IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 4, April 2017
ISSN (Online) 2348 – 7968 | Impact Factor (2016) – 5.264
www.ijiset.com

Application of Nanotechnology in Meat Packaging, review

M. Abd Elgadir

Department of Food Science &Human Nutrition, College of Agriculture and Veterinary Medicine, Qassim University, Saudi Arabia.

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 nancoatings 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 nancoatings, nanoemulsions, nanocomposite**.**

Corresponding author E.mail: mam.qassim@gmail.com

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

packaging [7 -14]. 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 nanolaminate 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 ngAgNPs/gsausage) 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

1. K.G. Grunert, C. Valli .Designer-made meat and dairy products: Consumer-led product development Livestock Production Science, 72 (2001), pp. 83–98.

2. M.Abd Elgadir, Md.Salim Uddin, Sahena Ferdosh, Aishah Adam, Ahmed Jalal Khan Chowdhury, Md.Zaidul Islam Sarker. 2015. Impact of chitosan composites and chitosan nanoparticle composites on various drug delivery systems: A review. Journal of Food and Drug Analysis, 23 (4): 619-629.

3. K.A. Abbas, A.M. Saleh, A. Mohamed and N. Mohd Azhan.2009. The recent advances in the nanotechnology and its applications in food processing: A review. Journal of Food, Agriculture & Environment Vol.7 (3&4): 1 4 - 1 7.

4. Brody A.L. Packaging of food. A.L. Brody, K.S. Marsh (Eds.), The Wiley encyclopedia of packaging (2nd ed.), Wiley, New York (1997), pp. 699–704.
5. Rhim JW. Park HM., & Ha CS. 2013. Bio-nanocomposites for food packaging applications. Prog Polym Sci. 38:1629–1652.

6. H. Mondry. Packaging systems for processed meat. S.A. Taylor, A. Raimundo, M. Severini, F.J.M. Smulders (Eds.), Meat quality and meat packaging, ECCEAMST, Utrecht, Holland (1996), pp. 323–333.

7. J.P. Kerry, M.N. O'Grady, S.A. Hogan. Past, current and potential utilisation of active and intelligent packaging systems for meat and muscle-based products: A review
Meat Science, 74 (2006), pp. 113–130.

8. X.D. Sun, R.A. Holley. Antimicrobial and antioxidative strategies to reduce pathogens and extend the shelf life of fresh red meats. Comprehensive Reviews in Food Science and Food Safety, 11 (4) (2012), pp. 340–354.

9. I.S. Arvanitoyannis, A.C. Stratakos. Application of modified atmosphere packaging and active/smart technologies to red meat and poultry: A review. Food and Bioprocess Technology, 5 (2012), pp. 1423–1446.

10. S.Y. Lee, S.J. Lee, D.S. Choi, S.J. Hur. Current topics in active and intelligent food packaging for preservation of fresh foods. Journal of the Science of Food and Agriculture, 95 (2015), pp. 2799–2810.

11. M. Ghaani, C.A. Cozzolino, G. Castelli, S. Farris. An overview of the intelligent packaging technologies in the food sector. Trends in Food Science & Technology, 51 (2016), pp. 1–11.

12. A.E. Kapetanakou, P.N. Skandamis. Applications of active packaging for increasing microbial stability in foods: Natural volatile antimicrobial compounds. Current Opinion in Food Science, 12 (2016), pp. 1–12.

13. S. Maisanaba, M. Llana-Ruiz-Cabello, D. Gutiérrez-Praena, S. Pichardo, M. Puerto, A.I. Prieto, et al.New advances in active packaging incorporated with essential oils or their main components for food preservation Food Reviews International (2016). 447-515.

14. Z. Fang, Wusgal, H. Cheng and L. Liang, 11 - Natural biodegradable medical polymers: Therapeutic peptides and proteins, In Science and Principles of Biodegradable and Bioresorbable Medical Polymers, edited by Xiang Zhang,, Woodhead Publishing, 2017, Pages 321-350.

15. C.E. Realini, B. Marcos. Active and intelligent packaging systems for a modern society. Meat Science, 98 (3) (2014), pp. 404–419.

16. EFSA. Scientific opinion of the scientific committee. The potential risks arising from nanoscience and nanotechnologies on food and feed safety. EFSA J. 2009; 958:1–39.

17. J. Lee, Y. Lee, K. Jones, E. Sharek, M.A. Pascall. Antimicrobial packaging of raw beef, pork and turkey using silver-zeolite incorporated into the material. International Journal of Food Science & Technology, 46 (11) (2011), pp. 2382–2386.

