The Veterinarian's Role in Maintaining Quality Assurance in Dairy Products

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Quality assurance in dairy products is a critical issue to the welfare and survival of the dairy industry in the United States. And the responsibility for providing a safe, wholesome and desirable milk product lies squarely on the shoulders of each sector of the industry that is involved in bringing milk and dairy products to the consumer. Quality assurance must begin with the dairy farmer, the producer. It is simply not possible to start with poor quality milk at the farm and expect to have a high quality, desirable product on the grocery shelf. The dairy industry in general, and the producer in particular are coping with the quality assurance challenge. The veterinary practitioner can have significant input into the quality assurance issue.

In the strictest sense, quality is defined as the "degree of excellence of a thing." (7) But what does it really mean to have a "quality lifestyle," or to own a "quality car"? The degree of excellence of a car is a very general, non-descript phrase. But define quality as "conformance to requirements." (3) Now there is tangible specificity to the term "quality car." That quality car will perform to the requirements you specified for it at the time of purchase. If you simply want reliable, economical transportation, a car that is easy to park and is inexpensive to maintain, then a Ford Pinto will be a quality car for you. On the other hand, if you want luxury (not to be confused with quality) such as power windows and door locks, automated inside temperature control, headlights that turn on or off automatically and a computerized information center, then you probably need to purchase a Cadillac to fulfill your requirements. However, your Cadillac is not a quality car when it fails to start, power windows malfunction, headlights fail to turn on, or the automated information center provides inaccurate information. When your luxury automobile is in the repair shop and unavailable for your use it's a "lemon"; clearly not a quality car.

Quality milk and milk products clearly conform to specific requirements. Those conformance requirements must be identified on the basis of flavor, shelf-life, keeping quality and consumer acceptance of a safe, wholesome product. Specific requirements of quality milk products include quantitative measurement of: bacteria, somatic cells, antibiotic residue, sediment, added water, butterfat, protein and chemical or pesticide residue. This paper will deal with specific requirements for bacteria, somatic cells and antibiotic residue in milk, their relationship to quality of the dairy product and the role the dairy practitioner can play in assisting dairy farmers to meet specific quality milk standards.

Bacteria Destroy Milk Quality

Bacteria destroy milk quality by changing milk's components. Butterfat and milk protein (primarily casein) comprise less than ten percent of milk by volume, yet are the major constituents that give milk its flavor. Bacterial proteases and lipases alter the composition of naturally occurring butterfat and protein causing fruity, cardboardy, rancid, putrid, bitter and/or degrees of other "off-flavors." Patel and Blankennagel (12) report notable flavor differences in milk samples with markedly different bacteria counts (Figure 1).

FIGURE 1. Flavor characteristics of some pasteurized milk samples with various SPC before and after heating and storage (12).

Sample No.	Raw SPC/ml	Weeks at 45 F	Pasteurized SPC/ml	Pasteurized Flavor
1	16,000,000	1	400	slightly bitter
		2	27,000	very bitter
2+	6,000	1	300	good
		2	100	good
2*	27,000,000	1	100	very bitter
		2	300	very bitter

\+ sample pasteurized immediately
* sample held at refrigerated temperature for 4 days, then pasteurized and tested

Bacteria have also been shown to alter physical characteristics of milk. (5) Ropey milk is an example of a physical change in milk caused by several bacteria including *Alcaligenes viscolactis, Enterobacter aerogenes* or *Streptococcus lactis.* Bacterial contamination of raw milk can significantly retard the production of fermented dairy products, especially cheese. Manufacture of these products depends upon a fermentation process utilizing a starter culture containing appropriate microorganisms which direct the development of curd and desired flavor. Contaminant bacteria compete with the starter organisms for available nutrients and thus may delay curd formation, damage flavor and present food poisoning problems. Spoilage of cheese and cottage cheese by bacteria in the raw milk supply can become evident either during production or ripening. (9) While much of the spoilage of manufactured products comes from contamination by bacteria after pasteurization, some spoilage does result from bacteria present in raw milk and from the presence of metabolites of bacteria that persist in milk following its pasteurization.

The degree of destruction of raw milk quality depends on the numbers and types of bacteria present. Federal interstate milk shipment regulations require less than 100,000 bacteria/ml SPC for individual producer milk and less than 300,000 bacteria/ml for co-mingled milk. Yet regulations within some states or requirements of many milk marketing organizations in the US differ markedly from federal regulations. California, for example, requires not only that individual producer milk be less than 50,000 bacteria/ml SPC, but also that it contain less than 750 bacteria/ml by the laboratory pasteurized count (LPC) method and less than 750 coliform bacteria/ml. Mountain Empire Dairymen's Association (one of the first producer marketing cooperatives to offer quality bonus premiums to its members) expects its producers to supply milk containing less than 20,000 bacteria/ml SPC and less than 30,000 bacteria/ml by the preliminary incubation (PI) test.

