

## INFLUENCE OF TEMPERATURE AND PACKAGING MATERIALS IN EWE'S CHEESES STORAGE

Paula M. R. Correia<sup>1\*</sup>, Raquel P. F. Guiné<sup>1</sup>, Melania C. Rodrigues<sup>2</sup>, Rita Mendes<sup>3</sup>

<sup>1</sup>CERNAS-IPV Research Centre, Polytechnic Institute of Viseu, Campus Politécnico - Repeses, 3504-510 Viseu, Portugal

<sup>2</sup>Food Industry Department, ESAV/ IPV, Quinta da Alagoa, Estrada de Nelas, 3500-606 Viseu, Portugal

<sup>3</sup>Lactínios Correia e Barreiros Lda, Avenida do Outeiro, 6270-192 Santa Eulália, Seia, Portugal

\*e-mail: paulacorreia@esav.ipv.pt

### Abstract

One of the major concerns in cheese production is the shelf life extension, and the use of different conservation methods is extremely important. During commercialization period several problems often appear, like molds or packages that change the characteristics of cheese, which concerns the producers because they can lead to significant economic losses. The objective of this work was to evaluate the quality of the effect of temperature and packaging material in ewe's cheeses during 120 days of storage.

Cheeses were produced by industrial manufacture from raw ewe's milk produced by animals of breeds Bordaleira Serra da Estrela and Churra Mondegueira, in Seia district, belonging to the PDO (Protected Designation of Origin) of Serra da Estrela cheese region of Portugal. Cheeses were subject to two different storage conditions: control chamber (CC) [ $16 \pm 1$  °C and RH (relative humidity) of  $75 \pm 2\%$ ], packaging in vacuum with a high barrier blade film and polyolefin shrink film; and refrigeration with a mean temperature of 7 °C and HR 47%, simulating the usual commercial storage. The ewe's cheeses were analysed in three different moments: at 1, 60 and 120 days. Several physicochemical parameters were evaluated: moisture, water activity, colour, and texture. A hygrometer, at 25 °C, was used to determine the water activity of cheeses. The colour parameters were measured using a colorimeter, and the Cartesian Coordinates were measured: L\*, a\* and b\* (CIE Lab colour space). A texturometer TA-XT2 was used for analysis of the textural parameters. A spreadability test was performed. The test consisted in measurement of force under compression with a probe P/1S (1 inch stainless ball). Sensory analysis was also performed, involving a descriptive sensory profile performed by

25 persons which evaluated the appearance, aroma, taste, texture and global appreciation.

The cheeses packed in polyolefin film presented molds after 20 days of storage. The moisture content and water activity were high in the initial stage of storage, but they decrease with storage time, and this effect was more evident in the unpacked cheeses. Vacuum packed cheeses stored in CC (CCP) presented similar colour parameters along storage time, with high L\* and low b\* values. The harder cheeses were the CC cheeses after 120 days (CC120) of storage, and the stickier ones were the CCP120. The refrigerated cheeses were the most appreciated by the panellists, followed by cheeses stored at the CC with vacuum package, and the buttery attribute showed high differences.

After 120 days of storage, the biggest differences between the two conservation processes were in the moisture content, stickiness and adhesiveness. Moreover, cheeses packaged with a high barrier blade film Polyethylene Terephthalate/Polyamide/Ethylene Vinyl alcohol/Polyethylene (PET/PA/EVOH/PE) preserved their moisture content and the water activity when compared with unpackaged cheeses. During storage cheeses changed their colour in all processes, being the cheeses in the control chamber were less dark and less yellow. In general, cheeses were less hard than the control, independently of storage process and time. The refrigeration process was the one that preserved the best characteristics of stored cheese. In conclusion, the conservation process, the storage time and the packaging material influenced the physical and sensorial properties of the cheeses.

**Key words:** Ewe cheese, Packaging, Storage temperature, Physical properties, Sensorial analysis.

## 1. Introduction

One of the major concerns in cheese production is the shelf life extension, and the use of different conservation methods is extremely important. There are some concerns related with the maintenance of the quality of cheeses during commercialization, since during this period several problems often appear, like molds or packages that change the characteristics of cheese. These usually lead to sales breaks and loss of product, which could put the producers under an economic risk, and contribute to the abandoning this activity. Moreover, some cheeses have a seasonal manufacture, related with the production of milk, thus if a conservation problem appears, all the work with cheese production will be compromised. These situations were identified by producers, associations, cooperatives and industrials of milk and cheese sectors in Portugal [1].

