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PREPARING EDIBLE FILMS FROM SOME POLYSACCHARIDE AND WHEY PROTEINS AND STUDYING SOME OF THEIR PROPERTIES

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ABSTRACT

This study aimed to prepare edible films based on polysaccharides and whey proteins. Seven formulations were prepared from dextran, xanthan, and carrageenan with whey proteins, glycerol, and black seed oil. The mechanical and barrier properties were studied for edible films like thickness, tensile strength, elongation, and water vapor permeability. The use of equal concentrations of polysaccharides (2gr) with the presence of whey proteins (1gr) and glycerol as plasticizers gave the best elongation at the break of the film (178%) and water vapor permeability the highest value(5.7g.mm/m2.h.kPa). Film Thickness was 56μm and Tensile 28MPa.This edible film was the best among the other formulation used in molasses medium.

Keywords: Edible films, dextran, xanthan, carrageenan, whey proteins.

تحضير اغشية صالحة للأكل باستخدام بعض السكريات المتعددة وبروتينات الشرش ودراسة بعض خواصها

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الخلاصة

هدفت هذه الدراسة إلى تحضير أغشية صالحة للأكل تعتمد على السكريات المتعددة وبروتينات الشرش. تم تحضير سبع خلطات من الدكستران والزانثان والكاراجينان مع كل من بروتينات الشرش والكليسرول وزيت الحبة السوداء. تمت دراسة الخواص الميكانيكية والحجزية للأغشية المصنعة مثل سمك الغشاء وقوة الشد والاستطالة ونفاذية بخار الماء. أعطى استخدام تراكيز متساوية من السكريات المتعددة (بنسبة 2٪) مع بروتينات الشرش (بنسبة 1٪) والكليسرول كمادة ملدنة أفضل الخلطات لتشكيل غشاء صالح للاكل في وسط المولاس اذ اعطى اعلى نسبة استطالة الى حد الكسر (178٪) وكانت أعلى قيمة نفاذية لبخار الماء (5.7 غم. ملم .م^2. ساعة .كيلوباسكال) .كان سمك الغشاء تقريبا 56 ميكرومتر وقوة الشد 28 ميغا باسكال .كان هذا الغشاء الصالح للاكل هو الافضل من بين التركيبات الاخرى المستخدمة في وسط دبس السكر.

الكلمات المفتاحية: اغشية صالحة للأكل، دكستران، زانثان، كاراجينان، بروتينات الشرش.

INTRODUCTION

Edible Films and coating are generally defined as thin layers of edible hazardous materials **(Kandasamy *et al.*, 2021)** Edible films and coating are made from natural sources such as polysaccharides, whey proteins, etc. **(Umaraw& Verma, 2017)** It replaces plastic film to prevent pollution caused by environmental pollution caused by packaging accumulation. Wax coating of fruits and vegetables, packaging of fast food, etc. **(Alsadi& Alanbari, 2021)**. Many polysaccharides or their derivatives were used in the preparation of edible films, alginate, pectin, carrageenan, starch derivatives, sulfur derivatives, and other materials in food packaging as sacrificial agents to prevent dehydration **(Song *et al.,* 2021)**. Protein materials differ in that they contain amino acids that differ in their numbers and types (polar and non-polar), which have a major role in forming bonds between molecules, depending on the type of protein, which can affect its chemical, physical and nutritional properties, as well as being unique in the formation of clots, gels and viscoelastic**(Abbas& Abdul-Rahman, 2020; Fattah, 2011)**. It is an important feature in material engineering to obtain the desired and suitable properties for packaging and its suitability for mixing with other biological materials such as fats to solve the problem of moisture sensitivity or laminating it with fatty materials **(Hammam, 2019)**.

MATERIALS AND METHODS

preparation of mixtures of polysaccharides

Each of the polysaccharides (carrageenan and xanthan) was weighed and added to glass flasks containing 100 ml of previously sterilized molasses with different proportions as shown in (Table, 1). Addition of a plasticizer (glycerol) at a rate of 0.2gr to improve the rheological properties of the produced casings, with the same ratio of black seed oilpurchased from the market. The space in the table indicates that the type of sugar has not been added to the mixture

Table (1): Preparation of polysaccharide mixtures in molasses medium.

