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THE RIPENING CONDITION EFFECT ON THE MAIN TEXTURAL PROPERTIES OF CASCAVAL CHEESE

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ABSTRACT

The textural characteristics represent a significant property used to distinguish various cheese types and are considered by the consumer as a determinant factor of acceptability and overall quality and preferences. Consequently, the main idea of the current research was to study the textural properties of Cascaval cheese during different ripening conditions and in accordance with the main chemical composition. The highest hardness under load was recorded by the unpacked ripened Cascaval samples, which also recorded the highest values for total mechanical work. The recoverable energy determined as the work of elastic deformation ranges from 0.19 to $0.31 \cdot 10^{-3}$ Joules, the highest values registered and the most resilient samples being represented by the ripened unpacked Cascaval. According to Pearson correlation results the modulus of deformability, hardness under load, total mechanical work, relaxation, and relaxation work positively influenced the TPA gumminess ($p < 0.01$, $p < 0.05$). It was also found that the texture parameters resulting from the application of the stress-relaxation method showed more correlations with the chemical composition of the tested samples compared to the TPA method, therefore the stress-relaxation method can be a more powerful tool in the evaluation of Cascaval cheese texture characteristics.

1. Introduction

Milk products inclusive cheeses, some of the oldest dairy products, represent an important group of foods largely consumed worldwide (Giosuè et al., 2022; Lei and Sun, 2019) due to the significant amounts of vital nutrients (valuable proteins, bioactive peptides, essential fatty acids, calcium, phosphorus, and vitamins like vitamin B12, vitamin A or vitamin D), (Roobab et al., 2021), and also of the probiotics content (Hernández et al., 2022).

According to Miller study (Miller et al., 2022) the mean cheese consumption reported globally was 8 g per day with a variation from 1 to 34 g per day, with the highest value of 34 g registered in Eastern-Central Europe and Central Asia, especially in the United Kingdom, France, and Turkey.

Among the categories of cheeses consumed in Romania, fresh cheeses, and cottage cheeses (cow or sheep) are preferred to the detriment of Cascaval cheese, which is more expensive. In 2019 cheese consumption from cow's milk was about 0.5 Kg per month, while sheep's cheese consumption was only 0.26 Kg per month, and the consumption of Cascaval cheese was 0.15 Kg per month (Petre and Drăghici, 2021).

The evaluation of cheeses' quality characteristics is critical for both consumers and the industry and when discussing the quality of cheeses, reference is made to the chemical composition, flavor, appearance, and physical properties represented by cheeses' sensory, textural, and rheological characteristics (Lei and Sun, 2019).

Food texture is a complicated attribute and according to ISO 11036, (ISO 11036:2020) represents all the mechanical, geometrical, and surface characteristics of a food product, being evaluated as a response of the food to a given constraint. The instrumental texture evaluation is categorized as an objective method of analysis and in comparison with the sensory evaluation offers faster and more accurate results (Guiné, 2022). The sensory evaluation is time-consuming and requires a much longer effort, is influenced by a lot of factors and its constancy and repeatability are tough to guarantee (Liu et al., 2019).

The textural characteristics represent a significant property used to distinguish various cheese types and are considered by the consumer as a determinant factor of acceptability and overall quality and preferences (Allen Foegeding et al., 2003). For texture analysis, the compression tests such as texture profile analysis (TPA) are usually used and textural parameters like hardness, springiness, adhesiveness, gumminess, chewiness, and cohesiveness are determined by the food response (Giha et al., 2021; Chen and Opara, 2013). The majority of cheese varieties are thought to be soft-solid material comprising networks composed of proteins, fats, and water; their textural characteristics are associated with the network composition, structure, and interactions between molecules within the network (Foegeding and Drake, 2007).

The Cascaval cheese, known also as Kashkaval in the Balkans (Nikolova et al., 2022), Kasseri in Greece, and Kashar in Turkey (Ozturk et al., 2022) is particularly popular in Eastern Europe and falls into the semi-hard pasta-filata (stretched curd) cheese category produced from cows milk, sheep milk, or a mixture of both (Gherghina et al., 2021). The production process implies curd stretching and kneading in hot water to obtain desired texture characteristics (plastic elastic consistency) and a fiber-like structure (Talevski et al., 2017). Furthermore, when it comes to Cascaval production, maturation is a critical and complex process that emphasizes the textural characteristics and the specific flavor (Andronoiu et al., 2015). Generally, the maturation process of cheese takes place under carefully controlled environmental conditions. Depending on the type of cheese, these parameters may vary in temperature, relative humidity, and time, which may have a distinct impact on the cheese's biochemical modification (Di Cagno et al., 2007).