Ewe's cheese produced in Portugal, and in the case of the present work cheese produced in Seia district (Portugal), is a traditional cheese with seasonal production, usually between October and May of the next year in relation with the milk production season. This cheese is characterized by a soft buttery paste, slightly yellow or white, obtained by slowly draining the curd after coagulation of raw sheep milk with aqueous extract of thistle flower (*Cynara cardunculus*). These cheeses commonly present a regular cylinder shape with slight bulging on the sides, and without sharp edges. Their texture and aroma are associated with the chemical composition and pH, as well as with microstructure [2, 3]. Colour and texture of ewe's cheeses are important quality factors. Colour is the immediate sensorial characteristic evaluated by the consumers, which can lead to the acceptance or rejection of a foodstuff, even before tasting [4]. Texture is the main quality attribute of cheeses, and greatly influenced by the processing factors [5]. The crumb of these cheeses is creamy and well-connected consistency, with a buttery texture, with a smooth and slightly acid aroma. Cheeses could be produced by handmade process, at a traditional way, or by small/medium enterprises which apply the same steps of handmade production but using specific equipment. These cheeses present some differences between them, such as fat, protein and moisture content, crust characteristics and crumb consistencies, due to the milk, manufacture and cure processes used [6, 7].

There are several conservation processes applied to cheese storage, considering the shelf life extension and quality, like the use of low temperatures [8 - 10], packaging [11 - 13], modified atmospheres [14 - 16], use of plant extracts [17], active coating [1, 18 - 21], and other combined processes [22 - 26]. However,

application and innovation studies regarding the conservation of ewe's cheeses produced, even in an international dimension, are still scarce.

Taking in consideration the previous comments, the present study aims to contribute to the knowledge of the effect of different temperatures and packaging materials on physical properties of ewe's cheeses during storage of 120 days.

## 2. Materials and Methods

### 2.1 Samples

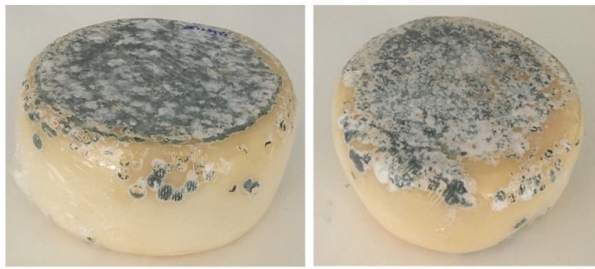
Cheeses were produced by industrial manufacture from raw ewe's milk produced by animals of breeds Bordaleira Serra da Estrela and Churra Mondegueira, in Seia district. The raw milk was coagulated using the flower of *Cynara cardunculus*. Cheeses were produced in Lactinios Correia and Barreiras enterprise, and they matured for 45 days, to obtain a semi-soft texture. When the cheeses, all from the same lot, were ready to go to the market, 30 cheeses were stored in two different conditions:

- Refrigeration (R): with a mean temperature of 7 °C and mean relative humidity (RH) 47% (considering all storage time). These conditions simulate the usual commercial storage of cheeses.
- Controlled chamber (CC): Temperature of  $16 \pm 1$  °C; RH of  $75 \pm 2$ %. These conditions are not considered the ideal ones, because of the high value of temperature and relative humidity.

In the controlled chamber the storage of three groups of cheeses were performed:

- First group without any packaging.
- Second group with a vacuum packaging, at a high barrier blade film PET/PA/EVOH/PE (Polyethylene Terephthalate/Polyamide/Ethylene Vinyl alcohol/Polyethylene), with the follow characteristics: thickness of 40  $\mu\text{m}$ ; weight by area of 39.3  $\text{gm}^{-2}$ ; traction retraction of 180%; brightness of 130%; opacity of 6%; barrier properties of 17  $\text{gm}^{-2}$  steam, 100  $\text{ccm}^{-2}$   $\text{CO}_2$ , 20  $\text{ccm}^{-2}$ . This film was designated as P.
- Third group a polyolefin shrink film, like a second skin (thickness of 12.5  $\mu\text{m}$ ; weight by area of 11.5  $\text{gm}^{-2}$ ; traction retraction of 130%; brightness of 130%; opacity of 2.8%; without barrier properties), designated as PS.

This last group of packaged cheeses was discarded after 20 days due to the high amount of mold (Figure 1), turning them unfit for consumption, thus they were not analysed.



**Figure 1. Appearance of packed cheeses with a polyolefin shrink film (PS cheeses), after 20 days of storage in the control chamber**

The ewe's cheeses were analysed in three different moments. The first moment was the first day of arrival, and then after 60 days and 120 days. Before the measurement of any characteristic evaluated, the cheeses were maintained during about 8 hours at room temperature (approximately 18 °C). The number of cheeses for each sample is presented in Table 1. The number of cheeses was limited because this type of cheese has a very high price.

