IS WEIGH TANK SAMPLING ACCURATE?[1]

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A method was developed for checking weigh tank sampling accuracy that was better than comparing samples from different locations in tanks. Long, narrow, deep weigh tanks with a steep pitch in the bottom yielded the most accurate samples. Cube-shaped tanks with a hopper at one corner, and round tanks gave excellent results. High fat milk was more difficult to mix than lower fat milk. Sampling location influenced gain or loss in fat.

Reference to the literature on weigh tank sampling soon establishes the fact that there are serious inaccuracies in producers' tests caused by obtaining samples that do not accurately represent the milk in the weigh tank. Marquardt and Durham (*5*) report only 31.5 per cent of the samples accurate in one plant over a two-year period. Bailey *et al.* (*2*) found only six of 23 plants with no variations and McBride (*6*) mentions the "unsolved problems in the field of butterfat testing."

Regarding the cause of the problem, Bailey *et al.* (*2*) and Bailey (*1*) attribute it to exhaustive creaming. Osborn (*7*) believes the use of electric milk coolers by producers increases the problem of accurate sampling. Whatever the cause, plant operators continue to complain about fat losses and producers about low tests.

Much research has been done on the subjects of accuracy of the Babcock test and composite vs. daily samples. Although tests must be accurate they are of no value unless the sample represents all of the milk being tested. The weigh tank sample must be accurate. This means that milk must be completely mixed in the weigh tank before a sample is taken. The cream that has risen on milk held overnight must be mixed with the rest of the milk in the can, and the milk from different cans has to be mixed together. In most cases this is attempted without the aid of mechanical mixing. This report deals with factors influencing the adequacy of weigh-tank sampling. A more detailed report has been published in bulletin form[2].

Bailey *et al.* (*2*) found that fat tests are lowest at the dumping end of the weigh tank and highest at the outlet end. Bailey (*1*) and Osborn (*7*) found the lowest testing milk at the dumping end of the tank 90 per cent of the time. Gould and Stout (*3, 4*) and Pegram (*8*) reported they found variations of two-tenths of one per cent from samples secured in different parts of the vat. Osborn (*7*) stated "The average variation on samples taken from the front and back of the weigh vats averaged approximately three-tenths of one per cent." Tracy and Tuckey (*10*) indicated that the location of the sample opening in the weigh can cover may cause wide variation in the fat test.

PROCEDURE

The study was divided into two parts: first, to discover the cause of the problem and develop a method of checking weigh tanks for sampling accuracy; and second, to study weigh tanks of various designs under actual operating conditions and evaluate the sampling accuracy.

The first part of the work was done with a weigh tank that was guaranteed by the manufacturer to deliver accurate samples. It was 46½ inches long, 24 inches wide and had a pitch, from dump end to outlet, of 0.52 inches per foot.

All cold milk was used in one set of trials. This milk had been cooled overnight to 38°F. in a farm can cooler and was exhaustively creamed. Another set of trials involved cooled (night) milk and uncooled (morning) milk dumped together. This was varied between dumping cold milk first and warm milk first.

Attempts were made to develop an accurate method of checking weigh tanks for mixing ability. Milk was dumped into the weigh tank and a sample taken. The milk was then stirred with a hand agitator at 60 strokes per minute. Samples were taken every 15 seconds for 90 seconds, at five different locations in the tank, center and each corner. All the samples were tested for butterfat and compared.

As each can was filled at the farm the milk was thoroughly mixed and a sample taken. Samples were taken from the weigh tank when the milk was dumped the next day. All samples were tested by the Babcock method using the utmost precaution to insure accuracy.

The second part of the study consisted of checking weigh tanks in 53 plants by the method developed in Part I. Samples were not taken at the farm. Milk was sampled at the usual sampling position, stirred with

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[2] Vermont Agricultural Experiment Station Bulletin 603, *Factors That Influence the Accuracy of Weigh Tank Sampling.*

a hand agitator for one minute at 60 strokes per minute and another sample taken. The tests were compared and analyzed in relation to; design of weigh tank, use of agitators, sampling location and fat content of the milk. The average number of shippers studied per plant was 49, ranging from 18 to 115.

RESULTS: PART I

Trial 1

When all cold milk was used only five of the 72 samples checked with the original test of the milk. Actual variations in test ranged from 0.1 to 0.9 with an average of 0.317. The higher fat milk showed the greatest variation.

Trial 2

Uncooled morning milk was dumped first and cooled night milk dumped on top of it. Twenty-eight of the 60 samples checked with the original test, 29 had variations of 0.1 and one had a variance of 0.3. When cold, night milk was dumped first, 32 of the 69 samples checked with the original test, 35 varied 0.1, one 0.2 and one 0.4.