This variety of pasta-filata cheese has been studied by other authors as well regarding the sensory properties developed at different maturation temperatures (Ivanova et al., 2021), the effect of raw and pasteurized sheep's milk on microbiological quality (Pappa et al., 2019; Samelis et al., 2019), the temperature influences on lipid hydrolysis and fat oxidation (Ivanova et al., 2020), the effect of temperature storage (Ivanov et al., 2021) and maturation temperature (Ivanov et al., 2018) on Kashkaval texture.

Due to the importance of the textural properties of cheeses for both consumers and processors, this study focused on the evaluation of instrumental texture characteristics of different Cascaval cheeses based on double compression and stress-relaxation methods in accordance with the chemical composition.

2. Materials and methods

The Cascaval samples were produced from raw cow milk (3.5 % fat) following the traditional technology (Andronoiu et al., 2015), which involves in the first phase the coagulation with rennet (Fromase® 50 Chr.Hansen) and ripening the cheese curd up to a pH of 5.0±0.1, followed by the cheese curd scalding in hot water, 73±2°C with 10 ±1% NaCl and manual kneading and stretching. After the forms removing the cheese samples were dried and divided into three categories (Fig. 1); the first one was directly analyzed (fresh Cascaval - A), the second category was ripened directly for sixty days without being packed (ripened Cascaval - B), and the third category was vacuumed in polypropylene (PP) and ripened also for sixty days (packaged Cascaval - C).

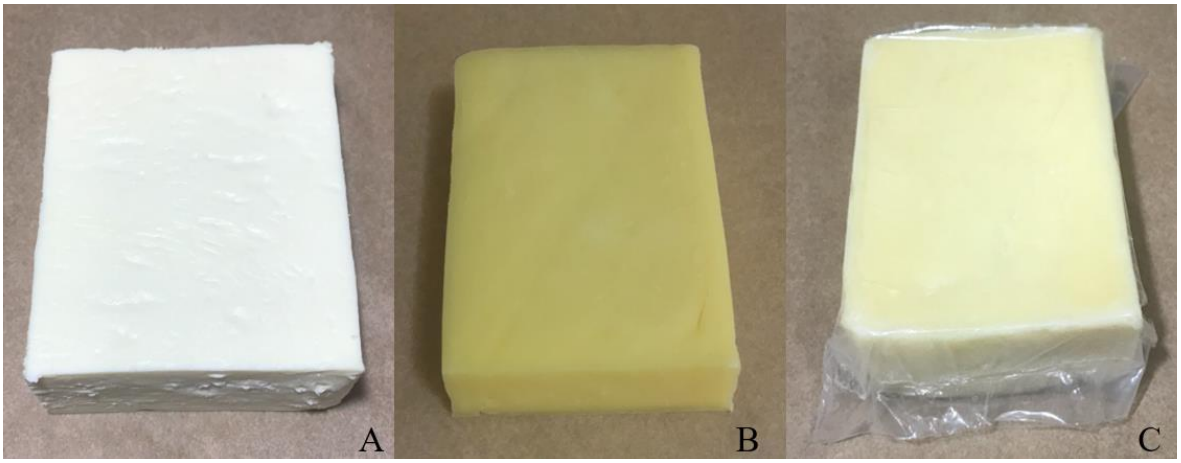

Figure 1. The appearance of fresh Cascaval cheese (A), ripened without packaging Cascaval cheese (B) and ripened in packaging Cascaval cheese (C).

2.1. Physicochemical analysis.

The fat content of Cascaval samples was determined by ISO 3433 (ISO 3433:2008), the protein content was measured by the Kjeldahl method (ISO 17837:2008), the moisture content was assessed by the oven drying to constant mass at 102±2 °C, and the dry matter was also determined according to ISO 5534 (ISO 5534:2004). The titratable acidity expressed as % lactic acid was measured using NaOH and phenolphthalein (Horwitz, 2010)**.** All used reagents were analytical grade from Sigma Aldrich (Germany) and the analyses were made in triplicate.

