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RESEARCH ARTICLE

Effectiveness of Edible Coating to Extend Shelf-Life of Dry Fermented Sausage

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Abstract

The manufacturing of rapid and shelf stable dry fermented sausages became an art and provided the market with a very diverse range of delicacies. Fermented sausages can be defined as a meat product made of a mixture of mainly pork meat pork fat, salt, curing agents, sugar, spices, and in many cases starter cultures are added. The mix, including as little oxygen as possible, is placed into steam - permeable casings and subjected to a fermentation and drying process. Fat is one of the important factors contributing to enhanced flavor, texture, juiciness, and mouth feel of dry fermented sausage. However, fat is easily rancid to create bad odor as well as lower product quality and shelf-life. Objective of the current research studied the feasibility of edible coating in extending shelf-life of dry fermented sausage. The dry fermented sausages were treated by different formulas (N_0: control; N_1: 2.0% wheat gluten; N_2: 2.0% w/w chitosan; N_3: 2.0% w/w sodium alginate; N_4: 2.0% w/w collagen) and in different concentration of chitosan (2.0%, 2.5%, 3.0%, 3.5%, 4.0%). The effectiveness of edible coating was based on the physicochemical attributes such as pH, water activity (a_w), TBARS value (mg/kg); biogenic amines such as tyramine (mg/kg), 2-phenylethylamine (mg/kg), tryptamine (mg/kg), cadaverine (mg/kg), putrescine (mg/kg) and histamine (mg/kg); antimicrobial capacities such as total plate count (cfu/g), *Enterobacteriaceae* (cfu/g), *Coliform* (cfu/g), *E. coli* (cfu/g), *Staphylococus* (cfu/g), *Listeria* (cfu/g), *Salmonella* (cfu/g), *Vibrio* (cfu/g), yeast (cfu/g), mold (cfu/g) and sensory characteristics of dry fermented sausage during storage. All treated samples were analyzed after 9 months of storage at ambient temperature under vaccum packing. Results revealed that the incorporation of 3.0% w/w chitosan could inhibit microbial spoilage and lipid oxidation and therefore maintain the sensory score of the dry fermented sausage for 9 months during storage. The study indicated that the combination treatment with edible coating could be commercially utilized to maintain the freshness and prolong the shelf-life of the dry fermented sausage.

Keywords: *Dry fermented sausage, Wheat gluten, Chitosan, Sodium alginate, Collagen, Antimicrobial, biogenic amine, Sensory.*

Introduction

Fermentation and drying can be considered to be the oldest way to preserve raw materials. Generally, fermented sausages are manufactured by chopping and blending raw meat, fat, salt, spices, certain additives, and starter cultures, followed by stuffing into natural or synthetic casing and ripening and drying. Fermented sausages have high biological value and are a good source of energy, vitamins, mineral, and proteins [1].

Fermented sausages contain a variety of animal fats that are added during sausage manufacture to a level of 10-25%. Following ripening and drying, the content of animal fat can reach 50%. In general, dry fermented sausages have a final pH ranging between 5.2 and 5.8, which is consistent with the lower lactic acid content (0.5%-1.0%), a moisture lower than 30%, and an M : P lower than 2.3 : 1.

The main difference with semidry fermented sausages is the long ripening and drying process, during which biochemical and physical changes occur that strongly influence their stability and safety. Due to a_w, which ranges from 0.85 to 0.91, dry fermented sausages exhibit high shelf stability and can be kept without refrigeration.

The long ripening process of dry fermented sausages promotes the growth of starter cultures, which contributes largely to their sensory quality, while safety is mainly ensured by drying and low a_w. Even when dry fermented sausages are mainly made with pork meat, the formulation, degree of grinding, level of fermentation, smoking intensity, temperature of ripening, and type and size of casing will determine final product characteristics.

Fermented sausages are products that contain a high percentage of fat. Fat is responsible for numerous properties of the fermented sausages. From a physiological aspect, fat is an important source of energy as well as of essential fatty acids and liposoluble vitamins [2].

Products formed during lipolysis and lipid oxidation have an important role in the formation of odour, taste and texture of the final product. However, fermented sausages also show some negative properties as a consequence of high content of animal fat [3]. Lipolysis is the first step in the process of auto oxidation of free fatty acids [4]. Moreover, the oxidative degradation of lipids of meat and meat products involves the oxidation of unsaturated fatty acids, especially polyunsaturated fatty acids and cholesterol [5].

