Effect of Rosemary Extract on the Chemical Composition and Quality Properties of Buffalo Burger During Cold Storage

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ABSTRACT
The current study aimed to use buffalo meat as an alternative to beef in the preparation of burgers. Compared to beef and sheep meat, this meat has first-class chemical, biological and nutrition characteristics, such as its fat, cholesterol, amino acids, vitamins and mineral components and positive effects on the health of humans. The findings suggest that buffalo meat is a healthy substitute to beef even in the case of a healthy person under some circumstances like pregnancy and so on as well as the people susceptible to cardiovascular and cerebrovascular diseases. The active compounds in rosemary extract were added to buffalo meat because it is known to preserve food better and keep the human organism fit. The chemical composition, sensory, and qualitative properties of the obtained burger were investigated with a refrigerated storage of (15) days. The content of buffalo meat in moisture, protein, fat and ash was (74.8, 21.3, 1.9, 1.03)%, respectively as shown in the study. It was also characterized by lower cholesterol content than that of beef since it was 45 per cent mg/ 100 g.

Keywords: Buffalo meat, rosemary, buffalo burger, healthy burger, rosemary extract, refrigeration of burger.

Introduction

Human consumption of animal food products is a very important focus, as red meat provides all essential amino acids, vital iron, zinc, calcium, fats, and B vitamins. Buffalo meat can be a suitable alternative to beef (27). The high nutritional properties of buffalo meat make it suitable for inclusion in the average diet, tailored to the needs and conditions of the population, particularly its chemical, biological, and nutritional properties, and its content of fats, cholesterol, amino acids, vitamins, and minerals (28). As Trichopoulou et al. demonstrates, (51) The calories in buffalo meat are 99 kcal/100g compared to 250 kcal/100g of beef. The fat content was also low in buffalo meat at 1.5 g/100g compared to 15 g/100g of beef. Animal meat contains biologically active peptides released during intestinal digestion of food, which exhibit many side effects on the human body as antioxidant, antimicrobial, antihypertensive, anticoagulant, cytostatic, immunomodulatory, anticancer and cholesterol-lowering properties. (25, 26). The distribution of fat in buffalo carcasses differs from that of cows. In buffalo carcasses, the fat covering is predominant and concentrated in the subcutaneous area, with small leaks into the muscle tissue. Therefore, the percentage of fat in buffalo meat is lower. In cows, however, the fat seeps into the muscle mass, making it more fatty. The fat on the outer surface of buffalo meat can be easily separated. Chakrabati et al. (30) and Cifuni et al. (31) also detailed this in their study of buffalo meat and its comparison to beef in terms of content, composition, and other components. Because meat and meat products are highly perishable due to their high fat and moisture content, as well as their protein and mineral content, there was a need to find inexpensive, safe, and healthy natural alternatives to synthetic antioxidants. Therefore, the need arose to use some herbs, such as rosemary and other herbs, as antioxidant dyes (32, 45). Rosemary extract is one of the herbal extracts with antimicrobial and antioxidant properties. Rosemary (*Rosmarinus officinalis* L.) is a plant belonging to the Muscle of the labia, an evergreen herb with a fragrant aroma. The most important of these compounds include tannins, bitter substances, phenolic compounds, and flavonoids (34). Vergara et al. (53) studied this. The effect of adding different forms of rosemary (such as powder, extract, and essential oil) to mutton burgers was investigated. They were able to show that the most successful outcomes were achieved by the use of extracts and essential oil since they produced the best effect on the color of the prepared burger with minimum growth of the microbes. Rosemary extract is also an

