Non-Food Radiation Technology Applications of Food Commodities

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Abstract

At present food irradiation is considered an effective, broad-spectrum, residue-free, mature technology. Expertise in irradiation processing exists in a network of centers around the world, some of them in developing countries like Brazil and Argentina in the South American region. The use of renewable resources coming from crops products is becoming attractive also for non-food applications. In this sense, a complete new approach of higher aggregated value of some commodities like soy and maize, for example, is as renewable resources to create functional polymers, mainly for innovative biodegradable packaging solutions. There is a need of innovative approaches to produce edible/biodegradable materials from natural polymeric macromolecules with adequate properties. Incipient researches pointed to the successful use of irradiation processing to obtain or modify different types of biodegradable/edible plastic materials. This new radiation technology application is particularly important for countries that are leading producers of soybean and other commodities.

1. INTRODUCTION

At present food irradiation is considered an effective, broad-spectrum, residue-free, mature technology which can play an important role to ensure food safety in developed as well as developing countries. It controls insect infestation, inhibits the germination of root crops, and prolongs the shelf-life of perishable produce [1]. Although some questionable and polemic experiments about the possibility of fat food-borne radiolytic compounds might promote experimental colon carcinogenesis [2] overwhelming evidences indicate that irradiated foods are safe and effective [3][4][5].

International standards to ensure the safety of irradiated products and to facilitate trade have been recommended by the Codex Alimentarius Commission which is recognized by the World Trade Organization (WTO). Good Irradiation Practices (GIPs) for a broad range of applications have been developed and widely disseminated by the International Consultative Group on Food Irradiation (ICGFI). It was established under the aegis of the Food and Agriculture Organization

* Former Brazilian Contact Point to the International Consultative Group on Food Irradiation (1993-2001)

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of the United Nations (FAO), the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA) [6].

Expertise in irradiation processing exists in a network of centers around the world, some of them in developing countries like Brazil and Argentina in the South American region. In this sense, Brazil had since 2001 one of the most comprehensive regulations on irradiated food [7]. Despite the value of this technology to the food industry and to the health and welfare of the public, only minimal application of this technology occurs worldwide mainly for spices and other dry ingredients. This underscores the importance of increasing the public's understanding of radiation risks relative to other hazards as well as the need for professional assistance for consumers regarding food safety issues [8].

2. EDIBLE AND BIODEGRADABLE MATERIALS FROM AGRICULTURAL ORIGIN

A complete new approach of higher aggregated value of some commodities like soy and maize, for example, is as renewable resources to create functional polymers, mainly for innovative biodegradable packaging solutions. Certain newly discovered characteristics of natural biopolymers should make them a choice material to be used for different types of wrappings and films.

Edible and/or biodegradable packaging produced from agricultural origin macromolecules provide a supplementary and sometimes essential means to control physiological, microbiological, and physicochemical changes in food products [9] [10]. It should be stressed that the material characteristics (polysaccharide, protein, or lipid, plasticized or not, chemically modified or not, used alone or in combination) and the fabrication procedures (casting of a film-forming solution, thermoforming) must be adapted to each specific food product and usage condition (relative humidify, temperature).

With plastics rapidly assuming a major role over other materials in food packaging, enhancements of polymer technologies are inevitably generating greater influence over the protection of foods and beverages from maker to consumer and beyond. Biodegradable plastics degrade completely into compounds produced in nature by the action of microorganisms under composting conditions. Being environmental friendly, biodegradable packages can be submitted to biological treatment as part of the organic fraction of the solid waste as appropriate form of disposal altogether the traditional feedstock such as food scraps and vegetable and garden waste [11].

Numerous works are been published describing the increasing importance of plant-based plastics that in addition of their bio degradability, they also presented other attributes like flexibility and flame-proof qualities.

The manufacture of edible/biodegradable films or coating can potentially add value to soy protein [12]. An study conducted to determine the effect of sodium dodecyl sulfate (SDS) on selected physical properties of glycerin-plasticized soy protein isolated films (SPI) showed that the SDS improved the water vapor barrier ability and the extendibility of SPI films, both desirable attributes when assessing the potential of such films for packaging applications [13]. Authors had reported that there is a close relationship between the conformation of the protein and the mechanical properties of films formed from soybean protein [14].

