Oxidative Reaction of Frozen-Stored and Heat Treatments Meat Products

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Oxidative Reaction of Frozen-Stored and Heat Treatments Meat Products

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Abstract. The exhaustion of ready-to-eat (RTE) products, have become growingly popular over recent years. In the United States, for example, 82.6% of consumers frequently eat fast food in restaurants at least once a week . Frozen storage is easiest way to preserve food from the negative impact of temperature , so It is included thorough evaluation of the quality parameters . In general, a reasonable temperature to store food is -18 °C for most frozen foods, and this will keep the quality in commercial storage meat products, in specially, the very popular meat products and widely consumed world wide . Meat and Its products are essential component for human nutrition. They compose of proteins , vitamins and minerals , as well as vital fatty acids. Meat is necessary to meet all of the dietary requirements , on the other hand, they are subjected to degrading processes ,such as microbial deterioration, oxidative processes which are the most important among them. Oxidative processes cause oxidation of lipids, pigments, proteins and vitamins. Furthermore, there is a nutritional loss that leads to produce hazardous compounds, therefore the meat industry's control of oxidative processes is requisite. The purpose of this study is to determine the significant alterations that happening in frozen meat products quality.

Keywords. Frozen stored, Meat products, Quality**.**

1. Introduction

Consumers in most countries are becoming increasingly interested in a variety of food selection ways to improve their lives. Diet is not the only factor that affect on consumer's well-being and health, but still has the major factor [1-3] tending to increase capita income in the developmental society, as well as demand the consumer's desire to buy food products: Baked goods, pizza, beef sandwiches, shawarma, and grilled chicken are examples of ready-made items that vary in their prices from place to another [4,5] subsequently, the customer became aware to has more purchasing power and health issues [2], As a result the rising of request for manufactured items, food scientists have become more interested in figuring out how to provide safe and healthy items of a quality desired by the majority of consumers[6].

Meat and its products are one of the most significant components of the human diet, providing protein, lipids, and some vitamins and minerals, all of them contributed to increase in their consumption [4,7]. This consumption is affected by many factors, the most important are the flavor, nutritional, and hygienic characteristics of the final product, as well as the cost and consumer and environmental factors, such as: psychological, health, family, educational, and economic conditions [2,8].

Due to its biological and chemical composition, as well as the presence of many factors affecting it, such as temperature, atmospheric oxygen, internal enzymes, humidity, light, and microorganisms, both

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fresh and processed meat are most perishable and spoiled products, as these factors can make changes in their composition,for instance, meat's color, texture, odor, and flavour [9].

2. Fast Food

Fast food refers to diets that are produced and supplied rapidly, so that the consumers do not wait a long time for their meals. It is distinguished by its flexibility in its consumption and the diversity of its preparation methods, making an excellent consumer items in current society[10,11], it has a distinctive taste,and attracting different age groups. Among of these popular groups are children and youth, in which the fast food has become part of their daily routine. The vast majority of parents are spending time in their work, while their children are spending most of their time away from their home, for example, most of them attend in places of education or participation in recreational activities, in addition to the economic and social situation, which is an important factor related to fast food consumption[12,13], Fast food is classified into several types:

1. Food that is sold in restaurants and is prepared quickly and served quickly, and many fast food restaurants offer home delivery service in the form of a box, such as pizza, fries, bakeries and pies.
2. High-energy foods, such as chocolate, ice cream, soft drinks, and pizza, that have high percentage of fat, sugar, and salt but low nutritional value of protein, fiber, vitamins, and minerals.
3. Foods that succumb special treatments, so that they are ready to be served as soon as they are dissolved or dispersed into a liquid and subjected to heat treatments with low cooking period, such as bakeries, corn flakes and soup powder.
4. Food and drinks prepared and sold by street vendors or vendors in streets and other public places [12] .

