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INFLUENCE OF DIFFERENT PROCESSING PARAMETERS IN PHYSICAL AND SENSORIAL PROPERTIES OF SERRA DE ESTRELA CHEESE

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Abstract

Cheese is a classical dairy product, which is strongly judged by its appearance, flavour and texture. Processing parameters that could affect cheese structure play a dominant role upon the features exhibited by the final product. Serra da Estrela cheese is a Protected Denomination of Origin (PDO) cheese manufactured from raw ewes 'milk and curdled with thistle flowers. The study aimed to evaluate cheeses physicochemical, microbiological and sensorial properties, produced with two thistle flowers ecotypes added in different quantities to milk, sheep bread, salt quantity and ripening moisture.

Two dairies were involved in this study, named as A and B, both with certification. The sheep milk chemical composition (moisture, protein, fat, solids-non-fat, lactose, solids, density, freezing point), and microbial analysis (coliforms and total enumeration of microorganism at 30 ^{0}C) were determined, using respectively a Lactoscan equipment and norms ISO 4832:2006 and 4833-1:2013. The clotting time, the evolution of weight loss and color, the texture (texturometer TA-XT Plus) and sensorial characteristics of cheeses were evaluated.

Both dairies presented similar chemical sheep milk composition and clotting time for the same thistles flower, varying from 36-47 minutes. The loss of weight showed similar decreasing and tendency. Generally, the thistle flower ecotype didn't influence the L, a* and b* color parameters, during the ripening process and in the final product there was a significant influence on a* parameter. The textural analysis revealed significant differences between the two dairies for the same thistle flower ecotype, considering the inner firmness, stickiness and adhesiveness. Cheeses presented similar sensorial properties, considering the different processing parameters studied.

Serra da Estrela cheese produced in both dairies presented different physical and sensorial properties, meaning that with a strong knowledge of the properties assign by processing parameters it is possible to produce a specific cheese attending to different consumer targets.

***Key words**: Serra da Estrela cheese, Thistle flower, Process parameters, Color, Texture analysis, Sensorial analysis.*

1. Introduction

Cheese is a food derived from milk that is produced in a wide range of flavours, textures, and forms by coagulation of the milk protein casein. Cheese structure characteristics are significantly affected by many parameters, from the characteristics of the raw materials used up to the processing factors.

One of the most traditional cheeses in Portugal is Serra da Estrela cheese, a product with Protected Denomination of Origin (PDO), which has a great economic importance and unique sensorial characteristics. This semi-soft type of cheese is manufactured from coagulation of raw ewes milk curdled with thistle flowers aqueous extract (*Cynara cardunculus*, L.) without addition of a starter.

During the last years, the manufacturing practices were improved, mainly because of strict governmental regulations. Some research has been done in order to optimize and control several quality factors in Serra da Estrela cheese, such as temperature of coagulation, the amount of plant rennet added to the raw 'milk, and the amount of salt added, which influence in the cheese's final characteristics (Macedo [1]).

The objective of this work was to evaluate some physical and sensorial properties of Serra da Estrela cheeses, produced with thistle flowers of two ecotypes, added in different quantities to milk. Other factors evaluated were sheep bread, salt quantity and ripening moisture.

2. Materials and Methods

2.1 Samples preparation

Cheeses were manufactured in two dairies: A and B, both certificated. The general cheese manufacturing methodology was the same, but there were some differences which are summarised in Table 1. Five cheeses were produced in both dairies for each thistle flower ecotype.

Table 1. Differences between the processing manufacturing in the A and B dairies

	A	B
Sheep bread	White Bordaleira	Black Bordaleira
Quantity of thistle flower (g)/ 1L milk	0.15	0.20
Quantity of salt (g)/1L milk	15	25
Ripening moisture	1st step- 7/8°C, 15/20 days, 90/95% Moisture 2nd step- 10/12°C, 20/25 days, 80/85% Moisture	1st step- 7/8°C, 15/20 days, 88/95% Moisture 2nd step- 10/12°C, 20/25 days, 78/80% Moisture

The manufacturing processes were done according to the following methodology: 20 L approximately of raw sheep milk was filtered through a fine, clean cloth and poured into a double-walled, food grade steel coagulation vat with controlled temperature. After the temperature of the milk had reached 30 ^{0}C, crude kitchen salt and the thistle flower aqueous extract were placed inside a cloth, submerged in the milk and agitated until complete solubilisation of the salt. The milk was then allowed to coagulate at 32 ^{0}C until complete clotting, after which time the coagulum was cut by stirring with 20 x 20 mm^2 knives. After 10 minutes, the curd pieces were poured into a fine cloth, which was hand closed and firmly pressed to expel the whey. Each cheese was then placed in a form and each cheese was surface-labelled using a food-grade casein marker.