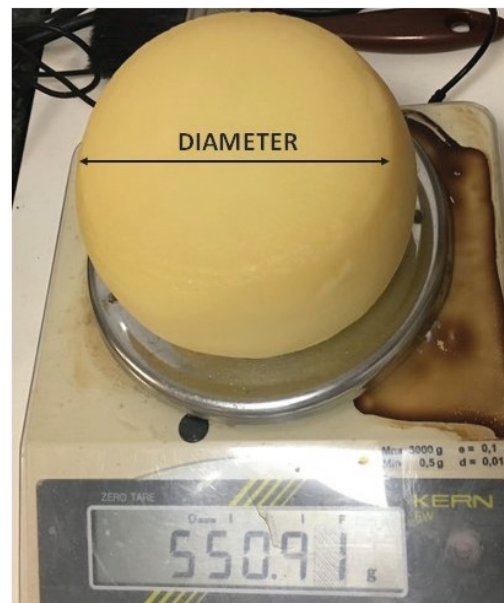
**Table 1. Number of cheeses by storage method**

Storage Method	Type of package	Day of analysis	Number of samples
Refrigeration (R)		0	4
	None	60	2
		120	2
Controlled Chamber (CC)		0	3
	None	60	2
		120	2
Controlled Chamber (CCP)	Vacuum	0	4
	with	60	2
	High barrier blade film	120	2
Controlled Chamber (CCPS)		0	3
	Polyolefin shrink film	60*	2
		120*	2

## 2.2 Physical properties of cheeses

The cheeses' weight and diameter were evaluated as shown in Figure 2. To determine the moisture content of cheeses a Halogen Moisture Analyser (Mettler Toledo HG53), set at an operating temperature of 120 °C, was used to evaporate the water until constant weight. A hygrometer (Rotronic), at 25 °C, was used to

determine the water activity ( $a_w$ ) of cheeses. At least 3 determinations were done in each cheese.



**Figure 2. Example of the weight and diameter of evaluated cheeses in the first day of experiments**

## 2.3 Evaluation of colour

The colour parameters were measured using a colorimeter Konica Minolta CR-400 (Figure 3), and the Cartesian Coordinates were measured:  $L^*$ ,  $a^*$  and  $b^*$  (CIE Lab colour space). Lightness is represented by  $L^*$ , and ranges from 0 (black) to 100 (white). Coordinates  $a^*$  and  $b^*$  can have negative or positive values, so  $a^*$  ranges from -60 (green) to +60 (red) and  $b^*$  ranges from -60 (blue) to +60 (yellow). The colour coordinates were measured in the rind of the cheeses. Ten measurements were made on each side (top and bottom), resulting in 20 measurements performed on each cheese.



**Figure 3. Example of a colour measurement of cheeses**

### 2.4 Analysis of texture

A texturometer TA-XT2 (Stable Microsystems) was used for analysis of the textural parameters. A spreadability test was performed. The test consisted in measurement of force under compression with a probe P/15 (1 inch stainless ball). The operational parameters were: pre-test speed = 1.5 mm/s, test speed = 2.0 mm/s, post-test speed = 10.0 mm/s, distance = 5.0 mm, trigger force = 0.5 N, load cell = 50 kg.

The curve force (N) versus time (s) (Figure 4) allows calculating the hardness and stickiness, according to:



**Figure 4. Example of a texture analysis performed to a cheese**

- Hardness (N) = Fh (maximum force).
- Stickiness (N) = Fs (minimum force).

Whole cheeses were used for the tests and three replications were made in each sample, distributed on the upper and bottom surfaces of the cheese.

### 2.5 Sensory analysis

The sensory analysis involved tests for descriptive sensory profile and was executed by a non-trained panel of 25 judges, but whose members had previous experience in sensory evaluations. The samples

