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# Texture of Serra da Estrela Cheeses from Different Dairies

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**Abstract**

*Serra da Estrela cheese is a product with Protected Designation of Origin, according to the European and Portuguese regulations, being undoubtedly the most appreciated of Portuguese traditional cheeses. Because the texture of this traditional product is one of its most valued attributes, the purpose of this work was to compare the textural properties of Serra da Estrela cheese manufactured in six different dairies as measured by three types of test: spreadability, puncture and compression test. The results obtained allowed to conclude that the samples presented considerably different textural properties regarding some parameters, while being similar for others. For example, the hardness and chewiness of the crust were variable, while the springiness and cohesion were very similar in all samples. Also, the results indicated that the properties of the crust were somewhat autonomous in relation to those of the inner paste, like for example adhesiveness and stickiness as obtained through the puncture test. Finally, from the analysis of the relations between the studied properties, only the correlation between hardness obtained with compression test versus hardness determined by spread test was found strong (correlation significant at p< 0.05). In conclusion, the results obtained proved the usefulness of using different methodologies to evaluate cheese texture, in a way that these three types of test are complementing in the definition of the texture profiles of the cheeses.*

*Keywords: Cheese quality, compression test, puncture test, spreadability*

## I. Introduction

Serra da Estrela cheese is an artisanal dairy product manufactured from raw ewe's milk coagulated with vegetable rennet from dried thistle flower (*Cynara cardunculus* L.), that is very much appreciated due to the unique organoleptic characteristics, like flavour, bouquet and smooth texture(Macedo et al., 1996; Tavaria et al., 2004). Cheese properties de-

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velop during coagulation and along ripening, and are influenced by factors such as pH, temperature, water activity and microflora. Also, the sensory profile developed results from multiple interactions between chemical and microbiological parameters. In the case of Serra da Estrela Cheese, the use of raw milk allows the establishment of an intense flavour when compared to cheeses produced from pasteurized or heat-treated milks, as a consequence of the native microbiota present in the milk, and most especially the high levels of native lactic acid bacteria (Reis and Malcata, 2011; Tavaria et al., 2004).

Althoughthe flavour profile of a food is usually the most important criterion for consumers' preference, undoubtedly that texture allied to taste also have pivotal roles on the moment of acceptance or rejection. While the development of specific flavour profiles is linked to chemical transformations and presence of aromatic compounds such as short-chain free fatty acids typically generated by oxidative deamination of free amino acids, the textural properties such as smoothness, stickiness or rheological characteristics are also influenced by the conditions of the maturation places, like moisture, temperature or light (Carocho et al., 2016; Dahl et al., 2000).

The perception of texture in the moment of eating and mastication of semi-solid products, like the case of the soft cheese Serra da Estrela, is mainly determined by the composition and structure of the food itself, but not exclusively. The first impressions are more intensively linked to the intrinsic properties of the food, but let us not forget that this will gradually change during oral processing, allowing to extend the pleasurable sensations (Cunha et al., 2016; Ningtyas et al., 2018).

Cheese structure is highly influenced by its composition, together with the arrangement of the macronutrients in the cheese matrix, affected by the processing operations. The major components in cheese are casein, fat, water, and also minerals. The firmness of the cheese structure is owing to to the casein matrix, that provides the hardness,whereas the smoothness comes from the water and fat globules present.Furthermore, the way in which the components are arranged in the cheese matrix also contributes to its texture, like, for example, in the case of Mozzarella cheese for which the hardness is determined by the fibrous protein matrix allied to a low amount of fat globules (Mistry and Anderson, 1993; Tran Do and Kong, 2018). In the case of Serra da Estrela cheese, the very smooth texture is due to the use of raw ewe's milk, which, among other constituents, has a very high fat content, ranging 50%. For example, the Serra da Estrela cheese with approximately one month of maturation shows the following chemical properties: 50% moisture (wet basis), 5% NaCL, 8% ash, 49% fat and 38% total protein, expressed as mass percentage of total solids in all cases (Freitas and Malcata, 2000).

The objective of this work was to compare the textural properties of Serra da Estrela cheese manufactured in different dairies at the end of production season, as measured by three types of test: spreadability, puncture and compression test (texture profile analysis).

## II. Material and Methods

**Samples**

The samples used for the study were obtained from 6 dairies situated in PDO region for Serra da Estrela cheese: Sabores & Ambientes in Oliveira do Hospital (D1), Casa Agricola dos Arais in Celorico da beira (D2), Casa da Insua in Penalva do Castelo (D3), Queijaria de Germil again in Penalva do Castelo (D4), Quinta de SÃčo Cosme in Gouveia (D5), Quinta da Lagoa in Nelas (D6).