Whey protein	Carrageenan	Xanthan	Symbol
1gr	2gr	2gr	M1
2gr	-	1gr	M2
2gr	1gr	-	M3
-	2gr	1gr	M4
1gr	1gr	1gr	M5
1gr	1gr	2gr	M6
1gr	2gr	1gr	M7

film forming

The method of **(Roy *et al.,* 2010)** was followed in preparing the films, as well as the method of **(Echeverría *et al.,* 2014)** and **(Abdul-Rahman, 2019)**was followed in preparing and coating the film for molding and shaping, with some modifications, as the prepared solution was poured into plastic petri dishes of polystyrene with a diameter of 9.1 cm and glass templates with a length of 22 cm, a width of 12 cm, and a thickness of 4 mm, according to the required tests, at the rate of 8 gm for each of the plastic dishes, and 30 gm in the glass templates. Finally, the films were removed from the dishes using a knife (spatula), and then the films were stored after placing them in polyethylene bags at a temperature of 25 ℃ and relative humidity of 50% RH until the necessary tests were conducted on them. as in (figure, 1).

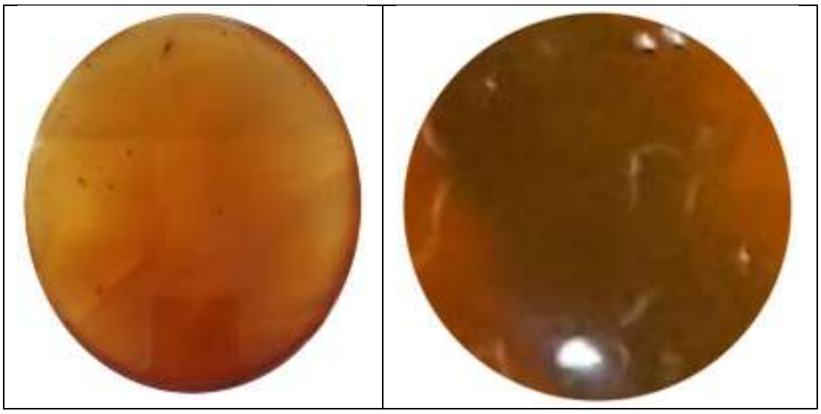


Figure (1): Visual appearance of the film forming**.**

Mechanical properties
Film thickness

The thickness of the edible films was estimated using **a** Digital Micrometer. Eleven readings were taken from different locations, then the average of these readings was calculated, which represents the thickness of the film**(Mohamed *et al.*, 2020)**.

Tensile (TS)&Elongation (EL)

The tensile strength and elongation to the cut-off point of the film were estimated using Tensile Strength Tester **(Tabari, 2018)** .

Water vapor permeability (WVP)

The water vapor permeability was estimated according to the gravimetric method, using the beaker method of the American Society for Testing and Materials E96. Which was mentioned by (**Chakravartula *et al.*, 2019)** with some modifications, as the cups were made locally from Teflon with different diameters (4.5, 3.5, 3.4) cm (external, internal, and depth), respectively, dried calcium chloride ($CaCl_2$) was added and covered with silicone grease on top of the surface of the cup. Then it was fixed by placing a steel ring with a diameter equal to the diameter of the cup (external and internal) in order to ensure the adhesion of the film sample to the surface, after that the cup and its contents were weighed with a sensitive balance to the nearest 0.001 g and then transferred to a desiccator containing a saturated solution of sodium chloride (NaCl) to reach a relative humidity of 75% RH, then left for 24 hours, after which 7 consecutive readings were taken every day for a week regularly to monitor the increase in weight. Calculations of the vapor permeability of the membranes were performed. Water as it comes:

