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Evaluation of two packaging systems for regional cheese

I. Pantaleão, M.M.E. Pintado, M.F.F. Poças *

Department of Packaging, Biotechnology College, Portuguese Catholic University, Rua Dr. António Bernardino de Almeida, 4200-072 Porto, Portugal

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Abstract

Saloio cheese – a regional Portuguese cheese – is currently sold unpackaged or in a vacuum package. Neither of these packaging systems is acceptable: the first system yields a cheese too hard, because of excessive water loss, while the second yields a white cheese with poor textural properties. The use of a packaging system with a tailor-made moisture barrier, i.e., allowing for water loss, but at a lower rate, is a way of extending the cheese's shelf-life.

The adequate water vapour permeability to preserve the cheese was previously determined as 6.8×10^{-7} g m/m^{2}day Pa at 8 °C. The objective of this work was to develop a packaging system providing the required relative humidity inside the package. Two systems were tested: (i) the active system *Humidipak*® and (ii) perforated plastic films.

Both packaging systems succeeded in extending the cheese's shelf-life by significantly decreasing the water loss. Perforated films require further study on moulds growth control.

Keywords: Active packaging; Perforated films; *Humidipak*®; Shelf-life; Cheese

1. Introduction

Cheese is a complex system where different reactions take place during the maturation and storage processes. After manufacture, semi-hard cheese undergoes a maturation process according to the ripening conditions the cheese is exposed to. This process influences texture, flavour, and all other chemical and physical properties of the cheese (Pantaleão, Pintado, Poças, & Malcata, 2004). When a packaging system is used, with the objective of extending the shelf-life of the product, the maturation process has to be considered. The need for a balance or optimization, between these two requirements, makes active packaging a promising option for cheese packaging applications.

Semi-hard cheeses generally have high water activities. Water activity (a_w) influences microbiological and physic-chemical evolution of the cheese over time (Saurel, Pajonk, & Andrieu, 2004). The control of a_w and moisture is very important for the preservation of quality and safety of these products.

In unpackaged cheese, water loss depends on the chemical properties of the cheese and on the storage conditions. Most authors have found that the water content of cheese was linked to its salt content (Payne & Morison, 1999). However, the thermodynamic driving force for water transfer out of the cheese and out of the package, in the case of packaged cheeses, depends also on the barrier to moisture that the package offers (Holm, Mortensen, & Risbo, 2006). In packaged cheeses, water loss depends not only on the storage conditions, but also on the permeability (P) of the packaging material.

The cheese under study is a cylindrical, straw coloured, semi-hard regional cheese. This cheese is frequently sold unpackaged, suffering from excessive water loss. The cheese has an attractive straw yellow colour, but after 2 months of storage the cheese has poor textural properties, presenting a too high hardness. When this cheese is packaged under vacuum using a high barrier plastic material, mould growth is

* Corresponding author. Tel.: +351 22 5580086; fax: +351 22 5580111.
E-mail address: mfpocas@esb.ucp.pt (M.F.F. Poças).

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retarded, but the cheese becomes white pale in colour and presents a wet surface due to water migration to the surface.

A way of extending the shelf-life of this type of cheese is by allowing water loss, but at a lower rate. The correct *P* of the packaging film – the one that yields the ideal RH (relative humidity) inside the package at real storage conditions – can therefore be the key to an extended shelf-life (Simal, Sánchez, Bon, Femenia, & Rosselló, 2001).

Two packaging systems, with potential for controlling water loss from *Saloio* cheese, were studied: (i) the active system *Humidipak*® and (ii) perforated plastic films. The first (i) is an active system that, by using saturated salts solutions, maintains constant the RH inside a closed or semi-closed system, like a package (How it works, 2005). The level of RH is defined according to the product and depends on the solution formulation. In the second case (ii), the permeability of a film can be adjusted by perforating the material with perforations of different density and size.

2. Materials and methods

2.1. Packaging systems

Two packaging systems were tested: the system with humidity control using the Humidipak® sachets, and the system with microperforated polyethylene (PE) film, which was used to make pouches (this experience was set up only as a screening study). Unpackaged cheese was used as a control in both cases.

