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Selection of biopolymers to develop a biodegradable and edible film for packaging of luncheon chicken meat slices

Dipanwita Bhattacharya[1]* and Kandeepan G[2]

Division of Livestock Products Technology, Indian Veterinary Research Institute, Izzatnagar, Bareilly-243122, Uttar Pradesh, India.

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ABSTRACT

Environmental concerns over disposal of non-renewable food packaging materials contributed to renewed interest in development of edible coating and films. Meat is one of the most nutrient rich food items and is therefore, highly perishable item due to a considerable microbial load and its autolytic degradation. Edible films and coatings extend the shelf life of foods and others by acting as barriers and also as carriers of substances to inhibit pathogenic and spoilage microorganisms. So, it was proposed to develop edible film as primary packaging material and LDPE film as secondary packaging material for luncheon chicken slices to protect from environmental hazards. The present study revealed 2% carboxy-methyl-cellulose (CMC) best suited for the preparation of edible film on the basis of parameters like elongation ability, film solubility and transparency. As in the cases of 1% and 1.5% levels of carboxy-methyl-cellulose (CMC) film, although they were superior in film solubility and elongation ability, it was difficult to wrap meat products with those films due to their poor mechanical property.

Key words: Chicken meat slices, CMC, Edible film, Luncheon, Meat packaging.

INTRODUCTION

Meat is one of the most nutrient rich food items for so many beneficial effects in human diet and health. Meat product is highly perishable item due to a considerable habitant of microbes and its autolytic degradation. Meat spoilage in supply chain creates great economic losses, by way of reduced product sale to producers at one end and also creates extra monitory burden for health care due to food poisoning among the consumers. The National Green Tribunal (2015) has directed the centre and various stakeholders to file their submissions on a proposal that there should be a complete prohibition on the use of plastic packaging in food and pharmaceutical formulations of any kind. Many state governments have banned the use of plastic packaging materials for food and pharmaceuticals, like, ban on plastic packaging for junk food products in Himachal Pradesh which has been declared by State Government in 1995. Natural polymers can be an alternative source for developing food packaging materials due to their palatability and biodegradability (Siracusa *et al.,* 2008). Factors contributing to renewed interest in development of edible coating includes consumer demand for high quality foods, food processors' needs for new storage techniques; environmental concerns over disposal of nonrenewable food packaging materials; and opportunities for creating new market outlets for film forming ingredients derived from under-utilized agricultural commodities. Edible films and coatings are an alternative to plastics to extend the shelf life of animal originated foods and others by acting as barriers to water vapor, oxygen, and carbon dioxide and as carriers of substances to inhibit pathogenic and spoilage microorganisms. The improvements in quality and shelf-life of edible coated food products have been achieved mainly by the control of gas or water vapor permeability (passive packaging) and partly by the application of bioactive agents into or onto the packaging materials (active packaging). The main advantage of edible films over traditional films is that it can be consumed with the product and thus to reduce the environmental pollution made by synthetics. Edible films and coatings have been particularly considered in food preservation, because of their capability for improving global food quality (Chillo *et al.,* 2008). An edible coating or film has been defined as a thin, continuous layer of edible material formed or placed on or between foods or food components (Bravin *et al*., 2006). Coating materials that are currently in use include polysaccharides (chitin, starch, cellulose derivatives and gums), proteins (soy, milk, gelatin, corn zein, wheat gluten) and lipids (oils, waxes, resins) (Sanchéz-Gonzáles *et al*., 2010). Durango *et al*. (2006) stated that polysaccharides have been used for edible films most frequently because of their excellent film forming properties derived from cellulose, starch, alginate and their mixtures.

*Corresponding author's e-mail: dr.dipanwita.vet@gmail.com
[1]Division of Livestock Products Technology, Indian Veterinary Research Centre, Izzatnagar, Bareilly-243122, Uttar Pradesh, India.
[2]National Research Centre on Meat, Boduppal Post, Chengicherla-500092, Hyderabad, Telangana, India.

