WATER SORPTION AND PERMEABILITY OF EDIBLE FILM MADE FROM AL-ESHAR (CALOTROPIS) AND GELATIN

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ABSTRACT

Al-Eshar (Calotropis) is a natural Eco-friendly Packaging materials whereas they are safety and healthy. Water permeability of edible film made from fine cottony pubescent hair of Al-Eshar plant and Gelatin was investigated. Edible films were prepared by adding 2 gm of Al-Eshar to different concentration of Gelatin solution (2, 4, 6 and 8%). Water vapor transmission rate and water vapor permeability was measured. The results observed that water vapor permeability was very low for all samples. In order to investigate the water sorption behaviour and isotherms of the film, the water sorption data were fitted to Peleg model. Gas permeability was measured for Al-Eshar edible films.

Keywords: Al-Eshar, Calotropis, edible films, Gelatin, Water permeability, Water Aborption

I. INTRODUCTION

More than five billion tons of waste from packaging materials is produced annually in the world, 30% of which are plastic compounds. Pollution with synthesized plastics, which is called white pollution, forms a major part of environmental pollution in industrial countries, and also in developing countries (Liu, et al., 2012).

Calotropis procera is a member of the plant family, Asclepiadaceae, a shrub widely distributed in West Africa, Asia and other parts of the tropics. The plant is erect, tall, large, branched and perennial with milky latex throughout .A large quantity of latex can be easily collected from its green parts. Local people use it successfully to combat some cutaneous fungal infections. The abundance of latex (containing alkaloids) in the green parts of the plant reinforces the idea that it produced and accumulated latex as a defence strategy against organisms such as virus, fungi and insects. (Abbas, et al., 1992 and Carlini & Grossi-de Sa, 2002(

It is known by various vernacular names like Swallow wort in English, madar in Hindi, and Alarka in Sanskrit. It is found in most parts of the world with a warm climate in dry, sandy and alkaline soils. Calotropis is primarily harvested because of its distinctive medicinal properties. It is commonly referred to as ark, swallow-wart or milkweed and it occurs frequently in Indonesia, Malaysia, China, and the Indian subcontinent as wasteland weed. Calotropis procera Linn is an erect, tall, large, highly branched and perennial shrub or small tree that grows to a height of 5.4 m, with milky latex throughout. The bark is soft and corky, the branches are stout, terete with fine appressed cottony pubescence (especially on young). The leaves are sub-sessile, opposite, decussate, broadly ovateoblong, elliptic or obovate, acute, thick, glaucous, green, covered with fine cottony pubescent hair on young but glabrous later and base cordate. Flowers in umbellate-cymes and tomentose on young, Calyx glabrous, ovate and acute. The corolla is glabrous, the lobes erect, ovate, acute, with coronal scales 5-6, latterly compressed and equally of exceeding the staminal column. (Ajay, et al., 2011)

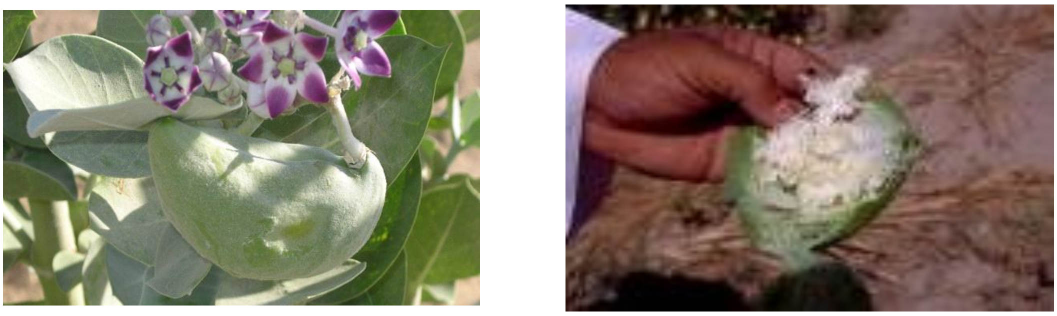

Fig. 1 Calotropis Procera Flowering Shoot

Gelatin is an abundant raw material, produced in the whole world at low cost and has excellent film forming properties (Gennadios et al., 1994). Edible films are a viable means for incorporating food additives and other substances to enhance product colour, flavour, and texture and to control microbial growth (Sorrentino, et al., 2007). Edible films or coatings constitute thin layers of material that are suitable for consumption and which act as a barrier against different agents (water vapor, oxygen, and moisture). They help to improve the quality and extend the shelf life of fresh and processed foods (Sánchez-González et al., 2011).

