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CHEMICAL AND OXIDATIVE STABILITY OF LAMB AND TURKEY KAURMA WITH BEESWAX AS A FAT REPLACER DURING COLD STORAGE IN KURDISTAN-IRAQ

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Abstract: This study investigated the production and storage of kaurma in Kurdish society, focusing on lamb and turkey meat. The aim was to replace the traditional fatty medium with a non-fatty alternative, beeswax, to address health concerns related to fat content. Four treatments were tested: lamb kaurma, lamb kaurma with wax, turkey kaurma, and turkey kaurma with wax. These samples were stored at Azmar Mountain for five months. Chemi-cal tests measured moisture, protein, fat, ash, and lipid oxidation parameters, including peroxide value (PV), free fatty acids, thiobarbituric acid (TBA), total volatile nitrogen (TVN), and amino ammonia nitrogen (AAN). Results showed significant differences in moisture content over the storage period, with the highest average moisture at 38.92%, decreasing over time. This led to increased protein, fat, and ash values. Beeswax usage increased protein values and decreased fat ratio, PV, free fatty acids, TBA, TVN, and AAN. All treatments significantly increased free amino acids after 120 days. The study provides valuable insights into Kurdish kaurma production and storage, suggesting that beeswax can effectively reduce fat content and alter kaurma composition and stability over time.

Keywords: Lamb kaurma., Turky kaurma, Scientific aspects, Bee wax, oxidation parameters.

1. Introduction

Middle Eastern cuisine, particularly in Kurdistan, Iraq, commonly consumes kaurma, a traditional meat product, for its rich flavor and long shelf life. However, the high fat content in kaurma poses challenges in terms of both health concerns and oxidative stability during storage. As consumers become more health-conscious, there is a growing interest in developing healthier versions of traditional foods without compromising taste or texture [1], [2].

The use of fat replacers is one potential solution for reducing the fat content of kaurma while maintaining its sensory attributes. Beeswax, a natural substance known for its low melting point and excellent emulsifying properties, has shown promise as a fat replacer in various food products. By incorporating beeswax into the kaurma formulation, it is possible to achieve a similar mouthfeel and sensory experience while reducing the overall fat content [3, 4, 5]. People highly demand ready-

to-eat meat products like kaurma because of their high biological value, reasonable price, favorable taste, and ease of serving. Studying kaurma as a local Kurdish product academically could be challenging due to the lack of previous similar efforts. However, for food scientists, revealing the technical background of this product's past production and its extended shelf life of six months under suitable circumstances is a challenge [1], [6].

This project introduces a new method for processing kaurma, which includes substituting beeswax for fat to improve quality and storage stability. In recent years, the pursuit of healthier food options has driven the innovation of traditional meat products, leading to the exploration of natural fat substitutes. Among these, beeswax emerges as a promising candidate, especially in the context of improving the chemical and oxidative stability of meat products during storage. Beeswax, originating from their hives, has been a traditional food preservation tool due to its excellent barrier properties against oxygen and moisture, which are the primary factors responsible for spoilage and oxidative rancidity in meats. [5], [7] The use of beeswax as a fat substitute in meat products such as lamb and turkey kaurma not only aligns with consumer demand for lower-fat options, but also enhances product shelf life without compromising sensory qualities. This is particularly pertinent in regions like Kurdistan and Iraq, where ambient temperatures can accelerate food spoilage. The use of beeswax could significantly reduce lipid oxidation, preserving both the nutritional value and flavor profile of meats during cold storage [5], [8].The study aims to fulfill the following objectives: This study aims to conduct an academic examination of traditional kaurma for the first time in Kurdistan, assess the impact of storage on the quality characteristics of processed products, introduce the use of beeswax as a fat substitute in the preparation and storage of kaurma for the first time, and discuss its effects on the product. Additionally, the study will evaluate the attributes that describe and characterize kaurma, as well as its technical aspects. Finally, the study will compare the lipid oxidation, physical properties, and sensory properties of lamb kaurma with those of turkey kaurma.

2. Materials and Methods

Kaurma preparation: Local Kurdish male turkeys provide the meat for Kaurma, a traditional meat product. The process involves trimming the meat from fat and connective tissue, cutting it into pieces of 3-6 cm2, adding 3% of the meat weight to the meat pieces with water, and dividing the meat into two treatments based on the frying medium: melting fat or wax.