2.2. Textural analyses.

The stress relaxation method is not so frequently used in the textural evaluation of food products compared to Texture Profile Analysis (TPA) which is widely used. Regarding the Cascaval cheese, there are no reported studies about the evaluation of texture properties through stress relaxation tests. The textural evaluation of Cascaval samples was made with a texture meter from Mark 10 (ESM 301), the used load cell had 100 Newtons (Mark 10 Corporation, USA). The Cascaval samples had cubic shapes with sides of 2 cm (Nyamakwere et al., 2022; Pappa et al., 2020) and were tested by a stress relaxation test and a TPA using a flat probe with a 5 cm diameter. The cheese sample compression rate was established at 30% (Gutt et al., 2014) and relaxation time was set at 10 minutes (t), (Peleg and Pollak, 1982) for the stress relaxation test and 50% for the TPA (Nyamakwere et al., 2022). The loading/unloading was set at 10 mm/min, the trigger force was set as 0.2 N. The output data (load, time, and deformation) for both tests were registered by the MESUREgauge software (Mark 10 Corporation, USA) with a reading rate of 8 points per second (pps). The MESUREgauge software and the resulting stress-deformation curves (Fig. 2) were the basis for the determination of textural properties like hardness under load (Hs, N/mm) calculated as the ratio of the maximum load and the corresponding deformation, total mechanical work (Wt, J) represented by the total area under the loading stress-relaxation curves, elastic mechanical work (We, J) represented by the area under the unloading curves, the loading modulus of deformability (E_L, Pa), relaxation (R, N/s, Eq. 1). The relaxation work (Wr, N·s) was represented by the area under the relaxation curves (Gutt et al., 2014; Zimbru et al., 2020a).

$$R = (F_i - F_f)/t \qquad (1)$$

Where F_i and F_f are the initial and final load of relaxation and t represents the time of relaxation in seconds.

The TPA primary parameters (hardness-H, adhesiveness-A, springiness-S, cohesiveness-C, viscosity-V) and secondary parameters (gumminess-G, chewiness-Ch, resilience-R) parameters were also calculated from the travel-load curves with MESUREgauge software (Mark 10 Corporation, USA), (Zimbru et al., 2020b; Pădureț et al., 2017).

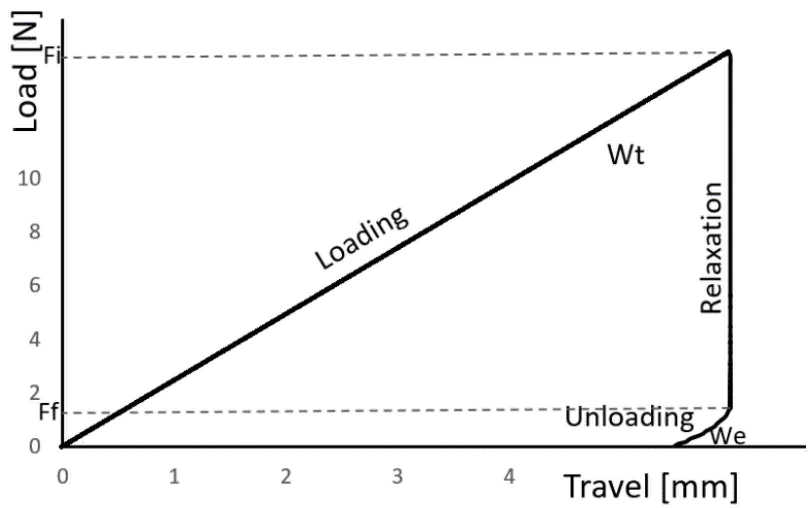

Figure 2. Loading - unloading curve of cheese during the stress-relaxation test.

2.3. Statistical analysis. For the sample's differentiation, the analysis of variance ANOVA (α=0.05) was conducted using Statgraphics Centurion XVI software and multiple comparisons of means using Fisher's least significant difference (LSD) at the 0.95 confidence level. The Pearson correlation was performed with SPSS 16 (SPSS Inc. Chicago, IL).