2.1.1. Plastic packages with Humidipak® sachets

This system includes a polyvinyl chloride (PVC) lid over a polystyrene (PS) base where the *Humidipak*® sachet could be placed (Fig. 1). Their original commercial application was as a cheese packaging system for use in association with oxygen absorbers. The packages were kindly supplied by *Plastiques de L'Arvor* (*Gestel, France*). The *Humidipak*® sachets were kindly supplied by *Humidipak Inc.* (*Wayzata-MN, USA*). This technology is claimed to allow for a two-way humidity control by continually responding and adjusting to the outside RH by either adding or removing water to maintain a predetermined level of RH inside the packages. The product consists of a gelled, saturated solution that is filled into a small sachet made of a material with very high permeability, but not allowing for liquid–water to pass through or leak into the container. This makes possible its use in association with food products. The saturated solution of a soluble substance is designed to maintain a specific level of relative humidity inside a closed system. *Humidipak Inc.* developed specific sachets to fit properly in the plastic package cavity. Sachets able to maintain two different levels of RH were selected and used according to results from a previous work (Pantaleão, Pintado, & Poças, 2004): level A – 78% and level B – 84%. The sachets were impregnated with antimicrobial (sodium propionate) to control moulds growth.

2.1.2. Perforated films

A PE film with a thickness of 7.5 μm kindly supplied by *Bolloré* (*Quimper, France*) was perforated and used to make pouches of 16×16 cm. The perforations were performed manually with needles of 0.25 mm in diameter (*BD Medical, USA*). The number of perforations per square meter of film was calculated based on the results of a previous experiment (Pantaleão et al., 2004) where different perforated films were tested. One of the films exhibited the required permeability (6.8×10^{-7} g m/m^2 day Pa), but yielded a cheese colour and texture not uniform, mainly because of the relatively large size and low density of perforations. In the present work, a new perforated film was developed with a similar permeability, but with improved size/density of perforations. The optimization was made in terms of surface open area per square meter of film. Several grids with different meshes were used to perforate the films (Fig. 2) and the permeability associated to each film was determined. A good correlation ($r^2 = 0.991$) between the mesh and the permeability was obtained (Fig. 3) and this was used to find the parameters (dimensions of the grid mesh) which yielded the required permeability of 6.8×10^{-7} g m/m^2 day Pa.

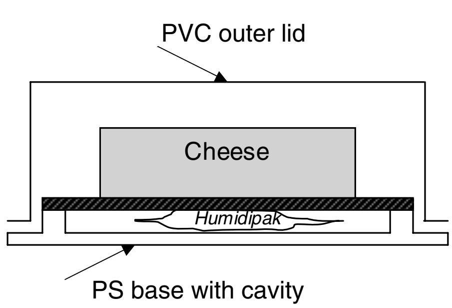

Fig. 1. Scheme of the packaging system with *Humidipak*® sachets.

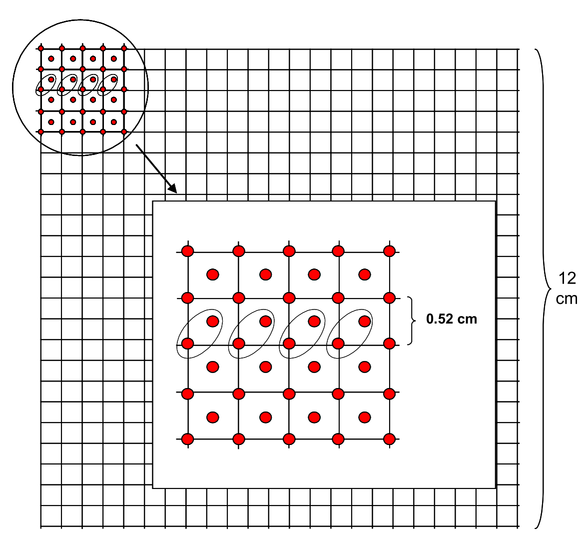

Fig. 2. Grid model for the film perforation.

