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Comparison of electronic systems with sensory analysis for the quality evaluation of parenica cheese

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Abstract: The applicability of electronic systems for the quality evaluation of parenica cheese was investigated in fresh smoked and unsmoked cheeses and after seven days of storage. These data were then compared with sensory evaluation results. Fresh samples had stable colour profiles determined by the electronic eye, while the differences in brown colour intensity were confirmed by sensory evaluation. A significant difference in the aroma profiles of samples was recorded by the electronic nose in samples produced in February, April, December (unsmoked cheese) and September (smoked cheese). Based on sensory analysis results using the Wilcoxon nonparametric test, a significant difference was confirmed in February (smoked cheese) and March (unsmoked cheese), when stored cheese had a stronger aroma than fresh cheese ($P < 0.05$). The suitability of electronic nose and electronic eye for monitoring of parenica cheese quality was confirmed.

Keywords: aroma compounds; colour stability; Slovakia; tasting; unripened steamed cow's milk cheese

Certain disadvantages of the sensory panel led to the development of alternative electronic methods in order to assess the sensory properties of cheese samples in a more objective way (Apetrei et al. 2010). An electronic nose (e-nose) is an odour detection device using a sensor array (Delgado-Rodríguez et al. 2012) or gas chromatography (Štefániková et al. 2019). E-nose can be used for diverse applications such as quality control (Buratti et al. 2018; Chen et al. 2018), process monitoring, durability assessment, origin ranking and originality control (Śliwińska et al. 2014; Li et al. 2017). A smartphone-based system with cell viability biosensor was

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used as the bionic e-eye by Su et al. (2018). Gan et al. (2019) created another type of bionic e-eye for MnO_2 nanosheets and MnO_2 oxalate detection system. Spectrophotometry (Buratti et al. 2018), digital imaging (Yang et al. 2018), LED (Apetrei et al. 2010) or scanning (Orlandi et al. 2018) devices have also been used for the colour analysis of various samples. However, currently there is no study investigating any samples (not only dairy or cheese products) using an electronic eye (e-eye) based on the complementary metal-oxide semiconductor technology camera operating with RGB and L^*, a^* and b^* parameters as it is presented in this study.

This study aimed to investigate the applicability of e-nose and e-eye with sensory evaluation for describing parenica (a traditional Slovak steamed cheese) and the quality assessment of smoked and unsmoked parenica during their storage.

MATERIAL AND METHODS

Parenica samples. The parenica samples were obtained from a Slovak dairy factory during 2018 (monthly between February and April, then in June, and from September to December). Cheeses were made from pasteurised cow's milk. A total of 24 parenica pieces (12 smoked and 12 unsmoked) were sampled on the day of their production (once each month), while 12 fresh samples (6 smoked and 6 unsmoked ones) were analysed on the next day. Subsequently, the analysis of another 12 samples (6 smoked and 6 unsmoked ones) stored at 4–8 °C for 7 days was carried out. The samples were stored in modified atmosphere packaging of 120 g in the refrigerator. In total, 192 samples were used.

E-nose analysis. The e-nose method (Heracles II; Alpha M.O.S., France) based on gas chromatography previously described by Štefániková et al. (2019) was used for aroma profile analysis. For each analysis, 2.5 g of a sample was incubated in a 20 mL vial in a block thermostat at 50 °C for 15 min (Autosampler; Alpha M.O.S., France) and a 5 mL volume of headspace gas was withdrawn using an autosampler syringe and injected into the e-nose. Each sample was weighed and placed in three different vials; each one being analysed once.

E-eye analysis. E-eye (IRIS VA400; Alpha M.O.S., France) ensures high resolution imaging under controlled lighting and imaging conditions in a closed chamber with white light uniformly dispersed avoiding any shadows. Each parenica sample was cut to approximately 5–7 cm long pieces. After automatic calibration of the e-eye with a certified colour checker, a piece was placed into the chamber and an image was taken using the complementary metal-oxide semiconductor technology camera operating with RGB and L^*, a^* and b^* parameters of the spectrum classification. The measurement evaluation of three images of three pieces from one sample was performed by the AlphaSoft software (Alpha M.O.S., France) combining image analysis and advanced multivariate statistics.

