DOI 10.5162/SMSI2025/D2.2

Quality assessment of raw fresh milk from several sources by no-destructive Raman sensor

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Summary:

Raman spectroscopy has emerged as a powerful, non-destructive tool for assessing the quality and authenticity of dairy products, particularly fresh milk from a variety of sources. By producing detailed molecular 'fingerprints' in the 200-2000 cm-¹ range, Raman spectroscopy enables rapid identification of milk composition and detection of potential adulterants, offering significant advantages such as faster analysis times, reduced costs and minimal sample preparation. Combined with multivariate statistical analysis, Raman spectroscopy offers a promising solution for authenticating milk and ensuring quality control throughout the dairy supply chain. In this study, Raman spectra of different milk types (cow, sheep) were collected and compared, revealing unique and common spectral features related to their composition. Although not aimed at detecting adulteration, this analysis highlights the potential of Raman spectroscopy as a tool for differentiating milk types based on their spectral characteristics, suggesting a potential application in milk quality control.

Keywords: Raman spectroscopy, milk adulteration, non-destructive analysis, food quality

Background, Motivation an Objective

The quality of milk and dairy products is fundamental to food safety and consumer confidence. In the dairy industry, the composition of milk varies significantly between species, and these molecular differences influence nutritional value, flavour and end product applications. Sheep and cow's milk have unique profiles due to their different chemical composition. Traditional methods of milk quality analysis, such as electrophoresis or chromatography, are complex and time-consuming, making them impractical for rapid and continuous screening [1].

The use of an accurate, non-destructive tool to characterise these differences in-situ and in real-time could be useful for the dairy product chain. Growing interest in more rapid and sustainable analytical solutions has focused attention on spectroscopic techniques, such us Raman spectroscopy, for the evaluation of dairy products. Raman spectroscopy offers a non-destructive, rapid and accurate approach to milk analysis, enabling the acquisition of unique molecular spectra or 'fingerprints', that reveal compositional details without the need for sample pre-treatment [2].

With this technique, we have analysed different samples of milk, such as sheep and cow, to identify the fingerprint of each sample and any compositional changes that may occur as a result of freezing. Differences in spectral peaks can be used to identify and monitor specific quality markers in both fresh and frozen milk in the supply chain, for milk quality.

Description of the System

Raman spectroscopy is a well-known laser based technique, based on molecular vibrations/inelastic light scattering [3].

For this study, the analysis was carried out using a table-top portable Raman system (i-Raman by B&W TEK Inc.), equipped with a GaAlAs diode laser at 785 nm with tunable power (300 mW max, limited to 70 mW in the present measurements) and an optical fiber probe. The measurements were performed on raw samples of cow's and sheep's milk taken from milkings of 24 and 72 hours duration, respectively, under fixed stall conditions. Some of the samples were frozen at -30°C and analysed after thawing at +4°C for 24 hours.

We immersed the optical fiber probe directly into 60 ml of raw milk at room temperature (see Fig. 1). This contact-based method preserves the natural state of the milk and allows accurate analysis of its molecular composition. The laser source was set to a power of 70 mW for 50 s, and data were acquired in the 200-3000 cm-¹ range. To increase accuracy and reliability, each sample was measured 10 times under the same

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conditions, ensuring consistent and reproducible spectral profiles for fresh and frozen milk.

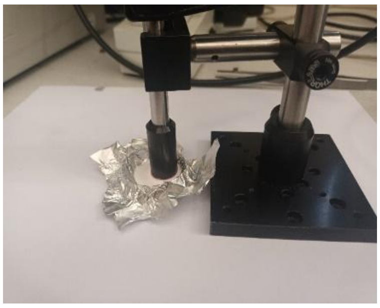

Fig.1 Adopted measurement procedure

Results

The results obtained highlight slight differences in the spectral features between fresh and thawed cow's milk (see Fig.2 and Fig.3). According to the literature [4,5] the bands at 870, 1076, 1296-1300, 1440, 1650, 1744, 2800-2900 cm^{-1} were detected in all samples, with evident variations observed in the intensity and in the shape of the bands.

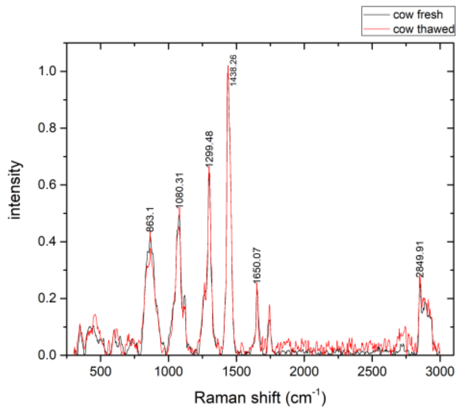

Fig.2 Raman spectra of fresh raw and thawed cow milk samples

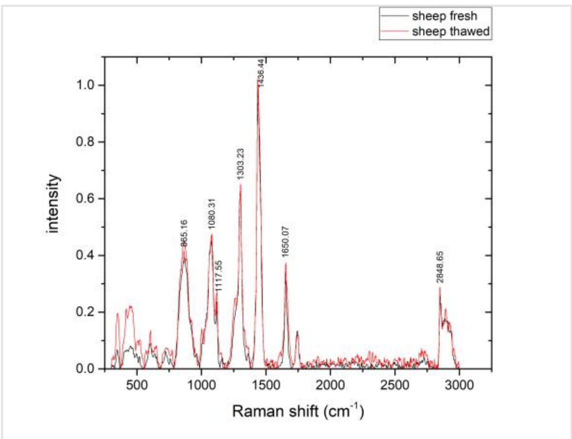

Fig.3 Raman spectra of fresh raw and thawed sheep milk samples.

The identified peaks are due to the main components of milk such as lipids, proteins and carbohydrate (lactose) [4,5], and the results for the frozen sheep milk samples showed a peak at 343 cm^{-1} representing the stretching and bending vibrations of the C-O-C [6].

Although there were variations in the Raman spectra of the milk samples, the visual discrimination of the latter by these spectral variations, was difficult and subjective. For this reason, future studies of the spectra, will be based on multivariate analysis, for example by using Principal Component Analysis (PCA).

Aknowledgments

This study was carried out within the Agritech National Research Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022). This manuscript reflects only the authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

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