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THE EFFECT OF COATING OAT STARCH ENRICHED WITH CARDAMOM OIL OR BAY LEAF (*LAURUS NOBILIS*) ON THE CHEMICAL PROPERTIES OF FROZEN DUCK BREAST

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ABSTRACT

This study was conducted in the Department of Animal Production, College of Agriculture, University of Basra, Iraq, from October 1, 2024, to January 1, 2025. Seventy-two pieces of fresh duck breast meat were collected from local markets in Basra. They were divided into six treatments as follows: T1 (uncoated negative control treatment), T2 (positive control treatment coated with polyethylene bags only), T3 (breast pieces coated with oat starch only), T4 (breast pieces coated with oat starch enriched with cardamom oil only), T5 (breast pieces coated with oat starch enriched with bay leaf powder only), T6 (breast pieces coated with oat starch enriched with cardamom oil and bay leaf powder). The treatments were stored in the freezer at 18°C for (0, 30, 60, 90) days. The chemical properties and oxidation indicators were studied. The study showed a decrease in the percentage of thiobarbituric acid (TBA) and peroxide number in treatment T6 and T4, respectively. As for the storage periods, oxidation indicators were reduced with the advancement of the storage period and improved chemical properties. We conclude that the treatments with oat starch fortified with cardamom oil or oat starch fortified with cardamom oil and bay leaf improved the quality of the meat and extended its storage life by reducing the oxidation indicators.

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INTRODUCTION

The coating process is considered an important part of food manufacturing, containing and facilitating the convenient transportation and sale of food products, preserving their qualitative characteristics, as plastic materials represent 70% of the total coating materials used in coating food products. Most plastic materials are not biodegradable and are derived from materials that are not renewable. The characteristic of the bladder with which it is described has made it useful, but its presence in the environment has become constant. The difficulty of disposing of its waste, which is excreted annually at a rate of thousands of tons, has become a major problem. These materials threaten the environment due to the pollution resulting from them and not being easily decomposed, and some of these materials also hurt human health (Ahmadreza *et. al., 2021*). Many recent trends have emerged in Coating systems, including active coating, which means a coating system. It has properties that go beyond the functions of trapping moisture, gases, dissolved materials, etc., by introducing effective components or materials into the Coating system to maintain the quality of the product and increase its shelf life (AL- Hilphy *et. al., 2022*). It also

includes carbon dioxide scavenging, oxygen scavenging, oxygen or carbon dioxide, moisture control agents, and antimicrobial coating techniques.

Carbon dioxide Scavenging and Oxygen or carbon dioxide and as a moisture control agent and antimicrobial Coating technologies (Plastic) 2020, according to (Khalaf *et. al., 2019*) Coating antimicrobial technologies Europe. The global production of Coating materials has increased, and coating reached 368 million tons in 2019. 40.5% of the plastic produced in food Coating applications is non-biodegradable, while less than 1% of the Coating materials are used as biodegradable. Much non-biodegradable plastic is in the environment, causing dangerous cross-contamination (AL- Hilphy *et.al.,2023*).

Many researchers are interested in producing biodegradable edible films to reduce synthetic or non-biodegradable plastics and preserve the environment's health (Tafa *et. al.,2023*). The importance of meat Coating includes improving the colour of the meat, increasing the shelf life and reducing meat loss. Moisture, improving live qualities, preventing loss of flavor, and providing information such as production and expiration date, additives and product information (Alkhashb *et. al., 2024*).

Cardamom *Elettaria cardamomum* is a large perennial herbaceous plant belonging to the Zingiberaceae and Maton cardamom families. It is known for its flavor components and bioactive compounds, which are of commercial importance in the cosmetics, food, and pharmaceutical industries (Castillo *et al*., 2023) and are used in perfumery and therapeutics (AL-Hilphy *et al*.,2020).

Avene sathee belongs to the Avonean family of Poaceae gramineae - Bay leaf is consumed as a culinary ingredient and used in many traditional practices. The symptoms differ as bay leaves are high in phytochemical compounds, such as phenolic compounds, and flavonoids such as quercetin. Moreover, both the malic and ethanolic extracts of Ural laurel have strong antioxidant activity and have strong reducing power, removing free radicals, removing excess ionic radicals, and removing hydrogen peroxide (Benli et. al., 2024). The study aimed to demonstrate the effect of oat starch supplemented with cardamom oil or bay leaf powder in packing duck breast pieces using the aloe vera method on the chemical properties and oxidation indicators stored by freezing (Soud *et.al., 2024*).

