

Impact of Aqueous Date Seed Extract on the Chemical Composition and Microbial Quality of Frozen Aged Beef

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Abstract

This study investigated the effect of aqueous extract of date seed powder on the chemical composition and microbial quality of frozen aged beef stored at -18°C for 90 days. Four treatments were applied: 0% (control), 5%, 10%, 15% extract, with three replicates each. Chemical analysis (moisture, protein, fat, and ash) and microbiological evaluation (aerobic and psychrotrophic bacteria) were conducted during storage. Results showed significant differences ($P \leq 0.05$) among treatments. The 15% extract significantly improved moisture retention (72.59%) compared to the control (70.07%), indicating enhanced water-holding capacity during frozen storage. Protein content was better preserved in treated samples, with the highest value recorded in the 15% treatment (18.20%) versus (16.67%) in the control, suggesting reduced protein oxidation. Fat percentage was lower in extract-treated samples (8.49-9.44%) compared to the control (10.71%), reflecting the antioxidant potential of phenolic compound in date seeds. Ash content was also reduced in the highest concentration (1.34%) compared to the control (1.81%). Microbiological analysis demonstrated a significant reduction in bacterial count in treated samples. The 15% treatment recorded the lowest aerobic (4.54 logCFU/g) and psychrotrophic counts (4.66 logCFU/g), whereas the control showed the highest values (5.01 and 6.07 logCFU/g).

Keywords: date seed extract, aged beef, Meat quality, Frozen storage.

Introduction

Meat is a major source of proteins, vitamins, and essential minerals. Therefore, it plays a vital role in human nutrition, because it provides proteins of high biological value that contribute to building muscles, in addition to its essential role in supporting various body functions, if consumed in a way to avoid health risks resulting from overeating these meats [1]. Older beef (Cull Cows) is one of the important sources of animal protein in the markets, but it suffers from low consumer acceptance as a result of its hardness and poor softness compared to the meat of

young animals. This is due to the high content of connective tissue, especially collagen, and the increase in its accidental bonds with age, which makes it more solid and less biodegradable by heat or enzymes. The high percentage of coarse fibers and low moisture content enhance this problem [2].

All these determinants led to the marketing of old beef often at lower prices or conversion to manufacturing industries, which limits its economic benefit. Hence the need for technological strategies or

natural additives to improve its quality [3]. When these meats are stored in freezing for long periods, the problems increase as a result of the formation of ice crystals within the tissues and the consequent loss of juice and high rates of fatty and protein oxidation, which leads to the deterioration of color, softness and flavor [4]. To reduce these effects, interest has increased at present in the use of plant extracts rich in phenolic compounds and flavonoids as natural antioxidants, as they work to inhibit oxidation and improve the color and sensory stability of meat [5]. In this context, the date kernels (*Phoenix dactylifera* L.) A promising option because it contains phenolic compounds with strong oxidative activity in addition to containing proteins, fibers and minerals, which make it a high-

value by-product [7]. Studies have shown that aqueous extracts from date nuclei have a significant ability to inhibit free radicals and reduce the growth of microbes with different effectiveness depending on the variety and extraction conditions [6]. Therefore, the objective of this study was to investigate the effectiveness of aqueous extract of date seed powder at different concentrations (5, 10, and 15%) in improving the chemical stability and reducing microbial growth in aged beef during frozen storage at -18°C for 90 days. Furthermore, the study aimed to explore the potential of date seed extract as a natural preservative capable of enhancing the quality attributes and extending the shelf life of frozen beef.

Material and Methods

Aqueous Extract Preparation

The aqueous extract of date seed powder was prepared according to the method described by [40]. Date seeds were separated from the fruits, thoroughly washed with distilled water to remove adhering pulp, and then dried at room temperature until complete dryness. The dried seeds were ground using an electric grinder to obtain a fine powder. The powder was mixed with distilled water at a ratio of 1:10 (w/v) and the mixture was left under continuous stirring for 24–48 h at

4°C to allow the extraction of bioactive compounds. After extraction, the mixture was filtered using Whatman No.1 filter paper to obtain the aqueous extract. The filtrate was collected and stored in sterile dark bottles at 4°C until further use in the experimental treatments.

. The experimental criteria were then prepared based on the concentrations required for the experiment.

Meat Samples

An old cow's meat was purchased from local markets in Samarra. The samples were prepared, cut into three iterations, and then divided into experimental coefficients. The meat was cooled for 24

hours. The experimental transactions were then prepared and saved in the specified concentrations for 24 hours. They were then dried by a piece of light cloth and frozen at -18°C for 3 months.