Fast food is characterized by its containing large amounts of fats and carbohydrates, thus calories are high, but often poor in beneficial nutrients, such as vitamins and minerals that are necessary for the body, fast-food consumption can reason serious problems,for instance, both obesity and cardiovascular disease are growing issues in today’s world, so expert panel of the World Cancer Research Fund and American Institute for Cancer Research recommend minimal fast-food consumption [14].

Most fast food is also prepared by roasting, grilling or frying such as grilled chicken, birker, pizza, sandwiches and french fries, frying is one of the most common methods used for preparation of foods throughout the world, as the process of frying is one of the oldest method for preparing food and improving the sensory properties of food by forming flavor compounds, catchy colors, and the formation of the desired crust and texture, but the temperature of the oil used during frying has a role in the oxidation and degradation of lipids, In addition, the phenomena of frequent use of frying oils and their negative repercussions causes oxidation[15,16].

3. Meat

Meat is one of the most basic components of human nutrition, defined as animal tissues that can be used as food.Meat has subjected to basic biological changes after the animal has been slaughtered, and become fit for consumption.

Meat is the favored food among other foods because it stimulates appetite and has a pleasant flavor and appealing taste, In addition It is easy to digest, Protein 17-20% has a high nutritional value since it contains all of the essential amino acids required for the construction of human tissues and vitality, and it accounts for 60-80 percent of the dry weight of red meat muscle [17,18].

Fat is one of the basic elements of the cell, and its quantity varies depending on the type of animal and the degree of its growth, as well as its distribution within the muscle and the location of the muscle inside the body of the animal, which is usually employed. When it comes to the production of meat products, It contains a variety of neutral fats, phospholipids, and fat-soluble vitamins, as well as cholesterol, saturated and unsaturated fatty acids such linoleic and linolenic acid, and cholesterol[19].As indicated in Table 1.

Table 1. The percentage of fatty acids in some animal tissues[20].

fatty acid%	Salmon	chicken	pig	cow	Lamb
Saturated fatty acid	21	35	40	45	53
Unsaturated fatty acid	79	65	60	55	47

Water is general medium for crucial processes, since it plays a key part in the changes that occur to meat throughout storage and processing, and the moisture content in meat varies according to type, variety, sex, age, and nutrition, as well as with different animal tissues[21].
Many vitamins, such as B12, B6, niacin, and folic acid are found in meat. Vitamins A and D are essential for the biological process in the body and many tissues. It also contains significant mineral elements such as iron, phosphate, calcium, zinc, and potassium[22,23].

4. The Effect of Storage on Meat Quality

Products of food, particularly meat, is susceptible to spoiling, which reduces its quality, renders it unsafe for consumption, and can cause variety of diseases including food poisoning. Microbial, enzymatic, or chemical damage are the most common causes of deterioration in fresh meat and its products. Meat can be preserved by some methods of preservation, The two most important methods are cooling and freezing [24].
According to various studies, the nutritional value of foodstuffs frozen are affected by the quality of the food product, the method of preparation and preservation, as well as the duration of storage time [19]. studied[25] the influence of freezing storage duration on meat quality, finding a reduce in the quality of these meats, changes in food quality are inevitable because of the formation of ice crystals and other physicochemical reactions, Although freezing is by far the most common method of food preservation.

5. Effect Heat Treatments and Frozen Storage on Lipid Oxidation

5.1. Oxidative Reactions

Fat oxidation is the main cause of the damage of many food products, which leads to present many diseases and physiological disorders. Oxidative reactions in food products have critical issues because of their harmful impact on health [26,27], DNA damage, lipid oxidation, and protein oxidation are three inevitable process that cannot be changed as a result of enhanced oxidation processes.

