DECEMBER, 1970
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Journal of

MILK and FOOD TECHNOLOGY

58TH ANNUAL MEETING
August 16, 17, 18, 19, 1971
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NOTICE
Page I and II
National Mastitis Council Meeting

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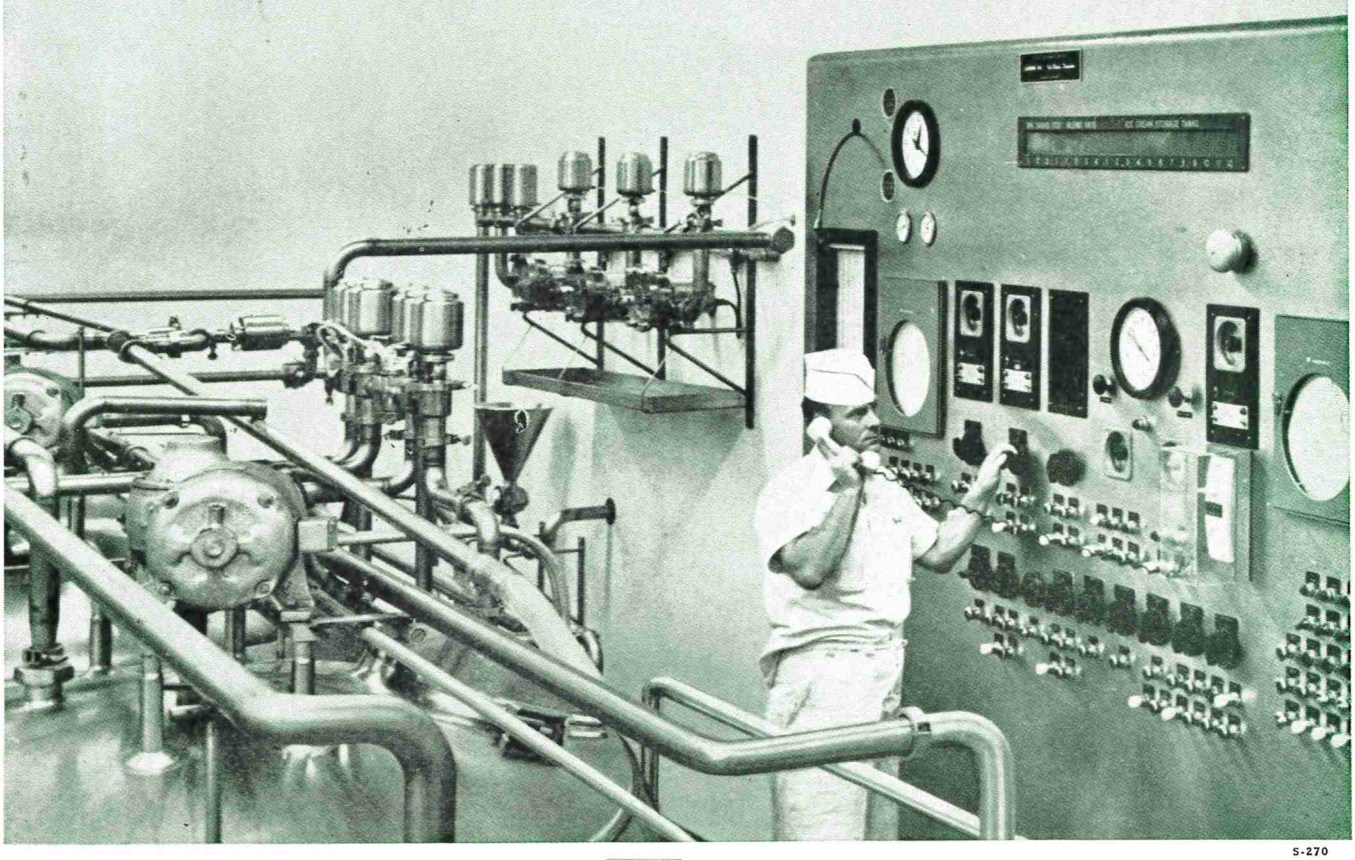

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Everyone interested in the prevention and control of bovine mastitis is cordially invited to attend the tenth annual meeting of the National Mastitis Council.

The program will emphasize the application of research information to the prevention and control of mastitis.

Dr. J. K. L. Pearson, Northern Ireland Ministry of Agriculture, will discuss "The Value of Cell Counting Methods in the National Herd" and "Progress Toward Mastitis Control—What Are Our Priorities?"

Featured speakers on the application of current research include Dr. W. N. Philpot, Louisiana State University; Dr. J. J. Mettler Jr., DeLavel Separator Company; Dr. D. H. Mercer, U. S. Food and Drug Administration; Dr. J. A. Jarrett, Rome, Georgia; Dr. A. M. Meek, Cornell University.

The current status and outlook for screening tests in milk quality control programs will be discussed by Dr. D. S. Postle, Cornell University, Dr. W. D. Schultze, USDA, Dr. W. W. Ullmann, Connecticut Department of Health, and Dr. J. C. Olson, Jr., FDA.

There will be three informal discussions on the evening of February 9:

1. Milking Practices—S. B. Spencer, Chairman, Pennsylvania State University

2. Dry Cow Therapy—Dr. R. P. Natzke, Chairman, Cornell University

3. Fieldman—Sanitarian Problems—H. J. Wilhelm, Chairman, Mountain Empire Dairymen's Assn.

Mr. W. D. Knox, Editor of *Hoard's Dairyman*, will summarize the 1971 program and give NMC a challenge for the future.

Plan now to attend this meeting. It will start at 9:00 A.M. on February 9 and adjourn at noon on February 10. Fill in the registration form and return it today to the National Mastitis Council. It will save for you and NMC if you send the registration fee with the form.

Send request for room reservation directly to the La Salle Hotel.

James W. Smith
President

NATIONAL MASTITIS COUNCIL ANNUAL MEETING

La Salle Hotel—Chicago, Illinois

February 8-10, 1971

PLEASE TYPE OR PRINT BOTH SECTIONS OF THIS FORM

Mail the top half to: National Mastitis Council, Inc., 910 Seventeenth Street, N. W., Washington, D. C. 20006

Fee of $15.00 per person includes registration, February 9 luncheon, and proceedings. Advance payment will save time at the registration desk. Your advance registration fee will be refunded if you are unable to attend. Make check payable to: National Mastitis Council, Inc.

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Journal of

MILK and FOOD TECHNOLOGY

INCLUDING MILK AND FOOD SANITATION

Official Publication

International Association of Milk, Food and Environmental Sanitarians, Inc.

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Vol. 22 December, 1970 No. 12

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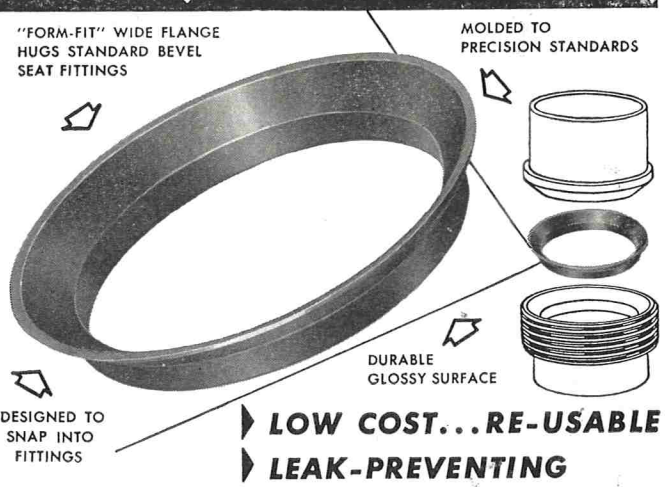

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In the past this *Journal* has been most concerned with the public health aspects of dairy products and other foods. We intend to continue and expand our efforts in this area. However, in keeping with the mandate of the founders, the needs of our readers, and the needs of research workers, we will, effective immediately, consider for publication papers in all areas of food and dairy science and technology. Examples of topics which are appropriate include:

- **Food, dairy, and environmental sanitation and hygiene**
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- **Agricultural sciences (animal, dairy, and poultry science; entomology; agronomy; horticulture; soil science; etc.) as they relate to food production, quality, safety, and processing.**

The Executive Board of IAMFES authorized expansion of the Editorial Board so that papers in all areas of food and dairy science and technology can be evaluated promptly. The Editorial Board now includes approximately 40 bacteriologists, chemists, sanitarians, and technologists from industrial, university, and government laboratories. These scientists are familiar with a wide array of foods such as dairy products, meats and meat products, poultry and poultry products, fish and other seafoods, fruits, vegetables, cereals, fermented products, food ingredients, confectionery products, etc.

