JOURNAL OF FOOD TECHNOLOGY
MEDWELL PUBLICATIONS

Effect of Silver Nanoparticles on Food Surface Packaging

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Key words: Packaging, food industry, silver nanoparticles, public health, infectious diseases

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Page No.: 7-11
Volume: 19, Issue 2, 2021
ISSN: 1684-8462
Journal of Food Technology

Abstract: Nowadays, the packaging is an essential and primary element in modernizing trade in goods that preserve food and quality. Food items related to different brands are presented in various packaging colors, shapes, symbols, designs and messages. All these factors help to make these food products more attractive to the consumer. Globally an essential public health issue is hygiene in hospitals, colleges, schools, air, water, animal husbandry, the textile industry and especially the food industry. However, several contemporary interventions have been introduced for reducing contamination but still, it needs attention. Indeed, >300 emerging infectious diseases are a significant threat to humans. Nanocomposites of polymers containing metal nanoparticles or metal oxides have been produced to improve their characteristics (properties of gas barrier, flexibility, antioxidant or antimicrobial properties, etc. Silver nanoparticles are used for food packaging due to their antimicrobial effects. However, nanoparticles migrating to food are not wholly studied by researchers.

INTRODUCTION

The manufacture of packaging is an industry worldwide characterized by its internal diversity and all factors that affect the business situation and condition. The infrastructure and the packaging system specifications include the correct packaging of preservation items. According to the interest of the consumer, fresh food with a long shelf-life and a sufficient quality is needed. It contributes to the advancement of innovative technologies and ideas for the proper packaging of technological systems. Packaging known as silent salesman and is the subject of much recent legislation[1].

However, this legislation largely ignores the nonverbal mark components of the kit. The verbal elements of a package accurately represent the characteristics of product. However, a package can be used to improve or weaken explicit oral statements of the marketer. The design of package such as color, form, images etc. often provide a statement and message about the product and its description. Perhaps this nonverbal statement and message is an undercover but not less significant message. In recent decades, many patterns related to shifts in the social and economic climate and the lifestyle have been noted in food consumption. The working habits, women's increased jobs, lack of leisure, the rise in income and various other factors have led to fast food, convenience food and food from home. The need for convenient, portable and easy-to-prepare foods that reduce the trouble of food shopping and preparation of meals makes packaged food an indispensable component in a modern lifestyle[2] (Fig. 1).

Fig. 1: Components in a modern lifestyle

Importance of packaging: Nowadays, the packaging is an essential and primary element in modernizing trade in goods that preserve food and quality. It is a significant factor for protecting products that are packed contrary to external conditions that affect the safety and the food product quality. Packaging makes the transportation and storage of food products easier. It is suggested that the packaging is essential and it helps to improve production strategies to make proper packaging gradually. When packaging of products is done, some points must be kept in mind like UV protection, transparency, environmental performance and a proper barrier to gas. For the reason of the packaging system of food products, the food industry has created new demands for the packaging market[3].

Food items related to different brands are presented in various packaging colors, shapes, symbols, designs and messages. All these factors help to make these food products more attractive to the consumer. Also, these different packaging styles facilitate consumers about the types of packed products[4]. Other types of brands, their unique packaging style and the use of packaging for the transportation of products are making progress day by day all around the world. Several studies suggested that packaging helped the consumer decide when the consumer did not know much about consequences. Packaging style, message and formula which are all mentioned, help acknowledge the effects[5]. Food packaging shall be used as a barrier to avoid damaging external factors such as sun, pollutants and humidity. In recent decades, food packaging innovations have rapidly evolved with increased demand from customers for high-quality food. Many new food packaging technologies have been launched with an active food packaging operation[6] (Table 1).

Food packaging shall be used as a barrier to avoid damages of external factors such as sun, pollutants and humidity. In recent decades, food packaging innovations have rapidly evolved with increased demand from customers for high quality food. Many new food packaging technologies has been launched with an active food packaging operation[7]. A good and active food packaging system can improve the effectiveness of the food shelf life by displaying functional properties like antimicrobial, antioxidant, water vapor barrier, maintenance, or enhancement of food quality. Including active components like antioxidants antimicrobials, packaging goals can be achieved[8].

Active packaging system: Active packaging is essential and helpful to protect food quality via up-to-date systems. It is distinguished from an intelligent packaging system that mainly compliments the active packaging and its role in connecting and interacting with the buyer. These systems include physical, biological and chemical activities that improve the shelf life of food products and significantly improve the microbial safety of food and prevent it from any contamination. The new packaging system is opposite to the traditional packaging system. Active packaging extends the shelf life of food products and preserves their quality during the reaction with development and the internal atmosphere. So, dynamic packaging system is considered innovative in the field of food packaging[3]. The use of an active packaging system promotes the shelf life of food commodities by several factors:

- By protecting from the substances which absorb (scavengers) or release (emitters) gases or steam
- Physiological processes like the breathing of fresh vegetables and fruits are kept controlled
- A chemical process, like oxidation of fats are avoided
- Microbiological changes for the reason microorganisms are handled
- Protect from insects that cause the infection

Active packaging is an innovative concept in which products, packages and the environment work together to prolong the shelf life and increase the safety or sensory qualities while maintaining the consistency of the product. This innovative thought has recently gained importance by implementing nanotechnological materials (such as nanoparticles and nanocoating in the food industry) to provide fresh food items with long storage life[9].

