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Research Article

Screening of Ingredients for the Formulation of Composite Film

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ABSTRACT

Composite films refer to systems where different biopolymers have been combined to achieve the beneficial properties. Carbohydrate, protein, and polysaccharides have been preferred for developing composite film. The combination of varying ratios of polysaccharides, starch and proteins in the form of blends offers the possibility of manufacturing composite films with improved properties to meet consumer expectations. In this study, different preliminary trials were conducted with broader range of different ingredients and plasticizers to study the detailed overview of these variables. Composite film, corn starch film and whey protein isolate film were made using solution casting method. For drying of films, hot air oven was employed. The time-temperature combination used for the formation of film was 40^{o}C for 16-17 hours for drying of the film considering requisite nature of film in hot air oven. Firstly, corn starch film and whey protein film were optimized after which composite film was made by mixing of both the ingredients. Composite film was made using corn starch, whey protein isolate, carrageenan and glycerol. The composite films may have useful applications in those food systems where the individual films corn starch and whey protein isolate film having some kind of disadvantages with respect to quality characteristics. Final acceptable film with flexibility and other characteristics were checked for all type of films. Corn starch film was developed with addition of corn starch @ 5% and glycerol @ 2%. The whey protein isolate film was developed using whey protein isolate @ 5% and glycerol @ 2%, whereas composite film was prepared with addition of corn starch @ 2.5%, whey protein isolate @ 2.5%, and carrageenan @ 0.25% and glycerol @ 2%.

Keywords: *Corn starch, Whey protein isolate, Carrageenan, Glycerol, Composite film.*

INTRODUCTION

The majority of waste generated by households consists of materials used to package food and other necessities. It should be evident that whenever possible easily recyclable of biodegradable materials should be used instead of synthetic polymers (Prakash et al., 2013).

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The Composite films were developed with incorporation of carbohydrate, protein, and polysaccharides to achieve beneficial properties. The combination of varying ratios of starch, polysaccharides and proteins in the form of blends offers the possibility of manufacturing composite films with improved properties to meet consumer expectations. One of the most abundantly occurring biopolymers in nature is starch. It is an inexpensive, widely available, edible, tasteless, colourless and biodegradable material (Schmidt et al., 2013). Starch based films are inexpensive, easy to handle but have poor mechanical properties and high-water affinity. The biggest sources of starch for the industry are corn, wheat, cassava and potato and quite recently rediscovered amaranth and quinoa (Araujo-Farro et al., 2010). In recent years, whey proteins are becoming increasingly popular. This is because they have high nutritional value and a useful configuration of molecules. Whey proteins are capable to form elastic films and employed as raw material for biodegradable packaging having good oxygen barrier, moderate moisture permeability and low mechanical properties compared with synthetic packaging materials (Gounga et al., 2007).

Polysaccharide having moderate strength, flexible good barrier against oils and fat, but due to its hydrophilic nature, it is not an effective good moisture barrier, whereas carrageenan being derived from red seaweed, having good gas barrier properties. Many polysaccharide-based films and pure whey-protein films are very brittle because they have a large cohesive energy. To overcome this, they need the incorporation of plasticisers to reduce this force by reducing the intermolecular hydrogen bonding occurring between the polymer chains (Jimenez et al., 2012). Alginates and carrageenan as biological polymers, and due to their gel formation capacity, have been widely exploited and studied regarding their good film forming ability (Pereira et al., 2011). There are several ways to obtain coatings and films from starch and whey proteins. During the manufacture of coatings and films, the main aim is to obtain homogeneous material, thin and strong (Fu et al., 2011). Films made from one type of film-forming substance often have limited properties. To improve the process, several mixtures of biopolymers are used. That is because films which consist of two to three types of ingredients with better properties than those made from a single type (Kurek et al., 2014).

The aim of the study was to screen those of ingredients for the formulation of composite film.

MATERIALS AND METHODS

2.1 Equipment

Magnetic Stirrer with Digital Hotplate, Glass Ceramic Top - Stirrer was rotated at 600 RPM for uniform mixing of slurry.

Hot Air Oven - (MAC Hot Air Oven, Model-OUT 95, Capacity – 95 L)

2.2 Ingredients

Corn starch: Corn starch was procured from Central Drug House.

Whey Protein Isolate –Mahaan Proteins Ltd.

