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Influence of *Moringa oleifera* Leaf Extracts on the Microbiological and Physical Properties of Chevon Meat

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Abstract | Chevon is one of the most favorable meats among Arabian populations. It is considered one of the primary sources of protein, fat, and water, which provides all essential amino acids, micronutrients, vitamins B6, B12, vitamin D, and omega-3 polyunsaturated fatty acids. It is the best medium for the growth of microorganisms and highly perishable food items. That increases the demand to find safe materials, extending the shelf life of meat. The study aims to examine *Moringa oleifera* extracts as natural preservatives by examining its antibacterial effect by (aquas & ethanolic) extracts by different concentrations (1.25, 2.5, 5, 7.5, 10, 12.5 & 15) cc against six foodborne microorganisms (*Listeria monocytogenes, Staphylococcus aureus, Salmonella typhi, Escherichia coli, salmonella enteritidis* and *Vibrio parahaemolyticus*). Finally, the different concretions of each extract were added to the chevon. Obtained results observed that all extracts have antibacterial effects to varied degrees against all tested microorganisms, and the extracts succeeded in extending the shelf life of chevon to about 17 days. The study results indicated that the natural products had a potent effect against the tested pathogens. So, it can be a natural alternative to conventional formulations for those interested in naturally based products.

Keywords: Ethanolic extraction, Water extraction, Foodborne pathogens, Antimicrobial agents, Meat preservation, Goat meat

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INTRODUCTION

Goat meat, known as "chevon," has a lighter color, different flavor, and delicate texture, just a few of its appealing characteristics. In addition to its richness of protein which averages between 20-25 grams/100 grams, lean chevon meat contains about 21-23% protein while, fatty chevon contains about 19-21%. It contains considerable omega-3 polyunsaturated fatty acids. (Allhyani, *et al*., 2021; El Sohaimy and Hafez, 2023; Singh *et al*., 2024).

Chevon deterioration occurs during storage and processing by enzymatic autolysis and lipid oxidation, which appear as fat rancidity and production of ketones, aldehydes & and peroxides, while the second type of deterioration by microbial spoilage, the source of microbial population, skin,

and intestinal microflora or from the surrounding environmental, the production processing, storage conditions, unhygienic handling. The growth of microorganisms in meat appears as slime, off odors, reduced water holding capacity, and changes in texture and appearance. In addition to the deterioration, ingestion of contaminated chevon with pathogens is the major cause of gastrointestinal disease throughout the world, such as *Escherichia coli, Staphylococcus aureus, Listeria monocytogenes, Salmonella typhimurium, Vibrio parahaemolyticus, Salmonella enteritidis* (Heifa'a *et al*., 2018; Pal *et al*., 2018; Allhyani *et al*., 2021; Abo hashem *et al*., 2022; Rahman *et al*., 2023).

Replacing chemicals with natural, safe preservatives has become one of the demands in food safety and preservation technology. Natural preservatives include all the natural extracts of different plant parts, such as fruits, stems, roots, seeds, leaves, and bark that inhibit one or more food spoilage and food pathogens (Abo Hashem *et al*., 2022).
Moringa oleifera is a member of the *Moringa oleifera, oleifera ceae* family. It is a subtropical and tropical plant that grows globally. It is also known as a 'drumstick tree' or a 'horseradish tree.' It is widely grown around the world because of its ability to survive both severe drought and moderate frost. *Moringa oleifera* is considered one of the most promising plants, and it has recorded very good results against almost all microorganisms. Its nutritional richness also characterizes it: the dried leaves contain 30.3% crude protein and 19 different amino acids (United States Food and Drug Administration, 2024). On the other side, dried leaves have more than 40 natural antioxidants due to their richness of minerals and vitamins. Their content of minerals about phosphorus (0.3%), manganese (86.8 mg/kg), copper (8.25%), sulfur (0.63%), and calcium (3.65%), The dried leaves were rich in iron (490 mg/kg), magnesium (0.5%), selenium (363 mg/kg), sodium (0.164%), potassium (1.5%), and zinc (13.03 mg/kg). They contained 17 fatty acids, including α-linolenic acid (44.57%), capric acid (0.07%), γ-linolenic acid (0.20%), heneicosanoic acid (14.41%), and palmitoleic acid (0.17%). The leaves were among the richest plant sources of vitamins A, D, E, K, C, and B, with vitamin E being the highest at 77 mg/100 g, followed by beta-carotene at 18.5 mg/100 g. Additionally, they had an acid detergent fiber (ADF) content of 8.49%, acid detergent cellulose (ADC) of 4.01%, overall fiber content of 11.4%, and acid detergent lignin (ADL) of 1.8%. The condensed tannins measured 3.2%, while total polyphenols were 2.02%. The composition included various fatty acids, amino acids, vitamins, and minerals (Matic *et al*., 2018).

