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Research Article

Effect of Addition Ginseng with Silver Nanoparticles Extract on Chemical, Microbiological and Sensory Properties of Chilled Minced Meat

Eman I Saafan*

Food Industries Department, Faculty of Agriculture, Mansoura University, Egypt

***Corresponding Author:** Eman I Saafan, Food Industries Department, Faculty of Agriculture, Mansoura University, Egypt.

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Abstract

Minced meat is a perishable food item, so antioxidants are added to extend its shelf life. The use of legal extracts as natural antioxidants has also proven its effectiveness as an antimicrobial. Therefor this paper showed that ginseng extract was evaluated to improve the chemical, physical, sensory and microbial criteria of chilled minced buffalo meat samples by the addition of 200ppm from ginseng with silver nano particles extract cold storage at 4_oC up to spoil in compared with synthetic one (TBHQ). Results for characterization of nano-particles using Transmission Electron Microscope (TEM) illuminated that ginseng extract (GE) particles sizes being 123:200 nm, while ginseng with nano silver particles extract (GSNPsE) was 22:30 nm. Also, results of bioactive compounds elucidated that antioxidant activity of ginseng with silver nanoparticles extract is 79.56 ± 0.51% while content of total phenolic compounds being 48.50 ± 1.2mg GAE/g and total flavonoids being 62.83 mg RE /g. (GE) and (GSNPsE) clearly showed that chlorogenic, m-Coumaric and Gentisic have highest amount in both of nanoparticles extract being (95.25 ± 4.45, 122.70 ± 4.20), (90.32 ± 2.85, 118.86 ± 3.10) and (65.30 ± 1.55, 78.22 ± 1.02) respectively, while the lowest amount of phenolic compounds detected with Quercetin and Naringin being (5.87 ± 0.76,7.18 ± 3.22) and (8.65 ± 0.15, 10.02 ± 1.25) respectively. Results of physiochemical assays for stored minced buffalo meat indicated that colour, pH and TBA were 6.28, 6 and 0.52 for minced buffalo meat sample which treated by (GSNPsE), while the control one was 4.8, 7.35 and 1.85 at 9th day. Moreover, the minced meat samples which treated with GSNPsE has high effect for inhibition zones against some selected microorganisms and had low Total Bacteria Count(TBC) in rapprochement with other dealed out minced meat buffalo samples during cold storage.

So, our study recommended that GSNPsE could be replaced a synthetic type of antioxidants (TBHQ) and used as antimicrobial compound in meat products under cold storage up to 9 days.

Keywords: Lipid Deterioration; Food Spoil; Nano Antioxidants

Introduction

Lipid oxidation and microbial spoilage are among the primary factors contributing to the degradation of food quality, safety, and shelf life. Lipid oxidation leads to the formation of secondary products that may pose health risks to humans. Compounds such as malondialdehyde and cholesterol oxidation products have been recognized for their cytotoxic and genotoxic properties, and have been associated with the pathogenesis of atherosclerosis, cardiovascular diseases, and various types of cancer [43]. In food systems, the incorporation of antioxidant and antimicrobial agents represents an effective approach to inhibiting lipid oxidation and regulating microbial proliferation. Natural additives derived from spices and herbs such as plant extracts, essential oils (EOs), and dried powders have garnered significant attention as sustainable alternatives to synthetic preservatives. These bioactive compounds contribute to the extension of food shelf life by delaying oxidative rancidity through their antioxidant mechanisms and exerting antimicrobial effects that inhibit spoilage microorganisms and foodborne pathogens [33].

The visual appearance of food is a key determinant of consumer perception and significantly influences purchasing decisions. Given the essential role of food in human survival, the continuous monitoring of food quality is vital and closely tied to public health and daily life. As the relationship between nutrition and health gains increasing attention, food manufacturers are under growing pressure to present their products in a way that aligns with consumer expectations for freshness, longevity, and safety. This necessitates the Odevelopment and application of advanced strategies to preserve food quality and enhance consumer trust [44].

Meat and meat products constitute a staple component of the human diet in both developing and developed countries due to their rich content of high-quality proteins, essential vitamins, and bioavailable minerals. As a key dietary source, meat plays a critical role in supporting proper growth and development in children, as well as maintaining the health and well-being of adults and the elderly. However, the complex nutrient composition of meat also makes it particularly susceptible to lipid oxidation and microbial contamination, posing challenges for quality preservation and food safety [13].

Essential extracts are concentrated liquids composed of complex mixtures of volatile organic compounds derived from various plant parts, such as leaves, flowers, or seeds. Historically, they have been utilized by humans for their natural properties, including fragrance, as well as antimicrobial and antioxidant activities, among others. Essential extracts, composed of volatile compounds produced by plants, are well known for their antimicrobial properties. This antimicrobial activity is primarily attributed to specific small terpenoids and phenolic compounds, including thymol, carvacrol, and eugenol, as well as other bioactive constituents such as citral, cinnamaldehyde, menthol, rosmarinic acid, and linalool [25]. These bioactive compounds exert antimicrobial effects against pathogenic bacteria through multiple mechanisms, including disruption of cell membrane integrity, inhibition of protein synthesis, and depletion of intracellular adenosine triphosphate (ATP) levels [8].

