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Combined effect of active coating and modified atmosphere packaging on prolonging the shelf life of low-moisture Mozzarella cheese

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ABSTRACT

In this work, the effect of active coating on the shelf life of low-moisture Mozzarella cheese packaged in air and modified atmosphere (MAP) was studied. The active coating was based on sodium alginate (2%, wt/vol) and potassium sorbate (1%, wt/vol). The MAP was made up of 75% CO_2 and 25% N_2 (MAP1), 25% CO_2 and 75% N_2 (MAP2), or 50% CO_2 and 50% N_2 (MAP3). The product quality decay was assessed by monitoring microbiological and sensory changes during storage at 4, 8, and 14°C. Results showed that the combination of active coating and MAP was able to improve the preservation of low-moisture Mozzarella cheese. Specifically, the shelf life increased up to 160 d for samples stored at 4°C, and 40 and 11 d for those at 8 and 14°C, respectively. A faster quality decay for untreated samples packaged in air was observed. In particular, the *Pseudomonas* spp. growth and the appearance of molds were responsible for product unacceptability. The combination of active coating and MAP represents a strategic solution to prolong the shelf life of low-moisture Mozzarella cheese and to ensure the safety of the product under thermal abuse conditions.
Key words: low-moisture Mozzarella cheese, active coating, modified atmosphere packaging, shelf life

INTRODUCTION

Mozzarella cheese is one of several pasta filata cheeses originating in Italy. Two main types of Mozzarella are produced, based on moisture content (US FDA, 1989). In particular, low-moisture (**LM**) Mozzarella cheese (moisture content: 45–54%) is often used for pizza toppings or as an ingredient in other foods, whereas high-moisture Mozzarella cheese (moisture content: 56–65%), which is the principal Italian Mozzarella exported, is usually consumed fresh as a table cheese (Gammariello et al., 2008; Conte et al., 2009; Del Nobile et al., 2009). Generally, LM Mozzarella cheese is packaged under vacuum in trays of polypropylene sealed with a plastic top film and stored at 8°C. In these conditions, the shelf life is less than 5 wk; as the product increases its firmness, the odor becomes unpleasant and develops a bitter taste.

Extending the shelf life of Mozzarella cheese is an important issue to the dairy industry, due to the high interest in extending the distribution of traditional products beyond market borders. The main ways of improving the food product quality and shelf life are based on using high-quality raw materials, developing process innovations, and adopting suitable storage conditions (Farkye et al., 1991; Kindstedt, 1993; Brody, 2001; Conte et al., 2009).

Edible films and coatings prepared from polysaccharides, proteins, and lipids have a variety of advantages, such as biodegradability, edibility, biocompatibility, aesthetic appearance, and barrier properties, against oxygen and physical stress. Edible films prepared from hydrocolloids, such as sodium alginate, form strong films and exhibit poor water resistance because of their hydrophilic nature (Guilbert, 1986).

The use of edible coatings for a wide range of food products has received increased interest, because coatings can serve as a carrier for a wide range of food additives, including antibrowning agents, colorants, flavors, nutrients, spices, and various antimicrobials that can extend product shelf life and reduce the risk of pathogen growth on the food surface (Cagri et al., 2004; Pranoto et al., 2005; Conte et al., 2009; Del Nobile et al., 2009).

The potential of modified atmosphere packaging (**MAP**) and active packaging to extend the shelf life of different dairy products has been demonstrated (Floros et al., 2000; Pantaleão et al., 2007; Papaioannou et al., 2007). Modified atmosphere packaging reduces physiological changes, respiration rates, oxidation reactions, and microbial growth by changing the level of gases that surround the product. To the best of our

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knowledge, very few papers have discussed Mozzarella cheese packaged in MAP. Eliot et al. (1998) reported that shredded Mozzarella cheese packaged in MAP containing levels of 75% CO_2 was well protected from undesirable organism and gas formation. Alves et al. (1996) also found that microbial growth in sliced Mozzarella cheese packaged in MAP was delayed with high concentrations of CO_2.

Considering the above, the aim of the current work was to evaluate how the combination of active coating and MAP can improve the shelf life of LM Mozzarella cheese. Specifically, the quality decay was assessed by monitoring the microbiological and sensorial subindices of the product and the effect of temperature was also investigated.