antioxidant and best results were also attained using it. This too was verified when combined with oil extracts by Sirocchi et al. (47) and Vasilatos and Savvadis (52). The study on the functional and sensory properties of refrigeration and freezing beef sausages with the use of rosemary leaf essential oil conducted by Al-Zaidi (24) took the same direction. It was also examined by Abandansarie et al. (2). Impact of rosemary extract as antimicrobial and antioxidant agent on minced beef kept under refrigeration. We noted that the extract containing many antimicrobial and antioxidant phenolic compounds made with stimulating of ultrasound is characterized by many antimicrobial and antioxidant phenolic compounds when it is coated on pieces of beef extending up to (21) days in the refrigerator.
Gahruie et al. (35) have also determined the influence of thyme, cinnamon, and rosemary extracts on the quality of beef burgers in terms of lipid oxidation, coloring and microbial quality. They showed that these extracts could be employed to substitute BHT which is a synthetic antioxidant.
The role of the addition of carnosic acid and rosemary on some qualitative and microbial properties of fresh and refrigerated minced beef was also investigated by Al-Rubaie et al. (19). The authors found that addition of rosemary enhanced the physical and chemical characteristics of minced beef. In this research, the addition of rosemary extract to a buffalo meat was sought as a substitute to beef meat and an examination of the chemical composition, qualitative nature, chemical and sensory constants during the periods of the day during refrigeration of the same.

Materials And Methods

The chemical content of buffalo meat was studied after finely grinding it and taking random samples. Rosemary extract was then added at a rate of 1% to the burger mixture, which consisted of 80% buffalo meat, 10% animal fat, 5% filler (sifted brown flour), 1% table salt, 0.8% black pepper, 0.8% ground garlic, and cold water for kneading. The mixture was thoroughly mixed, then divided into equal balls weighing 50 grams and made into buffalo meat burgers. The meat was refrigerated at 4°C for chemical, qualitative, and sensory tests every five days for periods of (1/5/10/15) days, as explained by Abdul Rahim (4). The rosemary extract was prepared according to what was mentioned in (41). 100 grams of ground rosemary powder was weighed, 500 ml of ethyl alcohol (98%) was added, and the mixture was thoroughly mixed in a magnetic stirrer. The mixture was left for 24 hours at a laboratory temperature of 25°C. The extract was then filtered using filter paper, and the filtrate was concentrated in a rotary vacuum evaporator at 40°C to remove the solvent. The filtrate was then left at room temperature until the dry matter was reached, which was used in the mixture. This is also what was mentioned in (36).

Chemical tests:
The percentages of (moisture, protein, fat, and ash) were estimated according to the A.O.A.C. (1) method, following all weights, preparation methods, and temperatures as mentioned therein. Cholesterol was estimated according to the Al-Salem method (20). Estimation of Chemical Indicators: The peroxide value (P.V) was estimated using the A.O.A.C. method (1). Free fatty acids (FFA) and total volatile nitrogen (TVN) were estimated according to the method of Al-Taie and Al-Moussawi (22). The thiobarbituric acid (TBA) value was estimated according to the method of Mahood, (41).
Physical Tests: The criteria of Dolatowski and Stasiak, (33) was introduced to determine the water-holding capacity of meat and the weight-loss percentage during cooking. Estimation of the pH was carried out following the technique of Capita et al. (29). Estimation was done on the percentage of diameter shrinkage in the cooking step based on Soltanizadeh and Ghiasi-Esfahani, (48).
An estimate of the sensory qualities was based on a questionnaire that was developed by Tahir, (49), and adopted by Abdul Rahim. (4)

Statistical Analysis:
Analysis of data to determine the impact of the various samples concerning the studied traits was conducted according to the completely randomized design (CRD) in the SAS_Statistical Analysis system (44). The least significant difference (LSD) test was used in comparing significant differences between means.

Results And Discussion

Table (1) indicates the results of the chemical content of buffalo meat compared to beef. It is observed in the table that the moisture level was highest in buffalo meat as against to beef whereas the percentage fat and ash were higher in beef as against to buffalo meat, with minimal difference between the two which showed signs of significance. The protein values of buffalo meat were less as compared to those of beef, and the difference was not significant. The beef also had a higher cholesterol level with a great difference compared to the buffalo meat, of which 65 mg/100 in beef and 45 mg/10 (C) in buffalo meat. In measurement of the pH, it was observed that it was close to each other with minute, insignificant differences between the two. These findings can be compared with those stated by Tamburrano et al. (50). When they did a research on the chemical and biological composition of the buffalo meat and how they affect the health of an individual, they revealed that the percentage of fat, cholesterol, ash and protein content in the buffalo meat is higher than even the cow meat. This is contrary to what it contains in milk, as buffalo milk is characterized by high concentration of fat, proteins and cholesterol as compared to cow milk.