Experimental Treatments

The experiment was divided into four experimental coefficients with three iterations, as shown in Table (1)

Table 1. shows the experimental treatments used in the study.

Treatment	Addition rate
1	0% aqueous extract of date seed powder.
2	5% aqueous extract of date seed powder.
3	10% aqueous extract of date seed powder.
4	15% aqueous extract of date seed powder.

Chemical Analysis of Meat Samples

The used pieces of meat were sampled, chopped with an 8 mm electric grinder, and then chopped again with a 5 mm hole. Then the minced meat was mixed until it became homogeneous, and a sample weighing about 200 grams was taken. A chemical analysis of the samples was then performed to estimate the moisture, fat, protein and ash content [8].

Microbial Tests

One gram of meat was taken and added to 9 mL of a sterile physiological peptone solution (0.1 g of peptone with 100 mL of distilled water in sterile conditions, resulting in the first dilution (1/10). 1 mL of this dilution was then added to 9 mL of sterile peptone, diluting 10^{-1} . Then 1 mL of this dilution was transferred to 9 mL of dilution solution, diluting 10^{-2} . Then 1 mL of this dilution was transferred to 9 mL of dilution solution, diluting 10^{-3} . This process was repeated until dilution resulted in the appropriate number of 25 to 300

colonies of microorganisms. Using the power plate counting method, 0.1 ml of suitable dilutions were transferred and placed in sterile petri dishes, and the appropriate media was poured over them according to the required test [41].

Statistical Analysis

The Statistical Analysis System (SAS) (2012) tool was used to look at the data and see how the different methods affected the traits that were being looked at using a completely randomized design (CRD). [42]multinomial test was used to find significant changes between means.

Model in mathematics:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where:

Y_{ij} is the value of the j th data that is linked to treatment i . μ is the trait's general mean.

It stands for the effect of treatment i . e_{ij} is the chance error, which has a mean of 0 and a range of $\pm 2e$.

Results and Discussion

Chemical Composition of Frozen Beef

Moisture Ratio

Table (2), which shows the effect of adding the aqueous extract of date kernels powder on the humidity of frozen aged beef, shows that adding the aqueous extract of date kernels powder to frozen aged beef led to a significant increase in humidity compared to the control treatment T1 during all storage periods (90 days), where the treatment T4 recorded the highest average humidity (72.59%), while the lowest value in the treatment T1 (70.07%) with clear significant differences at a probability level ($P \leq 0.05$).

This positive effect of the aqueous extract of date kernels powder is related to its rich A gradual decrease in humidity was observed with an increase in the storage period, as the period recorded 90days (70.39%), while the periods of 30 and 60days (71.53 and 71.73), respectively, were in line with what was mentioned in many previous studies, such as the study of [11], which showed that long-term freezing of meat affects water loss as a result of the formation of large ice crystals that lead to muscle cell damage. The results of this experiment are also consistent with what [20] indicated in his study on the impact of the storage period on different types of meat, namely cows, sheep, buffalo and chicken, and their preservation for a period of (1, 2, 3 and 4 months) by freezing, indicating a significant decrease ($P \leq 0.05$) in humidity. This is consistent with the results of previous studies, [17,18,19]The results of this study are

composition of phenolic compounds, dietary fibers and polysaccharides, which may contribute to improving the ability of meat to retain water, as indicated by [9]that phenolic compounds possess antioxidant properties, which reduces protein and fat damage during storage. Therefore, it preserves the protein structure that binds to water within muscle tissue. The polysaccharides in date kernels may also act as natural moisture stabilizers by forming a fine gel network that contributes to reducing water loss during freezing. This is consistent with what [10] stated about the role of plant extracts in improving the functional properties of frozen meat.

consistent with the findings of [18], which indicated that the addition of marjoram plant extract to ground beef stored by freezing for (1, 30 and 60 days) led to a high humidity in all addition coefficients compared to the control treatment. These results were supported by [19]. This study also agrees with the findings of [12] who indicated that the use of plant extracts such as pomegranate or olive extract contributed to improving the retention of meat moisture during storage.

While the results of this study differ with what [13] found about the existence of a significant decrease in moisture in the meat of mountain goats stored in freezing, as the percentage of loss in cellular fluid ranged from 12-16%, and the transactions used did not succeed in reducing this loss morally.