Sensory evaluation. The 9-point combined hedonic scale was used for sensory evaluation of white colour and cheese aroma intensity of unsmoked cheese as well as brown colour and smoked aroma intensity of smoked cheese. In total, 169 evaluators were involved, divided into 16 groups of 10–13 people, where 66% of the participants were females and the rest were males, aged 20–61 years. The Sensory Laboratory of the Slovak University of Agriculture in Nitra designed in accordance with ISO 8589:2007 (Sensory analysis – general guidance for the design of test rooms) provided controlled conditions. Obtained data were analysed by the Wilcoxon nonparametric test. Post-hoc tests were done by the Bonferroni correction (O'Mahony 2017).

Statistical analysis. The principal component analysis (PCA) (Alpha M.O.S., France), previously depicted by Štefániková et al. (2019), was used for multivariate statistical analysis. The results represent means of the measured values of three replicates from an analysed sample.

RESULTS AND DISCUSSION

E-nose analysis. Electronic nose (e-nose) is an odour detection device using a sensor array (Delgado-Rodríguez et al. 2012) or gas chromatography with flame-ionisation detector (GC-FID) (Štefániková et al. 2019). In this study, aroma profiles of 192 parenica samples were evaluated by the e-nose based on headspace GC-FID. Its advantage is the identification of compounds by matching the measured peaks with Kovats retention indices using the NIST library (National Institute of Standards and Technology) (Alpha M.O.S. software, France). The compounds identified by the e-nose with a discriminant of > 0.900 were selected, based on which a semi-qualitative evaluation was performed by principal component analysis (PCA). The comparison of fresh and stored unsmoked parenica samples (Figure 1) shows that their aroma profiles change in certain months of cheese production. A significant difference in the aroma profiles of these unsmoked samples was recorded in February, April and December. The PCA plots for data on smoked samples

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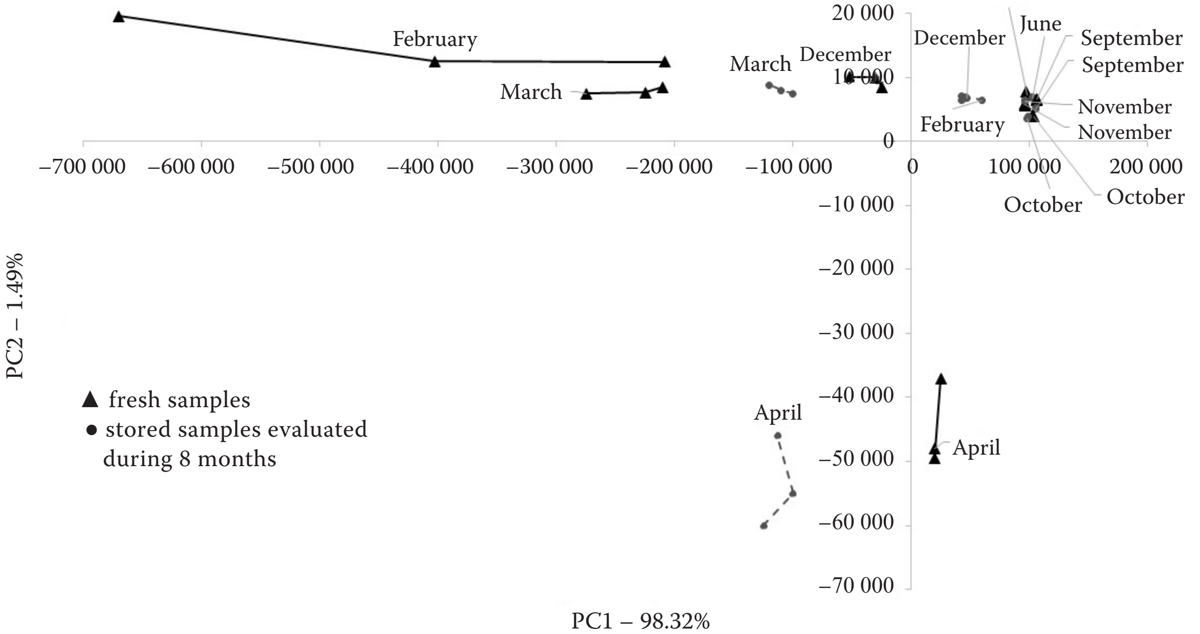

Figure 1. Projection of unsmoked parenica onto the space defined by the first two principal components (PC1/PC2) by e-nose

are shown in Figure 2. There was a significant difference in the aroma profiles of smoked parenica between the fresh and stored samples produced in September.

