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Edible Packaging: Composition, Shelf Life and Safety

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Abstract: Packaging today plays and important role in the quality of food products by providing protection from environmental, chemical and physical challenges. Edible food packaging is a type of packaging that is designed to be eaten or has the ability to biodegrade efficiently like the food that it contains. There are two of edible packaging that is edible films and edible coatings. Edible films have become widely used for a variety it could contribute to the reduction of environmental pollution. The use of edible packaging material has a short history. The development of food packaging has evolved as man's lifestyle has changed. Edible packaging have been used for centuries in food industries to preserve food product, that is not a new preservation technique. Protein based films or coatings were developed from different products, they exhibit properties like increase in tensile strength, flexibility, flavourless, transparency, good oxygen barriers and also can control bacterial growth. The biodegradability test proved that the films are biodegradable in natural environmental conditions. Polysaccharides films or coatings are developed from different products, they exhibit some properties like improvement of solubility, strong tensile strength, permeability, elongation break, flexibility, permeability of oxygen and water vapour, and also it decreased some properties by adding some products into polysaccharides like it decreased water vapour permeability and transparency. Lipids films or coatings are developed from different products, they exhibit some properties like improved flexibility, smooth, increase film permeability, elongation towards gas, water and soluble substance. Lipid coating packaging are retardation of water loss and dehydration, and also can control respiration rate, transpiration rate and binding of ethylene biosynthesis process, and also adding some products to lipids has decreased its tensile strength. Antioxidants are added to edible packaging materials to delay the rate of oxidation reactions. Antimicrobial agents to enhance the shelf of food products. Edible packaging using different materials like proteins, polysaccharides and lipids have shown safety useage of edible packaging.

***Keywords*: Biodegradeble, Edible films, Biopolymers, Tensile strength, Gelatin.**

I. INTRODUCTION

Edible food packaging is a type of packaging that is designed to be eaten or has the ability to biodegrade efficiently like the food that it contains. This type of packaging comes in many forms and is constantly being improved and innovated to be made from many different types of substances.[1]

Packaging today plays an important role in the quality of food products by providing protection from environmental, chemical, and physical challenges.[2]

A package has three important tasks: to protect the contents, to give good marketing to a product, and to deliver useful information to the customer. A fourth purpose is related to advertisement because easy to use packaging increases market opportunities. Edible films have become widely used for a variety of different products and different food categories such as meat products, vegetables or dairy products.[5] These thin layers of edible substances are created between food parts or on the surface. They have different properties, from controlling oxygen, carbon dioxide, taste and aroma between other food parts or the surrounding atmosphere to the capability of carrying a various array of food additives as preservatives, antimicrobial agents and antioxidants. They could offer all these functional properties as a packaging material if they are prepared in the correct way.[5]

Edible coatings are defined as a thin layer of edible material applied directly to the surface of food, usually by immersion or aspersion, while edible films are pre-formed in molds, dried and applied to food. The purpose of the use of films and coatings is to inhibit the migration of moisture, oxygen, carbon dioxide, flavours, and lipids, and carry food ingredients (antioxidants, antimicrobial agents, flavourings), and/or improve the mechanical and handling characteristics of the product. In some cases, the films and edible/biodegradable coatings can replace synthetic packaging.[7]

Development of edible and biodegradable films using natural biopolymers such as proteins, polysaccharides and lipids could also be useful in alleviating the landfill burden by replacing synthetic non-biodegradable packaging in some applications.[8]

II. HISTORY

The use of edible packaging material has a short history.[3] The development of food packaging has evolved as man's lifestyle has changed. For a very long period of time, people simply ate what they could gather in their immediate surroundings. As people shifted from a nomadic lifestyle to staying in a sheltered area, the need arose for containers to store food.[2] As an example of edible films, yuba (soy-milk skin) has been traditionally used in Asian countries since the fifteenth century. Wax coatings were applied to citrus fruits in the twelfth and thirteenth centuries, but only commercially utilized on apples and pears as recently as the 1930s. Wax coatings reduce moisture loss and slow down the respiration of coated fruits and vegetables, resulting in shelflife extension. Various waxes have been sprayed on the surface of fruits and vegetables as forms of hot-melt wax or emulsions. Lipid coatings (larding) on meats and cheeses have been used since the Middle Ages for shrinkage prevention.[3]

The use of edible packaging goes back to the 12th century where, in China, wax was used in citrus fruits to prevent moisture loss and to promote a shiny surface. This type of packaging can be produced from bioproducts, e.g., polysaccharides, proteins, lipids or bio composites, that are biodegradable, biocompatible and recyclable and of renewable origin. [4] Other 20th-century packaging developments such as packages incorporating antimicrobials and oxygen scavengers established new precedents for prolonging shelf life and protecting food from environmental influences.[13]