Numerous herbs and plant-derived extracts exhibit notable antimicrobial and antioxidant properties, making them promising candidates for use as natural additives in animal feed. Among these, ginseng a widely recognized and traditionally valued medicinal plant belonging to the *Panax* genus in the family *Araliaceae* has garnered considerable attention. For centuries, ginseng has been utilized as one of the most prominent herbal remedies, owing to its diverse pharmacological activities and health-promoting effects [27,34].

Ginseng has been reported to exert a wide range of physiological effects, including regulation of blood lipid profiles, reduction of blood glucose levels, cancer prevention, and protective actions on the liver, kidneys, and heart. Additionally, it exhibits immunostimulatory properties, contributing to enhanced immune system function [17]. Most clinical trials investigating ginseng have focused on its potential effects on fatigue, cognitive function, menopausal symptoms, and mild diabetic conditions. Between 2002 and 2017, a total of 134 clinical trials related to ginseng were registered, of which 60.4% were completed, while 23.1% were still actively recruiting participants [18].

Nanotechnology involves the fabrication and application of materials with dimensions ranging from 1 to 100 nanometers, impacting a wide array of scientific and industrial fields. Due to their significantly increased surface area to volume ratio, nanomaterials often exhibit enhanced chemical, thermal, optical, electronic, magnetic, and biological properties compared to their bulk counterparts [31].

Nanotechnology has emerged as a transformative advancement in the agri-food sector, offering the potential to enhance global food production, while also improving the nutritional value, quality, and safety of food products [39].

Nanotechnology holds significant potential to enhance current crop management practices in the near future. Silver nanoparticles, in particular, have found widespread applications in biomedical fields, including their incorporation as antimicrobial agents in prostheses, wound dressings, and coatings for surgical instruments. In food processing, nanoparticles are increasingly employed as nano-sized ingredients, additives, nutritional supplements, and components of functional foods. Owing to their unique physical and chemical properties such as distinctive optical, electrical, thermal characteristics, and high electrical conductivity silver nanoparticles have gained prominence across diverse sectors. Nano silver, a well-studied bio-system nanoparticle, demonstrates potent inhibitory, bactericidal, and antimicrobial effects, largely attributed to its high surface area and the substantial fraction of reactive surface atoms [40].

The main goal of such work is to enhancement of antioxidant and antimicrobial properties of Ginseng extract using Nano Silver particles of research.

Materials and Methods

Materials

Raw materials

Ginseng powder from Asian Ginseng (*Panax ginseng*) plucked were procured from local perfumery El-Mansoura, El- Dakahlia Governorate, Egypt.

Fresh minced buffalo meat was procured from Metro market on the day of slaughter from El-Mansoura City, El Dakahlia Governorate, Egypt.

Chemicals

All chemicals and Substances were taken out from El Gomhouria Pharmaceutical Company, Mansoura city, El Dakahlia Governorate, Egypt.

Microbial cultures

Two bacterial strains: *Escherichia coli* (Gram-negative) and *Staphylococcus aureus* (Gram-positive) along with a yeast strain (*Saccharomyces cerevisiae*) and a mold strain (*Aspergillus niger*) were obtained from the Department of Chemistry of Natural and Microbial Products, National Research Center, Cairo, Egypt. The microorganisms were subjected to rigorous verification to ensure purity and accurate identification, followed by sub-culturing to establish actively growing cultures for subsequent experimental use.

Methods

Ginseng extract

The method of [29] The extraction procedure was conducted as follows: the powdered sample was soaked in ethanol at a 1:1 (w/v) ratio for 48 hours. Subsequently, the mixture was filtered through cheesecloth under firm manual pressure. The solvent was then removed from the filtrate under vacuum at 60–65°C using a rotary evaporator to yield the crude ethanolic extract (Büchi rotary evaporator, Model R-200). The crude extract was stored refrigerated until use, and serial dilutions were prepared as needed.

Preparation of silver particles

Silver nitrate ($AgNO_3$) was employed as a precursor for the synthesis of silver nanoparticles, with ascorbic acid (99%) and sodium borohydride serving as reducing agents. Silver nanoparticles with concentrations ranging from 250 to 500 mg/dm^3 were prepared by the dropwise addition of silver precursors such as silver citrate, silver nitrate, or silver acetate into an aqueous sodium borohydride solution. Specifically, silver nanoparticles were synthesized by injecting a $NaBH_4$ solution into an aqueous $AgNO_3$ solution in the

presence of citrate ions. Furthermore, a subsequent treatment of these nanoscale spheres was performed using $AgNO_3$. The formation of silver nanoparticles was confirmed by UV-Vis spectroscopy, where the colloids prepared with silver citrate exhibited a strong surface Plasmon resonance band near 396 nm, indicating the successful reduction of silver ions to metallic silver in the aqueous phase [42]. After the synthesis of silver nanoparticles, 50 mL of ginseng extract was mixed with 10 mL of the silver nanoparticle solution. The resulting mixture, with a final silver nanoparticle concentration of 600 ppm, was gently stirred using a glass rod to ensure uniform distribution and subsequently stored at 4°C until analysis [45].