Polyunsaturated fatty acids having three or more double bonds are primarily tied to phospholipids and are important for the development of the characteristic flavor state of food. During secondary oxidation changes in free fatty acids, compounds such as aldehydes, ketones, carboxylic acids are being created. Aldehydes are the main products formed during the lipid oxidation. In addition to the important role in the formation of aroma, aldehydes have also toxic properties [6]. Propanal and hexanal are the most commonly used indicators of lipid oxidation in food due to their higher oxidative stability in detection compared to unsaturated aldehydes [7, 8].

Biogenic amines are compounds commonly present in living organisms in which they are responsible for many essential functions. They can be naturally present in many foods such as fruits and vegetables, meat, fish, chocolate and milk, but they can also be produced in high amounts by microorganisms through the activity of amino acid decarboxylases.

Excessive consumption of these amines can be of health concern because their not equilibrate assumption in human organism can generate different degrees of diseases determined by their action on nervous, gastric and intestinal systems and blood pressure. High microbial counts, which characterize fermented foods, often unavoidably lead to considerable accumulation of biogenic amines, especially tyramine, 2-phenylethylamine, tryptamine, cadaverine, putrescine and histamine.

Dry fermented sausages are worldwide diffused fermented meat products that can be a source of biogenic amines [9]. Microorganisms have a different ability in synthesizing decarboxylases. The production of BA in meat has been attributed to the action of several microorganisms: *pseudomonads, Enterobacteriaceae, enterococci and lactobacilli* [10, 11].

During dry fermented sausage ripening, proteins change as a consequence of the action of microbial and endogenous proteolytic enzymes [12]. Proteolysis is favoured by the denaturation of proteins as a consequence of acidity increase, dehydration and action of sodium chloride. High temperature, high pH and low salt content can accelerate the amino acid accumulation and, hence, stimulate amine formation [13].

PH is a key factor influencing the amino acid decarboxylase activity. Correlation between BA production and the decrease of pH in sausages caused by lactic fermentation has been evidenced [14]. Salt/water ratio during fermentation and storage of fermented sausages has an important role on microbial multiplication. Henry Chin and Koehler [15] demonstrated that NaCl concentration ranging from 3.5% to 5.5% could inhibit histamine production.

A different sausage diameter corresponds to different degrees of anaerobiosis, redox potential, salt concentration and aw values. Bover-Cid et al [16]. Found a relationship between BA content and the size of dry fermented sausages.

The diameter of the sausage affects the environment in which microorganisms grow; for example, salt concentration is usually lower and water activity is higher in sausages with a larger diameter. A larger diameter may be one of the reasons for a higher production of certain amines, such as tyramine and putrescine [17].

It is well known that temperature has a marked effect on the formation of BA in the fishing industry and in cheese. Several authors report that amine content depends on temperature, and increase with time and storage temperature [18, 19, 10]. The addition of sugars to sausages influences the population dynamics and, consequently, the production of BA because they can enhance the growth of starter cultures.

Tyramine and putrescine are the most common BA found in dry sausages and their presence is often due to the activity of LAB. High amounts of cadaverine and, to a lesser extent, of histamine have been detected in some samples, but the presence of these amines has been related to the low quality of raw materials in which high proliferation of microorganisms occurs. Chemico-physical productive parameters can select and favour amine-positive micro flora and influence the activity of amino acid decarboxylases.

While some of these parameters, such as sausage diameter (and, in turn, redox potential), depend on the type of products, other variables, such as temperature and the rate and entity of pH decrease, can be successfully modulated to avoid the growth of undesirable microorganisms. Regarding food borne intoxications, the accumulation of biogenic amines must be avoided in all kinds of food products. Moreover, biogenic amines can function as precursors for the formation of carcinogenic N-nitrosamines when nitrite is present [20]. There were several notable researches mentioned to application of edible coating in dry fermented sausage. Dry fermented sausage was coated with chitosan-caraway film. The effect of coating on the moisture content, color and lipid oxidation was investigated during a five month period of storage [21].

The effect of a chitosan coating with added essential oil of oregano (*Origanum vulgare*) on lipid oxidation of dry fermented sausage (Petrovská klobása) was investigated. Fatty acid profile, aldehyde contents and sensory analysis of odor and flavor were determined after drying and during seven months of storage [22].