Edible Packaging have been used for centuries in food industries to preserve food product, this is not a new preservation technique. • For example, waxing on fruit and vegetables and cellulose coating in meat casings. Edible coatings have been used since twelth century in China. • It was not until 1922 the waxing on fruits was invented and first time was commercially applied on fruits and vegetables.[19]

III. COMPOSITION EDIBLE PACKAGING

One major safety and quality function of packaging is to act as a barrier between the food and the environment by preventing direct physical contact. Packaging constitutes both flexible and rigid materials, alone or in combination with other preservation methods, to offer the necessary barrier, inactivation, and containment properties required for successful food packaging.[11]

Besides synthetically derived packaging materials mentioned above, flexible packaging can encompass the use of edible films, gels, or coatings made from polysaccharides, proteins, lipids, or composites of any or all three.[11]

Polysaccharides may include cellulose derivatives; starches and their derivatives; seaweed extracts such as carageenan and alginates; pectinates; and chitosan. Protein film formers include collagen, gelatin, whey protein, corn zein, soy protein, and wheat gluten.[12] Edible lipids include waxes, triglycerides, shellac, acetylated monoglycerides, fatty acids, fatty acid alcohols, and sucrose fatty acid esters. Lipid materials are not generally polymers and so cannot form standalone films.[12] Contrarily, films composed of lipids (waxes, lipids or derivatives) provide good water vapor barrier properties, yet they are non-transparent, inflexible and prone to rancidity. There are two types of edible packaging, films, and coatings. The difference between the two is that films are first formed separately and then applied to the food product, while coatings are formed and applied directly to the food. They can be superficial coatings or layers between compartments of the same food product. [20] Polysaccharides, proteins, and lipids are biopolymers used to fabricate edible films or coatings as packaging. While the polysaccharide (starch and derivatives, gums, etc.) and proteins (gelatin, gluten, etc.) [20]

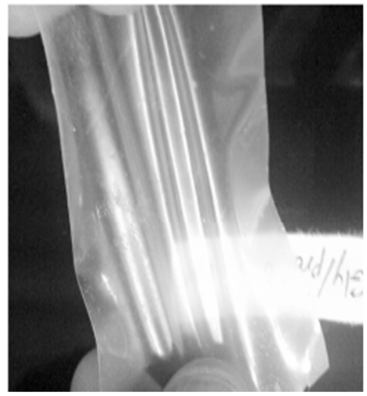
Polysaccharides are characterized by poor gas and water barrier properties, usually acting as sacrificing agents for moisture loss.[23] Proteins are known for their ability to form film, similar to that of polysaccharides with excellent mechanical and barrier properties, although they make poor water vapor barriers. [23]

A. *Protein Based*

Hydrocolloid used in making edible film is protein or polysaccharide. Protein can be derived from corn, soybean, wheat, gluten, casein, collagen, gelatin, corn zein, milk protein and fish protein. [6]

Protein-based films treated with ultrasound have lower water-vapor permeability than the films treated with heat.[5] Incorporation of lipid into protein films resulted in lower tensile strength at break, indicating that they became weaker and non-homogeneous.[8] The protein-based films are powerful oxygen blockers that help prevent food spoilage. When used in packaging, they could prevent food waste during distribution along the food chain.[9] All soy films with the addition of these modified starches demonstrated low values of tensile strength, elongation at break and they were opaque and homogenous.[18] Edible film of soy protein is more flexible than other protein films from plant sources.[32]

Milk protein based films have good mechanical properties, and act as excellent barriers to lipid, oxygen and aromas.[7] Milk protein forms flexible, flavourless and transparent films.[32] The milk-based packaging, however, has smaller pores and can thus create a tighter network that keeps oxygen out.[9] They made some improvements by incorporating citrus pectin into the blend to make the packaging even stronger, as well as more resistant to humidity and high temperatures.[9] After a few additional improvements, but it is less stretchy and is better at blocking oxygen. [9] The incorporation of different amounts of Mesquite gum (MG) on the whey protein isolate (WPI) allowed us to obtain composite films with improved flexibility without increasing plasticizer content and consequently without affecting negatively others characteristics such as water vapor permeability.[51]



There are different types of proteins such as the plant-derived proteins from corn, wheat and soy, etc., and animal-derived proteins such as collagen, keratin, casein and gelatin [5]. In refrigerated chicken breast meat the growth of bacteria responsible for spoilage has been controlled by a whey protein coating incorporated with oregano essential oil.[5]

Milk proteins have the ability to form malleable, transparent and tasteless films. Milk proteins are classified as caseins and whey proteins. Caseins can form films which are stable at different pH, temperature and salt levels.[5] Interesting results showed that whey-based films can be formed with excellent water permeability and good flexibility if almond oil is incorporated into the film formation matrix [5].

