Revista Científica, FCV-LUZ / Vol. XXXIII, Supl. Esp., 114 - 116, 2023, https://doi.org/10.52973/rcfcv-wbc017

EXPLORING THE BUFFALO WHEY: A LOOK AT NANOTECHNOLOGY IN SEARCH OF STRATEGIES FOR THE MODERN NUTRACEUTICAL INDUSTRY

Aprovechamiento del lactosuero de leche de búfala: una mirada a la nanotecnología en busca de estrategias para la industria nutracéutica moderna

Franco E. Vasile

Instituto de Investigaciones en Procesos Tecnológicos Avanzados (CONICET-UNCAUS)
Universidad Nacional del Chaco Austral, Chaco, Argentina.
**Corresponding e-mail: Vasile, Franco Emanuel (francovasile@uncaus.edu.ar)*

ABSTRACT

Buffalo whey is the most important by-product of the cheese industry. Whey proteins constitute the most exciting component from a technological and economic point of view. They present attractive, functional properties and, similarly to proteins of bovine milk whey, they could also be used as an ingredient (dairy beverages, nutritional supplements) and/or food additives (emulsifier, foaming agent, encapsulant) in novel applications with high-added value, such as nano or microencapsulation. However, buffalo whey has traditionally been used as a raw material for producing ricotta, as animal feed, or well discarded, constituting the main effluent in cheese-making establishments. The use of buffalo whey in novel applications poses a promising scenario, while research is still limited, which warns of endless possibilities.

Keywords: nanoencapsulation, bioactive compounds, bioaccessibility, functional foods.

RESUMEN

El suero de búfalo es el subproducto más importante de la industria quesera. Las proteínas del suero constituyen el componente más interesante desde el punto de vista tecnológico y económico. Presentan propiedades atractivas y funcionales y, al igual que las proteínas del suero de leche vacuna, también podrían usarse como ingrediente (bebidas lácteas, suplementos nutricionales) y/o aditivos alimentarios (emulsionante, espumante, encapsulante) en novedosas aplicaciones con alta valor añadido, como la nano o la microencapsulación. Sin embargo, el suero de búfala se ha utilizado tradicionalmente como materia prima para la producción de ricota, como alimento para animales, o bien desechado, constituyendo el principal efluente en los establecimientos queseros. El uso del suero de búfala en aplicaciones novedosas plantea un escenario prometedor, mientras que la investigación es aún limitada, lo que advierte de infinitas posibilidades.

Palabras clave: nanoencapsulación, compuestos bioactivos, bioaccesibilidad, alimentos funcionales.

INTRODUCTION

In the last two decades, nanotechnology has demonstrated a powerful ability to solve problems in various fields such as medicine, cosmetics, agroindustry, and the environment [1]. Concerning the food sector, nanotechnology has made it possible to improve the stability and bioaccessibility of bioactive compounds, that is, with a potential beneficial effect on health [2]. The resultant products could be consumed as nutraceuticals (supplements) or used as ingredients in the formulation of functional foods. The synthesis of nanomaterials through green methods and under mild conditions constitutes an essential aspect of sustainable development.

Given their biocompatibility properties, biosafety, and wide availability, proteins constitute excellent alternatives for manufacturing structures on the nanometer size scale (10E-9). In this context, buffalo whey represents a promising, renewable, and feasible resource, especially in developing countries, where its use would enable the generation of added value with imminent economic benefits [3]. Due to the nutritional quality and functional aptitude of its proteins, cheese whey has gained a prominent position among agri-food by-products, given its great capacity for reuse. This conference plans to present some novel uses of bubaline whey proteins, particularly as raw

material in synthesizing functional nanostructures and as nanocarriers of physiologically active compounds.

BODY PARAGRAPH

A group of young researchers at the National University of Chaco Austral currently works on obtaining, characterizing, and studying the properties of buffalo milk whey in nanotechnological applications. Firstly, whey was obtained at a laboratory scale from raw buffalo milk following the methodology proposed by Bustos et al. [4]. Milk was obtained by milking buffaloes in good health and nutrition under hygienic conditions. Mainly, milked buffaloes (Bubalus bubalis) were from the Pedro A. Silva Farm (Paso Florentín, Corrientes, Argentina). The Milk was packaged in aseptic containers and stored at freezing temperature (-18 °C). The Milk was suitably pasteurized (65 °C, 30 min) and subjected to routine tests to verify its hygienic quality. Enzymatic coagulation was then carried out by adding commercial rennet (1 g/L) to milk previously enriched with calcium ($CaCl_2$ 0.01% w/v) and acidified with lactic acid to pH 6 for 40 min at 35 °C.

