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Possible improvement of Biopolymer based Packaging Film

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ABSTRACT
Packaging materials has become an essential component in the present era of marketing. Although cheaper materials are abundantly available, research is heading towards green alternative of the same with comparable characteristics. Biopolymers are tried alone and in combination to improve their properties gradually. Improvement in the same is also possible through introduction of active ingredients. Moreover, extrusion processing is the way forward for proper blending of ingredients and to increasing throughput with critical control of its parameters.

Packaging is the method of protecting products in an enclosure for their safe storage, transport and use. It performs the function of containment, protection, handling, preservation, information, transmission and marketing. Polyethylene, PVC, PVOH, nylon and some other polymers are being used as synthetic polymers for packaging. Their application for different purposes depend upon the characteristics viz. tensile strength, elongation at break, puncture strength, water vapor transmission rate (WVTR), gas transmission rate, heat seal strength and antioxidant activity etc. However, biodegradable, edible and non-toxic biopolymers have become the demand of present era as green technology. Proteins, polysaccharides, lipids and resins are generally used as film forming substance. But their limitations are poor mechanical and barrier properties with limited shelf life of stored produce. Incorporation of active ingredients has also enlarged functional area of packaging. Thus, biopolymer based packaging film has been studied in terms of their characteristics of packaging materials, application of biopolymers for film formation, active packaging and extrusion processing.

Characteristics of packaging materials

Mechanical properties: Mechanical properties include tensile strength, elongation at break and puncture strength etc. Tensile strength is resistant to rupture when pulled from opposite sides, used for durability of the film and expressed as N/ m^2. Elongation at break is the capacity of film to resist change in shape before breakage. It is determined as the ratio of change in length to original length of the film. Puncture strength is the minimum force required to cause penetration in the film.

Water Vapor Transmission Rate: WVTR is the rate at which moisture passes through unit area of a film in 24h and expressed in g/m^2/day. It is important for maintaining the shelf life of food. Films having good barrier properties have low WVTR which keeps the moisture level within safe limit.

Gas Transmission Rate: It is the rate of gas passing through unit area of the film in 24h at specific relative humidity and temperature conditions and denoted as cm^3/ m^2/ day.

Heat seal strength: Heat seal strength is measured as force required for failure of heat seal. Heat sealing is important for maintaining the integrity and shelf life of the package.

Application of biopolymers: Biopolymer based packaging films are gaining interest for food applications as green alternative of plastic materials. It includes materials based on protein, starch or lipid. Application of single biopolymer film is limited because of poor properties. However, polymer-polymer interactions could improve the structures by introducing predominantly charge interactions rather than hydrogen bonding. Some of the suitable biopolymers are:

Chitosan: Chitin is a biopolymer which can be found in fungal cell walls and exoskeleton of crustaceans. Chitosan is obtained by de-acetylation of chitin and degree of the process predicts its nature. Chitosan (N-acetyl-D-glucosamine) is the second most widespread amino polysaccharide after cellulose. Food and drug administration also recommended it to be consumed with food as GRAS i.e. Generally Recognized As Safe. Chitosan is helpful in improving the antimicrobial effect with tensile and barrier properties. It has selective permeability to gases and high water vapour permeability. Improvement in chitosan films is possible by increasing the hydrophobic groups. Other processes include ultrasonic treatment and addition of cross-linking agents.

Due to its polycyclic nature chitosan shows antifungal and antimicrobial properties. Other important characteristics include haemostatic, anti-tumour and wound healing activity.

Carboxymethyl cellulose (CMC): CMC is a biopolymer derived from cellulose. It is a copolymer of β-D-glucose and β-D-glucopyranose 2-O-(carboxymethyl)-monosodium salt which are connected via b-1, 4-glycosidic bonds. CMC also have GRAS status for uses in food and pharmaceutical industry. Preliminary studies with 1% CMC showed that it had excellent film forming properties. However, formed films are of weak mechanical properties, which can further be improved by blending with other polymers.

