Effect of Packaging Films Releasing Antimicrobial Agents on Stability of Food Products

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Abstract: The study was aimed to (*i*) test the effect of polyethylene (LDPE) films coated by commercially available polyvinylchloride (PVC) lacquer with addition of nisin preparation Nisaplin® (5% w/w) and/or natamycin preparation Delvocid™ (10% w/w) on the growth of target bacteria, yeasts and moulds on the surface of soft cheese Blaťácké zlato produced by company Madeta, a.s., Veselí nad Lužnicí, and (*ii*) prepare and study the antimicrobial films with incorporated lactic acid or sodium lactate, suitable for packaging of raw chicken meat. The cheese in contact with nisin/natamycin treated film was stored at temperature 4°C and 23°C for 23 days, while chicken meat packaged in lactic acid/sodium lactate releasing films was stored only at 4°C for 7 days. Released antimicrobial agents caused retardation of tested microorganism growth by more than 1 logarithmic cycle on the surface of cheese Blaťácké zlato and by more than 2 logarithmic cycles in raw chicken meat.

Keywords: antimicrobial packaging; nisin; natamycin; cheese

INTRODUCTION

Active packaging systems based on the application of packaging materials with incorporated antimicrobial agents provides one of promising trends in food processing. Antimicrobial food packaging reduces, inhibits or retards the growth of pathogenic and/or spoilage microorganisms that may be present on packaged food surfaces due to releasing of antimicrobial components. These systems can contribute to the shelf-life extension, the quality maintenance and the storage stability improvement of packaged foodstuffs (Appendini & Hotchkiss 2002; Cooksey 2005).

Nisin, a bacteriocin produced by *Lactococcus lactic* subsp. *lactis*, has been shown to be able to be incorporated into various food packaging films (Quintavalla & Vicini 2002; Cooksey 2005). Nisin exhibits antimicrobial activity towards a wide range of Gram-positive bacteria, such as *Lactobacillus*, *Listeria, Bacillus* and *Clostridium,* and is particularly effective against bacterial spores (Delves-Broughton 2005).

Natamycin, also pimaricin, is a polyene antibiotic produced by actinomycetes *Streptomyces natalensis*. It is active against nearly all moulds and yeasts, but has a little or no effect on bacteria. It is widely used on products such as cheese and sausages. Natamycin was found to be effective in preserving soft cheese with no detrimental effect on ripening (Zeuthen & Bøgh-Sørensen 2003).

Lactic acid and its salts are commonly present in meat. These compounds are effective against a wide range of microorganisms. Lactate decreases water activity and undissociated lactic acid is able to pass through a cell membrane and inhibit the growth of microorganisms by pH decrease (Pipek 1998).

The aim of this work was to study the effect of the polyethylene packaging film coated with a lacquer containing nisin and/or natamycin on microbial stability of packaged soft cheese Blaťácké zlato and cellophane or polyethylene films with lactic acid, sodium lactate and nisin on the microbial stability of raw chicken meat.

MATERIALS AND METHODS

Packaging material. (*i*) polyethylene film (LDPE, thickness 60 μm, Martin Peroutka – polygrafická

výroba, Buštěhrad, CZ), surface treated with lacquer (Rotoflex L-1414 A, Rotoflex AG, Switzerland) with 5% (w/w) Nisaplin® (Danisco A/S, Denmark) of activity 1×10^6 IU/g and/or 10% (w/w) Delvocid™ (DSM Food Specialities, the Netherlands) containing 50% (w/w) of pure preservative.The thickness of final lacquer layer was 2 μm. Released amount of antimicrobial agents was determined to 900 IU/dm^2 for nisin and 1.3 mg/dm^2 for natamycin; (*ii*) cellophane (regenerated celulose) film (Naturflex, thickness 23 μm, Innovia, Great Britain) surface treated with 50% (w/w) lactic acid and 50% (w/w) sodium lactate solution (Sigma-Aldrich). The films released lactic acid up to the maximal level 12 mg/dm^2 and sodium lactate up to the maximal level 25 mg/dm^2; (*iii*) polyethylene film (LDPE, thickness 60 μm, Martin Peroutka – polygrafická výroba, Buštěhrad, CZ), surface treated with lacquer (Rotoflex L-1414 A, Rotoflex AG, Switzerland) with 10% (w/w) sodium lactate (Sigma-Aldrich). The thickness of final lacquer layer was 9 μm. The films released sodium lactate up to the maximal level 5 mg/dm^2.