Table 2. Effect of aqueous extract of date seed powder on the moisture content of frozen aged beef

Treatment	Period			Mean
	30	60	90	
T1	70.68 ^c ±0.47	70.37 ^c ±0.62	69.17 ^c ±0.76	70.07 ^c ±0.44
T2	71.63 ^{bc} ±0.55	71.00 ^{bc} ±0.71	69.57 ^{bc} ±0.85	70.73 ^{bc} ±0.61
T3	72.66 ^{ab} ±0.57	72.38 ^{ab} ±0.73	70.40 ^{ab} ±0.87	71.81 ^{ab} ±0.65
T4	72.05 ^a ±0.47	73.28 ^a ±0.63	72.43 ^a ±0.76	72.59 ^a ±0.42

The means of each group followed by a different letter indicate significant differences between them at the probability level ($P \leq 0.05$) according to Duncan's multiple range test

Protein ratio

It is clear from Table (3), which showed the effect of adding the aqueous extract of date kernels powder on the percentage of protein in the meat of aged cows stored in freezing, that the use of the aqueous extract of date kernels powder had a positive effect in maintaining the percentage of protein in the meat of aged cows stored in freezing. It is also noted that there is a significant increase ($P \leq 0.05$) in the percentage of protein in the meat of aged cows and for all storage periods that lasted 90 days. Significant differences were observed in the percentage of protein during storage periods, as the T4 treatment was the most effective, as it recorded the highest protein percentage (18.20%) compared to the T1, T2 and T3 coefficients, which amounted to (16.67, 17.47 and 17.53%), respectively. This hierarchy in the results indicates a relationship between the concentration of the aqueous extract of the date kernel powder or its active components and its ability to maintain protein. This may be due to the fact that the phenolic compounds in the date kernels that act as natural antioxidants prevent the oxidation and decomposition of proteins [14] or the inhibition of protein-decomposing enzymes may occur due to the compounds in the extract [15]. With regard to the effect of storage periods on the stability of the protein, a gradual decrease in the percentage of protein is observed with an increase in the storage

period in all transactions, as the percentage was after 30 days (17.66%) while it was in the periods of 60 and 90 days (17.25 and 17.22%) respectively. This may be due to the occurrence of endogenous enzymatic activity, as the effectiveness of protein-decomposing enzymes increases with the length of storage period [16]. Also, the occurrence of fat oxidation leads to the formation of secondary compounds that interact with proteins and lose their nutritional value [21].

The results of this study are consistent with previous research and studies in this field, where the study of [15] showed that adding date kernel extract to meat reduced fat oxidation and protein degradation by 20-30%, as shown by [14] that phenolic compounds in date kernels inhibit the growth of bacteria and improve protein stability. [23] also pointed out that the use of natural antioxidants preserves the protein structure and reduces its loss during storage, especially in meat exposed to long storage. Some previous studies have also pointed to the high percentage of protein with the effect of adding some natural additives to meat and its products when they are preserved by refrigeration or freezing [17,18,19]. Although there are many positive results of previous studies that agree with this study, some studies give different results such as the [22] that the ethanol extract of date nuclei has a higher antioxidant activity than the aqueous extract, which indicates that the

type of solvent used in the extraction directly affects the effectiveness of biocomposites in protecting the protein.

Table 3. Effect of aqueous extract of date seed powder on the Protein ratio of frozen aged beef

Treatment	Period			Mean
	30	60	90	
T1	16.92 ^{ab} ±0.08	16.76 ^{bc} ±0.05	13.33 ^c ±0.05	16.67 ^c ±0.17
T2	17.54 ^{ab} ±0.07	17.45 ^{bc} ±0.05	17.43 ^c ±0.05	17.47 ^{bc} ±0.18
T3	17.84 ^a ±0.05	17.65 ^{ab} ±0.05	17.10 ^{bc} ±0.04	17.53 ^{ab} ±0.13
T4	18.34 ^a ±0.06	18.24 ^a ±0.05	18.01 ^{ab} ±0.05	18.20 ^a ±0.16

The means of each group followed by a different letter indicate significant differences between them at the probability level ($P \leq 0.05$) according to Duncan's multiple range test