1. The relationship that represents the increase in the weight of the cup with the passage of time was drawn on graph paper, where a straight line was obtained, which is an indicator of reaching the steady state, g/day.
2. The slope of the straight line (in g/day) was calculated by means of linear regression. The rate of increase in weight of the cup, which is constant after reaching the steady state, was used to calculate the permeability to water vapor according to the following equation.

$$WVP = (W / t).(X.\Delta P.A)$$

3. W/t= The volume of permeable water based on the time calculated according to the linear regression($R2>0.99$) through the weight recorded within 7 days(g/day)
   A=The permeable area of the Film
   X= Film thickness(mm)
4. partial pressure estimation(ΔP) measured by the following equation

$$\Delta P = S(R1 - R2)$$

S= Saturated vapor pressure over temp.25℃ (3166 Kpa)
R1= Relative humidity of the glass desiccant (RH %75)
R2= Relative humidity under the Film inside the cup(RH %0)

RESULTS AND DISCUSSION

film thickness

Many mechanical tests were carried out on the film under study, one of the first of these tests was to estimate the film thickness in the natural medium. It appeared that the film thickness had increased supported by cholesterol, whey protein, and black seed oil, as it reached an a 56 micrometer (Fig 2). These results agree with**(Arham *et al.,* 2016)** and **(Caz_on *et al.,* 2017)** that the film thickness is affected by the type of materials and the presence of plasticizers, as the plasticizers contribute to improving the film thickness through the molecules of glycerol, whey protein, and black seed oil in the matrix of the membrane and interfering with the polymer chains. Plasticizers lead to an increase in the film thickness, taking into account that the use of plasticizers (used in the experiment) at higher than appropriate concentrations leads to a higher film thickness through the absorption of a proportion of moisture resulting from the swelling**(Jabur *et al.,* 2014)** .

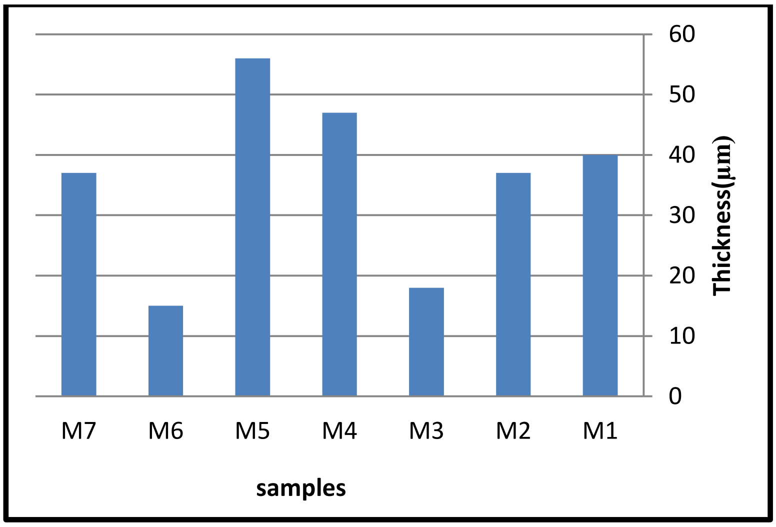


Figure (2): The films thickness prepared in molasses**.**

Tensile and Elongation

The mechanical properties of edible film determine how the film behaves during storage and handling. It also determines the strength of the film and its ability to support food safety. Therefore, it is necessary for the films to be flexible and strong when applied to food packaging **(Ghanbarzadeh & Almasi, 2011)**. The produced films are affected by the type of medium used in the production process and the additives, and thus the tensile strength and elongation change**(Al- Saaidi, 2009)**.