Edible films also may serve as gas and solute barriers, thereby improving the quality and shelf life of foods. Results from different experiments demonstrated that gelatin dips significantly improved oxidative and color stability of the treated products, as compared to untreated controls. Additional studies have demonstrated that gelatin can be used to carry antioxidants, to reduce oxidation, enhance color stability, to retain flavor, taste, and aroma of foods during refrigerated or frozen storage. Gelatin films have been used as a delivery system for applying antioxidants to poultry or applied directly to food surfaces or processed foods to prevent microbial growth, salt rust, grease bleeding, handling abuse, water transfer, moisture loss, and oil adsorption during frying. Despite these successes, gelatin lacks strength and requires a drying step to form more durable films (Cutter, 2006).

Water sorption isotherm equations are useful for predicting water sorption properties of hydrophilic films; they provide little insight into the interaction of water and film components. There are several mathematical models to describe water sorption isotherms of food systems materials, but no one gives accurate results throughout the whole range of water activities, or for all types of foods systems (Al-Muhtaseb, McMinn, & Magee, 2004).

Oxygen permeability (O_2P) of food packaging materials is of great importance for food preservation, since oxygen is the key factor that might originate oxidation, which initiates several deterioration reactions (Sothornvit and Pitak, 2007). Also the measurement of permeability of edible films to carbon dioxide provides important information for the development of edible films, especially for the design of modified atmosphere packaging (McMillin, 2008)

The objective of this study was to investigate the feasibility of the use of Al-Eshar soluble in Gelatin for the formation of edible film. The optimal process conditions for film preparation were investigated, as well as water vapor permeability and water sorption for these edible films.

II. MATERIAL AND METHODS

2.1. Materials

Calotropis (Al-eshar) was collected from Ismailia desert road, Egypt. Gelatin and Glycerol was obtained from Acmetic company.

2.2. Methods

2.2.1. Preparation of edible film

Four samples of Al-Eshar/gelatin edible film forming solution was prepared by dissolving gelatin in distilled water with stirring at 60°C using a thermostatic water bath ( ) and adding 1% glycerol as plasticizer in order to obtain (2, 4, 6 and 8%). Fine cottony pubescent hair of Al-Eshar plant (2 gm) was cut to very small pieces and added to different concentrations of gelatin solution, the mixture was stirred at 100°C and 400 rpm for 15 min. to obtain a homogenized solution. The prepared solution was poured into a petri dish and placed into a laboratory oven at 40°C for 24 hours to dry the samples, after drying the film was peeled off manually. Thickness of films was determined using a 0-25 mm manual micrometer with an accuracy of 0.01 mm. The reported values are the average of four readings taken randomly on each film sample. It was used in calculating the film WVP.

2.2.2. Moisture absorption

Moisture absorption is an important indicator of the sensitivity of material to moisture. The edible film made from Al-eshar and Gelatin was cut into dimension of 30 mm x 30 mm and placed inside a desiccator containing silica gel (0% relative humidity) for 5 days at a constant temperature of 303K (Suppakul, 2006). Desiccator acts as a humidity controller for film storage in the water sorption analysis including during film preparation. The weight of the film before it was placed inside the desiccator was measured and labelled as W_i. Then, the weight of the film after it was pre-dried inside dessicator for 5 days was measured and labelled as W_d. The initial moisture content was calculated using the following equation:

$$M_i = \frac{W_i - W_d}{W_d} \qquad (1)$$

Where, M_i is the initial moisture content (% dry basis), W_i is the initial weight of the sample (g), and W_d is the dry weight of the sample after pre-dried in desiccator (g).

The 5-days pre-dried films were then placed inside separate desiccators with different saturated salt solution in triplicate samples for each salt solution. The temperature was kept at 303K. Saturated salt solutions used in this experiment were Sodium Chloride. The weight gained for each sample was determined using digital balance for the first 2 and 5 hours. After that, the weight of the film was measured periodically every 24 hours for 7 days.

The moisture sorption data of the film was fitted to a mathematical model particularly Peleg model. Peleg model has been widely used to describe the sorption process. The following is the equation proposed by **(Peleg, 1998)**

$$M(t) = M_i + \frac{t}{k_1 + k_2 t} \qquad (2)$$

where, M(t) is the moisture after time t (%), M_i is the initial moisture (%), k_1 is the Peleg rate constant, and k_2 is the Peleg capacity constant.

