Heat Treatment and Change in The Qualitative Characteristics of Frozen Beef Burger Offered in The Local Market

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Abstract

The study was conducted to evaluate the effect of heat treatment on the quality of beef burger offered in the local markets for different brands during the periods of freezing storage that included 0, 3 and 6 months. The highest moisture loss was observed for the BM4 brand, with a significant difference from some other brands. The heat treatment had an effect on the physical properties of pH, the ability to hold water, the loss in weight when cooking, and the shrinkage in diameter, whose values differed according to the brands and the storage period, and the peroxide value PV and Thiobarbutyric acid values TBA differed according to the brand, as noted. as regards to protein oxidation, tryptophan fluorescence, Schiff base fluorescence, protein carbonylation were affected by Heat treatment, and a decrease in the content of thiol, Instrumental color of beef burger was affected by the heat treatment, being closely related with Maillard products formation and metmyogloben, cooked by grilling method varied according to the brand and the period of freezing storage.

Keywords: *Heat Treatment, Beef Burger, lipid oxidation, Protein oxidation, Tryptophan, Schiff base, Maillard.*

INTRODUCTION

Fast food is one of the foods most attracted to by different age groups, as the consumption of fast food has been linked to the lifestyle and concerns of modern daily life well as being prepared in different ways and easy to consume (Wazir et al., 2019) that meat is one of the basic materials for human nutrition, as it is an important nutritional vital substance It is defined as those animal tissues in which basic biological changes occurred after slaughtering the animal and became suitable for consumption. It is one of the few foods that provide complete protein, fats, mineral elements such as phosphorus, copper, iron, and some vitamins such as vitamin B1 niacin, and thus it is a major part of an important diet. For humans (Dave and Ghaly, 2011; Abdel-Naeem et al., 2021; Al-Shibli et al., 2022) Burger is one of the most common and most popular fast food consumed by the consumer. Several ingredients are included in its composition, as minced meat is the main ingredient in addition to fat, spices and seasonings. (Elibaid, 2019). The consumer's acceptance of meat and its products is affected by their suitability for food. Therefore, heat

treatment is one of the main methods for preparing products with appropriate sensory characteristics. In addition, it is a method through which it eliminates For microorganisms that cause several diseases, a certain temperature is used during the cooking process for a certain period that improves the quality characteristics of the product depending on the type of product and its components, such as the type of meat. The cooking process also affects its nutritional value by affecting its chemical content and the oxidation processes of fats and proteins (Yousif, 2008; Vu et al., 2022). Oxidative reactions in food products have been of great importance for a long time, as they are the main cause of spoilage in many food products, especially meat products, as changes are evident in the flavour, colour, texture, nutritional value, and the possibility of producing toxic compounds, and may cause many diseases and disorders (Kanner, 1994; Guo and Xiong, 2021). The oxidation of proteins is somewhat similar to the oxidation of fats during storage and production processes and begins through multiple pathways, defined as covalent modification resulting from interaction with ROS reactive oxygen species, or through secondary indirect methods such as endogenous oxidation products of fats (Sánchez-Moreno, 2002;Lund et al., 2011) Heat treatment is one of the methods affecting the chemical content and stimulating the oxidation processes that occur in food, depending on the nature of the food components and methods of manufacturing and preservation. Therefore, the study aimed to collect samples of frozen beef burgers from the local markets for different brands and to study the effect of heat treatment on the chemical content, physical properties and oxidative indicators in the quality of beef burgers offered in the local markets.

Material and Methods:

Sample Collection

Four brands of Beef Burger were collected 3 local brands and one imported BM1, BM2, BM3, and BM4 from the local markets during the storage periods 0, 3 and 6 months from the date of production by three replications, so that the number of samples collected reached 36. The samples were transported in a cork box containing Ice powder to avoid melting samples until they reached the laboratory.

Estimation of the chemical content of the meat products under study

Chemical Composition of Meat Products

The chemical content of meat burgers was estimated from moisture, fat, ash and carbohydrates according to the method described in AOAC (2002), while the protein content was estimated according to the method mentioned in Preason (1970).

Physical properties

Water Holding Capacity (WHC)

The water-holding capacity of the meat products under study was estimated after heat treatment and during the studied storage periods according to the method presented by Diniz and Martin (1997) described by YEE and AMIN (2020) by mixing 10 g of each sample with 20 ml of distilled water and mixing well to obtain a homogeneous mixture. , centrifuge at 3000 rpm for 25 min, filter the mixture using Whatman No.1 filter paper, and record the volume of filtrate using a graduated cylinder after 30 min, water carrying capacity was calculated as follows:

Water holding capacity (ml) = total water volume (ml) – the volume of water in the cylinder (ml)

pH

The pH value of the meat burger was estimated after the heat treatment by adding 50 ml of distilled water to 10 g of each sample and mixing well for 5 minutes. A pH meter was used to measure the pH value according to the method of Malik et al. (2021).

Cooking Loss

The weight loss percentage was estimated after cooking samples of the beef brisket after heat treatment (grilling) and during storage periods according to the method of Sánchez-Zapata et al. (2010) and described by Selani et al. (2016). From the following equation:

$$\text{Cooking loss (\%)} = \frac{\text{raw patty weight (g)} - \text{cooked patty weight (g)}}{\text{raw patty weight (g)}} \times 100$$

Diameter Shrinkage

The diameter of the Burger meat discs was estimated after the heat treatment (grilling) during the storage periods studied, according to what was shown by Sánchez-Zapata et al. (2010) cited in Selani et al. (2016). The shrinkage percentage was calculated as follows:

$$\text{Diameter shrinkage (\%)} = \frac{\text{raw patty diameter (mm)} - \text{cooked patty diameter (mm)}}{\text{raw burger patty diameter (mm)}} \times 100$$

Chemical properties

Fat oxidation

- Peroxide Value (PV)

The peroxide value was estimated by following the method of AOAC (2002) mentioned by Nayak et al. (2016), using 5 g of the sample and adding 30 ml of a mixture of 2:3 chloroform and glacial acetic acid (vol/v) with 0.5 ml of saturated potassium iodide solution. The mixture was incubated for 30 minutes in the dark, and 20 ml of distilled water was added to it with drops of 1% starch. Use 0.1 T of sodium thiosulfate solution to titrate the free iodine up to the endpoint.

$$\text{peroxide number} = \frac{\text{Vx N x1000}}{\text{Sample weight (g)}}$$

whereas:

V = The volume of sodium thiosulfate required for a sample (ml).

