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Effect of essential oil of cymbopogon citratus on physico-chemical properties, mechanical and barrier films of Chitosan

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The effect of essential oil (AE) lemongrass (Cymbopogon citratus) at concentrations of 0.05, 0.1 and 0.25% by physico-chemical, mechanical and barrier properties on chitosan films was investigated. The results showed that films made with the essential oil of Cymbopogon citratus at concentrations of 0.1 and 0.25% Tween show a significant impact on the film thickness with respect to control and films with 0.05% AE. Chitosan films with essential oil and Tween 20 showed an increase in the solubility values from control. The addition of the essential oil on chitosan films reveals an effect on the values of tensile strength and elongation. The addition of the essential oil of Cymbopogon citratus stable in the properties of water vapor permeability of films made based on Chitosan.

Edible Films, Chitosan, Cymbopogon Citratus, Mechanical Properties, Barrier Properties.

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Introduction

The Cymbopogon citratus, commonly known as lemongrass, is a plant that is cultivated in most tropical and subtropical countries, belongs to the grass family, is consumed as aromatic beverage and is used in traditional medicine (Schaneberg and Khan, 2002). Wannissorn et al. (1996) reported that citral is the main active component of lemongrass oil, giving it a characteristic odor (Parikh and Desai, 2011). Studies have shown that some components of the oil have antimicrobial effects (Bassolé et al., 2011) and antifungal (Wannissorn et al., 1996; Sánchez-García et al., 2007; Nguefack et al., 2009); in this context the essential oil of Cymbopogon citratus has been added in formulations of chitosan films (Ojagh et al., 2010).

Although some AE have been shown to provide a positive effect in the mechanical and water vapor permeability properties in edible films (Souza et al, 2011;.. Abdollahi et al, 2012), there is still little information (Peng et al ., 2013) to be added in chitosan films. To consider an edible film of good quality should have low water vapor permeability and good mechanical properties in addition to preventing moisture loss or absorption of water through the food matrix (Dotto et al., 2011). Currently, chitosan is a polymer that plays an important role in the global economy, as it is biocompatible, biodegradable, edible and antimicrobial (Martelli et al., 2013). It also has the ability to form films that are used in preserving fruits and vegetables, (Jiang et al, 2011;. Mura et al, 2011;. Jirukkakul, 2013), which have low oxygen permeability (Moreno Osorio et al, 2010;. Kim et al., 2003; and Korkhov Kerch, 2010;. De Moura et al, 2011), however the main drawback of their high permeability is water vapor, which could be improved by adding components such as AE (Cháfer et al, 2012;. Krkic et al, 2012.).

Target

The purpose of this study was to evaluate the physicochemical, mechanical and barrier properties of chitosan films adding citratus lemongrass essential oil at different concentrations.

Materials and methods

Materials

Chitosan, commercial grade, deacetylation greater than 80% and less than 0.5% insoluble material, glycerol and acetic acid were purchased from Sigma-Aldrich, St. Louis, USA The Cymbopogon citratus was acquired from the coarse center of Puebla.

Extraction of essential oil

The plants were dried at room temperature for one week, extending in trays, turning three times daily for ventilation and accelerate drying, preventing the growth of microorganisms. The essential oil of Cymbopogon citratus was obtained by the method of hydrodistillation from 50 g of plant material, the extraction time was 60 minutes (Baizabal, 2010).

Preparation of the film forming solution

Chitosan (1% w / v) in aqueous glacial acetic acid (0.1%, w / w 25 ° C) was dispersed. It was constantly stirred with a magnetic stirrer for 4 hours. After the chitosan was completely dissolved, filtered through a gauze. 2.5% glycerol (w / w chitosan) was added as plasticizer, stirring the solution for 1 hour. The essential oil of Cymbopogon citratus is dissolved in 0.1% Tween (v / v) and added to the solution to achieve concentrations of 0.05, 0.1 and 0.25%, stirred 1 hour and then bubbles were removed by placing the solution under vacuum.

