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PREPARATION OF EDIBLE FILMS FROM TAMARIND MUCILAGE AND STUDYING THEIR PROPERTIES AND APPLICATION IN PACKAGING OF CHEDDAR CHEESE

Ahmed H. A. Al-Jobouri
Researcher
ahmedhual@gmail.com
Date palm and Dates Center \ Horticulture Office \ Ministry of Agriculture

ABSTRACTS

The object of this study was to prepare Edible films from Tamarind mucilage solutions 0.5,1,1.5% and plasticized with glycerol 50% (w/w) of the mucilage. An increase in the thickness of the films and the elongation percentage were observed with an increase in the concentration of the mucilage, as it reached 0.06,0.09,0.11 mm and 26.7,30.2,33.4 %, respectively, while the tensile strength, solubility, and oxygen permeability rate decreased with the increase in the mucilage concentration and reached 15.62,12.81,9.78 MPa, 46.6,40.8,36.2 % and 32.91,28.78,25.55 ml / m^2. Day. respectively, The results showed the possibility of using tamarind mucilage films to produce cheddar cheese with good nutritional and qualitative properties.

Keywords: Mucilage, Tamarind, *Tamarindus indica* L., Edible film, Cheddar Cheese

تحضير اغشية من هلام نوى التمر الهندي ودراسة خصائصها وتطبيقها في تغليف جبن الشدر

احمد حسين الجبوري
باحث
ahmedhual@gmail.com
وزارة الزراعة / دائرة البستنة / مركز النخيل والتمور

المستخلص

هدفت الدراسة الحالية الى تحضير اغشية من محاليل هلام نوى التمر الهندي *Tamarindus indica* L. وبتراكيز 0.5،1، 1.5% والملدنة مع الكليسرول بنسبة 50% من وزن الهلام. لوحظ ازدياد في سمك الاغشية ونسبة الاستطالة بزيادة تركيز الهلام اذ بلغت 0.06،0.09،0.11 ملم و 26.7،30.2،33.4 % على التوالي، في حين انخفضت قوة الشد والذوبانية ومعدل نفاذية الاوكسجين مع زيادة تركيز الهلام وبلغت 15.62،12.81،9.78 ميكا باسكال و 46.6،40.8،36.2 % و 32.91،28.78،25.55 مل /م^2. يوم على التوالي . اظهرت النتائج امكانية استخدام اغشية هلام نوى التمر الهندي في انتاج جبن الشدر ذو صفات تغذوية ونوعية وصحية جيدة .

الكلمات المفتاحية : الهلام ، التمر الهندي ،*Tamarindus indica* L. ، الاغشية القابلة للأكل ، جبن الشدر .

INTRODUCTION

Packaging materials make up a high proportion of the cost of producing food products. Where it ranges between 20-50% depending on the nature of the product produced, it is necessary to find suitable alternatives that help reduce costs and ease of use, and in the preferred forms by consumers (Al-aswad. *et. al*., 2000). It is clean, pure, and non-polluting materials. It performs the required purpose in food processing, which is to prolong the preservation of food for the longest possible period without affecting its natural properties (Cimmino *et. al*., 2014). The materials used in its manufacture vary greatly, including solid minerals like cans, metallic and flexible, such as aluminium foil and tin. Glass in glass bottles, hard and semi-hard plastics, and various classes of flexible plastics such as polystyrene (PS), polypropylene (PP) and polyethylene (PE) approved by the Food and Drug Administration (FDA) as well as paper, cardboard, and wood (Tomas, 2010). Over the years, studies have shown that there are toxic effects in packing materials and their ability to spread to the packaged product as well as environmental problems resulting from the disposal, which called for researchers and manufacturers to produce covers of natural organic materials that are biologically degradable in the environment, including polymers such as polysaccharides, proteins, and fats. (Neethirajan, S.; and Jayasa, D. 2011). There are several techniques used to diagnose and characterize coatings (or films), such as UV radiation. Transmission & Scanning electron Microscope and FTIR technology (Filipponi, L. and Sutherland, D. 2013). As well as, several characteristics must be studied for testing, they are summarized by thermal properties (melting temperature, crystallization temperature), mechanical (tensile strength, elongation, and Yonk coefficients), and optical properties such as permeability and barrier (oxygen permeability and permeability of water vapor). Cheddar cheese is a common type of cheese and is prone to microbial and chemical damage during cooling and ripening, so there is an urgent need to reduce this deterioration and corruption of the product and increase its suitability (Yoon *et al*., 2016).

