CHAPTER 1: INTRODUCTION

State of the Cheese Industry

Cheese accounts for nearly 25% of total dairy department sales in supermarkets with a trend for continued growth. Per-capita annual consumption of cheese in the United States is at an all-time high according to the USDA and has doubled since 1975. In 1999, consumption averaged 30.5 lbs per person and is projected to increase to 35 lbs by 2005 (Berry 2002).

Convenience continues to be the primary factor that consumers consider when selecting which cheese form to purchase. Following its upward trend for the past decade, shredded cheese showed very healthy growth in 2001. Dollar sales of shredded cheese increased 7.8% to $1.8 billion, which composes a 24.4% share of the retail cheese business (Berry 2002).

One of the greatest challenges that shredded cheese manufacturers face is product return as a result of mold growth. Mold spoilage is commonly attributed to the increased surface area of the cheese shreds and the extra handling and exposure that the shreds experience in the cut and packing facility. In addition to enforcing Good Manufacturing Practices and preventing packages that leak, manufacturers have rather limited methods for reducing the opportunity for mold growth in shredded cheese (Berry 1999). In addition to an economic problem, mold growth on cheese must also be treated as a potential health hazard. Certain molds produce toxic substances called mycotoxins, which may cause acute or chronic disease conditions in humans. Some mycotoxins are carcinogenic, such as the aflatoxins produced by some strains of Aspergillus flavus and Aspergillus parasiticus. These molds are able to grow and produce mycotoxins on a variety of agricultural and food commodities (Rusul and Marth 1988).

A Comparison of Natamycin and Sorbic Acid

The number of antimicrobial preservatives approved for use in the food industry is remarkably small; sorbic acid and natamycin are most commonly used as antifungal agents to treat cheese products. Sorbic acid is also present in its salt forms of potassium sorbate, calcium sorbate, and sodium sorbate. Potassium sorbate is effective against toxic molds at concentrations of 0.10 to 0.15%. Natamycin is very effective in preventing mold growth and toxin production at very low levels of 0.001 to 0.005%. Natamycin has been observed to have an inhibitory effect that is greater on toxin production than on growth for all of the toxigenic molds (Ray and
Bullerman 1982). *Aspergillus* and *Penicillium* spp. can produce the same or even greater concentrations of mycotoxins in the presence of subinhibitory concentrations of potassium sorbate (Gourama and Bullerman 1988).

Studies have shown that the concentration of sorbate applied to the cheese surface must be about 200 times that of natamycin (de Ruig and van den Berg 1985). The Code of Federal Regulations (CFR) defines sorbic acid as a substance that is generally recognized as safe (GRAS) when used in accordance with good manufacturing practice (CFR 2001b). Sorbic acid is generally used at concentrations of 0.2-0.3% in cheese products (Finol et al. 1982). The CFR states that natamycin may be applied on cheese in amounts not to exceed 20 ppm in the finished product as determined by International Dairy Federation (IDF) Standard 140A:1992 (CFR 2001a). Natamycin is no longer restricted in its method of application, which may include dipping, spraying, or as a dry mixture with safe and suitable anticaking agents.

The use of sorbates contributes negative sensory qualities when applied to the coating of block cheeses. A chemical off-flavor and discoloration of the cheese coating were described in sorbate-treated cheeses (de Ruig and van den Berg 1985). This off-flavor is partly a function of the much higher concentrations of sorbate required to achieve the same antifungal effect as natamycin. Natamycin imparts no color, odor, or taste to food products. The flavor of cheese portions just below the rind was not affected by the natamycin treatment (de Ruig and van den Berg 1985).

Potassium sorbate and the rather insoluble calcium sorbate diffused into the center of a block cheese (about 50 mm migration) at 10 weeks storage. Such diffusion into the cheese decreases the concentration of sorbate on the surface, therefore, limiting the protection of the cheese from mold growth. Natamycin was detected in the cheese rind (about 1 mm thick) but none was detected below the rind after 12 weeks of storage. Since diffusion of natamycin is extremely small, a low concentration remains active on the cheese surface for a long duration (de Ruig and van den Berg 1985).

