AGRICULTURAL EXTENSION SERVICE · UNIVERSITY OF MINNESOTA

MINNESOTA DAIRY PRODUCTS PROCESSOR

Editor: V. S. Packard, Jr.
Extension Specialist, Dairy Products

July 1, 1978; No.

The problem of water adulteration of milk requires continuous monitoring. In a few instances, water is added intentionally. But the main concern, as use of pipeline milkers increases, is the chance occurrence of water being added by failure to drain lines or pumps, milk jars, or bulk tanks. This is a constant source of small but important amounts of water in milk. Unfortunately, field work is rarely, if ever, undertaken at these lower levels of water adulteration; yet they do add up to a significant problem overall. A number of dairy processors now intend to initiate field work at a lower freezing point than has been used in most past surveillance programs. Some details follow.

ORIGIN OF PRESENT FREEZING POINT BASE

The legal upper base for taking action in cases of water adulteration of milk is -0.525^{o}H. The H in this instance stands for Hortvet, the measurement for which cryoscopes generally are calibrated. This is a somewhat different standard than centigrade, though most results are given as centigrade.

The value -0.525^{o}H was established based upon work by R. W. Henningson (1), who surveyed milk samples over the U.S. (22 states) and 4 Canadian provinces. All samples were taken to be certain no water had been added. These were "pure" samples. This researcher found the "average" freezing point to be -0.5404^{o}H (reported as centigrade). The standard deviation was -0.00676^{o}H. With the average freezing point at -0.540^{o}H, legal action could be taken only at some point higher than this value in order to account for milk supplies which were "naturally" higher in freezing point than the average. An upper level which would in fact take into consideration 99 percent of all milk samples can be calculated using the standard deviation. You simply multiply the standard deviation by 2.326 and add that value to the mean (average). The upper level thus becomes -0.525^{o}H. And this is the level now used as a basis for taking both legal and fieldwork action.

LEGAL BASE ALLOWS NEARLY 3 PERCENT ADDED WATER IN "AVERAGE" MILK SUPPLIES

Although the legal freezing point base provides assurances that no legal action will be brought against a dairy farmer whose milk supply naturally exceeds the average value, it also allows up to nearly 3 percent added water on farms where the milk supply measures right around the average value. About as many milk supplies run lower than average in freezing point as run higher. These supplies could have more than 3 percent added water without legal or, under present practices, field action being taken.

But consider only the "average" milk supply. The amount of water that could be added without exceeding the legal base can be figured readily. Using Henningson's exact data, the calculations are:

UNIVERSITY OF MINNESOTA, U.S. DEPARTMENT OF AGRICULTURE, AND COUNTY EXTENSION SERVICES COOPERATING

$$0.5404-0.5247 = 0.157$$

$$0.157 \div 0.5404 \times 100 = \underline{2.9\%}$$

At worst, 2.9 percent added water is allowed in average milk supplies. Over the years this level (2.9 percent) has in effect become a tolerance. Several dairy organizations now propose to take field action at a higher freezing point base as a way of controlling these small, though significant, amounts of added water. The base that will be used has been established from data recently gathered in Minnesota and nearby areas of adjoining states.

SOME RECENT WORK

Five dairy organizations undertook a study of freezing point of milk in the Minnesota area. A total of 10,852 milk samples were analyzed during routine operations. Semi-automated cryoscopes were used in all cases. No attempt was made to secure milk known not to contain added water. These were simply run-of-the-mill samples analyzed in on-going operations of these industry laboratories. The results were pooled, put into a computer, and evaluated. Table 1 summarizes the findings.

The grand average freezing point may be seen to be -0.544°H. This value is slightly lower than that found by Henningson, though no attempt was made to obtain "pure" (unwatered) samples. While some samples no doubt contained some added water, an observed average of -0.544°H suggests the true average to be at least -0.540°H, as reported by the above researcher.

SETTING A WORKING FACTOR

A working factor, a freezing point value at which field action is taken, need not be limited to an upper level which would account for nearly all natural variations. Such a level is in fact too high to serve the most useful quality control effort. Instead, a freezing point base for field work might better be put at that point at which some majority of milk supplies would be expected to contain added water, though perhaps in amounts too small to exceed the legal standard. An appropriate base might well be about one standard deviation from the average. Such base would include 67 percent of all observations. Thus, field work could be expected to pay off, while minimizing unnecessary calls.

One standard deviation from the average in the work reported in table 1 yields a base freezing point of -0.537. Since some of the samples no doubt contained some added water, and since the cryoscopes themselves have a built-in variability, a reasonable "working" factor would appear to be -0.540°H. Field work at such point could be expected to uncover a number of bad practices or accidental water additions. Troubleshooting such farms could prove worthwhile. The five dairy organizations involved in this study have decided to use -0.540°H as a working base, and invite other firms to do likewise.

STILL ONE MORE STEP NEEDED

The Hortvet standard has been used for many years in the dairy industry. It is in fact used interchangeably with degrees centigrade, which is in error. Most cryoscopes are calibrated in degrees Hortvet and results reported in degrees centigrade. The original error, which has since led to use of this unconventional temperature standard, was made at a time when methods for detecting freezing point simply were not precise. That is no longer the case; yet the old standard persists. It would appear to be time the dairy industry converted to a true centigrade standard. It would not be difficult to do. The same salt standards would be used to calibrate cryoscopes. The devices simply would be set at equivalent centigrade values, rather than Hortvet. Readings would then be given directly in degrees centigrade.

Formulae for converting degrees Hortvet to degrees centigrade have been worked out by Precision Systems, Inc., of Sudbury, Mass. They are as follows:

$$^{\circ}C = \frac{(0.1915 \times -^{\circ}H) - 0.0004785}{0.199}$$

$$^{\circ}H = \frac{(0.199 \times -^{\circ}C) + 0.0004785}{0.1915}$$

Using the formula for converting Hortvet to centigrade degrees, some comparative readings of important values are given in table 2.

Table 1 Summary of Findings of Freezing Point Determinations on 10,852 Samples of Milk Tested by Cryoscopes

Organization	No. of Samples	Mean °Hortvet	Standard Deviation
1	353	-.543	0.0080
2	1,017	-.542	0.0056
3	666	-.539	0.0073
4	990	-.542	0.0079
5	7,826	-.544	0.0070
Grand total	10,852	-.544	0.0072

Table 2 Some Comparisons of Hortvet and Centigrade Readings

Degrees Hortvet	Degrees Centigrade
-0.422(1)	-0.4080
-0.544	-0.526
-0.540	-0.522
-0.537	-0.519
-0.530(1)	-0.5125
-0.525	-0.508
-0.621(1)	-0.6002

(1)Values designated as (1) are all standards based upon known amounts of salt in water. Salt levels are 6.892, 8.692, and 10.200 grams per 1.000 grams of water for the -0.422, -0.530, and -0.621 Hortvet measures, respectively.

Use of a centigrade standard would require a substitution of centigrade readings for those now measured and reported in degrees Hortvet. Though some confusion might be caused for a time, the lasting effect of such conversion would be to avoid confusion in the future. It seems a step well worth taking.

Reference: Henningson, R. W. 1969. Thermistor cryoscope determination of the freezing point value of milk produced in North America. J. Assoc. of Off. Analytical Chemists. 52:142-151.

Vernal S. Packard, Jr.

Vern S. Packard, Jr.
Extension Specialist, Dairy Products