N = Sodium thiosulfate titer

2- Thiobarbituric Acid(TBA)

The value of thiobarbituric acid was estimated according to the method of Soltanizadeh and Ghiasi-Esfahani (2015), the absorbance was measured at 532 nm, and the TBA content was calculated from the following equation:

TBA Malonaldehyde mg/kg = absorbance x 5.4

-Protein oxidation:

Determination of Carbonyl Groups (COOH)

(DNPH) 2,4-dinitrophenyl hydrazine was used for the determination of carbonyl groups according to the method of Levine et al. (1990) and Colombo et al. (2015) The protein was precipitated by taking 1 ml of the protein suspension and adding an equal amount of 20% TCA to it , then 1 ml of 20% TCA was used to wash the precipitated protein. Tubes incubatered for an hour in the dark at laboratory temperature. 1 ml of a mixture of ethanol and ethyl acetate at a ratio of 1:1 was used to wash the precipitated protein. 8 M urea

was used to dissolve the precipitated protein. At a wavelength of 370 nanometers.

$$\text{Carbonyl nmol /mg protein} = \frac{\text{As – Ab/£} \times 10^9 \text{ / Protein concentration (mg/mL)}}{\text{Sample weight (g)x1000}}$$

whereas:

As = absorbance of the sample

Ab = absorbance of the blank

£ = molar factor 22000 mol/cm

Determination of The Content of Thiol Groups

The reagent (DTNB) Ellman,s 5,5-dithiobis-2-nitrobenzoic acid, was used for the determination of thiol aggregates by following the method of Lund et al. (2007) and Soyer et al. (2010) by taking 2 g of the sample with 50 ml of 0.1 M Tris Buffer buffer solution pH= 8 containing 5% SDS and placing the mixture in a water bath of 80 °C for 30 minutes, centrifuged at 5000 rpm for 20 minutes, the solution was filtered and the protein was measured using the Kit Burit in the filtrate, then 0.5 ml of the filtrate was taken and mixed with 2 ml of the buffer solution with the addition of 0.5 ml of DTNB 10 mM, the samples were incubated in the dark for 30 minutes, the absorbance was measured at a wavelength 412 nm, the Blank control sample was prepared using the buffer solution instead of the sample.

$$\text{Concentrate SH nmol/ mg protein} = \frac{\text{As – Ab/£ x D} \times 10^9 \text{/ Protein concentration (mg/mL)}}{\text{Sample weight (g)x1000}}$$

whereas:

As = absorbance of the sample

Ab = absorbance of the blank

£ = molar factor 13,600 mol/cm

D = Number of times dilution

Fluorescence measurements of Schiff base structures (SB)

The method of Estevez et al. (2008) reported by Xia et al. (2021) using a Fluorescence Spectroscopy- LS-3- Perkin Elmer In the Photophysics Research Laboratory / College of Science , Taking 1 g of samples was homogenized in 20 mL of sodium phosphate buffer pH 6.5 containing 0.6 M NaCl for 30 s and then Filtered, and then taking 1 ml of homogenate was re-dissolved in 20 mL of 20 mM sodium phosphate buffer and was measured at The emission spectrum from 400 nm to 500 nm with excitation wave length at 350 nm

Fluorescence measurements of tryptophan

Fluorescence spectroscopy- LS-3- Perkin Elmer In the Photophysics Research Laboratory / College of Science, The tryptophan emission spectrum was estimated using the same method mentioned above according to the method of Estevez et al. (2008) reported in Xia et al. (2021), The emission spectrum of tryptophan was recorded from 300 nm to 400 nm with excitation wavelength at 283 nm.

- Determination of Pigments

1- Determination of Metmyoglobin pigment Met-Myoglobin(Met-Mb)

The method mentioned by Krzywicki (1982) presented in Zahir (2021) was used to

determine the pigment ratio of metmyoglobin, the absorbance was measured at wavelengths 525, 572 and 700 nm, and the pigment ratio of metmyoglobin was calculated based on the following equation:

Metmyoglobin dye (Met –Mb)%= 1.395-((A572 -A700)/(A525- A700)) x100

- Maillard products (MRPs) quantification

The pigments formed after the heat treatment were estimated according to the method used by Silva et al. (2016) by homogenizing 0.5 g of the sample with 4.0 ml methanol, the test tubes were closed tightly and placed in a shaker for one hour, the tubes were centrifuged at a speed of 5000 rpm for 20 minutes The absorbance of the upper layer of the supernatant was measured at a wavelength of 420 nm, according to the concentration of Maillard products, by following the Martins and Van Boekel (2003) formula using the molar absorption coefficient (1.0 ± 0.03 L mmol-1 cm-1).

$$A = € \times c \times b$$

whereas:

A = sample absorbance

C = concentration

b = light path (1cm)

Statistical Analysis

The ready-made statistical program (2009) GenStat Release 12.1 was used to analyze the results using the Completely Randomized Design (CRD) for all factors under study and at the probability level $p<0.05$ tested the least significant difference averaged R.L.S.D

Results and Discussion

1-Chemical Composition

The results in Table (1) showed that there were significant differences ($P<0.05$) in the percentage of moisture after heat treatment for the different brands offered in the local markets. BM4 had the lowest moisture content in all studied storage periods of 6 months, 57.36, 54.66 and 52.90%, respectively, with a significant difference in moisture percentages for all brands BM1 and BM2, with no significant differences with brand BM3 during all studied storage periods.