18. Agapi I. Doulgeraki, Spiros Paramithiotis, George-John E. Nychas, Characterization of the Enterobacteriaceae community that developed during storage of minced beef under aerobic or modified atmosphere packaging conditions, International Journal of Food Microbiology, Volume 145, Issue 1, 31 January 2011, Pages 77-83.

19. J. Sahoo, N. Kumar. Quality of vacuum packaged muscle foods stored under frozen conditions: a review. Journal of Food Science and Technology, 42 (2005), pp. 209–213.

20. P.E. Strydom, M. Hope-Jones. Evaluation of three vacuum packaging methods for retail beef loin cuts. Meat Science, 98 (2014), pp. 689–694.

21. Sajid Maqsood, Nassra Ahmed Al Haddad, Priti Mudgil, Vacuum packaging as an effective strategy to retard off-odour development, microbial spoilage, protein degradation and retain sensory quality of camel meat, LWT - Food Science and Technology, Volume 72, October 2016, Pages 55-62, ISSN 0023-6438.

22. Weiss J, Takhistov P, Mcclements J. Functional materials in food nanotechnology. J Food Sci. 2006; 71:107–116.

23. Brody AL, Bugusu B, Han JH, Sand CK, Mchugh TH. Innovative food packaging solutions. J Food Sci. 2008; 73:107–116.

24. Silvestre C, Duraccio D, Cimmino S. Food packaging based on polymer nanomaterials. Prog Polym Sci. 2011; 36:1766–1782.

25. Picouet PA, Fernandez A, Realini CE, Lloret E. Influence of PA6 nanocomposite films on the stability of vacuum-aged beef loins during storage in modified atmospheres. Meat Sci. 2014;96:574–580.

26. de Azeredo HMC. Nanocomposites for food packaging applications. Food Res Int. 2009; 42:1240–1253.

27. Malhotra B, Keshwani A, Kharkwal H. Antimicrobial food packaging: potential and pitfalls. Frontiers in Microbiology. 2015; 6:611.

28. Fernández-Pan I, Carrión-Granda X, Maté JI, Antimicrobial efficiency of edible coatings on the preservation of chicken breast fillets, Food Control, Volume 36, Issue 1, February 2014, Pages 69-75.

29. Sánchez-Ortega I, García-Almendárez B, Santos-López E M et al. 2014. Antimicrobial Edible Films and Coatings for Meat and Meat Products Preservation. The Scientific World Journal, Volume 2014 (2014, page 1-18.

30. Ercolini D, Russo F, Torrieri E, Masi P, Villani F. Changes in the Spoilage-Related Microbiota of Beef during Refrigerated Storage under Different Packaging Conditions. Applied and Environmental Microbiology. 2006;72(7):4663-4671.

31. Kotov NA. Layer-by-layer assembly of nanoparticles and nanocolloids: intermolecular interactions, structure and materials perspective. In: Decher G, Schlenoff JB, editors. Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials. Wiley-VCH; Weinheim, Germany: 2003. pp. 207–243.

32. Weiss J, Gibis M, Schuh V, Salminen H. Advances in ingredient and processing systems for meat and meat products. Meat Sci. 2010; 86:196–213.

33. Gharibzahedi, S. M. T. and S. Mohammadnabi (2017). "Effect of novel bioactive edible coatings based on jujube gum and nettle oil-loaded nanoemulsions on the shelf-life of Beluga sturgeon fillets." International Journal of Biological Macromolecules 95: 769-777.

34. Marchiore, N. G., et al. (2017). "Migration evaluation of silver nanoparticles from antimicrobial edible coating to sausages." LWT - Food Science and Technology 76, Part B: 203-208.

35. M.C. Cruz-Romero, T. Murphy, M. Morris, E. Cummins, J.P. Kerry, Antimicrobial activity of chitosan, organic acids and nano-sized solubilisates for potential use in smart antimicrobially-active packaging for potential food applications, Food Control, Volume 34, Issue 2, December 2013, Pages 393-397.

36. Lok CN, Ho CM, Chen R, He QY, Yu WY, Sun H, Tam PK, Chiu JF, Che CM. Silver nanoparticles: partial oxidation and antibacterial activities. J Biol Inorg Chem. 2007; 12:527–534.

37. Fedotova AV, Snezhko AG, Sdobnikova OA, Samoilova LG, Smurova TA, Revina AA, Khailova EB. Packaging materials manufactured from natural polymers modified with silver nanoparticles. Int Polym Sci Technol. 2010; 37:59–64.

38. Duncan TV. Applications of nanotechnology in food packaging and food safety: Barrier materials, antimicrobials and sensors. J Colloid Interface Sci. 2011; 363:1–24.

39. Panea B, Ripoll G, González J, Fernández-Cuello A, Albertí P. Effect of nanocomposite packaging containing different proportions of ZnO and Ag on chicken breast meat quality. J Food Eng. 2013; 123:104–112.