Another animal protein, frequently used in (edible) food packages is gelatin, obtained from the hydrolysis of collagen. Gelatin film increases the hydrophobicity even more, antioxidant activity—as was expected—but also better mechanical and water resistance.[5]

Egg white-based film is more resistant to breakage, to heat and to oxygen, and showed similar transparency, lightness and color [5].

When adding plant extracts or plant by products into protein-based food packages, an increased bacterial protection can be registered due to the presence of phenolic compounds. The main protein found in corn is zein [5]. By adding sugar plasticizers into zein films, the hydrophobicity can be enhanced. [5]

Bitter vetch protein films but with spermidine, without or with a low quantity of glycerol and it was demonstrated that, by increasing the plasticizer amount, the tensile strength was gradually reduced.[5]

Regarding the biodegradability, protein-based food packages are among the most feasible ones [5]. The inclusion of different components like natural antioxidants improves the antioxidant properties or strengthens the protein networks.[5]

Thermal degradation denatures whey protein, resulting in a more cohesive and stronger film than native proteins.[23] Gluten-based film Frequency (24 Hz) for 3–12 min, enhanced protein dispersion and the appearance of film.[26] The protein yellow pea protein isolate and yellow pea protein concentrate (YPI and YPC) films formed in this study had high water absorption capacity and solubility index due to the existence of carboxyl and hydroxyl groups in proteins.[47]

Gelatin-based films: flexible, clear, with good oxygen barrier properties, but poor moisture resistance; Classical formulations: 20-30 % gelatin, 10-30 % plasticizer and water.[25]

Gelatin and sodium caseinate were associated with the highest protective effect against osmotic and heat stress induced injuries during drying especially in the rice based films.[41]

The gelatin films presented good mechanical properties, with high elongation at break and showed low water vapor permeability and consequently can be applied in dry foods. The films exhibited intermediate solubility in water and good absorption of ultraviolet radiation, which could provide increased protection to packaged food. The biodegradability test proved that the films are biodegradable in natural environmental conditions.[65]

B. Polysaccharides Based

Polysaccharide used is cellulose and derivatives, starch and its derivatives, pectin, seaweed extract (alginate, carrageenan, order), gum (gum arabic and karaya gun), xanthan gum, chitosan and others. [6]

Edible biodegradable films were developed from corn starch 80:20 "waxy":regular "native" and modified starch had highest hydrophilic properties which increased its thickness, permeability and solubility, and with mayor stability in acidic and alkaline medium.[14] Microcrystalline cellulose on the properties of starch-based composite films of improved cassava varieties. MCC (0–30 %) has improved the properties of starch-based films of improved cassava varieties by increasing their strength and rigidity and reducing water vapour permeability and water content.[15] Rice starch dual modified (hydroxypropylated- crosslinking) produce films with strong tensile strength, elongation at break and solubility, while the transparency value decreased, as function of increment of concentration of the propylene oxide.[18] High hydrostatic pressure processing (HPP) for starch gelatinization was used for the preparation of the films instead of thermal processing (TP), and the results indicate that HPP can improve the physical property, water resistance, and thermal stability of the films compared to the films prepared using TP regardless of the starch type.[27] Starch- based films have some drawbacks, such as high hydrophyilicity and retrogradation, which make it undesirable for some applications.[27] Edible coatings are made from starch canna has the highest solubility.[29] The addition of sorbitol on starch-based edible coating solution is able to improve the flexibility of the film, mechanical properties, the permeability of oxygen and water vapor.[29] Highly water-starch and its film properties are heavily dependent on moisture content and also have relatively poor mechanical properties. Its films are very fragile and resistant to oxygen permeation.[35] Starch-based films with cellulose fibers showed increased tensile strength and lower water vapor permeability.[39] Gellan gum had a good effect in improving the film-forming, since composite film which was composed of the gellan gum and cassava starch had a relatively good mechanical properties and barrier properties.[43]Pea starch (PS) films were strong and elastic and possessed a good barrier property and physical integrity. High-amylose rice starch (RS) films showed similar properties at low Relative humidities (RHs) but they were weaker and more stretchable than PS film. Both films loosen their oxygen barrier properties slightly with increasing RH.[68]

Polysaccharide-based films have desirable gas barrier properties and also have the ability to adhere to the surface of fruits or vegetables. On the other hand, the hydrophilicity of these films contributes to increase the water permeability.[42]