It was observed in Table (1) that there were no significant differences in percentage of protein during each of the 3 and 6 months of the studied storage periods between the BM2 brand 18.65 and 18.6%, respectively, and the BM4 and BM3 brands of the beef burger after heat treatment, while the lowest percentage of protein during The same storage period amounted to 15 and 14.25%, respectively, for the BM1 brand, with a significant difference from all brands in all storage periods.

The results of the statistical analysis in the same table showed that the heat treatment had a significant effect ($P<0.05$) on the percentage of fat in the beef burger of the different brands, which decreased with the progression of the storage period, It was observed that the lowest percentage of fat in the beef burger was for the BM1 and BM2 brands after heat treatment 7-9.15 and 7.23-10.5%, respectively, during the studied storage period of 6 months of freezing, with no significant differences between the two brands, while a significant difference appeared from other brands, The results agreed with Al-Mrazeeq et al. (2010) when preparing chicken meat burgers that were frozen at -18 °C for 3 months to estimate the chemical content after

each month of storage and also after treatment. Thermal grilled it, and it was found that the percentage of fat in the chicken burger decreased after grilling with the progress of freezing storage.

Table (1) showed that the heat treatment led to a significant increase (P<0.05) in the percentage of ash and continued to rise with the increase in the storage period for the brands of frozen beef burgers, as a clear effect of the heat treatment appeared in 6 months of freezing compared to the beginning of storage for the meat burger beef, as the highest percentage of ash at the end of the freezing period was 3.12% for the BM2 brand, and the lowest percentage was 2.76% for the BM3 brand.

The results showed in the same table that the percentage of carbohydrates increased significantly (P 0.05) after the heat treatment with the advancement of the storage period for the brands of beef burgers. It was noted from the results that samples BM1 and BM2 had the highest percentage of carbohydrates after 6 months of production in the beef burger. It reached 16.7 and 15.77% compared to the BM4 brand of 13.5%, which recorded the lowest percentage of carbohydrates.

Table (1): The effect of heat treatment on the chemical content of freeze-stored beef burger brands

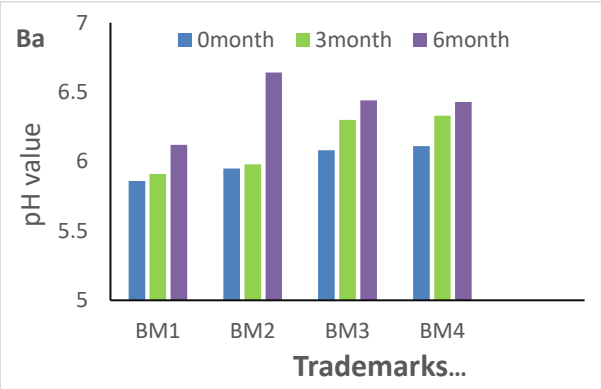
Carbohydrates	Ash	Fat	Protein	Moisture	Storage period/ Month	Trademarks
9.09	2.13	9.15	16.05	63.5	0	**BM1**
6.44	1.77	10.5	19.03	62.11		**BM2**
6.12	1.42	14.0	20.81	57.6		**BM3**
7.41	2.01	15.84	17.35	57.36		**BM4**
12.12	2.87	8.38	15	61.53	3	**BM1**
10.03	2.09	9.37	18.65	59.7		**BM2**
9.63	1.76	13.14	19.80	55.59		**BM3**
10.06	2.6	14.90	17.54	54.66		**BM4**
16.7	2.93	7.0	14.25	59.02	6	**BM1**
15.77	3.12	7.23	18.6	55.22		**BM2**
14.4	2.76	11.85	17.36	53.34		**BM3**
13.5	2.85	13.17	17.35	52.9		**BM4**
2.053	0.6877	1.725	1.544	2.378		**LSD**

2- Physical Properties

1- PH:

The results of the statistical analysis showed in Figure (1) that the pH values in the frozen-stored beef Burger brands for different brands were affected significantly (P<0.05) by the heat treatment, the beef Burger BM4 brand was 6.11-6.4 Significantly less affected by heat treatment than BM1 and BM2 brands during the 6-month freezing period, while no significant difference appeared with the BM3 brand in all studied storage periods 6.08-6.44.

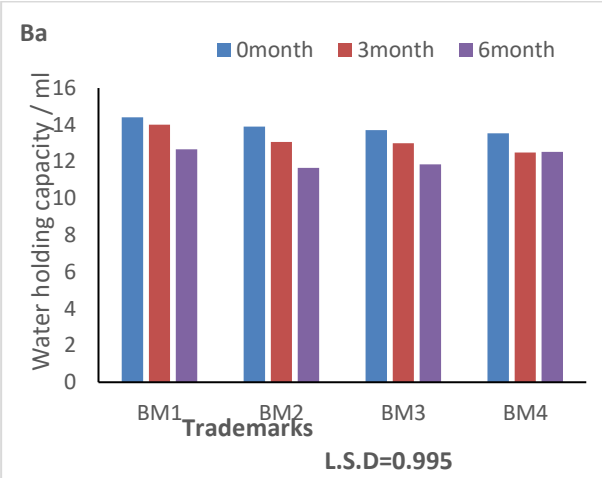
Figure (1) The effect of heat treatment on the pH in beef Burger offered in local markets



2-Water Holding Capacity:

The heat treatment in Figure (2) had a significant (P<0.05) effect on the water-holding capacity of the frozen meat burger samples, which decreased with the increase in the storage period. The water holding capacity was less after heat treatment in the beef burger 13.54 ml of the BM4 brand at the beginning of storage, with a significant difference with the rest of the brands, it decreased after 3 months of freezing storage to 12.49ml compared to BM1 14.01ml, while the results showed that the least water holding capacity after 6 months of storage was 11.66ml for BM2 with no significant differences with the brand Commercial BM3 and BM4 were 11.85 and 12.52 ml, respectively. The results agreed with Oroszvári et al. (2006) When preparing Burger beef patties from different cuts, they found that when cooked by frying at 50°C, 60°C, 70°C and 80°C, the water loss increased with the increase in temperature and with the length of time, as it depended on the water content of the sample in addition to the type of piece of meat. The decrease in the ability of meat to hold water when cooked was attributed to changes in the protein.