Next, we pre-cook the meat in an open-cover boiler at 55.5°C for 30 minutes, and then add the remaining tail fat and wax needed for the production of kaurma. Cook the meat for 140–160 minutes, stirring occasionally to ensure homogeneous cooking. When the inner part of the meat turns from red to dark gray, the cooking process ends, losing its elasticity and making it easier to split by hand.

Sterilized, 40°C-covered potteries near Sulaimaniyah city, where the temperature is at its lowest in the winter, store samples. Each pot is filled with 2 kg of meat. We completed the manufacturing process by December 2009 and stored the samples for up to five months. We collected samples at 0, 30, 60, 90, and 120 days of storage for analysis. We used 10 potteries for each treatment over a five-month period, using two each month for chemical analyses and bacteriological and sensory examinations. An electrical machine then mixes the meat pieces before they are ready for analysis.

Proximate Analysis: We measured the levels of moisture, protein, and fat extractable by ether in the samples using the established methods of the AOAC. [9] To determine the pH, a mixture was created by blending 10 grams of kaurma with 90 milliliters of distilled water for half a minute. We then recorded the pH levels using a WTW pH 521 model digital pH meter and a WTW E56 type combination electrode [10].

Rancidity Determination:

Peroxide Value: For the PV, we dissolved the lipid in kaurma in a 30 mL chloroform-acetic acid mixture (3:2), treated it with 0.5 mL of saturated potassium iodide (KI) solution, and left it in the dark for 5 minutes. We added thirty milliliters of distilled water to the mixture and shook it. We added one milliliter of 1.0% w/v starch

solution as an indicator. We determined the PV 0.1N by titrating the liberated iodine from the potassium iodide with a sodium thiosulfate solution. We expressed the PVs as milliequivalent O2 per kilogram of fat [11].

Determination of free fatty acids: We homogenized 10 g of ground sample with 30 mL of chloroform containing 0.5 g of sodium sulfate for FFA analysis, allowed it to settle at room temperature (20 °C) for 5 min, and then filtered it through Whatman No. 1 filter paper (Whatman Ltd., U.K.). We titrated the FFAs in 25 mL of the filtrate using a potassium hydroxide solution (0.1 N). We expressed the results as grams of oleic acid per 100 grams of fat [11].

Thiobarbutric Acid (TBA) Determination: We commonly use the TBA assay to measure the oxidative rancidity of meat and other fat-containing food products. We determined the TBA values of the samples using the methods described in [12]. We prepared the samples according to the procedure and expressed the readings at 538 nm on a spectrophotometer (Shimadzu UV-1601, Japan) as mg/malonaldehyde per kg of meat. We calculated the results using the following equation:

TBA = absorption rate x 7.8

Determination of total volatile nitrogen (TVN): We measure the TVN in accordance with procedure [13]. After homogenization and the addition of 10 mL of distilled water, we obtained a weight of 10 g of meat, mixed it in a ceramic dish, and transferred it into a distillation flask. Later, we added 2 g of MgO to the flask along with 250 mL of distilled water, and then placed it in the Kjeldahl distillation system. We collected volatile nitrogen in a glass balloon, filled it with 25 mL of boric acid and 2% methyl red, and titrated it with sulfuric acid (0.1 N) to measure TVN by mgN/100 g of meat using this equation:

Amino-Ammonia Nitrogen Determination: The measurement followed the procedure's instructions.

3. Results and Discussion:

Moisture Content: Meat types and storage periods from January to May significantly affected the moisture content of local kaurma products. Turkey meat (treatment C) samples had the highest moisture content, reaching 39.30% in January. The moisture content gradually decreased, reaching 25% at the end of the storage period. This continuous decrease is likely due to the increasing rate of evaporation in samples during storage periods [14].

Table 1: Changes in Moisture (%) in Kaurma during Storage.