Drainage of whey was complete by using a standard pneumatic press. The cheeses were then placed in the maturation room, with temperature and humidity control. The cheeses were finish after 45 days.

Two thistle flower ecotypes were tested in both dairies, the C-32 and the F-19. The main characteristics of these two ecotypes considering the results of exclusion molecular chromatography are showed in Table 2.

Table 2. Exclusion molecular chromatography characteristics of the thistle flower ecotypes used for cheese production

Ecotype	Area (mAU*mL)	Height (mAU)	Absorbance (280 nm)	Total cardosins (μg/mL)
C-32	21334	1192	0,534	474
F-19	18864	1218	0.474	419

2.2 Chemical analysis of sheep milk

An ultrasonic milk analyser LactoScan model Milkoscan S (Milkotronic, Lda, Nova Zagora, Bulgaria) was used to determined moisture, protein, fat, solids-non-fat, lactose, solids, density (kgm^{-1}), freezing point (^{0}C) in milk samples, which were collected (after milking), and frozen, until performing the analysis. These samples were related with the cheeses respectively. All the samples were analysed in triplicate for each determined parameter.

2.3 Microbiological analysis of sheep milk

The methods used to the microbiological analysis followed the regulation ISO 4832:2006, for the enumeration of coliforms, using the colony count technique, and the ISO 4833-1:2013, for the enumeration of microorganisms, using the colony count at 30 ^{0}C by pour plate technique. The results are expressed in CFU /mL (Colony Forming Units). All the samples were analysed in triplicate for each determined parameter.

2.4 Clotting time

The clotting time is the time necessary to curdle the milk after the addition of the C-32 and F-19 thistle flower aqueous extract. It was measured in minutes. The experiment was carried out in triplicate for each thistle flower ecotype.

2.5 Weight and colour evaluation during ripening

The weight of the cheeses was performed by weighing the cheeses during the ripening period. Five measures were done during one and a half months, in each cheese produced in both dairies. The measures started in April until middle of May. The first measure was measure immediately after the cheese produced.

The colour of all cheeses was measured using a hand-held tristimulus colorimeter (Chroma Meter - CR-400, Konica Minolta) calibrated with a white standard tile. A CIE standard illuminant D65 was used to determine CIE Cartesian colour space coordinates, L*, a*, b* values. The parameters measured were the brightness L*, which varies between 0 and 100 (from black to white, respectively), and the coordinates of opposed colour: a* and b*, which vary from -60 to +60, where the a* assumes negative values for green and positive values for red, while b* assumes negative values for blue and positive for yellow. In each cheese 25 measurements were made to access the mean value and standard deviation.

2.6 Texture evaluation

The texture profile analysis (TPA) for all samples was made by a texturometer (TA.XT. Plus from Stable Micro Systems). The test performed was measure force in compression and the probe used was P/2 (2mm diameter cylinder). The operational parameters were: pre-test speed = 2.00 mm/s, test speed = 1.00 mm/s and post-test speed = 1.00 mm/s, distance = 10.0 mm, trigger force = 0.029 N, load cell = 50 kg. Five measurements were carried for each cheese. The curve force (N) versus time (Figure 1) allows calculate the crust firmness inner firmness, stickiness and adhesiveness.