At concentrations above 30%, there was an increase in water vapor permeability due to the presence of agglomerated blackberry powder particles. Films incorporated with blackberry powder by sprinkling had higher antioxidant capacity and were more soluble in water, showing great potential to be used as a vehicle for releasing bioactive compounds into the surroundings.[16] Films from cross linked yam starch tend to be permeable to water vapor, due to their hydrophilic characteristics.[18] Buckwheat and tapioca starch film Improvement of physical properties, water resistance and thermal properties of film [27]

FOSs (fructo oligosaccharides) from a fermentation process by Bacillus subtillis natto and we employed the bacterial FOSs as a functional ingredient in edible cassava starch films. All formulations resulted in films with good appearance, easily removable from the plates without bubbles or cracks. The addition of FOSs resulted in higher solubility and elongation and decreased the water vapor permeability of films, thus proving FOSs to be a promising ingredient for use in edible starch films. [17] Cellulose such as carboxymethylcellulose (CMC), hydroxypropyl-cellulose (HPC), and hydroxy propyl methyl cellulose (HPMC) are water soluble and are good film formers. They are capable of yielding tough-flexible and transparent films owing to linear structure of the polymer backbone.[21]

Pectin coatings have been investigated for their ability to retard moisture loss and lipid migration and improve handling and appearance of food.[21] The pectin film showed the lowest: (1) water vapor permeability, (2) thickness, (3) water solubility, (4) tensile strength and (5) elongation. On frying, it showed the shortest time to change its color and size and the final color of the film after the contact time in both palm olein and palm stearin was black.[22]

Chitosan based films have proven to be very effective in food preservation.[21] The chitosan coating with ultraviolet ray were applied for the preservation of jujube during storage.[26] Rice protein hydrolysates RPH/ CS chitosan edible composite films exhibited excellent properties after ultrasound treatment with higher elongation at break and oxygen barrier, desirable tensile strength and water vapor permeability.[45]All of these three kinds of polysaccharides showed good film-forming properties, chitosan film was much more flexible than the others and the carboxymethyl chitosan (CMCH) film was the toughest one while the pullulan film showed the best water barrier property and water solubility.[53]Chitosan was more effective in the coating solution than in the film matrix. The addition of chitosan to a starch matrix produced less water vapor permeation and reduced solubility of the films in water.[58]

The alginate film presented the greatest tensile strength and elongation and the smallest oxygen permeability, the alginate film would be the most indicated for use a coating for sweet potato chips, since it presented the greatest tensile strength and elongation, guaranteeing that the coating would cover the material uniformly =, with less chance rupturing during processing.[22] Rheological properties of pullulan, sodium alginate and blend film forming solutions were investigated. In diluted solution, pullulan chains behaved as a typical random coil, however, sodium alginate chains tended to adopt an extended configuration.[52] The incorporation of cellulose whiskers to alginate-acerola puree films improved their water vapor barrier, as well as tensile strength and modulus, indicating that the whiskers improve the film applicability as edible packaging.[49]

Seaweed-based biopolymers such as carrageenans and alginates are among the most important biopolymers, the protective barrier of edible film can be formulated to prevent the transfer of moisture, gases, flavor.[24]

Amylose-based films: coherent, relatively strong, free-standing films; Amylopectin-based films: brittle and non-continuous.[25] Arabic gum solutions present good adherence properties and form film upon drying. Film barrier properties are improved by substituting 30 % of gluten by keratin.[25] Mesquite gum may be considered as a suitable structural support for preparing emulsions films.[59]

C. *LIPID Based*

Fat commonly used are natural wax (beeswax, carnauba wax, parrafin wax), acyl glycerol, fatty acids (oleic acid and lauric acid), and emulsifier. Composites are materials based on a mixture of hydrocolloids and lipids. In making edible film, is used polysaccharides as hydrocolloid. [4]

Adding glycerol to banana peel can make film characteristic more flexible, smooth, increase film permeability toward gas, water, and soluble substance.[5] Use of lipid coatings also reduces surface abrasion during handling of fresh fruit. Lipid materials offer many advantages for coating foods. The benefits offered by lipid-derived coatings are most notably in the area of retardation of water loss and dehydration.[21] Beeswax is relatively flexible and presents a viscoelastic behaviour.[25]

Higher glycerol concentrations in the chia mucilage (CM) films increased their elongation, and decreased their tensile strength.[48] Chia mucilage (CM) films exhibited high solubility in water, good thermal resistance, transparency, and UV light barrier properties, which could provide increased protection to packaged food. CM films have potential as edible film or coating, with the health benefits of CM soluble dietary fiber.[48] Hydrocolloids are used as a support matrix since they show excellent film-forming ability, good mechanical properties and selective permeability to gases.[61]