The leaves, seeds, bark, roots, sap, and flowers of *Moringa oleifera* are extensively used in traditional medicine, while the leaves and immature seed pods serve as food. The leaves are rich in minerals, vitamins, and other essential phytochemicals. Leaf extracts, frequently used to combat malnutrition, are also employed to enhance breast milk (Stohs and Hartman, 2015; Gopalakrishnan *et al*., 2016). It is an anticancer, antidiabetic, anti-inflammatory, potential antioxidant, and antimicrobial agent with a high degree of safety on consumers' health without any adverse effects on human health. Still, until now, there is a wide shortage of them as natural food preservatives. In addition to the nearly absent studies on chevon generally with complete absent studies in their preservation. This research aimed to study the effect of adding *Moringa oleifera* leaf extract against some meatborne pathogens and then evaluate their impact by different concentrations on the extension of chevon shelf life, which was gained.

MATERIALS AND METHODS

Microbiological Effect of *Moringa oleifera* Extraction

Plant extraction: The leaves of *Moringa oleifera* were collected on November 11, 2023, from Al Ghulah (22.0097982, 39.2557409) in desert conditions in Saudi Arabia. The collected plants were washed gently with water to remove impurities and dirt. Then, it is dried in a well-ventilated shaded area for several days, then dried in an oven for 1-2 days at 40-50°C. the final stage of dehydration using a dehydrator for 1-2 days at 40-50°C. The dried plant material was ground to pass through a 100 mm sieve, followed by sifting to uniform particle size. Then, the leaves were stored away from moisture and light (APHA, 2017).

Extraction Preparation

Leave powder mixed with two solvents, ethanol, and distilled water, at the following concentrations: 1.25%, 2.5%, 5%, 7.5%, 10%, 12.5%, and 15%. Add the plant powder to different solvents as follows: to prepare 1:10 (w/v), add 1 gram of plant powder to 10 ml of solvent, etc. The diluted leaves powder is stirred at 37°C/ 24-48 hr. The mixture was then filtered through double layers of muslin, centrifuged at 9000 rpm for 10 minutes, and filtered again using Whatman filter paper No. 41 to have a clear filtrate. The filtrates were evaporated and dried at 40°C under reduced pressure using a rotary vacuum evaporator and then stored at 5°C (Chemat and Cravotto, 2013) (Figure 1).

Bacterial strains: The antibacterial effects of *Moringa oleifera* leaf extract (ethanol and water) were assessed against six bacterial strains known to cause food poisoning. This included two Gram-positive strains (*Staphylococcus aureus* and *Listeria monocytogenes*) and four Gram-negative strains (*Escherichia coli, Salmonella typhi, Salmonella enteritidis,* and *Vibrio parahaemolyticus*). These bacterial strains were obtained from the General Authority for Food and Drug Administration in Jeddah.

Figure 1: *Moringa oleifera.*

Inoculum preparation

Each bacterial strain is suspended in sterile saline. the bacterial suspension spread evenly over the surface of Mueller-Hinton agar plates. Each bacterial strain was sub-cultured overnight at 35˚C on Mueller-Hinton agar slants. The bacterial growth was then harvested using 5 ml of sterile saline water. The absorbance was adjusted to 580 nm and diluted using a spectrophotometer to achieve a viable cell count of 10^7CFU/ml (Lakshmanan, 2022).

Determination of minimum inhibitory concentrations (MIC) of plant extract against tested microorganisms

To determine the MIC of the most effective plant extracts, which showed antibacterial solid activity at 10 mg/ml, the disk diffusion method was used. The efficacy of these extracts in controlling bacterial strains causing food poisoning was evaluated. Variations in the potent plant extract concentration (1.25%, 2.5%, 5.0%, 10.0%, 12.5%, and 15%) were discussed in water or ethanol as the plant powder solvents. Filter paper discs, which were sterilized by UV irradiation or autoclave, were then immersed in the sterilized filter paper disks with each concentration of *Moringa oleifera* extract, which was about 20-30 µL of extract to be enough to saturate the disk. Which was impregnated on the surface of Mueller-Hinton agar plates. The plates were refrigerated at 5˚C for 2 hours and then incubated at 35˚C for 24 hours. The inhibition zone diameter was measured (in millimeters) using a Vernier caliper or ruler and recorded for each concentration of the plant extract. MIC is determined by identifying the lowest concentration of the extract that produces a visible inhibition zone (Valgas *et al.*, 2007; CLSI Guidelines, 2022).