Conventional packaging has four basic functions: Contain, protect, inform, and provide convenience during storage and distribution steps with minimal interaction between packaging and content (Robertson, 1993). Muppalla *et al.* (2014) developed carboxy-methyl-cellulose (CMC)-polyvinyl alcohol based edible film for packaging of ground chicken meat. Roy *et al*. (2012) also developed a CMC based hydrogel to prove its biodegradability. Ghanbarzadeh *et al.* (2010) made a film of modified starch-carboxy-methyl-cellulose based film and studied its physical properties.

The importance of edible packaging in enhancing the quality and shelf life of stored meat products offers great scope for further research in this field. So, it was proposed to develop edible film as primary packaging material and LDPE film as secondary packaging material for luncheon chicken slices to protect from environmental hazards.

MATERIALS AND METHODS

Chemicals used: Carboxy-methyl-cellulose (CMC), chitosan, potato starch (SD Fine-Chem Limited, Mumbai, India), plasticizers glycerol (MERCK, Mumbai, India) and polyethylene glycol (PEG) (MERCK, Germany), acetic acid (MERCK, Mumbai, India) and other chemicals were obtained from standard firms.

Preparation of edible film: Casting is commonly used technique for edible film preparation on laboratory scale. Carboxy-methylcellulose and potato starch based films were prepared by the methods of Ghanbarzadeh *et al.* (2010) and Almasi *et al.* (2010) with slight modifications. CMC and potato starch solutions (1.0, 1.5 & 2.0% and 1.0, 2.0 & 3.0% respectively) were prepared by dispersing the polysaccharide in distilled water under continuous stirring and heating in the presence of 1.5 percent plasticizer (mixture of PEG and glycerol at 1:1 ratio) at 90°C and 550 rpm using hot plate with magnetic stirrer (Model 11,603, Merck Specialties Pvt. Ltd., MERCK, Mumbai, India) for 30 minutes with constant stirring. Most of the biopolymers are hydrophilic in nature, therefore, easily dissolve in water for film forming solution preparation. Water or solvent was evaporated from the solution in order to form the film (Lazaridou and Biliaderis, 2002; Rindlav-Westling *et al*., 2002). As a result of solvent evaporation, biopolymer increased with the result that hydrogen bonds were formed and basic film structure was formed. The addition of plasticizing agent such as PEG and glycerol into the film reduced the intermolecular forces and increased thermo stability of the polymeric chains, resulting in a better flexibility (Durango *et al.*, 2006). Then, film solution was cooled to 40°C and poured into glass petri dish of 8 inch diameter. The films on the plate were dried at 70°C for 8-10 h in hot air oven. After cooling to room temperature, each film was carefully peeled from the plate and packed in polyethylene bags and stored at refrigeration temperature (4±1°C) for further analysis. For preparation of filmogenic solution of chitosan it was continuously heated and stirred at 80°C and 550 rpm using hot plate with magnetic stirrer (Model 11,603, Merck Specialties Pvt. Ltd., MERCK, Mumbai, India) for 60 minutes and dried at 35°C for 24 h (Bourbon *et al*., 2012) in hot air oven.

Physico-chemical properties of film

Transparency: The transparencies of the film samples were measured according to the method described by Al-Hassan and Norziah (2012). A rectangular piece (3×2 cm) cut from each film sample was directly placed in a spectrophotometer cell. The absorbance was measured at 550 nm using a spectrophotometer (DU 600 Series, Serial NO - 4319158, Beckman Instruments Inc., Fullertron, California, USA).The measurements were carried out in six replicates for each film sample and the average values were calculated. The transparency of films was calculated by dividing the absorbance by thickness (mm). The higher values indicate lower transparency.

Film solubility: The solubility of film samples in water was measured by the method of Ghanbarzadeh *et al.* (2010) with slight modifications. Film samples were cut into 3×2 cm pieces and dried at 100°C for12 h. The dried film samples were dissolved in distilled water (20 ml) under gentle agitation using a magnetic stirrer at room temperature. After 2 minutes dissolution, the film was taken out and dried in the oven at 105°C until the weight became stable. Before and after dissolution, the accurate weights of the dried film sample pieces were measured, and the weight difference was considered as soluble solids. The water solubility of film was calculated as a percentage based on the initial weight of film. All the experiments were performed in triplicate.

$$\text{Film solubility (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

Where,
W_1 = dried weight of the film before dissolution
W_2 = dried weight of the film after dissolution