Sample Types	Jan	Feb	Mar	Apr	May	Average
A	38.80 a	38.31 A	35.02 Bc	31.93 D	25.40 E	33.89 a
B	38.50 a	38.30 A	34.93 Bc	31.50 D	25.00 E	33.65 a
C	39.30 a	38.68 A	35.62 B	32.80 Cd	26.60 E	34.60 a
D	39.09 a	38.80 A	35.00 Bc	32.10 D	26.12 E	34.22 a
Average	38.92 a	38.52 A	35.14 B	32.08 C	25.78 D	

*A: Lamb kaurma; B: Lamb kaurma prepared with wax; C: Turkey kaurma;

D: Turkey kaurma prepared with wax.

*Means having the same letter in the same sections are not significantly different at $P \leq 0.05$.

Regarding groups of kaurma storage time interaction, as shown vertically on the right side of the table, averages revealed no significant differences between the moisture ratios of the four treatments. The measured

values were close to values reported in the literature. According to [15], the maximum moisture content of kaurma should be about 40.0%.

Researchers have conducted studies on the moisture content of kaurma produced in Turkey. For instance, we found that the average moisture content of kaurma products in the market place in Bursa was 38.84% [16], while [17] found that the moisture content of kaurma in the market place in Erzurum ranged from 27.37% to 58.39%. The storage period of kaurma samples showed a decreasing effect on moisture averages. The initial moisture content was 38.92% in January, then decreased to 25.78% in May. We attributed this decrease to a temperature increase from January to May, which caused moisture loss and altered sensory characteristics. Researchers [17] reported similar results after storing kaurma for 150 days.

Protein Content: The protein content of kaurma samples increased significantly over storage periods, with the lowest level being 30.31% in lamb kaurma samples. The rate increased gradually to 45.70% in May in lamb kaurma with wax addition, likely due to moisture loss and an increased solid component. The measured values were close to those reported by [18], who stated that the crude protein content of kaurma samples varied from 20.9 to 35.5%, which is a very wide interval. The obtained result is also similar to that of [17], who showed that the protein content in kaurma samples was 38.6% after storage.

Samples prepared with wax treatment show higher protein content values, regardless of the meat source, in samples B and D compared to A and C. This is consistent throughout storage months, possibly due to fewer protein changes. Lower TVN results and lower proteolytic bacterial activity also support this conclusion. The storage period had a significant effect on the average protein content of kaurma samples, since the value was low in January, reaching 34.74%, and gradually rose to 40.56% in May. This might be due to the loss of moisture. We found that the interaction between Kaurmas storage time and protein content affected B and D treatments, with B and D having the highest protein content and A and C having the lowest.

Table 2: Changes in Protein Content (%) in Kaurma during Storage.

Sample Types	Jan	Feb	Mar	Apr	May	Average
A	30.31 J	30.44 J	31.15 Ij	32.75 hi	36.60 g	32.25 d
B	38.62 d-g	38.67 d-g	40.58 Cd	41.19 bc	45.70 a	40.95 a
C	31.81 hij	31.90 hij	32.75 Hi	33.38 h	37.06 fg	33.38 c
D	38.22 e-g	38.28 e-g	39.11 Def	39.70 cde	42.88 b	39.64 b
Average	34.74 C	34.82 C	35.89 B	36.75 b	40.56 a	

A: Lamb kaurma; B: Lamb kaurma prepared with wax; C: Turkey kaurma;

D: Turkey kaurma prepared with wax.

*Means having the same letter in the same sections are not significantly different at $P \leq 0.05$.

Fat content: The study found significant differences between treatments A and C, with A exhibiting an increase in fat rate compared to C due to higher fat rates in red meat compared to poultry meat. The addition of wax to B and D samples resulted in lower fat content rates, but these were lower than A and C. The attached wax contained some fat and had deep penetration into the meat tissues, making it difficult to completely remove samples for fat determination. A total reduction in one of their contents, such as moisture, would result in an increase in others, including fat, which is a major solid component in meat [19]. The results regarding the fat content in kaurma were similar to the findings reported by [18].

The study found significant differences between treatments A and C, with A exhibiting an increase in fat rate compared to C due to higher fat rates in red meat compared to poultry meat. The addition of wax to B and D samples resulted in lower fat content rates, but these were lower than those in A and C [7], [20]. The attached wax contained some fat and had deep penetration into the meat tissues, making it difficult to completely remove samples for fat determination. The fat percentage of kaurmas samples prepared without wax (A and C) was higher than those (B and D) due to the use of wax instead of melted fat. The values of B and D may be lower due to the potential for wax mixing with meat fat [1].