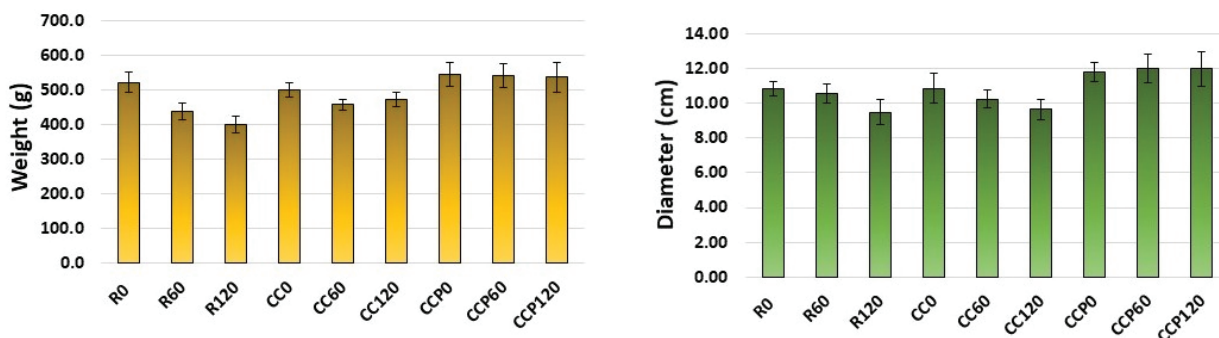
were placed whole over an odour-free, white plastic dish. Deionised water and unsalted crackers were provided for palate rising in-between the samples. Samples were served at room temperature and the tasting room was kept at  $22 \pm 2$  °C. The sensory attributes were evaluated for the dough and for the filling. For the dough were evaluated: appearance (colour, uniformity), aroma (pleasantness), taste (salt, pleasantness), texture (hardness, crunchiness, thickness) and global appreciation. For the filling were evaluated: appearance (colour, uniformity), aroma (pleasantness), taste (salt, curry, mushroom, and pleasantness), texture (moist, creaminess, uniformity) and global appreciation. Finally, an overall assessment of the whole samosa was undertaken. All attributes were scored on a scale varying from 1 (the lowest intensity of the attribute) to 5 (the highest intensity).

## 3. Results and Discussion

### 3.1 Physical properties

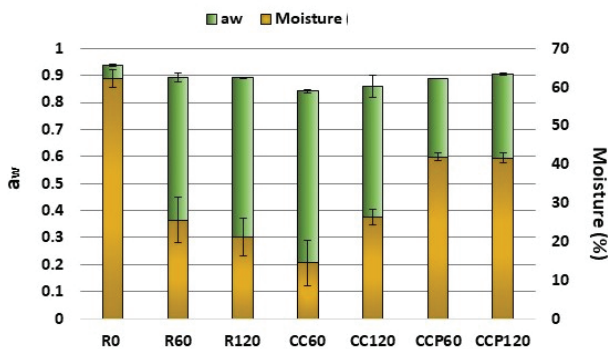
To determine the uniformity of the cheeses, their weight and diameter were determined (Figure 5). These determinations were done in the first day of the experiments, before their submission to the conservation process. The results show that the initial ewe’s cheeses had similar weight and diameter, with an average of 490.2 and 10.8 cm respectively. These results are advantageous since these parameters will not interfere in the results, meaning that the cheeses are quite similar considering the weight and diameter. During the storage processes, cheeses packaged with a high barrier blade film PET/PA/EVOH/PE preserved their dimensional characteristics, and the ones stored in the refrigerator were the ones with higher loss, decreasing their weight and diameter.

During storage the water activity ( $a_w$ ) and the moisture are important factors to be considered, since these parameters influence the microbiological and



**Figure 5. Weight and diameter of cheeses refrigerated (R) and storage in controlled chamber without package (CC) and with package (CCP), in the beginning (0), after 60 days (60) and 120 days (120) of storage**

physicochemical evolution of cheeses over time [27], and their control is important for the preservation of cheeses' safety and quality [13]. The results showed that moisture content and water activity values were quite high for the initial cheeses (62.2% for moisture and 0.94 for  $a_w$ ) and they decreased during storage (Figure 6). Pantaleão *et al.*, [13], also mention that semi-hard cheeses generally have high water activity values, and for unpackaged cheeses the water loss depends on the chemical properties and on the storage conditions. At the end of 120 days, the cheeses presented a moisture content of: 21.1%, 29.3%, 41.6%, and an  $a_w$  of: 0.89, 0.95, 0.90, for refrigerated, unpackaged and packaged



**Figure 6. Moisture content and water activity of cheeses refrigerated (R) and stored in controlled chamber without package (CC) and with package (CCP), in the beginning (0), after 60 days (60) and 120 days (120) of storage**

in control chamber, respectively. Thus, it is possible to mention that packaged cheeses better preserved the moisture content and the water activity when compared with unpackaged cheeses.