Institution of a page charge ($25.00 per printed page) in 1969 has permitted expansion of the *Journal* so that acceptable research papers can be published within six months (or less) after submission.

Research workers in all areas of food and dairy science and technology are invited to submit research and review papers. They will be handled promptly and, if acceptable, will be published with dispatch. Membership in IAMFES is not necessary for publishing papers in the *Journal of Milk and Food Technology*. Interested authors can obtain "Instructions to Contributors" from the Editor.

E. H. MARTH
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Madison, Wisconsin 53706

ACKNOWLEDGEMENT OF ASSISTANCE BY REVIEWERS

The Editor acknowledges with thanks the help provided by members of the Editorial Board in the review of manuscripts. Many of the scientists on the Board have devoted numerous hours to evaluation of papers and offering suggestions to authors for improvement of their manuscripts. These efforts result in publication of significant and readable papers.

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QUALITY AND ECONOMIC CONSIDERATIONS IN THE DATING OF MILK[1]

I. INFLUENCE OF MILK DATING ON QUALITY OF MILK. A REVIEW OF LITERATURE

G. H. Watrous, Jr., and E. D. Glass, Jr.
Division of Food Science and Industry
and
W. T. Butz, W. F. Johnstone, and C. W. Pierce
Department of Agricultural Economics and Rural Sociology
The Pennsylvania State University
University Park, Pa. 16802

(Received for publication August 10, 1970)

Abstract

The age of milk available for purchase by consumers in dating markets is not significantly different than in coding markets. Moreover, dating regulations do not necessarily assure rapid movement of milk through marketing channels.

Some means of age identification is desirable. To insure proper rotation of milk in the store, coding of packages will aid in rotation and expedite proper milk movement without implying that age is directly related to quality.

Organisms surviving pasteurization grow so slowly at 40 F or below that they play little or no part in milk spoilage.

Properly pasteurized milk, protected from contamination after pasteurization, may be expected to show no increase in bacterial levels for at least 20 days if the temperature is maintained at 40 F or below.

Psychrophilic organisms, commonly found in raw milk and often associated with pasteurized milk deterioration, are destroyed or inactivated by prescribed pasteurization procedures.

Research does not support the premise that there is a meaningful relationship between age of pasteurized milk and quality. A dating regulation which includes an expiration date may discriminate against the product by implying a deterioration of quality which actually is not occurring.

The purpose of this phase of the study was to review the recent literature on milk dating and other factors which can influence the quality of pasteurized milk; and to make an assessment of the significance of these factors on the quality of pasteurized milk.

Milk Dating and Its Purposes

The term milk dating is used to designate the practice of marking milk containers with a day of the week or date of the month where it can be readily seen and understood by consumers. Dating may or may not include specification of a maximum elapsed time between pasteurization and legal sale to consumer. Presumably placing an identifiable date or day on the milk package enables consumers to distinguish recently processed from not so recently processed milk and thus facilitates rapid movement of milk through distribution channels.

Historically, the premise for dating requirements in milk regulations of some state and municipal governments was the assumption that the quality of pasteurized milk was related directly to its age. Polikoff *(16)* and Kirchoff *(13)* have reported that the practice of dating pasteurized milk containers originated during the second decade of this century. Polikoff studied dating regulations of 13 cities; of these, six established dating requirements between 1912 and 1917. Of 15 cities with dating requirements studied by Kirchoff in 1950, seven had established the requirements between 1912 and 1921.

Although the practice of dating may have had some value as a means of insuring the quality of pasteurized milk in the past, significant technological innovations in milk production, processing, packaging, and distribution have improved the keeping quality of pasteurized milk to the point where dating as a public health measure may no longer be necessary.

The assumption that dating promotes more rapid movement of milk through marketing channels has been studied. Dahlberg *(6)* reported on the age of milk available for purchase by consumers in a dating market (New York City) and non-dating or coded market (Nassau, West Chester, and Suffolk counties) in 1957. In the dating market, 91.7% of the total milk inventoried (38,237 quarts) was marked as today's milk, 3.6% was yesterday's milk and 0.3% was two-to three-day old milk. The remaining 4.4% was predated, i.e., marked as tomorrow's milk. Predating by a maximum of 36 hr previous to the day shown on the container was legal, but distribution of predated milk to stores was in violation of the market's dating regulation.

In the non-dating market, 82.4% of the total milk inventoried (7,610 quarts) was coded as today's milk, 15.3% was yesterday's milk and 2.3% was two- to four-day old milk. Regarding the age differences found in dating and non-dating markets, Dahlberg concluded:

"Except for a shift of about 10% in the percentages of today's and yesterday's milk, which is

[1]This study was financed by the Milk Industry Foundation.

of no significance in milk quality, coded milk sold outside New York City, with no time limit for sale, was the same age as dated milk sold within the city."

In May of 1960, the New York State Legislature passed a law prohibiting local boards of health from adopting and enforcing milk dating regulations. This state law was subsequently amended and milk dating reestablished in New York City in May of 1962. In May of 1961, Dahlberg *(5)* investigated the age of milk available for sale in 154 stores in New York City during the period when dating of containers was not required (and coding was not practiced by the industry). Dahlberg elicited cooperation of three selected New York City processors who coded their milk for the period of the study. Coding practices were held confidential to insure that no rotation of product in the store sales case took place as a result of the code. Of the total milk (21,142 1-quart and 2-quart containers), 89.17% was today's milk, 9.36% was yesterday's milk, 1.37% was two- to three-day old milk, and 0.10% four- to six-day old milk. Significantly, all of the four- to six-day old milk was found in 2-quart containers in a single store. Dahlberg's principal conclusions regarding the age of milk offered for sale in undated (1961 survey) and dated (1957 survey) milk containers were as follows:

"Updated milk in 154 food stores surveyed had the same period of time from pasteurization to sale to consumers as previously found for dated milk, except in one food store. The milk in this one food store (which was older than necessary under good milk distribution practices and which may cause consumer complaint due to developed off-flavor) represented one container in each 4,000 sold. To provide a method of detecting these isolated instances of not maintaining an entirely satisfactory rate of movement of milk to consumers at all times, it is recommended again that retail undated milk containers should be marked by codes known to those responsible for proper handling of the milk, but not to the public."

Contrariwise, Kirchoff *(13)* reported seizures of overage milk in Jefferson County, Ala., in 1948. At that time the Jefferson County dating regulation permitted 60 hr elapsed time between pasteurization and time of sale in stores. In 1948, health department officials made 2,445 seizures of overage milk-37% was 3 days old, 32% 4 days old, 14.5% 5 days old, 9.5% 6 days old, 4.4% 7 days old, and 2.1% 8 or more days old.

TEMPERATURE OF MILK

The most recent data (1969) on the temperature of milk available for purchase by consumers is that of Barnard *(2)*. A summary of approximately 2 years' data (588 samples) on milk available in the sales cases of Pennsylvania stores revealed that 34.9% of all milk was stored at 40 F or lower, 46.6% was held between 41 and 45 F and 18.5% was stored at temperatures in excess of 45 F. Barnard's data also indicate that the temperature of milk available for sale in stores fluctuates seasonally. Bi-monthly temperature data for July-August 1968 showed 28.3% of the sample temperatures in excess of 45 F, as compared to 7.8% of sample temperatures in excess of 45 F during the most recent bi-monthly (Jan.-Feb. 1969) period.

Witter et al. *(22)* presented significant data on the temperature of milk available for purchase in stores in Chicago. Temperature observations were made on milk available for purchase during the summer and winter of 1957. A total of 60 temperature observations were made, 30 during April-July of 1957 and 30 during November 1957-February 1958. Although the observations were limited in number, results parallel those reported by Barnard. Of the 60 samples, 35.0% of all milk was stored at below 40 F, 48.3% was held between 40-45 F, and 16.7% was stored at temperatures in excess of 45 F.

