Development of a technology for polysaccharide-based film coating

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Abstract. This work describes the design of a film coating based on polysaccharides of bacterial and plant origin with several methods of application (by spraying, brushing and wrapping) on food. We used the bacterial polysaccharide xanthan as a thickener, the plant polysaccharide carboxymethyl cellulose (CMC) as a structurant, and the biological additive lecithin as a plasticizer. Depending on the film coating application method, concentrations of the studied polymers were selected with the same component composition. A technology for preparing the film coating was developed. The influence of heating (40, 50, 60, and 70 °C) on the solubility of polysaccharide solutions with several component ratios was studied; the temperature of 50 °C was chosen as resulted in a strong, stable, but not too viscous gel. The effect of concentration on the appearance and thickness of the film coatings was studied.

1. Introduction

In recent decades, film coatings have been widely using in many branches, namely: agriculture, medicine, processing and food industries [10]. Films used in the food industry are mainly considered as an alternative to primary packaging [6]. Films are most widely used as a means of packaging due to their low cost with no use of additional devices [3]. According to many developers’ experience, research is being conducted on the production of film coatings using polysaccharides of various origins, such as chitosan, pectin, xanthan, and carboxymethyl cellulose. In this regard, research is relevant on the selection of polysaccharides (xanthan and carboxymethyl cellulose) as part of biodegradable film coatings and technological parameters for the production of packaging materials with the prospect of further use in various industries.

2. Materials and methods

For prepare solutions for making film coatings, polysaccharides of various origins were used, namely: xanthenes («Rodejille», France) and carboxymethyl cellulose (CMC) from Fluca, as well as lecithin («Lecigran, Cargil», Germany) as a biological additive.

The components and the film coating were prepared according to the technique described in Ref. 4. Statistic processing of the data obtained was carried out using the experimental design technique and the Windows applications Microsoft Office Excel 2007 and MathCad 14.

3. Results and discussion

When designing film coatings, the proper choice of components, their properties and the temperature of formation of the film coating are essential factors. To form a film coating, we took the bacterial
polysaccharide xanthan, carboxymethyl cellulose, and lecithin. The following potential properties of compositions are characteristic of xanthan: the thickening ability of aqueous systems, shear stabilization, compatibility with aqueous solutions of organic compounds, as well as with anionic and nonionic compounds [5]. The plant-derived polysaccharide carboxymethyl cellulose was used as a structural. Since this substance is highly soluble in water; aqueous solutions thicken well with it. The viscosity of the substance does not change for a long time; it holds water and can form transparent durable films. It is insoluble in oil and fat, harmless to the human body; has neither taste nor smell. It is a highly polymeric substance resistant to sunlight. It has a stabilizing and binding effect [2]. As a biological additive, we used soya lecithin, a fat-like organic substance which is a complex of phospholipids. Nerve impulses are transmitted due to its components, inositol and phosphatidylcholine. It is also a lipotropic substance, i.e., one that dissolves and burns fat. Due to the action of inositol and choline, the liver, gall bladder and blood vessels are protected from cholesterol deposition, since these components prevent the formation of harmful plaques. Natural soya lecithin promotes fat dissolution and oxidation, but, unlike medications, it burns excess body fat only. This substance has a pronounced choleric effect. Lecithin inhibits the development and formation of gallstones. Besides, the body’s digestibility of consumed vitamins and drugs improves with its help [7].

The effect of heating on the solubility of PS solutions with several component ratios was studied. During our research, pilot samples Nos 1 - 17 were prepared in the following xanthan-CMC ratios: 10:90, 15:85, 20:80, 25:75, 30:70, 35:65, 40:60, 45:55, 50:50, 55:45, 60:40, 65:35, 70:30, 75:25, 80:20, 85:15, 90:10, respectively.

Initially, to make a film coating (film), we took the following ratios of xanthan and CMC: from 10 to 90% and from 90 to 10%, respectively, at temperatures of 40°C and 50°C. It was noted that with xanthan dosages from 30 to 40%, with CMC ones from 60 to 70%, respectively, and heating to 40°C, the polysaccharides did not dissolve together (Table 1).

| Polysaccharides | Weight fractions of the components, % | Samples |
|-----------------|--------------------------------------|---------|
| Xanthan         | 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 |         |
| CMC             | 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 |         |
| Lecithin        | 0.2 0.4 0.6 0.6 0.6 0.6 0.6 0.6 0.7 0.7 0.8 0.9 0.9 0.9 0.9 0.9 0.9 |         |

Note: - polysaccharides did not dissolve; + polysaccharides dissolved.

It was found that when the temperature was changed to 50°C at the same polysaccharide concentrations in samples 3, 5 and 10, a robust, stable gel was obtained, but not too viscous. Therefore, the polysaccharide ratios (xanthan/CMC) of 20/80, 30/70, and 55/45 were selected for further studies at 50°C (Figure 1).

However, during our research, it was noticed that at 50°C, the film solution was not sufficiently viscous. From the literature, it is known that the optimum temperature for the best rheological properties of xanthan solution is a temperature not higher than 75°C, and 50–60°C for CMC [2, 5]. Therefore, to make a film at the same component ratios, a temperature of 60°C was chosen.

Soya lecithin was added to the film with concentrations of 0.1 to 1.0%. As can be seen from Table 1, the optimal concentration was 0.6%, since at higher concentrations, the colour of the solution changed, and at a lower dosage, the film coating was less flexible.
Our film coating technology. Lecithin was dissolved in distilled water at 90-95°C. Xanthan was dissolved in distilled water at 39-41°C. Carboxymethyl cellulose was dissolved in distilled water at 49-53°C. Then, the resulting solutions of xanthan and carboxymethyl cellulose were combined and stirred at 60°C until complete dissolution of the resulting clots. In order for the film to be strong, glycerol was added to the resulting solution and heated up to 100°C. After that, the film coating was cooled.

Based on the film coating, pilot samples of packages were prepared depending on the application method on food, e.g. sample 3 was selected for spraying; sample 5 was selected for brush application; and sample 10 was suitable for wrapping (Table 2).

**Table 2. Composition of the film coating, depending on the application method**

| Components | Sample 3       | Sample 5       | Sample 10      |
|------------|----------------|----------------|----------------|
| Xanthan, % | 0.60 ± 0.02    | 0.90 ± 0.01    | 1.61 ± 0.01    |
| CMC, %     | 2.73 ± 0.02    | 2.05 ± 0.01    | 1.38 ± 0.01    |
| Lecithin, %| 2.40 ± 0.01    | 2.40 ± 0.01    | 2.40 ± 0.02    |
| Glycerol, %| 5.00 ± 0.01    | 5.00 ± 0.02    | 5.00 ± 0.02    |
| Water, %   | 90.47 ± 0.01   | 90.85 ± 0.02   | 90.81 ± 0.02   |

The resulting films were colorless and odorless, and in case of industrial need they can be colored with various dyes. Depending on the shape of the substrate, the films were round, rectangular, square, with curved edges, etc. No changes in color and shape affected the performance of the films.

4. Conclusion

Thus, in the process of our research, it was found that the concentration of polysaccharides affects the appearance of our film coatings (depending on the thickness of the film coating they turn out transparent or slightly unclear), the higher the concentration of polysaccharides, the greater the number of air bubbles. Our film coatings can be recommended for applying onto food products in various ways: the denser film (sample 10) is recommended for wrapping around the product; the less viscous (inconsistency) ones (samples 3 and 5) are recommended for application by brush and spray.

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