airy guidelines

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RANCIDITY AND FOAMING OF MILK

G. M. Jones
Extension Specialist, Dairy Management

The incidence of rancid flavors in milk has increased in recent years. Much of this is due to bulk handling of milk, combined with pipeline milkers or transfer systems, which result in excessive agitation and foaming of warm, raw milk.

What Is Rancid Milk?

Rancid milk has an objectionable taste. It is characterized by a sharp, unclean, and astringent flavor that lingers in the mouth for a while. Also, there is an obnoxious odor when this flavor is intense. One survey found that a rancid flavor was easily identified in 5.3% of 3,171 samples purchased from retail outlets. More recently the incidence has risen to 8%.

Rancidity is expressed by determining the acid degree value (ADV) of milk. Normal milk has an ADV of 0.40 to 0.60, while an ADV of 1.00 and higher indicates that milk has turned rancid. A rancid taste is usually evident when the ADV ranges from 0.80 to 1.50.

Causes of Rancidity.

Foaming is usually associated with rancidity. It is the formation of a physical phase in which air is incorporated into milk; in other words, bubbles. The causes of rancidity or excessive foaming are summarized in Table 1. Rancidity often can be related to the condition of the milking system. One milking machine factor is the admission of too much air into the claw at milking time, caused by leaks in the inflation or milk hose or by too much air admission through the air bleeder vent. Another factor could be the use of small claws which, when tilted slightly, cause flooding of the milk tube and consequently results in backward movement of milk, agitation, and vacuum fluctuation. This would be critical when milk flow from a high producing cow is heavy.

Violent agitation of milk will cause foaming and rancidity. Examples of violent agitation are: (1) the presence of air in a vertical pipe, such as risers and milk hoses from the claw to the milk line; (2) air leaks or excessive air admission; (3) leaky valves in the receiver jar; (4) pipeline restrictions, such as flooded milk lines or milk hoses; and (5) milk pumps running in a "starved" condition. Violent agitation can increase the surface area of the fat globule membrane and thus more of the membrane can come in contact with enzymes which break down fats. Violent agitation also results in rupture of the milk fat globule, especially those of smaller size.

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Structure of Milk Fat.

The mammary gland contains many secretory units, called alveoli, which are arranged into hollow bulb-like structures. Figure 1 depicts the microscopic appearance of three milk secreting cells and shows the release of a fat globule into the center of the bulb or alveolus. As the fat globule is released, it is encircled by a membrane which is derived from the cell's outer or plasma membrane. This membrane consists of an outside layer of protein and an inner layer of lecithin (phospholipid). Cholesterol and vitamin A also can be found in the phospholipid layer.

The fat globule membrane protects the fat fraction from being broken down to glycerol and fatty acids by a lipase enzyme which is present in milk. One of the primary fatty acids present in milk fat is butyric acid. The release of this fatty acid results in a rancid flavor. Normally this enzyme is inactive in the udder; however, its activity is facilitated when the fat globule membrane is disturbed, weakened, or damaged by some physical (e.g., violent agitation) or thermal manipulation. In addition, the membrane is not as protective during late stages of lactation.

One drop of milk may contain as many as 100 million fat globules. The size of a fat globule ranges from 1 to 10 millimicrons (μm)(there are 25,400 μm to an inch), but under certain conditions as many as 80% of the globules may be less than 1 μm in diameter, producing a large population of small droplets which may be more susceptible to foaming. When the composition of milk is relatively high in fat, the majority of the fat globules are relatively large in size. Jerseys and Guernseys produce milk with large fat globules. Fat globule size also increases when the cow consumes succulent feeds, or when she is sick, has been injured, or changes body condition. Numerous smaller fat globules are found when milk contains a lower content of fat, such as occurs in high producing cows, especially Holsteins, or when the ration is comprised of dry feeds. Fat globules become relatively smaller and more numerous during late stages of lactation. A high proportion of small fat globules results in greater membrane surface area per unit of fat and a greater requirement for plasma regeneration by the milk secreting cell. This puts a greater metabolic demand on the cell.

The function of the phospholipid layer is to stabilize the fat globule. Approximately 50% of the milk phospholipids are found in the milk fat globule. The phospholipid content in milk fat is highest in February and lowest in July. A cow at her peak lactation has an elevated blood lipid (fat) concentration. Approximately 90% of the serum lipids are found in lipoproteins which are comprised of phospholipids and cholesterol. The increased phospholipid level in blood and milk fat could result in the formation of smaller fat globules and could be linked with an increased rate of foam subsidence. Frequent milking will reduce the phospholipid and cholesterol content of milk, perhaps due to formation of larger droplets. This would suggest that milking high producing cows three times-a-day may reduce a foaming problem.

All cells contain a lysosome fraction, which is made up of hydrolase enzymes that could digest the cell and its surrounding membranes. The lysosome membrane separates the enzymes from the rest of the cell. Progesterone, estradiol, and high levels of vitamin A can assist in the destruction of the lysosome membrane, while vitamin E and low concentrations of vitamin A offer some stability. Pasture and succulent feeds contain more vitamin A and vitamin

E than dry feeds. Perhaps cows receive too much vitamin A when grazing pasture and inadequate amounts of vitamin E during drylot or winter feeding.

Foaming.