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Filming

Films were formed by the casting technique used by Eum et al. (2009), 200 mL of the chitosan solution was emptied containers in nonstick 20 x 20 cm and dried at 30 ° C for 48 h. Once dried, they were detached from the plate by keeping them at a relative humidity of 50 ± 5% for 48 hours to be analyzed subsequently. Each treatment was performed in triplicate

Film thickness

The thickness of the films was measured with a micrometer Bag (Mitutoyo No. 2412F, USA) with a resolution of 0.001 in. The films were measured in 8 points of the same sample was considered the average value.

Solubility

A modified method Andreuccetti et al. (2011) was used to measure the solubility of the film; pieces of film (2 x 2 cm) were cut dried at 70 ° C for 24 to 18 h in Hg for the initial dry mass. The films were placed in beakers containing 50 mL of 30 mL distilled water. The beakers were covered with plastic and stored at room temperature for 24 h. Then the remaining water in the beakers was discarded and the residual film was rinsed with distilled water. Waste film pieces were dried at 70 ° C to 18 in Hg to determine the dry mass. The solubility was calculated using the following equation:

$$(\%) = \frac{Mi - Mf}{Mi} x\ 100 \qquad (1)$$

Where: Mi and Mf are the initial and final mass of sample in grams.

Mechanical Properties

Tensile properties were determined using a model TA-TX2 texture analyzer (Texture Technologies Corp., USA) according to the method of Leerahawong et al. (2011) with some modifications. The films were cut into squares of 9 x 9 cm parameters for tensile strength, plastic circular cell diameter of 3.9 cm were used to maintain the fixed and stretched films. Strips of 6 x 1 cm were used to determine the percent elongation at break. For measuring the parameters described above a load cell of 25 kg, a cylindrical probe with diameter 0.4 cm, at a speed of 1 mm / s and the distance traveled by the needle was 20 mm was used. The tensile strength and elongation percentage were calculated using the following equations:

$$TS\ (MPa) = \frac{f}{A} \qquad (2)$$

Transversal area= Film thickness(mm) x film width (mm)

Where f is the breaking force (N) and A is the cross sectional area of the film in m2.

$$\text{Elongation } (\%) = \frac{\Delta L}{L} x\ 100 \qquad (3)$$

Where: L is the increase in length in the breaking point (mm) and L is the length of 20 mm initial attachment.

Water vapor permeability

The water vapor permeability was determined using the E96-E96-10 (ASTM) method, film rectangles 2 x 2 cm were cut and placed in the mouth of pesasubstancias (PS) with diameter of 2.01 cm, containing 2 g anhydrous calcium chloride (0% relative humidity) for a pressure gradient. The film joined the mouth of PS with parafilm to avoid leaks. PS were placed in a desiccator containing saturated NaCl (75% RH) at 25 ° C solution. Water transmission was calculated through the film PS weight gain.

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Weights were recorded every two hours for ten hours. Weight change of PS is plotted against time, the slope of each line by linear regression were calculated. The coefficient of water vapor transmission (WVTR) was calculated from the slope (gh-1) divided by the cell area (cm2), The permeaza WVTR was obtained by dividing the difference of water vapor pressure through the film (g / h.cm2.Pa). Thickness (mm) was measured and this determination permeability (WVP) (g.mm/h.cm2.kPa) was calculated. Three replicates were performed for each treatment.

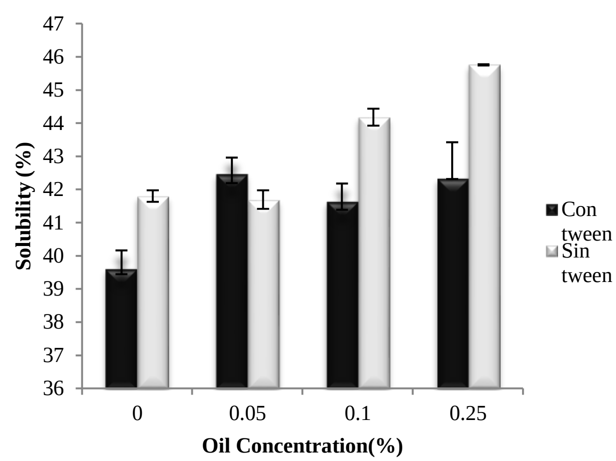
Statistical Analysis

An analysis of variance and Tukey tests were performed to assess differences between treatment means using the Minitab 16 software (LEAD Technologies Inc., NJ). A $P < 0.05$ was considered statistically significant.