Fat ratio

The results obtained in Table (4), which shows the effect of the aqueous extract of date kernels powder on the percentage of fat in aged beef stored by freezing, indicate that the percentage of fat in aged beef stored by freezing led to a gradual decrease with an increase in the concentration of the aqueous extract of date kernels. The results indicated that there are clear differences between all transactions in fat percentages at different storage periods (30, 60 and 90 days). The treatment T1 showed the highest average fat percentage (10.71%), while the transactions treated with the aqueous extract of date kernels T2, T3 and T4 (9.44, 8.49 and 8.63%), respectively. This indicates the effect of the extract in reducing the high fat percentage or stabilizing it during the storage period. The results also showed that the average fat percentage gradually increases with the length of the storage period in all transactions, but this rise was less severe in transactions containing the aqueous extract of date kernels compared to the treatment of T1. This decrease or stabilization in fat ratios can be explained by the antioxidant effects of date kernel compounds. Date kernels contain high ratios of phenolic compounds and flavonoids that work to

inhibit fat oxidation reactions and thus reduce the deterioration of fats or their decomposition into volatile secondary compounds that may be calculated within the total fat during chemical analysis [24], as shown by [27]. The incorporation of date kernel powder in meat products led to a decrease in peroxide values, which is reflected in the reduction of fat oxidation rates during long storage, [18]. The addition of marjoram to frozen beef led to a significant decrease ($P < 0.05$) in the percentage of fat in experimental transactions compared to the control treatment. This was confirmed by [26]. The use of natural extracts to superior transactions containing flavonoids and fenolates also acts as an oxidizer and thus preserves the cell membrane and fats [19,28]. The extract of date kernels extracted with water or for mixed solvents also showed antioxidant activity that exceeds the industrial antioxidant BHT in minced meat by significantly reducing oxidation rates [25]. In a study conducted on chicken meat, the ethanol extract from date kernels contributed to reducing protein and fat oxidation, delaying microbial activity, and improving consumer sensory acceptance within 14 days of refrigerated storage [27].

Table 4. Effect of aqueous extract of date seed powder on the fat ratio of frozen aged beef

Treatment	Period			Mean
	30	60	90	
T1	9.83 ^b ±0.08	10.56 ^a ±0.09	11.76 ^a ±0.07	10.71 ^a ±0.28
T2	8.78 ^c ±0.06	9.21 ^b ±0.06	10.34 ^b ±0.05	9.44 ^{ab} ±0.17
T3	7.65 ^c ±0.09	8.30 ^b ±0.09	9.52 ^{ab} ±0.08	8.49 ^b ±0.26
T4	7.63 ^c ±0.15	8.55 ^{ab} ±0.11	9.72 ^{ab} ±0.09	8.63 ^b ±0.33

The means of each group followed by a different letter indicate significant differences between them at the probability level ($P \leq 0.05$) according to Duncan's multiple range test

Ash ratio

It is noted from the results obtained in Table (5), which shows the effect of adding the aqueous extract of date kernels powder on the ash percentage in the meat of aged cows stored in freezing, that the effect of the aqueous extract of date kernels powder led to a significant decrease ($P \leq 0.05$) in the ash percentage of the treatment T4 (15% of the aqueous extract), which gave 1.32% in the first storage period (30 days) compared to the control transaction T1, which gave the highest values in all storage periods, and there were significant differences between the transactions and for the various storage periods. It is noted through the same table that there was a significant decrease ($P \leq 0.05$) in the ash percentage of the T4 transaction on all transactions and for all storage periods (30, 60 and 90 days), which amounted to (1.32,1.31 and 1.40%), respectively, followed by the transaction T3, in which the ash percentage was (1.47,1.44 and 1.53%), respectively, while the control treatment T1 showed the highest ash percentage in all storage periods, which amounted to (1.72 and 1.89 and 1.82%) respectively. Some studies indicated a decrease in the percentage of ash in the transactions to which plant extracts were added compared to the control treatment [19,30]. This increase in the percentage of ash with the increase in the storage period is attributed to the moisture loss resulting from the recurrence

of ice crystallization and the rupture of cell membranes during freezing and thawing, which reduces the ability of muscle fibers to retain water and leads to the concentration of inorganic elements in the remaining moist mass. This is consistent with what [11] reported about the effect of freezing storage in increasing The components measured on a wet basis. The differences between the coefficients showed that the high levels of the aqueous extract of the date kernel powder were accompanied by a regular decrease in the ash values. This can be explained by the fact that the aqueous extract of the date kernel powder contains mainly phenolic compounds and soluble substances more than it contains dissolved minerals and fibers, which reduces its direct contribution to increasing the ash content [29]. In addition, some studies have indicated that the polyphenols and dissolved components in the date kernel extract may enhance water retention within the flesh tissue [33].) The results of this study are also consistent with what [32] found, who found a high percentage of ash with extended storage in frozen meat products, which supports the general trend in the study. These results are also consistent with some studies that indicated that the use of date kernels is a rich source of fiber and biocomposites, which gives them the ability to improve the quality characteristics of meat and food products by enhancing water retention and reducing

chemical changes during storage, as indicated by [31] that the introduction of date kernel powder in meat products did not significantly change the ash content. This is partially consistent with the results obtained in the T2 and T3 coefficients, as the differences were not very large compared to the T1 control treatment.