Tamarind seeds mucilage are naturally available polymers and it has good characteristics of the above mentioned. As well as being against various types of microorganisms (Datta and Bandyopadhyay 2006). The mucilage is extracted from the endosperm of the tree seeds *Tamarindus indica* L. by drying and grinding the seeds, it gives an endosperm powder that has a high thickness of thickening by bonding with water, which is a highly branched polysaccharide with a high molecular weight measured at 52350 Dalton, and it consists of three types of mono sugars. D-glucose, D-calcux, D-xylose in molar ratios 1: 2: 3 respectively, Fig. 1. (Jassim,1987).

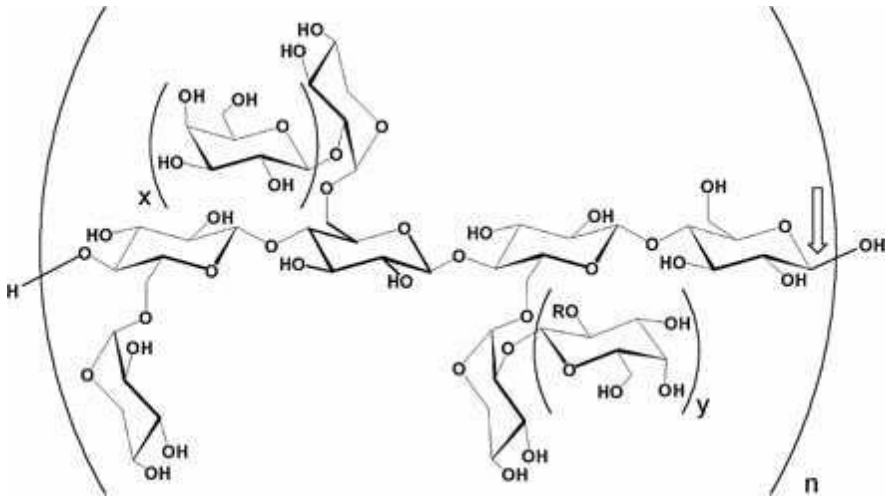

Figure 1. Chemical composition of *Tamarindus indica* L. Mucilage (Jassim,1987**)**

In view of the increased demand for natural polymers and the abundance of raw material (seeds), which are waste for the production of tamarind syrup. And lack of studies on this mucilage. Therefore, the study aimed to prepare mucilage films, and studying some of its different properties, and evaluate it as an edible film substance in cheddar cheese.

MATERIALS AND METHODS

Raw Materials

Tamarind was obtained from local markets in Baghdad, the seeds were isolated from the fleshy part of the fruit and washed to remove the leftover fruit the seeds were dried in sunlight. It was ground with a Laboratory Electric Mill Mixer (FM-300) to obtain the seeds powder, then sift the powder with a mesh of 40 mesh.

Mucilage extraction

The oil was removed from the tamarind seeds powder using the Soxhlet Apparatus intermittent extraction method by placing 5 g of the sample in a thimble and using hexane with a boiling point of 40-60 m ºC type (GCC) in the 6-hour extraction process (AOAC. 2005). The tamarind mucilage was extracted according to the method that was performed as described by (Kumar *et. al*., 2010). Soak 200 g of tamarind seeds powder in boiled distilled water for 5 hours to remove the outer dark layer of the seeds. The amount of distilled water was doubled with constant stirring in a water bath to reach a thicker texture cool the resulting solution and store in the refrigerator for the next day. Centrifuged at 500 rpm for 20 minutes. Separate the leachate formed and concentrate in a water bath at a temperature of 60 ° C until its volume drops to one- third of its original volume.

Let the leaching solution aside and reduce its temperature to room temperature. Add acetone as much as three sizes of leachate volume with continuous stirring. Dry under vacuum at a temperature of 50 - 60 ° C. The resulting powder is stored in tight containers.

Chemical composition of Mucilage

Moisture, ash, protein, fat, and carbohydrates in the mucilage powder were measured according to (AOAC, 2005).

Films Formation

The method was reported by (Tee *et. al*., 2016) was used in preparing the tamarind mucilage films with some modifications. Three mucilage films were prepared by using three concentrations of the mucilage solution (0.5, 1, and 1.5)% (A, B, and D) respectively. Sodium hydroxide was added in the mucilage solution and set the pH to 9. Then heating the solution at 80 ° C for 30 minutes with continuous stirring using the Hot Plate Stirrer. Glycerol was added as a plasticizer with 50% of the mucilage weight. The mixture was heated at 80 ° C for 5 minutes with continuous stirring. Let the mixture with continuous stirring without heating. Pour up to 10 ml of them into a petri dish and let them dry to 35 ° C for 24 hours. UV sterilized for an hour. The films were removed from the plates and placed for two days in a desiccator for use in testing their properties while providing 50% moisture and room temperature with potassium bromide at the bottom of the desiccator.

