Procedures Used by North Carolina Dairies for Vitamins A and D Fortification of Milk

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ABSTRACT

New research findings have documented fortification errors in fortified milk products all across the US milk industry. Also, the consumption of overfortified bovine milk has led the public to question whether vitamin fortification is safe. Therefore, North Carolina dairies were surveyed to determine vitamin fortification procedures used and to determine differences among these procedures. Of the parameters surveyed, the general conditions under which vitamin preparations were stored, the method used to add vitamin preparations to milk, and the point during processing at which vitamin preparations were added to milk were different among dairies. Forty-six percent of the dairies stored vitamin preparations under refrigerated conditions, and 54% stored vitamin preparations at ambient temperatures. The addition of vitamin preparations to bovine milk was accomplished by metered injection at 64% of the dairies and batch addition techniques at 36%. Vitamin preparations were added before fat content standardization and separation by 23% of the dairy processors; 77% added the vitamin preparations after this point. When dairies were asked at what point they added their vitamin preparations to the milk, nine different answers were given. Although other sources of error could also contribute to inconsistent concentrations of vitamin fortification, differences in fortification procedures may have a large impact upon the problem. The diversity of vitamin fortification practices used in North Carolina may be an indication of nationwide trends.

(**Key words**: milk, vitamins, fortification procedures)

INTRODUCTION

In the US, fluid milk products have been fortified with vitamins A and D since the 1930s to reduce the incidence of disorders caused by vitamin deficiency. Although milk fortification is considered to be beneficial, vitamins A and D can be toxic when consumed in high amounts. The dosage of vitamin A or D required to produce toxicity in an individual varies, but the FDA considers overfortification >6000 IU/qt (0.946 L) for vitamin A and 800 IU/qt for vitamin D to be harmful for consumption (5). The FDA has established several regulations regarding the addition of vitamins to milk. Fortification of milk with vitamin D is optional, but fortified milk must contain 400 IU/qt of vitamin D (4). Vitamin A addition to whole milk is optional, but lowfat and nonfat milk must be fortified so that each quart contains ≥2000 IU (4). The FDA allows annual confirmatory test results to deviate from the established values within a small range because of variability among methods and to estimate expected values that could be obtained with good manufacturing practices. Currently, the acceptable deviation range is 100 to 150% of FDA regulation values (5).

Variation of fortified vitamin concentrations in skim, lowfat, and whole bovine milk products has been documented (2, 6, 7, 9). One possible source of error in the fortification of milk products could be the type of fortification procedures used by dairy processors. Little is known about the effect of various types of fortification procedures upon final contents of vitamins A and D in milk products. In general, dairy processors have relied upon the distributors of vitamin preparations for information related to the proper incorporation of vitamin preparations into milk during processing.

This study was conducted to collect information about the fortification procedures used by the North Carolina dairy industry. The first objective was to survey the North Carolina dairy processors to determine the types of fortification procedures used. The second objective was to determine whether dairy processors used different procedures, stored vitamin preparations, added vitamin preparations to milk, and tested the vitamin content of milk.

MATERIALS AND METHODS

All 13 of the North Carolina dairy processors were contacted either in person or by fax and presented with a one-page survey (Figure 1). The survey ad-

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dressed questions related to aspects of the fortification procedure. Processors picked the appropriate response for each question from a list of supplied answers, and additional space was provided to write answers not listed. The results from the 13 surveys were compiled to determine the types of fortification procedures that were used by North Carolina dairy processors. The survey results from the dairy processors were compared to determine whether differences existed among the fortification practices used.

RESULTS AND DISCUSSION

Thirteen North Carolina dairy processors were contacted, and all responded to the questionnaire. All questions on each questionnaire were answered. On several of the questionnaires, additional information was added in the space provided. The additional information was related to the types of milk products produced by the dairies and to the point during processing at which vitamins were added. The questionnaires were filled out by dairy plant managers in most cases.

Question 1 of the questionnaire asked for information on the types of milk products that each dairy produced. All 13 dairies produced whole milk, skim milk, and lowfat milk products. In addition, three of the dairy processors produced lowfat chocolate milk, two produced whole chocolate milk, and another produced lowfat acidophilus milk.

Of the milk products produced by the North Carolina dairies, similar types of products were routinely fortified with vitamins A and D. All of the dairy processors fortified skim and lowfat milk products with vitamin A. The 3 processors that produced lowfat chocolate milk and the 1 processor that produced lowfat acidophilus milk fortified these products with vitamins A and D. Because vitamin fortification for these products is required by FDA, this response was expected. In addition, none of the processors indicated that they fortified whole milk products with vitamin A. This result was also expected because the native vitamin A content of raw milk ranges from 400 IU/qt to 1200 IU/qt (8), and little native vitamin A should be lost in whole milk products during processing (10). Twelve processors indicated that they fortified whole, skim, and lowfat milk products with vitamin D. One processor fortified whole milk with vitamin D but not skim or lowfat milk. The 2 processors producing whole chocolate milk fortified this milk with vitamin D. These results were consistent with previous research showing that 98% of whole milk products produced in the US are fortified with vitamin D (3).