Edible moisture barriers usually include lipids. Because of their apolar nature, these hydrophobic substances are capable of forming a water-impervious structure and reduce efficiently the water transfer.[25]

Aceto-stearin films have oxidative stability, especially if derived from hydrogenated vegetable oils, while aceto-olein films are less resistant to oxidation.[25] Lipid films, on the other hand, are resistant to moisture loss.[26] Lipids show strong water barrier properties but poor mechanical properties. The film properties, such as film solubility, water vapour barrier properties and mechanical properties, were found to be improved with the increase of olive oil concentrations. [28] The edible film made up of lipids provides gloss, reduction in moisture loss and reduced cost.[32] Waxes are useful on edible films or coatings for efficiency reducing moisture permeability for high hydrophobicity.[37] Stearic acid incorporation weakly increased film thickness, but the difference was not statistically significant ($p < 0.05$). Addition of 15% stearic-palmitic acid improved the film water vapor barrier by 13%.[30]

Edible coating of fruits with pure coconut oil has gaining interest for its anti-ageing properties by controlling respiration rate, transpiration rate and binding of the ethylene biosynthesis process. Physical, chemical and sensory parameters proved that coconut oil-beeswax (90:10 and 80:20) or only coconut oil coating of lemons and kept in modified atmospheric packaging (MAP) had a great effect to increase the shelf life maintaining quality during ambient storage.[36] It was observed that the beeswax (BW) decreased the affinity with water of the cassava starch (CS)-based material to a greater extent than the whey protein (WP) content, and this affected both the Xw, WVP, and Sc of the films.[38]

IV. SHELF LIFE OF EDIBLE PACKAGING

Whey protein edible film which contains 2.5% w/w of cumin, thyme and cinnamon essential oil can double the shelf life of fresh beef meat when stored under refrigeration.[5] A water insoluble coating composed of caseinate and whey protein could improve the shelf life of fruits and vegetables and eliminates bacterial contamination in meats. [21] Corn zein-based edible coatings widely used to extend the shelflife of nuts by retarding, rancidity, staling and sogginess.[25]

Minimizing the growth rate of foodborne pathogens by using antimicrobial agents in packaging material could extend the shelf life of packaged foods.[5] Antimicrobial materials for increasing the product's shelf-life.[26] Polypropylene film, Fresh-cut-melon, increased dry matter, titratable acidity and shelf-life and decreased soluble solid content. [26] Quality and shelf-life of fresh-cut fruits were improved by applying a xanthan gum based edible coating.[32] Citrus Wax (wood resins18%, Imazalil 0.3%, Thiabendazloe 0.5%) coating significantly (p 0.05) reduced physiological weight loss, increased shelf life and maintained the quality of fruits. [36] An active compound added to the matrix enhances properties such as antioxidant or antimicrobial activity and hence, improve the shelf-life of a product.[39] Antimicrobial edible films could be successfully employed in combination with modified atmospheric packaging (MAP) for significantly extending the life of composite sweet compared to conventional packaging techniques.[44] Alpha-tocopherol (TC) incorporated into Carboxymethyl cellulose (CMC) films showed a satisfactory stability over 8 weeks.[42]

Active packaging begins to be used on a larger scale simply because it helps improve the products' shelf-life and quality.[5] Extension of food products shelf life depends on the use of technological innovations to preserve the products.[21] Edible coating that have low water levels will be better able to reduce the damage and extend the shelf life of foodstuffs.[29] Edible film has the ability to lengthen the shelf life of foodstuffs packaged with it.[31] The films can be used as edible coatings for several foods such as fresh fruits and vegetables, extending their shelf life.[49] Edible packaging EP may extend or improve product quality and shelf-life by acting as carriers for additives (antioxidants, coloring agents, flavorings, or antimicrobials).[50] That low temperature storage conditions (fridge) and protein addition prolonged shelf-life (here in defined as the time required to reaching a minimum of 6 log CFU/g) which ranged from 27 to 96 days.[41]

The development of coating from water soluble polysaccharides has brought a surge of new types of coatings for extending the shelf life of fruits and vegetables. [21] Seaweed-based biopolymers edible films such as carrageenans and alginates improve food quality and to increase shelf life of food products.[24] The shelf life of the edible film as well as the food wrapped within the film is dependent on the transferability of the moisture between the film and its surroundings.[31] The films incorporating rice straw extracts could be used as packaging to prolong the shelf life of food products like nuts or ready-to-serve fruit salads due to their antioxidant activity.[40] Edible films based on binary starch gelatine or starch-sodium caseinate blends exerted the best L. rhamnosus GG survival without compromising mechanical, optical and barrier properties and the most compact (SEM) lowest VWP films as shown in the rice exemplar were most stable over shelf life.[41] The new calcium alginate–Capsule-based edible film can be potentialy used by the food industry as a pellicle to involve and increase the shelf-life of a variety of products.[56]