Evaluation of addition of Plant extraction on extension chevon meat shelf life

The scientific discipline of sensory evaluation measures, examines and interprets responses to food attributes as perceived by the senses of hearing, taste, touch, and smell (Huss, 1995). About 500 gm of the chevon meat were minced, then in a large bowl, the plant was extracted at a different concentration to the minced chevon meat and mixed all components, then the amount into evenly small meatballs using an ice cream spoon and weighed to ensure uniformity (around 1-2 inches diameter for each meatball). About 100 meatballs for each concentration of the plant extract and about 100 meatballs were kept without any addition (control samples). Each type of meatball is divided into parts; 50 meatballs are kept as raw samples, and the other 50 samples are cooked in heated oil and thoroughly cooked on all sides, which takes about 10-12 minutes. After that, the samples became ready to be stored in the refrigerator under the first shelf and stored at 4°C and tested samples every 3 days from each concentration and control samples (raw and cooked) microbiologically and physically (sensory analysis) of Chevon meatball. The panelists (who were 3 well trained and highly experienced food hygienist academic staff) were given the following five characteristics points: Very poor (1), poor (2), good (3), very good (4), and exceptional (5) are the possible outcomes. When evaluating the meatball samples' color, flavor, and consistency, the panelists considered these factors (Martinsdottir, 2002; Morten, *et al.*, 2016).

Antibiotics used against different tested Microorganisms

vancomycin, in the case of *Staphylococcus aureus*, while ciprofloxacin used against *E. coli*, fluoroquinolone was the best for *Salmonella spp.*, gentamicin used against *Listeria moncytogenes*, tetracycline was the best antibiotic against *Vibrio parahaemolyticus* (Giuseppe, *et al.*, 2024).

Determination of pH value

Use a digital pH meter, Blend 15 g meat muscle with 30 ml distilled water at 27-30°C, and note the pH with a glass electrode pH meter (Pippen *et al.*, 1965).

Statistical analysis

All values are shown as means plus standard error. This investigation used SPSS16 (2007) for statistical analysis.

RESULTS AND DISCUSSION

Experimental Tests to Evaluate Antimicrobial Activity of Different Used *Moringa oleifera* Leaves Extracts

According to Table 1, the mentioned result, we observed that the most effective concentration of *Moringa oleifera* leaves aqueous extract against *Staphylococcus aureus, Salmonella typhimurium, Salmonella enteritidis, Listeria monocytogens, Vibrio parahaemolyticus* used was 10% followed by 15% then 2.5% while other concentrations nearly had no effect. Although antibiotics have a nearly similar power of 10% conc. In the case of *E. coli*, the most effective results were 12.5% & 15%, followed by 1.25%, then 2.5%, 7.5% &10%,

while 5% nearly had no effect. Although antibiotic has a similar power of 2.5%, 7.5% & 10% conc.

The most effective concentration of *Moringa oleifera* leaves ethanol extract against *Staphylococcus aureus* used after the antibiotic was 15%, 10% & 12.5%, followed by 2.5%, then 7.5%. While the more effective concentration of *Moringa oleifera* leaves ethanol extract against Salmonella typhimurium used was just 12.5%, while other concentrations nearly had no effect. *Moringa oleifera* leaves ethanol extract against Salmonella enteritidis used was 10% & 7.5% followed by 5% & 12.5%, then 2.5%, against *Listeria monocytogens* used was 10%, 5%, 15% & 12.5% followed by 2.5%.

Table 2: Sensory analysis of the effects of the addition of *Moringa oleifera* extractions to Chevon meat.

Days	Raw				Cooked			
	color	odor	Consistency	pH	color	odor	consistency	pH
0	5	5	5	5.50	5	5	5	5.50
3	5	5	5	5.75	5	5	5	5.70
6	4	4	4	5.85	4	4	4	5.81
9	4	3	3	6.04	4	4	4	5.95
12	3	2	2	6.20	3	3	3	6.15
15	3	2	2	6.48	2	2	2	6.40
18	2	1	1	6.79	2	2	2	6.70
21	1	1	1	7.10	1	1	1	7.08

Sensory Evaluation of Addition of Plants Extraction on Extension Chevon Meat Shelf Life (Das *et al.*, 2012)

Where five corresponded to 'components characteristic of the highest quality'. Scores 4 consider 'very good,' 3 'good,' 2 'bad', and 1 'very bad'15. The results shown in Table 1 and Figure 2, described the sensory changes that appeared on chilled control chevon meat eight days before and after cooking as the deterioration signs became clear on the seventh day when all measures were subpar, and the raw chevon samples' consistency and odor were particularly poor. Their pH values were 6.2 and 6.3, respectively. After eight days of refrigeration, the entire batch was recorded. The pH of the raw and cooked chevon samples was 6.5 and 6.6, respectively. While the addition of 1.25% of *Moringa oleifera* water extract extended the shelf life of the treated samples to 11 days, the addition of water extraction at 5% showed the deterioration signs became evident on day nine, with all metrics being extremely low, and the pH of the raw and cooked samples being 6.17 and 6.20, respectively. addition of *Moringa oleifera* ethanol extract at 1.25% concentration to Chevon Samples, the deterioration signs became very clear on the 16th day as all parameters were very bad, pH was 6.41 and 6.43 in raw and cooked samples, while the addition of the ethanol extract at 5% was the worse quality

Table 1: Antimicrobial efficacy of ethanol and aqueous extract of *Moringa oleifera* against certain foodborne pathogens.