MATERIALS AND METHODS

This study was conducted in the Department of Animal Production, College of Agriculture, University of Basra, Iraq, during the period from 1/10/2024 to 1/1/2025, which aims to prepare oat starch fortified with bay leaf powder and cardamom oil in the laboratory and use it in different concentrations in wrapping pieces of meat, duck breast, in a way Age and study of their chemical properties and oxidation indicators when stored by renewal.

Starch Extraction

One of the Adresian process's main effects is mixing (0.5 grams of cellulose for every 100 grams of oatmeal and 20 ml of water) in the oatmeal and releasing the starch. The cellulose is added to the oatmeal for the year. Reem cellulose, the main ingredient in oats, is used to obtain fine flour with holes. Oat starch is extracted according to the (Ahmed *et. al., 2024*) method from the oat grains after working the grains well with water to remove dirt and impurities. The oat grains are then crushed

into small pieces, then the grains are ground and the mixture is mixed. Use the enzyme until it comes into contact with as much oatmeal as possible. Then, the mixture is filtered to separate the solid residue from the starch liquid using a net filter, a smooth agitator that completely separates the liquid from the starch. The aerosol liquid can be made with additional water, and any remaining food can be used.

Birds used in The Experiment

Seventy-two pieces of the most important breast of male ducks were used in this experiment, which were obtained from local markets in Basra. These pieces were divided into six treatments; each treatment had three replicates. Omar fed these pieces in a solution of oat starch prepared with cardamom oil or paper. Laurel or both according to Negative control treatment: (**TI**) pieces of duck breast meat, unwrapped. Positive control treatment: (**T2**) pieces of duck breast meat released in soft poly bags, drained from the pulp. Only the third treatment: (**T3**) pieces of duck breast meat divided with oat starch. Fourth treatment: (**T4**) pieces of duck breast meat separated with oat starch fortified with gel oil at only 1% ml percentage. Fifth treatment: (**T5**) pieces of duck breast meat seasoned with oat starch supplemented with leaf powder. Laurel only at a rate of 1% gm. Sixth treatment (**T6**) pieces of duck breast meat are divided with oat starch fortified with cardamom oil and bay leaves, mixed with 0.5 ml of cardamom oil. These are made from bay leaf powder, then stored by freezing at 18 °C per year (0,30, 60,90) days. The chemical properties (pH, moisture percentage), oxygenation indicators (**TBA**), peroxide number, and percentage of free fatty acids were studied, and the security properties were studied—measurements of chemical properties.

Measurements of chemical properties

Value pH (H)

The pH was estimated according to the method (*1975*) by John *et al., using a pH meter. They mixed minced meat with 10 ml of distilled water (p = 7) in a pot and then left it for a while. Facts: Then,* the value of pH in camels was estimated.

Moisture percentage

The percentage of moisture was estimated according to the method mentioned in AOAC (*2005*), by weighing 5 grams of meat samples from the breast piece and placing them in dishes with a known weight in advance, and placing the carcass with the sample in an electric oven at a temperature of (105) C until it stabilises. Weight: The lids were then taken out and weighed with the sample, and the percentage was calculated. For humidity, according to the following equation:

Moisture percentage = Weight of the sample before drying (g) - Weight of the sample after drying (g) / Weight of the sample before drying (g) × 100

Oxidation indicators

Thiobarbituric acid (TBA)

The method of Mehran *(1976) modified by Jalali et. al (2015*) is applied to estimate the value of Thiobarbituric acid. 5 g of minced meat was taken and dissolved in 10 ml of chloroform (and placed in a water bath for 5 minutes at 60°C) and 10 ml of a 0.07% solution of Thiobarbituric acid. In water, mixed with the same volume of Acetic acid, was added to it. The mixture was centrifuged at 1000 rpm for 5 minutes,

then the liquid was taken and placed in a boiling water bath for 30 minutes. The absorbance was measured at a wavelength of 532 nm at laboratory temperature, and the value of Thiobarbituric acid was estimated and expressed as mg of malondialdehyde. (MDA)/kg oil. The concentration was calculated from the following mathematical correlation:

