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FACT SHEET
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DAIRY INDUSTRIES NO. 9

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Oxidized Flavors in Milk—Cause and Control

Oxidized flavors usually are described as cardboardy, metallic, oily, or tallowy. Such off-flavors result from a chemical change in butterfat and/or fat-like compounds called phospholipids.

Because these off-flavors are defects of the fat portion of milk, the word rancid also may be used to describe them. Two types of rancidity--oxidative and hydrolytic--occur. The latter is a splitting of butterfat into its component parts. The dairy product tastes bitter or soapy and has a pungent odor (see Dairy Industries Fact Sheet No. 5, Hydrolytic Rancidity--Cause and Control). Oxidation, on the other hand, is a change within the structure of butterfat which may result in the release of flavor compounds.

Oxidation can occur in raw milk, in pasteurized milk, and in various manufactured products. Any dairy product that contains butterfat is susceptible to oxidation. And because some of the phospholipids stay in skim milk following separation of whole milk, even nonfat products can develop an oxidized flavor.

FACTORS RELATED TO OXIDATION (3, 4)

Several factors play a role in the development of oxidized flavors. They are:

1. Presence of oxygen. Oxygen is necessary for the reaction to take place. Since milk usually is saturated with air, the danger that the oxidation reaction will occur is always present. Milk from which the air has been removed does not develop oxidized flavors.

2. Contamination with some metals. Probably the most frequent cause of oxidation is contamination of milk and/or dairy products with small amounts of copper or iron. Extremely small quantities can bring about the reaction. While certain other factors may promote oxidation, metal contamination is one of the prime causes.

3. Presence of other pro-oxidants. Sunlight or strong artificial light tends to promote off-flavors usually characterized as oxidized.

Acidity (low pH) favors oxidation, i.e., ripened cream butter is more susceptible to oxidation than sweet cream butter. This fact is one reason why acid cream is neutralized prior to churning.

4. Presence of antioxidants. Antioxidants are compounds that slow down the oxidation process. Heat treatment of milk at temperatures above 170° F. promotes the release of antioxidants that are bound to milk proteins. A "cooked" flavor arises.

The antioxidants are used up during storage, and the cooked flavor disappears. Oxidized flavors may then develop.

Ice cream mix and cream for buttermaking often are pasteurized at high temperatures to promote the release of antioxidants, thus slowing down the oxidation process.

5. Homogenization. The process of homogenization tends to retard oxidation.

6. Cows' rations. Oxidation commonly is a winter problem associated with a lack of green feed in the ration. Supplementing rations with tocopherol (vitamin E) and ethoxyquin will significantly delay oxidation of milk (1).

7. Influence of bacteria. Oxidation has been found to be more of a problem in milk sheds that have milk with a consistently low bacteria count. Bacteria use oxygen in the milk and so reduce the amount available for oxidation. Some bacteria may produce antioxidants.

NATURE OF THE MILK

Milk has been classified arbitrarily according to its tendency to oxidize. This classification provides some insight into the problems surrounding control measures. The milk classifications are:

1. Spontaneous. This milk will undergo oxidation in 48 hours without added copper. The problem usually appears during late winter or early spring. Prolonged feeding of dry feeds encourages production of this kind of milk.

2. Susceptible. Small amounts of copper are needed to cause the reaction. Milks vary in this tendency. In some cases, 0.1 part per million (p. p. m.) of copper will cause oxidation; in other cases, 1 p. p. m. is necessary. After copper has been added to this kind of milk, off-flavors occur within 2 to 3 days of refrigerated storage.

3. Nonsusceptible. This milk is somewhat resistant to oxidation. No off-flavor develops after 2 to 3 days of cold storage even with 1 p. p. m. of added copper. Note, however, that copper contamination in excess of 1 p. p. m. can and does occur.

And market conditions require much longer storage periods than 2 to 3 days. Even nonsusceptible milk can readily oxidize under the right conditions.

CONTROL PROCEDURES

1. If possible, provide cows with green feed year around.

2. Provide cows with rations supplemented with tocopherol.

3. Avoid copper or iron contamination of milk. Both metals may be common to water supplies, or they may be absorbed from waterlines or storage tanks. Residual water in pipelines, milk utensils, or bulk tanks can be the source of these metals in milk.

Iron is present in rust. Milk that is handled in rusty equipment (milk cans, for example) will absorb iron. Retin milk cans regularly, and never put milk in rusty containers.

Copper is present in several metal alloys, including bronze, brass, "white metal" (commonly used in valves and fittings), and nickel silver. Two problems can arise when milk comes in contact with surfaces containing these metals.

First, the milk may absorb the copper directly. Sometimes the metal must be worn free of plating material before absorption takes place. This absorption takes place faster as the product temperature increases.

Secondly, the copper that is present in one fitting may be picked up by cleaning and/or sanitizing solutions and plated onto stainless steel surfaces throughout the line or equipment (2). The stainless steel then becomes a carrier of copper. For this reason, all milk contact surfaces must be stainless steel! One copper-containing fitting in a line can be the source of enough copper to readily cause an off-flavor in all the milk handled in the line. You can detect copper in metal by adding one drop of nitric acid to the metal. A bluish-green color will develop if copper is present.

REFERENCES

1. Dunkley, W. L. et. al. "Supplementing Rations with Tocopherol and Ethoxyquin to Increase Stability of Milk." Journal of Dairy Science. 1967. Vol. 50. Pp. 492-99.

2. Dunkley, W. L. and R. L. King. "Adsorption of Copper on Stainless Steel." Journal of Dairy Science. 1959. Vol. 42. Pp. 480-88.

3. Jenness, R. and S. Patton. Principles of Dairy Chemistry. John Wiley and Sons, Inc. 1959. Pp. 375-81.

4. Roadhouse, C. L. and J. L. Henderson. The Market-Milk Industry. McGraw-Hill. 2nd Edition. 1950. Pp. 215-17.

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