Concentrations	Staphylococcus aureus		E. coli		Salmonella typhimurium		Salmonella enteritidis		Listeria monocytogens		Vibrio parahaemolyticus	
	Aqueous extract	Ethanol extract	Aqueous extract	Ethanol extract	Aqueous extract	Ethanol extract	Aqueous extract	Ethanol extract	Aqueous extract	Ethanol extract	Aqueous extract	Ethanol extract
Antibiotics	3.3±0.28^{***A}	3.55±0.22^{***A}	3.33±0.05^{*A}	2.22±0.06^{*A}	2.67±0.14^{*A}	2.48±0.13^{***A}	4.17±0.51^{***A}	4.58±0.31^{***A}	5.36±0.59^{***A}	4.82±0.32^{***A}	5.84±0.31^{***A}	4.95±0.23^{***A}
1.25%	0.00±0.00^{nsB}	0.00±0.00^{nsB}	0.62±0.10^{*B}	0.00±0.00^{nsB}	1.27±0.20^{*B}	0.00±0.00^{nsB}	0.00±0.00^{nsD}	0.00±0.00^{nsB}	0.00±0.00^{nsB}	0.00±0.00^{nsB}	0.38±0.04^{nsB}	0.31±0.06^{*B}
2.5%	0.97±0.11^{nsB}	0.81±0.18^{*C}	0.31±0.05^{*A}	0.00±0.00^{nsB}	1.31±0.25^{*B}	0.00±0.00^{nsB}	0.13±0.02^{*C}	0.12±0.02^{*C}	0.00±0.00^{nsB}	0.45±0.09^{*C}	1.34±0.29^{*C}	0.00±0.00^{nsB}
5%	0.00±0.00^{nsB}	0.00±0.00^{nsB}	0.00±0.00^{nsC}	0.00±0.00^{nsB}	0.00±0.00^{nsC}	0.00±0.00^{nsB}	0.71±0.09^{*C}	0.74±0.14^{*D}	0.17±0.18^{*C}	0.71±0.16^{**D}	0.37±0.04^{nsB}	0.55±0.13^{**D}
7.5%	0.56±0.11^{nsB}	0.59±0.11^{nsB}	0.29±0.05^{*A}	0.00±0.00^{nsB}	0.00±0.00^{nsC}	0.00±0.00^{nsB}	0.76±0.15^{**D}	1.19±0.23^{***E}	0.00±0.00^{nsB}	0.00±0.00^{nsB}	0.19±0.03^{nsB}	1.01±0.14^{**B}
10%	1.68±0.34^{***D}	1.70±0.34^{***D}	0.27±0.05^{*A}	0.77±0.14^{***C}	2.33±0.54^{***D}	0.00±0.00^{nsB}	2.67±0.65^{***E}	1.45±0.27^{***E}	1.98±0.45^{***A}	0.89±0.15^{**D}	1.70±0.4^{***D}	0.00±0.00^{nsB}
12.5%	1.23±0.21^{nsB}	1.26±0.23^{*E}	1.53±0.26^{***D}	0.79±0.13^{***D}	1.80±0.31^{***E}	1.18±0.17^{**C}	1.59±0.26^{**F}	0.713±0.13^{**F}	1.01±0.23^{**D}	0.64±0.15^{**D}	1.39±0.29^{*E}	0.83±0.09^{*F}
15%	1.5±0.44^{**E}	1.77±0.41^{***F}	1.65±0.26^{***D}	0.67±0.13^{***D}	1.85±0.38^{***F}	0.57±0.12^{nsB}	1.33±0.29^{**F}	0.00±0.00^{nsB}	1.47±0.27^{**D}	0.70±0.16^{**D}	1.20±0.28^{**F}	1.07±0.22^{***G}

±SE are noticeably different in the line after a different letter (*P<0.005*)
***= highly significant; **= moderately significant; *= low significant; ns = non-significant.

