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Effectiveness of modified atmosphere packaging and ovine whey powder in extending the shelf life of whey cheesecakes

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ABSTRACT

The goal of this study was to determine if the combined use of modified atmosphere packaging (MAP) and substitution of 4% and 8% whey cheese with ovine whey powder (OWP) would extend the shelf life of whey cheesecake, compared with samples packaged in air and without OWP. To this end, whey cheesecakes were packaged under a N_2/CO_2 ratio of 70/30 and with air and stored for 60 days at 20 °C. Changes in microbial growth, in-package gas composition, chemical-physical parameters, texture, and sensory attributes were evaluated.

The use of OWP and MAP extended the shelf life to 21 and 45 days, respectively, compared with the control samples that spoiled after 11 days. The combined use of MAP and OWP at the highest concentration further increased the mould-free shelf life of the cakes to 60 days. All of the samples underwent a significant increase in hardness during storage, but sensory acceptability was not impaired. Panellists did not find differences in sensory properties between control and OWP samples and gave an acceptability score over the threshold during the entire storage period.

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1. Introduction

The shelf life of food strictly correlates with the rate at which degradation reactions occur. One main factor that, in general, is positively correlated with the impairment of food quality is the water activity (a_w) value; products with higher values are more likely to have a shorter shelf life than those with lower values (Barbosa-Cánovas, Fontana, Schmidt, & Labuza, 2007). Among high-moisture foods (HMFs), which are characterised by a_w values higher than 0.90 (Tapia, Alzamora, & Chirife, 2007), cheese cakes show the microbial spoilage as the critical descriptor of shelf life (Smith, Daifas, El-Khoury, Koukotsis, & El-Khouri, 2004). Approaches to reduce the microbiological alterations in bakery foods have relied on the application of strategies to prevent, stop, or control post-baking contamination (Smith et al., 2004). While the first two approaches are seldom used, control of post-baking contamination is the preferred means used by the food industry and includes the use of preservatives (Grundy, 1996; Saranraj & Geetha, 2012), recipe reformulation, or packaging conditions such as modified atmosphere packaging (MAP) (Kotsianis, Giannou, & Tzia, 2002; Sanguinetti et al., 2009) or active packaging (AP) (Gutiérrez, Batlle, Andújar, Sánchez, & Nerín, 2011; Siro, 2012). The use of preservatives is actually decreasing due to consumers' reluctance to buy products that contain them. Thus, the food/bakery industry is focusing on extending the shelf life of products by combining product reformulation and the use of MAP and/or AP, especially in HMFs such as baked goods in which a well-calibrated ingredient reformulation could result in a significant reduction of a_w values without changing the sensory properties. Product reformulation can act as a hurdle to microbial growth when paired with the well-known antimicrobial activity of MAP at O_2 and CO_2 concentrations lower than 1% and higher than 20%, respectively (Daniels, Krishnamurthi, & Rizvi, 1985; Ellis, Smith, Simpson, & Ramaswamy, 1993; Ellis, Smith, Simpson, Ramaswamy, & Doyon, 1994; Guynot, Marin, Sanchis, & Ramos, 2003; Guynot, Sanchis, Ramos, & Marin, 2003; Ooraikul, 1991; Sanguinetti et al., 2009; Smith et al., 1988; Smith, Ooraikul, Koersen, & Jackson, 1986; Smith & Simpson, 1995; Seiler, 1989).

One of the ingredients used in the bakery industry as a nutritional or texture enhancer is obtained from bovine whey, a by-

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product of cheese and casein production. Most whey products come in dry powder form and are produced by evaporation and spray drying or as concentrates obtained by ultrafiltration and spray drying. Lactose and proteins are the main constituents and result in texture modifications such as gelling, film formation, foaming and emulsifying (Kinsella & Whitehead, 1989; Zadow, 1992). Whey products are exclusively obtained from bovine milk, as ovine whey is used for the production of a whey cheese specialty, ricotta cheese (Diaz, Pereira, & Cobos, 2004). Recently, Secchi et al. (2011) used sorption isotherms and magnetic resonance imaging to show that ovine whey powders (OWPs) have good water-binding properties that delay the firming of cookies compared with control samples, without impairing the sensory properties. Sanguinetti et al. (2009) showed that MAP extended the shelf life of cheesecakes packaged under 30% or 80% CO_2 to 14 and 34 days, respectively, whereas air-packaged cakes were spoiled by mould after only 7 days. Although 80% CO_2 allowed a considerable extension in mould-free shelf life, the use of high CO_2 concentrations may result in other problems such as packaging collapse or sensory alterations due to the strong acidification of food.

The goal of this study was to determine whether the combined use of low CO_2 MAP (30%) and OWP would extend the shelf life of whey cheesecakes, which is normally 10 days.