3. Results and discussions

3.1. Physicochemical analysis.

Figure 3 shows the physicochemical characteristics of Cascaval cheese analyzed in this study. The fat content, protein, and moisture/dry matter are the main composition of cheeses, in addition, cheese proteins are valuable since they are almost completely digestible, and according to Fox 2004 (Fox et al., 2004) the cheeses protein content is influenced negatively by the fat content. The protein content of Cascaval samples ranges between 23.1% for fresh analyzed samples – A category and 24.5% for unpacked ripened Cascaval samples – B category, while the fat content varied from 41.2% registered for fresh analyzed samples – A category to 48.5% for unpacked ripened Cascaval samples – B category. For both fat and protein content, the packaged ripened Cascaval – C category presented intermediate values of 42.9% and 23.6%. The moisture content values are an important factor in cheese classification and according to McSweeney 2017, (McSweeney et al., 2017) the cheeses evaluated belong to the semihard category, with 43% - 55% moisture, (A category – 52.86% and C category – 45.1%) and hard category, with moisture content less than 42%, (B category – 41.3%). The dry matter content of Cascaval samples increased during ripening, the highest values were measured for B category, unpacked ripened Cascaval samples, (58.7%) due to the water evaporation and rind formation; similar observation was reported also by Andronoiu (Andronoiu et al., 2015). The cheese's moisture and fat content are two important factors of great importance that influence the texture parameters of cheeses (Gunasekaran and Ak, 2002) furthermore, other studies (Nogueira et al., 2021) have shown that vacuum-packaging provides a bitter taste to Canastra artisanal cheeses, while unpackaged cheeses show a dry and brittle texture. The titratable acidity results, expressed as lactic acid, were close to those reported by Tumbarski (Tumbarski et al., 2021) and the highest values were measured for the C category Cascaval samples that were vacuumed in a polypropylene bag and ripened for sixty days.

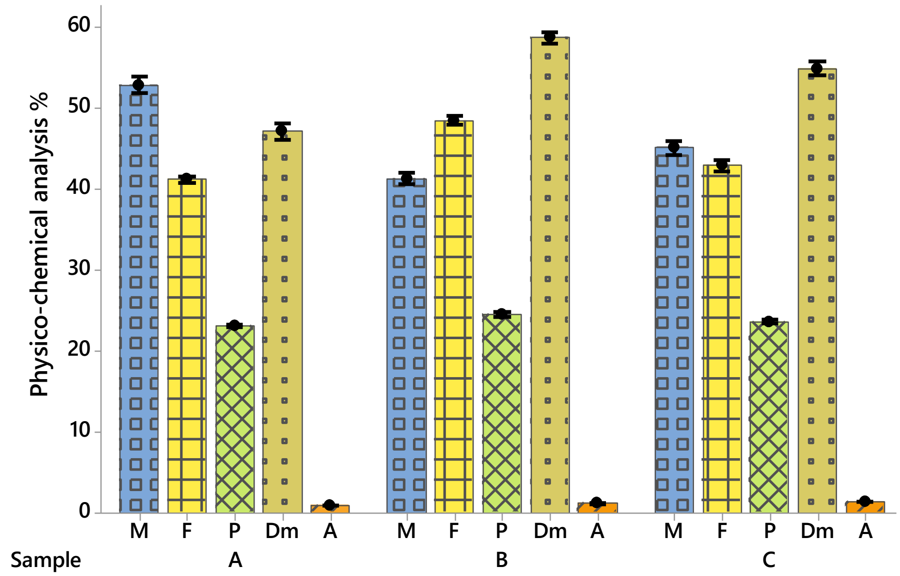

Figure 3. Physicochemical results of Cascaval samples: A-fresh Cascaval, B-unpacked ripened Cascaval, C- packaged ripened Cascaval, M-moisture, F-fat, P-protein, Dm-dry matter, A-titratable acidity

3.2. Textural evaluation.

According to Foegeding 2003 (Allen Foegeding et al., 2003), instrumental texture properties differentiate many kinds of cheese and are taken into account by consumers when determining a cheese's overall quality and preference.