5.2. Mechanism of Lipid Oxidation

Fat oxidation is one of the most common pathway for food quality degradation, particularly in meat products, as alteration in flavor, color, texture, nutritional value, and the potential for hazardous chemicals [28,29] .Unsaturated fatty acids are oxidized by atmospheric oxygen at normal temperature, while saturated fatty acids are oxidized at the high temperature associated with cooking processes, such as boiling, baking, frying and roasting. This is due to the high energy that breaks the bonds of these acids [30], Physical variables such as heat and light (ox-optical oxidation) or natural elements such as(iron) , H_2O_2 carry out the oxidation process[19,31].
Aldehydes, as well as a variety of Malondialdehyde (MDA), Hexanal, and 4-Hydroxy-2-Trans-Nonenal (4-HNE) compounds, are the most prevalent lipid oxidation chemicals that detect in meat, Lipids can be oxidized by three essential ways that include complex reactions: autoxidation, enzymatic-catalysed oxidation and photo-oxidation,The enzymatic and photo-oxidation mechanisms only differ from autoxidation in the formation of hydroperoxides, through the initiation stage [29,32].

5.3. Lipid Autoxidation

Many compounds are created as a result of the oxidation process, including peroxides (primary oxidation products) that can then fission to generate volatile and non-volatile low-molecular-weight molecules such as carbonyl, alcohol, hydrocarbons, and furans (secondary oxidation products) [31,32], As shown in Figure1.

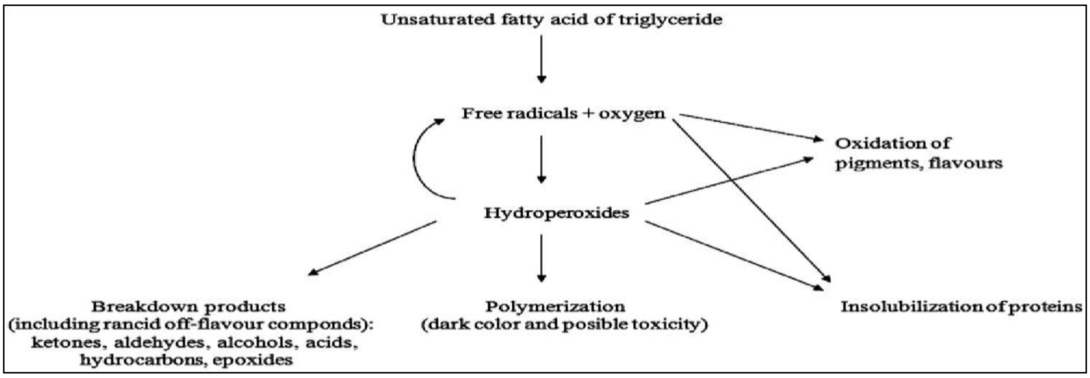

Figure 1. The mechanism of lipid oxidation [29].

5.4. Initiation is the First Stage

The covalent bond in the unsaturated fatty acid's hydrocarbon chain C-H is destroyed at this point, with the hydrogen atom freed from the carbon close to the double insulin in FA (RH) to form a free radical H• and an alkyl root R• .

RH → R • + H •

5.5. The second stage: propagation

The alkyl root reacts with molecular oxygen to produce many types of radicals, including the peroxyl radical (ROO •), which can combine with unsaturated fatty acids to form the hydroperoxide , This series of exchanges does not come to an end; instead, it continues and repeats multiple times.

$R\bullet + O_2 \rightarrow ROO\bullet$

ROO• + RH → ROOH + R•

5.6. The third stage: Termination

It is the last stage of the reaction in which stable compounds are formed in the case of a high percentage of free radicals

R• + R• → R- R

R• + ROO• →ROOR

$ROO\bullet + ROO\bullet \rightarrow ROO + O_2$

[33],investigated the impact of cooking parameters on mutton cooked at 100°C for 45 and 60 minutes, finding that the cooking duration had a significant influence on the increase in thiobarbituric acid level, As the oxidation process took place in both time periods.

[34],also studied the effect of different temperature (50,60,70,80,90) °C on the oxidation of chicken fats, then they were stored in the refrigerator, as the results showed that heat treatment had a role in fat oxidation by measuring the parameters of thiobarbutyric acid. Thiobarbituric was found that heating meat to 70 °C and storing it for 2 or 4 days was most effective in increasing the TBA content.