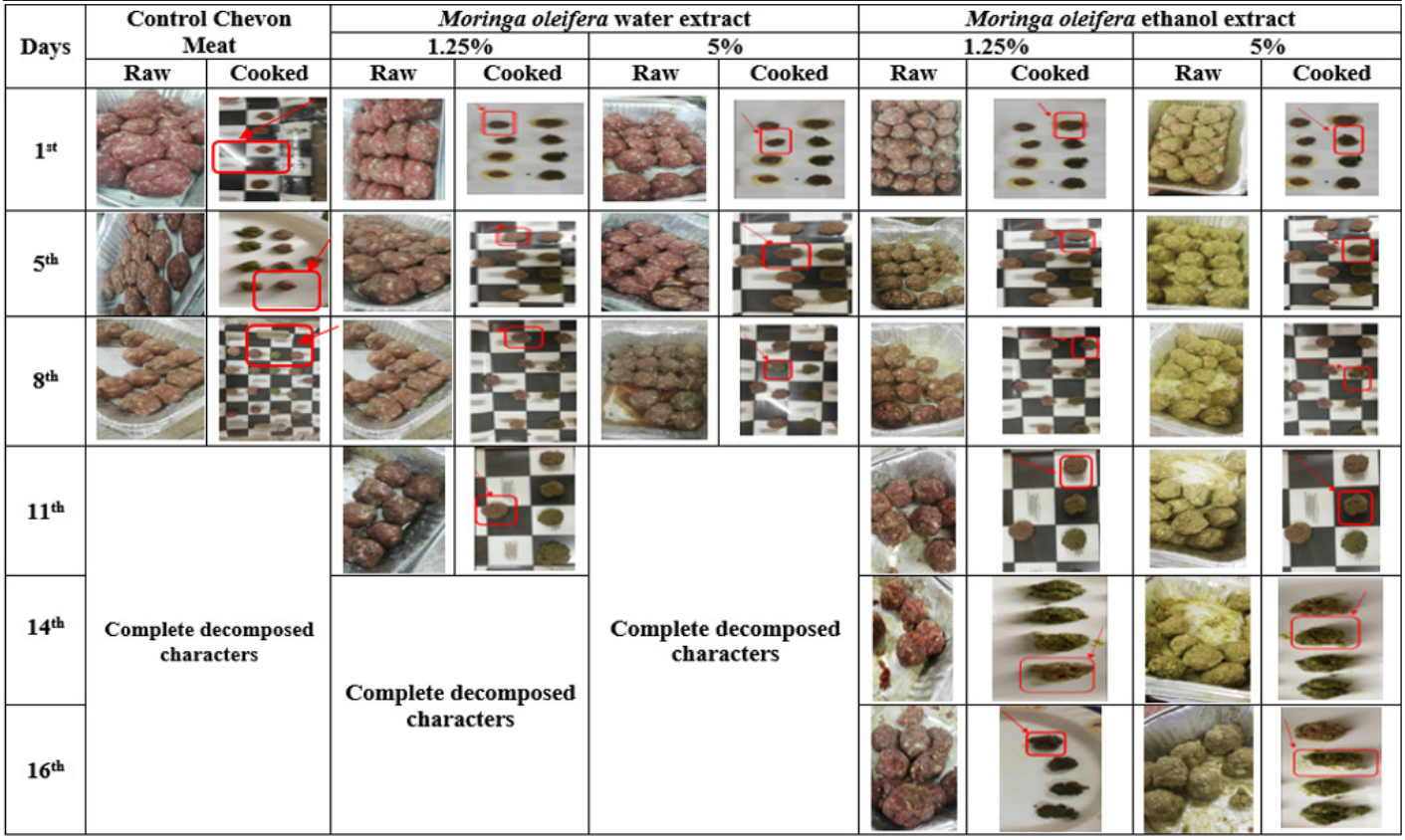

Figure 2: Sensory changes along the preservation period.

recorded during the 16th & 17th of storage as following; the color and odor of raw and cooked samples were very bad, the consistency remain its sound quality, the pH ranged from 6.33 – 6.38.

Experimental Tests to Evaluate Antimicrobial Activity of Different Used Moringa oleifera Leaves Extracts

The obtained results declared that the more effective concentration of *Moringa oleifera* leaves aqueous extract against *Staphylococcus aureus, Salmonella typhimurium, Salmonella enteritidis, Listeria monocytogens, Vibrio parahaemolyticus* used was 10% followed by 15% then 2.5% while other concentrations nearly had no effect. Although antibiotics have a nearly similar power of 10% conc. In the case of *E. coli*, the most effective results were in the case of; 12.5% & 15% followed by 1.25%, then 2.5%, 7.5% &10%, while 5% nearly had no effect. Although antibiotic has a similar power of 2.5%, 7.5% & 10% conc. Similar results reported by Paray *et al. (2018),* who studied the antimicrobial activities of crude aqueous extracts of *Moringa oleifera*, were determined in vitro by agar well diffusion method against pathogenic bacteria "*Escherichia coli and Staphylococcus aureus* as follows: 5.00±0.70 and 4.75±0.85 mm. respectively. *Staphylococcus aureus* was observed to be susceptible to the extracts. The results were based on various earlier reports advocating the antibacterial activity of *Moringa oleifera* extracts under the present study. Its extract is active against *S. aureus, E. coli,* and other Gram-positive bacteria (Narayanan *et al.*, 2011). The antimicrobial activity of its aqueous extracts (Shanthi and Nelson, 2013). Antibacterial activity of *Moringa oleifera* extracts against *E. coli, S. aureus, P. vulgaris*, etc. (Mishra *et al.*, 2014). *Moringa oleifera* water extract has been shown to have antibacterial activity against *Escherichia coli* and *Staphylococcus aureus*, with a distinct zone of inhibition spanning from 10±0 mm to 15.5±0.71 mm (Owolabi *et al.*, 2017). Components of the extract from *Moringa oleifera* include tannins, flavonoids, terpenoids, and alkaloids. The leaf of *Moringa oleifera* possesses an inherent antibacterial quality (Thilza *et al.*, 2010).