Figure 4 presents the results of the applied stress-relaxation method, and it can be noticed that the analyzed cheese samples were found to exhibit viscous and elastic comportment, specifically viscoelastic solid comportment, with a decrease in stress with time. Table 1 shows the textural parameters measured by the stress relaxation method. The hardness under load (Hs) of Cascaval samples varied from 2.39 N/mm to 3.23 N/mm, the highest values being recorded by the maturated unpacked, B category Cascaval, which also recorded the highest values for total mechanical work (Wt). The measured load values were close to those reported by Darnay 2019, (Darnay et al., 2019) for semi-hard goat cheese. The recoverable energy used for the cheese sample deformation is represented by the work of elastic deformation (We), which ranges from 0.19 to $0.31 \cdot 10^{-3}$ Joules, the highest values registered, and the most resilient samples being represented by the B-unpacked ripened Cascaval. The loading modulus of deformability (E_L) describes the material stiffness and was determined as the slope of the loading stress-strain curves, which is related also to the hardness texture parameter (Serna Cock et al., 2012). The data demonstrate that for Cascaval samples with high hardness and high values of total mechanical work, the modulus of deformability was higher. It can be observed that the modulus of deformability values increased during maturation time, with a high value registered for unpacked ripened Cascaval samples (B-161.5 KPa); the sample differentiation was done at a level of $p < 0.05$. Similarly, Watkinson 2001 (Watkinson et al., 2001) reported an increase in the modulus of deformability for Cheddar and Gouda cheese and this was associated mostly with the moisture decrease and partial triglyceride crystallization. As regards the relaxation and relaxation work results it can be noticed that the values are close to each other, the lower values being measured for unripened group samples (A), whereas the highest values were measured for maturated unpacked samples (B); the obtained results were in the same range to those previously stated for fresh meat (0.0113 – 0.044 N/s) (Gutt et al., 2014). In addition to the ones mentioned, Table 1 also presents the results of Cascaval TPA.