In addition to the quantity of bacteria in raw milk, the type of bacteria present also determines the amount of quality deterioration that occurs. Udder pathogens destroy milk quality by altering milk synthesis processes within the mammary gland. (This will be described further under the section pertaining to somatic cells.) Seldom are udder pathogens in high enough numbers in stored raw milk to have a major impact on milk quality. However, psychrotrophic bacteria, thermophiles and the heat resistant enzymes from bacteria that often contaminates raw milk during the milking process and storage on dairy farms do destroy milk quality. In recent years, changes in on-farm storage of refrigerated raw bulk milk has magnified the impact that psychrotrophs (bacteria that multiply at refrigeration temperatures) have on destroying milk quality.

Psychrotrophic bacteria are commonly found in the environment of the dairy cow. Soil, water, plants, animal feed and bedding are all sources of the psychrotrophs. In a review, Mikolajcik (9) cites examples of psychrotrophs cultured from bulk tanks, pipeline milking systems, rubber outlet plugs and gaskets. Surveys indicate psychrotrophs may be found in from 16-92% of all bulk milk tanks sampled. Quantity of psychrotrophic bacteria in each tank depend on age of the refrigerated milk and the degree of initial contamination.

Psychrotrophic bacteria destroy milk quality in two ways. Initially psychrotrophs produce off-flavors and odors during their growth in stored, refrigerated raw milk (even though some of these effects will not become evident until after pasteurization storage). Later, the psychrotrophs surviving pasteurization (thermophiles) may multiply in sufficient numbers during manufacture and storage to cause off-flavors, spoilage or changes in the physical form of some dairy products.

Evidence of the ability of psychrotrophs to multiply during cold storage was provided by Dommett and Baseby. (4) They recorded total bacteria counts, psychrotroph counts, temperature, times and volumes during 40 trials involving overnight storage of raw milk at two factories and subsequent transport to a larger regional facility. Total bacteria counts virtually doubled in 20 hours. The increases were explained by psychrotroph count increases alone with no evidence of contamination.

Most psychrotrophic bacteria are destroyed at pasteurization. Therefore, the level of psychrotrophs in raw milk immediately prior to pasteurization is critical. In many marketing areas in the US, milk can be held in excess of 6 days prior to pasteurization. Properly refrigerated milk can accumulate excessive levels of psychrotrophs during that time. Punch *et al* (13) found that when psychrotroph counts increase to levels of 10/ml, off-flavors and defects become evident. A survey done by Muir *et al* showed that 90% of 70 fresh raw samples received at a plant had psychrotroph counts of approximately 500,000/ml. When that milk was held for 24 hours at 46 F, the number of samples with counts greater than 500,000/ml rose to 85%. All samples had psychrotroph counts greater than 500,000/ml after 48 hours and 63% had psychrotroph counts in the ranges of 10 million/ml (a level beyond which off-flavors develop). Sample number 2 in a trial cited earlier (12) (Figure 1) demonstrates the impact psychrotrophs have on milk quality. The summary statement from the trial concluded: "even in the absence of post-pasteurization contaminants, off-flavors may be encountered if the raw milk contains large populations of psychrotrophs." (12)

A similar undesirable effect results in the production of cheese from milk with high psychrotroph counts. Curd formation and rennet clotting time are negatively affected by these bacteria. (9) Cheese aged six months had unacceptable flavors when manufactured from milk containing psychrotrophs.

Clearly, the lowest possible raw milk bacteria counts are necessary to maintain milk quality. Results (6 and 8) of daily monitoring of dairymen's bulk tanks indicate levels of less than 10,000 bacteria/ml SPC are realistic, attainable goals for dairy producers.

Somatic Cells Destroy Milk Quality

High SCC levels destroy milk quality in two ways: in the udder as a result of altered milk synthesis; and, in stored milk through continuous proteolytic and lipolytic activity.

Reduced milk yield results when SCC's are high. The cause is inflammatory response to the presence of bacteria in the udder. Changes in SCC's in normal, subclinical and clinical intramammary infection are shown in Figure 2.