Biodegradable packaging material based on cereal starch can be processed by using extrusion technology [15]. Corn by-product had been reported that functions as biodegradable packaging material [16]. Edible proteins obtained from maize are becoming the object of important studies [17]. As modified atmosphere packaging (MAP) is increasingly used with minimally processed produce, increased MAP usage creates a need for biodegradable films. Zein films plasticized with oleic acid had been proposed for biodegradable packaging applications [18][19].

Blends of starch with ethylene vinyl alcohol copolymers were described for use in biodegradable packaging [20].

A process for the preparation of lipoprotein and protein films from glandless and glanded cottonseed flour (delipidated or not) was described. Chemical modifications of cottonseed proteins by gossypol, formaldehyde, and glutaraldehyde were used to increase puncture strength and decrease solubility of the films within the scope of biodegradable packaging applications. Promising results were obtained with glandless flour [21].

2.1. Radiation-Technology for the Fabrication of Biodegradable Polymers

Biopolymer mixtures and complexes have application in the food industry, as packaging materials and pharmaceutical coatings. There is a continuing need to modify the properties of these materials for enhanced and novel applications. Electrochemical synthesis of anionic polysaccharide-protein complexes had been reported [22]. In a similar way, a gamma radiation novel method for the fabrication of gelatin-carragenan complexes was described [23].

A Canadian research group works with the use of irradiation to obtain edible coatings for fruits [24]. An Argentinean group published the use of gamma irradiation on the preparation of biodegradable plastic made from soy proteins isolate [25] and bean products [26]. On the other hand radiation crosslinking of natural polymers had resulted in the production of biodegradable plastics. A Japanese group described the effects of high-energy radiation on sodium carboxymethylcellulose and carboxymethylstarch and concluded that hydrogels of biodegradable cellulose derivatives were obtained [27].

Irradiation was also described to provide a quick and simple way to modify the physical, chemical and pharmaceutical properties of biopolymers such as starch, providing higher disintegration times of tablets [28].

3. CONCLUSIONS

There is an intense research for making the biodegradable plastic material. Some naturally occurring plastic materials have been made use of by man from the earliest times. Also, man-made plastic materials have been used ever since first polymers were fabricated. In order to turn biodegradables economically viable alternatives to synthetic polymers, innovative strategies to lower material costs will have to be employed. Many major chemical companies are becoming increasingly interested in developing technologies for the manufacturing of products from crops. So, if used wisely, ionizing radiation can be a useful tool for creating new plastic materials as well as to modifying already known natural edible/biodegradable polymers in order to obtain better specific properties.

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REFERENCES

1. ICGFI, "*Facts about Food Irradiation*", International Consultative Group on Food Irradiation, IAEA, Vienna, 46p., 1999.
2. Raul, F.; Gosse, F.; Delincee, H.; Hartwig, A.; Marchioni, E.; Miesch, M.; Werner, D., "Food-borne radiolytic compounds (2-alkylcyclobutanones) may promote experimental colon carcinogenesis", *Nutrition and Cancer – An International Journal*, **44** (2), p. 188-191 (2002).
3. Loaharanu, P., "Rising Calls for Food Safety. Radiation Technology Becomes a Timely Answer". *IAEA Bulletin*, **43**, p.37-42 (2001).
4. Young, A.L., "Food Irradiation. After 35 years, have we made progress: A government perspective", *Environmental Science and Pollution Research*, **10** (2), p. 82-88 (2003).
5. Michal, R., "Irradiated food, good; foodborne pathogens, bad". *Nuclear News*, p. 62-71 (2003).
6. ICGFI, "International Consultative Group on Food Irradiation", http://www.iaea.org/icgfi.
7. Brazil, Ministry of Agriculture. Decree n.21, January 26th, 2001, about Technical Regulation for Irradiated Foods, *Diario Oficial da União*, Brasilia, January 29th, 2001 Section I, p.35 (2001).
8. Wilcock, A.; Pun, M.; Khanona, J.; Aung, M., "Consumer attitudes, knowledge and behaviour: a review of food safety issues", *Trends in Food Science & Technology*, **15** (2), p. 56-66 (2004).
9. Guilbert S.; Gontard, N.; Gorris, L.G.M., "Prolongation of the shelf-life of perishable food products using biodegradable films and coatings", *Food Science and Technology-Lebensmittel-Wissenschaft & Technologie*, **29** (1-2), p. 10-17 (1996).
10. Guilbert, S.; Cuq, B.; Gontard, N., "Recent innovations in edible and/or biodegradable packaging materials", *Food Additives and Contaminants*, **14** (6-7), p. 741-751, (1997).
11. Degli-Innocenti, F.; Bastioli, C., "Definition of compostability criteria for packaging: Initiatives in Italy", *Journal of Environmental Polymer Degradation*, **5** (4), p. 183-189, (1997).
12. Park, S.K.; Bae, D.H.; Rhee, K.C., "Soy protein biopolymers cross-linked with glutaraldehyde", *Journal of the American Oil Chemists Society*, **77** (8), p. 879-883 (2000).
13. Rhim, J.W.; Gennadios, A.; Weller, C.L.; Hanna, M.A., "Sodium dodecyl sulfate treatment improves properties of cast films from soy protein isolate", *Industrial Crops and Products*, **15** (3), p. 199-205 (2002).