Size particle measurements of nanoparticles extract

Size particles of ginseng extract and ginseng with silver nanoparticles extract were measured using Electron Microscope Malvern (Zeta sizer – nano sizer) conferring to the method pronounced via [26].

Transmission electron microscope (TEM) analysis

Rendering to the method designated by [41] by using Transmission Electron Microscopy (TEM) Physical and a visual asset of the nano-particles extract was determined.

Assessments of bioactive compounds and antioxidant activity

Total phenolic compounds and total flavonoids

Folin-Ciocalteu procedure using standardized spectrophotometric to determine the total phenolic compounds (as gallic acid equivalent) and total flavonoids were take-out and appraised by the technique of [2].

Antioxidant activity (DPPH %)

2,2 diphenyl1-picrylhydrazyl (DPPH %) evaluate was passed obtainable conferring to the technique of [3].

Individual phenolic acid contents and flavonoids compounds in ginseng extract:

Compounds of Phenolic and flavonoids were resolute consuming HPLC conferring to [16].

Antimicrobial activity of ginseng extract and ginseng with silver nanoparticles extract:

The effect extracts (normal and nano-particles) on bacteria, yeast and mold growth was determined using the disc diffusion by measuring the diameter of inhibition zone (mm) [24].

Preparation of minced buffalo meat sample

About 1 kg of fresh minced buffalo meat was divided into 4 groups (250 g of each). The group (1) as the control group (untreated). The group (2) was treated by adding ginseng extract. The group (3) was treated by adding ginseng with silver nanoparticles extract. The group (4) was treated by adding TBHQ as synthetic one. All additives were added by Micro-pipet injection with concentration 200ppm. Each sample group was packed in polyethylene bags, properly labeled, and stored at 4°C in a refrigerator until spoilage occurred. Samples were transferred to refrigerator containers for determination of physio-chemical properties (pH value and colour) while Lipid oxidation using (TBA) assay, organoleptic examinations (colour and odor) and antimicrobial assay. The meat sample was taken every alternative day (0, 3, 6 and 9).

Physio-Chemical examination of minced buffalo meat samples during cold storage

- **Determination of colour:** The colour (at 440mm) was measured by reflectance spectrophotometry as described by [2].
- **Determination of pH value:** PH value was determined using a digital pH meter standardized at pH 4 and 7 according to [12].
- **Determination of Thio-barbituric Acid Value (TBA):** Method embrace for assessment of TBA by [36] was utilized as follow: TBA test which predicate on determination of malonaldehyde (MD) as an end product of lipid oxidation.

TBA value= R x 7.8 (mg malonaldehyde/Kg)

(Where, R = Reading of sample against blank)

Organoleptic examination of minced buffalo meat samples during cold storage

Appearance, colour and odor were evaluated for each minced buffalo meat sample according to [9]. The panelists were selected from the staff of Food Sciences and Technology department. Prior to testing, the panelists underwent training to familiarize themselves with the sensory vocabulary specific to meat products and to understand the evaluation procedure. The samples were coded and presented to the panelists in a randomized order to avoid bias. Panelists were asked to assess the samples and record their preferences using a nine-point hedonic scale. The scale was defined as follows: scores of 7 to 9 indicated "very good" quality, 4.0 to 6.9 indicated "good" quality, and 1.0 to 3.9 indicated "decomposed" quality. This scale was applied to evaluate the appearance, color, and odor of the samples.

Statistical analysis:

Statistical analysis of data from three independent replicates was performed using SPSS Statistics version 17.0 for Windows. Differences among treatments were evaluated by one-way analysis of variance (ANOVA), followed by multiple mean comparisons using the Post Hoc Least Significant Difference (LSD) test. Sensory attribute scores were compared across the different treatment groups to determine significant variations.

Microbiological examination of minced meat samples during cold storage:

- Aerobic Plate Counts (APC), according to [19].
- Enterobacteria Count (EBC), according to [19].

Results and Discussion

Characterization of ginseng with silver nanoparticles extract

The size particle measurements

Zeta potential refers to the electrical potential measured at the slipping plane near the surface of a particle in suspension. It is determined by applying an electric field to the colloidal system and measuring the velocity and direction of particle movement, which reflects the particle's surface charge and stability in the medium [21].

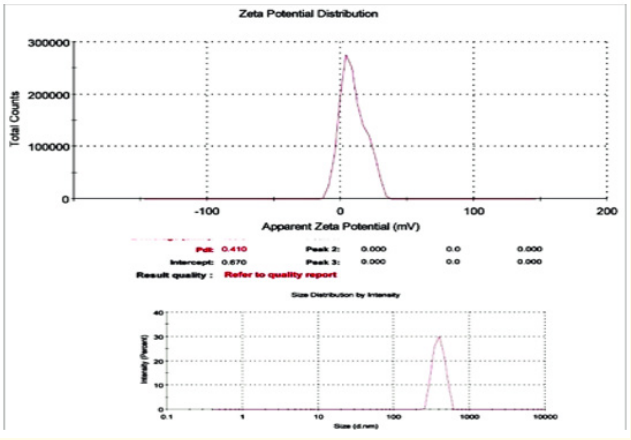

Figure 1: Zeta potential dimensions of regular ginseng extract and nano-particles one.

