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Development of active packaging containing natural antioxidants

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Abstract

Two active packagings, consisting of PET trays sprayed with citrus fruit extract and α-tocopherol, were developed and tested. A comparison of the antioxidant activity of the two packagings was carried out on cooked meat stored at 4°C. Lipid oxidation in citrus fruit extract-coated trays, measured with TBARS analysis, was significantly lower ($p<0.01$) than in uncoated (control) trays. Trays coated with α-tocopherol did not show any antioxidant activity. Morphology examination showed a more irregular coating for citrus fruit extract. Different orientations of the active phenolic groups on the PET surface could explain the differences in antioxidant efficacy of the two packagings.

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Keywords: active packaging; citrus extract; α-tocopherol; coatings; lipid oxidation

1. Introduction

The new concepts of active and intelligent packaging are influencing the marketing of food. An active package may be defined as a system that modifies the condition of the food to extend its shelf-life or improve food safety or sensory properties [1]. Physical polymer surface modification methods have been applied in food packaging to alter barrier properties, to improve the mechanical characteristics or to modify adhesion behaviour of food packaging polymers [2]. These technologies can be applied to the preparation of plastic surfaces coated with specific organic substances [3]. The use of natural compounds

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in the preparation of an active packaging with antioxidant properties is a relatively new approach to the problem of the preservation of meat products. The antioxidant can be added for preservation of the polymer against oxidation or for preservation of the packaged food. Synthetic additives with antioxidant activity have been widely used in the food industry but recent trends, driven by consumer concerns about synthetic food additives, are towards the use of natural antioxidants. These natural substitutes include herbs and spices extracts, which have been shown to be very efficient in preventing lipid oxidation in food products [4]. Bioflavonoids are among the major constituents of these plant extracts and they are known to act as antioxidants by scavenging the free radicals that form during the oxidative processes [5]. In the present study, a citrus extract, containing a mixture of bioflavonoids, was examined as a potential antioxidant for the development of active antioxidant packaging. α-Tocopherol was chosen as a second natural antioxidant for the comparison with the citrus extract, because it is known to exhibit good antioxidant activity [6]. The objective of this study was to examine the efficiency of citrus fruit extract and α-tocopherol sprayed (nebulised) onto the surface of recycled PET food trays in preventing lipid oxidation in cooked meat. Slices of cooked turkey meat were stored on coated trays at 4°C for 4 days and the ability of the two coatings to reduce lipid oxidation compared. Turkey meat was chosen as reference food due to its relative abundance of poly-unsaturated fatty acids (PUFA), which make it suitable for the evaluation of oxidative processes [7].

2. Materials & Methods

The antioxidant packagings were prepared by spraying the antioxidant compounds onto the surface of recycled PET trays, using a nebuliser. Surface morphology, roughness and film thickness of the α-tocopherol and citrus coatings were evaluated using a Wyko NT1100 (Veeco, Tucson, USA) optical profilometer in vertical scanning interferometry (VSI) mode, which allowed a 3 dimensional image of the coating to be built over several hundred nanometers. Surface wettability was examined by measuring water contact angles (WCA) on the coatings using the sessile drop technique at room temperature with an optical contact angle measuring instrument OCA 20 (Dataphysics Instruments GmbH, Filderstadt, Germany). For the experiment with antioxidant coated trays, the meat was cut into square shaped pieces of approximately 3 g. Meat samples were randomly placed on the PET trays which were immediately overwrapped with a catering film. Samples were removed immediately (day 0) and after 1, 2 and 4 days of storage in a refrigerator at 4°C, for measurement of lipid oxidation with the TBARS assay [8].

3. Results & Discussion

In the experiment for the evaluation of the antioxidant efficiency of the coated PET trays, the preparation of the meat was optimized to maintain the initial oxidation of meat samples at a value of ~ 2 mg malonaldehyde (MDA)/kg meat (Figure 1). The TBARS values of samples on the control trays increased significantly ($p<0.01$) at days 1 and 2, to reach a value of ~ 7 mg MDA/Kg meat, which remained unchanged thereafter. Meat on the α-tocopherol-coated trays did not show any reduction in TBARS values, compared to the control samples, over the 4 days of the experiment. TBARS values for turkey meat stored on the citrus-coated trays were significantly lower ($p<0.01$) than those of samples on the control trays and α-tocopherol-coated trays after 1, 2 and 4 days of storage. Since α-tocopherol was chosen as a second natural antioxidant because of its well know antioxidant activity in meat samples [6], the different antioxidant activity may be related to the different characteristics of the two coatings, which affected the interactions between the antioxidant molecules and the meat.

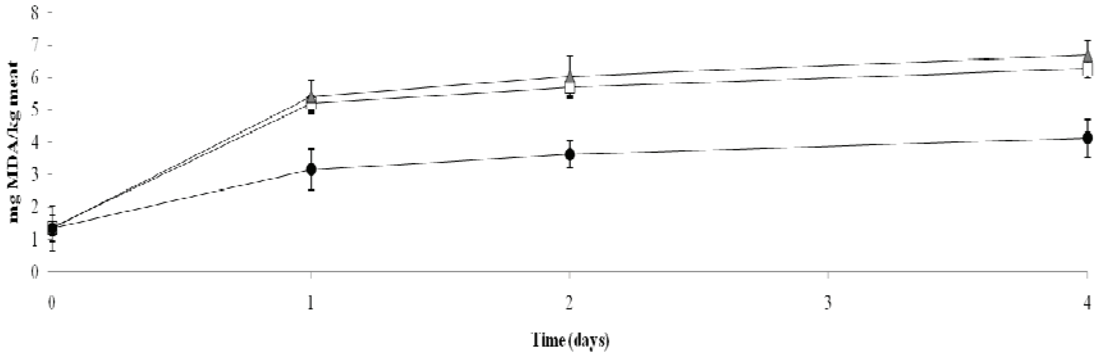

Fig. 1. Effect of α-tocopherol (▲) and citrus extract (●) coated PET trays on lipid oxidation (TBARS value) in cooked turkey meat slices stored for 4 days at 4°C. Meat stored on uncoated PET trays (□)