A possible cause of the changing aromatic composition of fresh samples (in February, March and December in unsmoked cheese and in March and April in smoked cheese) could be the changing composition of cow's milk during the year. The protein, fat and free fatty acid content in milk affects the cheese quality (Keresteš & Selecký 2005).

The compounds of biochemical reactions (carboxylic acids, alcohols, aldehydes, ketones, esters, sulphur compounds) of smoking (furans/furanones, phenols) and of milk flavour (terpenes) (Majcher et al. 2011) were also identified in this study (Table 1). Aldehydes and ketones represented the most abundant group of compounds

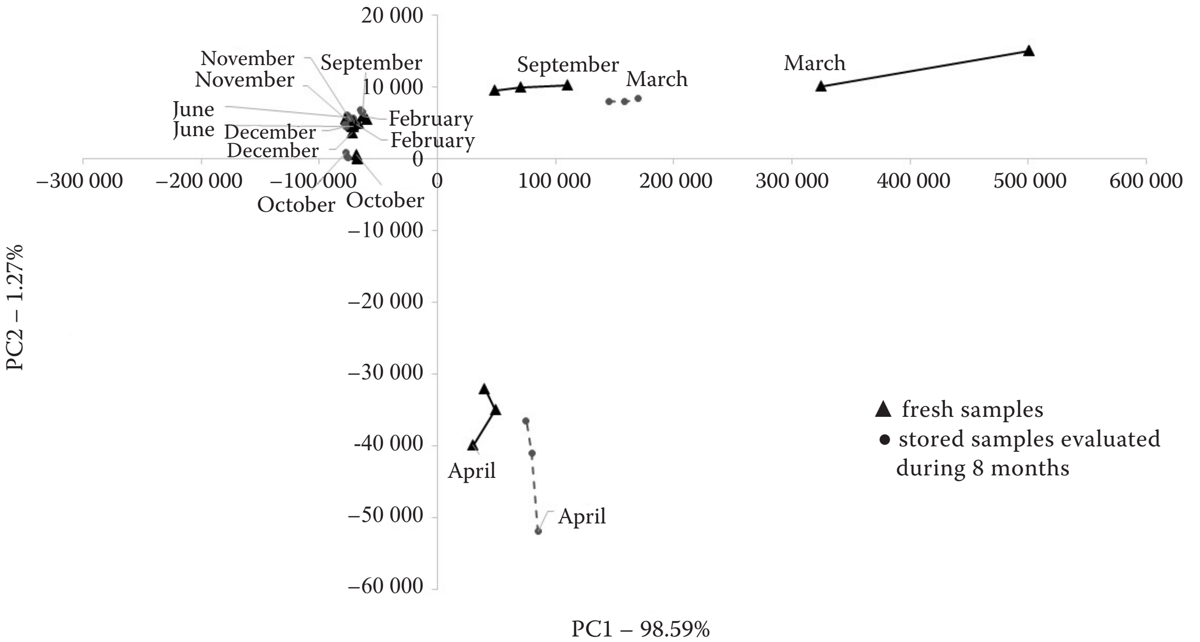

Figure 2. Projection of smoked parenica onto the space defined by the first two principal components (PC1/PC2) by e-nose

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Table 1. Significant aroma compounds (discriminant > 0.900) in unsmoked and smoked parenica samples identified by e-nose