The application of a biopolymer coating based on chitosan was tested. The optimized coating was formed as a twolayer coating, wherein the first layer (which is in contact with the product) was formed of chitosan with emulsified caraway essential oil as an active component, whereas the second layer was formed of chitosan with the addition of beeswax to optimize the moisture barrier of the coating. As a substrate, the traditional dry fermented sausage Petrovská klobása was selected. The coating was applied to the sausage after drying [23]. The aim of this current work was to study the feasibility of edible coating in extending shelf-life of dry fermented sausage.

Material and Method

Material

Dry fermented sausage was prepared by mixing comminuted fresh meat with salt contaminated with spices, or herbs; stuffing it into animal intestines; and then drying it.

Figure 1: Dry fermented sausage

Researching Method

Effect of Edible Film Coating to Physciochemical Quality, Antimicrobial Capacity and Sensory Score of Dry Fermented Sausage

The dry fermented sausages were treated by different formulas (N_0: control; N_1: 2.0% wheat gluten; N_2: 2.0% w/w chitosan; N_3: 2.0% w/w sodium alginate; N_4: 2.0% w/w collagen). The effectiveness of edible coating was based on the physicochemical attributes such as pH, water activity (a_w), TBARS value (mg/kg); biogenic amines such as tyramine (mg/kg), 2-phenylethylamine (mg/kg), tryptamine (mg/kg), cadaverine (mg/kg), putrescine (mg/kg) and histamine (mg/kg); antimicrobial capacities such as total plate count (cfu/g), *Enterobacteriaceae* (cfu/g), *Coliform* (cfu/g), *E. coli* (cfu/g), *Staphylococus* (cfu/g), *Listeria* (cfu/g), *Salmonella* (cfu/g), *Vibrio* (cfu/g), yeast (cfu/g), mold (cfu/g) and sensory characteristics of dry fermented sausage during storage. All treated samples were analyzed after 9 months of storage at ambient temperature under vaccum packing.

Effect of Chitosan Concentration to Physciochemical Quality, Antimicrobial Capacity and Sensory Score of Dry Fermented Sausage

After finding the optimal edible coating material, we conducted an experiment to verify the effect of chitosan concentration. Different concentrations of chitosan (2.0%, 2.5%, 3.0%, 3.5%, 4.0%) were examined. The effectiveness of edible coating was based on the physicochemical attributes such as pH, water activity (a_w), TBARS value (mg/kg); biogenic amines such as tyramine (mg/kg), 2-phenylethylamine (mg/kg), tryptamine (mg/kg), cadaverine (mg/kg), putrescine (mg/kg) and histamine (mg/kg); antimicrobial capacities such as total plate count (cfu/g), *Enterobacteriaceae* (cfu/g), *Coliform* (cfu/g), *E. coli* (cfu/g), *Staphylococcus* (cfu/g), *Listeria* (cfu/g), *Salmonella* (cfu/g), *Vibrio* (cfu/g), yeast (cfu/g), mold (cfu/g) and sensory characteristics of dry fermented sausage during storage. All treated samples were analyzed after 9 months of storage at ambient temperature under vaccum packing.

Physico-chemical, Microbial and Sensory Evaluation of Dry Fermented Sausage during Storage

The pH values were measured by using a digital pH meter. Water activity (a_w) was determined using Rotronic instrument. Biogenic amines such as tyramine (mg/kg), 2-phenylethylamine (mg/kg), tryptamine (mg/kg), cadaverine (mg/kg), putrescine (mg/kg) and histamine (mg/kg) were determined based on reversephase HPLC. The TBARS (mg/kg) test was performed by 1, 1, 3, 3-tetraethoxypropane using a spectrophotometer (Torres-Arreola et al., 2007). Microorganism such as Total plate count (cfu/g), *Enterobacteriaceae* (cfu/g), *Coliform* (cfu/g), *E. coli* (cfu/g), *Staphylococus* (cfu/g), *Listeria* (cfu/g), *Salmonella* (cfu/g), *Vibrio* (cfu/g), yeast (cfu/g), mold (cfu/g) were determined by 3M-Petrifilm. The sensory score regarding to flavor and aroma was carried out by selected panel of judges (9 members) rated on a nine point hedonic scale.