14. Subirade, M.; Kelly, I.; Gueguen, J.; Pezolet, M., "Molecular basis of film formation from a soybean protein: comparison between the conformation of glycinin in aqueous solution and in films", *International Journal of Biological Macromolecules*, **23** (4), p. 241-249 (1998).
15. Riaz, M.N., "Processing biodegradable packaging material from starches using extrusion technology", *Cereal Foods World*, **44** (10), p. 705-709, (1999).
16. Anon., "Corn by-product functions as biodegradable packaging material", *Materials Research Society Bulletin*, Warrendale, **22** (6), p. 5-6, (1997).
17. Lai, H.M.; Padua, G.W., "Properties and microstructure of plasticized zein films". *Cereal Chemistry,* **74** (6), p. 771-775, (1997).
18. Rakotonirainy A.M.; Wang Q.; Padua G.W., "Evaluation of zein films as modified atmosphere packaging for fresh broccoli", *Journal of Food Science*, **66** (8), p. 1108-1111, (2001).
19. Rakotonirainy, A.M.; Padua, G.W., "Effects of lamination and coating with drying oils on tensile and barrier properties of zein films", *Journal of Agricultural and Food Chemistry*, **49** (6), p. 2860-2863, (2001).
20. Nobes, G.A.R.; Orts, W.J.; Glenn, G.M.; Gray, G.M.; Harper, M.V., "Blends of starch with ethylene vinyl alcohol copolymers for use in biodegradable packaging", *Abstracts of Papers of the American Chemical Society*, 222, p. 98-IEC , Part 1, (2001).
21. Marquie, C.; Aymard, C.; Cuq, J.L.; Guilbert, S., "Biodegradable Packaging Made from Cottonseed Flour. Formation and Improvement by Chemical Treatments with Gossypol, Formaldehyde, and Glutaraldehyde", *Journal of Agricultural and Food Chemistry*, **43** (10) p. 2762-2767, (1995).
22. Zaleska, H.; Ring, S.; Tomasik, P., "Electrosynthesis of potato starch-whey protein complexes", *Carbohydrate Polymers*, **45**, p. 89-94 (2001).
23. Vieira, F.F.; Aliste, A.J.; Del Mastro, N.L., "Radiation novel method for the fabrication of gelatin-carrageenan complexes", *Proceedings of The Industrial Applications of BioPlastics 2002,* Central Science Laboratory, York, United Kingdom, 3-5 February, 2002, Proceeding of...
24. Vachon, C.; D'Aprano, G.; Lacroix, M.; Letendre, M., "Effect of edible coating process and irradiation treatment of strawberry (Fragaria spp) on storage-keping quality", *Journal of Food Science,* **68** (2), p. 608-612 (2003).
25. Salmoral, E.M.; Gonzalez, M.E; Mariscal, M.P.; Medina, L.F., "Comparison of chikpea and soy protein isolate and whole flour as biodegradable plastics", *Industrial Crops and Products,* **11**, p. 227-236 (2000)a.
26. Salmoral, E.M.; Gonzalez, M.E.; Mariscal, M.P., "Biodegradable plastic made from bean products", *Industrial Crops and Products*, **11**, p. 217-225 (2000)b.
27. Wach, R.A.; Mitomo, H.; Yoshii, F.; Kume, T., "Hydrogel of biodegradable cellulose derivatives. II . Effect of some factors on radiation-induced crosslinking of CMC", *Journal of Applied Polymer Science*, **81** (12), p. 3030-3037 (2001).
28. De Kerf, M.; Mondelaers, W.; Lahorte, P.; Vervaet, C.; Remon, J.P., "Characterization and desintegration properties of irradiated starch", *International Journal of Pharmaceutics*, **221** (1-2), p. 69-76 (2001).