Carrageenan: Carrageenan used for film preparation was procured from Central Drug House Pvt. Ltd.,

Glycerol: Glycerol used for film preparation was procured from Loba Chemie Pvt. Ltd.

2.3 Preliminary Trials for preparation of composite biodegradable film

During the preliminary trials, focus was given on screening of corn starch, whey protein Isolate, Carrageenan and Glycerol for preparation of film individually and also in combination. The following tables depicting various range of Corn starch, Whey Protein Isolate, Carrageenan and Glycerol as plasticizer for the preparation of film.

Table 2.1: Trials for Development of film with different concentration of Corn starches, Whey Protein Isolate, Carrageenan and glycerol as a plasticizer

Constituents	Plasticizer (Glycerol)	Constituents	Plasticizer
Corn Starch 4%	2%	Carrageenan 0.25	2%
Corn Starch 5%	2%	Carrageenan 0.5	3%
Corn Starch 6%	2%	Corn Starch 5% + WPI 5%	2%
Corn Starch 4%	3%	Corn Starch 5% + WPI 5%	3%
Corn Starch 5%	3%	Corn Starch 5% + WPI 5%+ carrageenan 0.5%	2%
Corn Starch 6%	3%	Corn Starch 5% + WPI 5%+ carrageenan 0.5%	3%
Whey Protein Isolate 4%	2%	Corn Starch 2.5% + WPI 2.5%	2%
Whey Protein Isolate 5%	2%	Corn Starch 2.5% + WPI 2.5%	3%
Whey protein Isolate 5%	3%	Corn Starch 3 % + WPI 2% + Carrageenan 0.25%	2%
Whey protein Isolate 5%	3%	Corn Starch 2.5% + WPI 2.5% + carrageenan 0.25%	2%
Whey protein Isolate 6%	3%	Corn Starch 2.5% + WPI 2.5% + carrageenan 0.25%	3%

2.3.1 Preparation of Corn starch biodegradable film

Corn starch biodegradable film was prepared as per the procedure followed by Basiak[9] with slight modifications.

2.3.2 Preparation of whey protein isolate film

Whey protein isolate biodegradable film was prepared as per the procedure followed by Wagh[10] with slight modifications.

2.3.3 Preparation of Composite biodegradable film

The composite biodegradable film was prepared as per the protocol followed by Basiak et al. (2014). with required modifications.

RESULTS AND DISCUSSION

Screening of various prime ingredients i.e. corn starch, carrageenan, whey protein Isolate along with glycerol for film formation

Biopolymers used in film preparation are often carbohydrates or proteins, create the basic network structure of the film. However, films prepared from biopolymers are often too fragile to stand handling, e.g. bending or stretching. Thus, they have to be plasticized using low molecular weight substances, such as polyols like glycerol, which decrease interactions between the biopolymer chains (Lu et al., 2009).

Corn Starch is used as the base component for making film because it has very good film forming properties. Corn Starch contains amylopectin and amylose contents which are helpful for making the compact structure to make film. The film forming properties of any polysaccharide depend upon the amylose amylopectin ratio of the starch. Corn Starch was tried in this study individually and in combination.

Whey Protein Isolate films exhibit valuable characteristics for food coating or packaging applications, such as transparency and excellent barrier properties against oxygen, and carbon dioxide. Likewise, protein-based films can function as excellent vehicles for incorporating a wide variety of compounds, such as nutrients, antioxidants, antimicrobials, antifungals, or flavours (Wagh et al., 2013; Chiralt et al., 2018). Whey protein Isolate was tried in this study individually and in combination.

Carrageenan's are natural hydrophilic polymers with a linear chain of partially sulphated galactans, which presents high potential of film-forming. Carrageenan has many applications in food and even non-food industries and is a high value functional ingredient in foods. Carrageenan can be used

to form film coatings. The coatings can prevent shrinkage, microbial contamination, and surface discoloration by delaying moisture transport (Varela et al., 2011; Han et al., 2008). Carrageenan was tried in this study individually and in combinations.

A composite material (also called a composition material or shortened to composite, which is the common name) is a material made from two or more constituent materials with significantly having different physical or chemical properties when combined as compared to the individual components. Proteins, polysaccharides, starch or a mixture of these which can provide better mechanical and/or barrier properties than individual film preparation.