40. Morones JR, Elechiguerra JL, Camacho A, Holt K, Kouri JB, Ramírez JT, Yacaman MJ. The bactericidal effect of silver nanoparticles. Nanotechnology. 2005; 16:2346–2353.

41. Kim JS, Kuk E, Yu KN, Kim JH, Park SJ, Lee HJ, Kim SH, Park YK, Park YH, Hwang CY, Kim YK, Lee YS, Jeong DH, Cho MH. Antimicrobial effects of silver nanoparticles. Nanomed Nanotechnol Biol Med. 2007; 3:95–101.

42. Althues H, Henle J, Kaskel S. Functional inorganic nanofillers for transparent polymers. Chem Soc Rev. 2007; 36:1454–1465.

43. Yam KL, Takhistov PT, Miltz J. Intelligent packaging: Concepts and applications. J Food Sci. 2005; 70:1–10.

44. NSI. Nanotechnology for sensors and sensors for Nanotechnology: Improving and protecting health, safety, and the environment. Nanotechnology Signature Initiative. Accessed on April 2017.

45. Mills A. Oxygen indicator and intelligent inks for packaging food. Chem Soc Rev. 2005; 34:1003–1011.

46. Villamizar R, Maroto A, Xavier RF, Inza I, Figueras M. Fast detection of Salmonella Infantis with carbon analytical nanotechnology for food analysis 17 nanotube field effect transistors. Biosens Bioelectron. 2008; 24:279–283.

47. Çubukçua M, Timurb S, Anik U. Examination of performance of glassy carbon paste electrode modified with gold nanoparticle and xanthine oxidase for xanthine and hypoxanthine detection. Talanta. 2007; 74:434–439.

48. Evans HM. Report of the national nanotechnology workshop, National Nanotechnolo-gical Initiative workshop. 2009. Nanotechnology enabled sensing; pp. 27–34.

49. Cockburn A, Bradford R, Buck N, Constable A, Edwards G, Haber B, Hepburn P, Howlett J, Kampers F, Klein C, Radomski M, Stamm H, Wijnhoven S, Wildeman T. Approaches to the safety assessment of

engineered nanomaterials (ENM) in food. Food Chem Toxicol. 2012; 50:2224–2242.

50. Akbarzadeh A, Rezaei-Sadabady R, Davaran S, Joo SW, Zarghami N, Hanifehpour Y, Samiei M, Kouhi M, Nejati-Koshki K. Liposome: classification, preparation, and applications. Nanoscale Res Lett. 2013; 8:102.

51. Bouwmeester H, Dekkers S, Noordam MY, Hagens WI, Bulder AS, de Heer C, Voorde TSE, Wijnhoven SW, Marvin HJ, Sips AJ. Review of health safety aspects of nanotechnologies in food production. Regul Toxicol Pharmacol. 2009; 53:52–62.

52. Underwood C, Eps AWV. Nanomedicine and veterinary science: The reality and the practicality. Vet J. 2012; 193:12–23.

53. Danhier F, Ansorena E, Silva JM, Coco R, Breton AL, Préat V. PLGA-based nanoparticles: An overview of biomedical applications. J. Control Release. 2012; 161:505–522.

54. Cushen M, Kerry J, Morris M, Cruz-Romero M, Cummins E. Nanotechnologies in the food industry – Recent developments, risks and regulation. Trends Food Sci Technol. 2012; 24:30–46.

55. Lovric J, Bazzi HS, Cuie Y, Fortin GRA, Winnik FM, Maysinger D. Differences in subcellular distribution and toxicity of green and red emitting CdTe quantum dots. J Mol Med. 2005;83:377–385.

Table 1: Selected Technique for packaging using nanotechnology

S.no	Type of technique used for packaging	Reference
1	Metallic nanoparticles in nanocomposite packaging	[36-39]
2	Metallic oxide nanoparticles in nanocomposite packaging	[40 -42
3	Nanodevice-combined polymers packaging	[43]
4	Nanotracers packaging	[44-48]
5	Nanosensors packaging	[22, 31, 48]

Table 2: Selected investigations on disadvantages of some nanomaterial used for packaging

Type investigation	**Disadvantages effect**	**Reference**
Skin toxicity	Skin cytotoxicity, genotoxicity and other influences may be induced by the use of some nanomaterials in food applications	[49, 50]
Acute toxicity	Acute oral toxic effects could be caused at elevated dosage levels with metallic nanoparticles such as zinc, titanium dioxides and copper.	[50-53]
Skin irritation	Bad skin irritation and other influences could be cause by some nanomaterials in food applications	[54]
Body Inflammation	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.	[55]
Genotoxicity		[49]