Table (1) Chemical level of buffalo meat and beef meat

Sample	Chemical content					
	Humidity%	**Protein%**	**Fat%**	**Ash%**	**Cholesterol mg/100 g**	**pH**
buffalo meat	74.8 ±2.86	21.3 ±1.56	1.90 ±0.08 b	1.03 ±0.04 b	45 ±2.75 b	5.4 ±0.26
beef	72.1 ±2.07	22.0 ±1.88	3.35 ±0.26 a	1.92 ±0.42 a	65 ±3.66 a	5.6 ±0.31
L.S.D value	3.019 NS	1.14 NS	1.416 *	0.505 *	17.94 *	0.447 NS

Means with different letters within a column are significantly different from each other .(P≤0.05) *

Table (2) shows the effect of adding rosemary extract on the chemical content of refrigerated buffalo meat burgers. It is noted from the table that the moisture content reached 66.32% and decreased slightly, insignificantly, with the continuation of the storage period, as it reached 63.60% in the last storage period (15 days). These results agreed with (11), who showed that adding plant extracts to burger mixtures increases the ability of the burger to retain water. This was also confirmed by (37) when adding it to oil extracts of meat, and also agreed with Abd El_ Qader et al (3). When adding cardamom oil to the burger mixture, they showed, in agreement with Al-Zaidi, (24), that the highest percentage of moisture was in the period of (1) day, then it began to decrease with the advancement of the storage period. They showed that this is normal, as the percentage of moisture decreases and is accompanied by an increase in the percentage of other dry materials such as protein, fat, and ash. This is what was actually observed, as the highest percentages of dry materials were recorded in the other period of time (15) days, as the percentage of protein, fat and ash increased from (20.30, 14.80 and 1.06)% in the period of 1 day to (1.45, 15.97, 21.85)% in the storage period (15) days, and these results were in agreement with Al Rubeii, (7) and Al-Taie, (23). This is also what Al_Zubaidi et al. (9) confirmed when they studied the effect of adding cinnamon and turmeric extracts in the manufacture of burgers and preserving them for 12 days in the refrigerator.

Table (2) Effect of adding rosemary extract on the chemical content of refrigerated buffalo meat burger

Storage period (day)	Chemical content %			
	Humidity	**Protein**	**Fat**	**ash**
1	66.32 ±2.36	20.30 ±1.02 b	14.80 ±0.56 b	1.06 ±0.03
5	65.59 ±2.09	21.10 ±0.97 ab	15.27 ±0.70 ab	1.20 ±0.06
10	64.44 ±1.78	21.60 ±1.15 ab	15.59 ±.58 ab	1.33 ±0.06
15	63.60 ±1.49	21.85 ±1.08 a	15.97 ±0.61 a	1.45 ±0.08
L.S.D. value	3.156 NS	1.527 *	1.178 *	0.166 NS

.Means with different letters within a column are significantly different from each other * (P≤0.05).

Table (3) shows the effect of adding rosemary extract on the chemical indicators of refrigerated buffalo meat burgers. It is noted from the table that adding the alcoholic extract of rosemary led to the emergence of very good qualities such as the peroxide value (P.V), the thiobarbituric acid value (TBA), and the total volatile nitrogen (TVN), in addition to the free fatty acids (FFA). The buffalo meat burgers were preserved by adding rosemary extract to it with a very good P.V value and within the acceptable level. This may be due to the fact that adding the extract affects the preservation of meat through its effect in inhibiting the oxidation of fats and attacking free radicals, which leads to a decrease in peroxide values. This was in agreement with Al-Dhaheri, (12) and (Shaker and Nasser (46). These values increased slightly significantly with the continuation of the storage period up to (15 days), as they recorded (1.45, 2.13, 2.80, 3.21) mill equivalents/kg fat, for the periods (15, 10, 5, 1) days, respectively. These results were also in agreement with Al-Dawkhi, (13) when using rosemary extract to preserve beef patties. They also agreed with Al-Qatifi, (18), who showed that storing meat leads to oxidation in fats and Then the formation of peroxides increases during storage, but when treated with extracts, the formation of peroxides is reduced due to the presence of compounds with inhibitory activity. These results were also consistent with Abandansari et al. (2) when they added rosemary extract to refrigerated beef.

