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Development and evaluation of a smart packaging for the monitoring of ricotta cheese spoilage

Abstract

Colorimetric Smart packaging pH indicator offers a potential use that could allow consumer evaluation of the food quality. In this study, it was developed a film based on chitosan, gelatin, PVA and red cabbage extract for food quality monitoring. Films were characterized by Thickness and swelling index. Proof-of-Concept application tests were conducted with Ricotta cheese for evaluated the potential use in the food spoilage. The results show that indicator film has high hydration capacity and during application in cheese, the film did not visually indicated color change after 7days refrigeration storage.

Keywords: pH indicator film, natural pigment, ricotta cheese

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Introduction

Food packaging technology is constantly evolving in response to growing challenges of a modern society, that search for more healthy and safe food, but with durability and convenience.[1,2] In this context, the smart packaging is one of the most dynamic technologies used to monitor the condition of the packed food or the environment surrounding the food.[1,3] This packaging represents an important evolution food industry by provide information about hazard analysis critical control point (HACCP) and consumers knowing what they are buying. Once smart packaging system is able of indicating inform about a change occurred in a product, such as temperature and pH by means of visual changes.[1] Thus, a packaging system color based pH indicator offer a potential use could allow consumer evaluation of the quality food before purchasing or opening the package.[4] Renewable sources, biopolymer and natural pigments for example, may be used as alternative for intelligent packaging. The employment of bio-based materials for the development of biodegradable films has generated significant interest in industry for being sustainable, renewable, abundant sources, friendliness to the environment, and potential to substitute for petrochemicals.[5–7]

Anthocyanins represent a large group of natural pigments from vegetable sources have great potential as an indicator of food spoilage in intelligent packaging systems, due the color instability of anthocyanins is influenced by its structure, pH, temperature, co-pigmentation, UV radiation, and presence of oxygen resulting different color.[8] Yoshida et al.[9] developed a pH indicator biodegradable film based on chitosan and containing grape as a pH indicator. Pereira Jr et al.[10] developed a colorimetric temperature-time indicator film for monitoring food quality using chitosan/PVA blend containing anthocyanin applied in milk. Silva-Pereira et al.[11] development a pH indicator biodegradable film based on chitosan and starch containing red cabbage extract as a pH indicator for monitoring fish spoilage. Ricotta is a soft Italian cheese, unripened and obtained by a combination of heat and acid. It can be produced using cheese whey, milk or a mixture of both. This cheese has high moisture content, and its initial pH is above 6.0, thus it is highly perishable and has a limited shelf-life even under refrigeration due to textural changes and mold growth.[12,13] The present study aimed to development pH indicators film based on detection of chemical changes associated with microbial growth in Ricotta cheese during refrigerated storage.

Materials and methods

Extract preparation

Red Cabbage (*Brassica oleraceae*) extract was prepared according to Fuleki and Francis,[14] with modifications. A sample of approximately 150.0g of red cabbage was crushed and macerated with 80mL of ethanol-water (7:3). The pH of the sample was adjusted to 2.0 with HCl (1 M). Subsequently, the material was stored at 5°C for 24h, protected from light. After this period, the material was filtered and the extract was centrifuged at 103xg for 10min. The supernatant was filtered on Whatman paper n°1 and the resulting extract was used for pH indicator film.

Preparation of the pH indicator film

A chitosan hydrogel was prepared by dissolving 1g of chitosan (Sigma-Aldrich Art No.448877, 80% deacetylated) in 100 mL of aqueous acetic acid 1% (v/ v) under magnetic stirring for 24h at room temperature (25°C). The PVA hydrogel was prepared by dissolving 1g of polymer powder (Sigma-Aldrich Art. No. 363146, 99% Hydrolyzed) in 100mL of distilled water under magnetic stirring at 70±2°C until complete dissolution had occurred. Gelatin hydrogel was prepared by dissolving 10g of gelatin (acquired in local market) in 100mL of distilled water under magnetic stirring at 40±2°C until complete dissolution had occurred. After the chitosan/PVA/gelatin ratio of 1.34:0.83:0.83 (v/v) was mixture and, a 1% solution of sodium tripolyphosphate ($Na_5P_3O_{10}$) 0.1% (w/v) relative to the total volume of the mixture was added to the final hydrogel in order to promote cross-linking. The final chitosan/PVA/gelatin/extract hydrogel was prepared with a casting technique, with incorporation of the 15% anthocyanin extract of the total volume of the mixture of hydrogels. The hydrogel was casted (70ml) in Petri (90mm diameter) plates and then placed in an oven at 25°C for 72h for solvent drying, resulting in the final pH indicator films.