Gelatin: Gelatin is protein based biopolymer with three dimensional structure and functional properties. It is an odourless, water soluble protein, which does not produce harmful by-products upon enzymatic degradation. Collagen obtained mainly from skin, bones and tendons of animals produces gelatine through partial hydrolysis. It develops film with poor mechanical strength and high water permeability. The properties are supposed to be improved by developing its nano-composite with nanoclays, nano-metals and organic fillers such as nanosilver, zinc oxide nano-particles, nano-copper and titanium dioxide nano-particles. These films show good mechanical properties along with antioxidant, antimicrobial and UV protection property.

Pectin: Pectin is a hetero polysaccharide found in cell walls of plants. Its commercial extraction is practiced from peels of citrus, mango, apple, watermelon, sugar beets etc. Its hydrophilic nature and presence of divalent cations causes formation of gel. This property makes it suitable to be used as stabilizing agent, gelling agent and thickener in varying food. It is also utilized as packaging material due to its biodegradable nature. Pectin based films are non-toxic, edible and have good biocompatibility. However, poor mechanical strength and high water permeability of pectin films are improved by blending with other biopolymers and fillers.

Starch: Starch films have been made using different plasticizers such as glycerol, sorbitol or xylitol. Starch from different plant sources such as corn, cassava, oat and pea etc. have been isolated and used for packaging film formation. The oxygen permeability of starch films varies inversely with the moisture content. Oxygen permeability of starch films can be decreased by using sorbitol. This interaction between starch and plasticizer is very specific.

Active packaging: Active packaging is an innovative food packaging concept that combines advances in food technology, food safety, packaging and material sciences in an effort to satisfy consumer demand for fresh-like, safe products. Active packaging remains an on-going development in food preservation technologies. It aims at development of products with improved shelf-life, safety and sensorial qualities. Apart from acting as selective barriers for moisture, gas and solute migration, active films operate as carriers of many functional ingredients such as antioxidants, antimicrobial and flavouring agents. When applied, antimicrobial packaging materials can effectively control microbial contamination of solid or semi-solid food products by inhibiting the growth of spoilage and pathogenic microorganisms on the surface of food products. Incorporation of antimicrobial compounds into films decreases diffusion rate as compared to the same, while spraying the antimicrobial agents on the surface of food system. There have been consumer demands for more natural preservatives, mainly because of safety concerns as residual chemicals in synthetic preservatives might be hazardous. In this context, use of essential oils and plant extracts in the packaging film imparts antioxidant and antimicrobial properties to improve safety and shelf life. Some of the active ingredients are mentioned here under:

Clove oil: Clove oil is a natural preservative and flavouring substance inhibiting growth of bacteria and moulds without harm. Essential oils are most commonly extracted through hydro distillation because of its non-toxic and non-explosive nature. Fatty acid ethyl esters are green alternative to the solvents because of amphipathic property with biodegradability, non-toxicity and non-irritability.

Thymus essential oil: Thymus essential oils and extracts with antimicrobial and antioxidant properties are widely used in pharmaceutical, cosmetic, herbal tea, flavouring agents and perfume industry along with its uses for flavouring and preservation of foods. Direct addition of essential oils to the food may affect sensory characteristics, so addition of essential oils to edible packaging instead can help imparting food safety and shelf life enhancing properties. Chitosan based edible films containing mild odor thyme essential oil may be an innovative preservation technique to extend the shelf life

of ready to eat meat products to replace the use of artificial chemical preservation agents.

Extrusion processing: Extrusion is the method commonly used to produce conventional packaging materials due to high throughput, proper mixing of ingredients and energy efficiency. It is helpful especially when more concentrated film solutions are fed and requires minimal space compared to the traditional method. However, this technology is yet facing challenges in manufacturing packaging materials of bio-plastics. However, production of biodegradable films is possible through optimizing and controlling its parameters viz. screw speed, temperature, feeding rate and screw configuration critically. Even small variations in processing parameters can result in the production of totally different product.

Conclusions: Biopolymers such as chitosan, pectin, gelatin, and starch and carboxymethyl cellulose are promising materials for development of packaging films. The moisture and gas barrier properties of these films depend on their structure. Generally, biopolymer films show less mechanical strength and less barrier properties. Incorporation of organic filler materials and nanoclays etc. improves the mechanical properties of the films. Addition of essential oil and bioactive extracts are meant for active packaging. Such materials will improve the antimicrobial and antifungal properties with shelf life extension. Apart from these, extrusion processing is significantly used to improve the properties of packaging films.