Films Thickness

The method was performed as described by (Leceta *et. al.,*2013) the thickness of films were measured by using a Chinese-origin micrometer with an accuracy of 0.01 mm. For each film, 5 readings were taken randomly, and the mean was taken to represent the thickness of the film.

Tensile Test

Tensile strength and percentage of elongation to cutting were measured according to (Ferreira *et. al.,* 2009).

Water vapor permeability (WVP)

The permeability of films was measured for water vapor according to the method described (A.S.T.M. 1996).

Oxygen permeability (OP)

The oxygen permeability rate for films was measured using the OTR device at the National Packaging Center / Industrial Research and Development Authority in Baghdad - IRAQ and its value is determined at a constant temperature of 23 ° C and 50% humidity and is measured according to the American classification (ASTM D3985 2010).

V: Sample Volume (cm^3)
A : Sample Area (cm^2)
t : Time (sec)

$$OP = \frac{V}{A\ t}$$

Water Solubility

Film susceptibility to water Solubility was measured according to the method used (Leceta *et. al.*,2013).

Cheese Coating Method

Cheddar cheese was wrapped according to was performed as described by (Pena-Serna *et. al.*, 2016). By exposing cheese blocks of about 500 g to ultraviolet light for the sterilization for an hour. Three layers of film solution were covered with tamarind seeds mucilage using a soft brush. On the first layer, They wiped the surfaces of the cheese with a film solution and left it to dry for an hour. The step is repeated in the second layer. In the third layer, it was wiped with a film solution and left to dry for 4 hours at room temperature and 50% humidity. Thus four samples of cheddar cheese, which represent film samples (A, B, and D), as well as the standard sample (C) was coated with paraffin wax are prepared as commercial packaging. Coated cheese samples were kept in cold rooms at 8 ° C for 90 days.

Microbial Analysis

All cultivated media attended into the laboratory. They were sterilized using autoclave at 121 ° C for 15 minutes. The total number of microorganisms and the number of molds was measured according to the method of APHA.,1978.

Sensory evaluation

Sensory evaluation of samples of cheddar cheese coated with the films under study and the comparison samples were conducted by specialized arbitrators in the field of food (academics and producers) and according to the sensory evaluation forms for coating film applications proposed from (Krochta, J .M. and DeMulder-Johnston,1997).

RESULTS AND DISCUSSION

The chemical composition of the mucilage powder was analyzed, the humidity, ash, protein, fat, and carbohydrates were (4, 5.9, 3.8, 14.65, and 76.58) respectively. Tis result close to which found by (Huanbutta K, and Sittikijyothin W. 2017; Verma Shubham *et. al.*,2014). The chemical composition of mucilage powder was different according to environmental conditions and fertilization as well as the different methods used in its extraction (Ravi Kumar *et.al.*,2010). The results are shown in Table 1. The thickness of the plasticized tamarind seed mucilage films (A, B,and D) by adding glycerol at 50% (w/w). As an increase in the thickness of the film was observed, the mucilage concentration increased by (0.06, 0.09, and 0.11) mm, respectively. This value is due to the increase in solids, which leads to increased cohesion and proper texture. These results were consistent with (Fakhreddin Salehi., 2019) when preparing films from different sources of polymers or gums.

Table 1 shows the tensile strength of the prepared films in this study, the tensile strength of the three films was (15.62, 12.81, and 9.78)Mpa, respectively. as it`s observed that the tensile strength of the mucilage decreases when the concentration of the mucilage increases, and this is consistent with what was reached by Nguyen, 2012. The glycerol separates the mucilage chains, creating hydrogen bonds between them and the mucilage (Kester and Fennema,1986).

Table 1. Characteristics of films prepared from tamarind seed mucilage

Films Characteristics*	A	B	D
Thickness (mm)	0.06	0.09	0.11
Tensile strength (Mpa)	15.62	12.81	9.78
Elongation (%)	26.7	30.2	33.4
Water Vapor Permeability (gm.mm/m².hr.KPa)	12.61	12.23	12.05
Oxygen Permeability (ml / m². Day)	32.91	28.78	25.55
Solubility (%)	46.6	40.8	36.2

*** The numbers in the table represent a rate of duplicates**

Table 1. shows the percentages of elongation of the three film samples. An increase in its percentage was observed with increasing mucilage concentration, (26.7, 30.2, and 33.4%), respectively. It is close to which found by (Kester, and Fennema,1986). The water vapor permeability of the films was measured, which was somewhat close to each other, as it reached (12.61, 12.23, and 12.05) gm / m². hour. KPa, respectively. This is consistent with that described by (Fakhreddin Salehi. 2019) when preparing films from different sources of gum.