Use of silver nanoparticles in food packaging and its effect on food: Globally an essential public health issue is hygiene in hospitals, colleges, schools, air, water,

Table 1: Framework for packaging

Package design	Liking for package	Communication through package	Usability of package
Attraction of buyer	Brand	Color	Ease of handling
Communication to the buyer	Country of origin	Symbols/logo	Disposability
Convenience in handling and using	Color connotation	Information about product	Moisture protection
Saleability of product	Symbol connotation	Brand image shape	Protection from ultraviolet
Green aspect	Size	Size	radiation

Table 2: Antibacterial activity of the biologically synthesized silver nanoparticles

	Zone of inhibition (mm in diameter)			
Name of the organism	AgNPs	$AgNO_3$,	F. Extract	Positive control
Pseudomonas aeruginosa	18	10	-	23
Staphylococcus aureus	12	9	-	17
Escherichia coli	11	8	-	16
Shigella sp.	22	10	-	26
Bacillus subtilis	10	7	-	14
Klebsiella pneumoniae	17	8	-	22

AgNPs = Silver Nanoparticles; $AgNO_3$ = Silver nitrate; F. Extract = Fungal Extract; Positive control = Streptomycin; (-) = No inhibition

animal husbandry, the textile industry and especially the food industry. However, several contemporary interventions have been introduced for reducing contamination but still, it needs attention. Indeed, >300 emerging infectious diseases are a significant threat to humans. Microbial infections are a substantial cause of different infections with >50% dieting of various infections in Africa. Various disinfectants have been used to remove bacteria to combat multiple processes. In the broader industries, nanomaterials have provided a new area to solve these problems. The International Organization for Standardization minutes that, even in its mixed domain due to its extraordinary properties, nanomaterials within the range 1-100 nm as a substance with specific external dimensions[10]. The various nanomaterials have been used as efficient disinfectants for optimizing their physicochemical qualities. Inorganic metals such as copper, silver and gold, include food supplies, pans, cups, jewelry and coins for the disinfection of water/food and human pollution[11]. Silver-based compounds and silver ions are, in particular, a well-known medically necessary antimicrobial agent from 1000 BCE and have been used as an effective health additive in both Indian and Chinese Ayurveda. Silver is preferred because of its different medical roles. Silver nitrate is used as usual for the use of antimicrobials. Still, today nano-based silver is antimicrobial due to its physical and chemical properties which have led to increased microbial surface-to-volume exposure, resulting in better antimicrobial activity[12].

At present, the use of waste by-product processing is taken into account in an environmentally friendly manner. Due to a wide range of applications for many product formulations in the field of personal care, food processing, pharmaceutical and environmental remediation, the development of nanotechnological products, in particular has become more demanding and fashionable[13]. The silver nanoparticle (AgNPs) is important because its fascinating features include reduction power, photochemical activity and electrical conductivity (Table 2). Antimicrobials and anti-cancer activities have many medicinal applications, including antioxidants[14].

In particular, biopolymers and silver nanoparticles (AgNPs) have the potential for active food packaging system development. The diameter of the silver nanoparticles (AgNP) is 1-100 nm. Typically, two methods are developed; one is the top-down approach, in which bulk metals are reduced by physical processing like grinding to a nanoscale. The other approach is the bottom-up approach which can be used in the assemblage of silver atoms biological and processes. Nanosized silver particles have a large surface-to-volume ratio at high temperatures[15].

The growing need for better fresh food safety and the need to protect pathogenic foods necessitated the development of antimicrobial food packaging as a matter of urgency. One of the most promising approaches is the combination of organic-inorganic and embedded polymer-metal nanoparticles. In particular, the silver nanoparticles (AgNPs) are antimicrobial, anti-inflammatory and antiviral and can be combined in active food packaging with non-degradable and comestible polymers[16] (Fig. 2).

Packaging usually includes a range of designs. The first kind, called as the primary packaging, consists of the boxes or materials that straight contact the food. Or a bag of peanuts, tuna canes, jam jars, or a covering of a chocolate bar, all known as primary package models, is a box in which a product's device can be accessed on the market[17]. Primary packaging is often primarily restricted in the outer box for storage and transport. For example, a cardboard box with about 20 or 40 tuna cans: secondary packages collected in a regulated 'lot' tertiary package, etc. A central multidisciplinary area of study, research and development is food packaging