Aceto-stearin films have oxidative stability, especially if derived from hydrogenated vegetable oils, while aceto-olein films are less resistant to oxidation.[25] Rice bran oil extended the shelf-life of kiwi fruit with good taste, colour, and firmness. Fresh cut fruits coated with candelilla wax extended the shelf-life of fruits.[32] Edible film incorporated with essential oil provides the microbiological stability to the food and it can extend the shelf-life of the food.[32] Fresh cut fruits coated with candelilla wax extended the shelf-life of fruits.[32] Guar gum-based edible coating fused with ethanolic and methanolic extract of fennel extended the shelf-life of lemons up to 180 days at 10°C (85% relative humidity) without any loss in phytochemical components and also delayed ripening process in the lemons.[33] Storage tests were carried out for the dried fish packaged with edible film containing 4% and 6% (v/v) of anise oil stored at 30 0 C for 28 days. This was found to extend the shelf life of the dried fish for up to 21 days.[34] Films made from mesquite gum as structural agent with good water vapor barrier properties can be developed for use in prolonging the shelf-life of fruits and vegetables.[59] Chitosan + Cinnamon oil treatment could maintain trout fillet shelf life till the end of the storage period (day 16) without any significant loss of texture, odour, colour or overall acceptability and without significant microbial growth, while control samples had a shelf life of only 12 days.[69]

V. SAFETY USEAGE OF EDIBLE PACKAGING

The safety issues are controlled by the active protein-based films and coatings using mechanisms such as decreasing the microbial development, delaying oxidation through antioxidant compounds and decreasing moisture migration. [5] Because single-serve pouches would need to stay sanitary, they would have to be encased in a larger plastic or cardboard container for sale on store shelves to prevent them from getting wet or dirty.[9] Edible film has the ability to lengthen the shelf life of foodstuffs packaged with it and to protect the foodstuffs from environmental effects such as moisture loss and the browning effect.[31]

Incorporation of spice extract or its essential oil into edible packaging exerts antimicrobial activity against the food pathogens thus preventing food spoilage.[32] Essential oil has the potential to control Mycoderma sp., Lactobacillus acidophilus, Saccharomyces cerevisiae, Aspergillus niger and Bacillus cereus.[32]

The edible film incorporated with anise oil at 4% and 6 % was capable of preventing the growth of bacteria, yeasts and mold on agar plates.[34] Essential oil is a valuable component for processing biodegradable packaging which can extend shelf-life and inhibit food pathogens and spoilage.[34] Pure coconut oil coating delay the appearance of moulds up to 18 days of storage and is useful for extending their shelf life with quality.[36]

Starchy films were mixed with chitosan and potassium sorbate compounds and active films used to inhibit E. coli growth and S Aureus, as well as the deterrence properties of the films.[35]

Chitosan coating together with cinnamon oil provides a type of active coating that can be utilised as a safe preservative for fish under refrigerated storage.[69]

Natural antimicrobials such as grape seed extract, and malic acid can be combined with nisin in an edible coating to provide additional safety and improve the quality of ready to eat (RTE) meat products.[70]

VI. PROPERITIES OF EDIBLE PACKAGING

A. Antioxidant

The combination of citric acid as cross-linker, cellulose fibers as reinforcement and active extract as antioxidant resulted in films with superior properties. Citric acid has been shown to work as excellent plasticizer and cross-linker to improve starch films in terms of their water sensitivity, thermal stability and tensile strength.[39]

Rice straw affected the physicochemical properties of the starch films enhancing the antioxidant properties of the produced starch films in terms of DPPH radical activity. The produced films were moderately transparent with a slight red-brownish color and very homogenous, very good oxygen barrier properties comparable to the commonly used synthetic plastic EVOH.[40] Active film from chitosan-based film could be achieved by incorporation with green tea extract (GTE), as a natural antioxidant. Addition of GTE improved mechanical, water vapor barrier and antioxidant properties of the resulting films.[54]

Alpha-tocopherol (TC) was incorporated into a Carboxymethyl cellulose (CMC) matrix, together with surfactants, at high concentration levels (5 g TC/100 g CMC) and the films obtained were stable and easily to handle. The inclusion of lecithin in CMC films helps to maintain the stability of TC after its release due to chemical interactions, justifying the higher antioxidant activity.[42]

Alkaline pre-treatment with sodium carbonate was carried out to produce a phenolic-rich extract from rice straw. This extract contained high amount of phenolic compounds and exhibited strong antioxidant activity. Rice straw could be utilized as a safe natural antioxidant source.[46]