With rising temperature, the amount of unsaturated and polyunsaturated fatty acids fell considerably. In heated chicken flesh, iron freeing and a rise in hydroxyl radicals were noted, whereas antioxidant enzyme activity reduced. significantly at elevated temperature.

[35],observed a stabilization of oxidative stress by storing lamb patties that were prepared from slaughtered lamb at the age of 10 months and stored at 4 ° C for 9 days, TBA levels were stable during the first five days of storage, while lipid oxidation levels decreased on the ninth day.

[36],studied the influence of fat content and storage temperature on the quality of frozen pork patties during storage to determine the thiobarbituric acid value of frozen pork patties with 10 and15% fat contents during storage at −5, −15, and −23°C for six months, The TBA values of the patties containing 10 and 15% fat were 0.60 and 0.61 mg/kg, respectively, at the start of storage, but increased to 1.20, 1.06, and 0.86 mg/kg, and 1.25, 0.95, and 0.84 mg/kg respectively during storage at −5, −15, and −23°C until storage periods reached five and four months, and then decreased to 0.82, 0.57, and 0.60 mg/kg, and 0.83, 0.62, and 0.68 mg/kg at six months of storage, respectively, Those patties held at -23°C had the highest TBA levels after four months, and those stored at -5 and -15°C had the highest TBA levels after five months. Then, regardless of fat content, the values dropped.
[37],studied The impact of the best frozen minced beef products were identified, and two types were obtained from a local provider. The patties were manufactured with 10 and 15% fat content were kept at−5, −15, and −23°C, and peroxide levels (POV) were measured during a 6-month period, When storage began, POV of the 10% samples was 2.16 meq/kg, whereas for 15% samples, it was 2.49 meq/kg. After a period of 6 months at −5, −15, and −23°C, however, POV increased in the 10% samples to 6.14, 4.33, and 3.01 meq/kg, and the 15% samples to 6.99, 4.44, and 3.12 meq/kg, respectively. The higher fat content in the 15 percent samples resulted in a higher POV at the start of the experiment was due to greater fat content.

5.7. Effect of Frozen Storage on Protein Oxidation

The current trend focuses on oxidative reactions of proteins [38],The oxidation of proteins is similar to the oxidation of fats during storage and production processes, they begin through multiple pathways. Protein oxidation can be defined as a covalent modification that occurs either:

1. directly through the formation of active oxygen radicals (ROS) [39],the occurrence of O_2 in the atmosphere is the first step of pollution events on earth free radicals, and reactive oxygen species (ROS) are produced by the normal vital metabolic activities of human body', as well as external sources such as X-rays, ozone, smoking, air pollution, pesticides, junk foods, and industrial toxins [40].

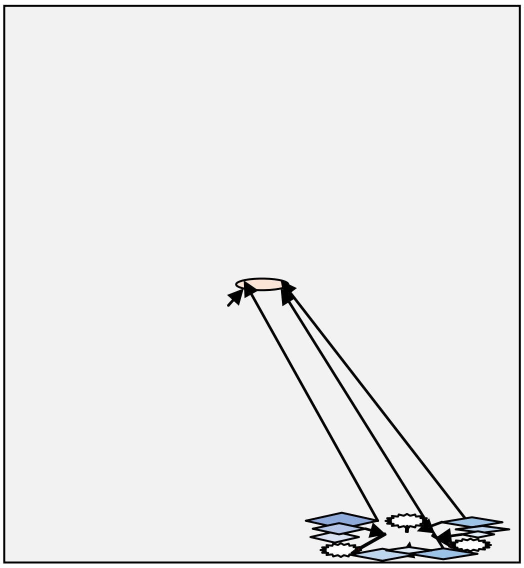

Figure 2. Some sources and production of free radical.

