Application of Nanotechnology in Meat Packaging, review

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Abstract

Currently nanotechnology is became one of the most rapidly emerging field in food research. It has a potential effects on providing solutions to various problems that facing food processing, consumption and storage. In the recent decades many attempts have been made to develop different nanostructures in different fields of food processing. In nanotechnology an intermolecular interactions could play an important role in different food processing application. Recently, most applications on nanotechnology in food production focusing on structure building, functional ingredients encapsulation, biosensors and packaging. Edible edible nanocoatings were used successfully in meat packaging as antimicrobial and antioxidant packaging materials. However, when nanocomposite are formed for this purposes, attention in selecting the materials should be taken into account due to health risks associated with the use of some nanomaterials.

Keywords: nanotechnology, meat packaging, Edible nanocoatings, nanoemulsions, nanocomposite.

Introduction

Meat and meat products are recognized as perishable food due to microbial contamination and both lipid and protein oxidation. Packaging of meat and its products is the most important step of processing these products and now a days became a growing demand by consumers and perceived as healthy and safe, nutritious and tender [1]. Application of packaging materials and technologies is considered as good step for drug delivery [2] as well as for keeping quality and safety properties of food products [3]. There are many reasons for packaging both fresh and processed meat products such as delaying microorganisms and lipid oxidation spoilage, permitting some enzymatic activity to improve products tenderness, retaining colour and aroma of the products, reducing weight loss and preventing contamination [4,5]. Currently most of the materials used for the packaging of food are not biodegradable which could cause environmental concerns. Therefore environment friendly packaging which made of biopolymers may not have optimal mechanical and barrier properties [6].

Several studies have been dedicated with the objectives of developing and using different types of packaging techniques such as biodegradable packaging, active packaging, edible coatings/films, intelligent packaging and nanomaterial
They have potential effects on ensuring products quality and safety, reducing environmental impact, prolonging of products shelf life and increasing the attractiveness of the packaged products to consumers and retailers [15]. EFSA [16] reported that the food packaging industry could significantly benefit from nanotechnology. This review article aiming at highlighting the applications of nanotechnology in meat packaging.

**Raw meat packaging and nanocomposite as an improved packaging system**

Fresh meat has plenty of nutrients and high water activity which enable bacterial growth and cause its spoilage. Even at chill temperatures meat rapidly loses its quality because of microbial activity [17]. Agapi et al. [18] revealed that the using of an appropriate packaging combined with storage conditions can play a major role in keeping quality of meat. Recently, some researchers used types of packaging systems without using any synthetic additives in order to minimize off-odour and lipid oxidation development which lead to significant retardation of microbial growth [19-21].

Several researches have been dedicated with the objectives of using nanotechnology in packaging [22-25]. There are many advantages of using nanotechnology in packaging such as mechanical and heat-resistant properties, enhanced barrier properties and improved biodegradability. In addition, nanomaterials could be also used in packaging as antimicrobial effects enhancer and spoilage detector through nanosensors [26] de Azeredo, (2009) and Silvestre et al., (2011) [24,26] explained that nanocomposites are formed when a polymer matrix is reinforced with fillers such as clays, silicates, cellulose microfibrils, cellulose whiskers, and carbon nanotubes in nanoscale leading to improvement in packaging properties. Nylon, polyamide, polyolefins and polystyrene are some examples of polymers used for this purposes [24].

Recently a demand for producing biodegradable packaging has led to the use of natural biopolymers such as cellulose, carrageenan and chitosan instead of synthetic ones [6].

**Selected studies in using edible coatings as nanolaminates for meat products packaging**

Application of edible coatings to meat, fish and poultry has attracted increasing interest because this technique providing new functionalities such as antifungal and antimicrobial activity [22]. Several researchers [27-29] have reported that food deterioration caused by spoilage bacteria and pathogens can be significantly reduced in meat products by antimicrobial-loaded edible coatings. This is important in the case of meat and meat products that packaged in an anaerobic conditions because microorganism growth can lead to decreasing sensory characteristics due to formation of surface slime [30].

Edible coatings are described as nanolamine used to cover food consists of more than one layer in nanoscale [22] such Layer by layer (LbL) deposition techniques [31] which could be used to cover food due to surface charges advantage. This type of coating has thickness of the coating can be regulated with precision (1 to 100 nm) [22]. Weiss et al. [32] stated that nanolaminates could be used as natural edible barriers for the simultaneous nutrition shelf-life extension.