Sample	Compound	Kovats retention index DB-5	Sensory descriptor
Unsmoked cheese	α-pinene	929	pine, terpenic
	3-methyl butanal	652	almond, fruity, green, herbaceous
	acetaldehyde	428	ethereal, fresh, fruity
	hexanal	801	fatty, fishy, fruity, grassy, green, herbaceous
	ethyl-2-methyl butyrate	849	apple, blackberry, fruity, green, sweet
	ethyl acetate	614	acidic, buttery, caramelized, ethereal, fruity, pungent, solvent, sweet
	ethyl propanoate	710	acetone, fruity, solvent
	pentane-2,3-dione	698	buttery, caramelized, creamy, fresh, fruity, sweet
Unsmoked and smoked cheese	2-methyl-1-propanol	626	alcoholic, bitter, leek, liquorice, solvent, winey
	ethyl butyrate	800	acetone, bubble gum, caramelized, fruity, sweet
	diacetyl	589	buttery, caramelized, creamy, fruity, spirit
	2-propanol	500	alcoholic, ethereal
Smoked cheese	ethyl isobutanoate	756	fruity, rubber, sweet
	acetic acid	619	acidic, pungent, vinegar
	butan-2-one	594	buttery, cheese, chemical, chocolate, ethereal, gaseous
	butanal	578	chocolate, green, malty, pungent
	methyl-2- methyl butanate	774	chewing gum, fruity, solvent, spirit
	propyl propanoate	808	apple, chemical, pineapple
	pentan-2-one	688	acetone, ethereal, fruity, thinner
	1-hexanol	870	floral, fruity, grassy, herbaceous, leafy, mild woody, resinous, sweet, toasty
	isovaleric acid	862	acidic, cheese, rancid, sweaty
	heptan-2-one	891	cheese, cured ham, fruity, gaseous, gravy, nutty, soapy, toasted
	benzaldehyde	970	almond, burnt sugar, fruity, woody
	α -phellandrene	1 004	minty, spicy, terpenic
	benzyl acetate	1 164	boiled vegetable, burnt, floral, fresh
	ethyl-3-(methylthio) propanoate	1 106	fruity, pineapple, sulphurous
	dimethyl disulphide	746	cabbage, onion, putrid, ripened cheese, sulphurous

identified as significant (dicsriminant > 0.900) in cheese samples and had been previously described by Bhandari et al. (2016). The aroma profiles of unsmoked samples were mainly characterised by hexanal, diacetyl and pentane-2,3-dione, but benzaldehyde, 2-butanone, 2-pentanone, furfural and 2-heptanone were identified in the smoked samples. Compounds of smoking such as dimethyl sulphide and dimethyl disulphide were also identified. Alpha-pinene and α-phellandrene identified from the terpene group are usually introduced into cheese flavour as milk constituents.

E-eye analysis. The bionic e-eye of varied types (Su et al. 2018; Gan et al. 2019) or spectrophotometric analysers (Apetrei et al. 2010; Buratti et al. 2018) were applied for colour analysis in the past. In this study, the analysis of RGB parameters was applied to the cheese samples and colours with a discriminant of > 0.900 were selected, based on which a semi-qualitative evaluation was performed by PCA. In the samples, colours with codes 4091–4095 of different content percentages were detected. Figure 3 shows changes in colour profiles of particular samples during storage. Significant

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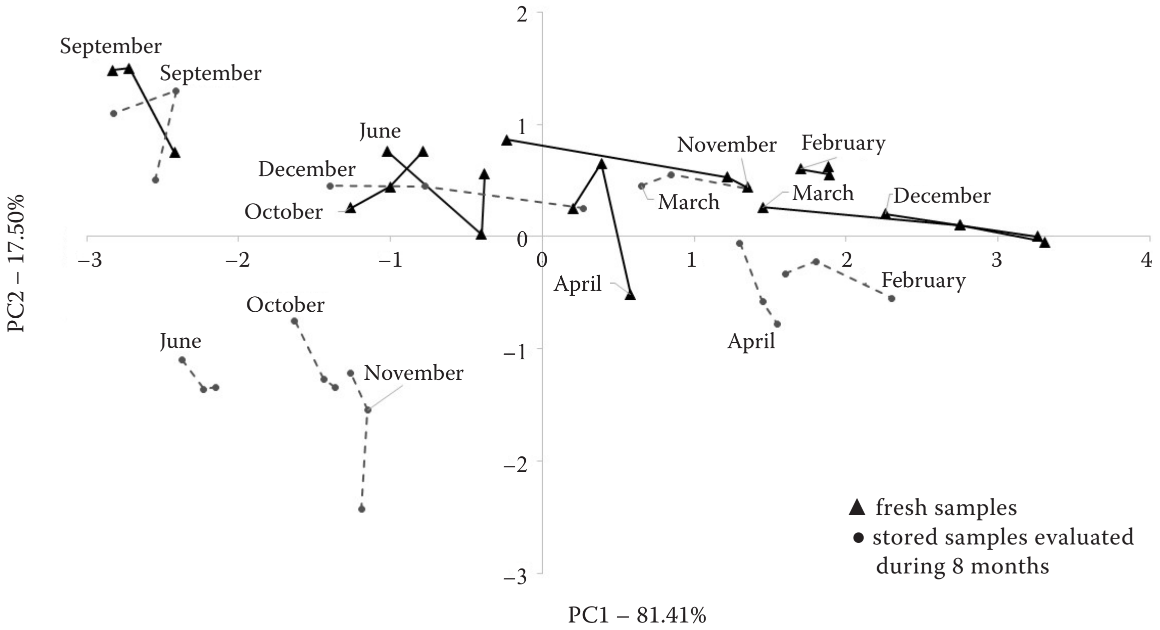

