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Rapid communication

Quality changes in semi-hard cheese packaged in a poly(lactic acid) material

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Abstract

A study was performed in order to evaluate the influence of barrier properties of a poly(lactic acid) (PLA) relative to an amorphous poly(ethylene terephthalate)/polyethylene (APET/PE) packaging material on quality of Danbo cheese during light exposure and storage in the dark. Results showed that moisture loss from cheeses packaged in PLA was approximately 10 times higher than from the reference packages, but dry surface spots were not observed before 56 days of storage in the PLA packages. Secondary lipid oxidation products were primarily developed when both oxygen and light were present. During light exposure, lipid oxidation of cheeses packaged in PLA was rather limited for the first 56 days of storage, whereas lipid oxidation was almost negligible when the cheeses were protected from light during the 84 days of shelf life. The results indicate that the present PLA can be used for packaging of Danbo cheese for a shelf life maximum of 56 days in order to protect against both moisture loss and lipid oxidation.

Keywords: Poly(lactic acid) (PLA); Semi-hard cheese; Water vapour barrier; Oxygen barrier; Light barrier; Moisture loss; Headspace gas concentration; Secondary lipid oxidation products

1. Introduction

From a food quality point of view, poly(lactic acid) (PLA) has proved suitable for packaging of foods requiring low to medium gas and water vapour barriers and with relatively short shelf lives. The scarce literature shows the potential of using PLA for packaging of orange juice (Haugaard, Danielsen, & Bertelsen, 2003; Haugaard, Weber, Danielsen, & Bertelsen, 2002), yoghurt (Frederiksen, Haugaard, Poll, & Becker, 2003), salad dressing (Haugaard et al., 2003) and sour cream (Holm & Mortensen, 2004), which are conventionally packaged in either polyethylene or polystyrene. In all studies, the foods packaged in PLA were better protected against chemical quality changes, including loss of ascorbic acid in orange juice and lipid oxidation in the fat-containing foods, than were foods packaged in conventional materials.

At present, the water vapour barrier properties of PLA are inferior to those conventionally used for high-barrier packaging (van Tuil, Fowler, Lawther, & Weber, 2000). The impact of high water vapour transmission rates (WVTR) is moisture loss, as documented for mushrooms packaged in PLA, where moisture loss was approximately four times higher than products packaged in a conventional synthetic material (Holm & Mortensen, 2004). In the evaluations of fresh orange juice (Haugaard et al., 2002), yoghurt (Frederiksen et al., 2003), salad dressing (Haugaard et al., 2003) and sour cream (Holm & Mortensen, 2004), moisture loss was not investigated, but as the WVTR

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of the actual PLA packages was low (0.1 g/package × day) (Haugaard et al., 2002), moisture loss is not likely to be a problem.

In addition to the WVTR, the oxygen transmission rate (OTR) of PLA materials is generally higher than that of conventional packaging materials for cheese, a category which includes laminates based on, e.g., poly(ethylene terephthalate) (PET) and polyethylene (PE). However, such a comparison is based on WVTR and OTR measured under standard conditions, namely 37.8 °C and 90% relative humidity (RH) (ASTM F1249) for WVTR and 23 °C and 0% RH (ASTM D3985) for OTR. These temperatures and relative humidities are far from the actual storage conditions of cheeses. Hence, more realistic comparisons may be made by measuring the barrier characteristics of the packaging materials under actual food storage conditions.

The aim of this study was to evaluate PLA for packaging of semi-hard cheeses, which require modified atmosphere (MA) packaging and have a shelf life of 84 days, hence constituting a rather complex food and placing severe demands on the barrier properties of the packaging material. The study focussed on the impact of the water vapour, gas and light barriers on the quality of the cheeses in order to pinpoint needed barrier improvements. The reference packages and the PLA-based packages were characterised and compared by making a priori calculations on the package transmission rates using available information on standard film permeabilities and geometric properties of the packages. The effects on quality were monitored experimentally during storage by measurement of moisture loss from the packages, changes in the headspace gas composition, development of secondary lipid oxidation products, as well as odour and visible mould growth.The study was designed to simulate chilled retail storage (4 °C), where products were exposed to light or stored in the dark.

2. Materials and methods

2.1. Packaging and storage of cheese

Blocks of Danbo cheeses (approximately 170 g 45+ semi-hard cheeses) were obtained from Arla Foods amba (Viby J, Denmark). The blocks were packaged in thermoformed, transparent PLA trays with a film thickness of 500 μm, closed with a lid made of 500 μm PLA film (Hycail bv, Noordhorn, The Netherlands), or for comparison purposes, a conventional reference package, consisting of a 420 μm amorphous APET/PE (380 μm APET/40 μm PE) tray (Amcor Flexibles, Lund, Sweden) closed with a lid made of 102 μm PET/PE film (36 μm PET/hot melt/40 μm PE) (Amcor Flexibles, Argentan, France). The dimensions of the trays were 17.5 × 8 × 2.5 cm. The surface area of the lids was 0.014 m^2 and the area of the formed trays was 0.0268 m^2. The cheeses were packaged in a MA consisting of 30% carbon dioxide and 70% nitrogen at Multivac (Vejle, Denmark). The packages were stored in a display cabinet under conditions similar to those in retail stores. The average temperature and relative humidity during storage were determined by temperature and relative humidity loggers (Testo logger 174 NTC Sensor) to be 4 ± 2 °C and 50 ± 10%, respectively. Samples were exposed, 24 h per day, to Philips TLD 18W/830 New Generation fluorescent light tubes (Philips, Eindhoven, The Netherlands) with an average light intensity of 1500 lx at the surface of the cheese measured with a Digital Light Meter (Model YF-172). Half of the packages were covered with black plastic, which resulted in a total light protection. The samples were rotated regularly to minimise possible temperature and exposure differences in the display cabinets.

2.2. Characterisation of the product

Characterisation of the cheeses was carried out using standard methods to include: total fat (IDF Standard 5B, 1986), total protein (IDF Standard 20B, 1993), total solids (IDF Standard 4A, 1982), salt (IDF Standard 88A, 1988) and pH.

Determinations of moisture loss, headspace gas composition, secondary lipid oxidation products, and evaluation of odour, surface-drying, and visible mould growth, were carried out after 0, 7, 14, 28, 56, 84 and 133 days of storage. Three PLA and three reference packages stored in the dark or exposed to fluorescent light were withdrawn at the respective times of analysis. A 4 mm thick slice was cut off the cheese surface facing the light source and used for further analysis, thereby illustrating a worst-case scenario.

2.3. Moisture loss

Moisture loss of the entire package, to include cheese, tray and lid, was measured as weight loss from the package, hence assuming that moisture loss was the main cause of weight loss from the cheese. Moisture loss at each time of sampling was calculated relative to weight at the time of packaging.

2.4. Headspace gas composition

Prior to opening the cheese packages, headspace gas composition, expressed as % oxygen and % carbon dioxide was determined using a CheckMate 9000 gas analyzer (FBI Dansensor, Ringsted, Denmark) and a needle inserted through a septum placed on the packages.