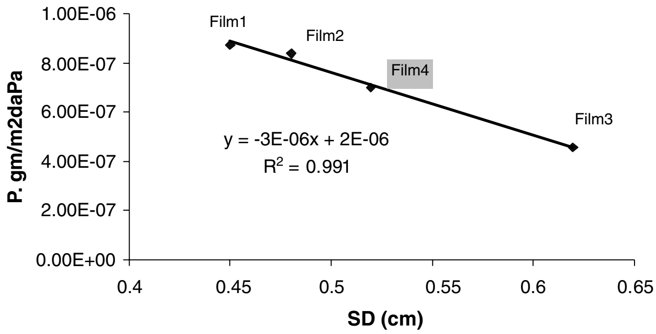

Fig. 3. Correlation between dimensions of the grid mesh for perforations measured in squares dimension (SD, cm) and permeability of the film.

The perforated films were tested for moisture barrier according to ASTM E 96 – 2000 "Standard test methods for water vapour transmission of materials".

2.2. Cheese

Cheeses were kindly supplied by *Queijo Saloio, Lda* (*Torres Vedras, Portugal*). *Saloio* cheese is a full fat regional cheese with a range of sizes, produced with a mixture of caprine, ovine and bovine pasteurized milk and submitted to a short ripening period (ca. 15 days for cheeses with 250 g) during which a straw coloured thin rind is formed. It requires controlled refrigerated conditions during distribution and sale. The cheese average physicochemical composition is: moisture content 46% ± 1.14 (w/w), fat 25% ± 0.5 (w/w), protein 18.4% ± 0.45 (w/w), total ash 3.58% ± 0.14 (w/w), chlorides 1.54% ± 0.03 (w/w), pH 4.8 ± 0.04 and total acidity 1.40 ± 0.02 ($g_{lactic\ acid}/100\ g_{cheese}$). Cheeses with two different sizes were used in the packaging experiments: small size (60 g) with ca. 3 cm in height and 4 cm in diameter for the experiment with the *Humidipak®* system and medium size (250 g) with ca. 5 cm in height and 7 cm in diameter for the experiment with perforated films. In spite of the standard size being 250 g, the experiment with *Humidipak®* sachets was performed with the small sized cheeses since this size adjusted better into the plastic packages commercially available.

2.3. Packaging and storage conditions

Fifty four cheeses of 60 g were packaged in the plastic packages along with the *Humidipak®* sachets: 27 at level A of RH (78%) and 27 at level B of RH (84%). The packages were sealed. Six cheeses were packaged in pouches made with the manually perforated film. All the cheeses were stored in a refrigerated chamber (*Fitoclima 5000 EDTU, Portugal*) at 8 ± 1 °C, 85 ± 2% RH. Storage time was 60 days for*Humidipak®* system and 84 days for perforated films.

2.4. Cheese analysis

The cheeses were sampled in triplicate every week for the cheese packaged in the system with *Humidipak®* sachets and for the respective control. Cheeses packaged in perforated film were sampled in triplicate but only twice – after 41 and 84 days (end of storage time). This was due to the difficulty in getting manually perforated film in the amount required for a more frequent sampling rate. However, the weight was evaluated every week by measuring the differences in packaged cheese.

All the cheeses were analysed in terms of physicochemical properties: moisture content, colour, texture and weight. Microbiological and sensorial analyses were also performed.

Moisture content was determined by weight loss via heating at 105 °C for 24 h (IDF, 1982).

Texture properties of cheeses were evaluated with a TA.XT Plus Texture Analyser (*Stable Micro Systems, Haslemere, England*) with a load cell of 30 kg and a 2 mm cylindrical plunger at a constant penetration speed of 2.00 mm/min (TPA) to obtain force vs. time curves (three penetrations per cheese). The software – *Texture Expert for Windows version 1.20, Stable Microsystems* – converted the force deformation readings into hardness.

Determination of colour was achieved using a Minolta Chroma Meter CR-300 (*Tokyo, Japan*). Changes in the surface colour of cheese were measured in CIE L^* a^* b^* colour system. Total colour difference (CD) was calculated as follows (Thompson, 2004):

$$CD = \sqrt{(L - L_0)^2 + (a - a_0)^2 + (b - b_0)^2} \quad (1)$$

where L_0, a_0 and b_0 are the initial values, obtained before packaging. Total colour difference, calculated as described, accounts for colour changes relatively to an initial point, despite changes being for brighter or darker yellow.

