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RESEARCH ARTICLE

Effect of Olive oil Concentrations on film properties of edible composite films prepared from Corn starch and Olive oil

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ABSTRACT:
Corn starch is a one of the edible polymers which has drawn research interest due to its abundance, renewability, low cost and biodegradability. In this work, edible composite films were prepared from corn starch and olive oil using casting method, varying the olive oil concentrations (0%, 2%, 5% & 10%). Glycerol and vinegar (5% & 5%) were used as plasticizers. The effects olive oil concentrations on film properties were investigated. The results show that the tensile strength and water barrier properties were improved with the increase of olive oil concentrations, while film solubility is decreased. SEM results are also presented.

KEYWORDS: Edible packaging, edible films and coatings, corn starch, olive oil, edible composite, lipid addition.

1. INTRODUCTION:
Edible packaging is one that uses edible ingredients to form a film and coatings for food packaging applications. Since these films and coatings can directly be consumed, they can be used to replace synthetic plastics or biodegradables that pose environmental problems. These edible packaging films and coatings are synthesized from hydrocolloids (polysaccharides and proteins), lipids and their composites. Due to the hydrophilic nature, hydrocolloids based films show poor water barrier properties but good mechanical properties. On the other hand, lipids show strong water barrier properties but poor mechanical properties. It is obvious that the film properties can be improved by combining both hydrocolloids and lipids, forming edible composites [1-4].

Starch is one of the abundant hydrocolloid polymers, which is colourless, tasteless, and edible. Starch contains amylase (20-25%) and amylopectin (75-80%), where amylase is a linear polymer and amylopectin is a branched polymer.

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It is naturally produced by plants in the form of tubers, seeds and roots. The commercial starch is normally extracted from potato, wheat, corn, cassava and quinoa. Starch is hydrophillic in nature, and the edible films produced from starch has high tendency towards water absorption [5-7].

Corn starch has attracted interest due to its abundance, easy availability, low cost and biodegradability. Edible films have been prepared from corn starch by many researchers [8-9]. Corn based films were studied by various researchers. The film formability of acetylated corn starch was investigated by Lopez et al. [10] and found that chemical modification had an effect on film formability and film properties. WVP was significantly improved and the lowest WVP obtained was 1.26 x10^{-10} g/s m Pa. However, unplasticized films are rigid and brittle. Thus the addition of plastizer was important to improve the mechanical properties of the film. The physical properties of high amylose corn starch based films were investigated by Bertuzzi et al. [11] through low temperature gelatinization method, and found that glycerol content of higher than 30% causes looser network, increased opacity and water sorption. Corn starch-chitosan composite films were prepared by Garcia et al. [12] to improve the mechanical and barrier properties of edible films. WVP of the prepared films ranged between 3.76 and 4.546 10-11 g/ s m Pa. The flexibility of the films increased with the addition of glycerol. Gutierrez et al. [13] prepared edible films from native and phosphatized corn starch and the phosphatized films improved interactions with glycerol than native starch. In the work of Lopez et al. [14], corn starch based films were prepared by adding chitosan/chitin by thermo-compression process. The addition of chitosan and chitin improved tensile strength and elastic modulus due to strong interactions between the hydroxyl groups of starch and amino groups of chitosan/chitin. The inclusion of 10 g of chitosan or chitin per 100 g of starch could decrease WVP to 35 and 56% respectively. In the work of Ghasemlou [15], corn starch based films were prepared by incorporating two essential oils (Zataria multiflora Boiss or Mentha pulegium) using solution casting technique to improve the tensile strength, WVP properties and antimicrobial activity. Increasing the content of oils increased elongation but no significantly improvement is observed in tensile strength. WVP of the films decreased and the oxygen barrier properties were unaffected. However, the antimicrobial activity was improved significantly.