Food sample. Portioned soft cheese Blaťácké zlato (the content of solids 51% (w/w) and from that 48% (w/w) of fat) produced by company Madeta, a.s. (Veselí nad Lužnicí, CZ) and raw chicken meat from a retail was used for analyses.

Sample preparation a microbiological analyses. Portioned cheese Blaťácké zlato was covered with above mentioned packaging film (see (i)) in contact with nisin and natamycin lacquer layer and weighted down with a glass plate for better contact of the samples. Before tests a part of the cheese was inoculated by *Penicillium expansum* by spraying on 0.2 ml microorganism suspension (density 10^5 CFU/ml). Portioned chicken meat was vacuum packaged (95% vacuum) using all above mentioned packaging films in contact with lactic acid, sodium lactate and nisin containing lacquer layer. The packaged cheese was stored at temperature 4°C and 23°C for 23 days, the packaged chicken meat at temperature 4°C for 7 days.

During storage the total count of microorganisms (PCA medium, 30°C, 48–72 h) and the count of yeasts and moulds (YGC medium, 25°C, 3–5 days) on the surface of cheese Blaťácké zlato were determined. The growth of psychrophilic and mesophilic microorganisms (PCA medium, 20°C and 30°C, 48–72 h) was monitored in raw chicken meat.

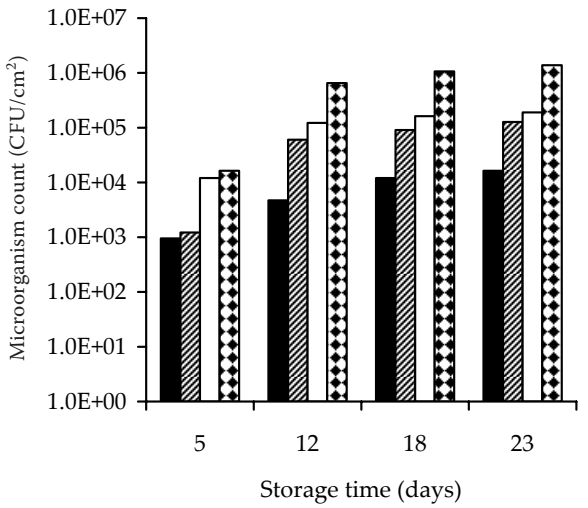

Figure 1. The changes of the total bacteria, yeast and mould count on the surface of Blaťácké zlato cheese packaged in the films with and without antimicrobial agents at temperature 23°C

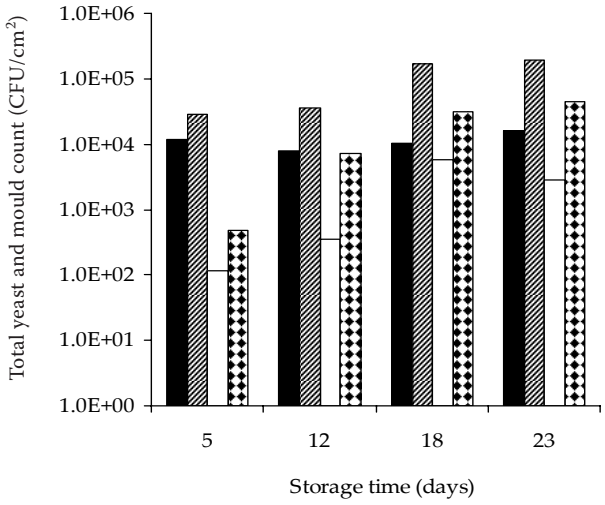

Figure 2. The changes of the total yeast and mould count on the surface of Blaťácké zlato cheese samples inoculated by *Penicillium expansum* and packaged in the films with and without natamycin at temperature 4°C and 23°C