Weight loss was evaluated with a *Mettler PM1200* (*USA*) precision balance. Samples from the *Humidipak®* experiment were analysed for mesophilic bacteria, lactic acid bacteria, yeasts and moulds, coliforms and staphylococci coagulase positive. Aliquots of 1 ml were taken and decimally diluted in sterile 0.1% (w/v) peptone water (*Sigma Chemical, St. Louis, Missouri, USA*), and then plated in duplicate on several selective media: Plate Count Agar, PCA (*Merck, Germany*) for total mesophilic counts, Violet Red Bile Lactose Agar, VRBL (*Merck, Germany*) for coliforms; MRS (*Merck, Germany*), acidified with acetic acid down to a pH of 5.5, for lactic acid bacteria; Baird-Parker Agar with Rabbit Plasma Fibrinogen, BPA + RPF (*bioMérieux, France*) for staphylococci coagulase positive; and Rose Bengal Agar (*Oxoid, England*) for moulds and yeasts. The poured plate technique was used for all media, except for RBA where the spread plate technique was used instead. PCA plates were incubated aerobically at 30 °C for 72 h, VRBL plates were incubated aerobically at 30 °C for 24 h, BPA + RPF plates were incubated aerobically at 37 °C for 48 h; MRS were incubated aerobically at 30 °C for 72 h and RBA was incubated aerobically at 25 °C for 5 days.

Sensorial analysis was performed for both types of cheese: 60 g and 250 g. The cheeses were evaluated by 15 members of a trained panel, familiar with regional cheeses. For evaluation of cheese appearance, the whole cheese was first analyzed by the panel and then it was cut into slices of ca. 2 cm and the pieces were placed on white plates. Panelists evaluated the cheese for appearance (surface color) and texture (firmness and hardness) using a 5-point scale. Panelists were also instructed to report any defects they noticed. Panelists used water to clean their palates between samples.

For all experimental evaluations cheeses were compared with unpackaged cheeses stored in the same conditions (control cheeses).

2.5. Statistical analysis

An Analysis of Variance (ANOVA) at a level $p \leqslant 0.05$, was performed to evalute differences between the packaging systems. Data were analysed using the Excel 2003 (*Microsoft, USA*).

3. Results and discussion

Weight loss of the packaged cheeses is shown in Fig. 4, for the *Humidipak*® and for perforated film experiments. It has significantly ($p \leqslant 0.05$) decreased in both cases when compared to the control, which means that the systems were able to retard water loss. Cheese packaged with *Humidipak*® sachets controlling RH at levels 78% and 84% lost respectively ca. 18% and 12% in weight, after 60 days of storage, whereas the control lost ca. 20% in weight. The perforated film also reduced the weight loss: after 84 days of storage the cheese lost ca. 20% in weight while the control lost 25%.

Experimental texture measurements are shown in Fig. 5. Hardness increased in both unpackaged cheeses and cheeses packaged with perforated film though the latter occurred at a slower rate. However, for cheeses packaged with the *Humidipak*® system hardness was almost constant over the storage period.

In terms of colour and based on instrumental results, the perforated film yielded a very uniform colour, close to the one obtained for the control. Colour difference for cheese packaged with *Humidipak*® level 84% RH was not significant as compared to the control, mostly due to the large variability of the results. For level 78% RH cheese colour was not very uniform over the whole cheese surface, since the rind presented areas with different yellow tones, which affected the average results (Fig. 6).

The results obtained for humidity loss (Fig. 7) are in agreement with results of other studied properties, namely