Figure 3. Projection of unsmoked parenica onto the space defined by the first two principal components (PC1/PC2) by e-eye

changes can be observed in stored samples (June, October and November) in the lower left quadrant. Conversely, samples from March and April appeared to have a stable colour profile. Other interactions of stored cheese are shown on the PC map. The colour changes of smoked parenica were statistically confirmed neither for PC1 axis nor for PC2 axis (Figure 4), except for cheese produced in December, when there was a significant colour change between the fresh sample (positive) and the sample after 7 days of storage (negative) (PC1 – 71.61%). Based on these results we can conclude that the colour of monitored products was stable during 2018. Minor colour changes in the stored samples occurred only in certain months.

Sensory evaluation. Some studies evaluated the traditional parenica using sensory analysis (Nedomová et al. 2017; Čuboň et al. 2019; Semjon et al. 2019). Our results agree with the studies of Forde & Fitzgerald (2000)

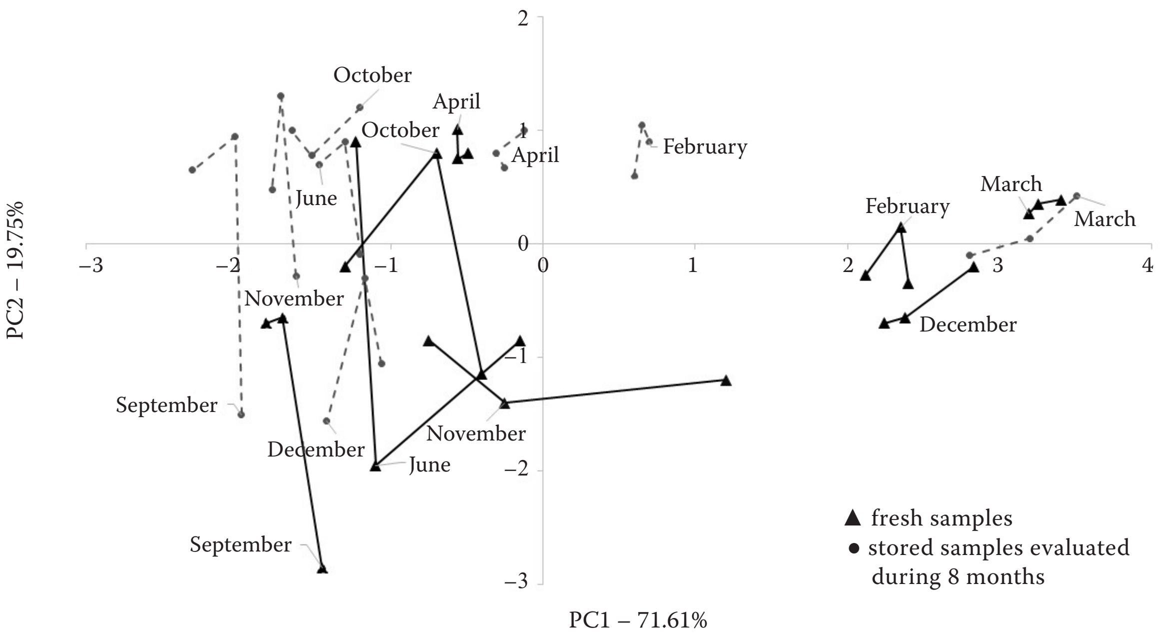

Figure 4. Projection of smoked parenica onto the space defined by the first two principal components (PC1/PC2) by e-eye