Antibacterial efficacy of extracts from *Moringa oleifera* against numerous bacterial species, including *Escherichia coli* and *Staphylococcus aureus* (Bukar *et al.*, 2010). *Escherichia coli* was inhibited by an aqueous extract of *Moringa oleifera* (12 mm inhibition zone) (Gomashe *et al.*, 2014). Aqueous crude extracts of *M. oleifera* leaf were efficacious against *E. coli* and a few other bacteria. *Escherichia coli's* inhibition zone was higher than *Staphylococcus aureus's* (Abalaka *et al.*, 2012). The antibacterial efficacy of *Moringa oleifera's* aqueous leaf extracts against harmful microorganisms such as *Staphylococcus aureus* and *Escherichia coli* (Priya *et al.*, 2011). *E. coli* was sensitive to *Moringa oleifera* extract (Oluduro, 2012). *Staphylococcus aureus* was susceptible to the antibacterial properties of the leaf water extract from *Moringa oleifera* (Vinoth *et al.*, 2012). On the other side, the *Moringa oleifera* leaf's aqueous extract had efficacy against *S. Typhi* and *E. Coli*, with diameter zones of inhibition meas-

uring 20±0.03 and 18±0.01, respectively, at all test concentrations. The 10–20 mg/ml range is the minimal inhibitory concentration (MIC) (Abalaka *et al*., 2012). However, the 20–40 mg/ml minimum bactericidal concentration ranges. while the antibacterial activity of the aqueous extract of the *Moringa oleifera* leaf showed activity against *V. parahaemolyticus* diameter zones of Inhibition of 15.9 mm. at a concentration of 20 g/180 mL (Peixoto *et al*., 2011). Nearly similar results were reported by Fouad *et al.* (2019), who examined the leaves ethanol extract and showed a distinctly superior antibacterial action against every tested strain of *S. aureus* and *E. coli*; the corresponding inhibition zone widths were 25.65±0.04, 30.5±0.28, and so on.

The test results revealed that the ethanol leaf extract of *M. oleifera* produced, in descending order, the highest zones of inhibition (25, 20, 12, 12, 11 mm) against all the Gram-negative bacteria (*S. typhi* ATCC 13311, *S. bodyii* ATCC 9207, *E. coli* O157 ATTC 700728, *E. coli* O78 (poultry isolate), *E. coli* O26 (poultry isolate) (Abd El-Moez *et al*., 2014). While the antibacterial activity of the ethanol extract of the *Moringa oleifera* leaf showed activity against *V. parahaemolyticus* diameter zones of Inhibition of 15.5 mm. at a concentration of 20 g/180 mL (Peixoto *et al*., 2011). On the other hand, the antibacterial activity of aqueous extracts and methanol extracts obtained from leaves *Moringa oleifera* against four food-borne microbial pathogens, *Escherichia coli, Vibrio parahaemolyticus, Salmonella enteritica,* and *Listeria monocytogenes*. All extraction procedures generally yielded extracts with antibacterial efficacy against all pathogens tested. Aqueous extraction revealed the lowest and strongest antibacterial activity. *Salmonella enteritica* had the highest antibacterial activity. The pathogen *Listeria monocytogenes* proved to be the most resistant to all extracts. Antibacterial activity was higher against gram-negative bacteria than against gram-positive bacteria (Dalukdeniya *et al*., 2016).

The aqueous leaf extract of *Moringa oleifera* contained several phytochemicals with antibacterial activity, such as glyphosate, 4-phenyl-1,2,3-thiadiazole, s-propyl 1-propanesulfinothioate, 2-Formyl-1-indanone, methyl cinnamate, 2-naphthol, evoxine, pseudopelletierine, 2-methylimidazole, 5-phenyl-1,3-pentadiyne, androsterone, Danielson, quinic acid, etc. Niazimicin, benzyl isothiocyanate, pterygospermin, and 4-{a-L-rhamnopyranosyloxy} benzyl glucosinolate are other substances that have been reported to be present in *Moringa oleifera* and to have some antibacterial action (Khosla, 2018).