Results and discussion Solubility

Edible films solubility is an important feature because it can influence the stability of the film in humid environments. The films made without tween 20, showed increased solubility values with increasing concentration of AE, presented the highest value of 45,759 ± 0021 at a concentration of 0.25%, as shown in Graphic 1. It showed a decrease solubility values in control and film AE 0.05%, this behavior may be attributed to the effects of crosslinking between the chitosan and the AE (Peng et al., 2013). Movies with tween AE showed increased solubility values from control. This is attributed to the weak interactions tween chitosan with AE, oil droplets migrate to the surface of the film, the film contacting with water the oil droplets which are in the surface of the film are released in the water, increasing the contact area of the film with water leading to increased solubility in the film, this effect was reported by Zhong and Li in 2011.

Significant difference ($p < 0.05$) was found in films made with 0.05, 0.1 and 0.25% tween 20 with respect to control. In films made without tween at concentrations of 0.1 and 0.25% AE significant difference ($p < 0.05$) was observed compared to the control and movies with 0.05% AE. The values obtained in this study are similar to those reported by Rhim et al., (1997) based films carrageenan. Higher solubility values of 92.3 ± 1.3 to 97.3 ± 1.5 were reported by Moura et al., (2011) films based on cellulose with chitosan. Moreover Rawdkuen et al., (2012) reported values of 43.96 ± 2.57 to 57.51 ± 2.04 in gelatin based films.



Graphic 1 Solubility of Chitosan films with essential oil of Cymbopogon citratus at concentrations of 0, 0.05, 0.1 and 0.25 with and without Tween AE. a-c

Different letter indicates significant difference between treatments, determined by the Tukey test (P0.05).

Elongation

Elongation is a measure of the stretchability of the film before breaking; this property is related to the intermolecular forces of the film. (Atares, et al., 2010).

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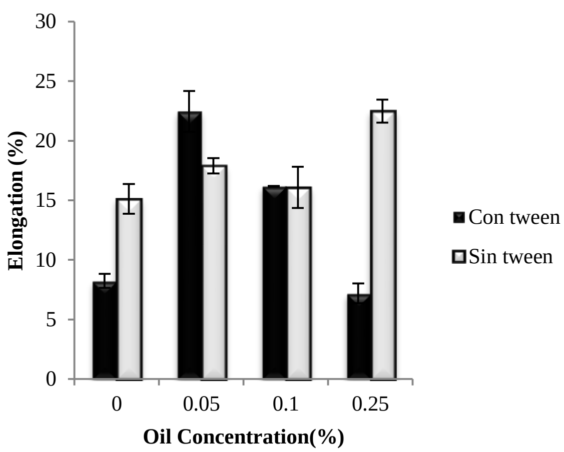
In Graphic 2 a significant (p <0.05) is observed in the elongation values by increasing the concentration of AE in films made with tween, indicating a loss of the macromolecular mobility. Sánchez-González et al., 2010; Ojagh et al., 2010; Peng and Li, 2014, reported that the elongation at break decreases on chitosan films by incorporating essential oils of bergamot, cinnamon, lemon and thyme, these authors report that chitosan composition, the plasticizer type and the presence of surfactants have an effect on the mechanical properties of the films. In films made without tween increased elongation values by increasing the oil concentration from 0.1 to 0.25% present. Higher elongation values were obtained by Leerahawong et al., 2011, in protein-based films obtained from squid, because the formulation of the film-forming solution.