(Figure, 3) shows that the use of equal proportions of dextran, xanthan, and carrageenan with the addition of whey protein and glycerol as a plasticizer increased the tensile strength in a film sample. The tensile was 21.4 MPa, this result agrees with **(Lavorgna *et al.*, 2010)** that reported that plasticizers such as glycerol contribute to increasing the tensile strength of chitosan membranes. The study realized by **(Yang, 2000)** indicated that a large number of branches in the composition of the polymer makes up the film leading to brittle films and a decrease in tensile strength. This explains to us the low tensile strength shown by the films produced from dextran produced from *Weissella cibaria* bacteria, xanthan, as well as carrageenan, as polysaccharides are generally one of the most important components of these films, as it contains 80% of carbohydrates and contains an amount of protein **(Salman & Salim, 2016).**

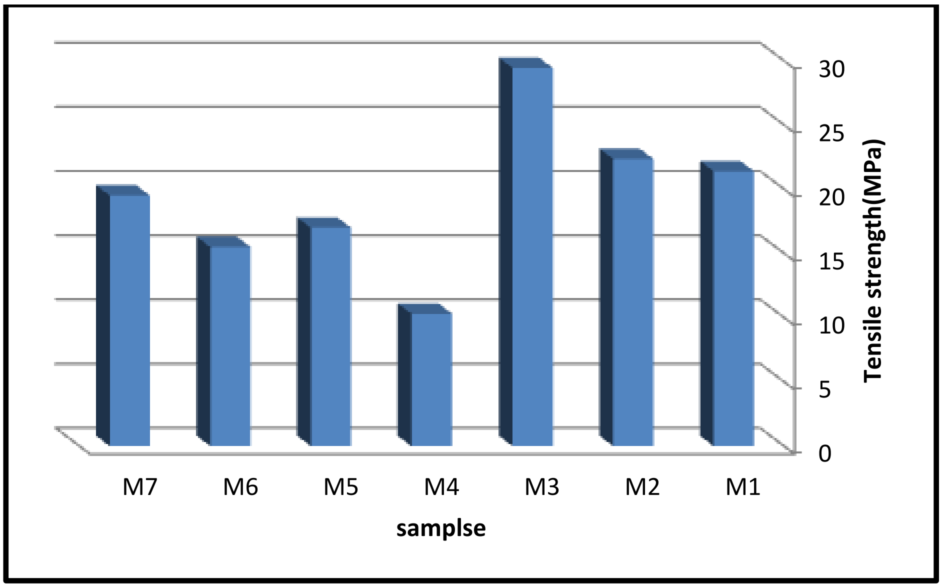


Figure (3): Tensile strength (MPa) for film samples.

The results show in (Figure, 4) the elongation at break of the film samples, which were high values for all samples, with a variation in these values due to the different composition of the production media, as we find that the highest elongation of 175%, and this is confirmed by the study of **(Vieira *et al.*, 2011)**. Which mentioned that the presence of sugary substances in the films gives rise to elongation.

The results showed that the plasticizer contributes to the effect on the elongation%, and this is consistent with what **(Zhang& Xia, 2008)** mentioned, that the plasticizers are added to the films to improve the mechanical properties so that the films become more flexible than during its role in reducing the bonds between the molecules and between the polymer chains, an increase in elongation with the increase of glycerol in chitosan membranes. **(Cheng *et al.*,2006)** indicated that plasticizers such as glycerol enhance the flexibility and stretching of the films, while (**Piyada *et al.*,2013**) indicated that films based on starch show weak mechanical properties. Several factors may affect the elongation ratio and tensile strength (TS), such as pH, and the high temperature when preparing film solutions, and the process of pouring solutions may cause water evaporates from this film**(Al-Kaisy *et al.*, 2007)**.