Elongation at break: The mechanical properties of the samples were measured by means of percentage elongation at break (EAB) tests. For calculation of elongation at break (EAB) edible films were cut into 8×2 cm strips then fixed on a manually formed scale and stretched the film manually until they broke. The elongation at break (EAB) of the samples was calculated as follows:

$$\text{Elongation at break (\%)} = \frac{A\text{-}B}{A} \times 100$$

Where,
A = initial point on scale
B= final point on scale after stretching of edible film

Statistical analysis: Three trials were conducted for each experiment with duplicate samples. The data generated for different quality characteristics were compiled and analyzed using SPSS (version 20.0 for windows; SPSS, Chicago, III., USA) with randomized block design and subjected to analysis of variance. one-way ANOVA was carried out for comparing the physicochemical properties of edible film.

RESULTS AND DISCUSSION

Standardization of level of raw materials and processing conditions for the preparation of edible film: In the preliminary trials, different biopolymers have been used to form an edible film and also standardized the processing conditions like temperature and time for the preparation of well dispersed film forming solution and suitable film drying conditions. On the basis of preliminary trials, it was found that carboxy-methyl-cellulose (CMC), potato starch and chitosan were the most suitable biopolymer to form edible film in laboratory condition. Preliminary trials also showed that 90°C for 30 minutes and 70°C for 8-10 h were the best suitable temperature and time combination for preparation of film forming solution and film drying, respectively for carboxy-methyl-cellulose (CMC) and potato starch (Soni *et al.*, 2016). For chitosan, these were at 80°C for 60 minutes and 35°C for 24 h respectively, as the best suitable time temperature combinations for the preparation of film forming solution and film drying. Bourbon *et al.* (2011) had developed film drying condition for chitosan film indicating 35°C for overnight. Chillo *et al.* (2008) had heated chitosan dispersion at 80°C for 60 minutes on a hotplate to dissolve it completely.

Standardization of level of carboxy-methyl-cellulose (CMC) for the preparation of edible film: Three different levels *viz.* 1.0%, 1.5% and 2.0% were used to form edible film from carboxy-methyl-cellulose (CMC) (Table 1). 2% level of carboxy-methyl-cellulose (CMC) was found to be more suitable for film formation on the basis of three different parameters *viz.* transparency, film solubility and elongation ability. Transparency of 2% carboxy-methyl-cellulose (CMC) incorporated film was found to be significantly higher ($p<0.01$) than others. In case of transparency, higher values indicated lower transmission of light across the film. In case of elongation ability 1.5% and 2% levels were significantly higher ($p<0.01$) than 1% level. For film solubility, 1% level was significantly higher ($p<0.01$) than 1.5% and 2% levels which were not significantly different between them . For good mechanical property 2% CMC was selected for film preparation.

Standardization of level of potato starch for the preparation of edible film: Three different levels *viz.* 1.0%, 2% and 3% were used to form edible film from potato starch. 1.0% level of potato starch was found to be not suitable for film formation. 3% level of potato starch was found to be more suitable for film formation on the basis of three different parameters *viz.* transparency, film solubility and elongation ability (Table 2). Elongation ability of 3% potato starch was found significantly higher ($p<0.01$) than 2% level. Transparency did not differ significantly but values were little more in 3% level of potato starch incorporated film. Film solubility differed significantly between these two levels.

Standardization of level of chitosan for the preparation of edible film: Three different levels *viz.* 1.0, 1.5% and 2% were used to form edible film from chitosan. 1.0% level of chitosan was found to be not suitable for film formation. 2% level of chitosan was found to be more suitable for film formation on the basis of three different parameters *viz.* transparency, film solubility and elongation ability (Table 3). Film solubility of 2% chitosan was found significantly higher ($p<0.01$) than 1.5% level. Elongation ability of 2% chitosan incorporated film was significantly higher ($p<0.05$) from 1.5% level of chitosan.