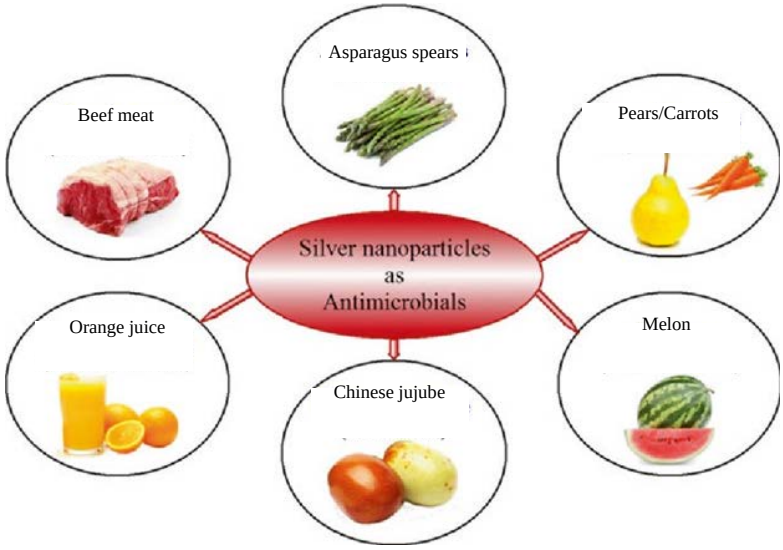

Fig. 2: Good food products

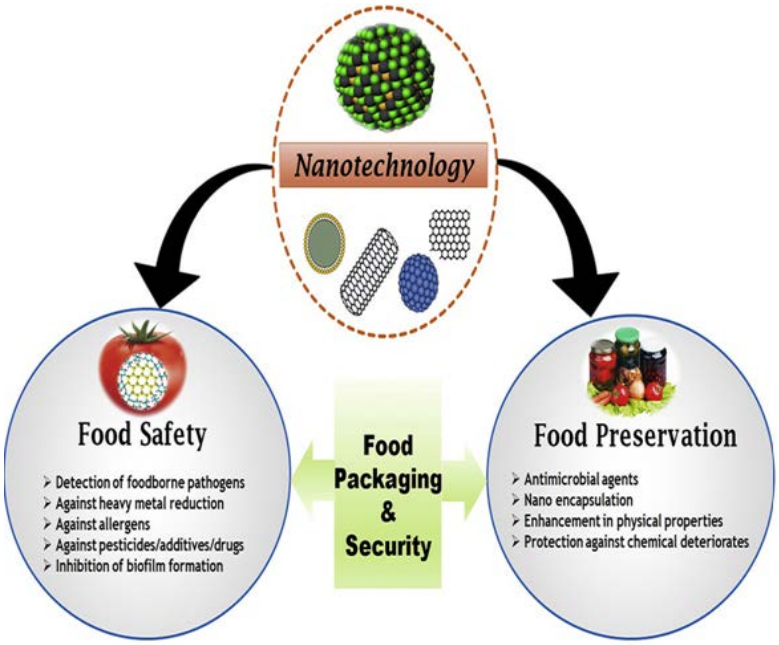

Fig. 3: Food packaging and security

itself. For the achievement of good food products (quality and protection, etc.) through storage and transport and enhance food safety by avoiding discrepancies with problems and conditions such as chemical pollutants, microorganism injury, oxygen, humidity and lightening obstacles, etc.[18] (Fig. 3).

Antimicrobials are most often used in metallic nanoparticles with various antibacterial activities and profitable abilities such as stability and have relatively low toxicity. Their skillful antimicrobial efficiency is related to the tiny size of particles resulting in the cell penetration of released Ag-ion interactions to amino and carboxyl peptidoglycan cell groups as well as the generation of oxidative stresses which affect the replication of DNA or collapse of the proton motive strength over the cytoplasmic membrane[19]. However, since there is some health and environmental issue with the overuse of Ag NPs due to accumulated increase in the amount of released Ag+ ions and it has been used to develop phytochemicals that have a double role in reducing and capping agents[20]. Nanocomposites of polymers containing metal nanoparticles or metal oxides

have been produced to improve their characteristics (properties of gas barrier, flexibility, antioxidant or antimicrobial properties, etc. Silver nanoparticles are used for food packaging due to their antimicrobial effects. However, nanoparticles migrating to food are not wholly studied by researchers. The ICP-MS and SEM-EDX research have measured migration solutions and analyzed nanoparticles dissolved in silver that are a key aspect of toxicity. For all analyzed samples, the total silver migration values ranged from 1.66-31.46 ng cm^{-2} migration of silver was observed (lower than the permissible limits)[7]. The samples were changed in size and morphology (from 10-60 nm) of silver nanoparticles and researchers also tested other nanosized materials that were migrated. Results from all the analyses proved that silver nanoparticles used for food packaging successfully promoted the shelf life of food by protecting it from micro organisms[21].

CONCLUSION

Packaging is an essential and principal element in modernizing trade in goods that preserve food and quality. Food items related to different brands are presented in various packaging colors, shapes, symbols, designs and messages. Worldwide it is an essential public health issue to ensure person hygiene in hospitals, colleges, schools, air, water, animal husbandry, the textile industry and especially the food industry. Nanocomposites of polymers containing metal nanoparticles or metal oxides have been produced to improve their characteristics properties of gas barrier, antioxidant or antimicrobial properties, etc. Silver nanoparticles are used for food packaging due to their antimicrobial effects. However, nanoparticles migrating to food are not wholly studied by researchers.

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