After that, the curd was cut, gently heated, and filtered with muslin to separate the whey. Skimming, dialysis, and lyophilization were then carried out. The buffalo whey protein concentrate (BWPC) obtained presented 56 % of total proteins, comprising six main fractions: β-lactoglobulin (43.3 %), α-lactalbumin (28.6 %), bovine serum albumin (10.2 %), α-lactalbumin dimers (7.5 %), lactoferrin (2.5 %) and immunoglobulins (2.2%). From this, the formation of nanostructures was studied by the interaction between BWPC/polysaccharides and BWPC/vitamins [4].

In the presence of polysaccharides (PS), proteins (PR) can form structures at the nanoscale based on the self-assembly or self-organization of individual molecules by controlling experimental conditions [5]. In particular, by pH control, initially disordered molecules with opposite charges can form spontaneously ordered structures or patterns without an external direction. Therefore, intimate knowledge of the molecular properties of the substances involved is required to predict their behavior and functionality [6]. In turn, the study of PS and PR interactions constitutes a decisive aspect in building nanomaterials, mainly when using scarcely studied protein sources such as buffalo whey (*Bubalus bubalis*) is intended to be used.

Experimentally, the formation of complexes between bubaline whey proteins (PR) and gum arabic as a polysaccharide (PS) was monitored in a ratio of 2:1 and 0.15% w/v. The pH was adjusted to the range of 3 to 6 by post-mixing acidification. Through turbidimetric analysis, structures in the range 4 to 5 were formed, thus confirming the ability of BWPCs to create polymeric structures through electrostatic interactions. The molecular complexes presented an intermediate charge distribution between proteins (+) and polysaccharides (-), denoting excellent colloidal stability. Under these conditions, the particles showed a monomodal size distribution centered at 250 nm. These structures are versatile and can be used as delivery vehicle systems for molecules of interest.

On the other hand, the ability of BWPC to form molecular complexes with bioactive compounds at pH 7 was also evaluated. Folic acid (FA), the synthetic form of vitamin B9, and tocopherol acetate, a variant of vitamin E, were used as a model of sensitive compounds. The formation of complexes was studied by spectrophotometric and fluorometric techniques as well as by in-silo molecular simulations. The results showed that non-covalent molecular interaction occurs, forming molecular complexes at the nanoscale. The complexes thus obtained showed the ability to retain and protect vitamins from harmful environmental factors and transport and release the bioactive compounds under simulated gastrointestinal conditions [4]. These results highlight the feasibility of using bubaline whey proteins as delivery and protection systems for sensitive hydrophilic (vitamin B9) and hydrophobic (vitamin E) compounds, laying the foundations for the design of new encapsulation/delivery systems.

CONCLUSIONS AND FUTURE TRENDS

Nanotechnology offers enormous opportunities regarding the use of buffalo whey. The possibility of generating innovative products with high-added value contributes not only to the economic benefit of dairy farms and industries but also to minimizing the polluting effect of this effluent. In this way, numerous possibilities are raised, which have been little explored in the science and technology of buffalo dairy products. In this way, it is expected to deepen the study of the potential uses of dairy components of bubaline origin, motivating the attention of researchers who place bubaline dairy derivatives at the center of cutting-edge research.

ACKNOWLEDGMENTS

The author of this work thanks the Institute of Science, Technology, and Innovation of Chaco (ICCTI) for the mobility scholarship and to the National Scientific and Technical Research Council (CONICET) and the National University of Chaco Austral (UNCAUS) for the resources provided to carry out the preceding investigations.

REFERENCES

[1] Santiago, L. G., & Castro, G. R. (2016). Novel technologies for the encapsulation of bioactive food compounds. *Current Opinion in Food Science*, *7*, 78-85.

[2] Zhang, Q., Zhou, Y., Yue, W., Qin, W., Dong, H., Vasanthan, T., (2021). Nanostructures of protein-polysacchari-

de complexes or conjugates for encapsulation of bioactive compounds. Trends in Food Science & Technology.

[3] Allahdad, Z., Varidi, M., Zadmard, R., Haertlé, T., Sawyer, L., & Saboury, A. A. (2020). Efficiency of milk proteins in eliminating practical limitations of β-carotene in hydrated polar solution. *Food chemistry*, *330*, 127218.

[4] Bustos, L F, Judis, M A, Vasile, F E and Pérez, O E (2022) Molecular interactions involved in the complexation process between buffalo whey proteins concentrate and folic acid. Food chemistry 396 133734.

[5] Wei, Z., Huang, Q., (2019). Assembly of protein–polysaccharide complexes for delivery of bioactive ingredients: A perspective paper. Journal of agricultural and food chemistry 67(5), 1344-1352.

[6] Hosseini SMH, Emam-Djomeh Z, Negahdarifar M, Sepeidnameh M, Razavi SH & Van der Meeren P (2016) Polysaccharide type and concentration affect nanocomplex formation in associative mixture with β-lactoglobulin. International journal of biological macromolecules. 93, 724-730.