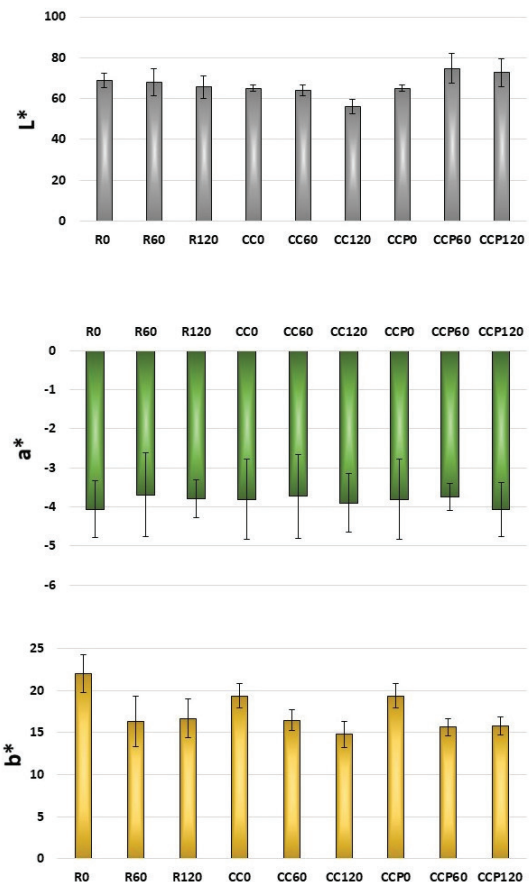
Furthermore, after 120 days, the water activity did not vary significantly. However, the moisture content decreased mainly in the control sample, which was stored in the refrigerator, being this type of storage the one usually used for commercial conditions of cheeses storage. Some authors mention that, in unpackaged cheese, water loss depends on the chemical properties of the cheeses and on the storage conditions [13]. This diminishment was probably due to some dehydration of the samples during storage, in this case due to the mean RH in the cool environment being lower than in the samples, and this is corroborated by the refrigerator RH, which was 47% during the days of storage.

Moreover, it was noticed that during refrigeration storage, the cheeses were cleaned several times to remove a few molds in their surfaces, which allowed to keep the cheeses in good conditions. This procedure was done more frequent until 60 days. However, the unpacked cheeses stored in the control chamber did not need to be cleaned.

### 3.2 Colour evaluation

Figure 7 presents the results of the evaluation of colour coordinates in ewe's cheese. The results indicate that all colour coordinates ( $L^*$ ,  $a^*$  and  $b^*$ ) vary with the conservation process and during the storage time. The values found are in the same range as those reported by several authors also for similar DPO ewe' cheese produced in the same geographical area [28, 29].

The results obtained for colour coordinate  $L^*$ , which represents lightness [varying from 0 (black) to 100 (white)], show that the analysed cheeses presented a light colour in the initial phase of storage, ranging between 65.07 and 68.91 (Figure 7). During storage, there was a decrease in lightness, more evident after 120 days, for unpackaged cheeses stored in the control chamber, meaning that the skin colour lost whiteness tending to acquire a straw-yellow colouration. In opposition, for the packaged ones, for the same storage conditions, the  $L^*$  coordinate increased, meaning that those cheeses became whiter, which could be a problem because consumers want a certain typical colour and if they became too whiter this could lead to economic losses.



**Figure 7. Colour coordinates of the cheeses refrigerated (R) and stored in controlled chamber without package (CC) and with package (CCP), in the beginning (0), after 60 days (60) and 120 days (120) of storage**

The profiles presented for  $a^*$  and  $b^*$  coordinates were similar for cheeses submitted to different storage conditions (Figure 7). The colour coordinate  $a^*$ , which represents green for negative values and red for positive, showed negative values, indicative of a very slight green colouration, which is also corroborated for other ewe's cheeses [28 - 30]. The time of storage almost had no effect on this parameter, for all storage conditions tested. The values for colour coordinate  $b^*$ , which represents blue colour when negative and yellow when positive, in the present case are positive, meaning that cheeses were yellow as expected. In the initial stage of storage, the  $b^*$  value of cheeses ranged between 19.38 and 21.99, like to other similar DOP ewe' cheeses, mainly Serra da Estrela cheese, a DOP cheese produced in the same region [28, 30]. Moreover, the  $b^*$  colour coordinate diminished during storage time, for all cheeses subject to different storage conditions, meaning that cheeses became less yellow.

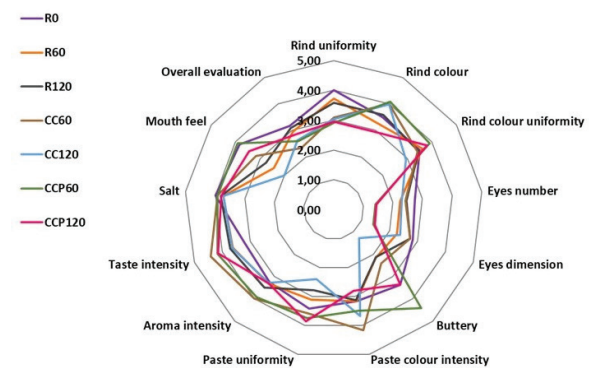
### 3.3 Textural analysis

The textural properties obtained by spreadability test are presented in Figure 8. Hardness represents the force necessary to compress a food between the teeth or between the palate and the tongue [31 - 33]. The cheese upon arrival, before storage, presented a mean hardness value of 84.47 N, and this value decreased greatly after 60 days of storage, for all conditions tested. Generally, in all cases the cheeses were less hard, and after 120 days of storage the cheeses conserved in the controlled chamber, without package, presented higher values than in the beginning of storage, almost double. This could be probably due to the high storage temperatures (16 °C) used in this process, despite the high RH (75%), meaning that temperature of storage is an important factor influencing cheese hardness, for unpackaged cheeses. Stickiness is also an important

