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Influence of Drying Plant Environment on Salmonellae Contamination of Dry Milk Products

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ABSTRACT

This study was done to correlate incidence of salmonellae found in the dry milk processing plant environment with finished product contamination. Three plants with various histories of environmental salmonellae incidence were chosen for the study. The daily plant samples representing one lot of production were placed in a 1500-g composite in a sterile sample container and submitted to the central analytical laboratory for analysis. Two samples of nonfat dry milk were found to contain salmonellae in 8 continuous months of sampling and testing. In each instance of finished product positive, the environment had at least four positive samples recorded in the routine environmental program during the week or on the day in which the positive product was noted. Repeat tests of the positive product were negative on one lot and confirmed the positive in two of three retests of the other lot. It may be concluded from this study that controlling salmonellae in the dry milk plant environment will effectively preclude finished product contamination since dry milks are produced in essentially closed systems in a process that includes a pasteurization step.

Dry milk products have been tested extensively for the presence of salmonellae by manufacturers, users and regulatory agencies. This extensive testing began approximately 14 years ago as a result of an outbreak of human salmonellosis traced to dry milk (*2,5*).

Silliker has stated that dairy products accounted for 4% of a total of 500 outbreaks of human salmonellosis during the 10-year period of 1966 - 1975 (*13*). One of the 20 dairy-related outbreaks is traceable to dry milk. The remainder of the dairy-related outbreaks is primarily traceable to consumption of certified raw milk (*9,12*).

The Food and Drug Administration (FDA) of the United States outlines a salmonellae sampling plan in its *Inspection Operations Manual* (*11*). This sampling plan is intended for use in determining the presence of salmonellae in processed human foods.

Foods are classified in 3 categories based on the number of salmonellae hazards perceived and whether the foods will be consumed by infants, the aged, or the infirm. Category II foods are defined as foods with all three salmonellae hazards: (*a*) a significant potential source of salmonellae, (*b*) the manufacturing process does not include a controlled step that destroys salmonellae and (*c*) the food has significant potential for microbial growth if "abused" in distribution or by consumers. Both raw fluid milk products and pasteurized dried milk products are placed in Category II.

FDA reports on its import surveillance program for 1975 and 1976, that all dry milk samples tested were negative for salmonellae (*3*).

The objective of this study is to show that control of salmonellae in the milk drying plant environment will prevent post-pasteurization contamination of the finished product.

MATERIALS AND METHODS

Sixty 25-g samples of dry milk were drawn from each day's production. A clean and sanitary stainless steel sampling tool, mounted in an "easy off" stainless steel lid for the sample container, was used to take each sample (Fig. 1). This sampling tool replaced the screw-cap lid on the 1-gallon plastic sample bottle at the start of the daily bagging operation (Fig. 2).

The sampling tool, which was washed and sterilized before each day's bagging operation, was designed to deliver 25 g in each sampling to the 1-gallon sample bottle. The sample bottles were sterilized in the central laboratory before shipment to the plant.

At the end of each day's bagging, the sterile screw-cap was replaced on the bottle and the sampling tool washed and sterilized in preparation for the next production run.

If the day's production were anticipated at 600 bags, a 25-g sample of dry milk was drawn from every tenth bag, if 300 bags were anticipated a 25-g sample was drawn from every fifth bag, and so on. When 4 days' samples were collected, they were sent to the central analytical laboratory for analysis.

TEST PROCEDURES

Each 1500-g daily product sample was divided into five 300-g portions and placed in five 1-gallon glass jars each containing 3000 ml of sterile 0.002% brilliant green water. The samples were mixed by attaching an Osterizer blade and collar and blending for approximately 30 sec.

