

# Mechanical Stability of Biobased Food Packaging Material

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## Abstract

The increasing demand for food packaging materials which satisfy people requirement provided trust for the development of many biobased materials derived from renewable sources with reduced cost and optimized performance. Mechanical stability properties such as tensile strength, young modulus, elongation at peak, lightness, Softness, transparency and loading force helps to ascertain the new innovations in biobased food packaging for commercial use. This review reflects on biobased polymers such as polymers directly extracted and removed from biomass such as polysaccharides (starch or cellulose) and protein (casein or gluten). Polymers produced by classical chemical synthesis using renewable biobased monomers such as polylactic acid and biopolyester. Polymers made from genetically modified bacterium or microorganism such as polyhydroxylalkanoates. Hence it is necessary to review the mechanical stability of biopolymer packaging materials based on complexity possibilities to control food stability and interreaction and absorption between chemical compounds and polymers.

**Keywords:** Mechanical stability, Biobased polymers, Packaging material, Food application

## 1. Introduction

The use of biomass and biological processes for the manufacturing of bio-packaging materials is an interesting design. Plastics that are from petrochemical polymers such as polyvinylchloride (PVC), polyethylene terephthalate (PET), polypropylene (PP), polyamide (PA), polyethylene (PE) and polystyrene (PS) have been used widely for packaging materials especially for food application, these petrochemical polymers have been used in market due to their characteristics such as softness, lightness, and transparency. However, materials which made from synthetic polymers especially for food packaging materials have been discouraged because of its non-biodegradable characteristic effects on the ecological systems and environment in the future. Therefore, attempt is being made to find new ways on innovating packaging materials that would be environmental-friendly, and less harmful for human as well as ecosystem. The new findings for food packaging application are about the biodegradable packaging materials. Development of packaging material involves numerous intrinsic considerations amongst which are mechanical, gas barrier, water vapor and thermal properties. This review evaluates the mechanical stability of biobased material for food packaging application. The mechanical stability of food packaging material is not only crucial in maintaining the quality of the foods but also it shields the food from contamination, microorganism, insects, pest, temperature and water activity. Moreover, storage and delivery condition of each food highly depends on packaging material as an essential factor in order to protect product shelf-life (Petersen *et al.*, 1997). Thus, selecting the most suitable biobased packaging material is of utmost importance in protecting food properties. Basically, three categories of biopolymers can be addressed based on source and manufacturing process. Polymers which are directly removed from biomass formed polysaccharides (starch or cellulose) and extracted from protein produced casein or gluten; polymers produced by conventional chemical separation using renewable biomonomers for instance polylactic acid and biopolyester produced through fermentation of carbohydrates feedstock; and polymers made from genetically modified bacterium or microorganism such as polyhydroxylalkanoates.

Numerous studies have attempted to explain the effective method for selecting biopackaging material. The basic procedure for selecting biobased or biopolymer packaging material was based on deteriorative reactions in food (Anker, 1996). For instance, microbiological, enzymatic and chemical changes in food (non-enzymatic browning, lipid hydrolysis, protein cross-linking, degradation of pigments, and polysaccharide synthesis) occurred simultaneously in foods and interrelate to storage condition are the main criteria for selecting biopolymer packaging. It is also essential to conduct constancy test of packaging material based on complexity possibilities to control food stability and the interface or immersion between chemical mixtures and produced polymer so that there is no influence for mechanical properties of the packaging material (Miller 1997; Kroetha, 1997; Auras *et al.*, 2005). Accordingly factors such as process-ability and mechanical characteristics (tensile strength, tear strength, burst strength, elongation, friction, puncture resistance, toughness, softness, solubility and

water absorption capacity) could affect the chemical resistance of the products. Hence it is necessary to perform the suitability test for biopolymer stored with food as a function of duration.