Selection of final film and standardization of level for the preparation of best edible film: From the individual studies of different biopolymers, 2% level of carboxy-

Table 1: Standardization of level of CMC for the preparation of edible film

Parameter	CMC (%)		
	1.0	1.5	2.0
Transparency	5.91 ± 0.14^{a}	3.94 ± 0.31^{b}	1.34 ± 0.02^{c}
Film Solubility (%)	99.81 ± 0.01^{a}	99.69 ± 0.01^{b}	99.68 ± 0.01^{b}
Elongation Ability (%)	36.33 ± 1.83^{b}	80.00 ± 1.94^{a}	75.17 ± 3.55^{a}

*Mean±S.E. with different superscripts in a row differ significantly ($P<0.05$); n=6; CMC= Carboxy-methyl-cellulose

Table 2: Standardization of level of Potato starch for the preparation of edible film

Parameter	Potato Starch (%)		
	1.0	2.0	3.0
Transparency	FNF	0.87 ± 0.11^{a}	0.67 ± 0.08^{a}
Film Solubility (%)	FNF	$97.31\pm.01^{a}$	96.53 ± 0.01^{b}
Elongation Ability (%)	FNF	$6.50\pm.56^{b}$	20.83 ± 3.13^{a}

*Mean±S.E. with different superscripts in a row differ significantly ($P<0.05$); n=6; FNF= Film not formed

Table 3: Standardization of level of Chitosan for the preparation of edible film

Parameter	Chitosan (%)		
	1.0	1.5	2.0
Transparency	FNF	1.72 ± 0.29^{a}	2.21 ± 0.30^{a}
Film Solubility (%)	FNF	84.67 ± 0.01^{b}	$85.59\pm.02^{a}$
Elongation Ability (%)	FNF	21.00 ± 1.60^{b}	28 ± 3.22^{a}

*Mean±S.E. with different superscripts in a row differ significantly ($P<0.05$); n=6; FNF= Film not formed

Table 4: Standardization of level and selection of biopolymer for the preparation of edible film

Parameter	Edible Film		
	2.0 % CMC	3.0 % Potato Starch	2.0 % Chitosan
Transparency	1.34±0.02[b]	0.66±0.08[c]	2.16±0.01[a]
Film Solubility (%)	99.60±0.01[a]	96.47±0.10[b]	84.96±0.13[c]
Elongation Ability (%)	79.50±0.42[a]	18.17±2.52[c]	32.50±2.23[b]

*Mean±S.E. with different superscripts in a row differ significantly ($P<0.05$); n=6

methyl-cellulose (CMC), 3% level of potato starch and 2% level of chitosan were selected and further the same parameters were repeated among these selected three to reduce error or work (Table 4) and among these three different biopolymers with different levels, 2% level of carboxy-methyl-cellulose (CMC) was selected on the basis of elongation ability, film solubility and transparency. It was observed that elongation ability and film solubility of 2% carboxy-methyl-cellulose (CMC) was significantly higher ($p<0.01$) than rest two levels of biopolymers. Transparency was found highly significant ($p<0.01$) in case of 3% potato starch than other two biopolymer films.

On the basis of the above experimental study, 2% carboxy-methyl-cellulose (CMC) was selected for the preparation of edible film on the basis of parameters like elongation ability, film solubility, and transparency. In case of 1% and 1.5% levels of carboxy-methyl-cellulose (CMC), though they were superior in film solubility and elongation ability, it was difficult to wrap meat products with that film as it showed a poor mechanical property.CMC is a cellulose ether that exhibits thermal gelation and forms excellent films due to its polymeric structure and high molecular weight chains (Ma *et al*., 2008). It is GRAS polymer widely used in food and pharmaceutical industry. Ghanbarzadeh *et al.* (2010) used various levels of CMC including 5%, 10%, 15% and others to produce modified starch/CMC based edible film. The goal of this work was the study of CMC on physical–mechanical properties of starch based composite films intended to be used as edible or biodegradable films. Muppalla *et al.* (2014) and Soni *et al*. (2016) had found 1% CMC showing excellent film forming properties but it had very weak mechanical properties. For packaging of luncheon chicken slices, CMC film was most suitable which reduces moisture loss or enhances the shelf life and quality of product.