Olive oil, as a lipid, can be beneficial to improve the barrier properties of hydrocolloid edible films. In the work of Ghanbarzadeh and Oromiehi [16], edible films were prepared from zein and zein-whey protein composite using glycerol and olive oil as plastizers. Films prepared by olive oil showed higher glass transition temperatures which provide better barrier properties. Replacing glycerol by olive oil was thus suggested for improved barrier properties the edible films. Gelatin–olive oil composite films were made by Ma et al. [17] through microfluidic emulsification method and found that the addition of olive oil improved the hydrophobic nature of gelatin films. The properties of chitosan and olive oil composite emulsion films were investigated by Pereda et al. [18] by varying the olive oil concentrations. They found that tensile properties of the edible films were increased and moisture sorption and water vapor permeability were reduced with the increase of olive oil concentrations. It was also found that the presence of olive oil entrapped part of the glycerol, reducing its loss in aqueous solution. Taqi et al. [19] prepared albumin (egg white) edible composite films (albumin-olive oil and albumin-oleic acid) and found that olive oil was suggested as more effective lipid than oleic acid for improving tensile strength while reducing the WVP and film solubility in water. There is no research work found in literatures on corn starch – olive oil composite films. In this research work, edible composite films were prepared with corn starch and corn starch – olive oil composite film using casting technique. The effect of olive oil addition on tensile strength, water permeability and film solubility were carried out and the results were discussed.

2. MATERIALS AND FILM PREPARATION:

2.1. Materials and Composition:

Corn starch, olive oil, glycerol and vinegar were purchased from local market in Chennai. The base or reference film was created from corn starch, glycerol and vinegar. Glycerol and vinegar were used as plasticizers to improve the flexibility and film formability. The test films were prepared from varying proportions of olive oil, along with corn starch, glycerol and vinegar. The bio-plastics were prepared in the compositions mentioned in Table 1. The film thicknesses were calculated using micrometer.

Table 1: Materials Composition

Specimen	Corn Starch (%)	Olive Oil (%)	Glycerol (%)	Vinegar (%)
Corn – Olive 0	90	0	5	5
Corn – Olive 2	88	2	5	5
Corn – Olive 5	85	5	5	5
Corn – Olive 10	80	10	5	5

2.2. Composite Preparation:

Corn starch solutions were prepared by dispersing 80 g starch powder in a beaker with 200 ml of distilled water, once the starch was dissolved completely and becomes a solution. On constant stirring in a hot water bath at a temperature of about 80ºC - 90ºC, a specific amount of glycerol and vinegar was added into the solution. The solution underwent gelenation process on constant heating and stirring, and the prepared gelatinized solution was transferred into a tray with adhesive coating or a glass plate layered with Teflon. The gelatinized solution which is pasted on to the plate was allowed to cool at a room temperature of 27 °C. It was allowed to release moisture content under Sunlight for about 72 h. The film was then removed from the surface of the glass or Teflon plate.

3. EXPERIMENTATION:

3.1. Water Vapor Permeabiltiy:

Standard test method (ASTM E96-80) was used to determine water vapour permeability. The corn starch film samples were kept tightly on a circular glass cup containing distilled water and placed in a chamber at 25 °C and 20 % RH. The fan in the chamber replenishes the stagnant air. The cup was weighed periodically using a physical balance and noted. The water vapour permeability was then determined using the following equation: $WVP = Q \cdot X / (A \cdot t \cdot (p1-p2))$, where Q/s is mass loss against time, A is the permeability area, X is the average thickness of the film and (p1–p2) is real vapour partial pressure difference (Pa) across the film.

3.2. Tensile Test:

Tensile strength was determined using tensile testing machine (Microlab, Chennai). The specimens were prepared as per ASTM D882-91. The specimens of 80 mm and 5 mm films were prepared and mounted between the grips of the tensile machine. Number of specimens prepared for each tensile test was chosen as at least 5. The grip separation and speed of cross-head were maintained at 50 mm and 5 mm/min, respectively. The tensile strength was determined by dividing maximum force value at breaking point by original cross sectional area. The test was repeated for all five specimens of each composition. The average of five tensile values was taken as the tensile strength of the particular composition.