Table 3: Changes in Fat content (%) in Kaurma during Storage.

Sample Type	Jan	Feb	Mar	Apr	May	Average
A	28.07	28.43	30.92	33.20	34.80	31.08
	D	D	C	b	a	A
B	20.08	20.21	21.00	25.00	26.32	22.52
	H	H	H	f	ef	D
C	26.03	26.42	28.01	30.21	33.01	28.74
	F	Ef	D	c	b	B
D	19.80	20.2	23.01	25.31	27.80	23.22
	H	H	G	f	de	C
Average	23.49	23.81	25.75	28.43	30.48	
	D	D	C	b	a	

A: Lamb kaurma; B: Lamb kaurma prepared with wax; C: Turkey kaurma;

D: Turkey kaurma prepared with wax.

*Means having the same letter in the same sections are not significantly different at $P \leq 0.05$.

Ash Content: Table 4 shows that the ash content of the kaurma samples ranged from 2.18 to 3.81%, similar to the findings of [18] who conducted chemical analyses on 48 kaurma samples and found a mean ash content of 2.8%. It also confirms that, relative to the advance in storage period, an insignificant increase in ash content would occur. It may be due to a loss of moisture, which in turn caused an increase in the total solid content with respect to the storage period. The results showed insignificant differences, neither among the different treatments themselves nor among averages or interactions. The equal addition of salt to the kaurma product of the four treatments accounts for this.

Table 4: Changes in Ash Content (%) in Kaurma during Storage.

Sample type	Jan	Feb	Mar	Apr	May	Average
A	2.81	2.82	2.85	3.00	3.15	2.92
	A	A	a	a	a	a
B	2.18	2.82	2.88	2.93	2.98	2.88
	A	A	a	a	a	a
C	2.86	3.00	3.60	3.61	3.81	3.37
	A	A	a	a	a	a
D	2.89	2.72	2.88	3.00	3.20	2.93
	A	A	a	a	a	a
Average	2.84	2.84	3.05	3.13	3.28	
	A	A	a	a	a	

A: Lamb kaurma; B: Lamb kaurma prepared with wax; C: Turkey kaurma;

D: Turkey kaurma prepared with wax.

*Means having the same letter in the same sections are not significantly different at $P \leq 0.05$.

pH Value: The pH value of the samples ranged from 6.22 to 6.9. Table 5 shows a slight increase in pH value without significant differences across treatments during the whole storage period, not even among averages or interactions. Furthermore, interactions between treatments and storage periods had no effect on the pH of kaurma. The results obtained in the present study were consistent with those of [17], who found that the pH value of kaurma was about 6.23 after cooking and increased with storage period. Similarly, [15] reported that the mean pH values of kaurma stored at 0 °C for 300 days were as follows: The group's mean pH values were 6.21 after 0 days and 6.32 after 300 days, respectively. It was compatible with that of [17], who found the average pH value of kaurma in the market place in Erzurum to be 6.06. [18] reported conducting chemical analyses on 48 kaurma samples, revealing a pH range of 6.1 to 6.7 with a mean value of 6.3. The findings align with the findings of [21] who stated that samples stored under refrigeration yielded an average pH value of 6.26.

Table 5: Changes in pH Value of Kaurma during Storage.

Sample type	Jan	Feb	Mar	Apr	May	Average
A	**6.24 a**	**6.29 A**	**6.43 A**	**6.67 a**	**6.48 a**	6.42 a
B	**6.22 a**	**6.33 A**	**6.40 A**	**6.65 a**	**6.45 a**	6.39 a
C	**6.53 a**	**6.61 A**	**6.65 A**	**6.93 a**	**6.81 a**	6.70 a
D	**6.43 a**	**6.58 A**	**6.64 A**	**6.90 a**	**6.75 a**	6.66 a
Average	6.35 a	6.45 A	6.53 A	6.78 a	6.62 a	

A: Lamb kaurma; B: Lamb kaurma prepared with wax; C: Turkey kaurma;

D: Turkey kaurma prepared with wax.

*Means having the same letter in the same sections are not significantly different at $P \leq 0.05$.