Beluga sturgeon fillets (BSFs) fish flesh is considered as one of the most deteriorated meat than other meat products due to its the presence of high contents of non-protein nitrogen,
unsaturated fatty acids and autolytic enzymes and high post-mortem pH. Gharibzahedi et al. [33] investigated edible coatings prepared from jujube gum and nettle oil-loaded nanoemulsions on the shelf-life of Beluga sturgeon fillets. They revealed that the shelf life of the fish fillets Beluga sturgeon fillets treated with nano edible active coatings can be significantly prolonged comparing to control sample (untreated sample). The edible nano edible coating formulated with 12% jujube gum and 3.5% nettle essential oil exhibited good stability in fillets pH, color and lipid oxidation, significant antimicrobial and antioxidant and weight and cooking losses effects. The shelf life of the treated fillets was extended up 15 days at refrigerated temperature of 4°C.

Marchiore et al. [34] successfully applied silver nanoparticles which obtained by a green route as edible coating to chicken sausages in order to control lactic acid bacteria growth on the sausages surface. They reported that the silver nanoparticles were able to inhibit lactic acid bacteria for 30 days and significantly (P < 0.05) increased the shelf life of the sausages at storage temperature of 10 ± 2 °C. However, they also found that the silver concentration was reduced to nanogram levels (5.3 ng AgNPs/g sausage) using a simple washing step before cooking.

Cruz-Romero et al. [35] investigated antimicrobial activity of chitosan and organic using nano-sized solubilisates in chicken fillets. Low- and medium-molecular weight chitosan in concentration of 1% were used as meat coating Nano-sized solubilisates of benzoic acid and sorbic acid had significantly higher antimicrobial properties than their non-nano equivalents. They found that (E. coli): (NCIMB 11943), Staphylococcus aureus (S. aureus): (NCIMB 13062), Bacillus cereus (B. cereus): (NCIMB 9373) and (Ps. fluorescens): (NCIMB 9046) and a microflora isolated from raw chicken sourced locally was also used. The results concluded that nano-sized solubilisates had significantly higher antimicrobial properties than their non-nano equivalents which could open opportunities for the nano-sized solubilisates derived from selected food compatible sources to be used successfully in nano-sized form as antimicrobial packaging materials.

**Conclusion**

It can be concluded that applications of nanotechnology using certain nanomaterial in meat packaging could be useful and could potentially benefit keeping quality of both raw and processed meat if the nanomaterial is carefully chosen. However, attention should be taken into account when nonomaterials are selected for this purposes due to health risks associated with the use of some nanomaterials such as skin toxicity, acute toxicity, skin irritation and genotoxicity.

**References**


Table 1: Selected Technique for packaging using nanotechnology

<table>
<thead>
<tr>
<th>S.no</th>
<th>Type of technique used for packaging</th>
<th>Reference</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Metallic nanoparticles in nanocomposite packaging</td>
<td>[36-39]</td>
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<tr>
<td>2</td>
<td>Metallic oxide nanoparticles in nanocomposite packaging</td>
<td>[40-42]</td>
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<tr>
<td>3</td>
<td>Nanodevice-combined polymers packaging</td>
<td>[43]</td>
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<tr>
<td>4</td>
<td>Nanotracers packaging</td>
<td>[44-48]</td>
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<tr>
<td>5</td>
<td>Nanosensors packaging</td>
<td>[22, 31, 48]</td>
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Table 2: Selected investigations on disadvantages of some nanomaterial used for packaging

<table>
<thead>
<tr>
<th>Type of investigation</th>
<th>Disadvantages effect</th>
<th>Reference</th>
</tr>
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<tbody>
<tr>
<td>Skin toxicity</td>
<td>Skin cytotoxicity, genotoxicity and other influences may be induced by the use of some nanomaterials in food applications</td>
<td>[49, 50]</td>
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<tr>
<td>Acute toxicity</td>
<td>Acute oral toxic effects could be caused at elevated dosage levels with metallic nanoparticles such as zinc, titanium dioxides and copper.</td>
<td>[50-53]</td>
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<tr>
<td>Skin irritation</td>
<td>Bad skin irritation and other influences could be cause by some nanomaterials in food applications</td>
<td>[54]</td>
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<td>Body Inflammation</td>
<td>Accumulation of some particulate of nanomaterials in immune cells as well as increasing levels of reactive oxygen species (ROS) were considered as causes of inflammation.</td>
<td>[55]</td>
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<tr>
<td>Genotoxicity</td>
<td></td>
<td>[49]</td>
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