The OP value of the prepared films was obtained (32.91, 28.78, and 25.55) ml / m². day, respectively. This finding is due to the form of the chemical composition and the percentage of solids, which blocks the amount of oxygen that penetrates into the film, as oxygen is the primary cause of food spoilage, hence increasing food preservation (Tihminlioglu, *et. al.*, 2010). The solubility of the films was measured in water reached (46.6, 40.8, and 36.2%), respectively. This is due to the difference in the degree of removal of acetyl groups between the samples, which in turn is reflected in the availability of free amine groups in the polymer, resulting in

NH3 groups, and these form hydrogen bonds with hydroxyl groups in water, so the solubility increases (Nemet *et. al.,* 2010).

Microbial Analysis

Microbial Analysis was performed on the coated cheddar cheese samples in this study, as well as the standard sample (C) (Paraffin wax) and for the periods (0, 30, 60, and 90) days of ripening. Table 2 shows the decrease in the total number of microorganisms in cheese-coated samples with mucilage films after the storage period of three months, as in the standard sample coated from 7.46×10^{4} to 5.8×10^{5} cfu. (Colony Forming Unit) . Whereas, it is observed that it decreased in wrapped cheese samples and ranged between (4.63×10^{5} to 8.54×10^{3}), (5.76×10^{5} to 6.28×10^{3}) and (2.87×10^{6} to 5.68×10^{3}) cfu. for A, B, and D samples, respectively. This indicates that covering the surfaces of cheddar cheese with mucilage films contributed to preventing the reproduction of air organisms by reserving oxygen, which is essential for their growth and thus prolonging their acclimatization phase (Torres *et. al.,* 1985). The total numbers of microorganisms increased in the wax-coated cheese sample due to cracks in it, allowing oxygen to penetrate and increase pollution.

Table 2. Total plate count in Cheddar Cheese Samples (Cfu)

Sample	Ripening (Day)*			
	0	30	60	90
A	4.63×10^{5}	1.83×10^{5}	5.48×10^{4}	8.54×10^{3}
B	5.76×10^{5}	2.38×10^{5}	5.64×10^{4}	6.28×10^{3}
C	7.46×10^{4}	1.56×10^{5}	2.93×10^{5}	5.84×10^{5}
D	2.87×10^{6}	8.21×10^{5}	6.51×10^{4}	5.68×10^{3}

*** The numbers in the table represent a rate of duplicates**

No growth of mold was observed during the ripening stages in the coated cheese samples, while slight growths in the mold began in the wax-coated cheese sample at the end of the ripening period (after 80 days). The results of the microbial examination indicate that the differences in the number of microorganisms between the samples were somewhat slight. And it is within the permissible limits in this type of cheese. This indicates the possibility of using films of Tamarind seed mucilage to produce healthy and nutritionally acceptable cheese.

Sensory evaluation

Table 3 Shows Result of the sensory evaluation of the studied cheese samples. It is the flavor, taste, texture, and fat separation. It was noted that the average score granted for the flavor and taste of samples A, B, and D ranged between 8-10 from the average of 10 degrees during ripening periods compared to the Standard Sample C as it ranged between 7-9. This indicates that the ripening process was very good and prevented the appearance of undesirable taste.

Table 3. Results of the sensory evaluation of Cheddar cheese Samples

Sensory Factor	Ripening (Day)	A	B	C	D	Sensory Factor	Ripening (Day)	A	B	C	D
Flavor	0	10	10	8	9	Texture	0	7	8	8	8
	30	9	9	9	9		30	7	8	9	9
	60	8	8	8	8		60	8	9	8	9
	90	8	8	7	8		90	9	9	7	9
Taste	0	9	10	9	10	Fat separation	0	10	10	10	10
	30	9	9	9	9		30	10	10	10	10
	60	8	8	8	8		60	10	10	10	10
	90	8	8	8	8		90	10	10	10	10

***The numbers in the table represent a rate of duplicates.**

Upon observing the Texture, the four cheese samples were given relatively ratings. However, by increasing the ripening period and at 90 days the grades were higher in mucilage-coated samples compared to the standard sample, due to the decrease in moisture loss and thus providing an environment with a water activity suitable for the work of the starter bacteria, which analyzes proteins and fats (Zheng *et. al.,* 2016). As for the separation of fat, no separation in fat was observed for all samples, as it was given high and similar scores. This is due to the role of the films and their chemical composition in reserving oxygen and fatty substances, which are regularly represented by the hydrogen penetration between the mucilage chains, which helps to use these films to preserve foods sensitive to oxidative rancidity. (Krochta and DeMulder-Johnston,1997).

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