www.ThePharmaJournal.com
The Pharma Innovation

**ISSN (E): 2277-7695**
**ISSN (P): 2349-8242**
**NAAS Rating: 5.23**
TPI 2023; 12(11): 1744-1746

www.thepharmajournal.com
Received: 15-08-2023
Accepted: 19-09-2023

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# Casein as encapsulating material for food applications

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**Abstract**
Casein proteins are cheap, non-toxic, easily available, highly stable, biodegradable and are GRAS approved, making it a suitable candidate for use in encapsulating material. Moreover, casein protein offers some unique features, making them appropriate for these uses. The proteins could be modified to improve the properties related to its specific use. The review highlights some interesting applications of different formulations of casein (nanoparticles, films, composites, hydrogels, microspheres) in the food industry.

**Keywords:** Casein, encapsulating material, food applications

## Introduction

Milk is mammal secretion which is a complex biological fluid containing good amount of lipids, proteins and minerals for providing essential nutrition for the development and working of muscle and tissues along with supporting the immune system of the newborn. The proteins in milk undergo a very rapid coagulation in the newborn stomach forming complexes with calcium phosphate. Milk proteins are broadly classified into two categories: casein and whey proteins. The caseins precipitates at pH 4.6 at 30 °C and comprises about 75–80% of total protein (Bhatt, Dar and Singh 2016) [1]. Casein micelles are the large particles in the form of colloids, constituting calcium phosphate and casein proteins (Rollema and Fox, 1992) [2]. Casein micelles basically solubilizes the phosphate and calcium along with imparting volatility to the molecules (Doherty *et al.* 2003) [3].

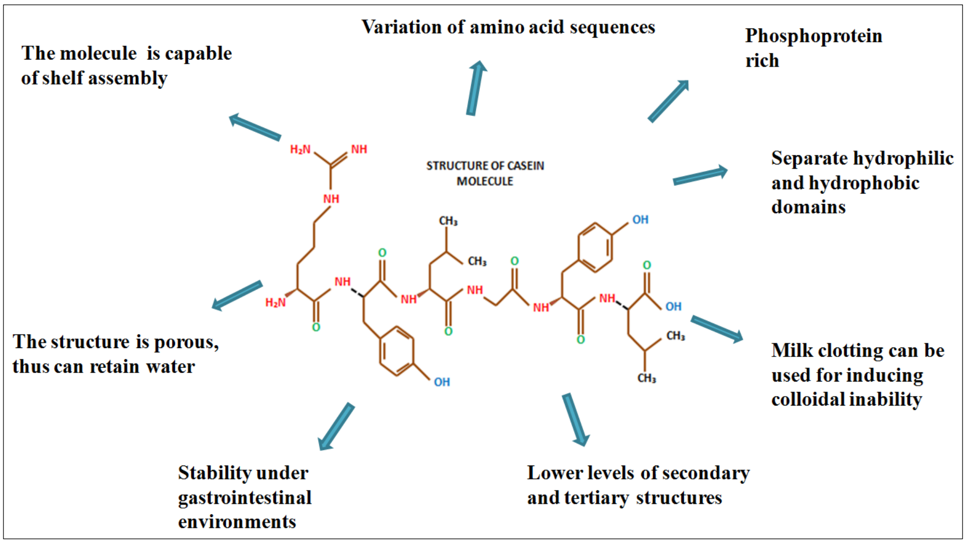


**Fig 1:** The structure and features of a casein molecule.

Both synthetic and natural polymers are being utilized as drug delivery carriers, however natural polymers are the best choice when it comes to applications to the food industry. Among natural polymers, the food proteins do offer various nutritional as well as functional properties (foaming, gelation, water binding, etc). The functional groups of these proteins aids in the interaction with numerous active compounds, thus binding reversibly with these groups and offering protection till these are released at their appropriate site in the body (Punia, 2022) [4].

