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Zein-based blend coatings: Impact on the quality of a model cheese of short ripening period

Carolina Pena-Serna [a, b, *], Ana Lúcia Barretto Penna [a], José Francisco Lopes Filho [a]

[a] Food Engineering and Technology Department, São Paulo State University, São Jose do Rio Preto, Brazil
[b] Research Group on Agrarian Sciences-GRICA, Faculty of Agrarian Sciences, University of Antioquia, Medellin, Colombia

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ABSTRACT

Two biodegradable zein-based blend coatings were evaluated according to the impact on the quality of the "Minas Padrão" cheese throughout a storage period of 56 days. Throughout the storage, the biodegradable-coated cheese samples showed similar physicochemical characteristics in comparison to unpackaged and plastic-packaged cheese samples in terms of chlorides, ash, protein and acidity. Besides that, cheese samples with biodegradable coatings exhibited ca. 30% lower weight loss and avoided microbiological contamination for more than 50 days when compared to unpackaged cheese samples that exhibited contamination after 21 days. Although cheese samples with biodegradable coatings exposed a positive behavior in comparison to unpackaged cheeses, some challenges remain and require further studies. For instance, as a consequence of the moisture loss, after 28 days of storage, the biodegradable-coated cheeses were 124% harder, displayed 30% less proteolysis and more than 50% change in color surface than cheese samples with polyethylene packaging.

1. Introduction

"Minas Padrão" is a semi-hard cheese and one of the most important cheeses in Brazil. It is a traditional cheese, widely consumed and prepared from cow's milk in few Brazilian states. According to *Laticínio Balkis*, the cheese supplier, "Minas Padrão" ripening is carried out after the cheese is salted in brine and packaged in a polyethylene packaging that undergoes thermal shrinkage. Cheese is ripened for 25 days under controlled conditions, 3.8 ± 0.5 °C and 85% relative humidity; thereafter, the cheese is distributed to the supermarkets across the country.

The commercial "Minas Padrão" cheese is distributed and commercialized in plastic packaging, in order to avoid external chemical or microbiological contamination and to help preserving the cheese quality. Plastics are the most frequently used food packaging materials (Lagaron and López, 2011; Siracusa et al., 2008); nonetheless, due to environmental concern and their low recycling rate (Siracusa et al., 2008; Salarbashi et al., 2014), new biodegradable and edible materials have been and are developed to reduce the plastic packaging usage (Auras et al., 2006; Fajardo et al., 2010; Salarbashi et al., 2014).

One material that has been used to produce biodegradable and edible films and coatings is zein, the main corn protein (Zhang et al., 2011; Wu et al., 2012), which is recognized by the U.S. Food and Drug Administration (FDA) as a GRAS (Generally Recognized as Safe) food ingredient (Scramin et al., 2011; U.S. Department of Health and Human Services (2015)). Zein films have exhibited glossy appearance, toughness, low water solubility, resistance to microbial attack and high hydrophobicity (Del Nobile, Conte, Incoronato & Panza, 2008). In spite of that, several authors have demonstrated that blend films, i.e. a combination of zein with other biomolecules, mainly lipids (Cuq et al., 1995; Wang and Padua, 2006; Arcan and Yemenicioğlu, 2013), allows for improving the functional properties of zein-based films.

In this regard, several studies have been focused on the development of new biodegradable and edible films, and the evaluation of their functional properties; nevertheless, few researches have explored their application to food (Gennadios et al., 1997; Fajardo et al., 2010).

For instance, some biodegradable materials that have been reported as cheese coatings are mainly polysaccharide-based, e.g. chitosan (Fajardo et al., 2010; Zhong et al., 2014), galactomannan (Cerqueira et al., 2010), alginate (Zhong et al., 2014), carrageenan, gellan (Kampf and Nussinovitch, 2000), and few protein-based

* Corresponding author. Agrarian Sciences Faculty, University of Antioquia, Medellin, Colombia.
E-mail address: carolina.pena@udea.edu.co (C. Pena-Serna).

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coating such as whey protein isolate-WPI (Ramos et al., 2012) and soy protein isolate-SPI (Zhong et al., 2014). In all the previously referenced cases, cheeses with biodegradable coatings exhibited better preservation of cheese physicochemical characteristics than the uncoated counterparts. Moreover, to the best of our knowledge, Ramos et al. (2012) reported the uniquely available study that has compared synthetic and biodegradable cheese packaging. According to Ramos et al. (2012), the synthetic nonedible coating made of polyvinyl acetate (PVA) and the WPI biodegradable coating displayed similar performance on cheese quality preservation; therefore, the WPI coating is a suitable alternative for cheese packaging.

Hereby, the current study aims to evaluate the impact of two zein-based blend coatings on the physicochemical characteristics of the "Minas Padrão" cheese, as a model for short ripened cheeses, in comparison to polyethylene packaged and unpackaged cheese samples.

2. Materials and methods

2.1. Materials

A commercial brand of the "Minas Padrão" cheese was obtained from *Laticínios Balkis* (Santo Antônio do Aracanguá, Brazil) on the day of production. For the preparation of the zein-oleic acid (Z-OA) and zein-oleic acid-xanthan gum (Z-OA-XG) coatings, the following components were used: corn-zein (Sigma, São Paulo, Brazil), 99.5% ethanol (Synth, São Paulo, Brazil), oleic acid (Synth, São Paulo, Brazil), glycerol (Dinamica, Diadema, Brazil), xanthan gum (ADM, Chicago, USA) and Emustab emulsifier (Duas Rodas, Jaraguá do Sul, Brazil) composed by water, distilled monoglycerides of fatty acids, sorbitan monostearate and polyoxyethylene sorbitan monostearate.

