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Application of biodegradable films made from rice flour, poly(butylene adipate-co-terphthalate), glycerol and potassium sorbate in the preservation of fresh food pastas

Gardênia Martins Sousa [a,*], Fábio Yamashita [b], Manoel Soares Soares Júnior [a]

[a] Universidade Federal de Goiás, Escola de Agronomia e Engenharia de Alimentos, Campus Samambaia, Rod. Goiânia/Nova Veneza, KM 0, 74690-900, Goiânia, GO, Brazil

[b] Universidade Estadual de Londrina, Centro de Ciências Agrárias, Rod. Celso Garcia, KM 380, 86057-970, Londrina, PR, Brazil

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A B S T R A C T

The objective of this study was to evaluate the shelf life of fresh lasagna pasta intercalated with extruded films made from blends of rice flour, poly(butylene adipate-co-terphthalate) (PBAT), glycerol and potassium sorbate, and quantify the concentration of sorbic acid that migrated from the films into the product. The microbiological analyses carried out at zero time showed the product to be within the standards established by Brazilian legislation, and the microbial count was lower in the food pastas containing sorbic acid that had migrated from the films. The presence of slime on the surface of the food pastas was one of the determinant factors in their shelf life. The addition of 3 g 100 g^{-1} potassium sorbate to the biodegradable films made of rice flour, PBAT and glycerol was recommended for application to fresh lasagna pasta, since this concentration was sufficient to extend the shelf life while maintaining a lower sorbic acid concentration in the final product.

1. Introduction

Polymers obtained from renewable sources widely used in the food industry, have been tested as raw materials in the production of a new type of more sustainable packaging with specific functionality, such as the control of moisture content, gases and the migration of food additives and/or nutrients. Of the polymers from renewable sources, starch, the largest constituent of cereal grains, including polished rice, is used to make biodegradable films (Liu, Kerry, & Kerry, 2005). An average of 14 g 100 g^{-1} broken grains are produced during the polishing of rice. This is an economic problem for the rice industry, since the value of these broken grains represent a fifth of that obtained in commercializing the whole grain (Silva & Aschieri, 2009).

The mixture of two or more different polymers is denominated a blend. These are prepared with the objective of improving the properties of the products, reducing costs and obtaining products with differentiated characteristics. Poly(butylene adipate-co-terphthalate) (PBAT) is a biodegradable aliphatic, aromatic co-polyester obtained by chemical synthesis, commercialized under the name of Ecoflex® (BASF, Germany) and has the potential to combine with starch and other biodegradable polymers to form polymeric blends (Shi, Ito, & Kikutani, 2005). Rice flour, obtained from the broken grains, can be used to lower the cost of films made from blends of biodegradable polyesters with rice flour, since the cost of PBAT is almost fifteen times higher than that of rice flour (Sousa, Soares Júnior, & Yamashita, 2013).

From the food safety point of view, antimicrobial substances used in the development of active films should be approved for food use, due to migration. Substances that are generally recognized as safe (GRAS) such as sorbic and propionic acids and their salts, and others, have also been incorporated into polymers in the production of antimicrobial films. For example, sorbic acid and its salts have been widely employed in active films since they are effective against molds, yeasts and bacteria (Jay, 2005). Chemical preservatives are used to inhibit microbial growth and increase the shelf life of fresh food pastas together with the use of refrigeration, since these products are packed without heat treatment (Silveira et al., 2007).

Food pastas are defined as products obtained from wheat flour (*Triticum aestivum* L.) and/or other species of the genus *Triticum*

* Corresponding author.
E-mail addresses: beleia@uel.br, gardeniams3@gmail.com (G.M. Sousa), fabioy@uel.br (F. Yamashita), mssoares@hotmail.com (M.S. Soares Júnior).

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and/or derived from hard wheat (*Triticum durum* L.) and/or derivatives from other cereals, roots and tubers, resulting from a mechanical pasting and rolling process without fermentation. Fresh or moist pasta refers to a product that was not submitted to partial drying. Fresh pasta should have a maximum moisture content of 35 g 100 g^{-1} in wet weight basis (wwb). Due to their composition and principally to their high moisture content, fresh food pastas are subject to the growth of a wide variety of microorganisms and hence to deterioration, and can even constitute a public health risk. Thus special care is required with regard to the commercialization of fresh food pastas, which can easily become contaminated for diverse reasons, such as the presence of contaminants in the raw materials, exposition to a contaminated environment or to inadequately sanitized equipment and utensils and a lack of rigorous hygiene by the handlers (Silveira et al., 2007). Considering the above, the objective of the present study was to evaluate and determine the shelf life of fresh lasagna pasta intercalated with extruded films made from rice flour, poly(butylene adipate-co-terphthalate) (PBAT), glycerol and potassium sorbate (active packaging system), with respect to the microbial, physical and chemical aspects, and quantify the concentration of sorbic acid that migrated from the biodegradable films to the fresh food pasta.