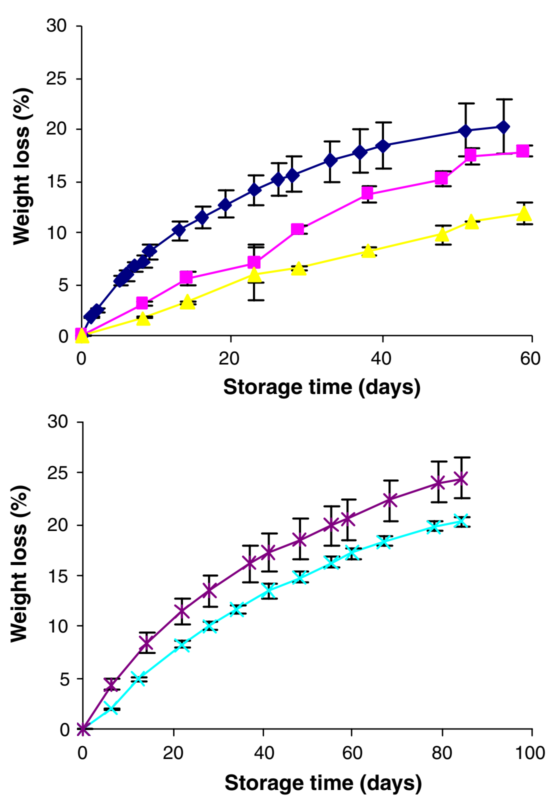

Fig. 4. Cheese weight loss (average and standard deviation) throughout storage time for both packaging systems and control cheeses (◆ *Humidipak*® control, ■ *Humidipak*® 78RH, ▲ *Humidipak*® 84RH, ✳ Microperforated film, ✕ Microperforated film control).

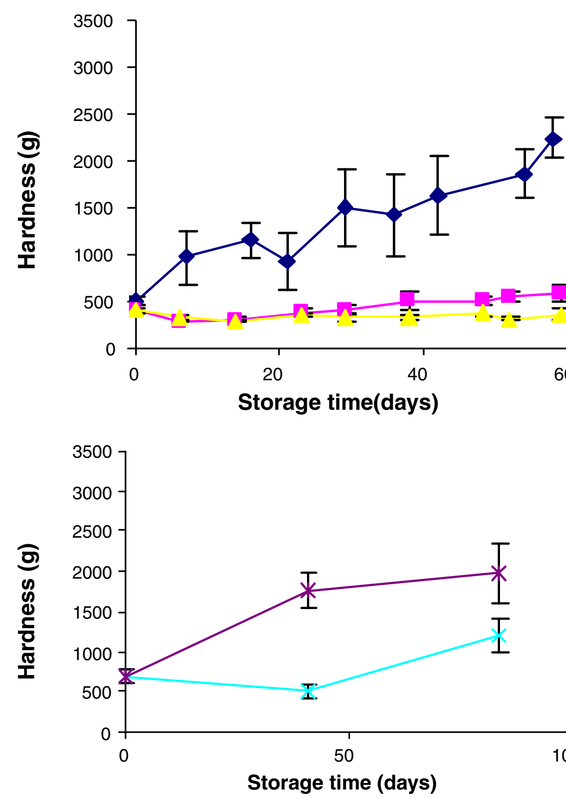

Fig. 5. Cheese hardness (average and standard deviation) throughout storage time for both packaging systems and control cheeses (◆ *Humidipak*® control, ■ *Humidipak*® 78RH, ▲ *Humidipak*® 84RH, ✳ Microperforated film, ✕ Microperforated film control).

with weight loss and hardness: the higher the moisture loss (lower final humidity), the harder the cheese got, as expected. The final humidity of cheese packaged with *Humidipak*® was 35% and 40% for RH levels 78% and 84%, respectively, after 60 days of storage. The cheeses packaged with perforated films achieved a final humidity of 28% after 80 days of storage, comparing to 22% of the respective control. A direct comparison between the systems is not possible, since the cheeses size is different, and thus also is the ratio of surface area for water loss/cheese volume or mass. Conversion of the results into standardized cheese surface area shows that the smaller cheeses present a higher rate of water loss, as foreseen (Fig. 8). This figure shows that cheeses with different sizes present the same initial rate of water loss, but during storage, this rate tends to a different value according to the cheese size. Additionally, the figure shows that the *Humidipack*™ system is more efficient in preventing water loss.

The results observed for sensory analysis of cheeses packaged with *Humidipack*™ system (Table 1) showed that surface colour became more intense with time for both packaged and unpackaged cheese. However, unpackaged cheese exhibited the most intense yellow colour (increasing from 3.0 to 5.0 points), followed by cheese packaged with *Humidipak*® 78% RH (increasing from 3.0 to 4.5 points),