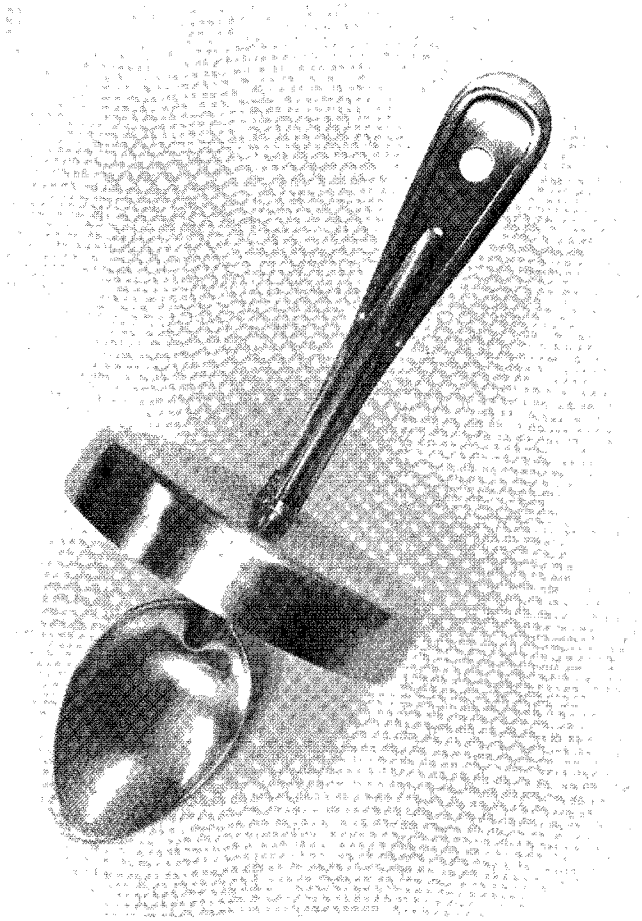

Figure 1. *Stainless steel sampling tool welded in an "easy off" lid, designed to deliver 25 g and minimize potential airborne contamination.*

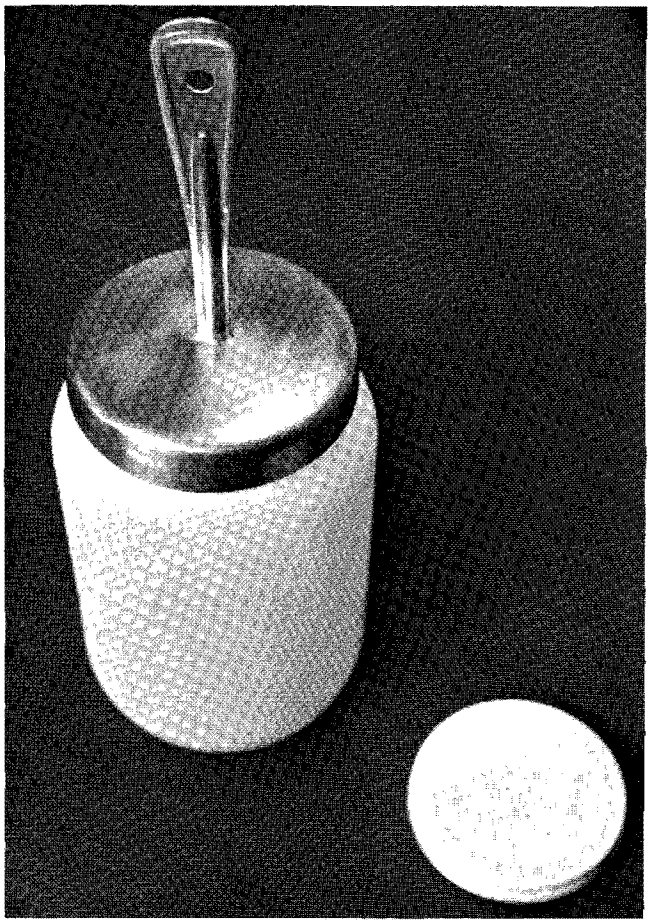

Figure 2. *A 1-gallon sample container with screw cap lid replaced by sampling tool.*

The five containers (pre-enrichments), each containing 300 g of the original 1500-g sample, were incubated 24 h at 35 C. After 24 h of incubation, 2 ml of mixed sample were transferred from each of the 5 jars to 100 ml of tetrathionate broth containing brilliant green and iodine (*1,10*).

Environmental samples were analyzed by placing 80 g of sample in 800 ml of brilliant green water, incubating 24 h at 35 C, and transferring 10 ml of the sample and brilliant green mixture (pre-enrichment) to 100 ml of tetrathionate broth containing brilliant green and iodine.