Statistical Analysis

The experiments were run in triplicate with three different lots of samples. Data were subjected to analysis of variance (ANOVA) and mean comparison was carried out using Duncan's multiple range test (DMRT). Statistical analysis was performed by the Stat graphics Centurion XVI.

Result & Discussion

Effect of Edible Film Coating to Physicochemical Quality, Antimicrobial Capacity and Sensory Score of Dry Fermented Sausage During Storage

The dry fermented sausages were treated by different formulas (N_0: control; N_1: 2.0% wheat gluten; N_2: 2.0% w/w chitosan; N_3: 2.0% w/w sodium alginate; N_4: 2.0% w/w collagen). The effectiveness of edible coating was based on the physicochemical attributes such as pH, water activity (a_w), TBARS value (mg/kg); biogenic amines such as tyramine (mg/kg), 2-phenylethylamine (mg/kg), tryptamine (mg/kg), cadaverine (mg/kg), putrescine (mg/kg) and histamine (mg/kg); antimicrobial capacities such as total plate count (cfu/g), *Enterobacteriaceae* (cfu/g), *Coli form* (cfu/g), *E. coli* (cfu/g), *Staphylococus* (cfu/g), *Listeria* (cfu/g), *Salmonella* (cfu/g), *Vibrio* (cfu/g), yeast (cfu/g), mold (cfu/g) and sensory characteristics of dry fermented sausage during storage. All treated samples were analyzed after 9 months of storage at ambient temperature under vaccum packing.

Table 1: Effect of edible film coatings to physicochemical quality, antimicrobial capacity and sensory score of dry fermented sausage during storage

Coating	Before storage	After 9 months of storage				
		N_0	N_1	N_2	N_3	N_4
pH	6.15 ±0.01^{c}	6.23 ±0.01^{a}	6.18 ±0.03^{bc}	6.15 ±0.00^{c}	6.20 ±0.02^{b}	6.21 ±0.01^{ab}
a_w	0.39 ±0.01^{c}	0.45 ±0.02^{a}	0.42 ±0.00^{b}	0.39 ±0.01^{c}	0.43 ±0.02^{ab}	0.43 ±0.03^{ab}
TBARS (mg/kg)	0.14 ±0.02^{d}	1.25 ±0.03^{a}	0.19 ±0.01^{c}	0.15 ±0.01^{cd}	0.23 ±0.01^{bc}	0.27 ±0.00^{b}
Tyramine (mg/kg)	0.05 ±0.00^{d}	0.24 ±0.03^{a}	0.17 ±0.01^{b}	0.06 ±0.00^{d}	0.11 ±0.02^{c}	0.20 ±0.01^{ab}
2-phenylethylamine (mg/kg)	0.11 ±0.01^{d}	1.67 ±0.02^{a}	0.36 ±0.01^{c}	0.12 ±0.02^{d}	0.45 ±0.02^{bc}	0.49 ±0.03^{b}
Tryptamine (mg/kg)	0.04 ±0.00^{d}	1.14 ±0.01^{a}	0.27 ±0.02^{c}	0.06 ±0.00^{d}	0.29 ±0.01^{bc}	0.33 ±0.02^{b}
Cadaverine (mg/kg)	0.34 ±0.01^{d}	1.16 ±0.00^{a}	0.34 ±0.01^{d}	0.38 ±0.00^{bc}	0.36 ±0.01^{c}	0.41 ±0.02^{b}
Putrescine (mg/kg)	0.25 ±0.00^{e}	2.49 ±0.02^{a}	0.47 ±0.00^{d}	0.28 ±0.03^{e}	0.63 ±0.02^{c}	0.74 ±0.01^{b}
Histamine (mg/kg)	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
Total plate count (cfu/g)	1.4x10^{3} ±0.02^{d}	6.4x10^{3} ±0.03^{a}	1.8x10^{3} ±0.02^{bc}	7.1x10^{2} ±0.01^{e}	2.1x10^{3} ±0.01^{b}	1.6x10^{3} ±0.03^{c}
***Enterobacteriaceae* (cfu/g)**	2.8x10^{1} ±0.03^{d}	4.5x10^{2} ±0.01^{a}	3.3x10^{1} ±0.03^{bc}	0.7x10^{1} ±0.00^{e}	3.8x10^{1} ±0.01^{b}	2.9x10^{1} ±0.00^{c}
***Coliform* (cfu/g)**	1.5x10^{1} ±0.01^{d}	3.1x10^{2} ±0.00^{a}	2.1x10^{1} ±0.01^{bc}	0.6x10^{1} ±0.03^{e}	2.5x10^{1} ±0.02^{b}	1.8x10^{1} ±0.01^{c}
***E. coli* (cfu/g)**	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
***Staphylococus* (cfu/g)**	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
***Listeria* (cfu/g)**	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
***Salmonella* (cfu/g)**	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
***Vibrio* (cfu/g)**	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
Yeast (cfu/g)	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
Mold (cfu/g)	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
Sensory score	8.45 ±0.02^{a}	8.11 ±0.03^{c}	8.38 ±0.00^{ab}	8.44 ±0.02^{a}	8.33 ±0.03^{b}	8.23 ±0.00^{bc}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%). N0: control; N1: 2.0% wheat gluten; N2: 2.0% w/w chitosan; N3: 2.0% w/w sodium alginate; N4: 2.0% w/w collagen)