3.3. Film Solubility:

Specimens of 50 mm x 50 mm were prepared from each film and initial weights were determined to a precision of 0.001 g. There were at least 5 specimens prepared for each composition. Each specimen was immersed in a 100 ml of phosphate buffer solution at 25 C. The solution was continuously stirred by a magnetic stirrer for about 30 min. The specimen is removed and the final weight was determined. Film solubility of each film was then was calculated using the following formula: Film Solubility = (Weight Loss/ Initial Weight) * 100. The test was repeated for all five specimens for each composition and the average value was considered as the film solubility of the film composition.

3.4. SEM Test:

Scanning electron microscopy (SEM) is used to morpholically study about the surfaces of materials, particles and fibres using image analysis. It uses narrow beam of high-energy electrons on the surface of the specimens and a variety of signals are obtained. Film samples of 5mmx5mm were cut into pieces and held in an alumium holder and sputtered with gold–palladium alloy. SEM photographs were taken for samples of corn starch as well as corn starch with olive oil.

4. RESULTS AND DISCUSSION:

The summary of results is shown in the table 2. The results of each film property are discussed in the following sections.

4.1. Water Vapor Permeability Test:

WVP is a highly important property for edible films, because most biopolymers produced from food ingredients are highly sensitive to water absorption. WVP results are shown in the figure 1. Experimental results of WVP of corn-olive oil composite films range from 0.0126 $x10^{12}$ to $0.00269x10^{12}$ mol mm s^{-1} Pa^{-1} which is higher than the WVP of corn starch film without olive oil addition. From the results, it is observed that the hydrophobic nature of the composite film has increased with the increase of the concentration of olive oil. The reason behind the improved WVP is attributed by non-polar and hydrophobic nature and larger molecular weight of olive oil.

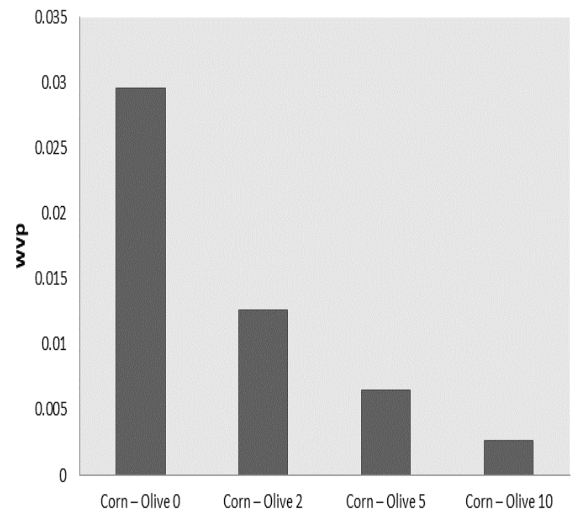


Figure 1: WVP of Corn-Olive oil composite film against Corn starch film

4.2. Tensile Strength:

Tensile strength results are shown in the figure 2. Experimental results of tensile strength of corn-olive oil composite films range from 7.83 MPa to 18.97 MPa which is higher than the tensile strength of corn starch film without olive oil addition. From the results, it is observed that the mechanical properties, i.e., tensile strength of the composite film have increased with the increase of the concentration of olive oil. The increase of tensile strength is due to strong cohesive force produced between the corn starch and the olive oil by cross-linking, which reduces the molecular mobility and free volume. The cross-linking leads to high structural bonding in the polymer networking causing increase in tensile decreasing.

Table 2: Film Properties of Corn-Olive Composite Films

Specimen	Thickness (mm)	WVP ($x10^{12}$ mol mm s^{-1} Pa^{-1})	Tensile Strength (MPa)	Film Solubility (%)
Corn – Olive 0	0.63	0.0296	5.12	24.56
Corn – Olive 2	0.71	0.0126	7.83	21.92
Corn – Olive 5	0.77	0.00652	11.04	19.06
Corn – Olive 10	0.50	0.00269	18.97	16.88