DELIVERY

Dahlberg *(6)* studied the time of delivery of milk to food stores in dating and non-dating markets. Significantly, deliveries arriving at stores prior to the arrival of store personnel were almost twice as common in dating markets (47% of stores served) as in non-dating markets (24% of stores served). Robinson *(18)* commented on the practice of delivery to stores prior to the arrival of store personnel:

"In addition to the economic aspect, dating of pasteurized milk has at times led to situations presenting public health hazards. In some instances, due to the limited time pasteurization plants are permitted to make deliveries after pasteurization, they are required to make store deliveries several hours before the stores open in the morning. The milk is set in the front doorway without protection from the heat . . ."

The temperature of milk obviously affects shelf life. If delivery practices permit temperature increases, product deterioration is encouraged. Thus the observations of Dahlberg and Robinson are important.

BACTERIAL QUALITY

Witter's review *(21)* shows either laboratory or commercial pasteurization to be effective in destroy-

ing psychrophilic bacteria in the concentrations usually present in raw milk. The so-called psychrophilic group of bacteria includes many organisms normally found in raw milk, water, and the environment of the animal. These organisms are cold enduring; i.e., able to grow at low temperatures, but will grow more rapidly as the temperature increases to a maximum of about 80 F.

Evans et al. *(8)* indicated that milk heated to temperatures in the range of 220 to 260 F for 0.6 sec had acceptable bacterial quality after 4 weeks of storage at 40 F. Use of temperatures between 240 and 260 F for 0.6 sec provided an additional acceptable bacterial shelf life (at 40 F) of 4 weeks, a total of 8 weeks.

More recently, Finley and Warren *(9)* found that UHT (Ultra High Temperature) processing of milk (200 to 220 F for 0.5 to 16 sec) imparted an acceptable shelf life as long as 20 weeks when kept at 32 F.

Dabbah et al. *(4)* found that psychrophilic organisms isolated from aged pasteurized milk were inactivated when heated at 131 F for 30 min. Growth was reactivated by holding the heated bacteria in a special medium at 68 F for 48 to 72 hr, or at 39 F for 2 to 3 weeks. It should be pointed out that 131 F and an exposure of 30 min is less lethal than 145 F for 30 min, the recognized USPHS standard. Significantly, Dabbah et al. were unable to find surviving organisms when the test culture was heated to 140 F for 30 min.

Grosskopf and Harper *(11)* in a recent study (1969) found that fluid pasteurized milk aseptically packaged in standard plastic coated paper containers and stored at 38.2 F had a shelf life of 4 weeks. Subsequent loss of quality was attributed to growth of a psychrophilic spore-forming organism. It would appear reasonable to assume that higher storage temperatures would have encouraged more rapid growth of this organism. Their initial results suggest about 25% of raw producers' milk supplies contain psychrophilic spore-formers that were capable of surviving even UHT pasteurization.

Perhaps the first conclusive evidence that psychrophilic organisms are destroyed or inactivated by laboratory and vat pasteurization was the work of Watrous et al. *(20)*. They also noted that the surviving thermoduric (heat resistant) organisms fail to reproduce for at least 20 days in laboratory pasteurized milk samples held at 40 F. Subsequent observations by Atherton et al. *(1)* showed that as the storage temperature of laboratory pasteurized milks was increased, some thermodurics entered a growth phase. Growth at 45 F was very slow for 12 to 15 days, and was more rapid at 50 F.

Many studies *(1, 3, 7, 10, 12, 19, 22)* have shown that as the storage temperature of pasteurized milk increases the bacterial populations also increase, indicating that pasteurized milk should be held at 40 F or below to achieve maximum shelf life.

Studies by Langlois et al. *(14, 15)* and by Randolph et al. *(17)* have indicated significant differences among plants with respect to keeping quality of their milk, suggesting that plant sanitation procedures and storage temperatures and times were important variables.

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QUALITY AND ECONOMIC CONSIDERATIONS IN THE DATING OF MILK[1]

II. EXTENT, NATURE, AND TRENDS IN MILK DATING

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ABSTRACT

There has been a sharp decline in the incidence and extent of dating ordinances in the past decade. Six areas now have dating ordinances compared with 21 in 1957. Per cent of the U. S. population residing in areas where dating of milk is required declined from 15 to 9% from 1957 to 1969.

No area has adopted dating regulations since 1957. Furthermore, enforcement of dating regulations is prohibited by state legislation in Illinois, Ohio, Connecticut, and Virginia.

Four areas which have retained dating ordinances have increased the time period allowable between time of pasteurization and sale of milk to consumers. Two jurisdictions do not specify a time limitation between pasteurization and sale of milk.

Expiration dating is required in New York City, Baltimore and Jefferson County (incl. Birmingham), Ala. Pasteurization dating is required in the State of New Jersey, St. Louis, and Suburban Philadelphia.

Adoption of the U. S. Public Health Service Grade "A" Pasteurized Milk Ordinance by many states appears to be the dominant reason for removal of dating ordinances by areas that formerly required dating.

This phase of the study was conducted to assess the number of states or other political subdivisions which currently require marking of milk containers with date markings that can be readily understood by the consumer. Principal features of the regulations were reviewed and patterns of change in numbers or regulatory provisions, if any, were identified and documented. A study conducted by the U. S. Department of Agriculture in 1957 provided a major bench mark from which to measure changes *(1)*.

INCIDENCE OF MILK DATING

To determine the extent of milk dating, a mail survey was conducted among health departments and/or agricultural departments of each of the states of the continental United States. The questionnaire was mailed to the respective officials during December 1968. In early January 1969, a follow-up letter and a second copy of the questionnaire were mailed to authorities in the 14 states who had not responded to the initial inquiry. By February 1969, a complete tabulation of the occurrence of milk dating regulation was available.

This survey and subsequent inquiries indicated that the following six jurisdictions, listed in descending order of population, required dating of milk in September 1969: (*a*) New York City, New York; (*b*) State of New Jersey; (*c*) Baltimore, Maryland; (*d*) St. Louis, Missouri; (*e*) Jefferson County, Alabama (includes Birmingham); and (*f*) Suburban Philadelphia, Pennsylvania (eight boroughs and/or townships).

The several boroughs and/or townships of Suburban Philadelphia were considered as one place for this study since the municipalities are interspersed in two adjacent Pennsylvania counties and the dating speci-

[1]This study was financed by the Milk Industry Foundation

fications in each municipality are essentially the same.

TRENDS IN MILK DATING

The incidence of milk dating has declined since 1957. No state, city, or other political subdivision has adopted a milk dating ordinance since the 1957 enumeration by the U. S. Department of Agriculture. Five of the six markets in which dating of milk is presently required have made revisions of their dating ordinances since 1957. Fifteen places which in 1957 required dating of milk have repealed or inactivated their dating ordinances.

Based on 1960 populations, markets requiring milk dating in 1957 included 14.9% of the U. S. population (Table 1). By 1969, however, only 9.1% of the 1960 population resided in dating markets. Marketing areas which have repealed dating legislation since 1957 contained 5.8% of the U. S. population in 1960.

The survey responses suggested that coding containers for inventory control is widely practiced by processors and stores for inventory control purposes. A few states and minor political subdivisions require coding identifiable by the health or regulatory agency but not readily decipherable by consumers.

SPECIFICATIONS OF ACTIVE DATING ORDINANCES

Dating regulations may be classified as (*a*) expiration dating or (*b*) time of pasteurization dating. The first is the most stringent. In general, in expiration dating the package must clearly show a date after which it is illegal to sell the milk. In time of pasteurization dating, the container must indicate the day or date of pasteurization, or as in the St. Louis market, the day after pasteurization. Some regulations specify a limitation on time between pasteurization and sale of the milk. None of the existing dating regulations were copied from a single model or one from another. The language and specifications of each are uniquely local.

Expiration date labeling is required in New York City, Jefferson County, Ala., and Baltimore, Md. New York City and Jefferson County, Ala., had expiration dating in 1957. Baltimore switched from pasteurization labeling to expiration dating in 1968. Pasteurization dating is required in the other three markets: St. Louis, State of New Jersey, and Suburban Philadelphia (Table 2). The Suburban Philadelphia regulation specifies a time limitation between pasteurization and sale, but this is not indicated on the label.

A few states actually prohibit minor jurisdictions from requiring the dating of milk. For example, the revised statute in Illinois (Sec. 220, Chapter 56 1/2) reads in part:

> ". . . however, no county, city, village, or incorporated town shall require the carton or container label to show the date of processing or a date before which such Grade A products must be sold, or after which dates such products must be sold, or after which dates such products may not be sold."