The milk used for the Serra da Estrela cheese came from manual milking and was filtered through a white cloth. To the milk heated at about 30 °C was added salt and vegetable rennet (dried wild thistle flower). After 45 to 60 minutes the curd was manually cut and filtered to remove the remaining whey. Then followed the steps of moulding, pressing and salting of the surface, and finally the cheese was ready for maturation, being turned and washed every day for the first 15 days and then more sporadically until the end of the ripening process, which lasted about 45 days.

**Compression test**

The texture profile analysis (TPA) for all samples was made using a texturometer (TA.XT. Plus from Stable Micro Systems). The test consisted in two consecutive compression cycles between parallel plates, with a 5 sec. interval, using a flat 75 mm diameter probe (P/75) and a 50 kg force load cell. The pre-test, test and post-test speed was 1.0 mm/s, in all cases, and the compression distance was 4 mm. The textural profiles obtained allowed calculating the following textural properties: hardness, adhesiveness, springiness, cohesiveness, resilience and chewiness.

For this test the evaluations were made in 3 different samples in both sides of the cheese (top and bottom), allowing to calculate the mean value and standard deviation.

**Puncture test**

In this case 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 and load cell = 50 kg. The curve force versus time allowed calculating the crust firmness, the inner firmness, adhesiveness and stickiness For this test the evaluations were made in 3 different samples in both sides of the cheese (top and bottom), with 5 perforations on each side.

**Spreadability test**

In this case the test also involved measure force in compression but using a spherical probe P/1S (stainless ball). The operational parameters were: pre-test speed = 1.50 mm/s, test speed = 2.00 mm/s and post-test speed = 10.00 mm/s, distance = 10.0 mm and load cell = 50 kg. The curve force versus time allowed calculating hardness and stickiness.

For this test the evaluations were made in 3 different samples in both sides of the cheese (top and bottom).

## III. Results and Discussion

**Compression test**

Figure 1(a) shows the hardness and chewiness of the samples studied, i.e., form the 6 different dairies. The hardness corresponds to the force required to deform the product at a certain distance, i.e., the force to compress between the molars, to bite with the incisors or to compress between the tongue and the palate (GuieÃl' et al., 2015). The results obtained for hardness showed that while the samples D1 and D3 were considerably harder as compared with the others, sample D2 and D6 might have been excessively soft, maybe due to incorrect storage conditions during the ripening process with incorporation of more water that recommended, or incomplete ripening. Chewiness, which corresponds to the effort required to chew the sample to a consistency that is appropriate to swallow it (Guine et al., 2015), is calculated from hardness according to equation (6), and therefore it is expected that the trends for these two textural parameters might be very similar, and again the chewiness was higher for samples D1 and D3 and lower for D2. Figure 1(b) shows the results obtained for adhesiveness, which is related to the force required to remove the material adhering to a specific surface (eg, lips, mouth, teeth) (Guine et al., 2015), being a measure of stiffness of the material. The values of adhesiveness are negative, because they correspond to a force in the contrary side of the movement. In the present study, the samples showed relatively small adhesiveness, because the measurements made were in the outer shell of the cheese, not penetrating the samples, as it happens, for example with the puncture test. The sample with highest adhesiveness was D2, again maybe due to a higher moisture content. The high values of the standard deviation observed in some cases are justified by the low absolute mean values, which are very close to zero.

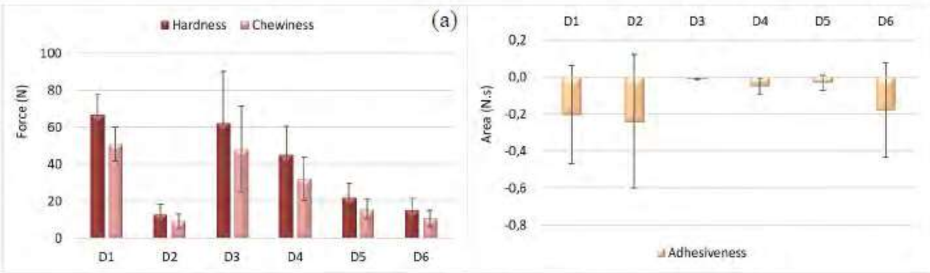


Figure 1. Compression test: (a) Hardness and Chewiness;(b) Adhesiveness.