2. Indirectly through by-products resulting from self-oxidation of fats [39]. The mechanism of protein oxidation in diets is still largely unknown, which affects the physical and chemical properties of protein and thus on the quality of meat.

- In the side chains of amino acids, such as oxidation of thiol groups, hydroxyls in cyclic compounds, production of carbonyl groups, and creation of hydroperoxides[41] cause protein solubility loss, loss of important amino acids, and increased aggregation[42].

- Many modifications occur in the fundamental chain of proteins, including local alterations in polypeptide organization, fragmentation, and polymerization of proteins[43,44].

Although, all amino acids are susceptible to oxidative reactions, cysteine and methionine are the most vulnerable due to the high reactivity of the SH groups[43]. The thiol group can be oxidized in two different ways: -

A. By oxidizing the SH group to generate Thiyl radicals, lead them to combine with other thiol groups to produce Disulfide Bonds or with O2 to make Thiyl Peroxy radicals (RSOO).

B. Non-free radicals (RS) such as (H2O2, 1O2), make together with thiol groups form a series of complex reactions, as with hydrogen peroxide many oxidizing compounds are produced, such as Unstable Sulfenic acid (CysSOH), Sulfinic acid (CysSO2H) and acid Sulfonic acid (CysSO3H) [45]. Oxyacids can also be produced by hydrolysis reactions or disulfonic compounds by interaction with other thiol groups[46]. As in the following figure(3) :-

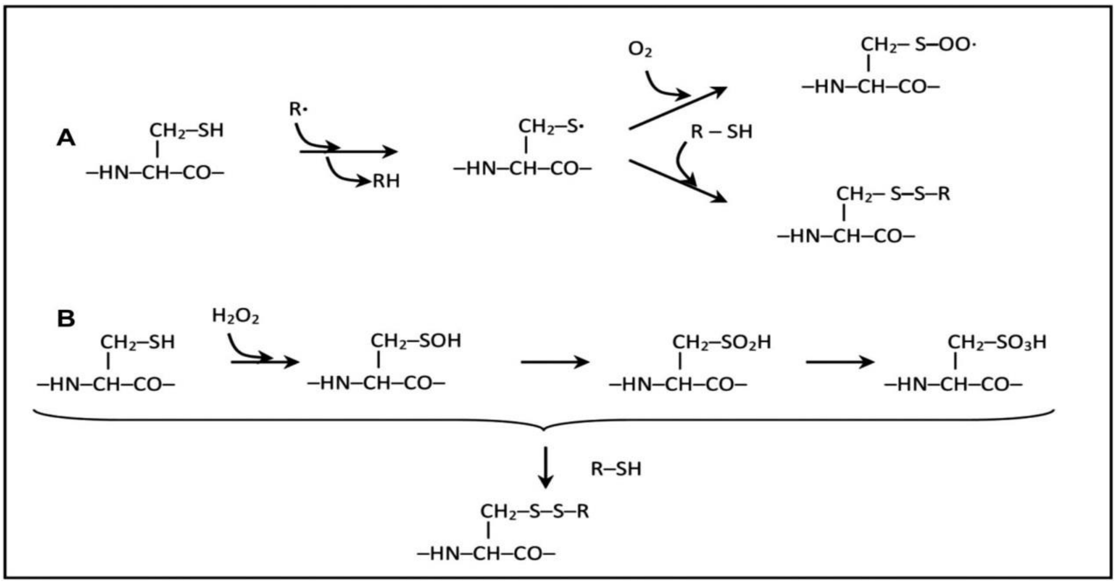

Figure 3. oxidation of cysteine through two pathways (A) oxidation with free radicals (B) oxidation with non- free radicals such as, H_2O_2[45].

The reaction is often accompanied by a loss of protein solubility and an increase in aggregation ability [42]. [47], cited that cold-stored pork pies lost a percentage of their thiols and generated Myosin disulfide cross-linkages.