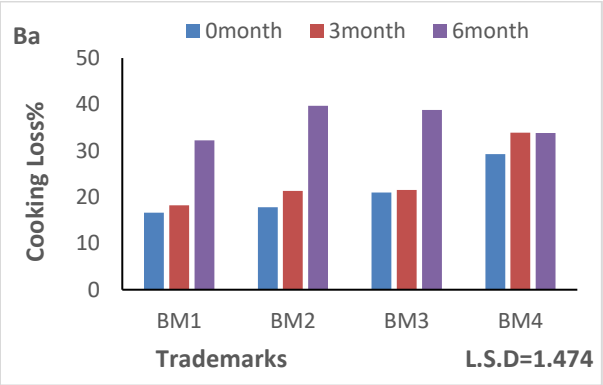
Figure (2) The effect of heat treatment on the Water Carrying Capacity in beef Burger offered in local markets



3- Cooking Loss

The percentage of loss during cooking in Figure (3) increased significantly (P<0.05) during the continuous storage period of freezing for the beef burger of the brands in the local markets, It was noted that the highest percentage of loss during cooking for beef burger was 29.3% at the beginning of storage for the BM4 brand, with a significant difference from the rest of the other brands. the highest percentage of loss during cooking at the end of storage was 32.25 and 39.7% for the BM1 and BM2 brands, respectively, with a significant difference from the previous storage periods. The results agreed with those of Salama et al. (2022) when they found an increase in the percentage of weight loss during the cooking of Berker camel meat that was frozen at -18 °C for three months continuously during the period of freezing storage.

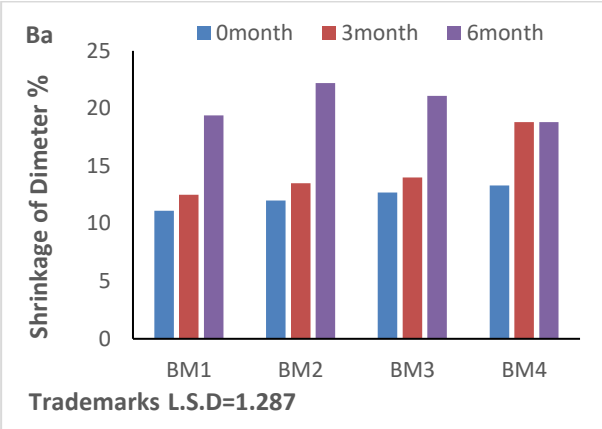
Figure (3) The effect of heat treatment on the Cooking Loss in beef Burger in local markets



4- Shrinkage of Dimeter

The results showed in Figure (4) that the percentages of shrinkage by diameter in the beef burger for different brands increased significantly (P<0.05) with the periods of freezing storage. The brand beef BM4 was the highest shrinkage rates after 90 days of storage, 18.8%, with a significant difference from The rest of the brands, BM2 and BM3 were characterized by the highest shrinkage rates at the end of the storage period, 22.2 and 21.1%, with a significant difference from the rest of the brands. The results agreed with those of Ragab et al. (2020) an increase in the percentage of weight loss after cooking and the percentage of shrinkage in diameter of beef Burger tablets that were stored for 3 months by freezing.

Figure (4) The effect of heat treatment on the Shrinkage of Dimeter in eef Burger offered in local markets

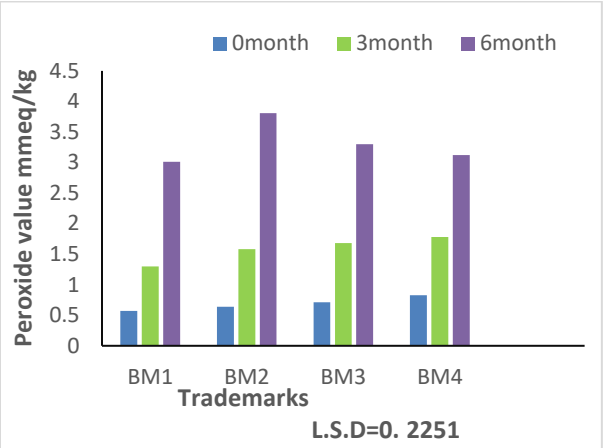


3- Fat oxidation

1- Peroxide Value (PV)

The value of peroxide in figure (5) was significantly affected (P<0.05) by the heat treatment with the sequence of the storage period For the brands displayed in the local markets of the beef burger, BM4 brand is shown the highest peroxide values at the beginning of production and after 3 months of storage were 0.83 and 1.78 mg eq/kg, respectively, with a significant difference from the BM1 brand, With no differences with the BM2 and BM3 brands, while the BM2 brand showed the highest peroxide value, which reached 3.81 mg eq/kg at the end of storage, with a significant difference from all brands.

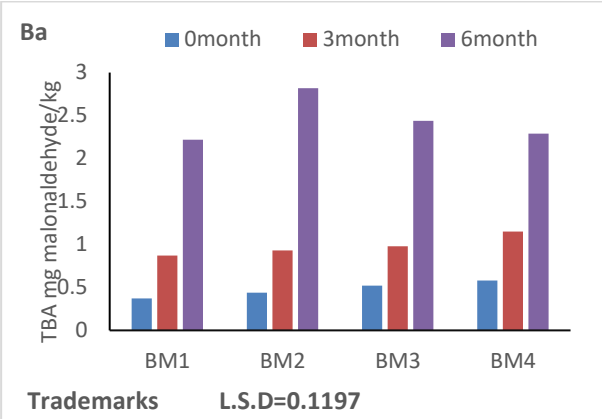
Figure (6) The effect of heat treatment on the Shrinkage of Dimeter in beef Burger offered in local markets



2- Thiobarbituric Acid(TBA)

The value of thiobarbituric acid was significantly affected($P<0.05$) in figure (5) by the heat treatment, as it increased in all brands of beef burger offered in the local markets with the continuation of the freezing storage period, The BM2 brand of beef bruger was the most affected by the heat treatment during the storage period of 180 days, 0.44-2.82 mg malonaldehyde/kg, with a significant difference with the BM4 brand in all storage periods 0.58-2.29 mg malonaldehyde/kg , With no significant differences between the mentioned sample and the two markers BM1 and BM3 at the beginning of production and after 3 months of storage.