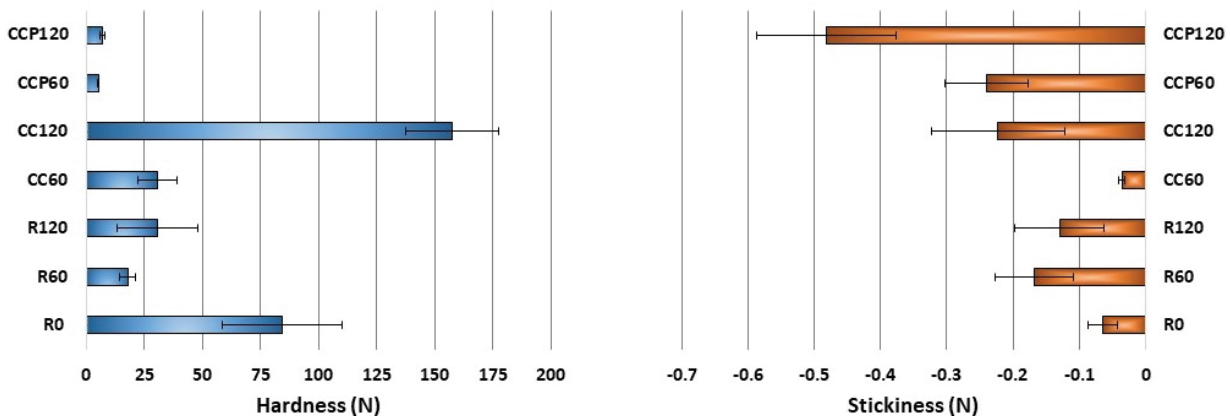
textural characteristic to take into consideration in cheese analysis. Generally, this parameter is higher in packaged cheeses probably due to the less moisture loss during storage, which preserves the slimy consistency of cheeses.

### 3.4 Sensorial characteristics

Figure 9 presents the sensorial characteristics of cheeses and it is possible to see that the conservation conditions had a marketed effect on cheese characteristics, despite the perception of salt being very similar. As mentioned before, the reference cheese (R0) was the one analysed in the first day, after maturation and considering that it was ready to go to the market, to be sold, which is represented with a purple colour. Hence, comparing the other cheeses with this one, the results show that the R0 presented the highest score for the overall evaluation, with 3.17 points, followed by refrigerated cheeses after 120



**Figure 9. Sensorial characteristics of cheeses refrigerated (R) and stored in controlled chamber without package (CC) and with package (CCP), in the beginning (0), after 60 days (60) and 120 days (120) of storage**



**Figure 8. Textural properties of cheeses refrigerated (R) and stored in controlled chamber without package (CC) and with package (CCP), in the beginning (0), after 60 days (60) and 120 days (120) of storage**

and 60 days of storage. These preferences could be related with the high scores attributed by the tasters to the rind uniformity, rind colour uniformity, and less paste colour intensity (whiter paste). Interestingly, the characteristics of the rind, the outside part of the cheese, are the first aspects of sensorial appreciation by the consumer, and it seems to have a striking effect on their choice. Moreover, the aroma and taste intensity, as well as paste uniformity increase with storage time, mainly in the cheeses conserved in the control chamber after 60 days. Furthermore, the eyes dimension and number decreased with storage time, being this effect more evident in CCP cheeses. Another important aspect is that the CC120 sample presented the lowest score for rind colour and paste uniformity, buttery and moth feel.

### Acknowledgement

This work is funded by National Funds through the FCT - Foundation for Science and Technology, I.P., within the scope of the project Ref<sup>a</sup> UIDB/00681/2020. Furthermore, we would like to thank the CERNAS Research Centre and the Polytechnic Institute of Viseu for their support.

### 4. Conclusions

This work focused on the evaluation of some physical properties of ewe's cheeses subject to different storage conditions during 120 days of storage, time usually needed to commercialise this type of cheeses. The present work allowed taking some conclusions, namely:

- The conservation process and the storage time have a marked influence in physical properties of semi-soft cheeses.
- After 120 days of storage, cheeses diverged importantly among samples, and the biggest differences between the two conservation processes were in the moisture content, stickiness and adhesiveness.
- The packaging material used on cheeses are an important factor for their storage.
- Cheeses packaged with a high barrier blade film PET/PA/EVOH/PE preserved their dimensional characteristics, as well as their moisture content and the water activity when compared with unpackaged cheeses.
- The colour of cheeses changed with the storage conditions and time. Unpacked cheeses became darker and less yellow, and these were more intense for cheeses in the control chamber.
- Regarding texture, generally, cheeses were less hard than the control, independently of storage process

and time. However, after 120 days of storage, cheeses conserved in the controlled chamber, without package, presented almost the double hardness of the control cheeses.