Due to the presence of hydroxyl groups, cyclic amino acids are susceptible to oxidation processes, while with Tyrosine is being more susceptible than Phenylalanine at the same protein and different protein chains, resulting in the formation of Dityrosine, which is responsible for the formation of cross-crosses within proteins, and thus the polymerization of proteins[43].

according to [48], Protein oxidation, in addition to lipid oxidation, has lately piqued the interest of food scientists due to its negative impact on food quality and human health. First, protein oxidation affects not only the eating quality of fresh meat (such as softness and juiciness), but also its processing qualities (e.g., solubility and gelation). Second, oxidative alteration of proteins can result in the loss of essential amino acids, as well as a reduction in protein digestibility and, as a result, food nutritional quality.. Third, some products from dietary protein oxidation are hazardous and have been reported to promote inflammatory conditions, linking to the onset of carcinogenesis in the gut. Finally, oxidation of myoglobin to metmyoglobin causes discoloration of meat and meat products.

5.8. Protein Chain Oxidation

Proteins are oxidized when catalysts such as metal ions and hydrogen peroxide presens, since the -carbon root for the amino acid is formed after the hydrogen atom removed at the -carbon site[41,44] (Stadtman and Berlett, 1997; Soladoye et al., 2015).

Cross-crosses arise within Pronene molecules or between molecules as a result of the interaction of the roots created with each other in anaerobic conditions, and when oxygen is present, the roots centered around the carbon atom turn into Alkylperoxyl radicals, which change into: -

1. A pathway in which the peroxyl radical is degraded into amines, thus subsequently there is fractionating proteins into amides and α-keto-acyl derivatives.
2. The peroxyl radical enters another pathway to create hydroperoxides[49].
3. Protein hydroperoxides can be decomposed by a mineral catalyst to form alkoxy radicals that undergo protein fractionation into carbonyl derivatives and amides[50], as shown in Figures 3 and 4.

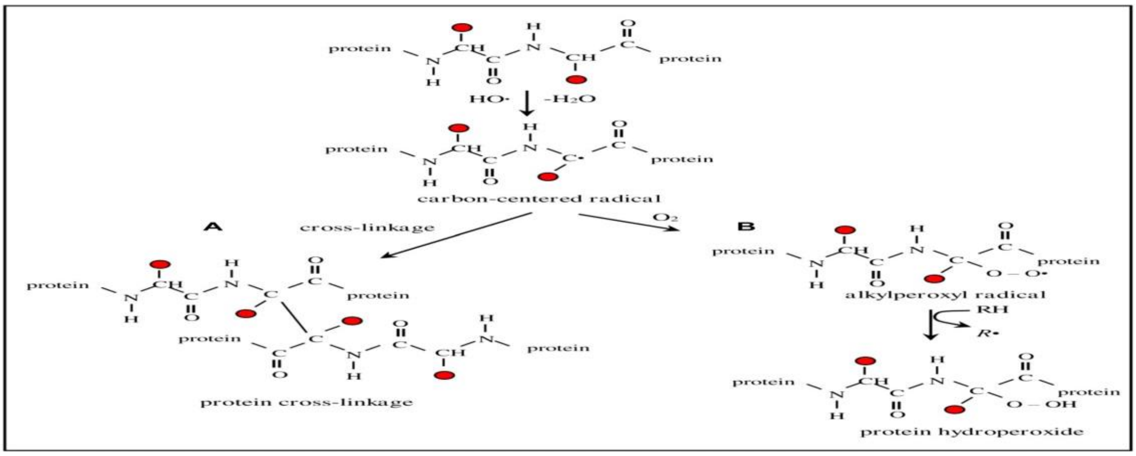

Figure 4. Mechanism of protein oxidation. (A) Cross-sectional junctions within protein (B) Hydroperoxide formation [49].