$$Concentration\ of\ Malondialdehyde\ (mg\ kg)\ =\ Optical\ Absorbance\ x\ 7.8$$

RESULTS AND DISCUSSION

pH

Table (1) shows the effect of coating with oat starch supplemented with cardamom oil or bay leaf powder on the pH of duck breast meat stored in the freezer for periods of 0,30, 60 and 90 days, as no significant differences were recorded between the average treatments in the pH values. While the average storage period, 0 day, showed a significant increase (P≤0.01) in the pH values, as it recorded 6.06, which did not differ significantly from the average storage period of 30 days, which recorded 5.89, compared to the average storage period of 60 days, which It reached 5.81, which in turn showed a significant increase (P≤0.01) when compared to the average storage period of 90 days, as it reached 5.74. The interaction values between transactions and storage durations showed significant differences between the transaction values at different storage durations, as treatment T5 showed at the sadness duration. There was a significant increase (P≤0.01) in the pH value, which reached 6.23 compared to the same treatment during the 90-day storage period, which reached 5.66.

Table (1): Effect of coating with oat starch supplemented with cardamom oil or bay leaf powder on the pH of duck breast meat stored in medium freeze (mean ± standard error)

Treatment	Period of Storage (Day)					
	0	30	60	90	AT	Significance
T1	5.94 ± 0.04	5.86 ± 0.05	5.81 ± 0.03	5.75 ± 0.05	5.84 ± 0.08	N.S
T2	5.94 ± 0.06	5.87 ± 0.02	5.81 ± 0.03	5.77 ± 0.02	5.85 ± 0.07	N.S
T3	6.06 ± 0.12	5.95 ± 0.05	5.88 ± 0.02	5.76 ± 0.05	5.91 ± 0.12	N.S
T4	6.10 ±0.17	5.85 ± 0.05	5.78 ± 0.02	5.75 ± 0.05	5.87 ± 0.16	N.S
T5	6.23 ± 0.15	5.92 ± 0.06	5.83 ± 0.02	5.66 ± 0.05	5.91± 0.22	N.S
T6	6.12 ± 0.21	5.88 ± 0.02	5.79 ± 0.01	5.75 ± 0.05	5.88 ± 0.18	N.S
AST	6.06^{a} ± 0.15	5.89^{a} ± 0.05	5.81^{b} ± 0.04	5.74^{c} ± 0.05		

LSD storage periods × treatment = 0.06. Large letters between the means indicate significant differences between the treatments. Small letters between the means mean that there are significant differences between storage periods (T1), such as unwrapped pieces of meat. (T2) Coating meat pieces in vacuum-packed soft poly bags only. (T3) The lifespan of a piece of meat with oat starch only. (T4) The lifespan of a piece of meat with oat starch supplemented with cardamom oil only. (T5) The lifespan of a piece of meat cooked with starch, Oats fortified with bay leaves only. (T6) The lifespan of a piece of coated meat. Oats fortified with cardamom oil and leaves.

Humidity%

Table (2) shows the effect of coating with oat starch supplemented with cardamom oil or bay leaf powder on the moisture percentage of duck breast meat stored in the freezer at storage periods of 0,30,60, and 90 days. It is noted that a highly

significant increase (P≤0.01) in the moisture percentage was observed in favour of the average coefficients. T2, T4, T6 compared to the average control treatment TI, which recorded the lowest moisture content, reaching 70.08, while the average of the two transactions reached T3, T5 (70.75,70,83) respectively. At the same time, the average storage period recorded a highly significant increase (P≤0.01) in the humidity percentage, reaching 73.11 compared to the 90-day storage period, which recorded 69.16. It is noted from the table that the humidity percentage decreases with the progression of the storage period, as seen in Table (2). between the values of the treatments and the storage durations, as treatment 16 showed a significant increase (P≤0.01) in the humidity percentage over zero during the storage period. It recorded 73.36 compared to treatment T1 when the storage period was 90 days, which reached 67.67.