2.2.3. Determination of Water vapor permeability (WVP)

The water vapor transmission rate [g./(s.m^2)] and water vapor permeability (WVP) through films was determined gravimetrically using the ASTM Method E96-95. A circular test cup was used to determine the WVP of the film. The film was first cut into circular shape that was larger than the inner diameter of the cup, the cup was filled with 50% distilled water and the film was sealed at the top using Paraffin oil, then the cups were placed in a desiccator containing calcium chloride with relative humidity RH (0%) and RH for water (100%). The weights of the cups were recorded every hour during 10 hours and to specimens of each film were tested. Linear regression was used to estimate the slope of this line in g/h. The water vapor transmission rate (WVTR) and water vapor permeability was determined using the following equations:

$$WVTR = \frac{\Delta m}{\Delta t \ A} \qquad (3)$$

$$WVP = WVTR \frac{L}{\Delta RH} \qquad (4)$$

Where, $\Delta m / \Delta t$ is the moisture gain weight per time (g/s), A is the surface area of the film m^2, L is the film thickness (mm) and ΔRH is the difference in relative humidity.

2.2.4. Measurement of gas Permeability

Gas (O_2 and CO_2) permeability at 30°C was measured in a designed stainless cell using a gas testing instrument, model Witt Oxybaby headspace gas analyser (O_2/CO_2) following the method described by García et al. (2000). The gas permeability (P) was calculated according to the following equation:

$$P = \frac{Q.X}{A.t.\Delta p} \qquad (5)$$

Where, P is the permeability of gas, (m^3/m.day.mmHg), Q is the quantity of gas diffused m^3, X is the thickness of film, A area of the film, m^2, t is the time, day and Δp is the pressure difference across the film.

III. RESULTS AND DISCUSSION

3.1. Preparation of Edible Films

Figure (2) shows the edible films prepared by mixing 2 gm of Al-Eshar with different concentrations of Gelatin solution (2, 4, 6 and 8%).

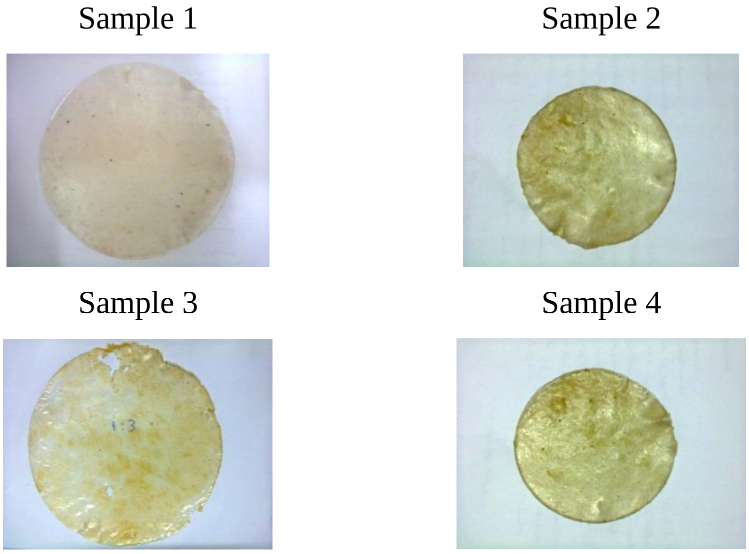

Fig. 2 Edible films made from Al-Eshar and Gelatin

Table (1) shows the thickness of edible films from Al-Eshar and Gelatin, the results observed that thickness of gelatin edible film without Al-Oshar was 0.082 mm. By adding Al-Oshar to gelatin with different ratios the thickness increased and the lowest thickness was for sample 2.

Table 1 Thickness of edible films made from Al-Eshar and Gelatin

Sample	Thickness, mm
Gelatin	0.082
1	0.192
2	0.106
3	0.177
4	0.298

3.2. Moisture absorption

The edible film made from Al-Ashar and Gelatin was first pre-dried for 5 days to remove initial moisture inside the film. After 5 days, it was found that the film loss an average amount of moisture content which was designated as the initial moisture content of the film, Mi. The initial moisture content was 0.45, 0.58, 0.73 and 0.92 % for samples 1, 2, 3 and 4 respectively.

Figure (2) shows the water sorption data of the four samples over a period of 7 days (168 hours), the results observed that that moisture content of the film increased rapidly for the first 5 hours which indicates early stage of the water sorption of the film. After around 24 hours and above, the moisture content of the edible film reached a plateau indicating that moisture content is equilibrated with the relative storage humidity.