After the tetrathionate broth (enrichment) was incubated 24 h at 35 C, a sample was taken from the enrichment utilizing an inoculating loop. The loops of enrichment were streaked on three Difco selective media -- Bismuth Sulfite, Xylose Lysine Desoxycholate and Hektoen Enteric agars. After 24-48 h of incubation at 35 C, typical salmonellae colonies were picked from plates and transferred to Difco Triple Sugar Iron Agar (TSI) slants and Difco Lysine Iron Agar (LIA) slants for incubation for 24 h at 35 C (*6,7*). Additional biochemical tests were made on positive TSI and LIA slants, using the BBL Minitek Numerical Taxonomy System (*4*). Salmonellae organisms were grouped by O antigen groupings and Spicer-Edwards rapid H antigen identification technique (*8,10*).

RESULTS AND DISCUSSION

The salmonellae surveillance program is based on intensive weekly sampling and testing of environmental conditions and weekly finished product analysis. The plant environment is a critical control point in the salmonellae surveillance program (see Fig. 3) with a prompt response to confirmed positives by intensified cleanup and sanitizing of those areas identified.

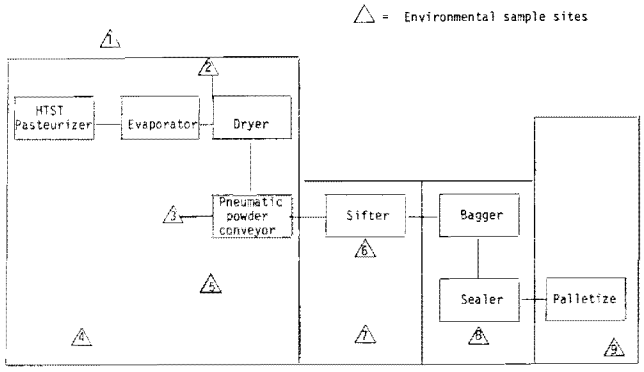

Figure 3. *Critical control point flow diagram of typical dry milk plant environmental surveillance program sampling sites.*
1. Roof debris. 2. Dryer intake air filter overlay. 3. Powder cooler filter overlay. 4. Dryer room floor sweepings. 5. Central/shop vacuum systems. 6. Sifter tailings. 7. Sifter room floor sweepings. 8. Bag room floor sweepings. 9. Warehouse floor sweepings. (At least 80 g of sample are taken, where available, aseptically with sterile spoons and placed in Whirl-Pak bags. Approximately 2 square feet of intake and/or powder cooler filter overlay cloth is taken aseptically with sterile scissors and placed in Whirl-Pak bags.)

The environmental sampling program is biased in that it is directed at those areas where salmonellae are most often noted. It should also be stated that numbers of environmental positives are inflated since positives result in increased sampling of the area until eliminated, as evidenced in Table 1.

TABLE 1. *Summary of routine environmental surveillance program during the 8 month study.*

Number of samples	Plant	Number of positives
223	A	0
313[a]	B	38[b]
130	C	4[c]

(a) Large number of samples taken in response to a flare-up of positives in routine surveillance (4 of 9 samples positive). In addition, 23 environmental samples taken as part of corporate plant inspection program during the week prior to the above flare-up. Nine of the 23 were positive for salmonellae.
(b) All salmonellae (including product positive noted in Table 2) in plant B reacted with 0 antigen group C_1 factor 7 and G complex in Spicer-Edwards Rapid H antigen identification technique.
(c) All salmonellae (including product positive noted in Table 2) in Plant C reacted with 0 antigen Group E_4 factor 19 and i antigen in Spicer-Edwards Rapid H antigen identification technique.

Good housekeeping has historically been considered an effective control measure in eliminating salmonellae from the drying plant environment. The level of housekeeping in the three plants in this study is essentially equivalent.

The study substantiates approximately 14 years of routine salmonellae surveillance. When environmental positives are noted, a prompt, intensified cleaning and sanitizing of that specific area results in negative analyses for at least 2 or 3 subsequent samplings.

When a plant exhibiting frequent (1 positive per week) or occasional (1 positive per month) environmental salmonellae positives is shut down for remodeling, equipment installation, construction, maintenance, or seasonal production, it will likely experience an increased incidence of environmental salmonellae positives after start-up and for some time thereafter. During these periods housekeeping generally suffers.