## 2.0. Mechanical Stability

Mechanical strengths are crucial for adequate design of biopolymer packaging films that must have a certain degree of resistance. The main essential measured values of the biopolymers associated with tensile strength, Young modulus, and elongation at breaking point, loading force, lightness, softness, plus transparency of the biopolymers. Balancing the mechanical properties and stabilities of biopolymers with synthetic polymers are the major concern of this invention of biobased polymers. The fact that the packaged food interrelates with the packaging material strongly emphasizes the need to select the material based on their mechanical performances (Siracusaa *et al.*, 2008). Generally measurements associated with tensile stress, elongation at breaking point and modulus of elasticity of sample were tested to the chemical resistance of product by immersed in verities of acid solutions from weak to strong as a function of duration, and at ambient temperature. The structural design of polymer also an essential criteria to determine the mechanical stability, consequently it will be developed to form the final product. In addition, it is important to evaluate the mechanical measurements under the condition of room temperature as several packaging materials which commercially available followed these conditions as well (Auras *et al.*, 2005; Auras *et al.*, 2003). As a result, repeated test were carried out to analyze the tensile strength (MPa), elongation at yield (%), elongation at break (%) and elastic modulus (GPa) of particular packaging material. These measurements are equally important as mechanical factors aspect of the biodegradable or biopolymer materials for comparison of the marketable non-biodegradable polymers. Furthermore, impact properties test can be used to conclude the amount of energy needed for the particular polymer deformation under specific conditions (Auras *et al.*, 2003). Presently, quite a few kinds of biopolymers on the market which were tested in terms of mechanical stabilities and chemical resistance properties for proper packaging usage: polyester, polyester amides, starch and cellulose materials, polylactic acid (PLA), and polyhydroxy acid (PHA). Up to the present time, PHA polymer in the category of most high-priced polymer while PLA has been growing alternative green packaging materials in food industries for their stable performances in every feature (Auras *et al.*, 2006). Besides, the degree of degradation of plastics also can be measured by their mechanical properties of the polymers (Swift, 1993 and Orhan *et al.*, 2000).

## 3.0. Tensile Strength and Young's Modulus

Biopolymer produced from polysaccharides or genetically modified bacterium or bioprocesses are commonly biodegradable, non-toxic and safe consumption materials. They replace synthetic polymers and can be used in multi-layer packaging as they provide opportunities for new product development. Current research interest is due to large surpluses of raw materials, which are produced in large amounts as by-products of agro-industrial processes, for example special attention is given to chitosan (CS), N-acetyl-D-glucosamine. This polysaccharide polymer is a by-product from some crustacean industries. It is biodegradable, stable with low toxicity and comparatively low cost material. Whey protein (WP) is another recognized biopolymer material which obtained from milk whey, a by-product of cheese-making with impeccable mechanical properties (Debeaufort *et al.*, 2000). Protein and polysaccharide matrices generally show good film-forming abilities. Texture analyzer is used to measure tensile strength properties. For easy handling, the films were plasticized with glycerol. Glycerol gives better capability of deformation without breaking by reduces the interactions between polymer bonds during certain stretching. No significant differences in tensile strength of single component films were observed during tests. Normally, the susceptible and brittle conditions of protein films prevent from cracking due to the robust interconnected energy and bonding of the material (Arvanitoyannis and Biliaderis, 1998). Mechanical stability properties for Whey Protein (WP) films are (TS 1.00 MPa, YM  $8.00 \times 10^{-2}$  MPa) (Ramos *et al.*, 2013) and (TS 10.50 MPa, YM 24.30 MPa) (Chen *et al.*, 2014). Measurements of Chitosan (CS) films is very difficult due to different film preparation, powder composition, solubilization method and plasticizer content (Butler *et al.*, 1996; Rivero *et al.*, 2009). In another article, it has been reported CS films to have a TS value around 8.91 MPa and an E of 38.50% (Chen *et al.*, 2014). Elongation at breaking point of CS film was seven times advanced than WP film. When comparing all film formulations, significant differences in mechanical properties were observed for different bilayer formulations. Bilayer films with a thicker chitosan layer (40 mm and 60 mm) had the highest TS, with values of 17.50 and 15.30 MPa, respectively (Chen *et al.*, 2014) as well as elongation and Young Modulus values. Thus, increasing chitosan content led to stronger films by the strong hydrophilic nature of chitosan as observed in water vapor sorption analysis. Other authors reported increment of tensile strength and reduction in elongation for soy protein films laminated by corn starch also could strengthen the mechanical properties of the particular biopolymer (Cho *et al.*, 2010).