Pectin, bacterial cellulose fibrils (BCF) content and preparation temperature on rheological properties of mixtures on the one hand, and the influence over the antioxidant activity and water resistance of the edible coatings.[50]

Addition of Licorice residue extract (LRE) improved the mechanical, water-, oxygen-, and light barrier, and antioxidant properties of the films. Antioxidant soy protein isolate films incorporating licorice residue extract have potential for application in fatty food packaging.[62]

Films with blackberry pomace extract showed the highest antioxidant capacity. Blueberry and blackberry pomace showed excellent antioxidant potential that was not diminished after the film production. Chitosan matrix was not significantly changed to influence permeability to oxygen and mechanical properties, while water vapour permeability slightly decreased. Antioxidant activity could be useful in preventing the oxidation of fatty acids in meat.[63]

Preparation of biodegradable films based on residues of beet root and gelatin capsules, less smooth and homogeneous surface. The studied films presented good thermal and mechanical properties. The degradation test clearly evidenced that the films are biodegradable and candidates to replace nonbiodegradable materials and can serve as a source of organic matter for composting. The results also showed that the films retarded the primary oxidation of sunflower oil, suggesting that they could be an excellent alternative in antioxidant food packaging.[64]

B. Antimicrobail

Antimicrobial agents from natural or synthetic sources have been explored with satisfactory results regarding the growth inhibition of spoilage and pathogenic microorganisms. Among the most studied antimicrobial agents are the organic acids and their salts (propionic, benzoic, sorbic), bacteriocins (nisin), enzymes (lysozyme, glucose oxidase), polysaccharides (chitosan), and natural plant extracts (essential oil from oregano, pepper, rosemary).[5]

Antimicrobial edible packaging is a promising application that can be used alone or synergistically in combination with other preservation such as refrigeration, modified atmosphere packaging, or irradiation to improve microbial stability.[8] Films made by alginic acid, were transparent and flexible, but they dissolved in water.[21]

Edible films without any antimicrobial agent did not display any antimicrobial activity. The results obtained from the storage study indicated an extended life of 42 days for treated samples compared to a life of 21 days in control samples at refrigeration temperatures (4±2 °C). Antimicrobial film-treated product did not exhibit any signs of spoilage (microbial growth or off flavors) until 42 days of storage.[44]

Antimicrobial film-treated samples exhibited statistically ($p \leq 0.05$) slower rate of changes in their physicochemical and microbiological properties.[44] The water vapor permeability coefficients of film using malic acid to dissolve was the smallest, and its antibacterial ability was the highest.[55] Chitosan- kudzu starch malic acid Ascorbic Ch-Ku (Ma)-As film possessed the strongest antibacterial and water vapor barrier ability.[55] Vitamin C addition proportionated a significant mechanical resistance reduction of calcium alginate– Capsule edible film, although its tensile strength (TS) showed a superior measure when compared to other films in the literature.[56]

Garlic oil had antibacterial activity on the four bacteria used. Incorporation of garlic oil into alginate edible film at levels more than 0.2% led to a significant inhibitory effect on Staphylococcus aureus and B. cereus.[57] An antibacterial alginate edible film incorporated with garlic oil is promising and has good potential in many food application.[57]

Interactions between chitosan–starch and/or Potassium sorbate (KS) could affect film physical properties and the antimicrobial activity of chitosan. Films based on chitosan–tapioca starch or chitosan–tapioca starch–KS could reduce the effect of an external Z. bailii contamination for an acidified (pH 4.5) high water activity (aw 0.98) semisolid product.[58]

The effect of Potassium sorbate (KS) and Carvacrol (CARV) addition on properties of tapioca starch- Hydroxypropyl methylcellulose- glycerol (TS-HPMC-GLY) based films. It was established that antimicrobials affected the film yellowness, tensile resistance and solubility in water (SW) but did not have any influence on WVP. An optimized film formulation containing 0.30 g 100 g-1 KS and 0.50 g 100 g-1 CARV showed a remarkably improved antimicrobial action against Z. bailii, L. plantarum and P. fluorescens.[60]

Antimicrobial coatings or films can be recognized as a necessity in the preservation of meats. Antimicrobial coatings offer several advantages such as improving the quality, increasing the shelf life, and reducing the growth rate of meat spoilage bacteria.[66]

The water vapor barrier of the edible packaging material from hydroxypropylmethylcellulose (HPMC) could be improved by using stearic acid as the hydrophobic compound.[67]

