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Application of Infrared Spectroscopy to the Monitoring of Lactose and Protein From Whey After Ultra and Nano Filtration Process

Myrna Solís-Oba,[1]* Ogilver Teniza-García,[1,2] Marlon Rojas-López,[1] Raúl Delgado-Macuil,[1] Joel Díaz-Reyes,[1] and Rosario Ruiz[1]

[1] Instituto Politécnico Nacional, Centro de Investigación en Biotecnología Aplicada, Carretera Estatal Santa Inés Tecuexcomac-Tepetitla Km. 1.5, Tepetitla de Lardizábal, Tlaxcala, 90700, México, telephone and fax (52) 248 48 70762.

[2] Colegio de Estudios Científicos y Tecnológicos del estado de Tlaxcala, calle Reforma No. 10, Tlatempan Apetatitlán, Apetatitlán de Antonio Carvajal, 90610, Tlaxcala.
myrobatlx@yahoo.com.mx

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Abstract. Whey is produced during cheese manufacture, some of its constituents are lactose and proteins. In different countries such constituents are separated for use as raw material; some of the processes to separate these components are by ultra and nano-filtration, however most common methods for the determination of lactose and proteins are not accurate. This paper shows that infrared spectroscopy is a good alternative for the quantification of lactose and proteins after ultra- and nano-filtration processes. Linear calibration curves were obtained with this analytical technique for aqueous solutions containing lactose or protein in the range 0 to 20%; after 20% lactose, the solution becomes saturated. Infrared spectroscopy is a rapid and precise method that could be successfully used to quantify these compounds and follow the ultra- and nano-filtration process applied to purify lactose and proteins from whey.
Keywords: FT-IR, lactose, proteins, whey, ultra-filtration, nano-filtration.

Resumen. El suero se produce durante la elaboración de queso, algunos de sus componentes son lactosa y proteínas. En diferentes países estos constituyentes son separados para usarse como materias primas; algunos procesos usados para su separación son por ultra y nano filtración, sin embargo, la mayoría de los métodos comerciales para cuantificar lactosa y proteínas no son exactos. En este trabajo se demuestra que la espectroscopía infrarroja es un buen método para cuantificar lactosa y proteína después de los procesos de ultra y nano filtración. Las curvas de calibración que se prepararon con esta técnica analítica midiendo soluciones acuosas de lactosa y proteína en el intervalo de 0 a 20% de estos componentes, mostraron buena linealidad; después del 20% la solución de lactosa se satura. La espectroscopia infrarroja mostró ser un método rápido y preciso que puede ser usada para cuantificar esos compuestos y dar seguimiento a los procesos de ultra y nano filtración aplicados para purificar lactosa y proteínas del suero.
Palabras clave: FT-IR, lactosa, proteínas, suero, ultra filtración, nano filtración.

Introduction

Whey is a yellow-green liquid separated from the curd during manufacture of cheese [1], it has long been considered by the dairy industry as a waste by-product, and it has been discarded with an environmental consequence [2]. This aqueous solution contains nearly all the lactose originally present in the milk, as well as some fat, protein, and inorganic salts [3-4]. The high cost of disposal and the need to reduce environmental pollution have prompted considerable efforts to increase use of cheese whey components. Some developing processes for recovering the whey components include electro-dialysis, formation of complexes, ethanol precipitation, sephadex gel filtration, and membranes [5-7]. Many membrane technologies, such as ultra-filtration (UF; lower than 100 angstroms or 150 KDa molecular weight) and nano-filtration (NF; lower than 10 angstroms or 20 KDa molecular weight), have been applied by the dairy industry to concentrate whey components and reuse the water in its processes [8]. NF is a process used to separate mineral salts from lactose, having previously removed the proteins by UF. Both, proteins and lactose, can be used as raw materials to prepare a variety of products [9].

Lactose measurements have been done using different methods. Polarimetry, based on the measurement of specific rotation of the polarized light due to the asymmetric carbon of lactose, has as main disadvantages the interference from other optically active components and the non differentiation between carbohydrates. Gravimetry is a very simple and cheap procedure, however, it can be affected by interference from all reducing carbohydrates and there is not differentiation between them. HPLC is a direct method, allowing differentiation between carbohydrates but it is somewhat expensive. Additionally, some of these methods are tedious and time-consuming due to long sample preparation [10-11]. For many years, the reference method for determining protein content has been the Kjeldahl method; however, as milk also contains other sources of nitrogen, calculated protein values can be overestimated. Proteins are also commonly quantified by colorimetric methods like Bradford assay. Using this method, non-accurate values are often obtained because it is linear over a short range, and Bradford reagent can be inhibited by several compounds such as detergents [12].

Infrared spectroscopy is a rapid, inexpensive, and sensitive technology used for the high-throughput analysis of food components without requiring special skills from users. This technique expresses typical vibration modes of covalent bonds in molecules, and thus, contains quantitative information about all the constituents that absorb IR radiation, including proteins, sugars and fats. The middle infra-red spectral region, between