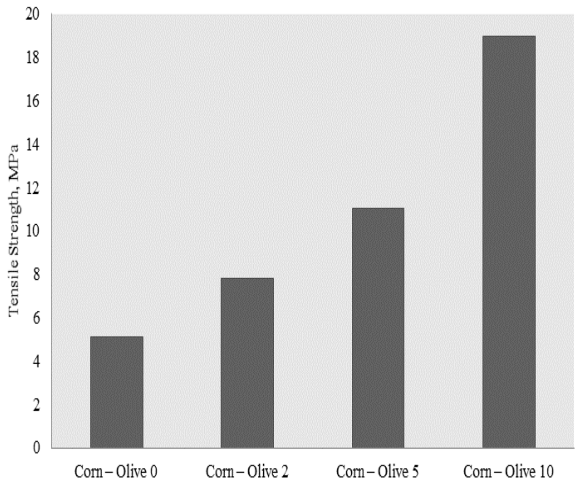


Figure 2: Tensile Strength of Corn-Olive oil composite film against Corn starch film

4.3. Film Solubility:

Film solubility is essential for the potential use of edible film for packaging applications. Since corn starch is hydrophilic in nature, it is essential to enhance the water resistance. Thus the addition of hydrophobic material might be beneficial in respect of insolubility. Film solubility results of the prepared edible composite films are shown in the figure 3. Experimental results of film solubility of corn-olive oil composite films range from 16.88 % to 21.92 % which is lower than the film solubility of corn starch film without olive oil addition. From the results, it is observed that the film solubility of the composite film have decreased with the increase of the concentration of olive oil. This is due to the hydrophobic nature of the olive oil and the increase of olive oil concentration has substantially reduced the film solubility of the edible film.

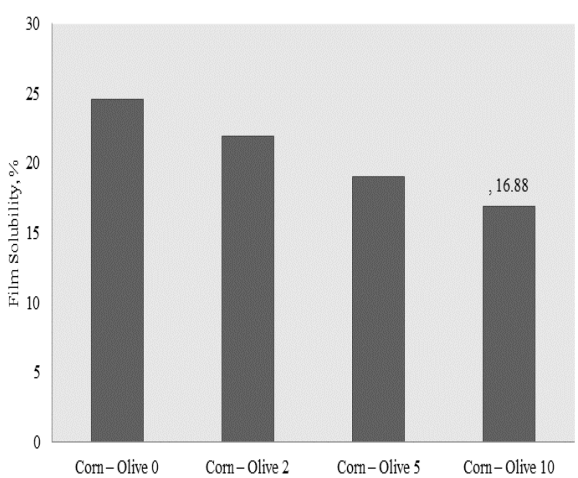


Figure 3: Solubility of Corn-Olive oil composite film against Corn starch film

4.4. SEM Analysis:

Figure 4 and Figure 5 shows the SEM images of corn starch edible film and corn starch-Olive oil edible film respectively. It is seen from the SEM images of the film prepared from corn starch (Figure 4) that the film surface is not smooth as compared to that of the composite film prepared from corn starch-Olive oil (Figure 5). Due to strong interactions of olive oil with corn starch, the film surface bonding was better and the surface was modified with smooth surface. It is also observed from SEM images that the plasticizing effect was improved by the addition of olive oil. Olive oil improves not only the water barrier properties, but also the film forming capacity.