According to previous studies, it has been described the modification of polymer content caused stronger tensile performance up to 50 % of the original value. One of the obvious example was in preparation of polymers based on chitosan with gelatin in aqueous solutions at 60 °C and evaporating at 22 °C by varying

temperature methods in order to transform the polymer structure (Arvanitoyannis *et al.*, 1998). On the top of that, development of different natures of chitosan-based Nano composite films related to Nano-silver, Ag-ion and Cloister chitosan-based Nano composite film reported to higher in not only tensile strength, but also in elongation and Young Modulus properties. In detail, these Nano composite films measured the tensile strengths of 35.1 MPa, 35.9 MPa and 38.0 MPa respectively in comparison with a tensile strength for original chitosan of 32.9 MPa (Rhim *et al.*, 2006). Followed by this, another article testified the addition of certain amount of water soluble Chitosan (WSC) to Nano composite film led to increase the tensile strength and seemed to approach the advanced stable properties polymers (Suzuki *et al.*, 2005). Another author have emphasized on the tensile strength of modified chitosan film and its interrelation with relative temperature as well as humidity condition (Srinivasa *et al.*, 2007b). The detail measurement values were described as 5.5 MPa to 40 MPa increase in tensile strength for comparative increment of temperature and humidity for about seven days of storage period. As supported for this statement, another study well-defined the chitosan has better mechanical performance than Poly-lactic acid (PLA) by comparing both properties (chitosan:PLA; 72.7 MPa: 64.4 MPa) (Suyatma *et al.*, 2005)

Another modified biofilm was mixture of Polyaniline-chitosan (PANI-CS) produced an increase in tensile strength. Increasing the PANI content caused higher tensile strength due to uniform distribution of its structural criteria (Thanpitcha *et al.*, 2006). For instance, polyaniline (PAN) synthesized by radical polymerization with polysaccharides chitosan and polyacrylonitrile also produced composite films with high deformation and strong characteristics. In detail, films of PAN-chitosan with 6% acrylonitrile comprised tensile strength of 52 MPa, while PAN-chitosan films with 6% polyacrylonitrile contained tensile strength of 55 MPa (Sidorovich *et al.*, 2006). In recent study, Mathew (2006) stated the tensile strength for mixture of chitosan starch composite films increased with an optimum tensile strength due to the intermolecular formation of hydrogen bonds among the NH<sub>3</sub> and hydroxyl groups of starch. Ban (2006) also studied starch based chitosan films and found a tremendous tensile increase by almost 10-fold increase in tensile strength was reached with 28% chitosan in the film compared with the original starch film. However, further increment of starch led to decrease of tensile strength due to intra-molecular formation among hydrogen bonds rather than intermolecular hydrogen bonds, consequently phase separation occurred between those two main compounds. A part from that, different biopolymers which formed from chitosan and whey protein edible films produced either in the absence or presence of microbial transglutaminase as a cross-linking enzyme or agent. The mechanical resistance of this film was reported to reduce with the addition of whey proteins compared to chitosan alone. Likewise, in the presence of transglutaminase, a noticeable development in the mechanical resistance of chitosan-whey protein films was observed. In details, tensile strength of chitosan-whey protein was of 9.5 MPa while chitosan-whey protein transglutaminase was about 26.2 MPa (Pierro *et al.*, 2006). In another research, the mechanical properties of a pure konjac glucomannan film was studied and found the tensile strength 20 % higher than chitosan (Li *et al.*, 2006). Thus modification process was carried out with chitosan added to the konjac glucomannan solution, resulted in increment of the tensile strength reached optimum at about 20 wt% chitosan, achieving 102.8 MPa. This is because the konjac glucomannan and chitosan polysaccharide molecular chains have approximately equal molecular plasticity (Li *et al.*, 2006; Kampeerappun *et al.*, 2007). The effect of chitosan coating contents on tensile properties in both the machine direction and transverse direction also studied by few researchers. The tensile stress at maximum load in both directions tended to increase. For example, the tensile stress of 1 wt% chitosan-coated film was 8.27 MPa in the machine direction. When the chitosan coating solution reached 4 wt%, the tensile stress was found to be 14.47 MPa. The tensile stress of 1 wt% chitosan coated film was 5.08 MPa, whereas that of 4 wt% chitosan-coated film was 9.6 MPa in the transverse direction (Bangyekan *et al.*, 2006).