Casein proteins are cheap, non-toxic, easily available, are highly stable, biodegradable and is GRAS approved, making it a suitable candidate for this purpose. The molecule do have some interesting features that approve its application in drug delivery (Figure 1). The swelling of the gel in response to pH variation, proves its usability for controlled release (Korhonen 2003) [5].

**Casein based nano-formulations**

When utilized in food products, The casein based formulations (nano) can improve almost all kind of food characteristics or may induce new functional properties. Recently Du *et al.* (2022) [6] has reported the improvement in the solubility, stability along with antioxidant activity of curcumin when loaded in goat milk casein nanoparticles. Wu *et al.* (2022) [7] has investigated antifungal applications of encapsulated natamycin in gliadin-casein nanoparticles and documented an improved photostability as well as controlled black rot in cherry tomato. The above studies indicate the potential of casein nanoparticles in various natural drug delivery systems. The casein micelles can be modified, formed into composites, manipulated into hydrogelsthat can effectively encapsulate the minerals, can join with the polymers to formulate nanobased capules for specific and controlled release of the materials in the gastro-intestinal tract (Sadiq *et al.* 2021) [8].

Casein based films are transparent, thin, have good strength as well as stability. The films have shown a low permeability to oxygen but a higher hydrophilicity along with a lower elastic properties, degrading their mechanical and barrier related properties (Chen *et al.*, 2019) [9]. The film becomes brittle undergoing a drying process, so the films are used in combinations with other type of natural materials. The nano-coatings of casein may be utilized for inducing gas, lipid or moisture barriers, thus improving the shelf life of food products. It can also act as carriers for agents that improve the characteristics of food materials such as flavor containing compounds or color imparting sources (Qureshi *et al.* 2012) [10]. It has been shown that casein crosslinked with dialdehyde tragacanth gum could be formulated into films with good physico-mechanical properties (tensile strength, barrier properties, water vapor permeability etc. The film was utilized as a coating to extend the shelf life butter-products (Khoshkalampour *et al.* 2023) [11]. The applications of casein films could be expanded using modification methods such as crosslinking in order to improve certain properties. The films crosslinked with tannic acid were explored for their use in food packaging. The crosslinking improved the mechanical as well as other important physico–chemical properties of the films (Picchio *et al.* 2018) [12].

A hydrogel is a 3D network made up of water soluble polymers incorporating a large content of water in them, therefore making them appropriate for the transporation as well as protection of bioactives (Nascimento *et al.* 2020a) [13]. Nascimento *et al.* (2020b) [14] explored the application of casein hydrogel as a carrier for the anthocyanins from joboticaba fruit. The release profile of the extract was studied at different pH, which could be put to use for delivering the extract to pH specific spots such as intestine.

Casein microspheres have also captured interest of researchers, owing to their better amphilicity, have a improved dispersibility, are inexpensive etc. The properties could be utilized for effective delivery of bioactives. Chitosan-casein based microparticles were found to be of higher potential for oral delivery of nattokinase enzyme for treatment of thrombosis related cardiovascular diseases (Zhang *et al.* 2020) [15]. He *et al.* (2015) [16] developed alginate-casein based microspheres for purpose of delivering nutrients (riboflavin). It was found that the microspheres completely released the riboflavin in response to intestinal fluid.

Casein based nanoscale capsules are beneficial for encapsulating the materials as compared to other type of structures due to polymeric shell protection against the external agents such as pH and light (Amrita, 2022) [4]. They can be influential in masking the unwanted flavours and can be effective in delivering the bioactives at target locations in GI tracts. Pan *et al.* (2013) [17] has shown an increase in dispersibility as well as bioactivity of curcumin, when encapsulated using casein based nanocapsules. Thus, proving the efficiency in delivering of lipophilic bioactive compounds.

**Conclusion and Future Recommendations**

The casein molecule could play an interesting role in food applications as a carrier for bioactives as well as drugs. There is a need for in-depth research about the mechanism of action. Research is required to explore more prospective of casein molecule in food industry applications.

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