Table (3) Effect of adding rosemary extract on the chemical indicators of refrigerated buffalo meat burger

Storage period (day)	Chemical indicators			
	P.V. mEq/kg fat	TBA mg Malonaldehyde/kg Meat	TVN N/100 meat amalgam	FFA %
1	1.45 ±0.07 c	0.84 ±0.03 c	6.03 ±0.27 c	0.41 ±0.07 b
5	2.13 ±0.11 b	0.97 ±0.06 bc	6.92 ±0.34 bc	0.59 ±0.04 ab
10	2.80 ±0.15 a	1.22 ±0.10 ab	7.55 ±0.38 ab	0.65 ±0.06 ab
15	3.21 ±0.14 a	1.40 ±0.09 a	8.25 ±0.52 a	0.71 ±0.07 a
L.S.D. value	0.554 *	0.318 *	1.026 *	0.287 *
.Means with different letters within a column are significantly different from each other .(P≤0.05) *				

The percentage of TBA, TVN and FFA also had very good values in the buffalo meat samples to which the alcoholic extract of rosemary was added, as it was noted that they recorded (0.84 mg malondialdehyde/kg meat and 6.03 mg N/100 g meat and 0.41%) in each of them, respectively, in the storage period (1 day). These values increased slightly significantly in the storage periods (10 and 15 days), while they recorded the lowest levels in the periods (1 and 5 days). This is due to the addition of the extracts, which led to a reduction in rancidity in the meat, as the extracts contain active compounds that have a natural antioxidant effect in meat stored in refrigeration and freezing. This is also what Al-rubeii & Al-alaq (10) indicated. The results were also consistent with (Al-zubaide et al. (9) when they added cinnamon and turmeric extracts and studied their effect on cooling meat. However, when Refrigeration: These values (TBA, TVN, and FFA) increased slightly and significantly up to 15 days, with the final values being 1.40 mg malondialdehyde/kg meat, 8.25 mg N/100 g meat, and 0.71%, respectively. The reason for the slight increase, while maintaining the permissible limits, of these indicators is due to the phenolic compounds and flavonoids contained in this extract (40). These results are consistent with those of Al-Ghanimi & Al-Rubeii (14) in their study of the effect of refrigeration on meat preservation. They are also consistent with Isaa & Abdulrahem (38) and Abdulrahem et al. (2022) in their assessment of these properties. Table (4) shows the effect of adding rosemary extract on the physical properties of buffalo meat burgers stored in refrigerated conditions. Water holding capacity, loss during cooking, and shrinkage in diameter during cooking were studied, in addition to the pH. It was noted that the burger prepared by adding rosemary extract to buffalo meat had very good physical properties that were maintained throughout the storage period and up to (15 days) in refrigerated conditions. It was characterized by a high water holding capacity and freshness retention of (40.09) %, which increased with increasing refrigerated conditions, reaching (42.90)% in the storage period (15 days). The shrinkage in diameter also increased during cooking and up to 15 days, reaching (11.8-13.0) % in the periods 1-15 days, respectively. The pH also increased with the increase in the storage period, which may be the reason for the increase in water holding capacity and the increase in freshness, which is directly proportional to the pH value. As for the loss during Cooking decreased slightly significantly with the continuation of the storage period, reaching (32.30)% in 1 day and (29.56) in 15 days. These results were consistent with Al-Qatifi, (18), Mahood, (41), Abdullah, (5), and Al-Obaidi, (17), who showed that adding extracts increases the water-holding capacity of burgers prepared from beef and buffalo meat. And it improves other physical properties such as reducing loss during cooking and others. It also agreed with Al_salmany & Al_Rubeii (21) and Al-Ghanimi, (14) when they studied extending the storage life of meat when stored in the refrigerator. This was also shown by (Al_zaidi & Ahmed (24) and Isaa & Abdulrahem (38) when they added the oil extract and studied its effect on preserving meat. These results also agreed with Kazem&Abdulrahem(39).

