The Role of Milk Quality and Mastitis Control in Addressing Future Dairy Food Marketing Opportunities in a Global Economy

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From the perspective of marketing and the global economy, the world is getting smaller. Multinational food retailing and food service companies have been very successful in expanding into international markets. Raw and processed food products are moving further than every before. The production, processing, and marketing of milk and dairy foods will have to adapt to this change. Whether you agree or disagree with the philosophy of the Wal-Mart approach to food retailing Wal-Mart is having, and will continue to have, a major impact on food retailing, manufacturing (i.e., need for longer shelf-life), and ultimately food production (i.e., origin and production conditions). Wal-Mart sells some dairy foods. Wal-Mart has 1489 stores, 1397 Supercenters, 532 Sam's Clubs, and 56 Wal-Mart Neighborhood Markets in the US. Wal-Mart became an international company in 1991. Today, Wal-Mart has 11 stores in Argentina, 24 in Brazil, 214 discount stores in Canada, 31 in China, 92 in Germany, 15 in Korea, 614 in Mexico, 52 in Puerto Rico, and 265 in United Kingdom. Wal-Mart employs over 1,000,000 people in the US and over 300,000 in its international operations. McDonald's has 30,000 restaurants in 119 countries serving 46 million customers each day. Pizza hut has more than 30,000 restaurants in over 100 countries. Dairy foods and food products using dairy ingredients are sold in all of these outlets. Today in the US, the total dollars spend for food eaten away from home exceeds the dollars spent on all food eaten at home. While cheese consumption has increased greatly in the US as a result of the increased number of meals eaten away from home, fluid milk consumption has declined because fluid milk products have not been able to compete well with other beverages in food service venues. Part of the disadvantage that milk has in food service handling and distribution systems is a short shelf-life and the need for transportation and storage of the full volume of the product instead of concentrate, as is the case for soft drinks. Development of products that will do well in these food marketing systems will require milk that far exceeds the microbial and somatic cell standards that are designed to ensure public health.

Nutritional quality and the important role of dairy foods in a well balanced diet is being more clearly recognized around the world. The World Health Organization (WHO) uses milk consumption as part of the evaluation of a country's living standards. Dairy foods provide a strong nutritional base in the diet. In China, the China Consumers Association and health professionals are recommending to the Chinese public to add dairy products to their diet and this was the 2001 theme for the China Consumers Association. The annual per capita consumption of milk in China is 6.4 kg, much less than the 105 kg world average. The Chinese market and in general the market in Asia appears to be on the verge of an increase in the consumption of dairy foods and dairy ingredients that will provide an opportunity for both domestic milk production and international marketing.

All of this has created, and will continue to create, new marketing opportunities for milk, milk products, and milk-derived ingredients on a global scale. The marketing opportunities in countries where per capita consumption of milk increases will be served by a combination of dairy foods produced from local and international sources of milk, dairy products, and milk-derived ingredients. However, the further dairy products and milk derived ingredients are moved and the longer the time of storage, the more important the quality of the original milk will become.

Milk Quality Characteristics Needed To Serve Current and New International Markets.

An international market can be served by either a locally based production of fresh milk or an imported base of manufactured dairy foods or milk based ingredients that can be used to make the final dairy products at the local level. Currently, international marketing of dairy foods and dairy ingredients is limited from a technological point of view by the stability of the microbial, sensory, and functional quality of the product. Most commonly, UHT shelf-stable liquid products, cheeses (in a processed shelf-stable, frozen, or refrigerated form), dry milk and whey products, and anhydrous milk fat are produced and distributed.

The loss of quality for all of these products is driven by three fundamental spoilage mechanisms: microbial, enzymatic, and chemical spoilage. The two most common approaches to eliminate or limit microbial spoilage are 1) to process the product at high temperatures and package aseptically to sterilize the product (must kill both vegetative cells and spores) and then protect the product from contamination or 2) dry the product so the water activity is so low that microbial growth is prevented. In both UHT (ultra high temperature) and dry products there can be continued enzymatic and chemical deterioration of milk components that can negatively impact the flavor or functionality of the dairy products or products containing dairy ingredients.

How Important is Mastitis Control?