Table (2): Effect of coating with oat starch supplemented with cardamom oil or bay leaf powder on the moisture content of duck breast meat stored in medium freeze (mean ± standard error)

Treatment	Period of Storage (Day)					
	0	30	60	90	AT	Significance
T1	73.00 ± 1.00	70.65 ± 0.57	69.00 ± 1.00	67.67 ± 1.52	70.08^{C} ± 0.77	**
T2	72.65 ± 0.57	71.67 ± 0.57	70.66 ± 0.57	69.33 ± 0.57	71.08^{A} ± 0.37	**
T3	73.30 ± 0.57	71.37 ± 1.52	69.65 ± 0.57	69.00 ± 1.00	70.83^{B} ± 0.24	**
T4	73.00 ± 0.00	72.00 ± 0.00	71.00 ± 0.00	70.00 ± 1.00	71.50^{A} ± 0.44	**
T5	73.34 ± 0.57	71.32 ± 0.57	69.65 ± 0.57	68.67 ± 0.57	70.75^{B} ± 0.31	**
T6	73.36 ± 0.57	72.33 ± 0.57	71.67 ± 1.15	70.32 ± 1.02	71.91^{A} ± 0.44	**
AST	73.11^{a} ± 0.58	71.55^{b} ± 0.85	70.27^{c} ± 1.12	69.16^{d} ± 1.29		

LSD storage periods × treatments = 0.85

Large letters between the means indicate significant differences between the treatments. Small letters between the means mean that there are significant differences between storage periods (T1), such as unwrapped pieces of meat. (T2) Coating meat pieces in vacuum-packed soft poly bags only. (T3) The lifespan of a piece of meat with oat starch only. (T4) The lifespan of a piece of meat with oat starch supplemented with cardamom oil only. (T5) The lifespan of a piece of meat cooked with starch, Oats fortified with bay leaves only. (T6) The lifespan of a piece of coated meat. Oats fortified with cardamom oil and leaves.

The reason for the decrease in the pH value may be due to the advance of the average storage periods, such as 0, 30, 60, and 90 days in freezing, and the increase in the level of nitrogenous compounds as a result of the breakdown of proteins due to proteolytic enzymes that are naturally present in the meat, as the pH is an important factor in determining the shelf life of packaged meat during storage. (Alagawany *et. al.,2022)*. The physical and chemical changes of processed meat during storage are one of the main causes of quality deterioration, as meat contains antioxidants such as myoglobin and haemoglobin that can promote the oxidation of trans fats, leading to quality deterioration and colour change due to oxidation of heme proteins and the formation of an unpleasant odour—production of volatile compounds (Hussain *et. al.,2021).* Therefore, in reality, edible coatings and films used to preserve meat must exhibit good properties that limit the deterioration of meat quality. Adding aromatic oils/vegetable essential oils in the coating formulation for food preservation has

proven effective in combating the deterioration of food components and improving the physical properties of coated meat *(Ibrahim et. al.,2023).*

It was found in Table (2) that there was a significant decrease in the moisture content of the untreated Sadr samples compared to the control sample (Duaa *et.al.,2024*). It was expected that the moisture content in the samples would decrease quickly after freeze storage due to evaporation during storage and the loss of water holding capacity (WHC) due to decomposition. This occurs due to the presence of ducks, while it was found that the moisture content was higher at the end of storage for samples coated and treated with essential oils. Microbial degradation and protein autolysis cause changes in pH, affecting the humidity percentage, as there is a direct relationship between them (Kim *et al., 2018*).

(Heydari *et. al,2020*) showed a linear relationship between pH and water-holding capacity, with a decrease in pH accompanied by a decrease in the WHC in the water-holding capacity of meat, which leads to increased water loss and a decrease in moisture content in the sample, which leads to a loss of protein structure, which It affects the pH change and reduces the effectiveness of the water binding capacity (Osman *et.al.,2025*). The percentage of protein mass in the treatments treated with laurel essential oil is expected to contribute to an increase in the moisture percentage. Therefore, these samples are expected to have a higher moisture percentage (Aljabary *et. al., 2023*). The treatments from the essential oil mixture resulted in the highest moisture percentage compared to the control treatment. Many researchers also noticed an improvement in the ability to bind water when adding oats to meat due to an increase in the level of beta-glucan, which is the soluble substance in oats, which can bind water in meat, which led to a significant decrease in the amount of water lost (Sadallah *et.al.,2021*).