.Table (4) The effect of adding rosemary extract on the physical properties of refrigerated buffalo meat burger

Storage period (day)	Physical properties %			
	Water holding capacity	Loss while cooking	shrinkage in diameter	pH
1	40.09 ±1.86 b	32.30 ±1.27 a	11.8 ±0.54 b	5.17 ±0.42 b
5	41.48 ±2.55 ab	31.52 ±1.38 ab	12.2 ±0.51 ab	6.29 ±0.37 a
10	42.63 ±2.06 ab	29.98 ±1.27 ab	12.5 ±0.62 ab	6.43 ±0.48 a
15	42.90 ±2.17 a	29.56 ±2.31 b	13.0 ±0.67 a	6.58 ±0.41 a
L.S.D. value	2.672 *	2.810 *	1.007 *	0.894 *
.Means with different letters within a column are significantly different from each other * (P≤0.05).				

Table (5) shows the effect of adding rosemary extract on the sensory properties of buffalo meat burgers. It was noted that the prepared burger had very good sensory specifications that were maintained throughout the storage period and up to 15 days, represented by color, flavor, freshness, juiciness, and general acceptance. It received very good grades from specialist evaluators throughout the storage period, as it recorded (6.16, 6.51, 6.50, 6.33, 6.33) for each of the above-mentioned qualities, respectively. These results were consistent with Mahmoud, (42), Al-Moussawi, (16), and

Salman, (43) when they estimated the sensory properties of burgers prepared from different types of meat by adding extracts to it and studying their effective effect on preservation.

Table (5) The effect of adding rosemary extract on the physical properties of refrigerated buffalo meat burger.

Storage period (day)	Sensory properties				
	color	Flavor	softness	Juice	General acceptance
1	6.33	6.33	6.50	6.51	6.16
5	6.16	6.16	6.33	6.50	6.16
10	6.16	6.00	6.00	6.16	6.00
15	6.00	5.93	6.00	6.00	5.90
L.S.D. value	0.438 NS	0.671 NS	0.591 NS	0.602 NS	0.429 NS
NS: Non-Significant.					

Conclusion

The study concluded that buffalo meat is considered to have a high nutritional value due to its high moisture and protein content and low fat, cholesterol and ash content compared to beef. The addition of extracts led to an improvement in the physical properties, chemical and sensory indicators as well as the chemical content throughout the storage period due to the presence of phenols and flavonoids in these extracts, which have a greater effect in preventing oxidation by acting as natural antioxidants instead of expensive synthetic ones that affect human health.