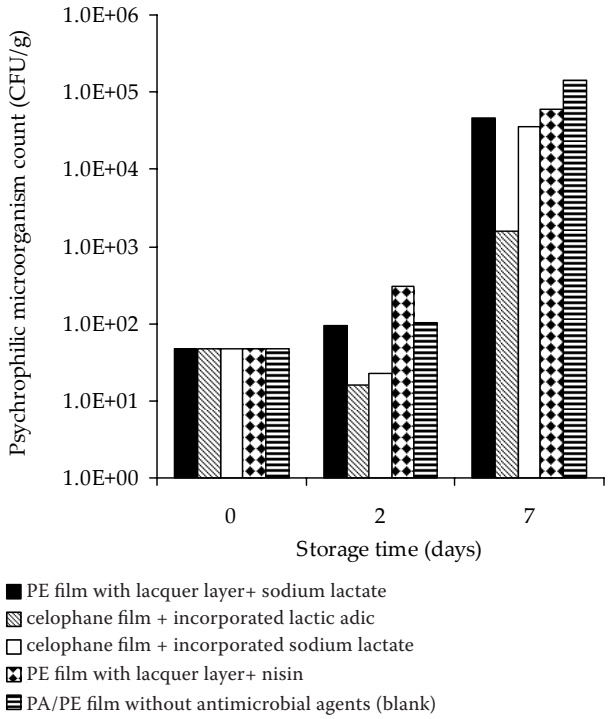

Figure 3. The changes of the total psychrophilic bacteria count in the samples of raw chicken meat packaged in the films with and without antimicrobial agents at temperature 4°C

RESULTS AND DISCUSSION

The initial total bacteria count (2.3×10^3 CFU/dm^2) and total yeast and mould count (1.3×10^3 CFU/dm^2) was determined on the cheese surface at the beginning of the experiment. In Figure 1 the total bacteria count as well as the total yeast and mould count on the sample surfaces of un-inoculated cheese are given. The microorganism count increased gradually during the storage time at 23°C. Released nisin and natamycin mainly influenced the rate of the microorganism growth. The count of all microorganisms was reduced by 1 logarithmic cycle on the samples in contact with the films containing nisin and natamycin.

Figure 2 compares the growth reduction of yeasts and moulds in cheese samples inoculated by suspension of *Penicillium expansum* (initial concentration 1.1×10^4 CFU/ml) treated with the film containing natamycin. It is evident, that the yeast and mould count rose slightly during the storage time at 23°C. Released natamycin slowed down the rate of the microorganism growth by 1 logarithmic cycle. During storage at temperature 4°C the yeast and mould count increased by 1 logarithmic cycle on the samples in contact with package releasing natamycin and by 2 logarithmic cycles in samples without natamycin.

The influence of packaging material on the psychrophilic bacteria count in the samples of raw chicken meat is summarised in Figure 3. Since the beginning of the experiment the inhibitory effect of the films containing lactic acid, sodium lactate and nisin has been observed. After 7 day storage at 4°C only cellophane film releasing lactic acid inhibited significantly the psychrophilic as well as the mesophilic bacteria growth (by 2 logarithmic cycles). The rest of the films releasing nisin and/or sodium lactate did not affect on the growth of tested microorganisms.

CONCLUSIONS

The results of this study have proved that active systems of food packaging based on the release of antimicrobial agents from the polymer and cellophane film did not inhibit the count of target microorganisms on the soft cheese Blaťácké zlato and raw chicken meat. The released antimicrobial agents caused the significant retardation of the microorganism growth during storage of tested food products.

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