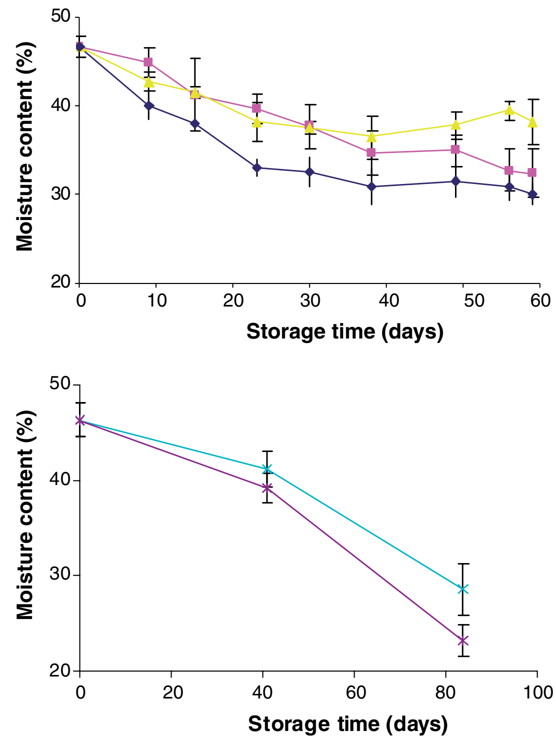

Fig. 7. Change in cheese humidity (average and standard deviation) throughout storage time for both packaging systems and control cheeses (*Humidipak*® control, *Humidipak*® 78RH, *Humidipak*® 84RH, Microperforated film, Microperforated film control).

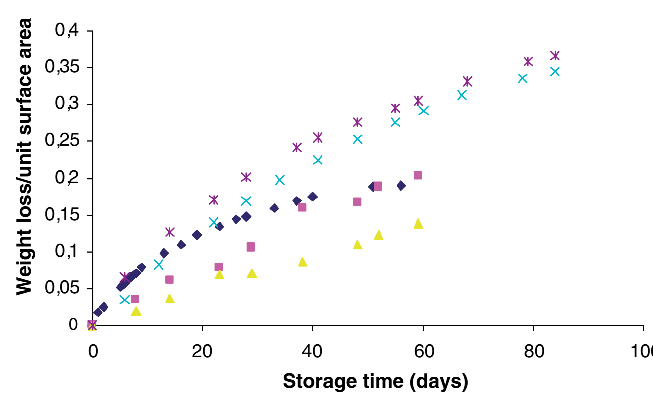

Fig. 8. Cheese weight loss/unit area throughout storage time for both packaging systems and control cheeses (*Humidipak*® control, *Humidipak*® 78RH, *Humidipak*® 84RH, Microperforated film, Microperforated film control).

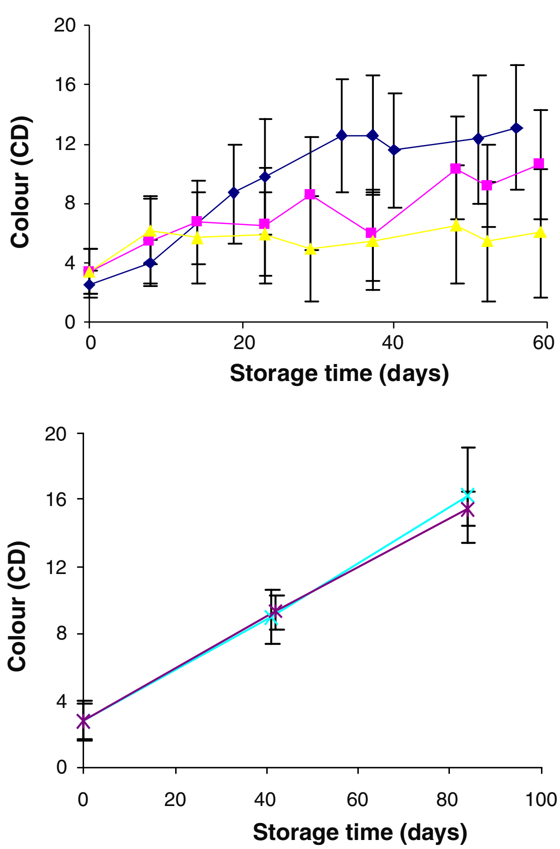

Fig. 6. Colour difference (average and standard deviation) throughout storage time for both packaging systems and control cheeses (*Humidipak*® control, *Humidipak*® 78RH, *Humidipak*® 84RH, Microperforated film, Microperforated film control).