CONCLUSION

Based on the three physico-chemical parameters i.e. transparency, film solubility and elongation ability, 2% CMC, 2% chitosan and 3% potato starch were selected as suitable for edible film formation. Among these three biopolymers 2% CMC was selected finally as per the above parameters and most importantly its good mechanical property and most suitable biopolymer to prepare edible film for wrapping chicken luncheon slices. This edible film of 2% CMC was used as primary packaging material and low density polyethylene film (LDPE) as secondary packaging material for chicken luncheon slices to enhance its shelf life and protect from environmental pollutions.

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REFERENCES

Al-Hassan, A.A. and Norziah, M.H. (2012). "Starch-gelatin edible films: water vapor permeabilityand mechanical properties as affected by plasticizer", *Food Hydrocolloids*. **26:** 108-117.

Almasi, H., Ghanbarzadeh, B. and Entezami, A.A. (2010). Physicochemical properties of starch–CMC–nanoclay biodegradable films. *International Journal of Biological Macromolecules*, **46:** 1-5.

Bourbon, A.I., Pinheiro, A.C., Cerqueira, M.A., Rocha, C.M., Avides, M.C., Quintas, M.A. and Vicente, A.A. (2011). Physico-chemical characterization of chitosan-based edible films incorporating bioactive compounds of different molecular weight. *Journal of Food Engineering*. **106:**111-118.

Bravin, B., Peressini, D. and Sensidoni, A. (2006). Development and application of polysaccharide–lipid edible coating to extend shelf-life of dry bakery products. *Journal of Food Engineering*, **76:** 280-290.

Chillo, S., Flores, S., Mastromatteo, M., Conte, A., Gerschenson, L. and Del Nobile, M.A. (2008). Influence of glycerol and chitosan on tapioca starch-based edible film properties. *Journal of Food Engineering*, **88:**159-168.

Durango, A.M., Soares, N.F.F., Benevides, S., Teixeira, J., Carvalho, M. and Wobeto, C. (2006), "Development and evaluation of an edible antimicrobial film based on yam starch and chitosan", *Packaging Technology and Science*. **19:** 55-59.

Ghanbarzadeh, B., Almasi, H. and Entezami, A.A. (2010), "Physical properties of edible modified starch/carboxy-methyl-cellulose films", *Innovative Food Science & Emerging Technologie.* **11:** 697-702.

Lazaridou, A. and Biliaderis, C.G. (2002). Thermophysical properties of chitosan, chitosan–starch and chitosan–pullulan films near the glass transition. *Carbohydrate polymers*, **48:** 179-190

Ma, X., Chang, P.R., &Yu, J. (2008). Properties of biodegradable thermoplastic pea starch/Carboxy methyl cellulose and pea starch/microcrystalline cellulose composites. *Carbohydrate Polymers*. **72:** 369-37

Muppalla, S.R., Kanatt, S.R., Chawla, S.P. and Sharma, A. (2014). Carboxymethyl cellulose–polyvinyl alcohol films with clove oil for active packaging of ground chicken meat. *Food Packaging and Shelf Life*. **2:** 51-58.

Rindlav-Westling, Å., Stading, M. and Gatenholm, P. (2002). Crystallinity and morphology in films of starch, amylose and amylopectin blends. *Biomacromolecules*, **3:** 84-91.

Robertson, G.L. (1993). Paper and paper-based packaging materials. *Food packaging, principles and practice. New York: Marcel Dekker Inc. p*. pp.144-72.

Roy, N., Saha, N., Kitano, T. and Saha, P. (2012). Biodegradation of PVP–CMC hydrogel film: A useful food packaging material. *Carbohydrate polymers*, **89:** 346-353.

Sánchez-González, L., Vargas, M., González-Martínez, C., Chiralt, A. and Cháfer, M. (2011). "Use of essential oils in bioactive edible coatings", *Food Engineering Reviews*. **3:** 1-16.

Siracusa, V., Rocculi, P., Romani, S. and Dalla Rosa, M. (2008). Biodegradable polymers for food packaging: a review. *Trends in Food Science & Technology*, **19:** 634-643.

Soni, A., Kandeepan, G., Mendiratta, S.K., Shukla, V. and Kumar, A. (2016). Development and characterization of essential oils incorporated carrageenan based edible film for packaging of chicken patties. *Nutrition & Food Science*, **46:** pp.82-95.