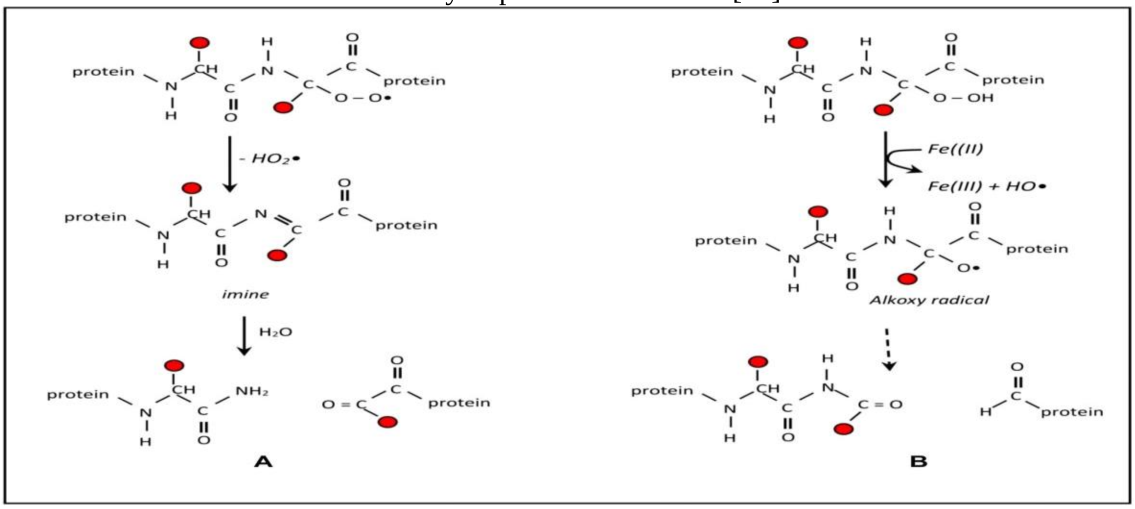

Figure 5. (A) Hydrolysis of the hydropiroxyl radical for proteins into imine and fractionation of proteins (B) Hydrolysis of the hydropiroxyl radical for alkoxy root proteins and fractionation of proteins [50].

Protein carbonylation processes and the fates of carbonylated proteins. The two kinds of protein carbonylation in plants are metalcatalyzed oxidation of the side chains of Arg, Thr, Pro, and Lys and the addition of lipid peroxidationderived RCS to the side chains of Cys, His, and Lys, resulting in carbonylated proteins. Carbonylated proteins and their fates. Carbonylated proteins may be found in a variety of foods. Protein carbonylation processes and the fates of carbonylated proteins. The two kinds of protein carbonylation in plants are metalcatalyzed oxidation of the side chains of Arg, Thr, Pro, and Lys and the addition of lipid peroxidationderived RCS to the side chains of Cys, His, and Lys, resulting in carbonylated proteins. Carbonylated proteins and their fates. Carbonylated proteins may be found in a variety of foods[51].as in the form 3.