In order to explain these differences in antioxidant effectiveness, surface physical properties of the coatings were investigated. Optical profilometry is a non-contact method of examining surface morphology to quantify surface roughness and to measure surface features. It gives various surface height statistics and provides a vertical resolution on the nanometers scale. Optical profilometry analysis showed marked differences in morphology and roughness values for the two coatings. The citrus coating was irregularly distributed (Figure 2a), with a rough surface, characterized by large areas with different thicknesses of antioxidant coating. The mean value of average surface roughness (Ra) was 1.13±0.18 µm.

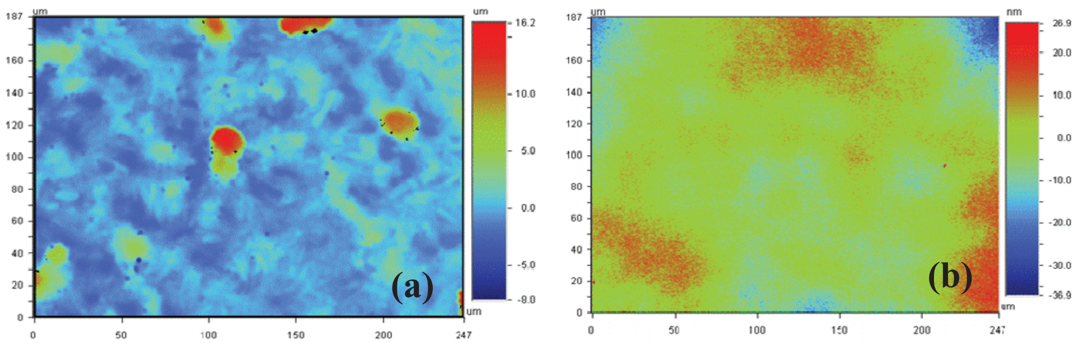

Fig. 2. Optical Profilometer images of Citrus extract (a) and α-Tocopherol coatings (b)

Trays coated with α-tocopherol, on the other hand, showed a more even distribution of the antioxidant film and a smoother surface (Figure 2b). The mean value of average surface roughness (Ra) was 0.19±0.08µm. Differences in the characteristics of the two coatings illustrated in the profilometry images may explain the differences in antioxidant activity between the two packagings. As a consequence of a non homogeneous distribution of citrus extract compounds on the PET surface, active polyphenolic groups may remain more exposed to the surface of the meat where they can effectively function as antioxidants. In the case of α-tocopherol, the active phenolic group of α-tocopherol may be separated from the meat by the hydrophobic phytol sidechain. This hypothesis seemed to be supported by the measurements of surface wettability of the two coatings.

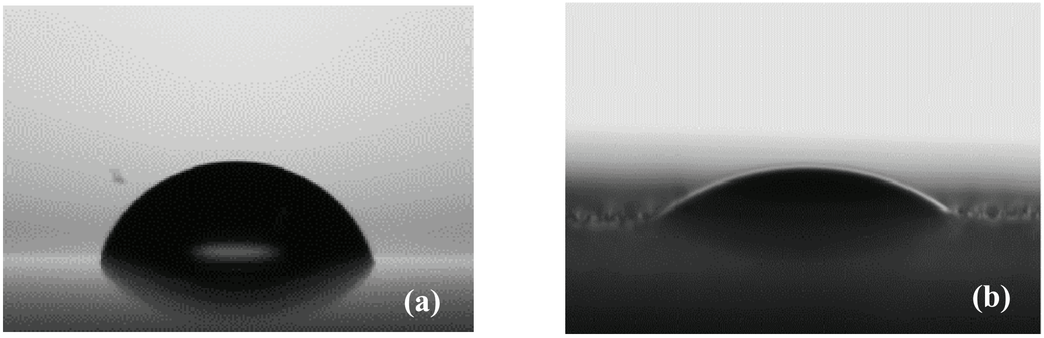

Fig. 3. Water contact angle images of citrus extract (a) and α-tocopherol coatings (b)

The citrus coated surface was more hydrophilic than the α-tocopherol coated surface, with water contact angle values of 22±0.6 and 75±0.5, respectively (Figure 3). This result may indicate the presence of hydrophilic groups, such as polyphenol groups characteristic of bioflavanoids, on the surface of the citrus coating. For the α-tocopherol coating a more hydrophobic character, is in agreement with the hypothesis that α-tocopherol molecules are orientated with their hydrophobic side chains at the surface of the coating.

4. Conclusion

Active packaging based on natural antioxidant compounds, obtained from citrus fruit extract, showed considerable capability in reducing oxidation in cooked turkey meat samples. On the other hand, a packaging prepared with α-tocopherol did not show any antioxidant property. It seems that, in contrast to citrus derived bioflavanoids, the active part of α-tocopherol molecules is not in contact with the meat surface and therefore the α-tocopherol coating did not show anti-oxidant properties.

Acknowledgements

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