Emerging nanomaterials applications for food packaging and preservation. Safety issues and risk assessment

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Introduction

Nanotechnology or “nanoscience” uses materials and structures, in the nanoscale range, usually 100 nm or less in at least one dimension, with a nanometer being 10^{-9} meters. Nanomaterial defined as material having one or more dimensions in the range 1–100 nm. The materials used in food packaging are intended to reduce or delay the deterioration of food quality, preventing the transportation of gases such as oxygen from the external environment to foods, for a specific period of time until it is used by the consumer. The contribution of nanotechnology to the development of food packaging systems has been enormous in last years. Concerning the acceptance of nanotechnology by the public in the field of foodstuffs, from studies related to consumer behavior, there is a greater acceptance of nanotechnology in the external environment such as food packaging than inside the food. The purpose of this work is to provide recent advances in the development of efficient nano-preservatives, multifunctional devices and systems that could be used to maintain food quality as well as contribute to extending the shelf life through food packaging as well as risk and safety issues.

Emerging nanomaterials in food preservation

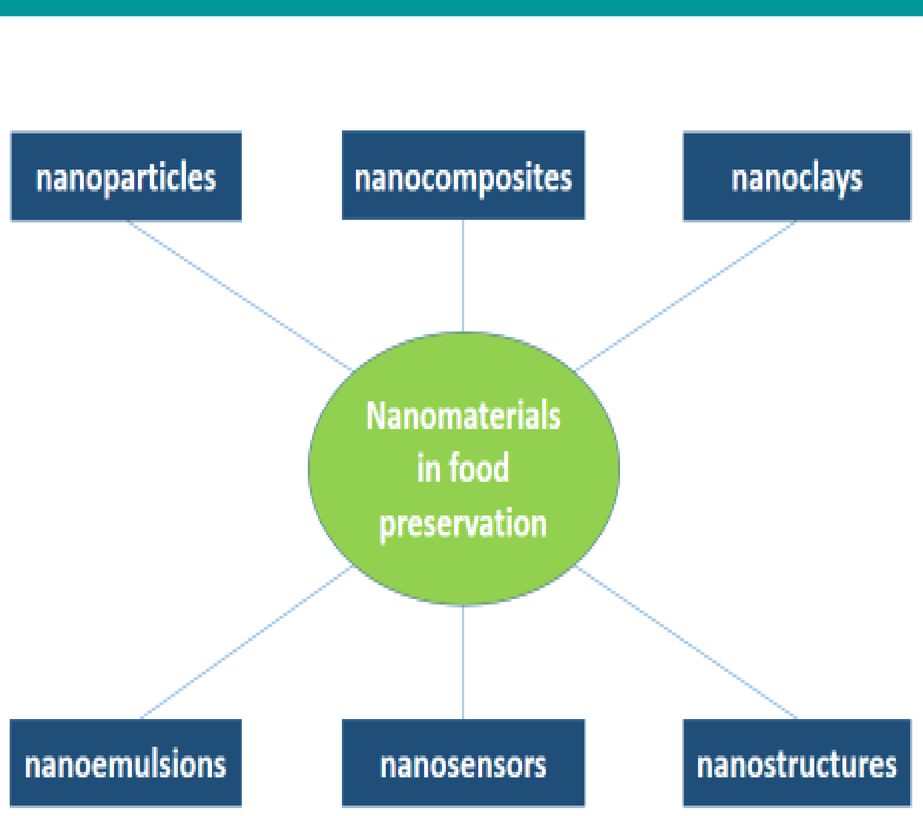

Fig. 1. Nanomaterials in food preservation

Recent studies of the use of nanomaterials in active food packaging applications

Food Matrix	Nanomaterials	Effect
Grapes	Nanocomposites of chitosan/gelatin and silver nanoparticles	Extend the shelf life for two weeks
Fresh-cut apple	Poly-lactic acid film incorporated with ZnO nanoparticle	Maintain the quality for two weeks
Peach	Chitosan-rice starch/ Nano-ZnO nanocomposites	Control the microbial growth and spoilage
Lamb meat	Cellulose nanofiber/whey protein/ containing TiO_2 nanoparticles and rosemary essential oil	Reduced microbial growth, extend the shelf life for 6 to 15 days
Fruits and vegetables	Silver nanoparticles	Absorption and decomposition of ethylene emitted
Chicken meat	Polylactide films and bimetallic Ag-Cu nanoparticles and and essential oil	Maximum antibacterial action during 21 days at 4 °C
Salmon	Chitosan/montmorillonite / α-tocopherol film	Inhibition of oxidation reactions
Bread	Carboxymethyl cellulose-chitosan-ZnO NPs nanocomposite	Extend the shelf life by 15 days
Lamb meat	Nano-composite films containing TiO_2 nanoparticles and rosemary essential oil	Extend the shelf life by 12–15 days

Regulations and safety issues-Risk assessment

- Regulatory systems are necessary to manage the potential risks posed by the use of nanotechnology in the food sector.
- The application of specific legislative framework of nanotechnology in food could lead to the widespread use of nanomaterials in food packaging.
- In the United States, Regulation 258/97 stipulates that if a nanomaterial is used as a primary ingredient, then it must be considered as "fresh food“.
- According to European Commission Regulation no. 2015/2283, EFSA must verify that for the involvement of mechanically engineered nanoparticles in food production, their safety assessment was performed using the latest generation of analytical techniques. EFSA has recently published its Risk Assessment Guidelines for the Application of Nanosciences and Nanotechnologies in the Food Chain.Long-term exposure to nanoparticles can cause oxidative stress in human cells, kidney and liver damage, and DNA damage.

Conclusions

- The mechanism of action of most nanomaterials used in food preservation is not fully understood.
- Additional research is needed to assess the safety of nanomaterials, to characterize them and to measure their reactivity.
- The toxicological risk involved in the use of nanomaterials in food packaging, especially in the case of edible nano-packaging, is significantly linked to the phenomenon of migration as well as to the occurrence of toxic effects on the exposed human body.

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