According to Arvanitoyannis (1998) a considerable decrease of elasticity modulus of up to 50% of the original values identified with an increase in the total plasticizer content of chitosan and gelatine films with water or polyols. The elastic modulus of mixtures of films is slightly larger than those of pure films (Suzuki *et al.*, 2005). Based on research study conducted by Srinivasa (2007b), three independent variables including temperature, relative humidity, and storage period influenced the modulus of elasticity. For example, it was found that at 20 °C, 40% relative humidity, and storage duration of 7 days, the optimum value for modulus of elasticity was 896.7 MPa. As a consequence, all blends show an increase in Young's modulus with accumulative PLA content. The values for Young modulus in both machine and transverse directions also lean towards increment for instance chitosan-coated film has Young modulus of 1 wt% 506.29 MPa in the machine direction while 1 wt% chitosan-coated film was 267.84 MPa in the transverse direction. Besides Chitosan and modified type, it has been investigated Nano-clay of pure PLA and PLA/clay Nano composite films has greater tensile strength, Young Modulus as well as elongation break point (Rhim, Mohanty, *et al.*, 2006). Based on the uniformity dispersion of the nano-sized clay particles which produces an ultra-high interfacial area and ionic bonds between the Nano clay and host polymer, it was found that well-developed polymer/clay Nano composite has highly stable mechanical strength compared to the pure polymer (Alexandre & Dubois, 2000; Pandey *et al.*, 2005; Sinha Ray & Bousmina, 2005). However, Ogata (1997) claimed the PLA/organoclay Nano composite could not be individually well dispersed in the PLA/clay blend due to its wide-angle X-ray scattering

measurements of the silicate layers. The Nano composite films are still comparable to those of commonly used plastic films although the strength of PLA films decreased slightly after compounding with Nano clays (Hernandez, Selke, & Culter, 2000). A appropriate selection of clay type and producing method to form an intercalation or exfoliation structure highly depends on the mechanical strength of PLA/clay composite (Alexandre & Dubois, 2000; Giannelis, 1996). Nevertheless, cloister was more effective in maintaining tensile strength property in comparison to the other Nano clays studies.