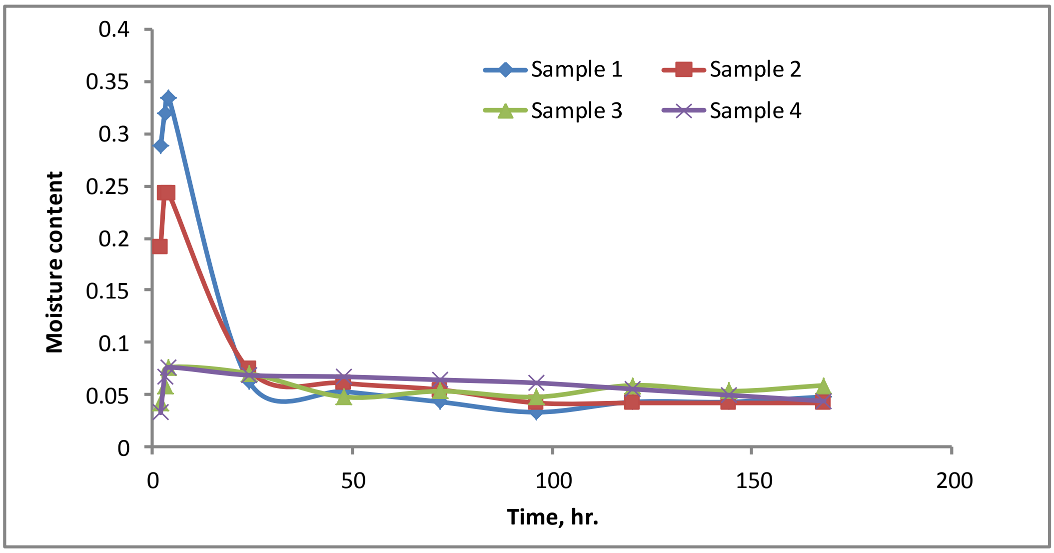

Fig (2): Water sorption of edible film made from Al-Eshar and Gelatin

The water sorption data of the film over a period of 7 days (168 hours) were then fitted using Peleg model (Equation 2) as shown in Fig. (2).

The Peleg parameters (Peleg, 1988), k_1 and k_2 are shown Table (2), As k_1 is a constant related to mass transfer, the lower k_1, the higher the initial water adsorption rate; k_2 is a constant related to maximum water adsorption capacity and the lower the k_2, the higher the adsorption capacity (Turhan, et al., 2002).

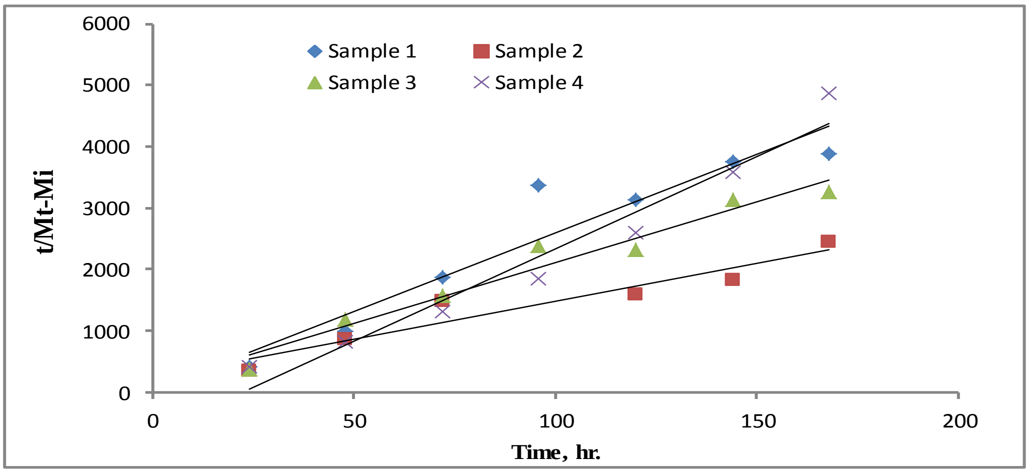

Fig3: Peleg Model

Table (2) Peleg model parameters

Sample	k_1	k_2
1	33.067	25.613
2	234.58	12.48
3	136.62	19.787
4	677.28	30.067

3.3. Water vapor permeability

The ability of packaging materials to refrain or minimize moisture transfer between the food and the surrounding environment is a crucial property for effective food packaging. Water vapor permeability should therefore be as low as possible in order to optimize the food package environment and potentially increase the shelf life of the food product (Mali, et al., 2004 and Hosseini et al., 2013).