Examination of results of samples taken from five locations in the weigh tank showed that 63.4 per cent of the 41 lots varied more from the actual test than from each other. One lot showed exactly the same test at all locations but showed a difference of 0.7 from the actual test of the milk.

Trial 3

Cold, creamed, night milk was used in this trial. Twenty-five lots of milk were used ranging in fat test from 3.9 to 5.7 per cent. As soon as the milk was dumped a sample was taken from the usual sampling location. The milk was then stirred with a hand agitator at 60 strokes per minute for 90 seconds and a sample taken every 15 seconds. It was found that in 20 of the 25 trials a sample taken anywhere in the tank after stirring for 30 seconds yielded the same test as the original milk. The other five lots varied only 0.1. Samples taken before agitation checked with the original test in only five cases and varied from 0.1 to 0.6.

This method of testing for weigh tank accuracy was tried out in eight milk plants using different types of tanks. They varied considerably with regard to sampling accuracy when samples were taken in the regular manner. After 15 seconds of hand agitation 33 of the 44 lots yielded accurate samples, two needed 45 seconds and nine needed 30 seconds.

CONCLUSIONS: PART I

The results show that all cold, creamed milk does not mix as well in the weigh tank as a blend of cooled and uncooled milk.

There is a definite relationship between the fat content of milk and accuracy of sampling, the higher fat milk being more difficult to mix.

The test of samples taken from different locations in the weigh tank is not a good criterion of sampling accuracy or mixing ability of a tank. The variation in tests between the usual sampling location and the actual test of the milk bears very little relation to the variation in tests between several sampling locations. This is in agreement with results reported by Powers (9).

It was demonstrated that it is possible to check the performance of a weigh tank by agitating the milk for 15 to 45 seconds with a hand agitator and comparing the test of the sample with that obtained at the regular sampling location before agitation.

PART II. COMMERCIAL PLANT STUDIES

In this part of the study 2597 lots of milk were

TABLE 1 — RESULTS OF CHECKING PLANT WEIGH CANS FOR SAMPLING ACCURACY

Tank No.	Number of samples	Weigh tank dimensions (inches) Length	Width	Depth	Percent no variation	Percent 0.1 variation	Percent over 0.1 variation	Greatest variation	Percent of errors in favor of producer
1	55	62	22	12-24	74	26	0	0.1	43
2	48	46	19	19-22	71	23	6	0.4	86
3[a]	57	38	18	23-26	61	33	6	0.3	34
4	46	58	35	9-13	50	30	20	0.5	87
5[b]	48	58	38	10-16	50	25	25	0.6	50
6	48	50	26	8-12	48	23	29	0.7	32
7	44	50	34	8-12	41	34	25	0.5	54
8	60	48	27	9-15	38	32	30	0.6	65
9	41	42	35	12-16½	32	34	34	0.6	61
10	115	48	36	15-18	43	22	35	0.8	45
11	57	35	30	15-19	18	46	36	2.1	79
12	27	48	36	20-24	30	37	33	0.4	52
13[c]	47	48	33	9-13	53	36	11	0.3	64
14[d]	18	48	36	20	56	28	16	0.2	100

[a] Tilted plate beneath strainer in hopper to direct milk into either side of double tank.
[b] Chute under strainer directs milk to center of tank.
[c] Blender under strainer.
[d] Plate under strainer directs milk to outlet end of tank.

checked in 53 different milk plants using the method described in Part I. It was decided to hand agitate for 60 seconds to make sure that all the lots of milk were completely mixed.

In analyzing data of this kind there are two main considerations: first, the percentage of samples showing little or no variation from the actual test of the milk; and second, the magnitude of the variations that do exist. For the most part, the results in Table 1 are reported with these two things in mind. This table does not list all of the tanks studied. Examples have been selected which represent types of design that gave various results.

Influence of design of tanks.

Tank No. 1 represents the group of tanks that gave the best results, 89 to 96 per cent of the samples varying 0.1 or less and none of the variations exceeding 0.3. These tanks are long, narrow, fairly deep with considerable pitch to the bottom. The bottom is curved from the sides to the center, gradually at the dump end and more steeply at the outlet end. This allows the milk to roll under and over creating a good mixing pattern. Tank No. 2 represents a group that showed 88 to 94 per cent with 0.1 or less variation and the greatest variation was 0.4. These tanks differed from the first group in one respect only; they were shorter. Both of the first two groups had one important characteristic, the width was less than half the length. Tank No. 3 was wider in relation to its length and has less pitch than tanks 1 and 2. The good results may be attributed to the influence of the tilted plate beneath the strainer.