Lipid oxidative changes in chitosan-oregano coated traditional dry fermented sausage were examined. Between coated and control sausage, a difference was observed after two months storage in fatty acid profiles (myristic, oleic and linoleic acids), but after seven months storage there was no difference.

Decrease in polyunsaturated acid content was observed (from 17.25% to 15.70%), as well as an increase in total aldehydes (from 4.54 µg/g to 31.80 µg/g), due to lipid oxidation during storage. After seven months storage, the content of most aldehydes was significantly lower in coated sausage than in the control. Sensory characteristics of odor and flavor were better for coated sausage, after seven months of storage. Results suggest that chitosan-oregano coating can be successfully applied to protect dry fermented sausages from lipid oxidation [22].

Effect of Chitosan Concentration to Physciochemical Quality, Antimicrobial Capacity and Sensory Score of Dry Fermented Sausage

Chitosan, as a semi-natural biopolymer, has been extensively studied for edible film application. Relative to the use of chitosan in the production of edible films in the food industry, this biopolymer possesses the following favourable properties: it is approved as an additive in the food industry in many countries, has the ability to form films with good gas barrier properties, demonstrates antimicrobial and antioxidant properties, three functional groups enable different modifications of the molecules in order to improve the properties, the source is a renewable raw material, which is also a waste material from the food industry, the resulting edible films can be consumed together with the product, or are rejected as biodegradable packaging [24].

After finding the optimal edible coating material, we conducted an experiment to verify the effect of chitosan concentration. Different concentrations of chitosan (2.0%, 2.5%, 3.0%, 3.5%, 4.0%) were examined. The effectiveness of edible coating was based on the physicochemical attributes such as pH, water activity (a_w), TBARS value (mg/kg); biogenic amines such as tyramine (mg/kg), 2-phenylethylamine (mg/kg), tryptamine (mg/kg), cadaverine (mg/kg), putrescine (mg/kg) and histamine (mg/kg); antimicrobial capacities such as total plate count (cfu/g), *Enterobacteriaceae* (cfu/g), *Coliform* (cfu/g), *E. coli* (cfu/g), *Staphylococus* (cfu/g), *Listeria* (cfu/g), *Salmonella* (cfu/g), *Vibrio* (cfu/g), yeast (cfu/g), mold (cfu/g) and sensory characteristics of dry fermented sausage during storage. All treated samples were analyzed after 9 months of storage at ambient temperature under vaccum packing. Results revealed in table 2. From table 2, the optimal chitosan coating concentration was noted at 3.0%.