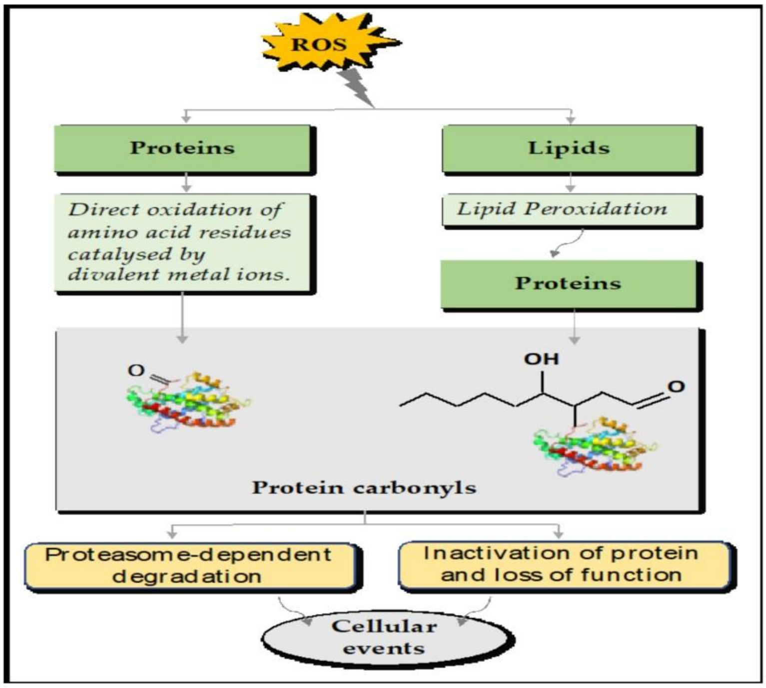

Figure 6. Protein carbonylation reactions and the fates of carbonylated proteins [51].

[33], investigated the effects of several cooking procedures on mutton cooked at 100°C for 45 and 60 minutes. Cooking time had a large effect on protein oxidation, resulting in a rise in the carbonyl content of cooked beef. The carbonyl content was high, similar to what was predicted following long-term freezing storage.

[52], used multiple methods of cooking (a) roasting at 180-200 ° C for 5 minutes, surface using an electric tray, (B) grilling at 200 ° C, for 15 minutes using an electric oven (C) frying with 15 ml olive oil At 160-180 ° C for 5 minutes and (d) cooking using sous-vide, cook in a water bath at 65 ° C for 8 hours. The heat treatment was considered complete when the samples reached an internal temperature of 75 ° C. The results showed that the heat treatment negatively affects the quality of meat and meat products (chicken) via increasing the production of types of free radicals (ROS), The application of heat-heating cooking techniques leads to alteration in protein structure and increased In the proportion of carbonyl formed, no differences were observed between the other thermal treatments. Heat treatments have a role in the oxidation of meat protein, as free thiol groups are converted into oxidation derivatives i.e. disulphide bonds, which enhances protein aggregation and loss of nutritional value, Cooking type has a noticeable effect on chicken thiol groups, as no difference in free thiols was observed between the treatments. By roasting and frying, while the samples that were cooked with sous-vide were cooked in a water bath with a lower level of free thiol groups, it was also shown in the figure that the long heating times make the sulfur amino acids cysteine in chicken meat more susceptible to reaction because cysteine is greatly affected by even oxidation conditions. At low ROS concentrations due to high sulfur affinity.

[53], investigated the effect of heat treatment on beef slices cooked at 145°C on electronic grills. The samples attained a temperature of 71.1°C, causing protein oxidation, a drop in sulfahydral concentration, and the generation of carbonyl compounds.

[54], investigated the effects of three different frozen storage temperatures (-8, -18, and -80 °C) on protein oxidation in beef patties for 20 weeks, After of frozen storage, frozen patties (F-patties) were thawed at 4°C and Cooked patties (UF-C and FC patties), It was found that the oxidative breakdown of The percent tryptophan losses in (frozen) F-8 °C patties (27.0%), F-18 °C patties (27.6%), and F-80 °C patties (24.2%) were significantly higher than in (unfrozen) UF-C patties (16.1 %).

[55], reported that carbonyl content was determined in chicken hamburger during frozen storage after(30, 60, 90 and 120) days, the total amount of protein carbonyls increased during the first 2 months in

frozen storage as It was noticed (2.355, 3.138 ηmol.mg-1 protein), while a significant decrease was detected by the end of the frozen storage time (4 months) to (2.285, 1.761 ηmol.mg-1 protein). [56], reported that thiol content was determined inT0: beef patties during frozen storage after 90 days, The primary thiol content of freeze was 58.28nmol / mg protein Compared to processed beef patties with different concentrations of sumac fruits extract T1: 0.05% and T2: 0.1% which were 59.58 and 61.42 nmol / mg protein respectively, in the last period of freeze T1 55.80 and T2 57.94 nmol / mg protein, respectively, compared to T0 52.48 decreased significantly.

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