- The best sensorial characteristics of stored cheeses, from the point of view of consumer, considering the overall appreciation, were obtained by the refrigeration process.
- For future works, it is important to study deeply the effect of some conservation processes in ewe's cheese characteristics, to determine an optimal storage process, packaging and aging combination for these cheeses, and no less important to investigate the factors that contribute to the physical changes of this foodstuff.

### 5. References

- [1] Moreira P. (2011). *Development of analytical methodologies for cheeses - Case study: Cheeses from Beira Interior* (in Portuguese). MS thesis, School of Agriculture, Technical University of Lisbon, Lisbon, Portugal.
- [2] Macedo A. C., Tavares T. G., Malcata F. X. (2004). *Influence of native lactic acid bacteria on the microbiological, biochemical and sensory profiles of Serra da Estrela cheese*. Food Microbiology, 21, pp. 233-240.
- [3] Reis P. J. M., Malcata F. X. (2011). *Ripening-related changes in Serra da Estrela cheese: A stereological study*. Journal of Dairy Science, 94, pp. 1223-1238.
- [4] Fuquay J., Fox P., McSweeney P. (2011). *Encyclopedia of Dairy Sciences* (2nd Ed.). Academic Press, Cambridge, USA.
- [5] Gunasekaran S., Ak M. (2002). *Cheese Rheology and Texture*. CRC Press, New York, USA.
- [6] Rodrigues R. C., Almeida J. C., Pereira C. D., Gomes D. S., Madaleno J. P., Oliveira M., J., Fonseca, M. L. (2000). *Serra da Estrela Cheese - Traditional Processes and Technological Innovations* (in Portuguese). Regional Directorate of Agriculture of Beira Litoral, Coimbra, Portugal.
- [7] Tavaría F. K., Franco I., Carballo F. J., Malcata F. X. (2003). *Amino acid and soluble nitrogen evolution throughout ripening of Serra da Estrela cheese*. International Dairy Journal, 13, pp. 537-545.
- [8] Alvarenga N. B. M. G. (2008). *Introduction of freezing technology in the production of sheep cheese* (in Portuguese). PhD thesis, School of Agriculture, Technical University of Lisbon, Lisbon, Portugal.
- [9] Mushtaq M., Gani A., Shetty P. H., Masoodi F. A., Ahmad M. (2015). *Himalayan cheese (Kalari/kradi): Effect of different storage temperatures on its physicochemical, microbiological and antioxidant properties*. LWT- Food Science and Technology, 63, pp. 837-845.
- [10] Ricciardi A., Guidone A., Matera A., Parente E., Claps S., Zotta T. (2015). *Evolution of microbial counts and chemical and physico-chemical parameters in high-moisture Mozzarella cheese during refrigerated storage*. LWT - Food Science and Technology, 63, pp. 821-827.
- [11] Conte A., Longano D., Costa C., Ditaranto N., Ancona A., Cioffi N., Scrocco C., Sabbatini L., Contò F., Del Nobile M. A. (2013). *A novel preservation technique applied to*