Table 2: Effect of chitosan concentration to physicochemical quality, antimicrobial capacity and sensory score of dry fermented sausage during storage

Coating	Before storage	After 9 months of storage				
		2.0%	2.5%	3.0%	3.5%	4.5%
pH	6.15 ±0.01a	6.15 ±0.00a	6.14 ±0.02ab	6.13 ±0.03b	6.13 ±0.00b	6.13 ±0.02b
aw	0.39 ±0.01a	0.39 ±0.01a	0.37 ±0.01ab	0.36 ±0.02b	0.36 ±0.03b	0.36 ±0.01b
TBARS (mg/kg)	0.14 ±0.02ab	0.15 ±0.01a	0.13 ±0.03b	0.11 ±0.02c	0.11 ±0.00c	0.11 ±0.03c
Tyramine (mg/kg)	0.05 ±0.00ab	0.06 ±0.00a	0.03 ±0.00b	0.02 ±0.01c	0.02 ±0.02c	0.02 ±0.00c
2-phenylethylamine (mg/kg)	0.11 ±0.01a	0.12 ±0.02a	0.08 ±0.02b	0.06 ±0.03c	0.06 ±0.01c	0.06 ±0.02c
Tryptamine (mg/kg)	0.04 ±0.00ab	0.06 ±0.00a	0.02 ±0.01b	0.01 ±0.03c	0.01 ±0.00c	0.01 ±0.03c
Cadaverine (mg/kg)	0.34 ±0.01ab	0.38 ±0.00a	0.34 ±0.02b	0.32 ±0.01c	0.32 ±0.03c	0.32 ±0.01c
Putrescine (mg/kg)	0.25 ±0.00b	0.28 ±0.03a	0.26 ±0.03ab	0.24 ±0.02bc	0.23 ±0.03c	0.21 ±0.00d
Histamine (mg/kg)	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
Total plate count (cfu/g)	1.4x103 ±0.02a	7.1x102 ±0.01b	4.2x102 ±0.01c	2.3x102 ±0.01d	6.7x101 ±0.02e	1.1x101 ±0.01f
***Enterobacteriaceae* (cfu/g)**	2.8x101 ±0.03a	0.7x101 ±0.00b	0.5x101 ±0.02bc	0.3x101 ±0.01c	0.1x101 ±0.00d	0.1x101 ±0.02d
***Coli form* (cfu/g)**	1.5x101 ±0.01a	0.6x101 ±0.03b	0.4x101 ±0.00bc	0.3x101 ±0.01c	0.1x101 ±0.03d	0.1x101 ±0.01d
***E. coli* (cfu/g)**	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
***Staphylococus* (cfu/g)**	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
***Listeria* (cfu/g)**	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
***Salmonella* (cfu/g)**	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
***Vibrio* (cfu/g)**	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
Yeast (cfu/g)	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
Mold (cfu/g)	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
Sensory score	8.45 ±0.02a	8.44 ±0.02a	8.44 ±0.02a	8.44 ±0.02a	8.44 ±0.02a	8.44 ±0.02a

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

Effect of chitosan-caraway coating on color stability and lipid oxidation of traditional dry fermented sausage was examined. The moisture content decreased rapidly during the storage and the coating did not slow down the loss of moisture. The Lightness (L*) of the sausage surface increased by the coating application, while the redness (a*) and yellowness (b*) did not change. The coated sausages showed a better color stability of the sausage core through the storage time. Also, coated sausage showed a better oxidative stability till the 60th day of storage, while this difference was not detected at the end of the storage period. Apart from slowing down sausage drying during the storage, chitosan-caraway coating was effective in preserving the sausage quality [21].

In another research, during two months of storage under controlled conditions, the influence of the coating on the loss of moisture, the oxidative stability and the sensory characteristic of aroma of the control sausage (without the coating) and sausage with the coating was monitored. The results obtained indicate a significant contribution of the applied dual layer chitosan-based coating to the preservation of the sausage quality parameters analyzed [23]. The only amines present at significant levels in fresh meat used for fermented sausage production are spermidine and spermine, and, to a lesser extent, putrescine [25]. High concentrations of putrescine and the presence of other amines have been attributed to microbial growth and depend on meat freshness.

Conclusion

Meat and meat products play an important role in human nutrition. Nowadays consumers demand high quality food with an extended shelf life without chemical additives. Edible coatings are a promising preservation technology for dry fermented sausage because they provide good barrier against spoilage and pathogenic microorganisms, limit the lipid oxidation. The films gas barrier properties contribute to extended shelf life because physicochemical changes, such as color, texture, and moisture, may be significantly minimized. Chitosan, the second most abundant polysaccharide in nature, after cellulose, has been tested for numerous applications, among which for edible film and coating. Chitosan-based coating showed positive results for shelf life prolongation of meat products. 3% w/w chitosan was appropriated for coating the dry fermented sausage for 9 months of storage at ambient temperature in vaccum packaging.

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