2.2. Cheese sample preparation

After production, 84 semicircular cheeses with an approx. net weight of 0.4 kg each, were packaged in the regular polyethylene (commercial) packaging and transported under refrigeration from the dairy company to São Paulo State University in São Jose do Rio Preto, Brazil. The amount of cheeses was randomly divided into four groups that were named as unpackaged cheese (negative control), commercially packaged cheese (positive control), Z-OA coated cheese and Z-OA-XG coated cheese; thus, each group was composed by 21 semicircular cheeses.

After 5 h from cheese production, cheeses were cut, in order to obtain experimental samples (that will be referred to as samples in the remainder of the document). Cheese cutting was made first in four similar pieces along the radius of the semicircular shaped cheese and then each piece was further cut transversally providing eight similar samples of approx. 0.05 kg.

2.3. Coating solution preparation

The two zein-based coating solutions were prepared by adding 20 g zein to 100 mL 95% ethanol, and mechanically stirred for 5 min at 65 ± 0.5 °C. Glycerol (2 g), emulsifier (1 g) and oleic acid (14 g) were added to both solutions. Xanthan gum (0.05 g) was also added to the Z-OA-XG solution; afterwards, Z-OA and Z-OA-XG solutions were stirred for 10 min and these were allowed to reach room temperature before applying on the cheese surface.

2.4. Cheese coating procedure

After the cheese cutting, Z-OA and Z-OA-XG experimental samples were coated with a three-layer coating, as follows. One layer of the coating solution was brushed on the surface of the cheese sample and after 1 h of drying; a second layer was applied, repeating the procedure until completing three layers. Once the three layers were applied, the coating dried during 4 h at 24 °C and 50% relative humidity (%RH). Thereafter, the samples of the four cheese groups were organized in plastic trays and stored under controlled conditions (3.8 °C, 85%RH). The brushing method was used in order to avoid contamination of the coating solutions with cheese residues (such as whey or cheese fragments) that might interfere with the formation of the coating. Furthermore, the application of the three layers of the coating solution to the cheese surface allowed for producing a homogeneous coating with similar thickness in comparison to the commercial polyethylene packaging.

2.5. Cheese chemical composition and physicochemical analyses

Throughout 56 days of storage time, the "Minas Padrão" cheese samples were tested for physicochemical characteristics such as titratable acidity, moisture, total ash, chlorides, lipids, total nitrogen and proteolysis rate. The results of the tests were expressed on dry basis. Three replicates of 200 g each were used to perform the physicochemical analyses; based on that, each replicate was composed by four samples (4 × 0.05 kg) belonging to each cheese group. The three replicates were taken at 0, 7, 14, 21, 28, 42 and 56 days of coating application. Furthermore, weight loss analysis was performed twice a week during the storage period using eight samples (replicates) of each cheese group.

Titratable acidity was assayed and expressed as lactic acid (Instituto Adolfo Lutz, 1985); moisture content was determined according to the 926.12 AOAC method by drying the cheese samples to constant weight at 70 °C in vacuum oven (AOAC, 1997); total ash content was analyzed by incineration at 550 °C according to the 935.42 AOAC method (AOAC, 1997); chloride content was measured through an argentometric method using the total amount of ash previously obtained (Instituto Adolfo Lutz, 1985); lipid content was tested by the Gerber-Van Gulik method (Instituto Adolfo Lutz, 1985)); weight loss was determined by weighing samples at the beginning (W_0) and throughout the storage period (W_i), the relative weight loss (ΔW) was calculated as follows $\Delta W = (W_0 - W_i)^*100/W_0$; total nitrogen content was assessed by the micro-Kjeldahl method in accordance with the 960.52 AOAC method (AOAC, 1997); furthermore, the total protein content was calculated multiplying the nitrogen content by the conversion factor 6.38; cheese proteolysis was analyzed by separating the nitrogenous compounds into solvent-soluble and solvent-insoluble nitrogen, followed by the fractionation of the soluble components with discriminatory precipitants and quantification with the micro-Kjeldahl method. Thereby, soluble nitrogen at pH 4.6 (pH 4.6-SN) was obtained by precipitation with hydrochloric acid 1.41 N and trichloroacetic acid soluble nitrogen (TCA-SN) was obtained by precipitation with TCA 12% (Merheb-Dini et al., 2012).

2.6. Cheese surface color analysis

The color surface change of cheese samples was analyzed throughout the storage period with a Chroma meter ColorFlex EZ (HunterLab Inc., Reston, USA) using the CIELab color scale (where L = lightness, a = red-yellow color, and b = blue-green color) under daylight ($D65$ illuminant). The total color difference (ΔE) was calculated as follows $\Delta E = [(L-L_0)^2 + (a-a_0)^2 + (b-b_0)^2]^{1/2}$, where L_0, a_0, and b_0 were the initial values (1 day of coating application) obtained for the samples of each cheese group, and L, a, b were the values measured during the storage period (Cerqueira et al., 2010;