Figure (7) The effect of heat treatment on the thiobarbituric acid values in beef Burger offered in local markets

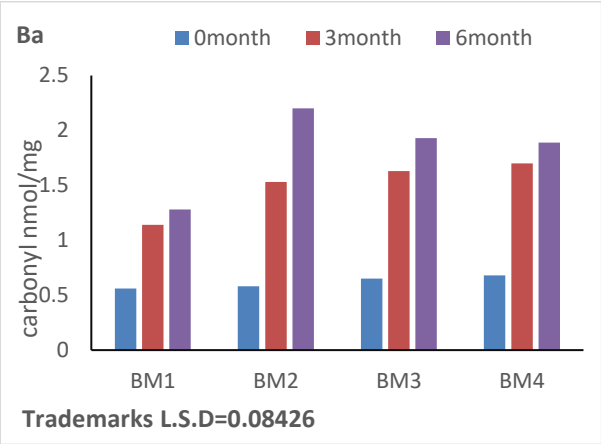


4-Protein oxidation

1-Carbonyl content

The results showed in Figure (5) the effect of heat treatment on the carbonyl content in the brands of beef burger in a significant manner ($P<0.05$) during the freezing storage periods. There were no significant differences in the carbonyl content between the BM3 brand and the BM4 brand during all storage periods. studied, as the two aforementioned signs were the highest in the carbonyl content 0.65-1.63 and 0.68-1.7 nmol/mg during the first three months of storage with a significant difference from the BM1 brand, and significant differences were observed between the BM4 brand in the carbonyl content in all storage periods and the BM2 brand 0.58-2.2 nmol/mg. The results agreed with the results of Xia et al. (2021) about estimating the carbonyl content of beef patties cooked on the grill in an electric oven at different temperatures of 150-310°C for 10 minutes for each side. A high carbonyl content was observed between 2.71-12.00 nmol/mg, respectively.

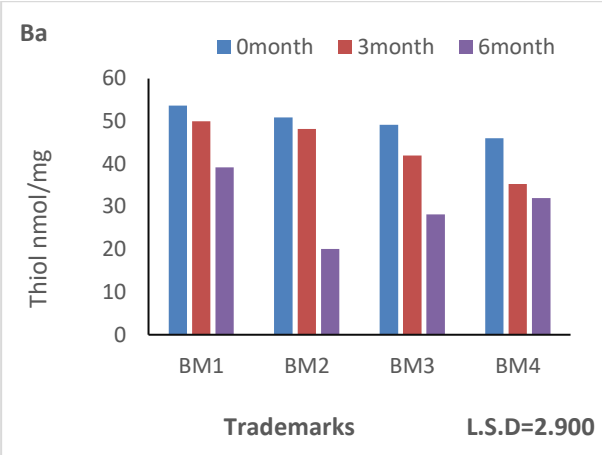
Figure (8) The effect of heat treatment on the Carbonyl content in beef Burger offered in local markets



2- Thiol Content

The heat treatment in Figure (6) affected significantly (P<0.05) on the thiol content in the brands of beef burger under study stored by freezing, the BM4 Burger beef brand showed the lowest thiol content after the heat treatment at the beginning of storage and after 3 months 46 and 35.5 nmol / mg With a significant difference from all brands, while the two brands BM2 and BM3 showed the lowest thiol content of 20.1 and 28.2 nmol / mg at the end of the storage period, with a significant difference from all brands and storage periods and between the same two signs, it agreed with the findings of Xia et al. (2021) when preparing tablets from beef and studying the effect of cooking at different temperatures starting from 150 to 310 Cº on the oxidation of beef proteins and fats, they found a decrease in thiol groups with increasing temperatures as a result of the oxidation of proteins from 43.83 to 7.97 nmol / mg compared to the content of Thiol in the control sample 83.90 nmol/mg The decrease in thiol content may be due to the formation of disulfide bonds through oxidation processes and the interaction of lipid oxidation products with sulfhydryl groups.

Figure (9) The effect of heat treatment on the thiol Content in beef Burger offered in local markets

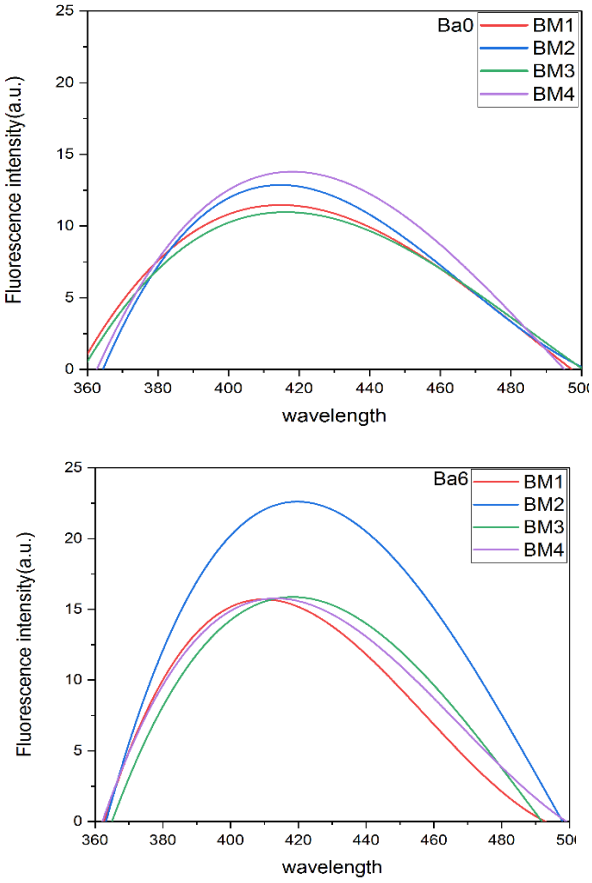


3- Fluorescence measurements of Schiff base structures (SB)