2. Material and methods

2.1. Material

The following ingredients were used to produce the films: poly(butylene adipate-co-terphthalate) (PBAT) – Ecoflex-F® provided by BASF (Ludwigshafen, Germany), rice flour (SL Alimentos, Londrina, Brazil), technical grade glycerol (*Dinâmica*, São Paulo, Brazil) and food grade potassium sorbate (Chenco Indústria e Comércio Ltda., Campinas, Brazil). The films were applied to fresh lasagna pasta supplied by the company Massas Vovó Dê Indústria de Produtos Alimentícios Ltda. (Londrina, Brazil).

2.2. Production of biodegradable films

The films were produced by blow extrusion process using the following temperature profile: 90, 120, 120 and 130 °C and a screw speed of 40 rpm according to Sousa et al. (2013). The film thickness was controlled during the process by adjusting the air flow, maintaining the balloon diameter at about 200 mm. Different blends were elaborated for film production in which the concentrations of PBAT and rice flour were fixed at 47 and 40 g 100 g^{-1}, respectively, varying the concentrations of the preservative potassium sorbate of 0, 1, 3 and 5 g 100 g^{-1} (m/m) and glycerol, substituting part of the latter by the preservative, since both acted as film plastifiers (Flores, Costa, Yamashita, Gerschenson, & Grossmann, 2010).

2.3. Production of fresh pasta

The food pastas were produced by a lamination process. The following ingredients were mixed with the iron and folic acid enriched wheat flour: eggs, salt, water and cassava starch. After mixing the ingredients, the dough was rolled and molded. The food pastas were laminated by two stainless steel rolls, and the sheets obtained cut into long strips. Stainless steel molds were used to give the desired format to the pasta, with dimensions of 160 mm in length by 110 mm in width. The food pastas were then submitted to a pre-cooking process in water at 98 °C for 2 min., and immediately removed for packaging. After pre-cooking, the final thickness obtained for the food pastas was 2 mm. After production, the fresh food pasta units were intercalated with the active biodegradable films produced (90 ± 10 μm thick) (Fig. 1). The fresh lasagna pasta contained no type of preservative. Food pasta units containing no preservative were intercalated with the low density polyethylene (LDPE) films (20 μm thick) normally used by the company, for use as the control. All the pastas were packed into laminated LDPE and nylon packets (LDPE/nylon/LDPE layers, each 15 μm thick), vacuum sealed (88 kPa) and stored under refrigeration at 7.0 ± 2.0 °C until analyzed. Thus the shelf life study was carried out on fresh lasagna pastas intercalated with polyethylene films and with biodegradable films containing 0, 1, 3 and 5 g 100 g^{-1} potassium sorbate (treatments: Control, MA0, MA1, MA3 and MA5, respectively). Each packet contained twenty five sheets of the determined sample, and the destructive analyses were carried out weekly for 42 days.

2.4. Microbiological evaluation

The following microbiological analyses were carried out on the experimental pastas: yeast and mold count, *Bacillus cereus* count, *Staphylococcus aureus* count, psychrotrophic organism count and the most probable number of heat tolerant coliforms. The analyses were carried out according to the techniques described in American Public Health Association (APHA, 2011). Samples of 25 ± 0.2 g were weighed, transferred to sterile stomacher bags, and homogenized for one minute in 225 mL of 0.1% peptone water Serial dilutions were made by transferring 1 ml of extract from each dilution. For yeast and mold count samples were inoculated in the petri dishes containing solid nutrient media and potato dextrose agar (PDA). The colonies were counted after 48 h incubation. *B. cereus* was determinated on Mannitol Yolk Polymyxin (MYP) agar and incubated at 30 °C for 24 h. *S. aureus* was enumerated by surface inoculation on Baird-Parker agar supplemented with egg yolk and potassium tellurite and incubated at 37 °C for 48 h. Population of psychrotrophic microorganisms were determined by pour-plate using Plate Count Agar (PCA) and incubated at 7 °C for 10 days. Heat tolerant coliforms was analyzed in tubes containing EC agar and Durham tubes. Tubes were incubated at 44.5 °C for 24 h and gas production was detected in positive tubes.

Fig. 1. Fresh lasagna pasta, after production, intercalated with experimental biodegradable films. [A, B, C, D] Means with the same letters for the same time did not differ at the level of 5% according to Tukey's test.; [1] Significant at 1% of probability; [2] The treatments Control and MA0 showed deterioration as from the 9th and 8th days of application, respectively, making it impossible to continue the shelf life study after this period; [3] The treatment MA1 showed deterioration as from the 18th day of application, making it impossible to continue the shelf life study after this period; MPN.g^{-1}: Most probable number per gram of sample; CFU.g^{-1}: Colony forming units per gram of sample.