The quality of long shelf-life dairy products is critically influenced by mastitis and is driven by the enzymatic deterioration of proteins and fats (Senyk et al., 1985; Saeman et al., 1988; Murphy et al., 1989). As raw milk somatic cell counts increase, the level of heat stable enzymes that originate from the cow (not bacteria) increase. The most important of these enzymes is the protease plasmin, because it is not completely inactivated by UHT. Pasteurization of milk actually increases the activity of plasmin and the rate of proteolysis in high somatic cell count pasteurized milk is faster than in raw milk. Native milk lipase is normally inactivated by pasteurization, but in high somatic cell count milk there are additional more heat stable lipases present in milk (originating from the cow) that survive pasteurization (Ma et al., 2000). The action of these enzymes produces off-flavors in milk (Ma et al., 2000; Santos et al., 2003ab) and dairy products (Barbano et al., 1991; Klei et al., 1998; Jaeggi et al., 2003). Because these enzymes cannot be totally eliminated by the thermal processing technologies that we have today and because these enzymes start to damage milk components before the milk leaves the udder, the best approach to minimize their impact is keep raw milk somatic cell count very low.

In studies conducted on the shelf-life of pasteurized fluid milk (Ma et al., 2000; Santos et al. 2003b), it was demonstrated that the number of days before an off-flavor would be detected in

2% fat milk (held at (6°C) 43°F) increased from 18 to 56 days, when the somatic cell count of the raw milk was decreased from 1,000,000 cells per ml to 25,000 cell per ml (Santos et al., 2003b) when bacteria count was kept low (i.e., <100,000 cfu/ml) throughout shelf-life (Figure 1). The ability to maintain flavor stability in dairy products, dairy ingredients, and food products produced using dairy ingredients will be the limiting factor in global marketing and distribution of dairy foods. In healthy dairy herds today, the majority of the cows have milk somatic cell counts of under 50,000 cells/ml. In these herds most of the bulk tank somatic cell count can be contributed by a relatively small number of individual cows. Milk with very low somatic cell count could be assembled if there was an economic incentive provided by the processor to do this. However, before fluid processors can achieve the full economic benefit of longer shelf-life of very low somatic cell count milk, the processor must be able to achieve very low bacteria counts after processing and maintain low bacteria count during refrigerated storage. If a processor can do this, then the true benefits of very low somatic cell count milk can be realized by a fluid milk or dairy based beverage processor.

<u>Can Filtration Technologies Remove Somatic Cells from Milk</u>?

Recently, there has been a large increase in the processing of milk ultrafiltration and microfiltration. Large pore microfiltration (1.4 micron ceramic membranes) is currently being used to remove bacteria from skim milk to increase shelf-life of fluid milk products. Recently, we have confirmed earlier work by Maubois that microfiltration can remove somatic cells from skim milk. Once the skim milk has been filtered, somatic cells are virtually undetectabile in the milk. However, when we have measured proteolysis in pasteurized microfiltered skim milk we have found that the removal of milk somatic cells did not decrease the extent of proteolysis by native milk proteases during refrigerated shelf-life. This is not surprising because the enzyme plasmin, which is not inside or bound to somatic cells, is the enzyme that causes the problem. The somatic cells produce an enzyme that activates plasmin and this activation occurs while the milk is in the udder. Later removal of the somatic cells during processing does not seem to decrease the extent of proteolysis that occurs in the fluid milk. Therefore, starting with the lowest milk somatic cell count possible at the farm will make the largest impact on reducing enzymatic degradation of fat and protein during the self-life of fluid milk beverages.

<u>Future International Marketing of Dairy Foods and Milk Derived Ingredients</u>.

In countries where the manufacture and local marketing of the dairy foods is common, dairy foods are produced from fresh milk ingredients. If those products are produced from the classical more stable dairy ingredients (stabilized by high heat and/or drying) that are used in export, the flavor and functional characteristics are not as good as from a fresh liquid ingredient and consumers would notice the difference. Ultimately, in an increasing segment of international marketing of milk and milk products there will be a demand for "fresher tasting" dairy foods, particularly in the rapidly growing international food service segment.