Processors routinely fortified milk products using vitamin preparations purchased from commercial suppliers. Question 10 requested that dairy processors indicate the brand, product name, and address of their vitamin preparation supplier. Dairy processors in North Carolina purchased vitamin preparations from three vitamin preparation suppliers. Four processors purchased brand A, 4 purchased brand B, and 5 purchased brand C. All dairy processors indicated that they purchased vitamin A and D preparations for skim milk fortification and vitamin D preparations for whole milk fortification. The vitamin preparations sold by these 3 suppliers have similar formulations for preparations that contain both vitamins A and D and preparations containing only vitamin D; the former had oil-based carriers, and the latter had water-based carriers. Oil-based vitamin

Survey of North Carolina Dairies

1. What type(s) of products do you fortify with vitamin D?
   ___ None ____ Skim Milk
   ___ Whole Milk ____ Low Fat Milk
   Other: _____
2. What type(s) of products do you fortify with vitamin A?
   ___ None ____ Skim Milk
   ___ Whole Milk ____ Low Fat Milk
   Other: _____
3. How are the vitamin preparations stored?
   ___ At Room Temperature
   ___ In a Refrigeration System
   Other: _____
4. At what point during processing do you add vitamin preparation?
   ___ HTST Balance Tank ____ Raw Tank
   ___ Pasteurized Surge Tank ____ Silo Tank
   Other: _____
5. How are vitamin preparations added?
   ___ Batch Method ____ Metered Injection Port
6. When do you add your vitamin preparations?
   ___ Before Separation and Standardization
   ___ After Separation and Standardization
   Other: _____
7. How do you determine the amount of vitamin preparation to add?
   ___ Use Guidelines Provided by Vitamin Distributor
   ___ Use Guidelines Developed by In-House Dairy Lab
   Other: _____
8. Do you test raw milk for natural vitamin content?
   ____ Yes ____ No
9. How are fortification levels tested in your products?
   ___ Rely on Regulatory Agencies to Provide Testing.
   ___ Send Products to Commercial Labs for Testing.
10. What is the brand, product name and address of your vitamin supplier?

Figure 1. Sample survey.

preparations are those that contain some type of oil as the primary ingredient. Water-based vitamin preparations contained water as the primary ingredient, and other ingredients (emulsifiers, polysorbate-80, monoglycerides, diglycerides, and lecithin) are added to suspend the vitamin into a water-oil emulsion.

All vitamin preparation suppliers (brands A, B, and C) provided information recommending storage conditions for vitamin preparations. Several vitamin preparation suppliers recommended refrigerated storage of oil-based vitamin preparations and storage at ambient temperatures of water-based vitamin preparations. Of the processors surveyed, 54% indicated that they stored all vitamin preparations at ambient temperatures, and 46% indicated storage at refrigerated temperatures. Information from brand A recommended storage of oil-based preparations at ambient temperatures and storage of water-based preparations at refrigerated temperatures. However, processors using this brand stored both preparations at the same temperature, 1 processor stored preparations under ambient conditions, and 3 stored them under refrigerated conditions. According to research from Cornell University by Steve Flecker (1995, personal communication), vitamin degradation can occur before the vitamin preparation expiration date when vitamin preparations are stored under improper conditions. Phase separations may also occur in both oil-based and water-based preparations when they are stored improperly because of the inherent emulsive nature of the preparations.

Both batch and injection techniques were used by processors for addition of vitamin preparations to milk during processing. Of the processors surveyed, 62% indicated that they added vitamin preparation to milk by metered injection, and 38% used batch addition. In a previous study, an attempt was made to correlate milk fortification errors with addition methods. The study results revealed that, although vitamin fortification concentrations varied among dairy processors, this variation did not depend upon method of vitamin addition (1). Fortification accuracy can be achieved using either method if done properly, but both methods provide an opportunity for enormous human error.

Nine different sites for addition of vitamin preparation were listed from 13 North Carolina dairy processors. Figure 2 shows a typical schematic of a dairy processing plant, indicating the locations where processors added vitamin preparations for both metered injection and batch additions. As shown in Figure 2, at least four distinctly different sites for vitamin preparation addition were identified. Of the processors indicating the use of metered injection, their placement of the pump was as follows: 3 at the HTST balance tank, 1 in line immediately following the balance tank, 1 in line at the press, 1 at the suction side of the homogenizer downstream from the heater section, 1 at the suction side of the booster