The Schiff base formation involves fabrication products from reaction between amino groups of basic amino acids (mainly lysine) with reactive lipid oxidative products, which work as an important conductor of protein co-oxidation. in figure (7) The heat treatment affected on the formation of Schiff base compounds in the beef burger under study increased after heat treatment, Trademark BM2 display higher Schiff base fluorescence compared to other brands at end of storage Ba6 compared to beginning of storageBa0. It agreed with the findings of Xia et al. (2021) when estimating the compounds of a chef's rule for beef patties cooked with a grill in an electric oven at different temperatures of 150-310°C for 10 minutes per side, observed through a rise in the cooking temperature from 150°C-230°C. A slight increase in the emission intensity of Schiff base compounds for meat patties until the emission intensity

increased significantly at a temperature of 310 °C.

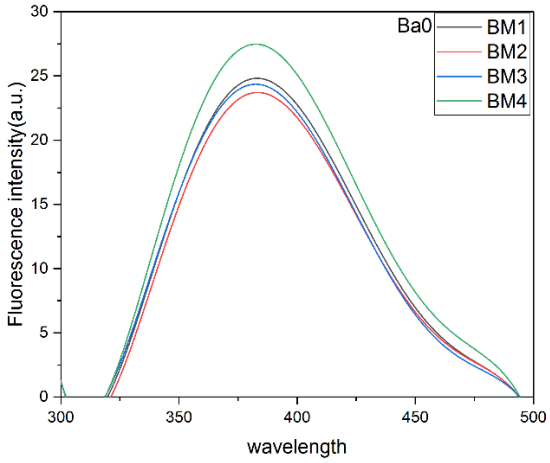
Figure (10) The effect of heat treatment on the Schiff Base in beef Burger offered in local markets Ba0 The beginning of storage and Ba6 storage end

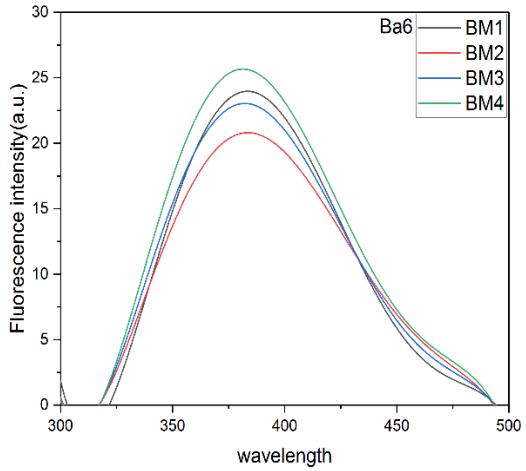


4- Fluorescence measurements of tryptophan

Tryptophan is very sensitive to oxidation and is used as of the markers of protein oxidation loss that is an aromatic amino acid. In the present study in Figure (8) showed the effect of heat treatment on the amino acid tryptophan content of burger meat products of different brands, which decreased with the progression of the freezing storage period after heat treatment, the florescence intensity of tryptophan was reduced among beef burger samples of all trademarks.The tryptophan fluorescence emission in BM4 brands higher than Other brands at The beginning and end of storage in fig(8-Ba0) and (8-Ba6), Emission intensity decreased after 6 months of storage after heat treatment, The lowered tryptophan content and higher tryptophan loss in BM2, Compared to other beef burger brands. The results agreed with those of Silva et al. (2016) when treating seasoned chicken products thermally, they found a decrease in the level of the amino acid tryptophan through a decrease in the emission intensity spectrum compared to fresh samples that were not heat treated agreed with the results of Xia et al. (2021). When the content of the amino acid tryptophan was estimated in beef patties cooked on the grill in an electric oven at different temperatures of 150-310°C for 10 minutes for each side, they found that the cooking temperature was inversely proportional to the intensity of tryptophan emission, as the decrease in the content Tryptophan significantly increased at temperatures higher than 200 °C compared to other samples.

Figure (11) The effect of heat treatment on the Tryptophan in beef Burger offered in local markets Ba0 The beginning of storage and Ba6 storage end

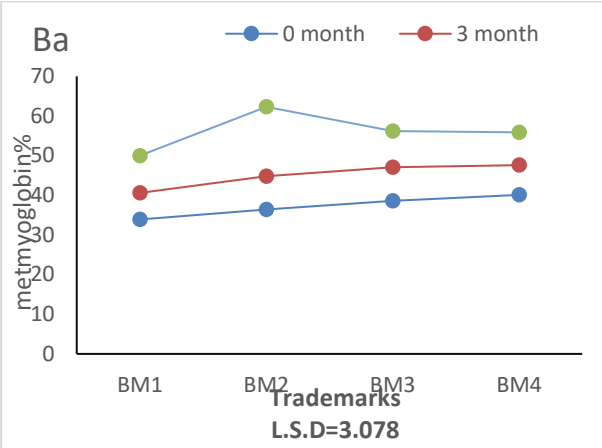




5- Metmyoglobin Pigment

The results of the statistical analysis, Figure (12), showed that the heat treatment had a significant (P≤0.05) effect on the percentages of metmyoglobin dye in beef burger of different brands and stored by freezing, which increased with the improvement of the storage period. No significant differences were observed between BM3 and BM4 markers38.6-56.20 and 40.1-55.9% Respectively, during all storage periods of 6 months, as the same two markers were the highest in metmyoglobin ratio during the first three months, the brand BM1 had the lowest percentage of metmyoglobin 33.9-50.0% after heat treatment during all storage periods compared to the rest of the brands of Burger beef. .The results agreed with The results of Ramadhan et al. (2011) when collecting ten frozen samples of uncooked chicken burgers of different brands from the local markets in Malaysia, it was found that there was an increase in the intensity of the colour of the brands in varying proportions after grilling them on medium heat for 10 minutes.