Liquid ultrafiltration (UF) concentrates of raw whole and skim milk are becoming common intermediate raw materials for further processing in the USA. Various technologies that involve the use of carbon dioxide addition, in combination with low temperature storage, are used to extend the shelf-life of raw milk concentrates by inhibiting microbial growth during transportation and storage. New technologies (e.g., microfiltration) that allow physical fractionation of the proteins in the skim milk portion of milk will produce liquid concentrates with different functionalities that will make them attractive as base materials for use as food ingredients or to formulate a liquid base that can be converted into a range of different dairy foods on demand. Liquid bases of dairy ingredients combined with nondairy ingredients that can be shipped long distances and converted to finished products on demand will become more common. Imagine a liquid concentrate shipped from a major milk producing country that could be converted to Mozzarella cheese (or other cheeses for food service) on demand in the receiving country with a specialized piece of equipment at a distribution center (with no whey produced) designed to supply all the pizza restaurants in a region of that country. A few basic liquid concentrates (shipped in large totes) could be used to produce fresher tasting locally manufactured fluid beverages, fermented beverages, frozen desserts, and cheeses in a country were there is not a strong base of milk production, but where the economy is developing and there is sufficient consumer purchasing power to support the marketing of these products. The advantage of this approach, compared to shipping finished products produced in another country, is that the consumer or food service product mix, packaging, and flavoring could be adapted to the local conditions. Parts of Asia may be an example of where this approach might work.

At the same time that the technologies are developing to produce milk solids fractions and concentrates by filtration, the non-thermal processes to kill or physically remove bacteria from liquids are also developing. All of these technologies will combine to produce higher quality liquid concentrates that can be moved long distances. While these processes will control microbial spoilage of the product, no technologies have been developed to remove, inactivate, or inhibit the action of enzymes originating form the cow (e.g., plasmin). Therefore, the stability and shelf-life of liquid concentrate bases will be influenced by the original quality of the raw milk, particularly milk somatic cell count. A supply of milk with low somatic cell count and a relative consistent average stage of lactation will be ideally suited for this type or approach.

Conclusions

Public health standards for bacteria and somatic cell counts of raw milk are designed to protect public health not to maximize dairy product quality and shelf-life. The ever increasing demands from the evolving structure and strategies of both national and international food retailing and food service present new challenges, but also new business opportunities to milk producers and dairy product manufacturers. A stronger partnership between milk producers and milk processors to equitably share the costs and benefits of improved milk quality provides an opportunity for expanded marketing and increased dairy product consumption for the future.

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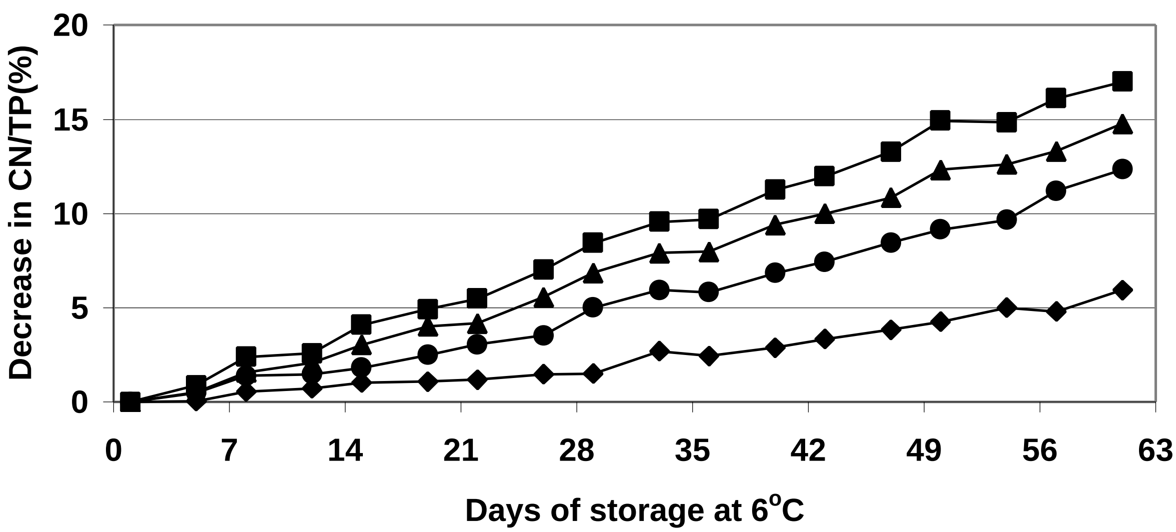

Figure 1. Effect of raw milk SCC (♦=26,000, ? =376,000, ? =726,000, and ¦ = 1,113,000 cells/ml) on mean proteolysis of 2% fat pasteurized, preserved milk at 6^{o}C (43^{o}F) from Santos et al., 2003b. A larger value for decrease in casein as a percentage of true protein (CN/TP, %) equals more proteolysis. At 5% decrease in CN/TP (%), panelists can detect an off-flavor in milk due to proteolysis (Santos et al., 2003a). At lower temperatures the shelf life is longer (see Santos et al., 2003b).