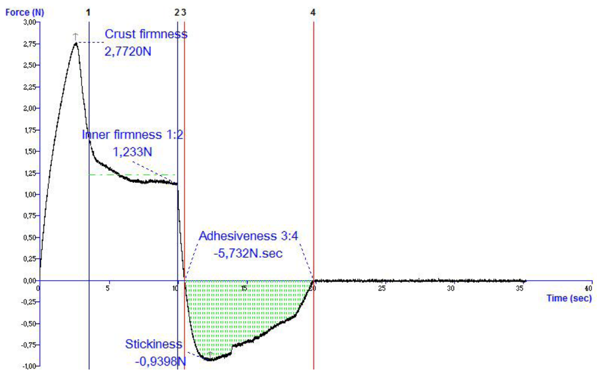

Figure 1. Example of a TPA obtained for a cheese sample

2.7 Sensorial evaluation

Eleven trained panellists carried out the sensory evaluation of the cheeses. Samples had presented intact form in first place and after in slice pieces identified by random three-digit codes. Testing was carried out in a tasting room equipped as specified in ISO Standard (ISO 8589/1988 [2]). Thirteen sensory attributes had assessed: a rind cheese aspects (thickness, uniformity, and colour), cheese past (uniformity, buttery, and colour), flavour intensity, taste and aroma (intensity, salt, acidity, bitter, remaining presence), and global appreciation. The attributes were evaluated using a structured scale of seven unit points applied a quantitative descriptive test, being at 1 for less and 7 higher intensity to all attributes except colour. For the colour the range was blank (1) to yellow (7).

3. Results and Discussion

The milk analysed from both dairies presented similar chemical composition, but different freezing points and density (Figures 2 and 3). The composition of the milk is very similar to other sheep milk values reported by other researchers (Boyazoglu [3]). The A dairy showed the highest values of freezing point and density. These differences could be explained by the type, quality and quantity of animal feed. The limited access to concentrate feed and ingestion of water in milking intervals could diminish the decreasing of the freezing point (Prates [4]).

The results of microbiological analysis showed that no coliforms were found in the sheep milks from both dairies. This result reflects the absence of faecal contamination, ensuring a satisfactory microbiological quality of milks. The mesophilic microorganisms growth at 30 ^{0}C presented different values, with the highest values occurring in the A dairy (Fig 4). These differences could be associated with different milking and handling protocols, thus leading to extensive and unpredictable variability. Furthermore, considering the Regulation CE 853/ 2004 ([5]), it could be used raw milk with a maximum content of 500000 UCF/mL. Thus, taking in consideration this statement it could be mention that these microbiological results were very good.

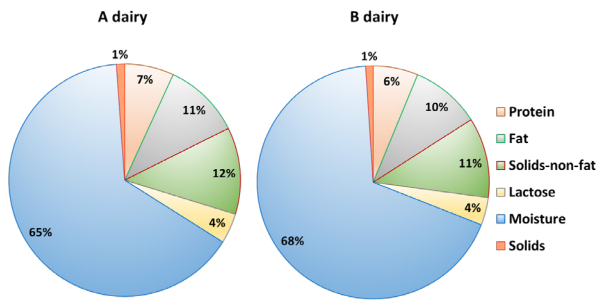

Figure 2. Chemical composition of sheep milk of A and B dairies. The results are expressed in percentage (g/100 g milk sample)

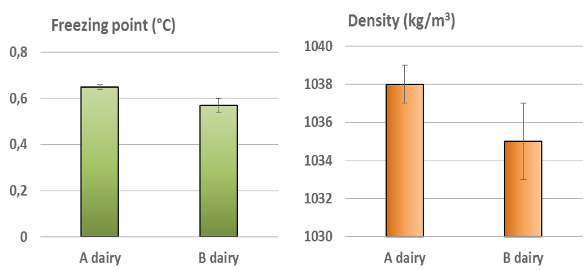

Figure 3. Freezing point and density of sheep milk of A and B dairies

The Serra da Estrela cheeses were produced with raw milk, without any standardizing thermal treatment, depending critically on their indigenous microflora for the development of the final characteristics. The contribution of such microflora, coupled with that of milk composition, which depends on the local animals diet and physiological conditions, eventually account for the unique flavour and texture of those traditional cheeses (Pereira [6]).

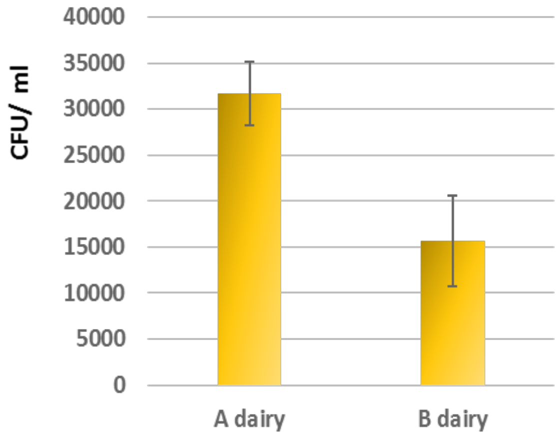

Figure 4. Total mesophilic microorganisms of sheep milk of A and B dairies. CFU - Colony Formation Unit

The B dairy presented low clotting times (Figure 5), which was due to the higher amount of thistle flower aqueous extract that was added to the milk (Table 1). The clotting time was not significantly different for both ecotypes in the same dairy.