The tendency of milk to foam is related to the presence of materials in milk which lower the surface tension of milk. Detergents and soaps help to remove dirt by reducing the surface tension of milk. Foaming occurs when surface tension is reduced. The protein and protein-phospholipid complex on the fat globule surface is one of the most powerful and significant depressants of surface tension. Violent agitation of milk could reduce its surface tension. Surface tension of milk increases as milk fat content is increased until it reaches 4% fat after which it is not affected. The high producing cow usually produces milk with less than 3% fat and with many smaller fat globules. As this milk has a smaller amount of fat in the globule, and a greater proportion of protein and phospholipid, its surface tension is lower and will make the milk more sensitive to foaming. This may explain why herds whose average production per cow has increased from 50 lb. to 60 lb. daily will suddenly experience excessive foaming. The milk resulting from higher production was more conducive to foaming and other management conditions, such as borderline milking systems, may have promoted the effect.

Good Management Prevents Foaming and Rancidity.

The value of continual observation of the milking system and the importance of feeding a concentrate to supplement the available forage cannot be overemphasized (Table 1). Eliminate sources of violent agitation of milk in the milking system. Balance the total ration and provide the right amounts of protein, energy, calcium, phosphorous, trace minerals, and vitamins A, D, and E. Even then some of the better cows will produce milk which is susceptible to foaming. More frequent milking may be needed for these cows.

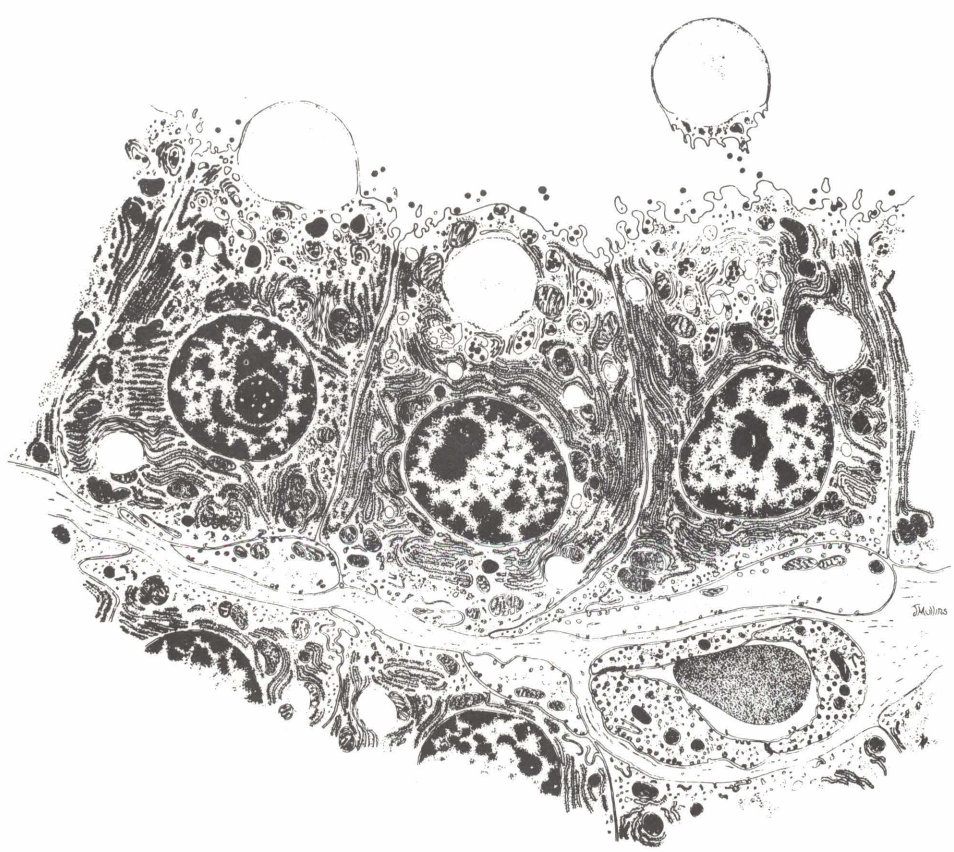

Figure 1. Structure of the milk secreting cell showing release of the milk fat globule, enlarged 5,000 times (courtesy of Dr. C. W. Heald, VPI&SU).

Table 1. Causes of rancidity and foaming and preventive measures.

Cause	Prevention
Inadequate bulk tank cooling capacity	Cool milk to less than 50° F within 1 hr and less than 40° F within 2 hr after completion of milking. Turn on agitator after blades are covered.
Starved milk pump	Check electric probes in receiver jar.
Air leaks in milk line	Tighten milk lines weekly. Often caused by vibrations during C.I.P. wash cycle.
Milk inlet valve	Rotate milk inlet valves to above horizontal so that milk drains into the milk line.
Starved milk hoses to high milk lines	Replace with low lines, especially if milk lines are 7 ft. above platform. Milk hose should not exceed 9 ft.
Risers in milk line	
Leaky check valves in receiver jar	
Too much air admission into claw	
Malfunctioning milking system	Have checked 2-3 times annually.
Late-lactation, low producing cows	Dry off cows producing less than 15 lb. daily.
Acute herd mastitis problem	Establish a mastitis control program.
Low quality forage	Feed to dry cows and yearling heifers.
Vitamin E	500-800 I.U. daily on drylot or winter feeding.
Imbalanced ration	See Feeding Guidelines for Dairy Cows by W. Ray Murley