Springiness or elasticity is defined as the rate of resistance with which the sample returns to its original form after removal of the force that caused partial compression (Guine et al., 2015). Resilience is how well a product struggles to regain its initial position, being an instant elasticity, since resilience is the measure of withdrawal from the first penetration, before the pause period is initiated (Guine et al., 2015). The results obtained for these two textural properties are shown in Figure 2(a), and they reveal that while the samples have a quite uniform elasticity (varying in the range 86%-91%, respectively for samples D6 and D3), the variability in resilience is somewhat higher, from 41% to 51%, respectively for samples D2 and D3, also. These results indicate that, as expected, these two properties are deeply linked, so that the samples with a higher elasticity reveal also a higher resilience.

Cohesiveness or cohesion is the degree to which the sample deforms before breaking, when biting with the molars (Guine et al., 2015).The results in Figure 2(b) indicate that all samples had a very similar cohesiveness, varying in the short range from 0.82 (samples D4 and D6) to 0.84 (D1 and D3). Because this softs paste cheese has a very smooth flesh with a high elasticity, the cohesion is also very high.

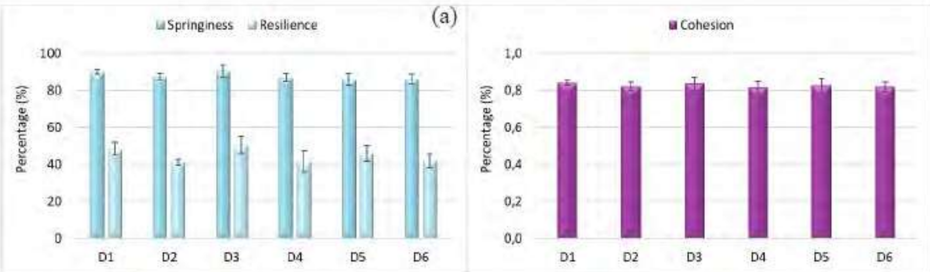


Figure 2. Compression test: (a)Springiness and Resilience; (b) Cohesion.

**Puncture test**

The results in Figure 3(a) correspond to the external and internal firmness, i.e. the firmness of the outer layer and the firmness of the inner mass, and have a similar meaning to that of the hardness, previously described when discussing the results of the compression test. The results indicated that the sample D3 had a harder crust (5.37 N), about double of that of sample D2 (2.47 N), which had the softer crust. Nevertheless, these variations were mainly in the crust, because the inner paste of the cheeses was very smooth in all cases, with values of inner firmness in the range 0.83 to 1.36 N (for samples D5 and D4, respectively).

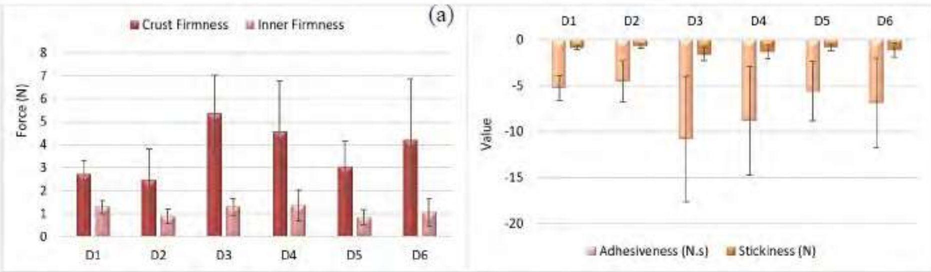


Figure 3. Puncture test: (a) Crust and Inner firmness; (b) Adhesiveness and Stickiness.

Adhesiveness has been explained in the previous section and stickiness corresponds to the minimal force of the probe when receding from the sample. In the case of the puncture test, these properties refer to the inner paste of the cheese contrarily to the compression test which only refers to the crust. The results in Figure 3(b) reveal that Sample D3 had the highest adhesiveness and stickiness, corresponding to a paste with a typical creaminess characteristic of the Serra da Estrela Cheese.

**Spreadability test**

The spreadability test also evaluates hardness and stickiness, but under the action of a spherical probe compressing, in this particular case, the outer crust of the cheese. Therefore, the results obtained for hardness would be expected to have some similarity in terms of trend to those of the compression test, although with a different amplitude of the values, given the area of the probe that transfers the force in both cases. In fact, the results obtained demonstrate this, with the exact same trend for the 6 samples analysed in terms of hardness with the spread test (Figure 4(a)) and with the compression test (Figure 1(a)). D1 was the samples with higher hardness in compression test and also in spread test, while D2 was the sample with lowest hardness in both tests.