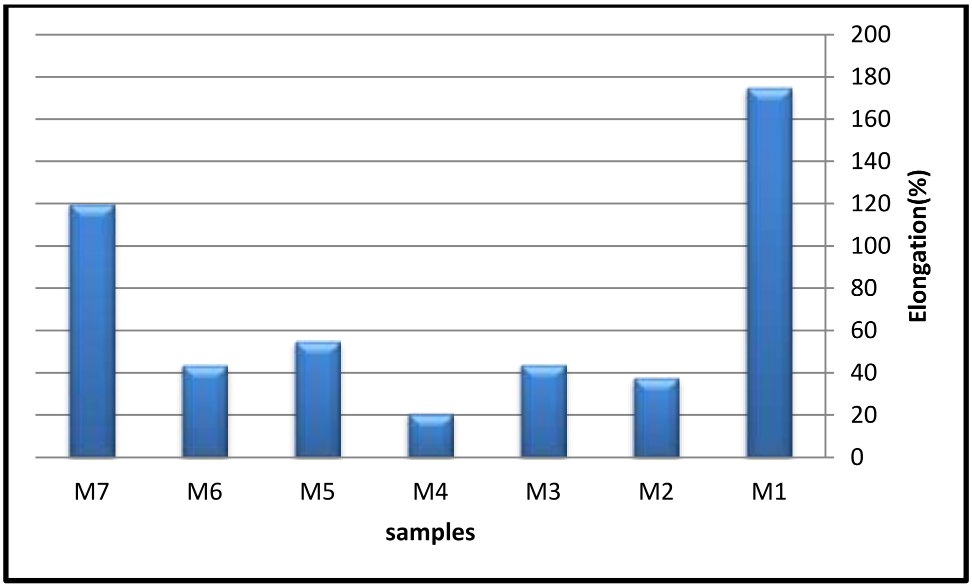
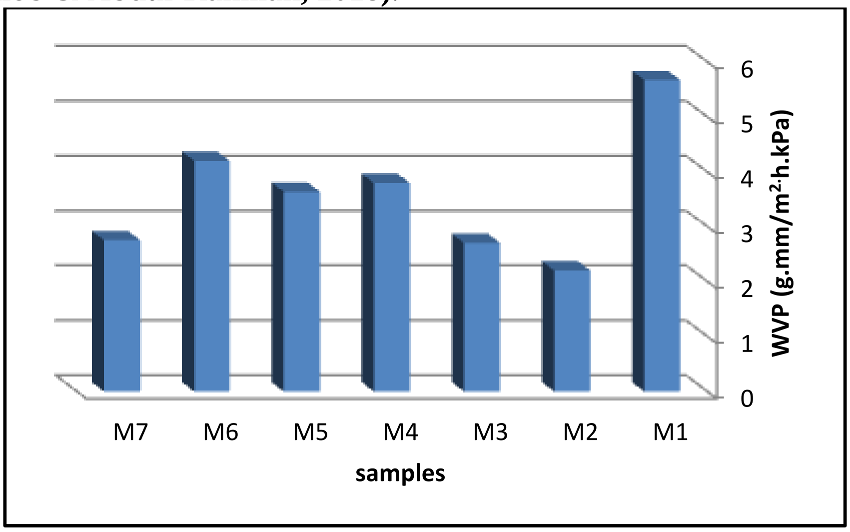


Figure (4): Elongation (%) for molasses film**.**

- **Water vapor Permeability**

(Figure, 5) shows the permeability values of the films under study to water vapor, as it reached the highest value(5.7g.mm/m2.h.kPa) by using equal proportions of the polysaccharides under study (dextran produced from the local isolate, xanthan and carrageenan) with a percentage of whey proteins and cholesterol. This may be because the films consist of proteins and polysaccharides It is a tight matrix and a hydrogen-bonded structure **(Tabari, 2018)**, and plasticizers (such as glycerol) affect edible films as they cause an increase in water vapor permeability **(Vieira *et al.*, 2011)**, and it was shown that the values of water vapor permeability decrease when increasing the percentage of whey proteins relative to polysaccharides may be due to the compact internal structure of the whey proteins films, which reduces the transmission of water vapor through these protein films **(Hammann & Schmid, 2014; Chalob & Abdul-Rahman, 2018)**.



- **Figure (5):** Water vapor permeability for molasses films**.**

CONCLUSION

The possibility of benefiting from isolated whey proteins and polysaccharides in the preparation of films for the purpose of food packaging. Supporting edible films with biologically effective materials and using them as natural food film such as black seed oil, due to its nutritional value addition and ease of use. The films intended for packaging have good mechanical and barrier properties and lack permeability to water vapor.

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