From accessible statistics in Figure 1 it perhaps will be potted that the typical size, density and the construction of masses of constituent part were more constant in ginseng extract with nano particles than normal one as attainable in Figure 2.

Transmission electron microscopy (TEM)

Transmission Electron Microscopy (TEM) offers direct insights into the structural features of nanostructured materials and is widely employed as a characterization technique in soft matter research and supramolecular chemistry [10].

Figure 2 (a and b) appeared that ginseng extract particles sizes being 123:200 nm whereas our gained consequences from TEM specified that constituent part size of regular ginseng extract particles which administered by nano-particles extract procedure were smaller than those of the derivation type and vacillated from 22:30 nm. Inevitably, it could be shortened from obtained consequence in Figures (1&2) that silver nano-particles extract intensification constancy of particles size and this belonging is enormously imperative for the preservative and influential effect.

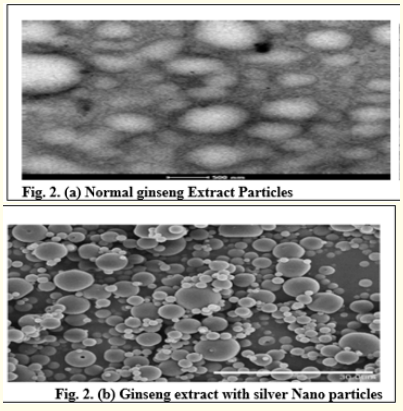

Figure 2: (a and b) TEM micrographs depiction exemplifying the size and geomorphology of ginseng extract at 200 nm and which by nanoparticles at 50 nm.

Radical scavenging activity (DDPH %), Total phenolic compounds and total flavonoids of ginseng extract and ginseng with silver nanoparticles extract

The antioxidant activity of the plant extracts was assessed using multiple assays, including DPPH radical scavenging, ferric reducing power, phosphor-molybdenum, and hydrogen peroxide scavenging methods [11]. Table (1) exhibited the antioxidant activity which was appraised consuming the DPPH method grasped to the highest antioxidant activity 79.56 ± 0.51% was recorded for ginseng with silver nanoparticles extract in compare with ginseng extract which was 60.31 ± 2.4%. This is might be due to volatile oils mixing have led to the positive and effective of nanoparticle reinforcement [6].

Table 1: Antioxidant activity of ginseng extract and ginseng with silver nanoparticles extract.

Antioxidants parameters	GE	GSNPsE
Antioxidants activity(%)	60.31 ± 2.4	79.56 ± 0.51
Total phenolic compounds (mg of GAE\g)	48.50 ± 1.2	56.66 ± 0.48
Total flavonoids(mgRE\g)	54.23	62.83

GE: Ginseng extract; GSNPsE: Ginseng with silver nanoparticles extract; (±): Mean there is high probability that actual results will vary within this range.

Among the various classes of phytochemicals, phenolic compounds have garnered significant attention in recent years due to their diverse bioactive properties. They have been extensively studied and applied across multiple fields, including the food, healthcare, and pharmaceutical industries [22]. This work assessed the total phenolic content (TPC) and total flavonoid content (TFC) of ginseng extract (GE) and ginseng with silver nanoparticles extracts (GSNPsE). TPC quantification in the GE (48.50 ± 1.2mg GAE/g), they revealed that values fell into the range reported in the literature for medicinal Chinese plants and medicinal Indian plants [5], while, GSNPsE is estimated 56.66 ± 0.48 mg GAE/g.

Flavonoid compounds are known for their wide range of biological activities, with particular emphasis on their antioxidant capacity. They play a key role in protecting cells from oxidative damage induced by free radicals, thereby contributing to the prevention of various oxidative stress-related diseases [35]. Also, results in the same table showed that total flavonoids content of the extracts was expressed as rutin equivalents (RE) in milligram per gram dry extract, ethanolic extract of Ginseng exhibited 54.23 mg RE\g while was 62.83 mg RE\g for ginseng with silver nanoparticles extract.