Figure (12) The effect of heat treatment on the percentage of metmyoglobin in beef Burger offered in local markets

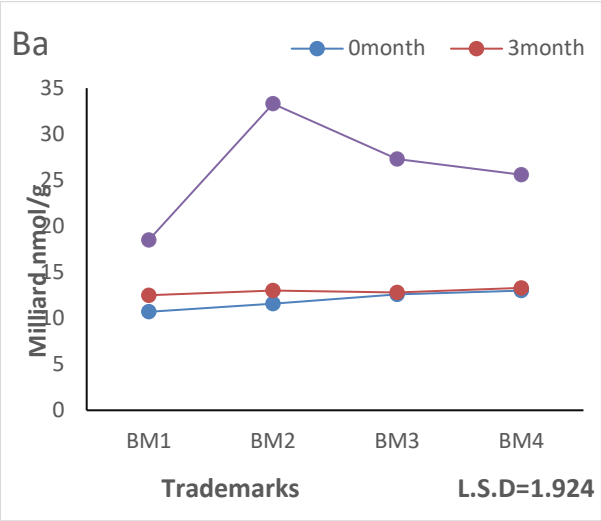


6- Products of the Maillard Reaction (MRPs)

The formation of the products of the Maillard reactions in Figure (13) in the beef burger affected by the heat treatment with persistence duration of freezing storage, significantly (P<0.05) for different brands, which increased with the advancement of the storage period, as the BM2 brand showed the highest content 33.3 nmol/g at the end of storage with a difference from all brands and the rest of the storage periods, while the BM1 brand had the lowest content of Maillard products in all studied storage periods 10.7-18.5 nmol/g with no differences Significant signs of BM2 and BM3 during the first three months of storage. The results agreed with those of Utrera et al. (2014) on studying the effect of freezing storage at -18 °C for 20 weeks for types of processed beef burgers on the formation of Maillard products after cooking them in a convection oven. It was found that there was a significant increase in the colour intensity after cooking as a result of the formation Products of the Maillard reactions. It also agreed with the findings of Silva et al. (2016) about the effect of different cooking methods on chicken breast products

in the formation of the products of the Maillard reactions.

Figure (13) The effect of heat treatment on the Products of the Maillard in beef Burger offered in local markets



Discussion

The difference in the percentages of chemical content of meat products of different brands prepared in a laboratory is due to the difference in storage conditions or to the different components of the product and their proportions according to the producing company, as most companies do their best to reduce costs such as using non-fresh meat previously frozen or using non-meat parts high in protein that are not Meat (Varnam et al, 1995; Babji et al., 2000) The freezing process helped in facilitating the loss of nutritional components during the heat treatment as a result of the denaturation of proteins and the loss of moisture and consequently a decrease in their percentage and the loss of proteins with the exuded liquid, The heat treatment also caused the liquefaction of fats because most of the fatty acids have a low melting point, which led to the loss of a percentage of them (Pathare and Roskilly, 2016) The heat treatment caused an increase in the percentage of ash and carbohydrates as a result of the loss of part of the moisture and an increase in the concentration of mineral salts that caused the increase in the percentage of ash (Al-juhaimi et al., 2016).

The difference in the physical characteristics of the meat products under study is due to several reasons, including the ingredients included in the composition of the product, such as spices, salt, acids, including acetic acid, proteins from vegetable sources, the condition of the meat used if it was frozen or fresh, and the different cuts of meat, as well as the conditions and methods of display and storage of the product (Darwish et al., 2012; Yadav et al., 2018; Jaiswal et al., 2022).

Heat treatment causes changes in muscle tissue proteins that lead to an increase in the pH values as a result of the denaturation of proteins and a change in the net charge as a result of the oxidation of some amino acids, which leads to the loss of acidic groups and the accumulation of basic groups(Oroszvári et al.,2006;Talukder and Sharma, 2010;Li et al.,2019), Changes in the nature of proteins as a result of heat treatment, net charge change, and an increase in pH values caused a decrease in the available polar aggregates, and thus a decrease in the water carrying capacity (Hamm and Deatherage, 1960), The decrease in the water-holding capacity of meat products with advanced storage helped to increase the weight loss during cooking as a result of the loss of moisture and the chemical components dissolved in it, because most of the weight that is lost during cooking returns to the water chemically bound to protein molecules, and the melting of ice crystals formed during storage as a result of heat treatment has a role in the effect On the loss during cooking with what it carries of chemical components

dissolved in water with the loss of a percentage of fat (Rahman et al., 2014) .

Heat treatment contributed to an increase in shrinkage rates with the progression of freezing storage periods, as shrinkage is one of the most important physical and qualitative changes that occur in the burger during the cooking process resulting from the denaturation of muscle proteins and the partial evaporation of water or its exudation with liquid and molten fat, which is formed during the denaturation of proteins Thermally a strong non-reversible gel, which allows for interactions between protein molecules to occur, causing strength to the protein matrix, as well as the fact that this matrix is responsible for the size and shape of the final products (Ziegler and Acton, 1984; Serdaroglu and Degirmencioglu, 2004; Kurt and Kilincceker, 2011).

The reason for the high peroxide values during of some meat products is attributed to the formation and accumulation of hydroperoxides, which are among the important primary products in the self-oxidation of fats by the action of several catalysts that facilitate the extraction of a hydrogen atom H from unsaturated fatty acid to form unstable free radicals in a step Initiation, which is the first step in the oxidation process, the free radical is linked once it is formed with oxygen O2 to form the peroxide radical ROO, which has the ability to interact with another unsaturated fatty acid to form hydroperoxides ROOH with the formation of a new free radical that enters again in a series of reactions in the reproduction stage until reaching The last stage of the reaction in which more stable compounds are formed, the hydroperoxides are unstable intermediates, unstable and odorless, which are broken down and decomposed to form secondary oxidation products such as aldehydes, ketones and alcohols, as the high values of thiobarbituric acid indicate a high secondary oxidation products from the decomposition of primary products (Zahid et al., 2022), and the value of thiobarbituric acid should not exceed 0.9 mg malonaldehyde / kg h. Because of the Egyptian Standard Specifications (ESS,2005).