Figure 4(b) presents the results obtained for the stickiness measured with the spherical probe, but in this case this property might not be directly linked to the spreadability of the puncture test because one was determined in the crust while the other was determined in the inner flesh. The obtained results corroborate this thesis, since the sample D3 showed the highest stickiness of the inner flesh, -1.54 N (Figure 3(b)), but the lowest in the crust, -0.05 N (Figure 4(b)), meaning that although this cheese had a more gluing paste the outer crust was more dried. An opposite trend was observed for sample D2, which had the highest crust stickiness, -0.21 N (Figure 4(b)), and the lowest paste stickiness, -0.68 N (Figure 3(b)).

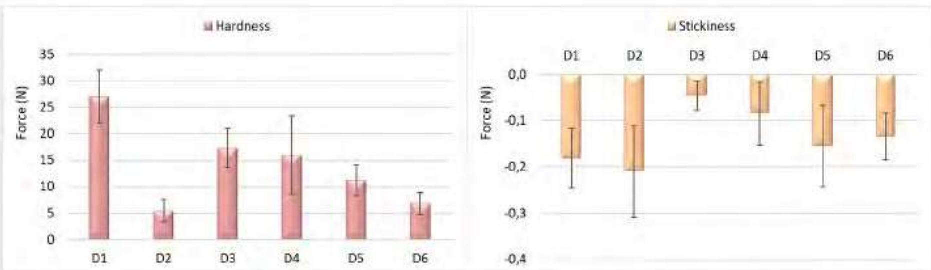


Figure4.Spreadability test: (a) Hardness; (b) Stickiness.

**Interactions between textural parameters** The results obtained for the textural properties through the compression, puncture and spreadability tests the same type of attribute were analysed to verify if there were direct correlations between the different types of evaluations. In this way, linear regression was applied to the plots of one variable against the other, allowing to determine the equations and corresponding correlation coefficients (R). Furthermore, ANOVA results were also determined to evaluate if the regression was significant, considering a level of significance of 5%. In this way, for each case the obtained regression was:

Hardness (Compression) versus Crust firmness (Puncture):

$$\mathbf{Hc} = 2.125\mathbf{CFp} + 28.141 \qquad (R = 0.168, p = 0.334) \tag{1}$$

Hardness (Compression) versus Inner firmness (Puncture):

$$\mathbf{Hc} = 26.065\ \mathbf{IFp} + 7.793 \qquad (R = 0.483, p = 0.003) \tag{2}$$

Hardness (Compression) versus Hardness (Spread):

$$\mathbf{Hc} = -0.898\ \mathbf{Hs} + 6.226 \qquad (R^2 = 0.830, p < 0.005) \tag{3}$$

Stickiness (Puncture) versus Stickiness (Spread):

$$\mathbf{Sp} = -2.223\mathbf{Ss} - 1.271 \qquad (R^2 = 0.314, p = 0.062) \tag{4}$$

Adhesiveness (Compression) versus Adhesiveness (Puncture):

$$\mathbf{Ac} = -0.012\ \mathbf{Ap} - 0.193 \qquad (R = 0.244, p = 0.158) \tag{5}$$

The values of the correlation coefficients indicate that for most cases there was no meaningful correlation between the variables, with exception for 'Hardness (Compression) versus Hardness (Spread)'., for which the value of R indicates a strong correlation. This means that there was a correlation between the results of the compression test and the spread test in what concerns hardness, even though the absolute values obtained with both tests differ. Furthermore, in the case of 'Hardness (Compression) versus Inner firmness (Puncture)' a significant correlation was also found, although the value of R indicated that the correlation is moderate.

## IV. Conclusions

This work allowed concluding that the samples at study showed considerably different textural properties in regards to some parameters, while being similar for others. For example, the hardness and chewiness of the crust were fairly variable, while the springiness and cohesion were very similar in all samples. Furthermore, the results showed that the properties of the crust were quite independent from those of the inner paste, as expressed for example in the values obtained for adhesiveness and stickiness through the puncture test. Finally, from the relations between the studied properties, only the correlation between the hardness obtained with compression test versus hardness determined by spread test was found strong, being significant at the level of 5% significance. In conclusion, the results obtained showed the usefulness of using different methodologies to evaluate cheese texture, because they complement each other in some ways and allow to determine different parameters to obtain a more complete description of the textural properties for this type of product.

## V. Acknowledgements

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