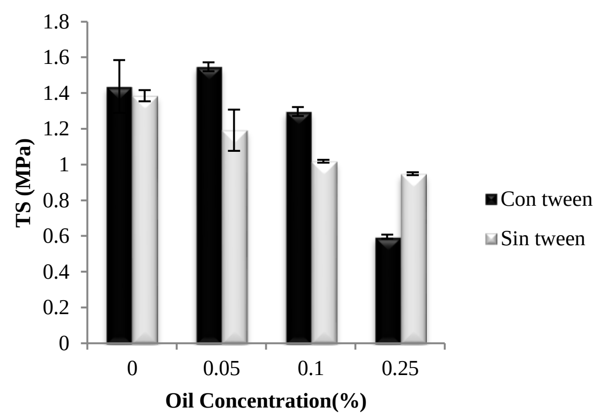


Graphic 2 Elongation chitosan films with essential oil of Cymbopogon citratus at concentrations of 0, 0.05, 0.1 and 0.25 of EO with and without Tween. a-c

Diferent letters indicates significant difference between treatments, determined by the Tukey test (p < 0.05).

Tensile strength

The effect of increasing concentrations of AE in films with and without Tween shown in Graphic 3, the results showed a decrease in the values of tensile strength with increasing concentration of AE, with and without Tween. This behavior is considered because of a strong interaction between chitosan and AE producing a crosslinking effect, decreasing the free volume and molecular mobility of the polymer. Having the lowest value of 0.5960 ± 0.011 in films with 0.25% Tween EO, showing significant difference (p <0.05) compared to films made with 0.05 and 0.1% of EO. Peng, et al., (2013) reported a decrease in the TS values AE lemon incorporate chitosan films relative to the control. However Ojagh, et al., (2010) reported an increase in TS values by adding cinnamon AE films, this behavior is attributed to the type of chitosan, plasticizer type and interactions between the AE and chitosan.



Graphic 3 Tensile Strength on films of chitosan with essential oil of Cymbopogon citratus at concentrations of 0, 0.05, 0.1 and 0.25 of EO with and without Tween. a-c

Diferent letters indicates significant difference between treatments, determined by the Tukey test (p < 0.05).

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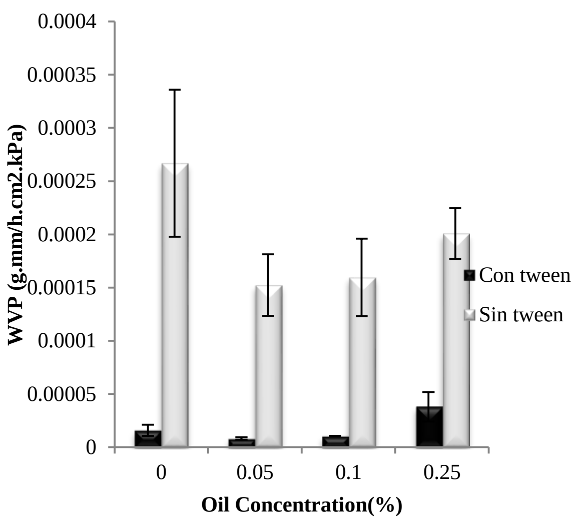
Water vapor permeability

One of the main functions of edible films is to minimize moisture transfer between the food and the atmosphere surrounding it. Therefore the water vapor permeability should be as low in order to increase the shelf life of the food (Hosseini et al., 2013). Lower permeability values are presented in movies with tween compared with the values displayed in movies without tween. AE adding chitosan films without tween improved barrier properties to water vapor in the films, this effect was reported by Ojagh et al., (2010) AE chitosan films with cinnamon. Movies made with 0.05% Tween AE and had lower permeability values of 0.8309 ± 0.11 × 10-5 g.mm/h.cm2.kPa.



Graphic 4 Water vapor permeability in chitosan films with essential oil of Cymbopogon citratus at concentrations of 0, 0.05, 0.1 and 0.25 of EO with and without Tween. a-b

Diferents letters indicates significant difference between treatments determined by the Tukey test ($p < 0.05$).

Conclusions

This study shows that chitosan films formulated with essential oil of Cymbopogon citratus at concentrations of 0.25% Tween have a significant effect on the film thickness. Films with AE and tween showed increased solubility values from control. A significant decrease in elongation values to increase the concentration of AE in films made with Tween was shown. Adding chitosan films AE has an effect on the values of tensile strength. The essential oil of Cymbopogon citratus showed stability properties of water vapor permeability of films made based on chitosan. Chitosan is a biopolymer promising for food packaging, the moisture sensitivity can be improved by adding AE of Cymbopogon citratus.

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