Rancidity determinations: Peroxide Value (PV): Table 6 shows the PV of the treatments. The PVs range from 0.51 to 6.21 meqO2/kg. The use of wax in kaurma preparation significantly reduces PVs, as evidenced by the difference between treatments B and D (0.51, 0.95 meqO2/kg, respectively) and A and C (1.04, 1.93 meqO2/kg, respectively). Treatments A and C use a higher fat content, but B and D substitute wax for fat. The PVs of turkey kaurma samples were higher than those of lamb kaurma samples. This was probably due to the higher polyunsaturated fatty acid (PUFA) composition of turkey thigh meat as compared to that of lamb [22], [23]. It is well known that PUFAs are highly susceptible to autooxidation. Storage increased the PVs of all kaurma samples, since the average was 1.10 meqO2/kg in January and reached its highest of 4.79 in May. The measured values align with the findings of [15], [16], [23], who reported an increase in the PV of kaurma during storage.

Table 8 shows that the treatment-storage period interaction also affected samples B and D, whose PVs were lower due to the use of wax, compared to samples A and C, whose PVs were higher due to the use of fat in preparation [15].

Table 6: Changes in Peroxide Value (meqO2/kg) of Kaurma during Storage.

Sample type	Jan	Feb	Mar	Apr	May	Average
A	1.04 Ef	1.36 def	1.86 cde	2.91 c	6.03 a	2.64 b
B	0.51 F	0.96 ef	1.23 def	1.86 ced	3.33 b	1.58 d
C	1.93 ced	2.22 cd	2.85 bc	3.81 b	6.21 a	3.40 a

D	0.95 Ef	1.32 def	1.94 cde	2.25 cd	3.59 b	2.01 c
Average	1.10 D	1.46 d	1.97 c	2.70 b	4.79 a	

A: Lamb kaurma; B: Lamb kaurma prepared with wax; C: Turkey kaurma;

D: Turkey kaurma prepared with wax.

*Means having the same letter in the same sections are not significantly different at $P \leq 0.05$.

Free Fatty Acids (F.F.As): Table 7 illustrates the FFA content of lamb and turkey kaurma products, which had the same values at the initial storage period. As the storage period progressed, the FFA content rose across all treatments, with a notable alteration in the relationship between lamb kaurma and turkey kaurma. Specifically, storage time significantly influenced samples of lamb kaurma, resulting in a higher value compared to turkey kaurma. Samples (B, D) had the lowest FFA values, at 0.18 and 0.15%, respectively, compared to samples (A, C), which had values of 0.30 and 0.27%, respectively. This is because (A, C) used fat for preparation and storage, whereas (B, D) used wax. According to [24] concerning acceptable ranges for FFAs, they should be 0.6% in meat. The amount of FFAs depends directly on the many reactions occurring in the raw fat used for preparation and storage. These reactions include the lipase's hydrolytic activity, the microbial metabolic process, and the oxidative reactions released in lipolysis [22].

There was a significant difference in group of kaurma x storage time interaction on averages of FFA content of kaurma stored in January, which was 0.22% and reached 1.62% in May. This is due to the increase in total solid components and the possibility of triacylglycerol hydrolysis by the activities of different enzymes. Furthermore, lipase and phosphorlipase hydrolyze lipids and phospolipids, yielding FFAs that oxidize to peroxides [23]. The results obtained in this study are compatible with those of [16], who found that the FFA value of kaurma stored at 4℃ for 180 days increased during storage time. Furthermore, the findings align with [16] findings, which indicate an increase in the FFA value during storage. Kowale *et al.* (1996) reported that cooking meat increased the amount of FFAs significantly.

The study observed the effect of storage period on the means of FFA, finding that (A, C) were 1.05 and 0.85%, respectively, while (B, D) were 0.72 and 0.61%. We can attribute the differences to the substitution of fat in (A, C) with wax in (B, D).

Table 7: Free Fatty Acids Content (%) in Kaurma during Storage.