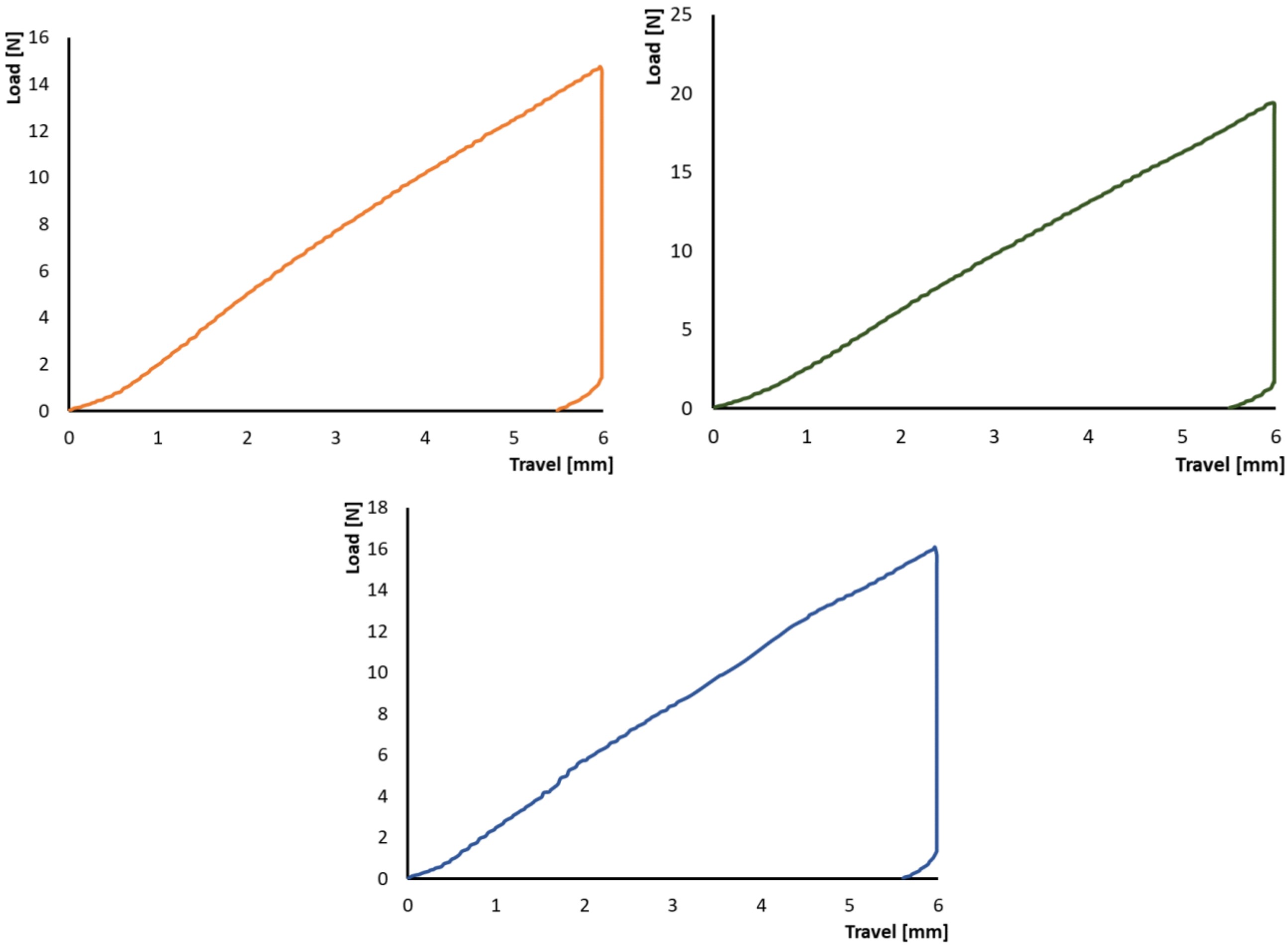

Figure 4. Stress-relaxation curves of Cascaval samples: A-fresh Cascaval (—), B-unpacked ripened Cascaval (—), C- packaged ripened Cascaval (—).

Table 1. The textural properties of Cascaval samples.

Sample		A	B	C
Stress-relaxation texture parameters				
Hardness under load - Hs	[N/mm]	2.39b (0.16)	3.23a (0.17)	2.68b (0.13)
Total mechanical work - Wt	[$\cdot 10^{-3}$ J]	42.53b (2.58)	54.36a (4.58)	47.32b (2.91)
Elastic mechanical work - We	[$\cdot 10^{-3}$ J]	0.28a (0.10)	0.31a (0.09)	0.19a (0.08)
Modulus of deformability – E_L	[KPa]	123b (3.85)	161.5a (8.23)	134b (5.89)
Relaxation - R	[N/s]	0.022c (0.001)	0.029a (0.001)	0.025b (0.001)

Relaxation work - Wr	[N·s]	2035c (12)	2576a (22)	2133b (19)
TPA texture parameters				
Hardness	[N]	16.48b (1.08)	19.74a (0.42)	18.7a (0.32)
Viscosity	[N]	0.32c (0.10)	0.80a (0.08)	0.64b (0.05)
Cohesiveness	[%]	47.65a (3.01)	47.68a (2.21)	44.57a (2.87)
Adhesiveness	[mJ]	0.48b (0.10)	1.05a (0.21)	1.06a (0.23)
Springiness	[%]	75.35a (2.58)	67.20b (1.98)	63.98b (1.58)
Gumminess	[N]	7.85b (0.58)	9.41a (0.34)	8.33b (0.51)
Chewiness	[N]	5.91ab (0.48)	5.33b (0.19)	6.32a (0.28)
Resilience	-	0.24a (0.02)	0.23ab (0.01)	0.21b (0.01)

Mean values and standard deviations. Different letters (a–c) in a row show significant differences between samples ($p < 0.05$) evaluated with One way ANOVA test.