The rise in the values of peroxide and thiobarbituric acid after the heat treatment of the brands of Beef Burger stored with the progression of the freezing period may be due to the increase in the loss of moisture content, which helped in raising the fat content in the meat products under study after cooking, and the heat treatment may lead to damage to cell membranes and release Some catalysts for oxidation such as metals (Rao et al.,1996; Oppong et al.,2021), or it may be due to the oxidation of oxymyoglobin to metmyoglobin that can react with hydrogen peroxide H2O2 resulting from the oxidation process to form feryl hem protein radicals that It can increase lipid oxidation by removing a hydrogen atom from unsaturated fatty acids, thus starting the oxidation process again(Gheisari et al., 2010; Shimizu and Iwamoto, 2022).

Proteins in meat products undergo a series of chemical changes during the manufacturing processes that the product goes through, such as protein denaturation, protein hydrolysis, and oxidation processes, It is possible to estimate the oxidation of proteins through various criteria, including the depletion of some of its components, such as the loss of tryptophan and the sulfhydryl groups (SH), and the formation of different products such as carbonyl and Schiff's base. The change in the pigment of the meat is also an indicator of the oxidation process (Li et al., 2019). The reason for the increase in carbonyl groups and the

loss of thiols for the meat products under study stored by freezing after heat treatment is due to the loss of moisture and the rise in total nitrogen as a result of the loss of myofibrils and sarcoplasm. The release of bound iron and oxygen from oxymyoglobin, which creates conditions for the production of free radicals, as a result of the change in the nature of the protein and the opening of the protein chain, which facilitates the exposure of amino acids to the attack of gradually formed radicals, including the products of fat oxidation, which facilitates the loss of thiol groups and the accumulation of carbonyls (Khan and Berg, 1965; Filgueras et al., 2011; Wazir et al., 2019).

Which helps remove the amine group of the side chains of amino acids such as lysine, threonine, arginine and proline to form a carbonyl radical, which depends on the role of metal ions in the interaction with H2O2 to form the hydroxyl radical •OH or the most effective and active alkoxyl root RO·, which leads to the formation of a protein radical for the carbon atom α-carbon, in the presence of transition metals such as iron and copper, hydrolyzes the side chains of sensitive amino acids to form an aldehyde group (Akagawa et al.2006; Feng et al., 2016; Soncu, 2020).

The loss of thiols is attributed to the amino acids most susceptible to oxidation, cysteine and methionine, which are preferred targets for oxidation due to the high reactivity of SH-groups, even at low concentrations of ROS, which works to extract hydrogen atoms from thiol groups to form thiyl radicals RS• , Which can be converted into Disulfide Bonds (RS-SR) by means of two adjacent thyl radicals or interact with oxygen O2 to form thiyl peroxy radicals (RSOO), and thiol groups may undergo a series of complex interactions, as they form with hydrogen peroxide many Oxidizing compounds such as unstable sulfenic acid (CysSOH), sulfinic acid (CysSO2H) and sulfonic acid (CysSO3H) (Claiborne et al., 2003; Zhang et al., 2022).

The reason for the high concentration of Schiff base compounds in frozen beef burger after the heat treatment under study during freezing storage and after heat treatment is due to the interaction between carbonyl groups of aldehyde compounds as by-products of fat oxidation, in particular MDA Malondialdehyde and protein carbonyl with the electron-rich side chain of acids The amino acids of proteins such as lysine, histidine, glutamine and cysteine form Schiff's base, which is considered a stable radical, as fluorescence occurs when the structure – N = CH - CH = CH, there are several factors involved in helping to catalyze this reaction, including the components included in meat products such as the percentage of fat , proteins and moisture, as well as the processes that the product goes through that accelerate the formation of these products, such as the duration and temperature of the heat treatment at which the product is prepared for consumption, as the increase in the intensity of light emission is considered an indicator of the rise in fat oxidation in meat products stored by freezing and heat treatment. (Gatellier et al., 2010; Wazir et al., 2019).

Heat treatment causes denaturation of myoglobin and other proteins between a temperature of 55-65 C and may occur between 75-80 C, which increases with the rise in temperature and the ease of exposure to oxidation processes. The chemical state of myoglobin differs in its sensitivity to heat, as metmyoglobin is the least thermally stable and therefore the most likely to cause early brown color to form Ferrihemochrome, while deoxymyoglobin is more thermally stable than

oxymyoglobin and both are more heat resistant than metmyoglobin, as the final color of the product depends on the concentration of the three forms of myoglobin (King & Whyte 2006; Mancini and Ramanathan, 2020). The oxidation of tryptophan can be attributed due to the high temperatures reached during the heat treatment, as well as various oxidants, especially effective oxygen, that can affect tryptophan due to the high perturbation in muscle tissue cells that are Enhanced during heat treatment and cryopreservation (Min et al. 2008)).

The brown colour in meat products after heat treatment is due to several factors, including a change like the myoglobin pigment, Maillard reaction, The Carbonyl compounds that come from fats can replace reducing sugar as a source of carbonyl to increase the interaction with protein, as fats are oxidized by some reactive oxygen species (ROS) to form aldehydes and ketones, which then interact with amino acids to form Maillard products and dark brown colour. This enhances the increase in Maillard products as storage progresses (Poulsen et al.,2013; Wazir et al.,2019; Augustine et al.,2020). The type of heat treatment affects the rate and extent of Maillard reactions in meat products depending on the method of heat transfer, where it is Air in an oven (roasting) is less effective in forming MRPs than conduction via a heated surface (barbecuing) or frying (Bordin et al., 2013; Rolda´n et al., 2015), also the rate of formation of Maillard MRPs depends on the raw materials included in the product, transition metals, oxidants and antioxidants as well as reaction time and heat treatment temperature, concentrations of reactants, moisture ratios and pH have an effect significantly over the rate of the Maillard reaction (Poulsen et al., 2013; Chen et al., 2022).

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