The additional of plasticizers in the material films such as Polysaccharide film affect their elastic modulus tensile strength. Additional of plasticizers into Polysaccharide film are inversely proportional to tensile strength and elastic modulus. More amount of plasticizers in films resulted low tensile strength and elastic modulus. Besides, in the literature, (Dorgan *et al.*, 2006) showed that there are three factors in order to determine the mechanical properties of PLA that refer to chain architecture, molecular weight of polymers, and the degree of crystallinity. These would result on PLA orientation itself which enhances heat stability and strengthen the molecular weight. But, limitations still occurred such as low melt strength, thus the mechanical properties of PLA is similar to Polyethylene terephthalate (PET) which possess a heat seal initiation at 80°C. In addition, (Holm *et al.*, 2006) proved that 75% molecular weight of PLA decreased and 35% of tensile strength loss when they did hydrolysis of PLA at 25°C in 130 day time length. Therefore, it has been shown that varying the molecular weight of biopolymers could affect their tensile strength. Besides, the physical properties of copolymers like polyhydroxyacid (PHA) able to be adjusted by two factors which are molecular weight structures and their compositions. As a result of the enhancement, the PHA resembles a large of properties, changed from hard crystalline polymer to become an elastic rubber at melting point of 50°C to 180°C (Sudesh *et al.*, 2000). This also has been proved by using the polyhydroxybutyrate (PHB) that is commonly known as a hard and being a highly crystalline thermoplastic polymer, and it is quite similar with PHB homopolymer that is stiff and brittle. The Introduction of high-viscosity (HV) comonomers has been improved their mechanical properties by decreasing the percentage of crystallinity and the melting point. Final product was defined has low stiffness and a high toughness of PHB (Bohlmann 2005). Few article proved that the melting temperature PHB with no HB has been decreased from 179°C to 137°C by additional of 25%HV (Hocking & Marchessault, 1998). Besides, compare to PP, PHB has different resistance to dynamic compression than PP. The deformation percentage 50% lower and it resembles that PHB is more rigid and less flexible. The performance of PHB could be better than PP when the temperature is higher or in the other hand its performance decreases as process occurs at normal freezing and refrigeration conditions (Bucci *et al.*, 2005). An enhancement on mechanical properties and thermal stability without major decrease in barrier properties has been proven during blending process of amorphous PLA with PCL (Cabedo *et al.*, 2006). In addition, (Noda *et al.*, 2004) claimed that by blending a small amount of ductile PHA and PLA, the toughness of PLA increased with a non-reduction in optical clarity.

#### 4.0 Relative Elongation

Physical and biological forces can be main factors of the initial breakdown of polymers. Physical forces; freezing/thawing, wetting/drying or heating/cooling can affect mechanical properties of polymer materials (Shah *et al.*, 2008). Relative elongation is one of the important mechanical properties which can affect the biodegradable rate during the degradation process. This statement can be explained when the result of percentage elongation values for starch blend film decreased in inoculated soil faster than in non-inoculated soil. 56% elongation of starch blend films decrease faster in inoculated soil compare to 12% elongation decreasing in non-inoculated soil within in the fixed time basis (Mostafa *et al.*, 2010). An additional of plasticizer also provide to increase the percentage of elongation. (Arvanitoyannis *et al.*, 1998) claimed that the percentage of elongation of chitosan and gelatin films increased up to 150% with the additional of plasticizers (water or polyols), compare with original values. In the literature by (Rhim *et al.*, 2006), four different types of chitosan-based nanocomposite films had been tested for their elongation percentage. The result showed an increasing of elongation percentage; Na-MMT Cloisite 30B (organically modified MMT) chitosan-based nanocomposite film, 66.3 5.3%; nano-silver chitosan-based nanocomposite film, 46.3± 7.6%; Ag-ion chitosan-based nanocomposite film with elongation 38.9 ± 1.4%. Another finding, (Suzuki *et al.*, 2005) that provided amylose films blended with chitosan showed an increment on elongation percentage. This could be claimed that blend films can improve the percentage of elongation and the blend films resembles as a stronger films than single films formed. Besides, (Srinivisa *et al.*, 2007a) proved that temperature and humidity can affect the elongation properties. They found the optimum value for percentage elongation was 896.7 within 7 days period, at 20°C and 40% humidity. In addition, (Suyatma *et al.*, 2005) claimed that chitosan performance was better than PLA when chitosan-PLA blends showed lower percentage of elongation. The range of blend chitosan-PLA was at average 80/20, 4.2% elongation at break. This is also has been approved when PANI-chitosan blends also showed decreasing percentage from 17.02 1.6% (pure chitosan) to 7.58 1.1% (with 10% PANI) elongation at break when PANI gradually mixed with chitosan. The blended films also became more brittle after blended compare to the original chitosan films (Thanpitcha *et al.*, 2006). The experiment has been developed by blending chitosan with