Prior to this statute, Chicago and a number of Illinois municipalities had dating requirements. Ohio and Connecticut also prohibit dating requirements by lesser jurisdictions. The code of the City of Richmond, Va., contains a dating (day of week) requirement but its enforcement is prohibited by a statewide law passed in 1962.

TABLE 1. AREAS REQUIRING DATING OF MILK, WITH POPULATIONS, 1957 AND 1969. (ALL POPULATION DATA BASED ON 1960 U.S. POPULATION OF 179,323,000.)

Area	Resident population[a] 1960		
Areas requiring the dating of milk in 1969			
New York City, New York	7,781,984		
State of New Jersey	6,066,782		
Baltimore, Maryland	939,024		
St. Louis, Missouri	750,026		
Jefferson County, Ala. (incl. Birmingham)	634,984		
Suburban Philadelphia area[b]	175,903		
Total population of above areas in 1960		16,348,583	
Per cent of total U.S. population in 1960			9.1
Areas repealing milk dating ordinances since 1957[c]			
Berwyn, Illinois	54,224		
Chicago, Illinois	3,550,404		
Cicero, Illinois	69,130		
Forest Park, Illinois	14,452		
Maywood, Illinois	27,330		
Napierville, Illinois	12,933		
Waukegan, Illinois	55,719		
Boston, Massachusetts	697,197		
Cleveland, Ohio	876,050		
Louisville, Kentucky	390,639		
State of Connecticut	2,535,234		
Detroit, Michigan	1,670,144		
Richmond, Virginia	219,958		
Newton, Massachusetts	92,384		
Pontiac, Michigan	82,233		
Total population of above areas in 1960		10,349,031	
Per cent of total U.S. population in 1960			5.8
Per cent of U.S. population in 1960 living in areas having milk dating regulations in 1957			14.9

[a]U.S. Census.

[b]This area includes Lower Merion Township and Narbeth Borough in Montgomery County; Haverford Township, Radnor Township, Sharon Hill Borough, Yeadon Borough, Alden Borough and Lansdowne Borough in Delaware County. The Boards of Health of Lower Merion Township, Lansdowne Borough and Narbeth Borough are associated as Pennsylvania Milk Control District No. 1.

[c]By repeal, supersession, or inactivation.

TABLE 2. SUMMARY OF LIMITATIONS BETWEEN TIME OF PASTEURIZATION AND SALE, BY AREA, 1969.

Expiration dating	
New York City, N.Y.	Expiration date shown on container shall not be more than 66 hr after 6:00 a.m. following pasteurization.
Baltimore, Md.	Expiration date shown on container shall be 90 hr from day of pasteurization—"Day of Pasteurization" means the 24-hr period ending at 6:00 a.m. during which the milk was pasteurized.
Jefferson County, Ala.	Expiration date shown on container shall not exceed a time period of more than 120 hr (5 days) from time of pasteurization.
Pasteurization dating	
State of New Jersey	Containers shall be marked with the day of the week on which milk was pasteurized or with the term "pasteurized" during the 24-hr period ending 6:00 a.m. (*day of week at end of this period*).
	There is no legal restriction on the time between pasteurization and sale.
St. Louis, Mo.	Milk pasteurized one day will show the following day on the label, except when there is a complete shut down of pasteurization it may show the day following the day of shut down. No milk may be delivered prior to day shown on label.
	There is no legal limitation on time between pasteurization and sale.
Suburban Philadelphia, Pa.	The day of pasteurization shall be marked clearly on the container.
	All milk shall be delivered to the consumer within 60 hr after midnight of the day of pasteurization.

New York City established its dating requirement as early as 1914. According to Leland Spencer, "the dating of milk has been a troublesome issue for the New York City Board and Department of Health for a long period of time" (2). In 1953 the New York Commissioner of Health invited all interested persons to attend a Board of Health hearing to consider the elimination of milk dating. Milk processors favored repeal on the ground that dating served no useful purpose and added to the costs of processing and distribution. Producer representatives favored elimination because they felt the practice reduced availability of milk to consumers. Elimination of dating was vigorously opposed by drivers' unions and some consumer groups. The unions argued that abolition of milk dating would tend to cause larger loads and less frequent delivery and thus would reduce employment of drivers.

Significantly, spokesmen for both the New York State Department of Health and the U. S. Public Health Service testifying at the 1953 hearing stated that their agencies no longer recommend the dating of milk. Referring to this controversy, Spencer states ". . . the dating issue was almost wholly economic and political, bearing little or no relation to the protection of public health."

In a 1952 New York court case (West Chester Milk Council, Inc. vs. City of Mt. Vernon) the State Health Department told the court, "Any regulation requiring the dating of milk serves no useful purpose . . ."

The controversy over dating appears to have sometimes been between milk processors and producers on one side, and drivers' unions and certain consumer groups on the other, with the health department in the middle.

The persistence of this issue can be illustrated by actions of the New York legislature and the Department of Health. The legislature amended the N. Y. Public Health Law in 1960 to prohibit local boards of health from adopting and enforcing milk dating regulations. In 1962, the foregoing state law was again amended by removing the prohibition. The New York City Board of Health responded by reenacting a dating ordinance on March 6, 1962.

Adoption of the U.S. Public Health Service Grade A Pasteurized Milk Ordinance and Code (1965) by many states appears to have reduced the concern of state and lesser jurisdictions for dating. In the mail survey discussed previously, this Ordinance and Code was cited frequently by respondents as the reason for the repeal or deactivation of dating ordinances. For example, the City of Detroit had a milk dating ordinance which was superseded by the adoption of a state-wide uniform inspection program on January 1, 1966. Several respondents voluntarily indicated that use of the U.S. Public Health Service Ordinance had eliminated the need for dating regulations as a factor in the supply of pure and wholesome milk to consumers.

Many state and local public health officials have indicated that under modern methods of processing, refrigerating, and retailing milk, dating of milk cannot be justified on grounds of protecting the health of consumers. Responses to this effect were noted in the replies of public health officials to the mail survey. For instance, E. G. Huffer, Chief, Division

of Milk Control, Department of Public Health, State of Illinois, wrote:

> "From a public health point of view, dating has no significance. . . "

Representative of other replies were the comments of G. C. Fulkerson, Supervisor, Milk and Food Sanitation Section, Bureau of Environmental Health Services, Tennessee Department of Public Health, who stated:

> "There are no areas in the State that require milk dating on the label. Dating of milk is unenforceable and can't be justified from a health standpoint."

H. Mazer, Chief, Bureau of Milk and Chemistry, Department of Health and Hospitals, City of Boston, summed up the views of public health officials in stating simply that:

> "Under present marketing conditions, dating has no valid relevance."

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QUALITY AND ECONOMIC CONSIDERATIONS IN THE DATING OF MILK[1]

III. DELIVERY PRACTICES AND COSTS. DIFFERENCES BETWEEN DATING AND NON-DATING MARKETS

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ABSTRACT

Stores located in markets in which dating of milk was required generally received more frequent delivery of milk than stores in non-dating markets. The greatest difference in frequency of delivery between dating and non-dating markets occurred among small stores (stores purchasing less than two cases per delivery). Small stores in dating markets received one more delivery per week than small stores in non-dating markets.

Volume of unsold milk returned by stores was higher in dating than in non-dating markets. Elimination of milk dating could lead to more efficient, less costly systems of delivery to stores. Potential savings from elimination of milk dating currently range from 0.8 of a cent to 1.4 cents per quart, depending primarily upon the extent to which fluid milk processors have already adopted systems of less frequent delivery to small and medium stores.

One of the principal objectives of this study was to ascertain differences, if any, between dating and non-dating markets with respect to processor practices and costs in delivering milk to stores. To obtain information regarding delivery practices, questionnaires were mailed to fluid milk processors in each of the six marketing areas requiring dating. Data collected in the mail survey, conducted during April and May 1969, related to delivery practices in 1969.

Each of the six marketing areas studied included both dating and non-dating sections; the non-dating territory being that part of the area in which dating was not required. For example, the Baltimore marketing area consisted of a dating section (Baltimore City) and a contiguous non-dating section (other portions of the Baltimore metropolitan area). Processor-distributors participating in the study delivered milk to stores located in Baltimore City as well as to stores located in sections of the marketing area in which dating of milk was not required.

With the exception of the New Jersey area, processors participating in the study accounted for well over 50% of the total sales of milk to stores in their respective marketing areas. In the New Jersey area, processors in the study accounted for about one-third of the sales through stores.