Neutrophils make up greater than 50% of somatic cells present in milk from cows with elevated SCC's. These neutrophils contain active proteases, lipases, phospholipases and chemical inhibitory to bacteria, all of which are carried into milk. In addition, tissue damage allows leakage of blood plasma constituents into the milk. Blood plasma contains additional proteases and lipases and especially plasmin. Milk quality deterioration is the result of the amount and/or activity of proteolytic activity in the udder. Milk from high SCC cows has reduced lactose, fat, protein, calcium and phosphorus.

FIGURE 2. Changes in types of somatic cells present in milk with increasing somatic cells. (1)

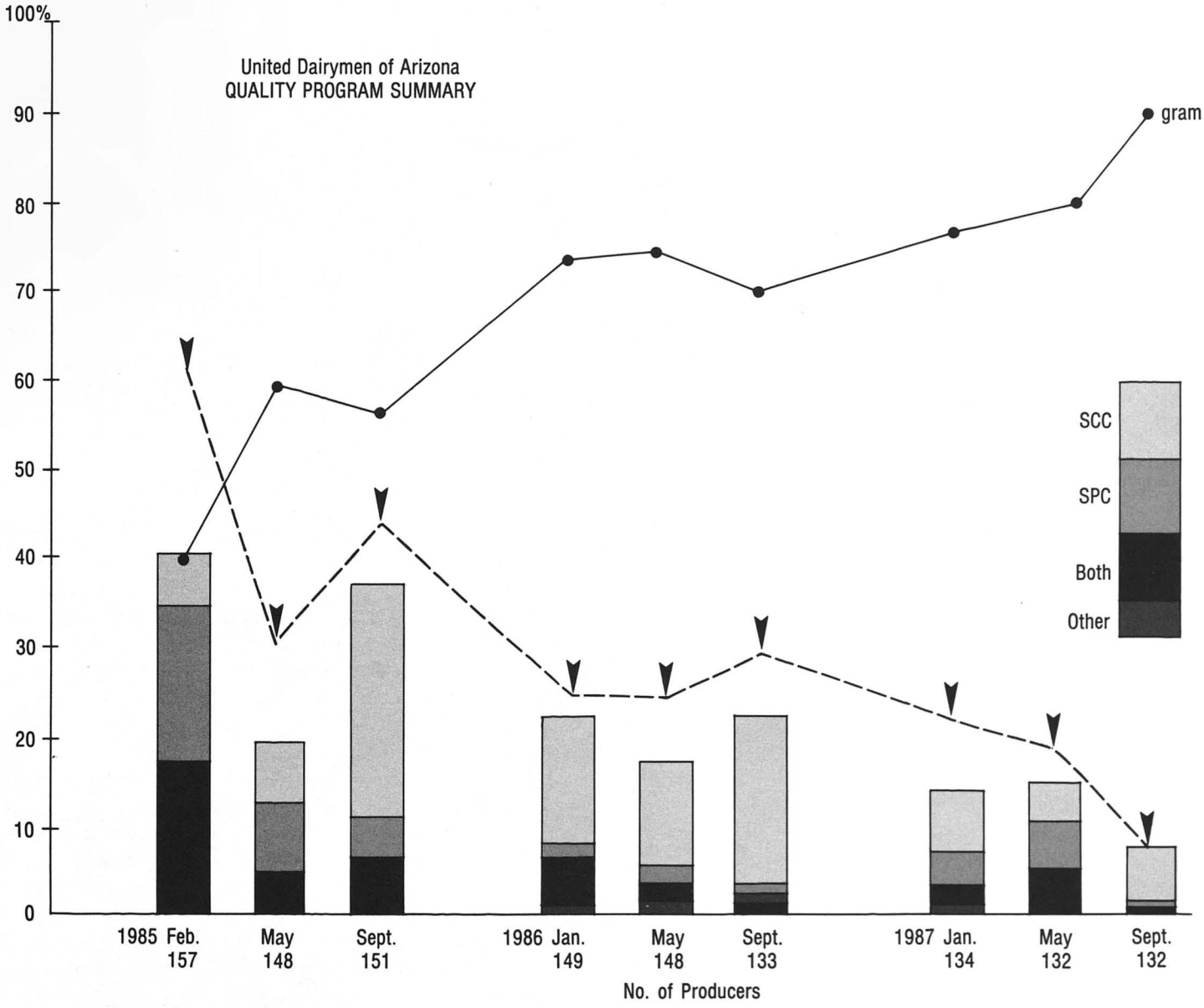
Milk Type cells/ml		Somatic Cell Type lymphocyte	neutrophil	epithelial
normal	%	6.1	9.1	84.8
(<100,000/ml)	#	6,061	9,091	84,848
subclinical	%	4.8	47.6	47.6
(500,000)	#	23,809	238,095	238,095
	increase	3.9×	26×	2.8×
clinical	%	2.6	71.6	25.8
(1,000,000)	#	25,848	716,000	258,182
	increase	4.3×	79×	3.0×

FIGURE 3. Comparison of tyrosine values (TV) in milk samples grouped by SCC classifications. (14)

SCC	Tyrosine value* Raw Milk at 3 days	Lab pasteurized at 14 days
50,000	5.6	4.5
100,000	7.2	5.4
200,000	8.3	10.1
500,000	8.9	13.3
1,000,000	9.7	19.3
2,000,000	13.7	21.9

* tyrosine value as an index of proteolysis

FIGURE 4:
Summary.