and the best result was observed for cheese packaged with *Humidipak*® 84% RH which maintained an almost constant colour throughout storage time (increasing from 3.0 to 3.5 only). In terms of texture, the best marker was hardness, which revealed an important difference between experimental and control cheeses. The best result was obtained with cheese packaged with *Humidipak*® 84% RH as its hardness increased only 0.5 points throughout storage time. Firmness also showed similar conclusions, although the difference between cheese packaged with

Table 1
Average points attributed to cheeses packaged with *Humidipak®* sachets in a 5-point scale (colour: 1-ivory to 5-yellow; Firmness: 1-firmless to 5-firm; Hardness: 1-soft to 5-hard)

Days	Surface colour	Firmness	Hardness
Cheese packaged with Humidipak® 78% RH			
0	3.0	3.0	2.5
8	3.0	3.0	2.0
15	3.0	3.5	2.0
20	3.5	4.0	2.5
29	4.0	4.0	2.5
36	4.5	4.5	3.0
51	4.5	4.5	3.5
59	4.5	4.5	3.5
Cheese packaged with Humidipak® 84% RH			
0	3.0	3.0	2.5
8	2.0	2.5	2.0
15	2.0	3.5	2.0
20	2.5	3.5	2.0
29	3.0	4.0	2.5
36	3.5	3.5	2.5
51	3.5	3.5	2.5
59	3.5	3.5	3.0
Unpackaged cheese			
0	3.0	3.0	2.5
8	3.5	3.4	3.0
15	4.0	3.8	3.5
20	4.0	4.0	3.5
29	4.5	4.5	3.5
36	4.8	4.8	4.0
51	4.8	5.0	4.5
59	5.0	5.0	4.5

Humidipak® 78% RH and unpackaged cheese was almost not noticeable. Sensorial parameters correlate well with experimental measurements for both surface colour and hardness and this selects *Humidipak®* level 84% RH as being the best solution.

The microperforated film showed to maintain the initial measured sensory characteristics (surface, colour, firmness and hardness). These characteristics increased only 0.5 points in a 5-point scale, after 41 days (Table 2).

After that, as the subsequent sampling was performed after 84 days of storage, the properties at this point were close to those of unpackaged cheeses in terms of water loss.

Table 2
Average points attributed to cheeses packaged with microperforated films (colour: 1-ivory to 5-yellow; Firmness: 1-firmless to 5-firm; Hardness: 1-soft to 5-hard)

Days	Surface colour	Firmness	Hardness
Cheese packaged with microperforated films			
0	3.0	3.0	2.5
41	3.5	3.5	3.0
84	5.0	4.5	4.0
Unpackaged cheese			
0	3.0	3.0	2.5
41	4.8	5.0	4.5
84	5.0	5.0	4.5

The panel noticed that at the end of storage, cheeses presented some moulds on the surface.

Microbiological analysis of cheese (results not shown) packaged with *Humidipak®* showed that there was no growth of pathogenic or contaminants, which confirms the ability of this system to guarantee the safety of the cheese for, at least 60 days. The efficacy of sodium propionate, impregnated in the sachets, was also confirmed throughout this storage time, since mould growth was not observed (<100 cfu/g). On the other hand, the system did not inhibit lactic acid bacteria growth. These bacteria, used as a starter, were present at high and constant levels (ca. 3.0×10^7 cfu/g) throughout storage time.

The results showed that both systems are promising solutions in terms of extension of the shelf-life of this type of cheese.

The perforated films require further testing, with a higher frequency sampling over an extended storage time, for validation of the results obtained in the present experiment. This system controls the RH inside the package, providing good conditions for preserving the cheese. It is a very cost effective way to extend the cheese's shelf-life. However, it is not very effective at controlling mould growth. The solution may lay in a reformulation of the antimicrobial coating mixture presently used to coat the cheese. This issue must be further investigated.

The experiment with the *Humidipak®* system was programmed to last only 2 months but, at level 84% RH, the shelf-life could probably be extended even further, as texture was still very soft. In general, level 84% has proved to impart better properties to the cheese. Depending on the added value to the cheese, due to its shelf-life extension, this solution, although more costly, may be considered for implementation.

Acknowledgements

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