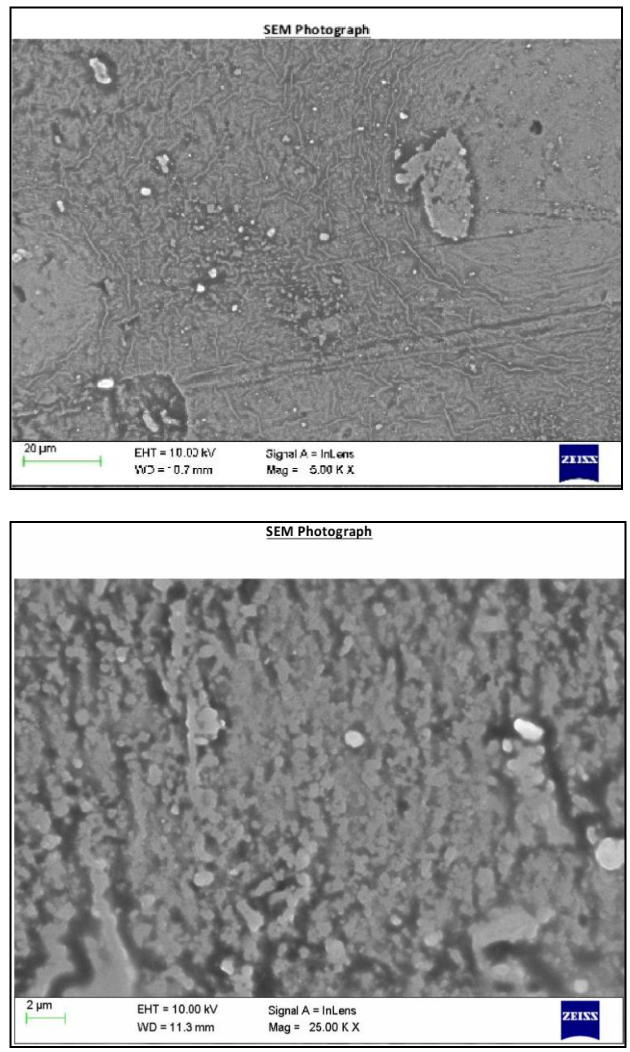
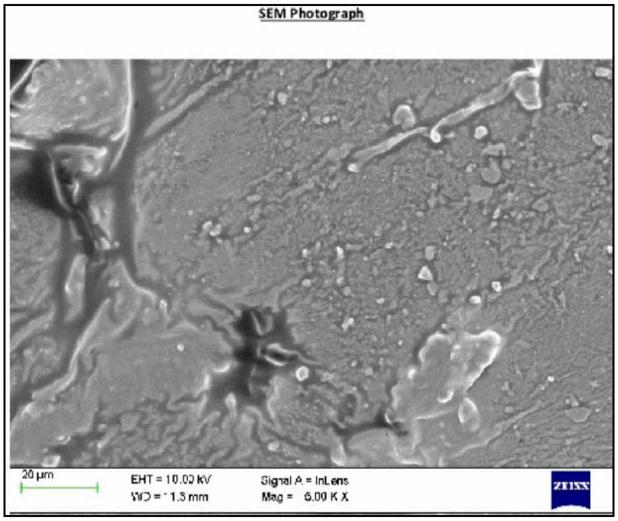


Figure 4: SEM Images of Corn Starch Film



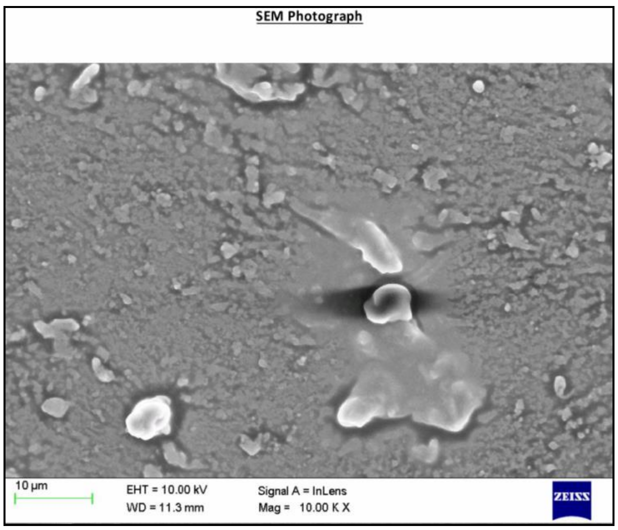


Figure 5: SEM Images of Corn Starch and Olive Oil (5%) Composite Film

CONCLUSION:

In this work, the effects of lipid addition on starch based edible composite films were investigated. The edible composites, made of corn starch and olive oil, were produced using casting method by varying the olive oil concentrations (0%, 2%, 5% and 10%). Glycerol and vinegar (5% and 5%) were added to improve plasticizing effect. The specimens were made ready and tensile strength, water permeability and film solubility were determined for composite and non-composite films. 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. The results show that the addition of olive oil will improve the properties of corn starch based films so that they become more suitable candidates for packaging applications.

Nomenclature:

WVP : Water Vapor Permeability
ASTM : American Society for Testing and Materials
SEM : Scanning Electron Microscopy

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