Tanks 4, 5, and 6 represent a group showing less accuracy. Not more than 84 per cent of the samples varied 0.1 or less and in one case only 71 per cent met this standard. Variations ran as high as 0.7. Most of the tanks had a width that was more than half the length and were quite shallow.

Tanks 7 through 12, showed poor results. The best one had only 75 percent of the samples varying 0.1 or less, the others ranging from 69 down to 31 percent. Individual variations were as high as 2.1 with only two as low as 0.4. None of them had a width less than half the length and some of them would be classed as shallow.

Number 13 shows a departure from this trend. It showed fairly good results, although the width was over half the length and it was a very shallow tank. However, it had a blender under the strainer which apparently assisted greatly in mixing the milk.

Number 14 was another type that would have been expected to show poor results. The width was two-thirds of the length and although deep had a flat bottom. The fairly good results may have been caused by the presence of a chute under the strainer which directed the milk toward the outlet end of the tank. One unusual feature of this tank was the fact that it was the only one in which 100 percent of the errors were in favor of the producer.

These results indicate that the width of weigh tanks generally should be less than half the length; average depth over 10 inches with a steep pitch in the bottom. The extra length gives the milk room to travel and create a roll, and the steep pitch causes it to go down, up and over developing a good mixing action.

Effect of sampling location.

Records were kept of the gain or loss of fat for each plant on the days that the weigh tank was checked. These were gains or losses caused by inacurate sampling only. The sampling location was in most cases the determining factor as to whether a plant had a gain or loss. Figure 1 shows the gains and losses according to sampling location. They are expressed in percentage of total fat received on the day of the tests. It is evident that except for one case the plant gained fat when the sample was taken near the dump end and lost fat when sampling was done near the outlet end. The results for the producer would, of course, be the exact opposite of this. These were all tanks that had shown poor mixing ability without agitation.

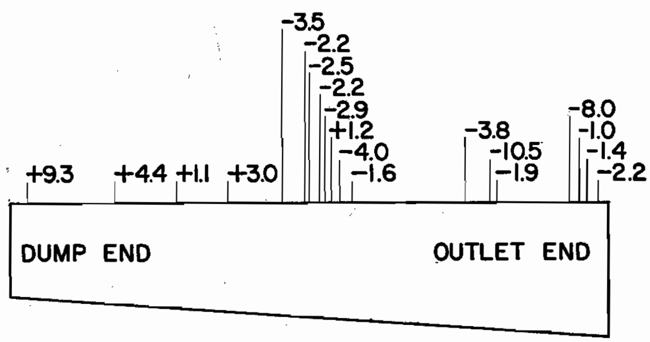

Figure 1. Percent gain or loss in butterfat as influenced by sampling location; based on 19 trials on different weigh tanks.

Mechanical Agitators

Eight tanks equipped with mechanical agitators were studied. Five gave excellent results although they were not of the type of design that gives good results without agitation. The other three gave very poor results. These three agitators were high speed with propellor blades only 2¾ inches long. This type of agitator merely bores a hole in the milk without doing much mixing.

Round Tanks

Five round weigh tanks were studied. They varied from 15 to 19 inches in depth and all had hoppers. All gave excellent results which may have been partly caused by the use of hoppers.

Square Tanks

Two of these were studied. They actually were the shape of a cube. The outlet was in the center of the bottom. Both were equipped with hoppers. One gave excellent results and the other poor. The good one had the hopper on one corner and the poor one had the hopper in the center of one side. With the hopper on one corner it was noticed that the milk rotated rapidly in the tank setting up a good mixing pattern.

Influence of Fat Content of Milk

All samples were divided into two groups; those testing 4.0 percent or less and those testing over 4.0 percent. Fifty-four percent of the lower fat group and 46 percent of the higher fat group showed no variation. Only four of the 1073 lower fat samples had a variation over 0.5 but 48 of the 1890 higher fat samples exceeded this figure. Eleven of these 48 had variations of 1.0 percent or more.

SUMMARY

A method was developed and tested for checking the accuracy of weigh tank samples.

Design of weigh tanks is important in obtaining accurate samples. The best results were obtained from: (*a*) rectangular tanks with a width less than half the length, average depth of 10 inches or more and a steeply pitched bottom; (*b*) cube shaped tanks with a hopper on one corner and, (*c*) round, deep tanks.

Fat content of milk has some influence on sampling accuracy. Creamed milk testing over 4.0 percent fat is more difficult to mix than lower fat milk.

Agitators are of value if selected carefully. The disadvantages are that they may not be of correct design for the tank and they may be shut off or cease to operate because of mechanical failure.

Gain or loss of fat caused by inaccurate sampling was definitely influenced by the sampling location.

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