References

1. A.O.A.C. 2010. Official Methods of Analysis. 18th ed. Washington, DC-USA.
2. Abandansarie, S. S. R., P. Ariaii, and M. C. Langerodi. 2019. Effects of encapsulated rosemary extract on oxidative and microbiological stability of beef meat during refrigerated storage. Journal of Food Science & Nutrition **7**: 3969–3978.
3. Abdal-Qadir, M. O., A. A. Mohammad, K. A. Mohammad, A. Mohammad, and S. A. Arabi. 2014. The effect of different level of dietary cotton seed oil on broiler chickens production. International Journal of Agricultural Policy and Research**. 2** (9): 311–320.
4. Abdul Rahim, B. A. R. A. 2010. A study of the effect of using some plant-based meat substitutes in burger manufacturing on their chemical and sensory properties. In The Fourth International Conference of the Food Industries and Nutrition Research Division, National Research Center, Cairo, Egypt.
5. Abdullah, E. N. 2021. The Use of Star Anise *(Illicium verum)* Essential Oil in Extending the Shelf Life of Refrigerated Beef Burger Patties. Master's thesis, College of Agricultural Engineering Sciences, University of Baghdad.
6. Abdulrahem, B. A. A., I. M. K. Al Aubadi, and M. M. A. Mohamed. 2022. Effect of concentrations of basit seed gum on the sensory properties of chicken sausage. Basrah Journal of Agricultural Sciences **35** (1): 229–242.
7. Al Rubeii, A. M. S. 2008. Effect of some medicinal plants supplementation on muscles weight, chemical composition, carcass fat partitioning and distribution of Awassi lamb. Journal of Agricultural Research, Kafrelsheikh University **34** (2): 445–463.
8. Al Zaidi, R. M., and M. M. Ahmed. 2020. The effect of adding some essential oils to the physicochemical properties of frozen beef sausage with different storage periods. Plant Archives **20** (Supplement 2): 2605–2609.
9. Al Zubaidi, L. A., A. M. Al-Rubeii, and A. S. Al-Salmany. 2021. Effect of cinnamon and turmeric nanoparticles extract on microorganisms of fresh ground beef during cold storage. IOP Conference Series: Earth and Environmental Science **910**: 012058.
10. Al Rubeii, A. M., and M. M. Al Alag. 2018. The bio-preservation of buffalo meat manufactured (pastrama) by using *Lactobacillus plantarum* bacteria. The Iraqi Journal of Agricultural Sciences **49** (1): 152–159.
11. Al-Alwani, D. H. A. 2017. The Effect of Adding Calanoic Acid and Rosemary to Fresh and Cooked Ground Beef during Refrigerated Storage for Different Periods. Master's thesis, Al-Qasim Green University, College of Agriculture.
12. Al-Dhaheri, S. K. M. 2012. A Study of the Effect of Adding Marjoram (*Origanum majorana* L.) and it's Extracts on Some Qualitative Characteristics of Frozen Minced Beef. Master's thesis, College of Agriculture, University of Baghdad.
13. Al-Dokhi, M. A. H. S. 2014. The Effect of The Ethanol Extract of *Allium Cepa* and *Rosmarinus Officinalis* on Extending the Shelf Life of Refrigerated and Frozen Beef and Camel Meat Discs. Master's thesis, College of Agriculture, University of Basra.