MATERIALS AND METHODS

Active Coating and Packaging of LM Mozzarella Cheese

Low-moisture Mozzarella cheese samples (~150–200 g) were kindly provided by a local cheese factory (Capurso Azienda Casearia SpA, Gioia del Colle, Bari, Italy) and brought to our laboratory in boxes containing 10 pieces each under refrigeration (4°C). According to information supplied by the manufacturer, all cheeses were produced by a common-milled curd procedure using starter culture that consisted exclusively of *Streptococcus thermophilus*, and with fermentation-produced chymosin as coagulant. Samples were removed from their packages and subjected to the active coating treatment. In particular, samples were dipped into a sodium alginate solution prepared by dissolving sodium alginic acid powder (2%, wt/vol) and potassium sorbate (1%, wt/vol) in sterile distilled water tempered to 50°C. Then, the coated samples were immersed into a crosslinking solution of calcium chloride (5%, wt/vol) for 1 min to promote the alginate gel-forming process. After treatment, the coated LM Mozzarella cheese samples (**COAT**) were air dried for 2 min. Then, 2 pieces per package were placed in commercially available bags (nylon/polyethylene) with a thickness of 95 μm (Valco S.r.l., Bergamo, Italy). The bags were 170 × 250 mm long, with an oxygen transmission rate of 49.39 $cm^3/(m^2 \cdot d)$, carbon dioxide transmission rate of 162.83 $cm^3/(m^2 \cdot d)$, and water vapor transmission rate of 1.64 $g/(m^2 \cdot d)$. In addition, LM Mozzarella cheese samples without active coating were used as control (**CTRL**). All samples were sealed in air and under modified atmosphere conditions. The gas combinations used were the following: **MAP1**: 75% CO_2 and 25% N_2, **MAP2**: 25% CO_2 and 75% N_2, and **MAP3**: 50% CO_2 and 50% N_2. All samples were stored at 4, 8, and 14°C. The sodium alginic acid, potassium sorbate, and calcium chloride were from Farmalabor S.r.l. (Canosa di Puglia, Italy).

Microbiological Analyses

Microbiological analyses for total viable count (**TVC**), *Pseudomonas* spp., *Enterobacteriaceae*, lactic acid bacteria (**LAB**), and lactococci were performed according to the International Organization for Standardization (ISO, 2001; ISO 8261:2001). Media and conditions used for the enumerations were as follows: plate count agar (Oxoid SpA, Milan, Italy) incubated at 30°C for 24 to 48 h for TVC; *Pseudomonas* agar base (Oxoid SpA) with 10 mg of cetrimide/L, 10 mg of fucidine/L, and 50 mg of cephaloridine/L selective supplement (Oxoid SpA), incubated at 25°C for 48 h for *Pseudomonas* spp. count; for *Enterobacteriaceae*, violet red bile glucose agar (Oxoid SpA) incubated at 37°C for 18 to 24 h; de Man, Rogosa, and Sharpe (MRS) agar (Oxoid SpA) incubated anaerobically in HP 11 jars (Oxoid SpA) at 37°C for 2 to 4 d for LAB; and M17 agar (Oxoid SpA) incubated anaerobically in HP 11 jars (Oxoid SpA) at 37°C for 48 h for lactococci. The microbiological analyses were carried out twice on 2 different batches.

To determine the effectiveness of the packaging strategy, the microbiological acceptability limit (**MAL**), defined as the storage time at which microbial counts of the selected spoilage group reached the threshold value permitted, was calculated as reported by Del Nobile et al. (2009). The microbiological limit was fixed at 10^6 cfu/g for *Pseudomonas* spp. (Conte et al., 2009).

Sensory Analysis

Low-moisture Mozzarella samples were subjected to sensory analysis by a panel consisting of 7 trained evaluators. The panel was selected and trained according to the International Organization for Standardization method 8586-1993 (ISO, 1993). The selection was made considering various aspects: interest and motivation, eating habits (consumption of dairy products), ability to communicate sensations, time available for analysis sessions, ability to concentrate, and performance training. Eight sessions of 1 h each were required to define the sensory profile and to familiarize the testers with the characteristics of LM Mozzarella cheese. After training, panelists were asked to evaluate color, odor, taste, and firmness attributes of LM Mozzarella cheese. Low-moisture Mozzarella samples were presented to panelists with and without active coating and they were asked to describe differences between samples using a scale from 1 to 7 (Corradini and Innocente,