Sensory Evaluation of the addition of *Moringa oleifera* extraction on the extension of Chevon meat shelf life

The replacement of these chemicals with safe preservatives has become one of the biggest demands in food safety and preservation technology, such as natural preservatives, including all the natural extracts of different plant parts that have an inhibiting effect on one or more food spoilage and/or food pathogens (Sánchez-Ortega *et al*., 2014; Saad *et al*., 2019).

The sensory qualities of Chevon beef were refrigerated eight days before and following cooking. The most important characteristics of many meat kinds that significantly impact the industry are pH, texture, oxidative stability, water-holding capacity (WHC), and sensory attributes. One of the most crucial markers of raw meat quality is pH, as it directly affects the stability and properties of proteins. The polypeptide chain network contracts with a decrease in pH, which reduces the molecule's ability to store water. Changes in sarcoplasmic and myofibrillar proteins happen when the pH falls quickly, which lowers WHC. Certain meat characteristics, including color, texture, hardness, juiciness, and tenderness, are linked to WHC. The discharge of water droplets from the muscle causes drip loss. One of the most crucial components of meat quality, color is also the first sensory feature that consumers look at. Meat's color and appearance are related to its hardness, juiciness, shelf life, and maturing period. The tenderness of flesh is determined by its texture. One of the most important aspects of meat quality is tenderness, which is determined by the skeletal muscle's integrity, structural arrangement, and makeup (Alarcon-Rojo *et al*., 2019).

Moringa oleifera is a highly valuable plant in many tropical and subtropical areas. It has a wide range of medical applications and high nutritional value. This plant's varied sections include a profile of vital minerals and amino acids, beta-carotene, and phenolics (Biswas *et al*., 2012). It is known in English – as Moringa oleifera Drumstick tree or Horseradish tree (Aney *et al*., 2009; Patel *et al*., 2010).

The addition of *Moringa oleifera* water extract by 1.25% extended the shelf life of chevon from 8 days to 11 days as almost all parameters remained good during the 6th & 7th day of storage. The deterioration signs became clear on the 11th day as all parameters were very bad in raw chevon samples; pH was 5.85 to 6.17 in raw and cooked samples. While the addition of *Moringa oleifera* water extract by 5%, 10%, and 15% did not report the same efficiency on the shelf life of chevon as it extends it just from 8 days to 9 days, the quality became bad in almost all parameters from the 7th days of storage while the deterioration signs become very clear on the 9th days as all parameters were very bad, pH were 6.17 and 6.20 in raw and cooked samples.

Adding *Moringa oleifera* ethanol extract by 1.25% extended the shelf life of chevon from 8 days to 16 days as almost all parameters remained very good during the 8th & 9th day of storage. The deterioration signs became very clear on the 16th day as all parameters were very bad in raw chevon sam-

ples, the pH was 5.85 to 6.43 in raw and cooked samples. While the addition of *Moringa oleifera* ethanol extract by 5% extended the shelf life from 8 days to 17 days were, the worst quality recorded during the 16th & 17th of storage as follows: the color and odor of raw samples were very bad while, the color becomes better after cooking to good quality while the odor not affected by cooking, the consistency not affected by cooking and remain its good quality, the pH ranged from 5.85 – 6.38. On the other hand, the addition of *Moringa oleifera* ethanol extract by 10% and 15% did not report bad significance on the shelf life of the chevon meat from the first day of addition as all physical characters (Color, Odor, and Consistency) were very bad during all days of storage, pH was ranged from 5.85 to 6.44 on raw and cooked samples.

Similar results reported Das *et al*., (2012) *Moringa oleifera* extract, as a natural antibacterial agent, can ensure microbiological safety in the food business. The antibacterial mechanism of *Moringa oleifera* extract against *Listeria monocytogenes (L. monocytogenes,* ATCC 19115) in terms of cell morphology, membranal structures, and other factors, ATP content, DNA, and respiratory metabolism are only a few examples. The inhibitory effects of *Moringa oleifera* extract on three important enzymes in this pathway were demonstrated by the results of respiratory metabolism. Using laser scanning confocal microscopy (LSCM), the loss of intracellular DNA of *L. monocytogenes* was notably seen after *Moringa oleifera* extract treatment, and the interaction between *Moringa oleifera* extract and DNA was characterized as embedded binding. The expression of pathogen virulence genes was likewise suppressed by *Moringa oleifera* extract treatment (Cui *et al*., 2020).