Oxidation indicators

Thiobarbituric acid

Table (3) shows the effect of coating with oat starch supplemented with cardamom oil or bay leaf powder on the (TBA) of duck breast meat stored in the freezer at storage periods of 0, 30, 60, 90 days. The table data showed significant differences between the average of the treatments, as the average of the two treatments showed a T4 and T6 decrease. Significantly ($P\leq0.05$) in TBA values as we recorded 0.35 mg/malon Aldehyde kg each compared to the average control treatment T1, which recorded 0.41 mg of malondehyde kg, and the rest of the average treatments. In contrast, the rest of the T5, T3, T2 treatments did not show any significant differences between them, as the TBA value for each of them reached 0.38, 0.38,0.37, respectively, which showed a significant superiority ($P\leq0.05$) when compared to the control treatment. Table (3) shows the average storage periods by freezing at 0, 30, and 60 and 90 days in the concentration of Thiobarbutic acid for duck breast meat coated with oat starch supplemented with cardamom oil or bay leaf powder in TBA, as it was observed that a highly significant decrease (($P\leq0.05$) occurred in the values of thiobarbutic acid (TBA) in favor of the average storage period 0 day, as it amounted to 0.29 mg malondehyde/kg, compared to the average storage period of 90, which recorded the highest value, amounting to 0.47 mg malondehyde/kg. It is noted from the table that there is a significant increase ($P\leq0.05$) in TBA values between the average storage periods as the storage period progresses.

Table (3) shows the interaction between the values of the treatments and the storage durations. Treatment 16 showed a significant decrease (P≤0.05) in the value of TBA, as it reached 0.28 mg malondialdehyde/kg at the storage duration of 0 day. At the same time, it is noted from the table that the value of TBA in treatment T1 increased during the storage period of 90 days, reaching 0.55 mg malondialdehyde/kg.

Table (3): Effect of coating with oat starch supplemented with cardamom oil or bay leaf powder on the TBA values of medium freeze-stored duck breast meat (mean ± standard error)

Treatment	Period of Storage (Day)					
	0	30	60	90	AT	Significance
T1	0.31 ± 0.01	0.36 ± 0.01	0.41 ± 0.03	0.55 ± 0.05	0.41^{A} ± 0.09	**
T2	0.30 ± 0.01	0.35 ± 0.02	0.41 ± 0.02	0.45 ± 0.05	0.37^{B} ± 0.06	**
T3	0.30 ± 0.00	0.34 ± 0.01	0.39 ± 0.01	0.51± 0.02	0.38^{B} ± 0.08	**
T4	0.29 ± 0.01	0.32 ± 0.02	0.38 ± 0.02	0.41± 0.02	0.35^{C} ± 0.05	**
T5	0.30 ± 0.02	0.35 ± 0.02	0.38 ± 0.02	0.51± 0.02	0.38^{B} ± 0.08	**
T6	0.28 ± 0.02	0.32 ± 0.02	0.38 ± 0.02	0.41± 0.02	0.35^{C} ± 0.05	**
AST	0.29^{d} ± 0.01	0.34^{c} ± 0.02	0.39^{b} ± 0.02	0.47^{a} ± 0.06		

LSD storage periods × treatments = 0.01. Large letters between the means indicate significant differences between the treatments. Small letters between the means mean that there are significant differences between storage periods (T1), such as unwrapped pieces of meat. (T2) Coating meat pieces in vacuum-packed soft poly bags only. (T3) The lifespan of a piece of meat with oat starch only. (T4) The lifespan of a piece of meat with oat starch supplemented with cardamom oil only. (T5) The lifespan of a piece of meat cooked with starch, Oats fortified with bay leaves only. (T6) The lifespan of a piece of coated meat. Oats fortified with cardamom oil and leaves.

The reason for the low values of oxidation indices (TBA) of duck breast meat coated with oat starch, fortified with cardamom oil or bay leaf powder and stored by freeze may be due to the different durations of oat starch with a diverse content of active compounds such as beta-glucan and avenanthramides that have activity (Al-Hilphy *et.al.,2024*). It has strong natural antioxidant properties by terminating initiation reactions and processes that help spread oxidative chains (Putri *et. al., 2023*). These compounds play a major role in promoting health and preventing oxidation, making oat starch a valuable nutritional supplement (Joanna & Marzena*,2024*). This diverse content also contributes to reducing spoilage and deterioration of meat stored for different periods, as this effect is one of the important factors in Poultry industry because it reduces fat oxidation, improves the quality of meat and its products, raises the nutritional value of meat, as well as prolongs its shelf life by interacting with free radicals and hydroxyls and converting them into stable compounds. (Al-Hilphy *et. al., 2022*). Moreover, cardamom oil is an important source of a mixture of limonene, flavonoids, and flavonoids that have a high potential as antioxidants by inhibiting the action of peroxides and their association with free radicals, as well as inactivating oxidation cofactors such as metals (Hussain *et. al., 2021*). Also, bay leaf powder is one of the rich sources of seolin, linalool, beta-pinene, and the beta-carotene formula, which prevents the formation of free radicals by binding to the terminal ionic oxygen groups by giving the ionic terminals an electron and transferring it from the carotenoid pigment to the free radicals, which renders the free radicals inoperable (Sebo *et. al., 2019*). The main action is due to the phenolic