Continued enzymatic activity destroys milk quality of stored unprocessed and post-pasteurized milk. Especially plasmin, which is not inactivated by pasteurization, causes deterioration of stored milk. Measurement of tyrosine values (an indicator of proteolytic activity) in fresh and processed milks verifies the negative effect of elevated SCC's on milk quality (Figure 3).

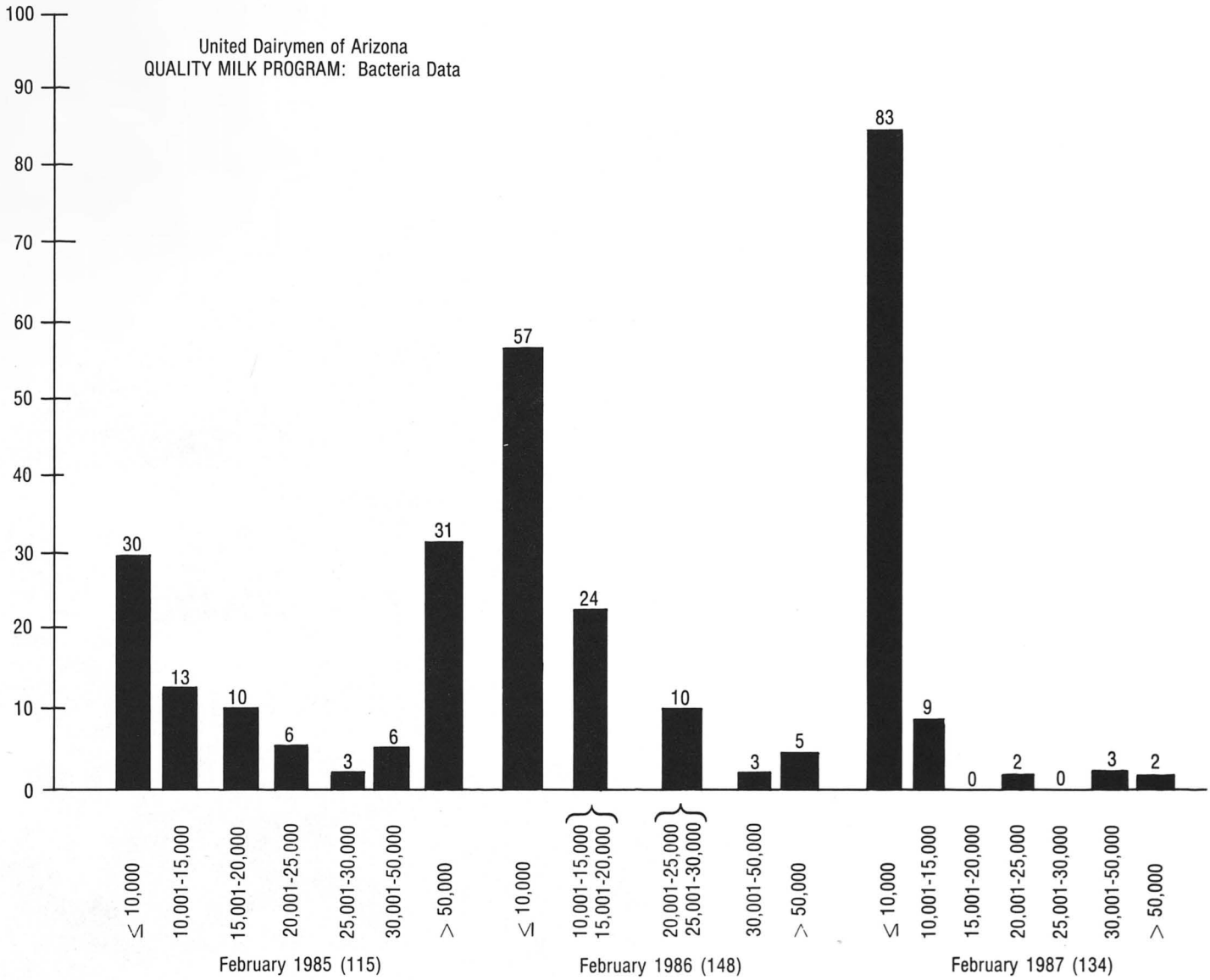
Increased proteolytic and lipolytic activity indicated by elevated SCC's reduces milk quality and yield of manufactured product by 10-15%. Quality continues to deteriorate with time. Co-mingling of high SCC milk with low SCC milk will result in some damage to milk casein and fat in the high quality milk. (1)