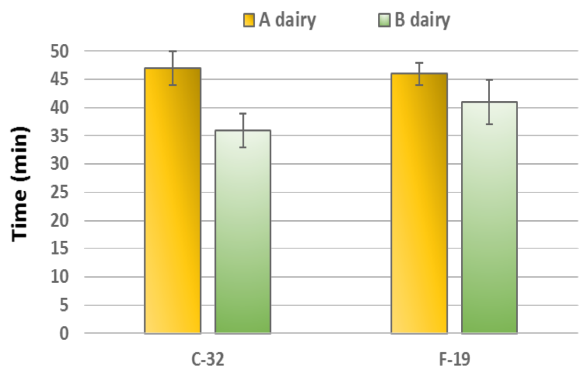

Figure 5. Clotting time of raw ewes 'milk considering the C-32 and F-19 thistle flower ecotypes in A and B dairies

Figure 6 showed the loss of weight of Serra da Estrela cheeses during ripening. The profile is very similar for all the cheeses produced with the two thistle flowers in the two dairies. The differences between the samples result from different initial weight of the cheeses. A potential function was fit to the experimental results, and the results are shown in Table 3.

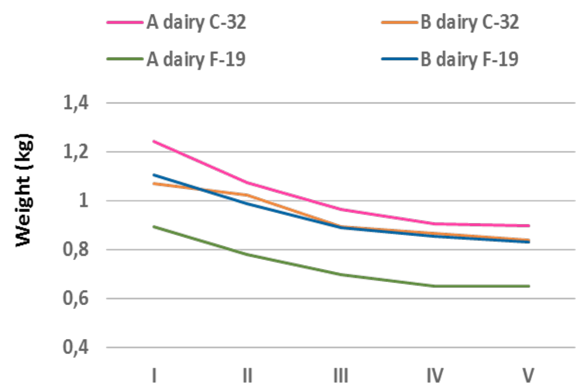

Figure 6. Weight (kg) of cheeses during the ripening in A and B dairies, with C-32 and F-19 thistle flower ecotypes. I - Day one, when cheese was manufacturing (4th April); II - 17th April; III - 2nd May; IV - 9th May; V - 16th May

Table 3. The potential functions and the correlation coefficients of the weight loss during ripening of Serra da Estrela cheeses produced in A and B dairies

	A		B	
Thistle flower ecotype	**Function**	**R^2**	**Function**	**R^2**
C-32	$y = 1.2374x^{-0.213}$	0.984	$y = 1.0916x^{-0.164}$	0.934
F-19	$y = 0.8918x^{-0.211}$	0.983	$y = 1.1073x^{-0.184}$	0.990

The colour parameters of Serra da Estrela cheeses produced in A and B dairies are showed in Figure 7. The L* colour parameter results presented values closer to 100, meaning that cheeses are very white, and this characteristic is more evident in cheeses of B dairy, being this difference less important at the end of ripening. It is also important to notice that the thistle flower ecotype did not influence the cheese L* parameter, since no significant differences were found. The L* parameter is similar for both faces of the cheese, and this could be due to the process of handling during ripening, since the cheeses were turned over every day.

The a* colour parameter shows a big difference in the end of ripening time. The a* values were negative for the cheeses of A dairy, meaning that they presented a predominant green colour (although not intense), and positives for cheeses of B dairy, meaning that the cheeses have a predominant red colour (again not very intense). The different thistle flower ecotypes also did not influence the colour of cheeses. It was still observed that the a* parameter was similar for both faces.

The b* assumed positive values meaning a predominance of the yellow tonality, and this colour was more intense in cheeses of A dairy. No significant differences were found for the two thistle flower ecotypes and between cheeses faces.