Bioactive component of ginseng extract and ginseng with silver nanoparticles extract:

Ginseng is renowned for its widespread application as a natural remedy to enhance cognitive function and support immune system function. It comprises 80:90% organic and approximately 10% inorganic substances including several active constituents like ginsenosides [32]. Compounds of Total phenolic of ginseng etha-

nolic extract and nano ginseng silver NPs extract were detached and acknowledged by HPLC and the results were revealed in Table (2). Results in Table (2) showed the effective of ginseng with silver nano particles extract in compared to the normal one dispensary. Nearly about phenolic compounds (17 compounds) were identified composition of ginseng extract was influenced by with nanoparticles of silver. In Ginseng extract and Ginseng nano silver extract it is clearly visible that chlorogenic, m-Coumaric and Gentisic have highest amount in both of nanoparticles extract being (95.25 ± 4.45, 122.70 ± 4.20), (90.32 ± 2.85, 118.86 ± 3.10) and (65.30 ± 1.55, 78.22 ± 1.02) respectively, while the lowest amount of phenolic compound detected with Quercetin and Naringin being (5.87 ± 0.76, 7.18 ± 3.22) and (8.65 ± 0.15, 10.02 ± 1.25) respectively in both of the experimental used extracts. Also, from the same table Myricetin, Biochanin A and Kaempferol were not detected in the extracts. As can be seen from analysis, results showed that there was considerable chemical variation between normal extract and nanoparticles one including major components.

Table 2: The individual phenolic compounds in ginseng extract and ginseng with silver nanoparticles extract.

Phenolic compounds	GE	GSNPsE
p-Coumaric acid	65.31 ± 3.51	73.52 ± 4.50
Ferulic acid	20.52 ± 1.55	21.15 ± 0.75
m-Coumaric acid	90.32 ± 2.85	118.86 ± 3.10
Chlorogenic acid	95.25 ± 4.45	122.70 ± 4.20
Myricetin	ND	ND
Quercetin	5.87 ± 0.76	7.18 ± 3.22
Gallic acid	48.11 ± 0.21	55.32 ± 1.11
Gentisic acid	65.30 ± 1.55	78.22 ± 1.02
Rutin	62.54 ± 4.21	72.34 ± 0.68
Vanillin	22.61 ± 1.90	34.48 ± 1.25
Biochanin A	ND	ND
Catechin	17.32 ± 1.32	22.78 ± 0.25
Naringin	8.65 ± 0.15	10.02 ± 1.25
Hydroxycinnamic acid	9.11 ± 1.22	15.76 ± 0.13
Protocatechuic acid	35.21 ± 3.10	47.11 ± 0.5
Hydroxybenzoic acid	10.21 ± 1.12	13.53 ± 0.8
Kaempferol	ND	ND

ND: Not detected; GE: Ginseng extract; GSNPsE: Ginseng with silver nanoparticles extract; (±): Mean there is high probability that actual results will vary within this range.

Flavonoids are a class of plant secondary metabolites known for their diverse biological activities and beneficial physiological effects in humans. These naturally occurring compounds are widely utilized in the pharmaceutical, cosmetic, and nutraceutical industries due to their therapeutic potential. Ongoing research aims to further elucidate the bioactivity and expand the potential applications of flavonoids, thereby enhancing our understanding of their role in promoting human health [38].

The total flavonoid content was determined using a spectrophotometric method with aluminum chloride. The flavonoid content is expressed in terms of QE/100 g of dry matter. As recorded results in Table (3) flavonoid compounds were fractionated and identified as flavanols, flavones, flavonols and flavanones. Catechin was the furthermost flavonoid compounds in ginseng extract and nanoparticles extract being (88.24 ± 3.50 and 101.07 ± 2.81 mg/g), followed by Quercitin and Myricetin were (63.40 ± 2.25 and 58.15 ± 4.22 mg/g) respectively for ginseng extract and (68.85 ± 1.75 and 76.43 ± 4.50 mg/g) respectively for nanoparticles extract. Flavanones appeared as one compound in both extracts was Naringenin which being 1.90 ± 0.22 and 2.23 ± 0.52 mg/g for ginseng extract and nanoparticles extract respectively.

Antimicrobial activity bioassay of ginseng extract and ginseng with silver nanoparticles extract

Nanomaterials have attracted considerable interest across a broad spectrum of applications, ranging from healthcare to industrial sectors, owing to their unique physicochemical properties derived from their nanoscale size and shape. In this context, metal ions and metallic nanoparticles (NPs) have been widely investigated for their antimicrobial potential against a variety of pathogenic microorganisms. Among them, silver (Ag) has long been recognized as one of the most effective antimicrobial agents, valued for its strong and broad-spectrum inhibitory activity [4].

The biological activity of extracts on this study depends on the diameter of inhibition zones against some selected microorganisms. Results in Table (4) illustrate the extent of powerful effect of nano particles extract against microbial growth.

Table 3: The individual Flavonoids compounds in ginseng extract and ginseng with silver nanoparticles extract.

Flavonoids compounds	GE	GSNPsE
A. Flavanols		
1-Catechin	88.24 ± 3.50	101.07 ± 2.81
2-Epicatechin	2.22 ± 0.42	2.58 ± 1.04
3-Epigallocatecin gallate	1.73 ± 0.23	1.06 ± 0.51
B. Flavones		
1-Quercetin	63.40 ± 2.25	68.85 ± 1.75
2-Apigenin	22.17 ± 0.25	1.20 ± 0.33
C. Flavonols		
1-Myricetin	58.15 ± 4.22	76.43 ± 4.50
2-Resveratrol	10.78 ± 1.55	10.80 ± 0.61
3-Morin	5.23 ± 0.25	6.025 ± 1.25
4-Quercetin	2.04 ± 0.25	2.25 ± 0.55
D. Flavanones		
1-Naringenin	1.90 ± 0.22	2.23 ± 0.52

GE: Ginseng extract; GSNPsE: Ginseng with silver nanoparticles extract; (±): Mean there is high probability that actual results will vary within this range.