- fiordilatte cheese*. *Innovative Food Science & Emerging Technologies*, 19, pp. 158-165.
- [12] Fabris S., Freire M. T. de A., Reyes F. G. (2016). *Plastic packaging: Types of materials, food contamination and aspects of legislation* (in Portuguese). *Revista Brasileira de Toxicologia*, 19, pp. 59-70.
- [13] Pantaleão I., Pintado M., Pocas F. (2007). *Evaluation of two packaging systems for regional cheese*. *Food Chemistry*, 102, pp. 481-487.
- [14] Khoshgozaran S., Azizi M. H., Bagheripoor-Fallah N. (2012). *Evaluating the effect of modified atmosphere packaging on cheese characteristics: a review*. *Dairy Science and Technology*, 92, pp. 1-24.
- [15] Kirkin C., Gunes G., Kilic-Akyilmaz M. (2013). *Preservation of precut white cheese by modified atmosphere packaging*. *International Journal of Dairy Technology*, 66, pp. 576-586.
- [16] Rodriguez-Aguilera R., Oliveira J. C., Montanez J. C., Mahajan P. V. (2011). *Effect of modified atmosphere packaging on quality factors and shelf-life of surface mould ripened cheese: Part I: Constant temperature*. *LWT - Food Science and Technology*, 44, pp. 330-336.
- [17] Caleja C., Ribeiro A., Barros L., Barreira J. C. M., Antonio A. L., Oliveira B. P. P., Barreiro, M. F., Ferreira, I., C. F. R. (2016). *Cottage cheeses functionalized with fennel and chamomile extracts: Comparative performance between free and microencapsulated forms*. *Food Chemistry*, 199, pp. 720-726.
- [18] Angiolillo L., Conte A., Zambrini A. V., Del Nobile M. A. (2014). *Biopreservation of Fior di Latte cheese*. *Journal of Dairy Science*, 97, pp. 5345-5355.
- [19] Gorrasi G., Bugatti V., Tammaro L., Vertuccio L., Vigliotta G., Vittoria V. (2016). *Active coating for storage of Mozzarella cheese packaged under thermal abuse*. *Food Control*, 64, pp. 10-16.
- [20] Pierro P. D., Sorrentino A., Mariniello L., Giosafatto C. V. L., Porta R. (2011). *Chitosan/whey protein film as active coating to extend Ricotta cheese shelf-life*. *LWT - Food Science and Technology*, 10, pp. 2324-2327.
- [21] Yu Z., Cavender G., Zhao Y.Y. (2014). *Investigation of different coating application methods on the performance of edible coatings on Mozzarella cheese*. *LWT - Food Science and Technology*, 56, pp. 1-8.
- [22] Çetinkaya A., Atasever M. (2015). *The effects of different salting and preservation techniques of kasar cheese on cheese quality*. *Turkish Journal of Veterinary and Animal Science*, 39, pp. 621-628.
- [23] Conte A., Gammariello D., Di Giulio S., Attanasio M., Del Nobile M. A. (2009). *Active coating and modified-atmosphere packaging to extend the shelf life of Fior di Latte cheese*. *Journal of Dairy Science*, 92, pp. 887-894.
- [24] Del Nobile M. A., Gammariello D., Conte A., Attanasio M. (2009). *A combination of chitosan, coating and modified atmosphere packaging for prolonging Fior di latte cheese shelf life*. *Carbohydrate Polymers*, 78, pp. 151-156.
- [25] Mastromatteo M., Conte A., Lucera A., Saccotelli M. A., Buonocore G. G., Zambrini A. V., Del Nobile, M. A. (2015). *Packaging solutions to prolong the shelf life of Fiordilatte cheese: Bio-based nanocomposite coating and modified atmosphere packaging*. *LWT - Food Science and Technology*, 60, pp. 230-237.
- [26] Rodriguez-Aguilera R., Oliveira J. C., Montanez J. C., Mahajan P. V. (2011). *Effect of modified atmosphere packaging on quality factors and shelf-life of mould surface-ripened cheese: Part II - Varying storage temperature*. *LWT - Food Science and Technology*, 44, pp. 337-342.
- [27] Saurel R., Pajonk A., Andrieu J. (2004). *Modelling of French Emmental cheese water activity during salting and ripening periods*. *Journal of Food Engineering*, 63, pp. 163-170.
- [28] Correia P. M. R., Vítor A., Tenreiro M., Correia A. C., Pinto A. (2014). *Influence of different processing parameters in physical and sensorial properties of Serra de Estrela cheese*. *Journal of Hygienic Engineering and Design*, 8, pp. 135-140.
- [29] Guiné R. P. F., Tenreiro M. I. C., Correia A. C., Correia P. M. R., Barracosa P. (2016). *Analysis of factors influencing the physical, chemical and sensorial properties of Serra da Estrela cheeses*. *Food Measure*, 10, pp. 643-657.
- [30] Correia P., Vítor A., Tenreiro M., Correia A. C., Madanelo J., Guiné R. (2016). *Effect of different thistle flower ecotypes as milk-clotting in Serra da Estrela cheese*. *Nutrition and Food Science*, 46, pp. 458-475.
- [31] Cruz A. C., Guiné R. P. F., Gonçalves J. C. (2015). *Drying Kinetics and Product Quality for Convective Drying of Apples (cvs. Golden Delicious and Granny Smith)*. *International Journal of Fruit Science*, 15, pp. 54-78.
- [32] Guiné R. P. F., Almeida I. C., Correia A. C., Gonçalves F. J. (2015). *Evaluation of the physical, chemical and sensory properties of raisins produced from grapes of the cultivar Crimson*. *Food Measure*, 9, pp. 337-346.
- [33] Guiné R. P. F., Henriques F., Barroca M. J. (2014). *Influence of drying treatments on the physical and chemical properties of cucumber*. *Food Measure*, 8, pp. 195-206.