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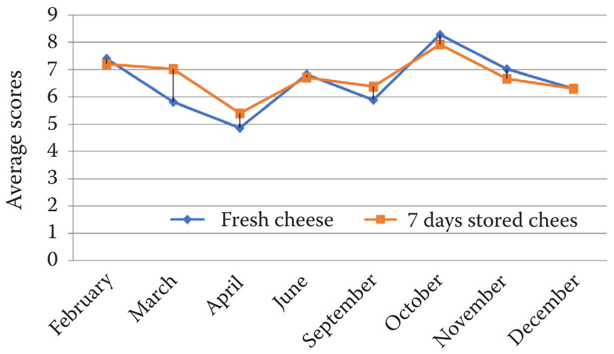

Figure 5. Sensory analysis of the white colour intensity of unsmoked fresh and 7 days stored parenica evaluated during 8 months

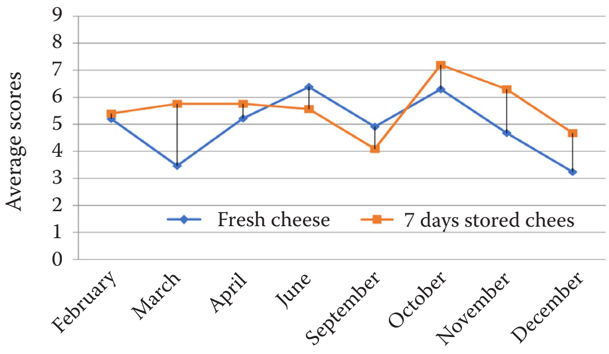

Figure 7. Sensory analysis of the brown colour intensity of smoked fresh and 7 days stored parenica evaluated during 8 months

Figure 6. Sensory analysis of the aroma intensity of unsmoked fresh and 7 days stored parenica evaluated during 8 months

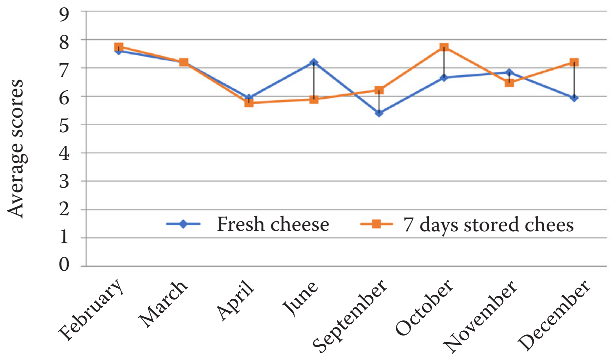

Figure 8. Sensory analysis of the aroma intensity of smoked fresh and 7 days stored parenica evaluated during 8 months

as well as Zajác et al. (2019) that textural and sensory cheese characteristics are changing during ripening. There are many factors that can cause quality differences – the temperature of milk pasteurization, salting, drying as well as smoking temperature (Zajác et al. 2019).

The intensity of unsmoked cheese white colour attribute (Figure 5) among the samples showed no significant difference ($P > 0.05$) by the Wilcoxon test. By using the nonparametric Wilcoxon test for panel mean scores for the cheese aroma intensity of unsmoked cheese (Figure 6), we found a significant difference in March, when cheese stored for 7 days had a stronger aroma than fresh cheese ($P < 0.05$). According to the results obtained from the sensory analysis of brown colour intensity (Figure 7), there were significant differences in fresh and also in stored samples of smoked cheese. The samples stored for 7 days were significantly browner in March and November than fresh samples ($P < 0.05$). The evaluation of smoked aroma intensity in smoked cheese (Figure 8) proved that there existed a significant difference between the samples analysed fresh and stored for 7 days. The samples stored for 7 days had a significantly stronger smoked aroma than fresh samples in February ($P < 0.05$). In the other monitored months, we did not find any significant differences between the fresh and 7 days stored samples.

CONCLUSION

Quality evaluation of 192 parenica samples by two electronic systems coupled with sensory evaluation was carried out throughout the year 2018. Good colour stability of products obtained during 2018 was confirmed. On the other hand, cheese samples had significant differences in their aroma profiles during the year. Our results show that the electronic systems used appear to be a more objective tool for the characterisation and quality evaluation of parenica samples in the routine analysis over a short period of time and it can be the appropriate complement to sensory evaluation. The identification of volatile organic compounds is a great benefit of the e-nose based on gas chromatography.

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