[1]This study was financed by the Milk Industry Foundation.

TABLE 1. NUMBER OF MILK PROCESSOR-DISTRIBUTORS PARTICIPATING IN STUDY OF DELIVERY PRACTICES IN DATING AND NON-DATING MARKETS, BY MARKETS, 1969.

Marketing area	Number of processors	Number of routes on which milk was delivered to stores	
		Wholesale routes	Mixed routes
		——(Number)——	
New York City, N.Y.	10	629	332
State of New Jersey	9	176	223
Baltimore, Md.	3	42	201
St. Louis, Mo.	9	204	44
Jefferson County (incl. Birmingham), Ala.	5	139	35
Suburban Philadelphia, Pa.	8	247	603
Total	44	1,437	1,438

A total of 44 processor-distributors in the six marketing areas provided information on delivery practices (Table 1). Processors participating in the survey operated more than 1,400 wholesale routes. In addition, processors in the study operated more than 1,400 mixed routes from which both retail and wholesale stops, including stores, were served.

DELIVERY PRACTICES

Frequency of delivery

Stores located in dating sections of markets generally received more deliveries per week than stores in non-dating portions of markets. Since frequency of delivery directly influences costs of delivery, unit costs of delivery are usually higher in dating than in non-dating markets. Eventually, these higher costs are passed on to consumers.

Small-size deliveries. The more frequent service to stores in dating markets was especially evident among the smaller stores (stores purchasing less than two cases per delivery). In dating markets, for instance, small stores served from mixed routes received an average of 4.6 deliveries per week (Table 2). In contrast, stores of comparable size on mixed routes in non-dating markets were served 3.6 times per week—or one delivery less per week. In all markets except Jefferson County, Ala., stores receiving small deliveries from mixed routes received more deliveries per week in dating than in non-dating sections of the market. In Jefferson County there was

TABLE 2. FREQUENCY OF DELIVERY TO STORES, BY SIZE OF DELIVERY AND TYPE OF ROUTE, DATING AND NON-DATING SECTIONS OF SIX MARKETING AREAS, 1969.

Marketing area and size of delivery[a]	Type of market and type of route			
	Dating section of market		Non-dating section of market	
	Mixed routes	Wholesale routes	Mixed routes	Wholesale routes
	——(average number of regular deliveries per week per stop)——			
Small deliveries				
New York City, N.Y.	6.0	6.0	4.0	5.3
State of New Jersey	5.2	5.3	4.0	4.2
Baltimore, Md.	3.7	4.0	3.5	3.0
St. Louis, Mo.	3.7	3.0	2.5	2.3
Jefferson County (incl. Birmingham), Ala.	3.0	5.0	3.0	4.3
Suburban Philadelphia, Pa.	5.8	5.2	4.6	4.6
Average for six marketing areas	4.6	4.8	3.6	4.0
Medium deliveries				
New York City, N.Y.	6.0	6.0	4.3	5.7
State of New Jersey	5.6	5.9	5.7	5.5
Baltimore, Md.	5.0	5.0	5.0	4.5
St. Louis, Mo.	4.0	4.6	4.3	3.7
Jefferson County (incl. Birmingham), Ala.	4.0	5.0	3.0	5.0
Suburban Philadelphia, Pa.	5.8	5.3	4.2	4.3
Average for six marketing areas	5.1	5.3	4.4	4.8
Large deliveries				
New York City, N.Y.	—	6.0	—	6.0
State of New Jersey	—	6.1	—	5.0
Baltimore, Md.	—	5.0	—	5.0
St. Louis, Mo.	—	5.3	—	5.0
Jefferson County (incl. Birmingham), Ala.	—	5.5	—	5.2
Suburban Philadelphia, Pa.	—	5.2	—	4.9
Average for six marketing areas	—	5.5	—	5.2

[a]Size of delivery defined as follows: small—less than 2 cases per delivery; medium—2 to 10 cases per delivery; large—10 cases or more per delivery.

no difference between dating and non-dating sections of the marketing area in terms of frequency of mixed-route delivery to stores receiving less than two cases per delivery.

Similarly, small stores served from wholesale routes received more frequent delivery of milk in dating than in non-dating markets. The frequency of service for small orders on wholesale routes averaged 4.8 deliveries per week per store in dating sections of markets as compared to 4.0 deliveries per week per store in non-dating sections of markets. Wholesale routes in all six markets served small stores more frequently in the dating section of the market than in non-dating sections.

In the Baltimore and Birmingham markets, dating requirements appeared to have little impact on the frequency with which small deliveries on mixed routes were made. In these two markets, there were either no differences or only minor differences in frequency of delivery between dating and non-dating segments of the marketing areas.

In contrast, in the other four markets, there were relatively wide differences between the dating and non-dating segments of the marketing area in terms of the frequency of small deliveries per store served from mixed routes. The maximum difference occurred in the New York City marketing area. Within the City (the dating portion of the market) stores receiving small orders from mixed routes received six deliveries per week. By comparison, outside the City (in the non-dating segment of the marketing area), small deliveries on mixed routes were served only four times a week.

The non-dating portion of the St. Louis marketing area had the least-frequent deliveries to small stores. This size of delivery in the non-dating section of the St. Louis market received an average of less than three deliveries per week, whether the store was served from a mixed or a wholesale route.

Medium-size deliveries. Stores purchasing from 2 to 10 cases per delivery (medium stops) were generally served more frequently in dating than in non-dating markets, irrespective of whether the store was served from a mixed or a wholesale route. Differences in frequency of delivery per store between dating and non-dating markets were smaller, however, than was true for small-size deliveries.

Medium-size deliveries on mixed routes were made an average of 5.1 times per week in dating markets and 4.4 times per week in non-dating markets. For this size of delivery, in four of the six markets studied, the frequency of delivery on mixed routes was equal to or higher in dating sections of markets than in non-dating sections.

On wholesale routes, frequency of delivery to medium-size stores averaged 5.3 deliveries per week in dating markets and 4.8 deliveries per week in non-dating markets. In five of the six markets, the frequency of delivery to medium stores on wholesale routes was higher in dating than in non-dating markets. In the Jefferson County marketing area, medium-size deliveries from wholesale routes were made five times a week in both the dating and non-dating sections of the market.

Large-size deliveries. In all six markets, deliveries to large stores (stores purchasing 10 cases or more per delivery) were made from wholesale routes only. In dating markets, large stores received an average of 5.5 deliveries per week. In non-dating markets, these stores were served 5.2 times per week.

In all markets except Baltimore and New York City, stores in the dating sections of the markets received milk deliveries more frequently than stores in the non-dating sections. In Baltimore and New York City, large stores in each market received the same number of deliveries whether the store was located in the dating or non-dating section of the market.

In summary, information supplied by fluid milk processors concerning frequency of delivery indicates rather conclusively that stores in dating markets generally received deliveries more frequently than stores in non-dating markets. This result was observed for all sizes of deliveries, although there were exceptions noted in some markets. The magnitude of the difference in frequency of delivery between dating and non-dating markets declined as size of delivery increased.

Place of delivery

Only minor differences were noted between dating and non-dating sections of markets with respect to the place where milk was delivered to a store. In both dating and non-dating markets, for example, milk was delivered more often to the display case or to the store's cold room than to any other locations in the store. Among small- and medium-size deliveries, the display case was the most common place of delivery to stores in dating and non-dating markets (Table 3). The store's cold room was the second most common place of delivery for small and medium stores.

With large deliveries, the cold room and the display case were the principal places for delivery of milk, although delivery to the store's dock was much more common than with stores receiving small or medium deliveries.

Volume of milk returned by stores

In each of the six marketing areas, the proportion of milk returned by stores was higher in dating sections of markets than in non-dating sections of markets. Among dating markets, the volume of returned

TABLE 3. PLACE OF DELIVERY TO STORES, BY SIZE OF DELIVERY, DATING AND NON-DATING MARKETS, 1969.

