01	0.66
Sinapic acid	86.01	0.51
Salicylic acid	16.22	3.01
Rutin	155.21	194.01
Ellagic acid	245.2	199.6
Myricetin	36.44	38.22
Trans cinnamic acid	11.89	7.41
Quercetin	14.01	5.32

Table 5. Screening of the antimicrobial capacity (inhibition zone diameter in mm) of dill and celery seed extracts toward pathogenic microorganisms

Microorganism	Seed extract	
	Dill	celery
Staph aureus	36	28
Pseudomonas aeruginosa	23	18
Salmonella typhimurium	28	26
Listeria monocytogenes	27	25
E. coli O157:H7	34	24

Table 6. Effects of dill and celery seed extracts on TBA and TVN through the storage period for three months

Treatments		TBA values mg malonaldehyde/kg				TVN values mg/100g			
		0	1	2	3	0	1	2	3
		Months				Months			
Control		0.44 ^{a}	0.53^{a}	0.62^{a}	0.73^{a}	6.20^{a}	8.14^{a}	10.08^{a}	11.91^{a}
Dill seed extract	0.5%	0.35^{a}	0.38^{b}	0.42^{b}	0.49^{b}	5.67^{ab}	7.06^{b}	8.05^{b}	8.88^{b}
	1.0%	0.28^{b}	0.30^{b}	0.34^{c}	0.39^{c}	5.07^{b}	6.44^{c}	7.79^{b}	8.64^{bc}
	1.5%	0.19^{c}	0.21^{c}	0.23^{d}	0.25^{d}	4.53^{c}	5.6^{d}	6.7^{c}	7.9^{c}
Celery seed extract	0.5%	0.37^{a}	0.39^{b}	0.42^{b}	0.45^{b}	5.7^{b}	6.9^{b}	8.1^{b}	9.1^{b}
	0.1%	0.31^{ab}	0.34^{b}	0.39^{bc}	0.42^{b}	5.29^{b}	6.49^{c}	7.69^{b}	8.79^{b}
	1.5%	0.20^{c}	0.24^{c}	0.26^{d}	0.28d	4.8b^{c}	5.91^{cd}	6.9^{c}	8.00^{c}

The same small letters within the same column indicate no significant differences between treatments, whereas different small letters indicate significant differences between treatments (P < 0.05) according to Duncan's multiple comparison test

The highest rates of TBA were found in control samples (0.44), while treated samples with 1.5 % dill and celery seed extracts had the lowest rate (0.19) and (0.2), respectively. These findings agree with those of Sayas-Barberá et al. [36], who stated that adding antioxidant-active substances, particularly those derived from plants with a high phenolic ingredient content, reduces the rate of peroxidation. In addition, the Egyptian Organization for Standardization and Quality (EOSQC)-2005 [37] stated that TBA levels are restricted to 0.9 mg of malonaldehyde per kilogram of meat products.

The breakdown of protein in stored meats generates volatile nitrogen substances, hydrogen sulfide, and amines, causing a loss in the bioavailability and quality of proteins, as well as a reduction in their capacity to bind to water. However, there is a reduction in nutritional value, as protein is a particularly vital component in animal-based foods [38]. The breakdown of protein and nitrogenous substances into volatile nitrogen can additionally be triggered by microbiological action, which may enhance the TVN levels in meat products during preservation [39]. In Table 6, the mean TVN amounts for various procedures during preservation are displayed. The TVN of all specimens rose considerably (p 0.05) but at varying rates throughout the frozen preservation of beef burgers, reaching a peak in the third month relative to the starting number of the control specimen. The burger specimens augmented with 0.5%, 1.0%, and 1.5% dill and celery seed extracts had lower percentage rises relative to the starting points. In the third month, the burger treated with 1.5% dill seed extract had the lowest TVN (7.9 mg/100g), while the control burger had the highest TVN (11.91 mg/100g). No one of the produced beef burger specimens surpassed the quality standards stated by the EOSQC (2005) [37], as the highest TVN value (collected by the control in the third month) became 11.91 mg/100 g. Ozogul et al. [40] stated that green tea, oregano, and laurel extracts applied to fish burger portions throughout refrigeration reduced TVN levels.

These findings agree with those of Ragab et al. [41], who concluded that the protective impact of marjoram against microbes that accelerate the breakdown of protein to volatile nitrogen during preservation could be attributed to the reduced TVN levels. In addition, Kowalczyk et al. [42] discovered that the inclusion of chokeberry leaf extract, relative to the controls, increases the shelf-life storage time, according to instrumental. Additionally, these burgers earned a greater score for quality as a whole.