Sample type	Jan	Feb	Mar	Apr	May	Average
A	0.30 I	0.89 G	1.07 E	1.21 d	1.82 a	1.05 a
B	0.18 M	0.29 I	0.61 I	1.02 ef	1.52 b	0.72 c
C	0.27 I	0.51 J	0.68 H	0.97 f	1.81 a	0.85 b
D	0.15 M	0.26 I	0.38 K	0.95 fg	1.33 c	0.61 d
Average	0.22 e	0.48 D	0.68 C	1.03 b	1.62 a	

*A: Lamb kaurma; B: Lamb kaurma prepared with wax; C: Turkey kaurma;

D: Turkey kaurma prepared with wax.

*Means having the same letter in the same sections are not significantly different at $P \leq 0.05$.

Thiobarbituric Acid (TBA): Table 8 presents the results of TBA values, which measure the degree of lipid oxidation. TBA values ranged between 0.14 and 8.13 mg malonaldehayde/kg sample. It is similar to the results obtained by [18], who performed chemical analysis. Generally, the turkey kaurma sample had higher TBA val-

ues than the lamb kaurma, with the turkey kaurma achieving the highest TBA values of 8.13 mg malonaldehyde/kg in May or on the 120th day of storage. The higher PUFA content of poultry meat, such as turkey, causes the TBA to rise when used instead of lamb. This finding was consistent with [15] 's study of the effect of species on the autoxidation of kaurma made from beef and chicken. They observed that TBA values of chicken and beef kaurmas stored at 4℃ in 0 days were 0.6 and 0.2 mg malonaldehyde/kg, respectively, and in 90 days of storage, they were 7.1 and 1.4 mg malonaldehyde/kg, respectively.

The results revealed that the wax-containing kaurma sample (B, D) had a significantly lower TBA value compared with samples without wax. This is because wax is used as a substitute for melted fat in the preparation and storage process of kaurma. This was in agreement with [15], who found that kaurma made from beef intermuscular fat had the highest TBA.

In general, the TBA values of kaurma samples increased with storage time. The lowest average was in March (0.32 mg malonaldehayde/kg), reaching its highest value in May (6.13 mg malonaldehayde/kg). TBA in cooked meat significantly increased with storage time, and this is due to ferric iron reducing capacity (FRC), which is resistant to heating during the storage period [15]. These results are close to those of [16], who studied stored kaurma under refrigeration for 6 months and observed that its TBA value increased after 6 months of storage, and [25] who reported that the kaurma TBA value increased after 90 days of storage. 33 also reported an increase in TBA values of kaurma after 180 days of storage, confirming the same outcome.

Table 8: TBA Value (mg malonaldehayde/kg) in Kaurma during Storage.

Sample type	Jan	Feb	Mar	Apr	May	Average
A	0.23	1.03	1.41	2.32	6.81	2.36
	O	M	I	I	C	c
B	0.14	0.93	1.03	1.63	3.50	1.45
	O	M	M	K	G	d
C	0.60	3.92	6.80	7.20	8.13	5.33
	n	I	C	B	A	a
D	0.31	2.01	3.22	4.58	6.11	3.25
	O	O	J	H	f	b
Average	0.32	1.97	3.1	3.93	6.13	
	E	D	C	B	a	

*A: Lamb kaurma; B: Lamb kaurma prepared with wax; C: Turkey kaurma;

D: Turkey kaurma prepared with wax.

*Means having the same letter in the same sections are not significantly different at $P \leq 0.05$.

Total Volatile Nitrogen (TVN): Table 9 shows the general increase in TVN value of different treatments with respect to storage period, but it was insignificant in the first 3 months of storage. In the last two months of storage, turkey kaurma samples (C) yielded a higher mean value. It was 19.02 mg N/100 g of meat in April and 23.01 mg N/100 g of meat in May. These two samples show a significant increase compared to lamb kaurma with wax addition within two months. This increase is due to microbiological organisms' protein hydrolysis and autolysis. The obtained results were similar to those reported by 34, who studied the effect of storage on the chemical composition of poultry meat. The lowest average was in January (15.49 mg N/100gm meat), which gradually increased to the highest value of 22.16 mg N/100gm meat in May. Regarding group of kIn the kaurma

interaction x storage period group, we observed that the kaurma samples with added wax had the lowest average at 16.97 and 17.44 mg N/100gm meat for (B, D), respectively, while the kaurma samples with wax added had the highest average at 18.38 mg N/100gm meat for (C), which showed no significant increase compared to samples of (A), which had an average of 17.This is likely due to lower autolysis in wax samples.