Table 4: Diameter of inhibition zones (mm) of ginseng extract and ginseng with silver nanoparticles extract against some selected microorganisms.

Microorganisms	Diameter of inhibition zones (mm)	
	GE	GSNPsE
Gram negative bacteria *Escherichia Coli*	32	40
Gram positive bacteria *Staphylococcus aureus*	41	52
Yeast strain *Saccharomyces cerevisiae*	47	55
Mold *Aspergillus niger*	49	61

GE: Ginseng extract, GSNPsE: Ginseng with silver nanoparticles extract.

From these resulted are noticed in Table (4) showed that the highest antimicrobial activity was recorded for nano extract with inhibition zones ranged from 40 to 52mm for Gram negative bacteria and Gram positive bacteria respectively. From the same data, it could be shown that mold strain was more sensitive to both tested extracts than bacteria and yeast.

Physio-Chemical properties of minced buffalo meat samples during cold storage period at (4_oC)

Colour value

From the values of reflectance spectrophotometry, it could be observing that the red colour of all minced buffalo meat decreases in all modified atmospheres; the most apparent are the changes of redness colour [15].

There was a noticeable effect of the extracts used, whether natural ginseng extract or added to silver nanoparticles, in preserving the red pigment of the meat as much as possible during the cold storage period. The results are shown in Figure (3) discern that the best results over nine days of cold storage are due to samples to which ginseng extract with silver nanoparticles were added which colour value was ranched 6.6 ± 2: 6.0 ± 1 from zero day to day nine which were similar to those treated with TPHQ compound in the same concentration. On other hand, colour in control sample after nine days of cold storage its value is reduced by measurement which reached to 4.8 ± 1. This may be due to small size of nano particles which increase the surface area of distribution of colour.

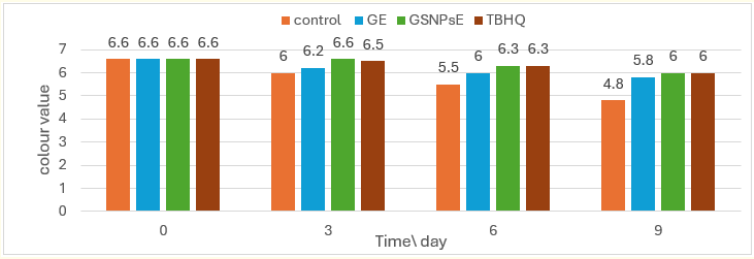

Figure 3: Colour values of minced buffalo meat samples during cold storage period at (4_oC).
TBHQ: Tert-Butyl hydroquinone.

PH value

According to numerous studies, the ultimate pH of meat is considered one of the most critical indicators of meat quality and should be included as a standard parameter in meat quality evaluation [1].

Figure (4) Showed the pH values during cold storage. In all samples, there was increasing in PH values which probably related to protein breakdown for the production of free amino acids leading to the formation of NH_2 and amines components of alkaline reaction [23]. The results shown in the same table that the effective-

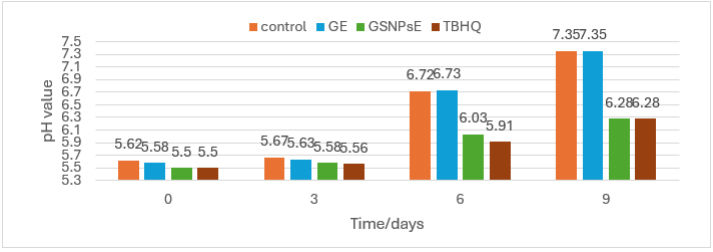

Figure 4: PH values of minced buffalo meat samples during cold storage period at (4_oC).

ness of ginseng extract with silver nanoparticles, are close to the synthetic compound in compare with those control one.

TBA value

Lipid oxidation is a primary factor contributing to the deterioration of fat-containing food products, leading to rancidity, off-flavor development, and the generation of potentially toxic and carcinogenic compounds that may compromise both nutritional value and consumer safety [37].

The amount of TBA is related to the antioxidant activity of extracts. TBA values showed in Figure (5) that lipid oxidation in-

creased until day 9 among all minced buffalo meat samples treatments. The properties of the nano extract had a serious impact in reducing the occurrence of lipid oxidation within the samples, the results of which differed during the period of cold storage, whether compared to the control sample or the sample treated with ginseng extract only.

Moreover, the results of meat sample treated with ginseng extract with silver nanoparticles by concentration (200 ppm) at the end of the study period recorded better numbers and greater stability against oxidation was observed in minced buffalo meat sample treated with GSNPsE in compare with the others. This observation was in agreement with [28]. It has been reported that certain natural preservatives with antioxidant activity may have either positive or negative impacts on other quality attributes, particularly sensory properties, which can ultimately influence consumer acceptability of the final product [14].