Water vapor transmission rate (WVTR) is the rate of water vapor being permeates through the film. WVTR was determined from the slope of the regression line of sample weight versus time graph whereby the slope was then divided with the area of the film being exposed to transmission (Equation 1). Figure (3) shows the relation between weight and time. The results observed that Weight of the cups decreased as time increased for all samples studied.

Table 2 shows the slope of linear regression line of sample weight versus time graph and water vapor permeability of the edible film for different concentration of gelatin and constant concentration of Al-Eshar. The results observed that WVTR for gelatin film without Al-oshar was 11.704 and increased by adding Al-oshar to gelatin. WVTR decreased with the increasing of gelatin concentration and the lowest WVP was for sample 2 (0.04 g. mm/ m^2. mmHg).

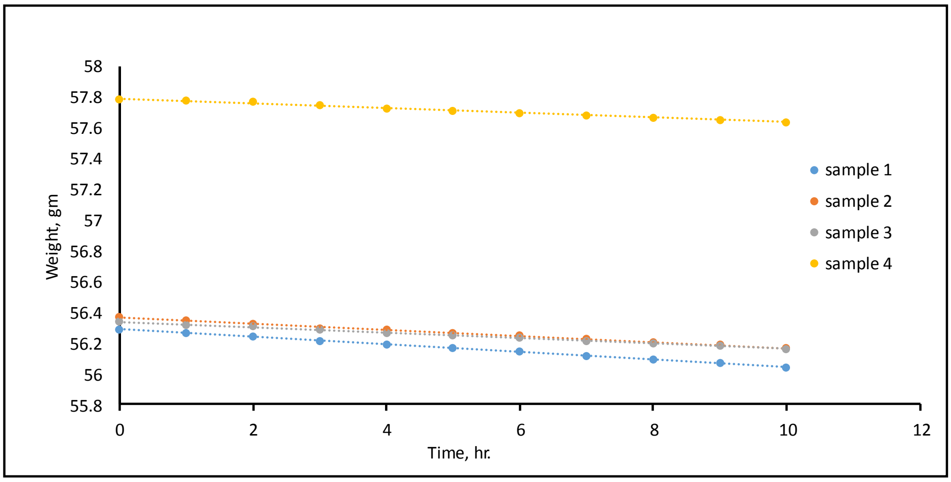

Fig3: The relation between weight and time for edible film made from Al-Eshar and Gelatin

Table (3) Water vapor transmission rate and water vapor permeability

Sample	slope	Area, m^2	WVTR	WVP, (g. mm/m^2. day. mmHg)
(gelatin)	0.0147	0.0013	11.704	0.023
1	0.0246	0.0013	19.586	0.09
2	0.0198	0.0013	15.764	0.04
3	0.0175	0.0013	13.933	0.059
4	0.0154	0.0013	12.261	0.087

3.4. Gas Permeability

Gas permeability was measured using a stainless steel cell and Oxygen analyser instrument. The results observed that O_2 permeability for gelatin film was higher than the blend of El-Oshar and gelatin. O2 permeability increased with increasing gelatin concentration that gives high barrier properties to Oxygen as gelatin concentration increased in agreement with the work of (Bertan et al., 2005; Hassan and Norziah, 2012) who reported that oxygen permeability increased as gelatin content increased., while CO_2 permeability decreased with increasing gelatin concentration, this may be explained by the distribution of Al-Eshar particles in different concentrations of Gelatin solution.

Table (4) Gas permeability for edible films made from El-Eshar and Gelatin

Sample	O_2 Permeability (m^3/m.day.mmHg)	CO_2 Permeability (m^3/m.day.mmHg)
Gelatin	4.98509E-06	2.18519E-06
1	2.87843E-09	7.38277E-09
2	3.6965E-09	5.70713E-09
3	8.87278E-09	3.05121E-09
4	11.4598E-09	2.48953E-09

IV. CONCLUSION

Edible films made from Al-Eshar and Gelatin with different ratios was prepared by heating and mixing at 400rpm to have a homogenized solution. WVTR and WVP were investigated, WVTR decreased as concentration of Gelatin increased, while WVP didn't give a trend and the lowest permeability was for sample 2. The moisture content of the film increased rapidly for the first 5 hours which indicates early stage of the water sorption of the film. After around 24 hours and above, the moisture content of the edible film reached a plateau indicating that moisture content is equilibrated with the relative storage humidity. Gas permeability was also determined by using a stainless steel permeation cell. O_2 permeability increased with increasing gelatin concentration, while CO_2 permeability decreased.

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