# BIODEGRADABLE WHEY PROTEIN FILMS WITH CARDOON EXTRACT AS NATURAL ALTERNATIVES TO NATAMYCIN IN CHEESE PRESERVATION

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Nowadays, consumers demand more natural foods with fewer synthetic additives, which drives research into biodegradable active packaging enriched with plant extracts, essential oils, or agro-industrial by-products rich in bioactive compounds. Cardoon (*Cynara cardunculus* L.) is a multipurpose crop whose flower is traditionally used in cheesemaking, while its leaves, a major by-product, are rich in antimicrobial and antioxidant compounds. Whey, another by-product of the cheese industry, can be used to produce biodegradable films and coatings, whose functionality can be enhanced by incorporating natural extracts. In cheesemaking, natamycin is widely applied to prevent fungal growth, but concerns over its excessive use highlight the need for safer, natural alternatives.

This study aimed to evaluate the potential of whey protein-based films incorporated with cardoon leaf extract (0.5, 1.0, and 2.0 % w/v) to extend the shelf life of cheese in order to understand if it can be a substitute to natamycin. Cheeses were wrapped in the active films and stored at 5 ± 2 °C for 30 days. Samples were analysed for microbial growth, physicochemical parameters (moisture, pH, titratable acidity), and lipid oxidation.

Results indicate that active films, particularly the whey protein film with 2.0 % cardoon extract, were effective in delaying microbial development in both rind and interior, presenting the lowest counts of total viable microorganisms (6.77 ± 0.52 Log CFU/g), moulds and yeasts (5.38 ± 0.12 Log CFU/g), and *Enterobacteriaceae* (4.26 ± 0.10 Log CFU/g) compared to control samples (untreated and without extract). The films also helped retain rind moisture and limited titratable acidity increases, indicating delayed microbial metabolism. Lipid oxidation remained at low levels, with films containing 2.0 % cardoon extract showing the strongest antioxidant effect.

Overall, the incorporation of cardoon-based extracts into whey protein films demonstrated antimicrobial and antioxidant properties, contributing to improved cheese preservation during refrigerated storage. This sustainable approach reduces reliance on synthetic preservatives while valorising agro-industrial by-products.

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