Place of delivery	Size of delivery and type of market					
	Small delivery		Medium delivery		Large delivery	
	Dating section of market	Non-dating section of market	Dating section of market	Non-dating section of market	Dating section of market	Non-dating section of market
	(Number of processors indicating delivery made to this place)[a]					
Store dock	11	11	10	11	17	16
Store cold room	21	20	28	28	30	32
Display case in store	31	30	32	30	30	26
Processors' dock	4	3	4	3	4	5
Other	1	1	1	1	1	1

[a]Number of processors in each column totals more than the number of processors in study inasmuch as most processors indicated more than one place of delivery for each size of delivery.

milk expressed as a proportion of the volume of milk delivered to stores ranged from 1.5% in St. Louis to 8.3% in Jefferson County (Table 4). In non-dating markets, by contrast, the comparable proportions ranged from 0.7% in the non-dating section of the New York City marketing area to 1.8% in the non-dating portions of the Jefferson County marketing area.

These results tended to substantiate the findings of previous studies of differences between dating and non-dating markets in volume of unsold milk returned by stores. The study by Wilson *(3)* of several Alabama markets reported higher returns of unsold milk from dating than from non-dating markets. In the Alabama study, the volume of returns on 92 wholesale routes operating in Jefferson County (Birmingham market) was compared with volume of returns from 27 wholesale routes operated in Montgomery, Ala.—a non-dating market—during April 1966. On a volume basis, returns as a proportion of deliveries amounted to 7.7% in Birmingham and 3.4% in Montgomery. The value of returns totaled 8.0% of the value of deliveries in Jefferson County and 3.4% in Montgomery. These results were directly comparable to and agreed closely with the present findings in the dating and non-dating sections of the Jefferson County marketing area.

The U. S. Department of Agriculture conducted a study in 1957 of the incidence of milk dating and the effect of dating on delivery practices *(1)*. Data were collected from dating and non-dating markets in all regions of the country. The study reported that returns on wholesale routes averaged 5.5% in dating markets in which a 36- or 48-hr limit was placed on sale of milk. In all dating markets, returns on wholesale routes averaged 2.8% of wholesale load-outs. In contrast, in non-dating markets, the volume of returns was 2.3%. In the study conducted by the U. S. Department of Agriculture, volume of returns on wholesale routes was expressed as a percentage of load-out. This method of calculating returns results in a lower estimate of returns than an estimate based on deliveries. Although the findings in the study by the U. S. Department of Agriculture are not directly comparable to results in either the present analysis or to the Alabama report, results from all three studies do support the general conclusion that the volume of returned milk is higher in dating than in non-dating markets.

TABLE 4. FLUID MILK PRODUCTS RETURNED BY STORES, DATING AND NON-DATING MARKETS, BY MARKETS, 1969.

Marketing area	Volume of returned milk as proportion of store deliveries[a]	
	Dating section of market	Non-dating section of market
	(Percent)	
New York City, N.Y.	2.6	0.7
State of New Jersey	3.2	1.0
Baltimore, Md.	4.0	1.5
St. Louis, Mo.	1.5	1.1
Jefferson County (incl. Birmingham), Ala.	8.3	1.8
Suburban Philadelphia, Pa.	5.4	0.8

[a]Percentages calculated from unweighted averages. Data in study suggest that weighting of returns according to size of business would have resulted in reducing the estimated percentage of returns for each marketing area.

EFFECT OF DATING REGULATIONS ON PROCESSING AND DISTRIBUTION COSTS

Differences between dating and non-dating markets in terms of processors' practices in delivering milk to stores generally result in higher delivery costs in dating than in non-dating markets. In addition, dating regulations also may affect processing practices and costs of processor-distributors.

One of the most recent and comprehensive studies of the effect of dating regulations on processing and delivery costs of milk processors was conducted in New Jersey in 1963. The study was carried out by Case and Company, a management consultant firm, for the New Jersey Department of Agriculture *(2)*.

The 1963 analysis indicated that a savings of 1.649 cents per quart could have been realized in processing

TABLE 5. ESTIMATED SAVINGS IN MILK PROCESSING AND DELIVERY COSTS FROM ELIMINATION OF MILK DATING, NEW JERSEY, 1963 AND 1969.

Cost item	Savings[a] 1963	1969
	-(Cents per quart)-	
1. Cost that would be eliminated with no change in operation:		
A. Processing and dumping returned milk	.076	.101
B. Delivering and picking up returns	.027	.029
Subtotal	.103	.130
2. Cost savings assuming changes in operation and scheduling:		
A. Operating plant 5 days rather than 7 days a week	.081	.415
B. Better direct labor utilization based on longer runs and fewer change-overs	.314	
C. Serving neighborhood stores and small supermarkets on every-other-day delivery	.911	.695
D. Placing approximately one-half of neighborhood stores on retail system	.240	.162
Subtotal	1.546	1 272
Total possible savings	1.649	1.402

[a]Source: *1963 data from Cost Reductions from Elimination of Milk Dating, Estimates of Case and Company,* as Reported to the New Jersey Secretary of Agriculture, NJDA Milk Study No. 5, July 1963. 1969 data supplied by Case and Company, Inc., New York, N.Y.

and delivery costs if milk dating was eliminated in New Jersey (Table 5, column 1). The major savings would have been achieved by serving small stores less frequently (Items 2C and 2D). In 1963, for instance, these two changes in delivery practices could have reduced delivery costs by 1.151 cents per quart, or 70% of the total possible savings. Based on the volume of 312 million quarts sold through stores during 1963, the fluid milk industry in New Jersey could have realized a yearly reduction of $5.1 million in processing and delivery costs if milk dating regulations had been eliminated.

Case and Company also compiled during the summer of 1969 an estimate of savings in milk processors' costs that could be presently realized if dating regulations in New Jersey were repealed. This estimate, shown in column 2 of Table 5, totaled 1.402 cents per quart.

The principal source of potential savings—in 1969 as in 1963—would be a system of less frequent deliveries to the smaller grocery stores (Table 5, Items 2C and 2D). These two items accounted for slightly more than 60% of the total saving possible in 1969 through elimination of milk dating.

Differences in estimated savings in New Jersey: 1963 and 1969

Estimates by Case and Company indicate that the total saving that could be realized in New Jersey by eliminating milk dating regulations has declined from 1.649 cents per quart in 1963 to 1.402 cents in 1969. This decrease in savings resulted solely from reductions in possible savings from less frequent delivery. Costs—and thus the possible savings—of all processing activities, such as handling of returns, 5-day plant operation and fewer product change-overs, increased between 1963 and 1969. Principal reason for these increases was the rise in wage rates during the 1963-1969 period.

Increases in wage rates, especially those of wholesale deliverymen, also had an impact on possible savings from less frequent delivery to stores. The cost saving for Items 2C and 2D declined between 1963 and 1969, because by 1969 many processor-distributors had adopted the practices of every-other-day delivery to small stores and/or service of small stores from home-delivery routes. Cost savings realized from more efficient delivery systems more than offset the increase in wage costs between 1963 and 1969. The net effect was a reduction in cost savings that could be realized from repeal of milk dating legislation. In brief, the greater adoption in recent years of more efficient delivery practices, such as less frequent delivery to small, neighborhood stores—as well as the decline in numbers of such stores—has resulted in a more economical system of delivery to stores in New Jersey. Consequently, the cost savings that can be realized by the industry from elimination of milk dating has declined as more and more processors in the fluid milk industry have adopted more efficient delivery practices.

Similarly, the cost savings resulting from less frequent operation of a processing plant would be expected to be less than 0.415 of a cent in markets which have already adopted plant schedules of 5- or 6-day operations. Thus, the possible savings in New Jersey markets from elimination of milk dating probably varies from 1.0 to 1.4 cents per quart, depending upon the rate at which processors in the market have adopted more efficient processing and delivery practices. In markets where those practices have been widely adopted, the potential cost savings is approximately 1.0 cents per quart. Possible savings of up to 1.4 cents could be realized in New Jersey markets where less frequent processing and delivery schedules have not been widely adopted by processors.

TABLE 6. ESTIMATED ANNUAL INDUSTRY SAVINGS FROM ELIMINATION OF MILK DATING, BY MARKETS, 1969.