compounds found in cardamom oil, oat starch, Bay leaf in antioxidant effect is linked to the reduction properties it possesses by breaking the chains resulting from oxidation reactions, as well as the high ability to donate electron to free radicals or fatty acids, which contributes to making these compounds act as radical scavengers (Faraj et.al., 2025). As for the reason for the increase in the values of all oxidation indicators in meat stored by freezing below a temperature of 180°C, this is normal and this formation is due to the formation of quinones, aldehydes, peroxides, free radicals, and oxygen groups (ROS) that cause the unacceptable odor and rancid flavor that led to the deterioration of the quality of meat and its products (Amaral *et. al., 2018*), because as we know, duck meat is more delicate. It is susceptible to oxidation because it contains unsaturated fatty acids. Research results have shown the ability of encapsulation with fortified oat starch to scavenge free radicals and protect the myoglobin pigment (Vaishali *et. al., 2024*). Beta-carotene has also shown the ability to reduce active oxygen radicals (Reactive oxygen species) levels. ROS inhibits lipid peroxidation by increasing the formation of enzymes that hydrolyse peroxides, such as glutathione. Glutathione peroxidase (GPX) (Al-Hmedawy *et.al.,2018*).

CONCLUSIONS

1. The results showed that using starch coated with cardamom oil and bay leaf powder improved the chemical properties of frozen duck breast meat.
2. The results showed an improvement in oxidation indicators at the fourth and sixth treatments compared to the control treatment, and a prolongation of the shelf life of the treated meat.
3. The use of an oat starch coating enriched with cardamom oil or a combination of both improved the chemical properties and extended the meat's storage life.
4. The study showed that wrapping duck breast meat with oat starch coated with cardamom oil, bay leaf powder, or both is an effective, safe, and sustainable method of improving meat quality and extending its shelf life.
5. The study showed an improvement in the chemical properties with the progression of storage periods compared to the control treatment.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

تأثير طلاء نشأ الشوفان المدعم بزيت الهيل أو ورق الغار (*Laurus nobilis*) على الخواص الكيميائية لصدر البط المجمد

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الخلاصة

أجريت هـذه الدراسة في قسم الإنتاج الحيواني بكليـة الزراعة جامعة البصرة _ العراق خلال الفترة من 2024/10/1 ولغاية 2025/1/1 أخذت 72 قطعية صدر من لحم البط الطازج من الأسواق المحلية في البصرة. قسمت إلى ست معاملات وفقاً ما يلي: T1 (معاملة السيطرة السالبة غير المغلفة)، T2 (معاملة السيطرة الموجبة المغلفة بأكياس البولـي أثيلين فقط)، T3 (قطـع الصدر المغلفة بنشأ الشوفان فقط)، T4 (قطع الصدر المغلفة بنشأ الشوفـان المدعـم بزيت الهيل فقط)، T5 (قطع الصدر المغلفـة بنشأ الشوفـان المدعـم بمسحوق ورق الغار فقط)، T6 (قطـع الصدر المغلفة بنشأ الشوفـان المدعم بزيت الهيل ومسحوق ورق الغار). تـم تخزين المعامـلات بالتجميد عند درجـة حرارة ¯ 18 مْ لمدة (0، 30، 60، 90) يومـاً. وتـم دراسة الخواص الكيميائية ومؤشرات الأكسدة وقد بينت الدراسة انخفاض نسبة حامض الثايوباربيتوريك (TBA) ورقم البيروكسيد في المعاملة T4, T6، على التوالي. أما في المدد الخزين يلاحظ انخفاض مؤشرات الأكسدة مـع تقدم مدة الخزن وتحسن في الخواص الكيميائية. ونستنتج أن المعامـلات المعاملـة بنشأ الشوفان المدعم بزيت الهيل أو نشأ الشوفان المدعم بزيت الهيل وورق الغار حسنت مـن جـودة اللحـوم وإطالة العمر الخزني لها من خلال اخفاض مؤشرات الأكسدة.

الكلمات المفتاحية: الشوفان، زيت الهيل، البط، ورق الغار.

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