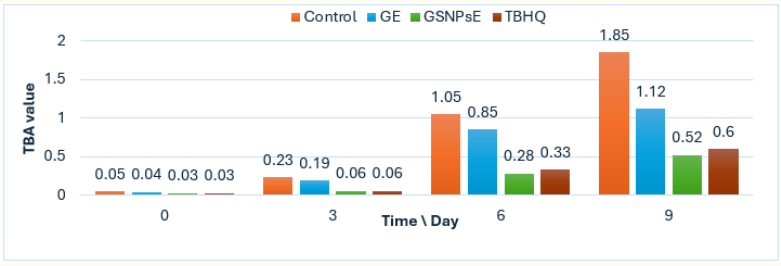

Figure 5: TBA values of minced buffalo meat samples during cold storage period at (4_oC).

Organoleptic examination of minced buffalo meat samples during cold storage period:

Sensory evaluation is a scientific discipline used to assess, analyze, and interpret human responses to the characteristics of food as perceived by the senses such as appearance, aroma, taste, texture, and overall acceptability through trained or untrained panelists [20]. Due to the involvement of human perception, sensory analysis inherently carries a degree of subjectivity. In this study, the sensory characteristics of minced meat samples with various treatments, including a control, were evaluated and compared. Sensory assessments were conducted on days 0, 3, 6, and 9 of cold storage. A panel of 10 trained tasters was engaged to evaluate the samples based on key sensory attributes. As shown in Table (5) results indicated that sensory properties of different treated minced beef samples during cold storage were enhanced by using ginseng extract, ginseng extract with nanoparticles of silver extract and TBHQ compared to the untreated (control) samples at0 day, 3rd day, 6th day and 9th day of the storage period, respectively. Generally, samples ginseng extract with nanoparticles of silver extract and TBHQ demonstrated that the highest enhancement of sensory attributes, while the samples treated with ginseng extract demonstrated lower enhancement.

The presented data table illustrates the impact of various treatments on the sensory quality attributes color, odor, and appearance of a product stored under refrigeration for up to 9 days. The treatments included an untreated control, ginger extract (GE), ginger with silver nanoparticles extract (GSNPsE), and (TBHQ), a commonly used synthetic antioxidant. Sensory evaluations were conducted at 0, 3, 6, and 9 days and results are expressed as mean ± standard deviation. Statistical significance among treatments was indicated by different superscript letters. At day 0, all treatments exhibited similarly high sensory scores (approximately 8.30–8.35),

Table 5: Organoleptic examinations of minced buffalo meat samples during cold storage period.

Treatment	Cold storage/day	Colour	Odor	Appearance
Control	Zero	8.30 ± 0.15^{a}	8.35 ± 0.15^{a}	8.35 ± 0.15^{a}
	3	6.85 ± 0.20^{a}	6.65 ± 0.22^{a}	7.00 ± 0.22^{a}
	6	5.70 ± 0.24^{a}	5.25 ± 0.21^{a}	5.45 ± 0.20^{a}
	9	4.35 ± 0.17^{a}	4.30 ± 0.20^{a}	4.60 ± 0.16^{a}
GE	Zero	8.30 ± 0.15^{a}	8.35 ± 0.15^{a}	8.35 ± 0.15^{a}
	3	7.00 ± 0.25^{a}	7.00 ± 0.30^{ab}	7.10 ± 0.26^{a}
	6	6.20 ± 0.23^{a}	5.80 ± 0.35^{a}	6.20 ± 0.24^{b}
	9	5.10 ± 0.16^{b}	5.00 ± 0.22^{b}	5.10 ± 0.14^{b}
GSNPsE	Zero	8.30 ± 0.15^{a}	8.35 ± 0.15^{a}	8.35 ± 0.15^{a}
	3	8.00 ± 0.22^{b}	8.00 ± 0.26^{c}	8.00 ± 0.22^{b}
	6	7.50 ± 0.13^{b}	7.40 ± 0.21^{b}	7.60 ± 0.16^{c}
	9	7.20 ± 0.20^{d}	7.00 ± 0.24^{d}	7.20 ± 0.24^{d}
TBHQ	Zero	8.30 ± 0.15^{a}	8.35 ± 0.15^{a}	8.35 ± 0.15^{a}
	3	8.00 ± 0.24^{b}	7.60 ± 0.27^{bc}	7.80 ± 0.21^{b}
	6	7.10 ± 0.10^{b}	7.00 ± 0.21^{b}	7.20 ± 0.13^{c}
	9	6.60 ± 0.10^{c}	6.30 ± 0.11^{c}	7.00 ± 0.10^{c}

a-b- c-d values with different superscripted significantly (P<0.05) different.