2. Materials and methods

2.1. Sample preparation

Control ovine whey cheese cakes were produced in a local plant (Esca Dolciaria Snc; Dorgali, Sardinia, Italy) according to the formulation and methodology reported by Sanguinetti et al. (2009), but with the substitution of the ovine cheese filling with ovine whey cheese. Two other batches were prepared by substituting 4% or 8% of the ovine whey cheese with OWP (Alim21, Alimenta Srl; Macomer, Sardinia, Italy). All of the batches and relative codes are reported in Table 1. Freshly prepared cheesecakes were cooked at 180 °C in a rotor oven for 12 min, and after cooling at room temperature in air, were packaged inside multilayer (EVOH/PS/PE) gas barrier trays (six cheese tarts/tray) (Aerpack B5-30, Coopbox Italia; Reggio Emilia, Italy) that were hermetically closed with a multilayer (EVOH/OPET/PE) gas and water barrier film with a thickness of 54 μm (EOM 360B, Sealed Air; Charlotte, NC, USA). The gas transmission rates for the tray were: O_2, 1.07 $cm^3\ m^{-2}\ 24\ h^{-1}\ bar^{-1}$ at 23 °C; CO_2, 5.35 $cm^3\ m^{-2}\ 24\ h^{-1}\ bar^{-1}$ at 23 °C; water vapour, 6.3 $g\ m^{-2}\ 24\ h^{-1}$ at 38 °C. The gas transmission rates for the film were: O_2, 4 $cm^3\ m^{-2}\ 24\ h^{-1}\ bar^{-1}$ at 23 °C; CO_2, 13 $cm^3\ m^{-2}\ 24\ h^{-1}\ bar^{-1}$ at 23 °C: water vapour, 9 $g\ m^{-2}\ 24\ h^{-1}$ at 38 °C. Each batch was packed in ordinary atmosphere (ORD) and in MAP with CO_2:N_2 at a 30:70 gas ratio using a packaging machine (Mod. Reetray 250, Reepack Srl; Seriate, Italy). Storage was done under controlled temperature conditions (20 °C ± 0.5). An appropriate number of samples were prepared in order to have a sufficient number of cakes for the six batches. Analyses were performed at 0, 10, 20, 40, and 60 days.

Table 1
Codes used for the 6 batches of cheese cakes.

Ovine whey powder (%)	Packaging	Code
0	ORD[a]	Ctr
	MAP	MAP
4	ORD	4%
	MAP	4%MAP
8	ORD	8%
	MAP	8%MAP

[a] ORD = ordinary atmosphere packaging; MAP = modified atmosphere packaging.

2.2. Microbiological analysis

Three cheese cakes (one from three different trays) were homogenised, and 10 g was added to 90 mL sterile water and mixed for 2 min in a Stomaker Lab blender 80 (PBI; Milan, Italy). Decimal dilutions were obtained with sterile 0.1% peptone solution and used on specific microbiological media to enumerate the total microbial count (TMC), as well as the presence of *Staphylococci*, mould and yeast. TMC was determined in Plate Count Agar (PCA) medium (Oxoid; Milan, Italy) after incubation at 30 °C for 48 h, whereas *Staphylococci* were detected and enumerated on Baird Parker Agar (BPA) (Oxoid) after 48 h at 37 °C. Mould and yeast were detected on Yeast Peptone-Dextrose (YPD) Agar incubated for 4 days at 25 °C. Counts were expressed as colony-forming units per gram (CFU/g). Three repetitions of each analysis were performed at the inspection times reported.

2.3. Chemical-physical analyses

Homogenised samples of whole cheesecake were used to check for changes in a_w and moisture content (%) over time. The a_w was determined using an AQUALAB instrument (Series 3, Decagon; Pullman, WA, USA) calibrated in the range of 0.1–0.95 with LiCl, NaCl and KCl solutions of known activity (Labuza et al., 1976). The moisture content was obtained after the sample was dehydrated in a vacuum oven for 12 h at 70 °C (AOAC, 2012). Triplicate determinations were performed (one cheesecake sample from three different trays) and each measurement was repeated five times.

2.4. Texture and colour determination

The texture of the freshly prepared cakes and changes during storage were evaluated using a texture analyser (mod. TA-XTplus Texture Analyser, Stable Microsystems; Godalming, UK) fitted with a 30 kg load cell. The Texture Expert program (version 1.21) was used for data processing. A puncture test was carried out using a 5 mm diameter cylinder probe (mod. P/5). The contact plate of the texture analyser was replaced with a confectionery holder supplied with a top and bottom hole of 6 mm in diameter. The following speed parameters were set on the instrument: pre-test, test and post-test speeds of 2 mm/s, 1 mm/s and 5 mm/s, respectively. After reaching a penetration depth of 40 mm, the probe returned to its start position. Two parameters were taken into account to evaluate changes in texture: the maximum force (N) reached during puncturing and hardness (N*s), defined as the area under the curve up to the maximum force (N) divided by the time (s) between the two points.

The surface colour of the cheesecakes was determined with a CM-700d spectrophotometer (Minolta; Osaka, Japan) using a D65 illuminant and a CIE 10° standard observer angle. L*(lightness), a*(redness) and b*(yellowness) were acquired, and a* and b* were used to compute the hue angle. Before measurement, the spectrophotometer was calibrated against a white tile supplied with the instrument. Measurements were taken from six cheesecakes after 1 day of storage to check for any change occurring due to a probable enanced Maillard reaction derived by the use of OWP. Readings were performed on two different points of each sample.

2.5. Gas analysis

The headspace gas evolution of MAP trays during storage, with O_2, CO_2 and N_2 components, was determined using a gas analyser

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