other materials, chitin and PAN. Result from (Sidorovich *et al.*, 2006) showed R-PAN–chitin (6%) acrylonitrile had 2% elongation and films of A-PAN–chitin (12%) had 2.2% elongation. Percentage elongation increase with addition of starch and protein such as whey protein at the different protein. Blending chitosan – whey protein showed an improvement in the mechanical resistance (Mathew *et al.* (2006); (Di Pierro *et al.*, 2006). And, Bangyekan *et al.* (2006) found that the chitosan coating contents could provide effect on tensile properties of chitosan-coated starch films. According to the study, it also affect the percentage elongation at break in the same time that tended to be at lower percentage as chitosan added in composition.

### 5.0 Loading Force

Loading force usually used to measure the binding between molecules to improve the mechanical properties and chemical bonding of biopolymers. Stability of bioplastic is measured by the applied load including force and torque which should not be exceeding the first yield. Generally, materials with higher modulus have higher loading force to break the plastic materials. For instance, bioplastic based on albumin inherently had much higher loading force with modulus strength (Jones *et al.*, 2013). This has been shown with improved bioplastic of 80:20 albumins: rubbers and as a result, they need higher load to break compare of using albumin-water and albumin glycerol. This characteristic is due to the natural rubber also contributing to high loading-bearing materials in the plastic that lead possibility for plastic to endure higher stress (Carvalho *et al.*, 2003). In contrast, biopolymer albumin-water possesses the highest amount of extension that exclude load bearing characteristic. This is due to the bonding that occurs as similar as plasticization process occurred. Besides, the ductile characteristics of these bioplastics based on albumin, water and rubber allowed large amount of extension before breaking, stiff plus needed greater load to break (Pomme *et al.*, 2005; Verbeek and den Berg, 2010). The large chemical structure and bonding of these bioplastic enable to plasticization by increasing elongation and toughness to break at room temperature (Ullah *et al.*, 2011).

### 6.0 Softness

Possess an excellent barrier properties, toughness, flexibility and low cost has made the polyolefin become as a core for the study of biodegradable polymer. It is also due to polyolefin coming from less percentage oil fraction. However, polyolefin has an opposite characteristic with biodegradation polymers criteria; hydrocarbon hydrophobic polymers, resistant to pro-oxidant, highly resistant to hydrolysis and not biodegradable. Therefore, introduction to pro-oxidant additives has been implemented to promote the oxo-biodegradation by producing less molar mass of oxidation compounds from microorganisms. As the natural compounds like cellulose and starch naturally are hydrophilic polymers, water swella or wettable and biodegradable. Examples of these hydro-biodegradable aliphatic polyesters are polylactic acid (PLA) and poly hydroxyacid (PHA) (Scott & Wiles., 2001). Thus, further modification processes and methods were studied by numerous researches in past few years. In addition, (Scott, 2001) described that oxo-biodegradation is a slower process compare to the hydro-biodegradation at ambient temperature. He also claimed that molecules of alcohols, aldehydes and ketones would be degradable with less molar mass during the oxo-degradation of carboxylic acid. This process produced by peroxidation which is the main cause of the loss of mechanical properties of hydrocarbon polymers. Then, fungi, bacteria, and enzymes were considered based on the bio-assimilation process which provide an increment to biomass and finally created to CO<sub>2</sub> formation. Synthetic polymers commonly contain antioxidants and stabilizers that function as mechanical oxidation preventer during the process by provide the required shelf-life. Therefore, at one side the antioxidant is needed due to enhance the quality of these materials, but in contrast it is better to not add these molecules for biodegradation process. Hydro-biodegradation has become a popular process to provide bio-assimilable products from biopolymers. Aliphatic polyester was an example of biomaterial from hydrolyzed and bio-assimilated rapidly in an aqueous environment like cellulose and starch (Scott & Wiles, 2001).