However, the effect of the aqueous extract with its highest concentration of 15% in the T4 treatment showed a significant decrease, which shows that the nature of the form (raw powder versus aqueous extract) and the level of concentration are all crucial and important factors in determining the final result.

Table 5. Effect of aqueous extract of date seed powder on the Ash ratio of frozen aged beef

Treatment	Period			Mean
	30	60	90	
T1	1.72 ^{ab} ±0.02	1.89 ^a ±0.01	1.82 ^a ±0.02	1.81 ^a ±0.011
T2	1.63 ^b ±0.01	1.77 ^{ab} ±0.02	1.61 ^{ab} ±0.01	1.67 ^{ab} ±0.011
T3	1.47 ^c ±0.01	1.44 ^{bc} ±0.01	1.53 ^b ±0.02	1.48 ^b ±0.014
T4	1.32 ^d ±0.02	1.31 ^d ±0.01	1.40 ^{bc} ±0.01	1.34 ^{bc} ±0.017

The means of each group followed by a different letter indicate significant differences between them at the probability level ($P \leq 0.05$) according to Duncan's multiple range test

Number of aerobic bacteria

Table (6) shows the impact of the use of the aqueous extract on the numbers of aerobic bacteria in the meat of aged cows stored by freezing, where a significant increase ($P < 0.05$) was observed in the logarithm of the total number of aerobic bacteria, as the numbers in the control treatment T1 (4.86, 4.99 and 5.19 units of bacterial colony/meat gum for the periods (30, 60 and 90 days) respectively, and the results showed a significant decrease ($P < 0.05$) in the numbers of aerobic bacteria in the transactions in which the aqueous extract of the date kernels powder was added to it, if the treatment T4 (15% of the aqueous extract of the date kernel powder) recorded the lowest number of aerobic bacteria, as the logarithm reached the total number of bacteria (4.41, 4.56 and 4.67) units of bacterial colony/meat gum for the periods (30, 60 and 90 days) respectively, followed by the treatment T3 (10% of the aqueous extract of the date kernel powder), where the logarithm reached the total number of bacteria (4.53, 4.68 and 4.79) units of bacterial

colony/meat gum for the periods (30 and 90 days, respectively). This decrease can be attributed to the richness of date nuclei in phenolic compounds and flavonoids that possess antimicrobial properties through several mechanisms, including disrupting the permeability of the cell membrane or inhibiting the activity of bacterial enzymes. Many studies have supported these results, as [34] indicated that date nucleus extracts contain effective phenolic compounds capable of impeding the growth of bacteria, making them a successful natural alternative to industrial preservatives in meat and its products. The results of this study are also consistent with rumor [12] which proved that date nucleus extract has inhibitory activity against types of aerobic and anaerobic bacteria such as *Staphylococcus aureus* and *Escherichia coli* thanks to its high content of phenolic and flavonoid compounds. As for the impact of the transaction on the algorithm of the preparation of aerobic bacteria, it is noticed that there is a significant decrease in the addition transactions compared to the control treatment. This effect was evident with the progress of the storage

period, as the T4 transaction was significantly superior ($P<0.05$) to the rest of the experiment transactions, as it was at its lowest level at the period of 30 days and

then begins to increase until the end of the storage period until it reaches its highest value at the period of 90 days, and this is consistent with what [35,36]

Table 6. Effect of aqueous extract of date seed powder on the number of aerobic bacteria in frozen aged beef

Treatment	Period			Mean
	30	60	90	
T1	4.86 ^a ±0.12	4.99 ^a ±0.10	5.19 ^a ±0.11	5.01 ^a ±0.11
T2	4.61 ^b ±0.09	4.65 ^b ±0.08	4.82 ^{ab} ±0.14	4.69 ^b ±0.10
T3	4.53 ^b ±0.15	4.68 ^b ±0.09	4.79 ^b ±0.12	4.66 ^b ±0.12
T4	4.41 ^c ±0.10	4.56 ^c ±0.11	4.67 ^b ±0.09	4.54 ^c ±0.10