Thickness of the film

Film thickness was measured using digital caliper with precision of 0.02mm and repetition precision of 0.01mm (Mitutoyo-Digimatic®, Japan) at five random positions. Results were expressed with mean and standard derivation.

Determination of Swelling Index (Si %)

Swelling Index was determined by the method previously described.[10] Initially, the TTI samples were cut into 4.0cm^2 slices and then the samples were kept in a desiccator with silica-gel for 7days. After this procedure, samples were weighed and then subjected to immersion in beakers containing 250mL of distilled water for different time intervals (0.5, 1.0, 3.0, 5.0, 7.0 and 10.0min) at room temperature (25°C). At each time interval, samples were removed, dried and weighed. The Swelling Index (Si%) was calculated by Equation (1):

$$Si(\%) = \frac{(Final\ weight - Initial\ weight)}{Initial\ weight} \times 100 \quad \text{..... (1)}$$

Application of the pH indicator film

The pH indicator film (4 cm^2) was maintained in contact with ricotta sample (acquired in local market) and vacuum-packed into heat-shrinkable plastic bags and stored at 8°C for 7days. After color changes occurred in the pH indicator film, samples were evaluated for pH and mesophilic microorganism counts. The pH (pH meter T-100 Tekna, DM22-Digimed, São Paulo, SP, Brazil) was determined by introducing the electrode directly in the sample, and microbiological analyses were performed. Mesophilic microorganism was enumerated on PCA plates and incubated at 35°C for 48hours.

Results and discussion

Thickness and swelling index

The film produced from chitosan/gelatin/PVA blend incorporated red cabbage extract were homogeneous, transparent, colored light brown and average thickness of 0.07±0.01mm. The period of hydration of the indicator film was ten minute (Figure 1). After this time, swelling index was not evaluated, due to erosion of the film not observed an equilibration period of hydration and a reduced mass. The behavior could be attributed the hydrophobicity of the polymers and with reorientation of polar functional groups toward to the top surface of the blend films.[15] Perreira Jr et al.[10] recorded maximum hydration period of 3minutes for Chitosan/PVA/Anthocyanin films, after this time, a reduced mass was observed. This behavior is attributed to the chains attached by cross linking the polymer blend, since they lose their mobility after a period of hydration, hindering the access of solvent and consequently the hydration of the film. Other factor can be contributed to this behavior is the cross linking promoted by tripolyphosphate that promotes an interaction between the hydroxyl hydrogen and oxygen from the chitosan pyranosidic ring, causing a reduction in the number of hydrogen bonds to water.

Application of the indicator film

The indicator film color was initially light brown. After seven days of refrigeration storage, it was not observed visible change in the film indicator color (Figure 2). These results may be associated with maintenance of pH (4.48) and viable numbers of mesophilic microorganism (7 cycles logarithms) when compared with initial time. Thus, although the film is very sensitive to pH changes (data not shown), it cannot be applied to monitor Ricotta cheese spoilage caused by microbial contamination.

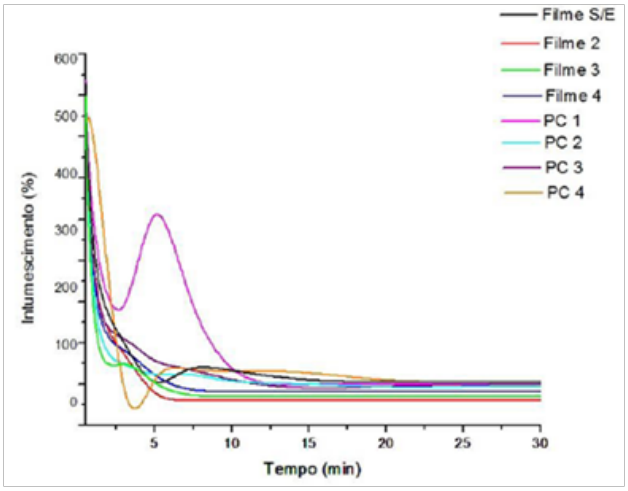

Figure 1 Hydration time and swelling index of indicator film (PC 1). Swelling (%)xTime (min).

Figure 2 Color change of indicator film under refrigeration: (A) 1day (B) 7days.

Conclusion

A biodegradable pH sensitive film was developed from renewable sources. In the proof-of-concept tests with Ricotta cheese, its applicability in this type of cheese was not possible. Further studies are necessary to evaluated the film potential to be applied as a smart food packaging.

Acknwledgements

None.

Conflict fo interest

The author declares no conflict of interest.

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