with no significant differences, indicating that the initial quality of the samples was consolidated for all groups. However, as storage time progressed, notable differences emerged among the treatments. By day 3, the control group showed a decline in sensory quality, though differences were not statistically significant. GE-treated samples maintained slightly better scores than the control, while TBHQ-treated samples exhibited further improvement. Notably, GSNPsE-treated samples maintained the highest scores across all attributes, with statistically significant differences compared to the control and GE groups. These results suggest that GSNPsE was more effective at preserving early sensory quality. At day 6, the control group experienced further degradation, particularly in odor and appearance. GE-treated samples also showed a marked decline. TBHQ-treated samples retained moderate quality, but GSNPsE samples continued to outperform all other groups, with significantly higher scores across all sensory parameters. This indicates that the ginger with silver nanoparticles extract was effective in slowing down sensory deterioration during mid-storage. By day 9, the control group showed substantial quality loss, with all attributes scoring below 4.6, suggesting near rejection levels. GE treatment offered minor protection, but the sensory attributes remained significantly reduced. TBHQ maintained acceptable quality, though scores had declined. In contrast, GSNPsE-treated samples retained high sensory ratings (above 7.0), with statistically significant differences from all other treatments. These findings clearly highlight the superior efficacy of GSNPsE in preserving sensory quality during extended cold storage. Overall, the results demonstrate that GSNPsE is the most effective treatment among those tested. Its superior performance is likely due to the enhanced bioavailability and antioxidant activity of ginger compounds when delivered through nanoparticle systems. While TBHQ provided good protection, GSNPsE preponderance it, and GE alone was considerably less effective. These findings suggest that ginger with silver nanoparticles extract offer a promising, natural, and efficient alternative to synthetic preservatives for extending the shelf-life and maintaining the sensory quality of refrigerated products.

Microbiological examination of minced buffalo meat samples during cold storage period at (4°C)

It's important to assess the aerobic bacteria and entero bacteria counts because they are considered as an indicator for the microbiological quality of the meat products and help in assessing the keeping quality of further processed meat products [7]. It was measured to determine the impact of different extracts on reducing the bacterial growth in refrigerated minced meat as shown in Table (6). It is evident that during the initial period of cold storage, the increase in total viable bacteria count (aerobic and entero) was lower in treated meat samples in compared with control one, probably because of the presence of the active components in the used extracts which acted as a hurdle for the growth of microbes and later due to lipid oxidation an increase in microbial growth occurred. These results agree with the results confirmed by [30]. The results in Table (6) observed that the control minced buffalo meat sample always had high Total Bacterial Count (TBC) throughout storage period compared with all treated meat samples. The effect of the active compounds of ginseng extract appears during the refrigeration period compared to the untreated sample. Furthermore, the samples treated with ginseng extract with nanoparticles of silver extract had low TBC compared with other treated minced meat buffalo samples during cold storage. It is also evident that the preservative effect of ginseng extract added to silver nanoparticles were more effective compared to the effect of TBHQ, whose preservative value decreases and which affects microbial growth upon reaching the sixth day of storage.

Table 6: Changes of Total Bacterial Count Aero Bacteria Count and Entero Bacteria Count of minced buffalo meat samples during cold storage.

Cold storage/day	Control	Minced buffalo meat sample treated with		
		GE	GSNPsE	TBHQ
ABC				
Zero time	$5.19X10^5$	$4.18X10^5$	$5.19X10^5$	$5.19X10^5$
3	$6.11X10^7$	$5.19X10^7$	$5.21X10^6$	$4.53X10^6$
6	$4.25X10^{10}$	$7.53X10^6$	$4.14X10^8$	$4.22X10^8$
9	$5.33X10^{12}$	$4.22X10^8$	$3.15X10^8$	$3.13X10^9$
EBC				
Zero time	$9.32x10^3$	$9.32x10^3$	$9.32x10^3$	$9.32x10^3$
3	$7.24x10^4$	$7.24x10^4$	$6.81x10^4$	$7.03x10^4$
6	$8.15x10^5$	$7.24x10^5$	$8.25x10^3$	$4.11x10^5$
9	$3.25x10^8$	$8.95x10^6$	$5.25x10^4$	$4.25x10^5$

ABC: Aero Bacteria Count; EBC: Entero Bacteria Count.

Through these obtained results which are consistent with the results which shown in Table (4), for effective of ginseng extract with silver nanoparticles for inhibition zones against some selected microorganisms. Also, the efficiency of the ginseng extract becomes clear, and its efficiency was increased through the use of silver nanoparticles, when used at the recommended concentration, showed high efficiency during the cold storage period of minced meat through chemical, physical and sensory properties, as well as in reducing the microbial load.

Conclusion

This study explored that the antioxidant and antimicrobial effectiveness of silver nanoparticles with ginseng extract in reducing oxidation and micro-organisms growth in refrigerated minced buffalo meat. The results of this study demonstrate that all tested treatments, particularly when combined, significantly reduced the growth of various microorganisms that contribute to spoilage in meat products. Also, the effect of these nanoparticles on the sen-

sory properties of the samples treated with them was also demonstrated throughout the period of refrigeration storage, which also demonstrated their efficiency at the end of the period to a degree that exceeds that of the synthetic antioxidant.

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