### 7.0 Transparency and Lightness

Generally, the non-composite films for food packaging are transparent and colorless (Sonthornvit *et al.*, 2010). However, incorporation of edible films with fatty acid gives impact on film color. Assimilation of hydroxyl propyl methyl cellulose (HPMC) with fatty acid (stearic acid) showed lightness higher than free acid film (Septi *et al.*, 2002). This is due to stearic acid that effect on film color in a white coloration indication. Therefore increasing the latter occurs once the content of stearic acid increase. This showed that the additional amount of fatty acid into the films resulted to the transparency effect. (Young and Paulson, 2000) claimed that the increasing of the opacity is parallel to the concentration of lipids that has been added during incorporation of gelatin films and stearic-palmitic. This is because of the light scattering factor from lipid that distributed throughout the polymer network and consequently increasing the film whitishness (Debeufort *et al.*, 2000). In short, transparency and lightness of films as food packaging material was highly dependent on its composition. Additional content gradually decline the transparency and lightness of the edible films. (Sonthornvit *et al.*, 2010)

claimed that transparency and lightness were significantly influenced when the films blend with other materials where. This had been proved when the whey protein isolated (WPI) non-composite films tested with the presence of different amount of clay and it results low transparency and lightness value at higher clay contents. This is because of the aggregation of Nano-particles, in-turn, that hinder light transmission (Sonthornvit et al., 2010). Therefore, transparency and lightness decrease as its additional materials added into biodegradable films. The presence of plasticizers and proteins would affect the transparency of coated films for food packaging. (Joo Won Lee et al., 2008) claimed that the transparency for protein-coated films gradually higher in the following orders of protein such as corn zein (CZ)(16.9-19.7), soy protein isolates (SPI)(13.3-30.3), and whey protein isolate (WPI)(17.8-28.6). In addition, other plasticizers added into the protein-coated films, the transparency values also increased. High transparency and high lightness of food packages are important as they get highly demand from consumers (Introzzi et al., 2012). Biopolymers formation has slightly effected on its transparency and lightness so that they could be marketable for consumers. During the experiment of PLA-limonene blends for making biopolymer food packages, (Arrieta et al., 2013) found that PLA and PLA-limonene samples showed high lightness values which mean that they are in high brightness characteristics even additives added to the PLA. Lightness for PLA is  $(94.08 \pm 0.07)$  and PLA-limonene  $(93.86 \pm 0.10)$ . Also, there are no major differences for total colour values. (Yoo S & Krochta, 2011) did a comparison of films transparency between biopolymer, biopolymer blended and synthetic polymer films. The result showed that biopolymers such as hydroxyl propyl methyl cellulose (HPMC) films were quite transparent, and their percentages of transparency were higher than synthetic polymers like LDPE, HDPE, and PP films.

The application of biodegradable materials which use the edible films for food packaging has been a trend nowadays. The biodegradable materials for food packaging include categories of biopolymers, bio-based Nano-composite and biomass which can break down naturally by enzymatic action of microorganism and produce carbon dioxide and methane gas at the end of process. Biopolymers specially has been a trendy materials that would be used for food packaging as it could be a biodegradable food packaging material and it has potential to produce transparent films and coatings that can provide enhancement on certain mechanical properties (Sonthornvit & Krotcha, 2000, 2005). Mechanical properties could be as well related to the mechanical stability and it is include transparency and lightness aspects.

## 8.0 Conclusion

In short, this review indicates the essentials of biobased packaging material from biomass associated with foodpackaging. A few factors like humidity, number and type of microbes and temperature ( $50^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ ) are parallel to the rate of biodegradation process. There are great possibilities and future for packaging based on biobased materials. Thus, there is a high demand for biodegradable and biobased polymer products. Although the oxo-biodegradation mechanism has been implemented to biodegrade natural polymer (rubber, lignin, and humus) and synthetic polymers, it was not satisfied or fulfills the rate of mineralization criteria as implied for standard biodegradation. Therefore, several of new researches including legislation, processing technology, and compatibility studies of foods and packaging should be initiated in order to promote biobased materials as good commercializable and eco-friendly food packaging material.

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