Finally, when *Moringa oleifera* extract was used to preserve animal protein products, it was discovered that it could effectively prevent the development of *L. monocytogenes* while also prolonging shelf life without altering sensory evaluation. The ability of *Moringa oleifera* leaf extracts to be employed as natural preservatives has been demonstrated. *Moringa oleifera* leaf extracts' antibacterial efficiency as preservatives for minced meat. Different quantities of preservatives were used to prepare four samples of minced meat. First, no preservative was used; second, 0.1% sodium sulfite was used to preserve the meat; third, 1% *Moringa oleifera* leaf extract; and fourth, 2% *Moringa oleifera* leaf extract. The minced meat samples were tested regularly (after 1, 12, 24, 48, and 72 hours) for color stability, sensory analysis, and microbial load (Total Bacterial Count, *Coliforms, Salmonella, Escherichia coli, and Staphylococcus aureus*). Not every sample had *Salmonella* or *Escherichia coli* found in it. The samples had varying numbers of total bacteria, *staphylococcus aureus*, and coliform, ranging from 4.3–5.98 log CFU/gram, 1.32–3.91 log CFU/gram, and 3.4–5.3 log CFU/gram, respectively. The color spectrum was 5–14, 53.2–44.2, and 12–15 in that order. Graph Pad Prism 4 one-way ANOVA was used to analyze the differences and determine if there was a significant difference (α 0.05). It was determined that the shelf life of the minced meat maintained with sodium sulfite and the one preserved with *Moringa oleifera* leaf extracts did not differ significantly (Nyathi, 2017).

The antibacterial activity of methanol extracts of this plant's leaf was seen against all microorganisms. Ethanol extracts have stronger antibacterial properties. This could be because the ethanol leaf extract contains many alkaloids and saponins. The content of phytochemicals may vary depending on the solvent employed in the extraction; ethanol is a polar solvent. The phytochemicals present, and hence the antibacterial activities, were discovered to be significantly affected by the plant's age (Akinyeye *et al*., 2014).

Tests were conducted on the antifungal and antibacterial properties of the roots, leaves, and seeds of the *Moringa oleifera* plant against oral infections, including *Candida albicans, Streptococcus aureus,* and *S. mutans*. To determine which of the three organic solvents—acetyl acetate, acetone, and ethanol—had the best antibacterial activity, *M. oleifera* plant extracts were prepared for this investigation. The efficiency of antimicrobial potentials (inhibition zones) against *S. aureus* and *S. mutans* varies. Conversely, no extract exhibited antifungal efficacy against *Candida albicans* (Elgamily *et al*., 2016). while the leaf extracts of *Moringa oleifera* exhibited antibacterial activity against six Gram-positive bacteria (*Bacillus megaterium, Bacillus subtilis, Bacillus cereus, Staphylococcus aureus, Streptococcus-B-haemolytica, and Sarcina lutea*) and four Gram-negative bacteria (*Shigella sonnei, Shigella shinga, Pseudomonas spp., and Pseudomonas aeruginosa*). *S. aureus and Streptococcus B-haemolytica* were the only Gram-positive and Gram-negative bacteria not inhibited by the fresh leaf ethanol extract (1175 µg disc-1) (Rahman *et al*., 2009).

M. oleifera leaves contain several phytochemicals, such as saponins, phenolics, flavonoids, tannins, and other antimicrobial compounds. Cell membrane disturbances are the mechanism of action for these drugs. This, together with the action of—lactams on cell wall transpeptidation, could result in the combinations having a stronger antibacterial impact (Moyo *et al*., 2012).

CONCLUSIONS AND RECOMMENDATIONS

According to the results, 10% of *Moringa oleifera* leaves aqueous and ethanol extract should be used against *Staphylococcus aureus, Salmonella typhimurium, Salmonella enteritidis, Listeria monocytogens, and Vibrio parahaemolyticus*.

For *E. coli*, the lowest and most effective concentrations of *Moringa oleifera* leaves aqueous and ethanol extract should be used, followed by 5% and 7.5%, then 1.25% & 12.5%. In addition, the study suggested using 12.5% of the ethanol extract from *Moringa oleifera* leaves to combat *Salmonella typhimurium*. 15% of the ethanol extract from *Moringa oleifera* leaves was used to combat *Vibrio parahaemolyticus*, 10% or 5% of the ethanol extract from the leaves was used to combat *Listeria monocytogens*, and 7.5% of the ethanol extract from the leaves was used to combat *Salmonella enteritidis*. A promising natural preservative for various kinds of minced meat products is *Moringa oleifera*.

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NOVELTY STATEMENT

This study is the first to evaluate the Impact of leaf extracts from *Moringa oleifera* on the microbiological and physical characteristics of Chevon meat.

AUTHOR'S CONTRIBUTION

AAA: performed all the laboratory examinations and shared in writing the article. MNB: bring the *Moringa oleifera* leaves, shared in supervision of the study and revised the manuscript. NTE: Corresponding author of the manuscript, study design, drafted, shared in PCR test, written and revised the manuscript, and data analysis. All authors. All authors read and approved the final manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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