Incorporation of natural antimicrobials to edible films may have supplementary applications in food packaging. The use of plant extracts combined with organic acids and nisin in the whey protein isolate (WPI) coating can be used to inhibit the growth of L. monocytogenes, E. coli O157:H7, and S. typhimurium in ready to eat (RTE) meat products stored at refrigeration temperature.[70]

VII. CONCLUSION

Edible packaging gained more importance in today's situation. Edible packaging uses sustainable, biodegradable material that is applied as a consumable wrapping or coating around the food, which generates no waste. These edible packaging is made from different materials like Protein (corn, soybean, wheat, gluten, casein, collagen, gelatin, corn zein, milk protein and fish protein), Lipids and also Polysaccharides. They exhibit some properties like Antioxidant and Antimicrobials. Edible packaging exhibit shelf life for some products like meat and meat products and fresh fruits and cut fruits, etc, and also has some safety usage of edible packaging.

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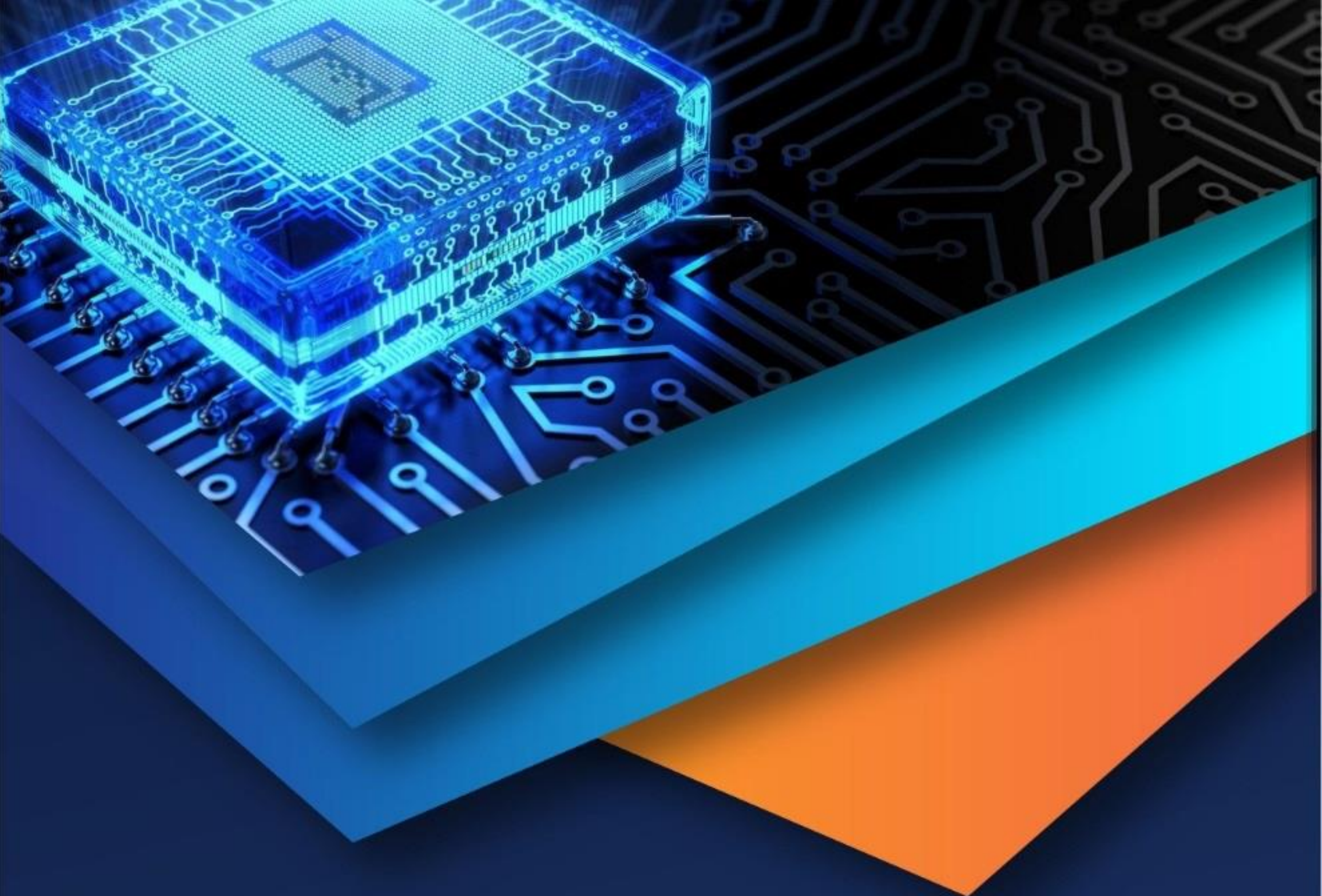

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