14. Al-Ghanimi, G. M. 2024. Functional Properties of Bovine Skin Elastin Degraders and Their Applications in the Shelf Life of Refrigerated and Cold-Stored Minced Beef. PhD thesis, College of Agricultural Engineering Sciences, University of Baghdad.
15. Al-Ghanini, G. M., and A. M. Al-Rubeil. 2020. Effect of antioxidant protentiat of astaxanthin and allyl isothiocyanate in quality characteristics of raw ground beef meat during cold storage. Plant Archives **20**: 673–679.
16. Al-Mousawi, H. F. 2022. A Study of the Qualitative and Sensory Properties of Camel Burgers Using Bay Leaf And Lemongrass Extracts During Refrigeration and Freezing Preservation. PhD thesis, College of Agricultural Engineering Sciences, University of Baghdad.
17. Al-Obaidi, F. K. M. 2024. The Effect of Adding Aqueous and Alcoholic Extracts of Cauliflower (*Brassica oleracea* Var. Botrytisi) and Cabbage (Brassica Oleracea Var. Capitata) On The Qualitative And Sensory Characteristics Of Frozen Beef Burgers. Master's thesis, College of Agricultural Engineering Sciences, University of Baghdad.
18. Al-Qatifi, H. K. H. H. 2019. The Effect of Onion, Potato, and Lemon Powder Extracts on Preserving the Ferrochemical Properties of Refrigerated and Frozen Beef Discs and Identification of Their Active Compounds. Master's thesis, College of Agriculture, University of Basra.
19. Al-Rubaie, A. M. S., D. H. A. Al-Alwani, and A. A. A. Al-Qutbi. 2017. Evaluation of the addition of carnosic acid and rosemary on some qualitative and microbial characteristics of fresh and chilled minced beef. Iraqi Journal of Agricultural Research (Special Issue) **20** (5): 34–46.
20. Al-Salem, A. M. A. 2014. A Study of the Chemical Content and Qualitative Properties of Fresh, Frozen, and Butchered Sheep, Cow, Buffalo, and Camel Fat. PhD thesis, College of Agriculture, University of Basra.
21. Al-Salmany, A. S., and A. M. Al-Rubeii. 2020. Effect of cinnamon and turmeric nanoparticles extract in quality characteristics of ground beef during freeze storage. Plant Archives **20** (Supplement 1): 350–356.
22. Al-Taie, M. A., and U. A. H. J. Al-Moussawi. 1992. Practical Meat and Fish Technology. Dar Al-Hikma Press, University of Basra.
23. Al-Taie, Z. H. A. 2021. The Effect of Adding Lysine and Arginine to Improve the Qualitative and Calculation Characteristics of Beef Burger. Master's thesis, College of Agricultural Engineering Sciences, University of Baghdad.
24. Al- Zaid , R. M . K., Al-Attar, E.J ., &Hadi, M. T. (2023, April). Detection of mineral and microbial contaminants in some types of imported meat. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1158, No. 11, p. 112025). IOP Publishing.
25. Battic, M., M. Boskovic, J. Ivanovic, J. Janjic, M. Dokmanovic, R. Markovic, and T. Baltic. 2014. Bioactive peptides from meat and their influence on human health. Technologija Mesa, ID: 207308044.
26. Bordoni, A., L. Laghi, E. Babini, M. Di Nunzio, G. Picone, A. Ciampa, V. Valli, F. Danesi, and F. Capozzi. 2014. The foodomics approach for the evaluation of protein bioaccessibility in processed meat upon in vitro digestion. Electrophoresis Assist **35**: 1607–1614.
27. Borghese, A. 2013. Buffalo livestock and products in Europe. Buffalo Bulletin **32**: 50–74.
28. Brunner, E. J., A. Mosdol, D. R. Witte, P. Martikainen, M. Stafford, M. J. Shipley, and M. G. Marmot. 2008. Dietary patterns and 15-year risks of major coronary events, diabetes, and mortality. American Journal of Clinical Nutrition **87**: 1414–1421.
29. Capita, R., Z. Llorente-Marigomez, M. S. Prieto, and A. C. Carlos. 2006. Microbiological profiles, pH, and titratable acidity of chorizo and salchichon (two Spanish sausages) manufactured with ostrich, deer, or pork meat. Journal of Food Protection **69** (5): 1183–1189.
30. Chakrabarti, S., S. Guha, and K. Majumder. 2018. Food-derived bioactive peptides in human health: Challenges and opportunities. Nutrients **10**: e1738.
31. Cifuai, G. F., M. Conto, A. Amici, and S. Faill. 2014. Physical and nutritional properties of buffalo meat finished on hay- or maize silage-based diets. Animal Science Journal **85**: 405–410.
32. Devatkal, S. K., P. Thorat, and M. Manjunatha. 2014. Effect of vacuum packaging and pomegranate peel extract on quality aspects of ground goat meat and nuggets. Journal of Food Science and Technology **51** (10): 2685–2691.
33. Dolatowski, J. Z., and D. M. Stasiak. 1998. The effect of low frequency and intensity ultrasound on pre-rigor meat on structure and functional parameters of freezing and thawed beef *Semimembranosus* muscle. Proceedings of the 44th International Congress of Meat Science and Technology, Barcelona, Spain.
34. El-Rajoob, A. O., A. M. Massadeh, and M. N. Omari. 2008. Evaluation of Pb, Cu, Zn, Cd, Ni and Fe levels in *Rosmarinus officinalis* (rosemary) medicinal plant and soils in selected zones in Jordan. Environmental Monitoring and Assessment **140**: 61–68.
35. Gahrure, H. H., S. M. H. Hosseini, M. H. Taghavifard, M. H. Eskandari, M. T. Golmakani, and E. Shad. 2017. Lipid oxidation, color changes and microbiological quality of frozen beef burgers incorporated with Shirazi thyme, cinnamon, and rosemary extracts. Journal of Food Quality **2017**, Article ID 6350156, 9 pages. https://doi.org/10.1155/2017/6350156.
36. Harbone, J. B. 1973. Phytochemical Methods. Chapman and Hall, London and New York.
37. Huang, B., J. He, X. Ban, H. Zeng, Y. Yao-x, and Y. Wang. 2011. Antioxidant activity of bovine and porcine meat treated with extracts from edible lotus (*Nelumbo nucifera*) rhizome knot and leaf. Meat Science **87**: 46–53.