The means of each group followed by a different letter indicate significant differences between them at the probability level ($P \leq 0.05$) according to Duncan's multiple range test

psychrotrophic bacteria counts

Table (7) shows the impact of the use of the aqueous extract on the numbers of cold-loving bacteria in the meat of aged cows stored in freezing, where a significant increase ($P<0.05$) was observed in the logarithm of the total number of cold-loving bacteria, as the numbers in the control treatment T1 (5.23, 6.12 and 6.88) were the units of a bacterial colony/meat gram for the periods (30, 60 and 90 days), respectively. The results also showed a significant decrease ($P<0.05$) in the numbers of cold-loving bacteria in the transactions in which the aqueous extract of the powder of the date kernels was added to it, as the treatment T4 was recorded (15% of the aqueous extract of date kernel powder (the lowest number of cold-loving bacteria, as logarithm reached the total number of bacteria (3.98, 4.67 and 5.33) units of a bacterial colony/meat gram for the periods (30, 60 and 90 days) respectively, followed by the treatment T3 (10% of the aqueous extract of date kernel powder), where logarithm reached the total number of bacteria (4.45, 5.21 and 5.89) units of a bacterial colony/meat gram for the periods (30, 60 and 90 days) respectively. This indicates the effectiveness of the aqueous extract of date

kernel powder as a natural antimicrobial as This was pointed out by [37]who indicated that the extract of date kernels is rich in phenolic substances that show activity against the positive and negative bacteria of Cram dye. The antibacterial activity in date kernels is attributed to the ability of phenol compounds such as (gallic acid and tannins) to destroy the cell membrane and increase its permeability, which leads to the disruption of vital functions of bacteria. These compounds also have antioxidant effectiveness that reduces oxidative damage to meat ,as Kadhim et al. (2025) pointed out in their study that the extracts of date kernels contain gallic acid in high proportions, which shows antibacterial strength, especially *S.aureus*, as well as *P.aeruginosa*. The results of this study also showed that the use of the aqueous extract of date kernel powder led to a significant decrease in the numbers of cold-loving bacteria, which indicates that the increase in the concentration of the extract enhances its effectiveness and inhibits bacterial growth. This is in line with what Abdelrahman et al. (2022) found when using date kernel extract in chicken meat, where it was noted that the total numbers of bacteria decreased and the shelf life of the product was extended. It was also noted that the increase in storage periods

(30, 60 and 90 days) was associated with a gradual increase in the numbers of bacteria for all transactions, but the increase was less severe in meat treated with the aqueous extract of date kernels powder compared to the control treatment. This

may be due to the fact that the vital activity of phenolic compounds continues to impede the growth of bacteria despite the length of the storage period, and this is consistent with what he found (Al-Dhahiri, 2012, as well as Andres et al., 2013).

Table 7. Effect of aqueous extract of date seed powder on the number of psychrotrophic bacteria in frozen aged beef

Treatment	Period			Mean
	30	60	90	
T1	5.23 ^b ±0.12	6.12 ^a ±0.14	6.88 ^a ±0.16	6.07 ^a ±0.14
T2	4.87 ^{bc} ±0.15	5.76 ^{ab} ±0.13	6.42 ^{ab} ±0.14	5.68 ^b ±0.13
T3	4.45 ^c ±0.10	5.21 ^b ±0.13	5.89 ^{ab} ±0.12	5.18 ^c ±0.12
T4	3.98 ^d ±0.08	4.67 ^c ±0.09	5.33 ^b ±0.10	4.66 ^d ±0.09

The means of each group followed by a different letter indicate significant differences between them at the probability level ($P \leq 0.05$) according to Duncan's multiple range test

Conclusion

The results of this study demonstrated that the incorporation of aqueous date seed extract into aged beef stored at -18° C for 90 days significantly ($P \leq 0.05$) improved chemical stability and reduced microbial load compared to the control .The treated samples ,particularly at the 15% concentration ,exhibited enhanced moisture retention and better preservation of protein content, along with a reduction in fat percentage and lipid – related deterioration during frozen storage

.Moreover, the extract significantly decreased aerobic and psychrotrophic bacterial count throughout the storage period , indicating strong antimicrobial activity .These findings reflect the antioxidant and microbial properties of phenolic compound present in date seed and confirm the potential of aqueous date seed extract as a natural preservative to improve quality and extend the shelf life of frozen aged beef as an alternative to synthetic additives.

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