Plant A had a major equipment installation a few months before the beginning of this project and no environmental positives were noted. Laboratory records for Plant A indicate only one environmental positive in 14 years of weekly testing under the routine surveillance program.

Even under environmental conditions that are considered out of control, more than two weekly environmental samples positive for salmonellae, finished product contamination, if any, will be at very low levels, as evidenced in Table 2. The actual incidence of salmonellae positive dry milks is practically negligible.

In addition to the sampling and testing program described here, many users of dry milk products duplicate the analyses for salmonellae. In only one instance in this 14-year period has a positive found by a user been confirmed in our laboratory. Investigation of this product showed that it was a blend of ingredients from several suppliers. Analyses of these ingredients in our laboratory indicated the salmonellae came from an ingredient from a supplier that does not have a comprehensive surveillance program as described here.

TABLE 2. *Summary of finished product testing of 1500-g samples during the 8 month study.*

Number of samples	Plant	Number of positives
204	A	0
136[a]	B	1[b]
204	C	1[c]

(a) Due to availability of milk, drying was done only 3-4 days per week in plant B as opposed to 6-7 days per week in plants A and C.
(b) The positive product sample was produced on the same day as 4 environmental positives were noted. See note (b) Table 1.
(c) The positive product sample was produced the day after 4 salmonellae positive environmental samples were taken. This product was negative for salmonellae on a 1500-g recheck. See note (c) Table 1.

Thousands of additional salmonellae analyses have been done by our customers of dry milk products. Relatively few instances of positives have been reported. In every instance, the serotypes reported were different from those found in the plant environment where the product was manufactured. Intensive sampling and testing of returned product consistently produced negative results.

CONCLUSIONS

An effective two-step critical control point program of the dry milk processing plant environment, as described in this study, will prevent salmonellae contamination of finished product. This program will: (*a*) emphasize housekeeping and sanitation practices as the basic method of maintaining control, and (*b*) verification by routine weekly analysis of environment samples taken from those specific areas mentioned previously.

If more than two environmental samples, other than dryer tailings, are positive in a weekly analysis, finished product must be tested. Since sifter tailings come directly from the dryer, any positive tailings will require mandatory testing of the finished product. In addition, finished product made following shutdown for major repair, construction, etc., must also be tested on the basis of 1500-g composite samples of the finished product lot(s) for at least 5 consecutive days after start-up.

The user of dry milk products from a supplier with this type quality control program is assured a salmonellae-free ingredient. That user should need only perform spot analyses for salmonellae at the same frequency as other non-critical acceptance criteria noted in its ingredient specifications.

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Tracings from the three hydrothermographs indicated that the relative humidity never exceeded 80%. The hydrothermograph located adjacent to the chamber indicated that operation of the carcass-cleaning unit caused no increase in humidity. In fact, the highest humidity reading, 78%, occurred over a weekend. No moisture was observed on walls around the washing area.

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TABLE 2. *Average air velocity through the entrance and exit of the model chamber under selected experimental conditions.*

Variable Set No.	Section of sampling grid: Horizontal divisions: Top	Upper middle	Lower middle	Bottom	Vertical division: Left	Center	Right
	(Rate in m/min through entrance: Location A-)						
1	33	19	14	1	37	18	-4
2	15	6	1	2	15	4	0
3	20	7	6	35	16	20	16
4	-24	-20	-13	108	5	10	23
5	-23	-22	-12	104	8	12	15
6	3	0	0	50	17	2	21
7	1	0	2	1	1	0	2
8	0	0	5	3	0	0	6
9	0	0	2	2	0	0	2
10	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
	(Rate in m/min through exit: Location D-)						
1	-7	-76	-73	-31	-43	-54	-45
2	-18	-53	-60	-28	-29	-49	-41
3	0	-45	-48	23	-21	-20	-11
4	-1	-26	-27	-4	-12	-18	-14
5	0	-37	-40	-13	-24	-24	-20
6	-2	-34	-44	16	-18	-15	-15
7	-3	-23	-26	19	-9	-11	-4
8	-1	-34	-36	-11	-20	-22	-19
9	-2	-26	-36	-4	-21	-19	-11
10	0	-3	-8	8	-1	-3	-2
11	-5	-41	-39	-17	-21	-32	-25
12	-5	-41	-40	-17	-21	-32	-25

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