Marketing area	Volume of fluid milk products sold through stores[a]	Potential cost savings from elimination of dating	Total possible industry saving per year
	(Million quarts)	(Cents per quart)	(Thousand dollars)
New York City, N.Y.	950.0	1.2 to 1.4	11,400 to 13,300
State of New Jersey	515.7	1.0 to 1.4	5,157 to 7,220
Baltimore, Md.	58.6	0.8 to 1.0	469 to 586
St. Louis, Mo.	65.3	0.8 to 1.0	522 to 653
Jefferson County (incl. Birmingham), Ala.	32.0	0.8 to 1.0	256 to 320
Suburban Philadelphia, Pa.	9.1	1.0 to 1.2	91 to 109

[a]Estimates of quantity of fluid milk products sold through stores were calculated from data compiled by (1) Dairy Division of the U.S. Department of Agriculture; (2) Metropolitan Dairy Institute, Inc., New York, N.Y.; (3) New Jersey Milk Industry Association, Inc.; (4) Division of Dairy Industry, New Jersey Department of Agriculture; (5) Department of Agricultural Economics, Auburn University, Auburn, Alabama; (6) Alabama Milk Control Board, Montgomery, Alabama; and (7) Pennsylvania Milk Marketing Board.

Estimated possible savings in other dating markets

Savings in milk processing and delivery costs resulting from elimination of milk dating would accrue principally from savings in delivery costs. As indicated above, more than 60% of the possible cost saving that would result from elimination of milk dating in New Jersey would stem from introduction of less frequent delivery systems to stores purchasing small quantities of milk per delivery.

Information available on frequency of delivery in dating markets suggests that in 1969 most processors in the Baltimore, Jefferson County, and St. Louis marketing areas were already serving small stores on an every-other-day schedule (see Table 2). Elimination of milk dating in these three markets, therefore, would result in a smaller savings than in New Jersey. In these markets, cost savings from elimination of dating regulations would probably range from 0.8 to 1.0 cent per quart (Table 6). Industry savings in each of these three markets could approximate one-fourth to one-half a million dollars annually if milk dating was eliminated.

The largest potential savings in costs probably exists in New York City. In this market, the majority of processors in 1969 were regularly making six deliveries per week to small- and medium-size stores. Elimination of milk dating in this market would provide a possible reduction of industry processing and delivery costs of 1.2 to 1.4 cents per quart. On an annual basis, repeal of dating legislation could effect a reduction of industry costs of 11 to 13 million dollars.

Cost savings from elimination of milk dating would probably be slightly less in the Philadelphia Suburban market than in New Jersey. On wholesale routes, small-and medium-size deliveries were less frequent in the Pennsylvania market than in New Jersey. Conversely, on mixed routes, the frequency of delivery was somewhat higher in the Philadelphia Suburban market than in New Jersey. With most of the volume of milk sold to stores being delivered on wholesale rather than mixed routes, cost savings from elimination of dating would average slightly less in the Philadelphia Suburban market than in the New Jersey markets. Potential cost savings in the Philadelphia market would be expected to approximate 1.0 to 1.2 cents per quart. Industry savings through elimination of milk dating could total approximately $100,000 annually for this market.

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EFFECT OF SOLUTE CONCENTRATION AND PRE-SOIL INTERACTION ON THE MICROFLORA OF DAIRY ORIGIN ON STAINLESS STEEL SURFACES[1]

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Abstract

Use of modern dairy food processing equipment creates a complex microenvironment. Closed systems reduce air drying. The rate and extent of drying are dependent on temperature and humidity of the environment. These factors were studied to determine their impact on the microflora of films of milk on stainless steel surfaces. An ecosystem was established to simulate dairy food equipment by using 1 cm² pieces of stainless steel in controlled humidity chambers. Presoiling, water loss from a film of milk, and solute concentration were studied to determine their influence on the fate of the microflora. Temperature and humidity of the atmosphere influenced the rate of moisture loss from films. Pre-soiling reduced the rate of water loss from films of milk sufficiently to allow bacterial growth at 12-80% relative humidity (RH). Results indicate bacteria can grow in a film placed in humidities well below the 95% RH limit previously projected. Apparently the substrate is influenced by interaction of the milk film and the stainless steel surface.

Modern methods of handling milk, including pasteurization, have reduced the magnitude of quality problems encountered in the dairy food industry. However, public health hazards and shelf-life limitations remain, because of occasional incomplete cleaning and/or inadequate sanitization. With closed systems and CIP (cleaning-in-place), internal surfaces of equipment are the primary source of contamination *(9)*. Modern processing and cleaning systems have created a relatively unstudied microenvironment. Microenvironment includes the chemical and physical factors that affect the individual microorganisms directly, whereas the ecosystem is the product of all factors which affect the entire system *(4, 8)*.

Considerable study has been conducted on the effectiveness of cleaning surfaces of dairy equipment. Primary attention has been given the affinity of milk for metal surfaces *(3)*. Cleanability associated with surface finish also has received considerable attention as exemplified by the work of Kaufmann et al. *(5)* and Masurovsky et al. *(6)*. At present, no process is available which removes all potential contaminants from these surfaces *(10, 12)*.

Residual soil and available moisture are important factors which control the fate (increase, decrease, or change in nature of the population) of the microflora. Available moisture in the microenvironment is directly related to the humidity of the ecosystem, which influences growth *(11)*. The extent of influence only can be predicted after equilibrium has been reached. No data are available to indicate the time involved between a common soiling operation and equilibration of the film with the atmosphere. Barnhart et al. *(2)* showed that most milk films on stainless steel in 12-80% relative humidity (RH) had fewer microorganisms after 16 hr than were present in the original inoculum. These results were not in harmony with the high bacterial populations normally associated with inappropriately maintained dairy equipment. Thus, a factor(s) other than milk on equipment receiving normal cleaning and storage must be involved in producing an abundant outgrowth of the microflora.

This work was undertaken to determine moisture loss, solute concentration build-up, and soil build-up as factors in the competitive growth of the microflora of dairy origin in a film on stainless steel.

Materials and Methods

Inocula and microenvironment

Pieces of 1 cm² stainless steel were cut from commercial 16 gauge plate of #4 finish. Individual pieces were placed in petri dishes and sterilized in hot air. Grade "A" mixed raw milk was taken as needed from a commercial source and a Standard Plate Count was made *(1)*. To the individual pieces an inoculum of 0.01 ml of milk was added and then spread with a sterile glass rod to attain an exposure of approximately 90% of the upper surface without contaminating the edges of the test pieces. Petri dishes were left open during incubation at controlled temperatures in small desiccators with 12, 50, and 80% RH obtained by the method of Winston et al. *(13)* for 16 hr to simulate overnight storage. After incubation each 1 cm² piece was placed into 2.5 ml of sterile phosphate buffer *(1)* in a 15 x 125 mm test tube and shaken for 15 min on a mechanical shaker. Results demonstrating the validity of this method were given in a previous publication *(2)*. General plating and counting procedures were those shown in *Standard Methods for the Examination of Dairy Products (1)*.

[1]Published with the approval of the Director as paper No. 2574, Journal Series, Nebraska Agricultural Experiment Station, Lincoln.

TABLE 1. EFFECT OF LAYERS OF PRE-SOIL ON THE FATE OF THE MICROFLORA IN A FILM OF MILK WITH INCUBATION AT 20 C FOR 16 HOURS

Layers of pre-soil	Inoculum (total count/ml)	Numbers recovered after exposure to different humidity		
		12% RH	50% RH	80% RH
0	57 x 10^2	17 x 10^2	20 x 10^2	20 x 10^2
1	150 x 10^2	120 x 10^2	120 x 10^2	110 x 10^2
2	150 x 10^2	93 x 10^2	120 x 10^2	110 x 10^2
3	250 x 10^2	230 x 10^2	200 x 10^2	750 x 10^2
4	30 x 10^4	160 x 10^4	110 x 10^4	120 x 10^4
5	8.4 x 10^4	300 x 10^4	160 x 10^4	260 x 10^4

TABLE 2. FATE OF THE MICROFLORA IN A FILM OF MILK DURING 16 HOURS INCUBATION

Temp. (C)	Per cent of initial inoculum recovered from various humidities		
	12% RH	50% RH	80% RH
10	70	68	80
20	402	367	616
30	44	16	33

TABLE 3. EFFECT OF INCUBATION FOR 16 HOURS ON THE NATURE OF THE MICROFLORA IN A FILM OF MILK

Microorganisms	Per cent of isolates	
	Initial inoculum	After incubation
Micrococci	22	46
Streptococci	20	18
Bacillus sp.	3	2
Gram-positive non-sporeforming rods	37	26
Gram-negative proteolytic rods	12	2
Coliforms	1	0
Others	5	5

Determining the nature of the microflora

A random design was used to obtain isolates from plate count agar. Nature of the isolates was determined by Gram staining, catalase production, spore formation, gas production in brilliant green lactose bile broth for indication of coliform bacteria, growth in litmus milk, and proteolysis on plate count agar plus skim milk. Isolates were grouped according to those physiological activities which are of importance to the dairy food industry (7).