Different preliminary trials were conducted with broader range of different ingredients and plasticizers to study the detailed overview of these variables. Corn starch, Whey protein, Carrageenan taken as base component of the edible film. Food grade biopolymers gave brittle and stiff characteristics due to excessive interactions between the polymer molecules. To build up the physical and mechanical properties such as to increase the flexibility and tearing strength, glycerol was used as a plasticizer.

Glycerol was used as plasticizer in film applications because of its plasticization ability due to its low molecular weights. Plasticizer is added to the film to give better handling properties like flexibility and elasticity. Plasticizer decreases interactions between biopolymer chains thus preventing their close packing which results in lower degree of crystallinity in the film. Pores and cracks in the film could be also prevented by using plasticizers as well. Plasticizer is an essentially required raw material helpful in providing desired flexibility to the film (Schmidt et al., 2013).

Different trials were undertaken at specific temperature and time conditions. The results of these trials were described in the Table 3.1.

Table 3.1: Screening of corn starch, carrageenan, whey protein isolate and glycerol for resultant film

Type of starch	Glycerol	Observations for film formation
Corn Starch 4%	2%	Torn Off
Corn Starch 5%	2%	Very Good Formation
Corn Starch 6%	2%	Difficult to Peel
Corn Starch 4%	3%	Hard Formation
Corn Starch 5%	3%	Good Formation
Corn Starch 6%	3%	Not Properly Formed
Whey Protein Isolate 4%	2%	Hard Formation
Whey Protein Isolate 5%	2%	Very Good formation
Whey protein Isolate 5%	3%	Good Formation
Carrageenan 0.25%	3%	Film not formed
Carrageenan 0.5%	3%	Film Not Formed
Corn Starch 5%+ WPI 5%+Carrageenan 0.25%	2%	Hard formation
Corn Starch 5% + WPI 5% + Carrageenan 0.25%	3%	Hard Formation
Corn Starch 2.5% + WPI 2.5% + Carrageenan 0.5%	2%	Carrageenan Separation
Corn Starch 2.5% + WPI 2.5%+ Carrageenan 0.25%	2%	Very Good Formation
Corn Starch 2.5%+ WPI 2.5% + Carrageenan 0.25%	3%	Good Formation

3.1.1 Table 3.1 depicted that the plasticizer at two different levels i.e. 2 and 3 per cent were added and concentration of corn starch varied from 4-6 per cent. Corn starch @ 5% with 2% plasticizer was observed to be suitable for the formation of film with desired visual appearance. This film was easy to peel off without any fear of getting torned off. However, film with lesser or higher concentration of corn starch was either torned off or was sticked to the base of petri plate while removing the film Basiak et al. (2014) whereas whey Protein Isolate @ 5 per cent concentration with 2 percent glycerol levels produced very good film (Chiralt et al., 2018). Replacement of corn starch and whey protein isolate with carrageenan does not form acceptable films.

Formation of Composite film involves the use of corn starch, whey protein Isolate, carrageenan, glycerol at different concentration as shown in Table 3.1. Addition of corn starch @ 2.5%, Whey Protein Isolate @ 2.5%, Carrageenan @ 0.25% resulted in the formation of composite films with better properties. However, corn starch @ 2.5%, Whey Protein Isolate @ 2.5%, Carrageenan @ 0.5% results in separation of carrageenan which affected the appearance and properties of composite film. Therefore, carrageenan was selected with 0.25 concentrations for preparation of composite film. The composite film was easy to peel off. Other concentration of composite film was unable to give required flexibility and peeling off character to the films. Similar, observations were recorded by Basiak et al. (2014).

Corn starch film **Whey protein isolate film** **Composite film**

Fig 3.1 Optimized films of corn starch, whey protein isolate and composite film

CONCLUSIONS

Final acceptable film with flexibility and other characteristics was optimized for Corn starch film with corn starch @ 5% and glycerol @ 2%, whereas in whey protein isolate film at whey protein isolate 5% and glycerol 2% having film forming properties. Composite film at Corn Starch @ 2.5%, Whey Protein Isolate @ 2.5%, Carrageenan @ 0.25%, Glycerol @ 2% was used for preparation of composite film. In conclusion, we have demonstrated the potential to produce blend corn starch–whey protein isolate-carrageenan-glycerol self-supported films. The polymer concentration enabled miscibility and solubility of both polymers in the film-forming solutions. However, the composite films may have useful applications on those food systems where the individual films (corn starch and whey protein isolate film) lacks the desired quality characteristics.

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