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# ANALYSIS OF BIOLOGICALLY ACTIVE SUBSTANCES IN MILK AND VETERINARY PRODUCTS USING INFRARED (IR) SPECTROSCOPY

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**Abstract:** Infrared (IR) spectroscopy is an effective analytical method used for the determination and evaluation of biologically active substances in milk and veterinary products. Milk contains important biochemical components such as proteins, fats, lactose, vitamins, and mineral compounds that influence animal health and product quality. IR spectroscopic analysis allows rapid identification of these components based on characteristic molecular vibrations and absorption bands. The technique is widely applied for monitoring milk composition, detecting pathological changes associated with animal diseases, and assessing product safety. In addition, IR spectroscopy is used in veterinary pharmaceutical analysis to identify active ingredients, evaluate chemical stability, and detect impurities in veterinary preparations. The non-destructive nature, high sensitivity, and rapid analysis capability make IR spectroscopy a valuable tool for quality control and veterinary diagnostics. The application of this method contributes to improving dairy product safety, animal productivity, and the effectiveness of veterinary treatments.

**Key words:** Infrared spectroscopy, milk analysis, veterinary products, biologically active substances, dairy quality control, veterinary diagnostics, protein and lipid analysis, food safety, pharmaceutical analysis.

## Introduction

Milk and veterinary products play an important role in animal health management, food safety, and agricultural productivity. Milk is considered a biologically complex system containing essential nutrients such as proteins, lipids, carbohydrates, vitamins, enzymes, and mineral substances that are necessary for the growth and physiological development of animals and humans. The qualitative and quantitative composition of these components directly reflects the health condition of dairy animals and the hygienic quality of animal-derived products. Therefore, accurate analytical methods are required for monitoring biologically active substances in milk and veterinary products.

In veterinary practice, the analysis of milk composition is essential for early diagnosis of metabolic disorders and infectious diseases such as mastitis, which significantly affects milk quality and animal productivity. Changes in protein structure, fat composition, or lactose concentration may indicate physiological stress or pathological processes occurring in animals. Traditional chemical analysis methods often require complex sample preparation and longer analysis time, which limits their practical application in routine veterinary control.

Infrared (IR) spectroscopy has emerged as a rapid, non-destructive, and highly informative analytical technique for studying biological materials. The method is based on the absorption of infrared radiation by molecular vibrations, allowing identification of functional groups present in organic compounds. Each biochemical component of milk and veterinary pharmaceutical

products produces characteristic absorption bands that can be used for qualitative and quantitative evaluation[1-14].

The application of IR spectroscopy in veterinary science enables rapid assessment of milk quality, detection of adulteration, identification of biologically active compounds, and monitoring of veterinary drug formulations. In addition, the technique provides valuable information about molecular interactions and structural changes occurring during storage, processing, and treatment procedures. Therefore, IR spectroscopic analysis has become an important tool for improving veterinary diagnostics, ensuring product safety, and enhancing the quality control systems of dairy and veterinary products[15-24].

**Materials and Methods**

The study was conducted to analyze biologically active substances present in milk and veterinary products using infrared (IR) spectroscopy. Fresh milk samples were collected from clinically healthy dairy animals under hygienic conditions to prevent external contamination. In addition, veterinary pharmaceutical products containing biologically active compounds such as vitamins, antimicrobial agents, and mineral supplements were selected for comparative analysis. All samples were stored at controlled temperatures prior to analysis to preserve their physicochemical properties.

Milk samples were initially filtered to remove mechanical impurities and then homogenized to obtain uniform composition. A small portion of each sample was used directly for spectroscopic analysis without complex chemical treatment in order to preserve the natural molecular structure. Veterinary pharmaceutical preparations in solid form were finely ground, while liquid formulations were analyzed in their original state.