Figure 7. Colour characteristics of cheeses during the ripening in A and B dairies, with C-32 and F-19 thistle flower ecotypes. I - 15th days after cheese manufactured; II - One month after cheese manufactured; III - One and an half month after cheese manufactured; A - face A; b - Face B (the other face)

The results of the texture analysis made to the cheeses produced with the thistle flower ecotype C-32 (Figure 8) show similar values for crust firmness in both dairies. However, the cheeses of A dairy presented a softer inner flesh, when compared to the cheeses from B dairy. Also the stickiness and adhesiveness were lower in the cheeses from A dairy. In global the results reveal that these cheeses have a relatively soft crust (lower than 4 N), and they are very adhesive and sticky, as a result of the creamy flesh that characterizes this soft paste type of cheese.

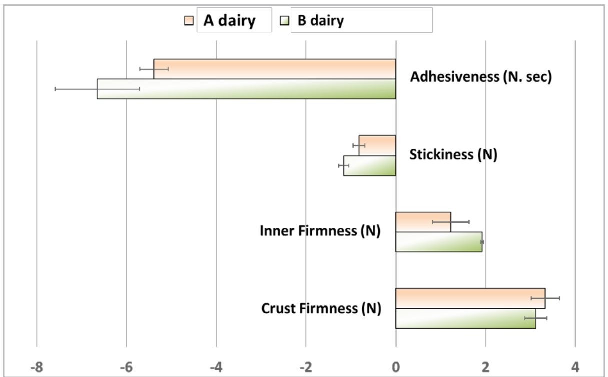

Figure 8. Texture of cheeses from A and B dairies produced with the thistle flower ecotype C-32

The sensorial analysis was just performed on cheeses produced with the thistle flower ecotype C-32 (Figure 9). In general, the panellists gave high scores to the rind colour and uniformity (which was corroborated by colorimeter analysis), paste uniformity and flavour intensity to cheese of B dairy. The cheese produced in the A dairy was, in general, less appreciated in almost all characteristics, but globally it obtained a higher punctuation in the global appreciation, probably due to the less intensity of bitter, and high ring thickness. The high ring thickness showed by the cheese produced by the A dairy could be related to the high content of moisture during ripening (Table 1). The paste buttery was the sensorial parameter less appreciated, despite of the cheeses presenting a softer inner flesh in the textural analysis. The salt attribute had almost the same punctuation even though the B dairy added more quantity of it to the produced cheeses (Table 1).

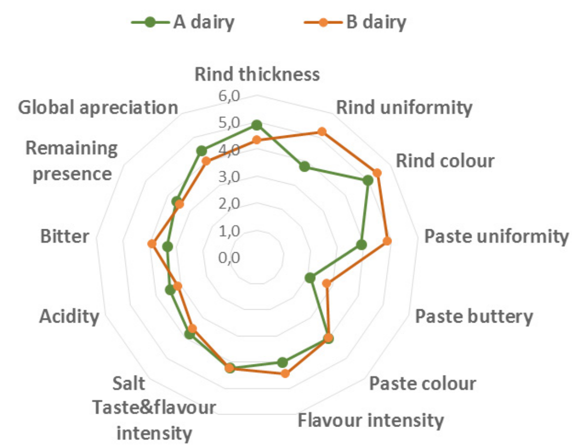

Figure 9. Sensorial evaluation for cheeses from A and B dairies produced with the thistle flower ecotype C-32

4. Conclusions

- Serra da Estrela cheese produced in both dairies presented different physical and sensorial properties.

- The cheese weight loss during the ripening time presented similar profiles for cheeses produced with the two thistle flower ecotypes and for both dairies, and it is predicted by a potential function.

- The studied thistle flower ecotype did not influence significantly the clotting time and colour parameters, with exception to the a* colour parameter which could vary from green to red.

- Cheeses presented good colour uniformity, and there were no significant differences between both sides. Generally, the cheeses of B dairy presented a white colour, with a predominant red colour and a light yellow colour. The A dairy cheeses were darker, with a predominant green colour and more intense yellow colour.

- The texture and the sensorial analysis were just performed for the C-32 thistle flower ecotype and the results were quite different for both dairies. This could be understood as a consequence of the different process parameters, which in this study could be related with the ripening conditions and also with the amount of microorganisms that intervened during the maturation stage.

- The obtained results showed that, it is important to continue the search in order to acquire a strong knowledge of the properties assigned by processing parameters to produce a specific cheese attending to different consumer targets.

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