The effectiveness of sorbates is dependent on many factors such as pH, concentration, temperature, mold strain, and other environmental factors. Finol et al. reported that several *Penicillium* species that were isolated from spoiled cheese have the ability to grow in the presence of 0.9% sorbate at 4 °C. As a result, cheeses with potassium sorbate as a preservative
are sometimes spoiled by molds, even if the cheeses are refrigerated. During growth of *Penicillium* spp. 71-100% of sorbic acid was degraded from media (Finol et al. 1982).

Sorbic acid can be degraded by various yeasts and molds isolated from cheese sources. Sensidoni et al. (1994) showed that sorbate resistant strains of molds and yeasts were able to grow in media with 3,000 ppm potassium sorbate and were able to metabolize it to *trans*-1,3-pentadiene, which gives a hydrocarbon-like odor and taste to the product. The presence of *trans*-1,3-pentadiene may also be a toxicological problem since a similar compound, 1,3-butadiene, has been shown to have mutagenic and carcinogenic properties (Sensidoni et al. 1994).

*Zygosaccharomyces bailii* is a common food spoilage yeast that is extremely resistant to weak acid preservatives such as sorbic acid. *Z. bailii* was able to grow at concentrations of sorbic acid of greater than 600 ppm at pH values less than the pKa of the preservative (Pitt 1974). This indicates an ability to grow at concentrations greater than the taste threshold and the legal limits for sorbic acid in certain foods (Thomas and Davenport 1985). Ethyl alcohol, a fermentation product probably from yeasts was also found in cheese (Sensidoni et al. 1994).

The stability and effectiveness of natamycin is affected by light, extreme pH values, oxidants, substrate and fungal species. Natamycin possesses a much broader spectrum of activity against molds and yeasts than any other fungicide used for food application. Natamycin is active at very low concentrations against nearly all molds and yeasts present in food products. The sensitivity of most molds to natamycin is less than 10 ppm, and yeasts have even greater sensitivity (Stark 2000).

While most preservatives, such as sorbic acid, induce resistance, yeasts and molds are not able to develop significant resistance to natamycin. This is attributed to natamycin’s mechanism of action, which interferes with an essential compound of the fungal cell membrane. In the food industry, resistance to natamycin has never been observed during its decades of usage (Stark 2000).

Natamycin is practically insoluble in water. This very low aqueous solubility requires its application as an aqueous suspension to the shredded cheese surface, which results in clogging of spray nozzles and a nonuniform distribution to the cheese surface. Solubility may be a limiting factor in the bioavailability of active natamycin, since the dissolved fraction must diffuse to the site of action and bind to the target organism (Stark 2000).
dry powder mixed with an anti-caking agent likely limits the availability of natamycin to elicit an antifungal response.

During the ripening and storage of cheese products, the natamycin is decomposed (Lück and Jager 1997). Natamycin is an extremely sensitive compound to ultraviolet (UV) light (Thoma and Kübler 1998). Cheese products are exposed to high-intensity fluorescent lighting in the retail dairy case, until consumer purchase and storage. The UV light emitted from the fluorescent lamps impacts the cheese product through the sections of the polymer packaging that are translucent. Critical amounts of natamycin treated onto these cheese products are likely degraded by the time of purchase by the consumer.

**Research Objectives**

The objectives of this research are: (a) to find a new delivery system for natamycin, which increases its aqueous solubility and (b) to increase the chemical stability of natamycin so that it has a prolonged antifungal effect on the surface of the food product. The accomplishment of these objectives should dramatically increase the antifungal efficiency of natamycin and, therefore, allow consumers to purchase shredded cheese products of greater quality and safety.
References