Infrared spectroscopic measurements were carried out using a Fourier Transform Infrared (FT-IR) spectrometer operating in the spectral range of 4000–400 $cm^{-1}$. Samples were analyzed using the attenuated total reflectance (ATR) method, which allows rapid and non-destructive examination of biological materials. For solid veterinary products, the potassium bromide (KBr) pellet technique was also applied when necessary to obtain clear spectra.

The obtained infrared spectra were recorded and processed using specialized analytical software. Characteristic absorption bands corresponding to functional groups such as O–H, N–H, C–H, C=O, and C–O were identified to determine the presence of proteins, lipids, carbohydrates, and other biologically active substances. Comparative spectral analysis was performed to evaluate differences between milk samples and veterinary products, as well as to detect structural variations associated with biological activity and product quality. All measurements were repeated several times to ensure accuracy and reproducibility of the results.

**Results and Discussion**

Infrared (IR) spectroscopic analysis was carried out to determine the composition and structural characteristics of biologically active substances present in milk and veterinary products. The obtained spectra provided important information about the molecular structure of proteins, lipids, carbohydrates, and pharmaceutical components contained in the analyzed samples.

The IR spectra of milk samples showed characteristic absorption bands related to the major biochemical constituents. A broad absorption peak observed in the region of 3200–3400 $cm^{-1}$ corresponded to O–H and N–H stretching vibrations associated with water molecules and milk proteins such as casein. Strong absorption bands detected near 2920–2850 $cm^{-1}$ were attributed to C–H stretching vibrations of fatty acids and lipid components. The presence of amide I and amide II bands around 1650 $cm^{-1}$ and 1540 $cm^{-1}$ confirmed the protein structure of milk, which plays an essential role in nutritional quality and animal health monitoring.

In veterinary pharmaceutical products, characteristic peaks corresponding to biologically active compounds were clearly identified. Absorption bands in the region of 1700–1600 $cm^{-1}$ indicated carbonyl (C=O) functional groups commonly present in antibiotics, vitamins, and therapeutic agents. Peaks observed between 1000–1200 $cm^{-1}$ were associated with C–O and C–N vibrations, confirming the presence of organic active ingredients used in veterinary formulations.

Comparative analysis revealed noticeable spectral variations between normal milk samples and samples affected by quality changes or physiological disorders. Slight shifts in protein and lipid absorption regions suggested biochemical modifications that may occur due to animal metabolic stress or inflammatory conditions such as mastitis. These results demonstrate the potential of IR spectroscopy as a rapid diagnostic tool in veterinary monitoring systems.

Furthermore, the analysis confirmed that IR spectroscopy allows fast and non-destructive evaluation of veterinary products without complex chemical preparation. The reproducibility of spectral data ensured reliable identification of biologically active substances and detection of possible impurities or degradation processes during storage. Overall, the obtained results indicate that IR spectroscopic techniques significantly improve quality control, safety assessment, and diagnostic efficiency in veterinary and dairy product analysis.

**Conclusion**

The results of infrared (IR) spectroscopic analysis demonstrated that this method is an effective and reliable tool for the identification and evaluation of biologically active substances in milk and veterinary products. Characteristic absorption bands obtained in the IR spectra allowed accurate determination of major biochemical components such as proteins, lipids, carbohydrates, and pharmaceutical active ingredients.

The analysis confirmed that structural changes in milk composition can be detected through variations in protein and lipid absorption regions, which may indicate physiological disorders or health problems in dairy animals. In addition, IR spectroscopy enabled rapid identification of biologically active compounds present in veterinary pharmaceutical preparations and helped assess their chemical stability and purity.

The non-destructive nature, high sensitivity, and rapid analytical capability of IR spectroscopy make it highly suitable for routine veterinary diagnostics and quality control of animal-derived products. Therefore, the application of IR spectroscopic techniques contributes significantly to improving milk safety, monitoring animal health conditions, and ensuring the effectiveness of veterinary medicinal products used in modern animal healthcare systems.

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