3.6 Effects of Dill and Celery Seed Extract Inclusion and Storage on Burger Total Plate Count

Table 7 shows the total bacterial count alteration in beef burgers with different levels of tested extracts during the frozen storage period. The results indicated that dill and celery seed extracts had a minor impact on the microbial burger quality; however, the growth rate became slow.

The results showed that dill and celery seed extracts had a slight effect on microbial burger quality, but the rate of growth was slow. This could be attributed to the polyphenol levels in dill and celery seed extract, which reduce the development rate and maximal growth number of the intended microbe while prolonging its late phase [43].

Table 7 reveals that dill and celery seed extracts had been integrated into the beef burger composition as antimicrobial substances and that both extracts yielded favorable outcomes as antibacterial remedies. However, dill seed extract exhibited greater antimicrobial activity than celery seed extract. These findings agree with those of Paven et al. [30], who exhibited that the extracts of *Anethum graveolens* seeds may be considered an abundant natural antioxidant source, especially recommended to be employed for healthy reformulation of food products with extended shelf-life to protect human health and promote wellness. In addition, Monica and Diana [6] noted that celery (*Apium graveolens*) seeds are essential to the diet of humans because of their antimicrobial properties.

3.7 Beef Burger Sensory Evaluation

Table 8 demonstrates the impact of dill and celery seed extracts on the sensory qualities of beef burgers. All sensory evaluation parameters of cooked burger samples prepared by adding 0.5%, 1.0%, and 1.5% dill and celery seed extracts were satisfactory. There was no significant effect on color and appearance score between the control sample and the burger addition with 0.5 and 1% of dill and celery seed extracts. On the other hand, the highest scores of tenderness and juiciness were found in burgers supplemented with 1 and 1.5% of dill and celery seed extracts compared to the other samples. However, the minimum value of taste and flavor was obtained by 1.5 dill and celery seed extracts. The burger with the lowest overall acceptability score was treated with dill and celery seed extracts. However, this may be due to the high polyphenol content of dill and celery seed extracts, which reduces taste and flavor Table (8). These outcomes agree with those of Al-Moghazy et al. [44], who stated that the sensory evaluation of burgers treated with 1, 1.5% of *portcula* extract showed no differences between control and treated samples.

Table 7. Effects of dill and celery seed extracts on beef burgers total plate count during the storage period

Treatments		Total plate count log10 CFU/g			
		0	1	2	3
		Months			
Control		2.65^{a}	3.13^{a}	3.54^{a}	3.89^{a}
Dill seed extract	0.5%	2.47^{bc}	2.83^{bc}	3.25^{ab}	3.64^{bc}
	1.0%	2.18^{c}	2.35^{d}	2.56^{d}	2.75^{d}
	1.5%	2.09^{d}	2.17^{d}	2.24^{e}	2.36^{e}
Celery seed extract	0.5%	2.57^{ab}	2.96^{ab}	3.12^{cd}	3.68^{ab}
	1.0%	2.38^{c}	2.65^{c}	3.01^{cd}	3.35^{c}
	1.5%	2.46^{bc}	2.61^{c}	2.80^{d}	2.97^{cd}

The same small letters within the same column represent no significant differences between different treatments, while different small letters indicate significant differences between different treatments (P<0.05) by Duncan's multiple comparison test

Table 8. Effect of addition dill and celery seed extracts on beef burger sensory characteristics

Parameters	Treatments						
	Control	Dill seed extract			Celery seed extract		
		0%	1%	1.5%	0%	1%	1.5%
Colour	8^{ab}	8^{a}	8^{ab}	7^{b}	8^{ab}	8^{a}	7^{b}
Taste	9^{a}	8^{a}	7^{b}	5^{b}	9^{a}	8^{a}	7^{b}
Flavor	9^{a}	7^{b}	6^{b}	5^{b}	8^{b}	7^{b}	6^{b}
Tenderness	8^{a}	8^{a}	9^{a}	9^{a}	8^{a}	8^{a}	9^{a}
Juiciness	8^{a}	8^{a}	9^{a}	9^{a}	8^{a}	9^{a}	9^{a}
Appearance	8^{a}	8^{a}	8^{a}	9^{a}	8^{a}	8^{a}	9^{a}
Overall acceptability	8^{ab}	8^{ab}	8^{a}	7^{b}	8^{a}	8^{a}	7^{b}

** Scores ranging from 0-3 = very poor, 4 = poor, 5 = fair, 6-7 = good, and 8-10 = very good. ** In rows, means with the same superscript are not significantly different, while different small letters indicate significant differences between different additions (P<0.05) by Duncan's multiple comparison test*

4. CONCLUSION

To conclude, adding 0.5, 1, and 1.5% dill and celery seed extract can successfully improve the quality and nutritional value of burgers and their shelf life. Therefore, it may provide an alternative means of utilizing this type of raw meat, thereby reducing economic losses in the meat industry.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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