38. Issa, R. K. M., and B. A. A. Abdulrahem. 2023. Effect of oily extracts on chemical parameters of frozen-stored beef burger. Latin American Journal of Biotechnology and Life Sciences **8** (1): 1–11.
39. Kazem, F. J., and B. A. A. Abdulrahem. 2024. Studying the effect of some plant extracts on tenderizing aged beef stored frozen. IOP Conference Series: Earth and Environmental Science **1371**: 062044.
40. Khan, R., B. Islam, M. Akram, S. Shakil, A. Ahmed, S. M. Ali, M. Siddiqui, and A. V. Khan. 2009. Antimicrobial activity of five herbal extracts against multi-drug resistant (MDR) strains of bacteria and fungi of clinical origin. Molecules **14**: 586–597.
41. Ma Hood, R. Q. 2022. The Effect of Using Some Plant Extracts to Improve the Quality Characteristics of Frozen-Stored Beef Burgers. Master's thesis, College of Agricultural Engineering Sciences, University of Baghdad.
42. Mahmoud, M. A. D. 2024. Improving the Shelf Life of Beef Burgers Using Composite Nanofibers Using Electrospinning Method. PhD thesis, College of Agricultural Engineering Sciences, University of Baghdad.
43. Salman, A. M. K. 2022. Identification Of Active Compounds In Fig And Olive Leaves And Their Use In Meat Curing And A Study Of Their Physicochemical And Storage Properties. Master's thesis, College of Agriculture, University of Kufa.
44. SAS. 2018. Statistical Analysis System, User's Guide. Version 9.6. SAS Institute Inc., Cary, NC, USA.
45. Shah, M. A., S. J. D. Bosco, and S. A. Mir. 2014. Plant extracts as natural antioxidants in meat and meat products. Meat Science **98** (1): 21–33. https://doi.org/10.1016/j.meatsci.2014.03.020.
46. Shaker, H. H., and A. K. Nasser. 2017. The effect of adding sprouted barley, flax seeds, and flaxseed to improve the properties of frozen ground beef patties. *Journal of Thi Qar University for Agricultural Research* **6** (1): 270–282.
47. Sirocchi, V., Devlinghers, N. Furpeelman, G. Sagratial, G. Maggi, S. Villor, and P. Ragaert. 2017. Effect of *Rosmarinus officinalis* essential oil combined with different packaging conditions to extend the shelf life of refrigerated beef meat. Food Chemistry **221** (April): 1069–1076. https://doi.org/10.1016/j.foodchem.2017.01.054.
48. Soltanizadeh, N., and H. Ghiasi-Esfahani. 2015. Qualitative improvement of low-meat beef burger using vera. Meat Science **99**: 75–80.
49. Tahir, M. A. 1979. Effect of Collagen on Measured Meat Tenderness. PhD thesis, University of Nebraska, Lincoln, NE, USA.
50. Tamburrano, A., B. Tavazzi, C. A. M. Calla, A. M. Amorini, G. Lazzarino, S. Viacenti, T. Zottata, M. C. Campagna, U. Moscato, and P. Laurenti. 2019. Biochemical and nutritional characteristics of buffalo meat and potential implications on human health for a personalized nutrition. Italian Journal of Food Safety **8**: 8317.
51. Trichopoulou, A., C. Bamia, and D. Trichopoulos. 2009. Anatomy of health effects of Mediterranean diet: Greek EPIC prospective cohort study. BMJ **338**: b2337.
52. Vasilitos, G. C., and I. N. Savvaidis. 2013. Chitosan or rosemary oil treatments, singly or combined, to increase turkey meat shelf life. International Journal of Food Microbiology **166** (4): 54–58. https://doi.org/10.1016/j.foodmicro.2013.06.018.
53. Vergara, H., A. Cozar, and N. Rubio. 2021. Lamb meat burgers shelf life: Effect of different forms of rosemary (*Rosmarinus officinalis* L.). Cyte Journal of Food **19** (1): 606–613.