The hardness, viscosity, adhesiveness, and gumminess texture parameters of ripened Cascaval samples showed higher values compared to fresh ones. Also, other authors (Pappa et al., 2020) reported higher hardness values (22-24 N) for sheep–goat milk Kashkaval cheese using the same sample dimensions with the difference that the sample was compressed to 60% of its original height, this aspect could explain the slight difference between values. The ANOVA statistical analysis highlighted differences in hardness, which varied from 16.48 to 19.74 N, at a level of $p<0.05$; the ripened Cascaval samples, B and C categories belonged to the same statistical group. This variation could be due to the moisture decrease, a recent study reported by Nyamakwere 2022 (Nyamakwere et al., 2022) also supports that cheese hardness values increase as the moisture content decreases. The TPA viscosity, calculated as the negative force of the TPA curve, ranged between 0.32 N for fresh Cascaval (A-category) to 0.80 N for unpacked ripened Cascaval (B-category), whereas the packaged ripened Cascaval samples (C-category) showed middle values; the statistical analysis differentiates the samples at $p<0.05$. The recording of the TPA in load versus travel made it possible to calculate the Cascaval adhesiveness as energy expressed in millijoules, according to Bourne 2002 (Bourne, 2002) and ISO 11036:2020 (ISO 11036:2020, n.d.). The analyzed ripened Cascaval samples displayed a higher adhesiveness compared to the fresh ones, there were no differences between unpacked or packaged ripened samples. Considering the statistical analysis results it can be observed that the cohesiveness values of Cascaval cannot be used in sample differentiation; the obtained results belong to the same statistical group. Among the secondary texture parameters, gumminess and chewiness are more complex properties and are directly influenced by the cohesiveness values. Furthermore, cheese chewiness is influenced by the softness of the cheese body and also by the structure of the casein network (Tudoreanu and Dumitrean, 2009). The unpacked ripened Cascaval (B-samples) presented the highest gumminess 9.41 N, followed by packaged ripened Cascaval 8.33 N (C-samples), while fresh Cascaval samples (A-category) had the lowest result 7.85 N. The springiness decreased after sixty days of ripening, from 75.35% to 63.98%, similar to the results reported by (Fuentes et al., 2015) for vacuumed pasta-filata Mexican cheese. According to Tudoreanu and Dumitrean, 2009 (Tudoreanu and Dumitrean, 2009) the decrease in Cascaval springiness involves the proteolytic breakdown of the protein matrix, leading to a creamier dairy product. In the case of textural parameters, resilience can be defined as the ability of the tested sample to return to its initial position/shape (Zimbru et al., 2020b). The resilience of the tested Cascaval samples were close to each other, ranging between 0.21 to 0.24, with the fresh samples (A category) showing a higher capacity to return to their initial position/shape than ripened ones.

3.3. Pearson correlation

Between physicochemical characteristics of Cascaval samples, stress-relaxation, and TPA texture parameters was performed, and a strong positive correlation ($p < 0.01$) was recorded between protein content and hardness under load, whereas the dry matter content influences, at the same level, the TPA hardness and viscosity results, and consequently these textural parameters are both negatively influenced by the moisture content ($p < 0.01$). The influence of protein content on Kashkaval hardness was also reported by Pappa 2020, (Pappa et al., 2020). Another positive correlation ($p < 0.05$) was observed between fat and modulus of deformability, hardness under load, relaxation work, and gumminess, and also between protein content and total mechanical work, modulus of deformability, relaxation, and gumminess. It could be observed that the modulus of deformability increased with both fat and protein content.

According to Pearson correlation results the stress-relaxation and TPA texture parameters of Cascaval samples were connected between them. The modulus of deformability, hardness under load, total mechanical work, relaxation, and relaxation work positively influenced the TPA gumminess ($p < 0.01$, $p < 0.05$). Based on the Pearson statistical analysis, it was found that the texture parameters resulting from the application of the stress-relaxation method showed more correlations with the chemical composition of the tested samples compared to the TPA method, therefore the stress-relaxation method can be a more powerful tool in the evaluation of Cascaval cheese texture characteristics.

4. Conclusions

The main composition of analyzed Cascaval samples was influenced by the ripening condition, both fat and protein content of the packaged ripened Cascaval presented intermediate values. The dry matter content of Cascaval samples increases during ripening, the highest values were measured for unpacked ripened Cascaval samples, due to the water evaporation and rind formation. In terms of textural evaluation, it could be observed that the Cascaval modulus of deformability, hardness under load, TPA hardness, and viscosity increased during the ripening period, whereas springiness decreased after sixty days of ripening. It could also be observed that the modulus of deformability increased with both fat and protein content, while the relaxation work was influenced only by fat content. The data also showed that for Cascaval samples with high hardness and high values of total mechanical work, the modulus of deformability was higher.

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