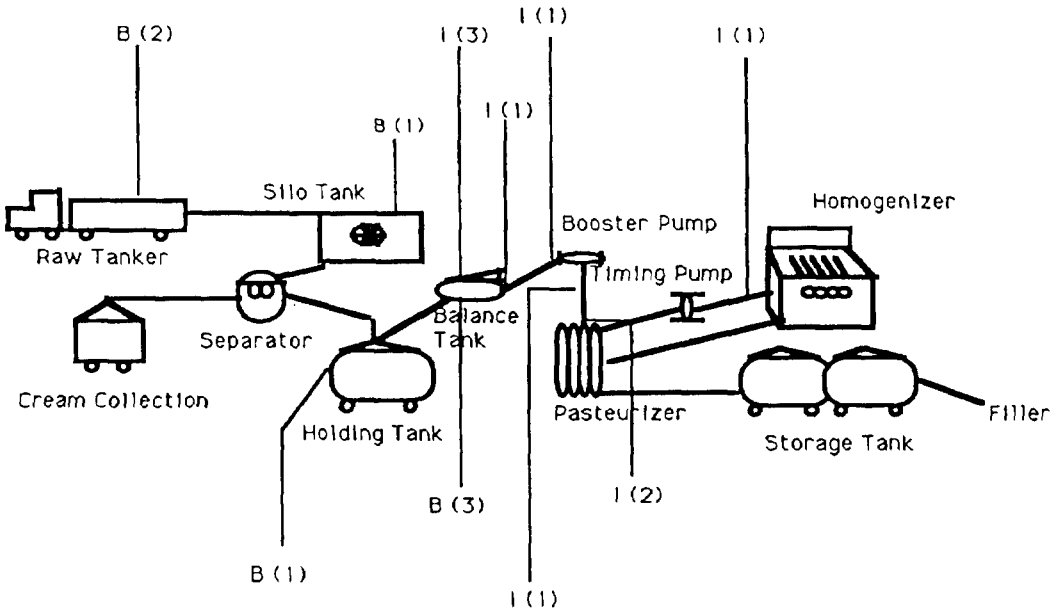

Figure 2. Dairy plant schematic. B = Batch Method; I = metered injection method.

pump, and 2 in-line prior to pasteurization. Of the processors using the batch technique, 3 added vitamin preparations at the HTST balance tank, 1 at the silo tank, 1 at the holding tank, and 2 at the raw tank. Three processors indicated addition of vitamin preparation before standardization and separation at either the raw tank or the silo tank. Fortification before standardization may influence final vitamin concentrations in milk products because vitamins A and D are fat soluble, and their addition at this point may cause reduced vitamin concentrations in lowfat milk products as well as elevated vitamin concentrations in cream-based milk products. Three processors indicated that they added vitamin preparations at the balance tank using metered injection. To fortify milk accurately using a metered injection procedure, the metered pump must be calibrated using an established flow rate. The flow of milk through a balance tank fluctuates. Addition of vitamin preparations at this point could cause an error in fortification.

Other factors may cause variation in accuracy and consistency of vitamin fortification for certain points. At some points of addition, vitamin preparations may settle on the bottom of tanks. At other points, vitamin preparations may have a better opportunity to be mixed uniformly into the milk. Further research is needed to determine how addition of vitamin preparations at different sites affects final vitamin concentrations in fortified milk products.

The dairy processors surveyed indicated that they used similar guidelines to determine the amount of vitamin preparation to add per volume of milk. All three suppliers of vitamin preparations provided guidelines indicating the amount of preparation to add per volume of milk for proper fortification. Twelve North Carolina dairy processors used these guidelines, and 1 processor used guidelines developed in-house because of repeated underfortification using distributor guidelines.

To ensure that the volume of vitamin preparation added to milk complies with FDA regulations, milk products are tested annually for final concentrations of vitamin fortification. Question 8 of the survey asked dairy processors about routine testing procedures. All dairy processors routinely tested fortification of milk products. Of the dairies surveyed, 7 indicated that they relied on regulatory agencies to provide fortification concentration testing for their milk products, and 9 indicated that they sent samples to commercial labs periodically for testing.

Dairy processors were also asked about additional testing of natural vitamin concentrations in raw milk. Only 1 of the 13 dairy processors indicated that they tested raw milk for natural vitamin content. This result was also expected; dairy processors were not usually equipped to test vitamin concentrations in milk in-house as part of regular quality control. Because of the time required to conduct FDA-approved testing, if processors tested raw milk for natural vitamin concentrations, the milk could be processed, sent to a store, and sold before vitamin concentrations became available. The natural vitamin content of raw milk varies extensively because of factors such as season, breed of the cow, and diet of the cow. Because dairy processors cannot routinely determine the vitamin concentration of all dairy products produced before sales, uniform guidelines must be established for vitamin preparation storage and addition in order to produce quality milk products that consistently meet FDA requirements.

CONCLUSIONS

The results from this survey indicate that various fortification procedures are used in the North Carolina dairy industry. The inconsistencies in procedures for vitamin fortification may contribute to variability among dairies in final vitamin concentrations in milk. The method used to add vitamin preparations to milk, the temperature at which vitamin preparations are stored, and the point during processing at which vitamin preparations are added differed among the North Carolina dairy processors.

Some of this variation might be eliminated by standardization of fortification procedures. Continued research must be conducted to determine which fortification practices should be used to achieve optimal fortification results. Because vitamins A and D cannot be tested routinely by dairies in-house as part of quality control, standard fortification procedures that optimize consistency and accuracy should be developed and implemented to help processors meet FDA requirements for vitamin fortification of milk.

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