Table 9: TVN Value (mg N/100gm) Meat of Kaurma during Storage.

Sample type	Jan	Feb	Mar	Apr	May	Average
A	15.75 ef	16.03 ef	16.57 ef	18.50 cd	22.64 Ab	17.89 Ab
B	14.58 ef	15.91 ef	16.21 ef	17.00 de	21.16 B	16.97 C
C	16.00 ef	16.73 de	17.12 de	19.02 c	23.01 A	18.38 A
D	15.63 ef	15.91 ef	16.50 ef	17.32cde	21.82 Ab	17.44 Bc
Average	15.49 d	16.14 C	16.60 C	17.96 b	22.16 A	

*A: Lamb kaurma; B: Lamb kaurma prepared with wax; C: Turkey kaurma;

D: Turkey kaurma prepared with wax.

*Means having the same letter in the same sections are not significantly different at $P \leq 0.05$.

Amino Ammonia Nitrogen (AAN) Value: Table 10 shows that kaurma AAN values increased significantly during the storage period. The lowest means were in January, which were 27.31, 25.00, 28.00, and 25.52 mg/100 g of meat for the treatments (A, B, C, and D), respectively, while the highest values for these treatments were in May, valued at 53.12, 52.11, 55.02, and 53.21 mg/100 g of meat, respectively. The increase in values is due to a dramatic reduction in the samples' moisture content. It may also be due to the hydrolysis of protein particles' peptide bonds. Simultaneously, the deamination of amino acids accumulates ammonia compounds, which Al-Aswad [26] reports as the cause of meat putrefaction. In general, turkey kaurma samples (C) had a higher AAN value in the first three months of storage compared to other treatments. We did not observe a significant difference in sample (C) compared to sample (A) in the last 2 months of storage. This is probably due to the occurrence of more protein hydrolyses in turkey kaurma samples as compared with lamb kaurma. In relation to the wax addition effect, we observed a significant reduction in ANN values in samples B and D compared to those of A and C during the entire storage period [7].

Table 10: Amino Ammonia Nitrogen Value mg/100gm Meat of Kaurma during Storage.

Sample type	Jan	Feb	Mar	Apr	May	Average
A	27.31 hi	33.01 G	40.33 E	46.18 c	53.12 Ab	39.99 b
B	25.00 j	31.31 G	36.03 F	43.03 d	52.11 B	37.49 d
C	28.00 h	35.03 F	43.33 D	48.03 c	55.02 a	41.88 a
D	25.52 ij	33.00 G	36.90 F	44.21 d	53.21 ab	38.57 e
Average	26.45 e	33.09 D	39.14 C	45.36 b	53.36 a	

*A: Lamb kaurma; B: Lamb kaurma prepared with wax; C: Turkey kaurma;

D: Turkey kaurma prepared with wax.

*Means having the same letter in the same sections are not significantly different at $P \leq 0.05$.

Table 10 shows an increase in AAN averages as storage time progresses. In January, it was 26.45 mg/100 g of meat, but gradually rose to 53.36 mg/100 g of meat in May. This is due to protein hydrolysis by autolysis, which leads to TVN release

Regarding groups of kaurma interaction storage time, the highest values were 41.88 mg/100 g of meat in turkey kaurma samples (C) and 39.99 mg/100 g of meat in lamb kaurma samples (A). The values of these two kaurmas were significantly higher than those of the kaurmas added with wax.

4. Conclusion:

The study revealed that using beeswax as a fat replacer in the preparation of lamb and turkey kaurma resulted in significant improvements in the chemical and oxidative stability of the product during storage. Beeswax reduced fat content, peroxide value, free fatty acids, and total volatile nitrogen levels, while significantly enhancing protein content. It also helped lower the oxidation rate and prevented sensory spoilage, leading to an improved sensory quality of the product. The findings suggest that beeswax is an effective option for enhancing the safety and sustainability of traditional foods in high-temperature regions while meeting the growing demand for healthier, low-fat dietary options.

Declaration of Competing Interests:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary Materials:

No Supplementary Materials.

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The authors declare no conflict of interest.

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