Antibiotic Residues Destroy Milk Quality

Antibiotic residue in milk and milk products can induce an allergic reaction or toxicity symptoms in individuals who consume them. The presence of antibiotics in milk used for processing inhibits starter cultures, damages flavor and delays cheese processing. Antibiotic residues above limits allowed by FDA are illegal.

The cause of antibiotic residues in milk and cull dairy cows can be due to: improper identification of treated cows, unobserved withdrawal times or extra label use or improper dosage of antimicrobials.

FIGURE 5. United Dairymen of Arizona Milk Quality Program — distribution of bacteria counts over 3 years.



The Veterinarian's Role in Quality Assurance

Responsibility for improving raw bulk milk quality is the dairyman's. Practitioners have the opportunity to service dairymen seeking assistance with milk quality problems in the same way many are providing service in the areas of fertility, mastitis control and calf-raising programs. Initially, there must be a perceived need for help on milk quality problems on the part of the dairy farmer. Once he calls, the veterinarian must be geared up to deliver service in all areas relating to milk quality.

Milk quality enhancement programs provide dairy farmers with monetary incentive to produce milk which meets specific quality criteria. National Milk Producer's Federation (NMPF) surveyed its membership in 1985 with regard to milk quality programs offered by its member cooperatives. (11) Seventy-five percent of the cooperatives responding to the survey had some form of milk quality program. Three-fourths of these co-ops utilize a premium payment plan; one-fourth rely on a penalty scheme to induce members to produce high quality milk. Most quality programs evaluate bulk milk for bacteria, SCC, antibiotic residues, sediment and added water. Several include protein or solids-not-fat (SNF) determinations as components of their programs. The survey indicated a variety of tests were used to quantify bacteria; SPC was most commonly utilized. Premium payments for low bacteria counts (generally 10,000-25,000 bacteria/ml) ranged from 3 cents to 80 cents per hundredweight of milk. SCC's were 100,000-700,000 with most quality programs paying a premium for milk with less than 400,000 SCC. Premiums were 5 cents—35 cents per hundredweight of milk.

A milk quality enhancement program was initiated at United Dairymen of Arizona (UDA) in February, 1985. This cooperative has 150 members producing milk from approximately 75,000 dairy cows. Approximately 65% of the milk is utilized for Class I fluid milk sales; the balance for manufactured products. The organization markets 1.2 billion pounds of milk annually.

The UDA quality premium program was initially structured to return an additional 3 cents per hundredweight to dairymen whose milk contained: 1). less than 30,000 bacteria/ml SPC; 2). under 300,000 SCC; 3). no sediment; 4). no added water; 5). no antibiotic residue; 6). pesticide less than 0.05 ppb; and, 7). aflatoxin less than 0.5 ppb. Impact on milk quality in Arizona is presented in Figure 4.

Initially, only 45% of all Arizona dairy producers qualified for the premium. Currently, 80-90% qualify each month (even though bacteria levels to qualify have been reduced to 15,000 bacteria/ml). Figure 5 demonstrates the change in distribution of bacteria counts over the course of the program.

Four factors emerge as reasons for milk quality improvement in Arizona since the implementation of the UDA milk quality program: 1). increased money returned to dairymen; 2). competent field, laboratory and service staff to assist dairymen having on-farm quality problems; 3). veterinary practitioner involvement with herds having high bacteria and/or high SCC problems; and, 4). general increased awareness of the benefits of improved quality milk to producers, handlers and to the customer.

The emergenc of milk quality enhancement programs provides the incentive for dairymen experiencing quality problems to seek the services of those who can assist him to correct those problems. Veterinarians can seize this opportunity to expand their services to include monitoring milk quality for clients. (2) That service requires the practitioner be prepared to deal with ALL high bacteria count problems (differentiate udder pathogens from environmental contaminants and eliminates whichever is the source of the problem); attack high SCC herds with aggressive SCC reduction strategies and eliminate antibiotic residues by becoming knowledgeable of FDA policy and intensifying communication with clients regarding the use and observing withdrawal times for antibiotics used in the herd.

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