Pre-soiling stainless steel

Pre-soiling was obtained by repetition of the previously described inoculation procedure and drying at low humidity until no visible moisture was apparent. Each piece was then taken by the edges with sterile forceps and rinsed by gentle back and forth action five times in a beaker of tap water of approximately 200 ppm hardness. The gentle rinsing or washing action was chosen to simulate superficial washing, which occurs with inappropriately treated equipment. Test pieces were again dried in a desiccator at room temperature. The residue remaining on the surfaces was termed "soil," and successive layers of soil were added as deemed appropriate for the specific experiment.

Determinations of moisture loss from films of milk.

A 0.01 ml sample of mixed raw milk was added to the surface of each 1 cm^2 piece of previously tared stainless steel. At intervals during the test period, in atmospheres of controlled humidity, the loss of moisture by difference in weight was determined, successive weighings revealing the rate of moisture loss. Exposure to different humidities provided various rates of moisture loss.

Effect of solute concentration on the fate of the microflora

To provide a different approach, yet involve the same materials for various solute concentrations, nonfat dry milk was added to mixed raw milk. Quantities were added to obtain gradations in solute concentration similar to those present during moisture loss from surface films. Whirl-Pak plastic bags (Nasco Company, Fort Atkinson, Wisconsin) were convenient containers for the test samples as mixing, breaking lumps, and incubation could be performed without external contamination. Following incubation for 16 hr at 32 C, the number of microorganisms was determined using the plate count. These counts were compared with initial counts; the latter included those contributed by the raw milk and the nonfat dry milk.

RESULTS

Pre-soiled surfaces

When layers of pre-soil were applied before the test raw milk inoculum, results indicated an increase in bacterial growth after the fourth or fifth layer of

TABLE 4. EFFECT OF PRE-SOIL TREATMENT ON THE DESORPTION OF A MILK FILM TO AN EQUILIBRIUM LEVEL AS INFLUENCED BY TEMPERATURE AND HUMIDITY

Temperature (C)	Number of layers of pre-soil	Equilibration time in hours at three levels of humidity		
		12% RH	50% RH	80% RH
10	0	1	2	3
	1	1	2	3
	2	2	3	3
	3	3	5	4-5
	4	5	5-6	6-7
20	0	1	1	2
	1	1	1	2
	2	2	2-3	3-4
	3	3	3-4	4-5
	4	5	5-6	8-10

TABLE 5. EFFECT OF SOLUTE CONCENTRATION ON THE SURVIVAL AND GROWTH OF BACTERIA IN RAW MILK WITH VARIOUS ADDITIONS OF NONFAT DRY MILK SOLIDS AT 32 C FOR 16 HOURS

Grams of NFDM added per 10 g milk	Per cent moisture	Initial count/g	Total count/g after incubation
0	87	160 x 10^3	250 x 10^7
2.2	71	41 x 10^4	39 x 10^8
4.4	60	59 x 10^4	92 x 10^7
6.6	52	73 x 10^4	44 x 10^7
8.8	46	99 x 10^4	280 x 10^6
10.0	43	87 x 10^4	200 x 10^6
15.0	35	100 x 10^4	73 x 10^6
20.0	29	109 x 10^4	33 x 10^6

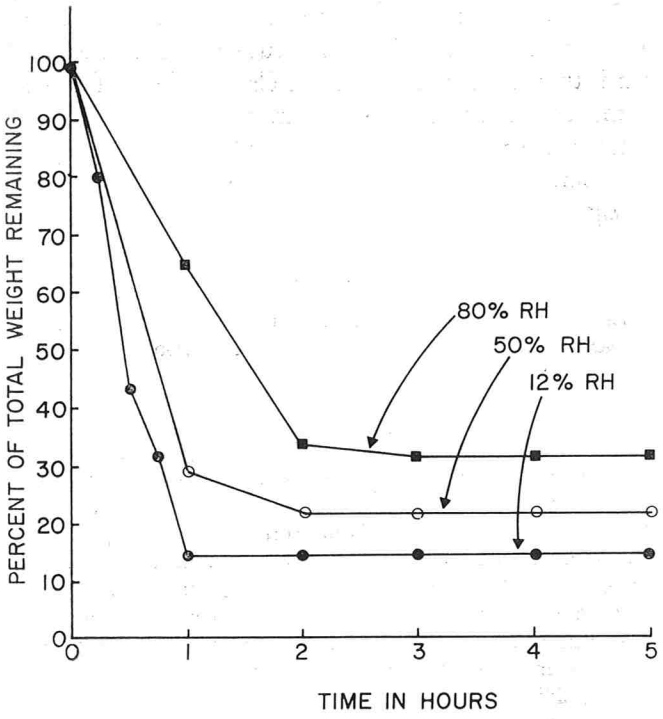

Figure 1. The effect of relative humidity on the desorption isotherm of milk at 10 C on stainless steel surfaces.

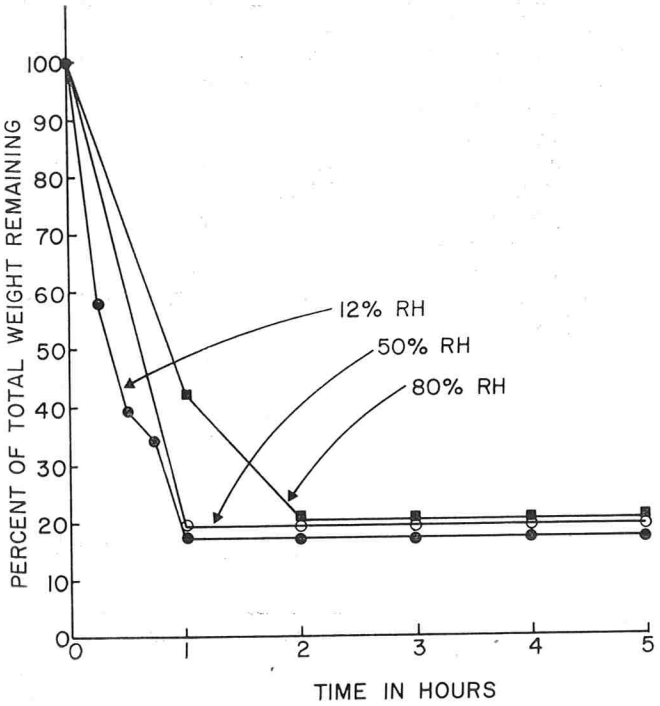

Figure 2. The effect of relative humidity on the desorption isotherm of milk at 20 C on stainless steel surfaces.

pre-soil. Typical results from one of three series are given in Table 1. The count on the inoculum represents an average of duplicate plates. Counts of organisms after exposure to humidities represent an average of six plates – duplicate plates from each of three stainless steel test pieces. Since the inoculum was fresh raw milk, a different count was obtained each day for each sample. Thus, the results with the various degrees of pre-soil are related only to the horizontal figures which reflect storage at the different humidities. For example, without pre-soiling the inoculum of 5,700 decreased to 2,000 when stored at 80% RH. After five layers of pre-soil, however, an inoculum of 84,000 grew to 2,600,000 at 80% RH.

Further observations on the effect of surface soil on the fate of the microflora were confined to the use of four pre-soil treatments with variables limited to temperature and humidity.

Fate of microflora in a film of milk

The data for 12, 50, and 80% RH at incubation temperatures of 10, 20, and 30 C are presented in Table 2. At 10 C there was a reduction in numbers to 70, 68, and 80% for 12, 50, and 80% RH, respectively. Incubation at 20 C resulted in a 6.0-fold increase of microorganisms at 80% RH. At 30 C there was a reduction in numbers to 16% of the original inoculum. Thus it is apparent that temperature and humidity are important factors in determining the fate of a microflora in a milk film left on equipment.

Isolates from plates used to obtain the above counts were retained for further study. Table 3 represents a compilation of data on 383 isolates from films incubated at 12, 50, and 80% RH and 10, 20, and 30 C. During incubation there was an increase in the percentage of micrococci and a decrease in the percentage of gram-negative rods and gram-positive nonsporeforming rods.

Desorption isotherm of surface layered milk

Samples of approximately 0.01 ml of raw milk were added to previously weighed 1 cm^2 pieces of stainless steel. Weighing at intervals reflected the loss of water. Figures 1 and 2 represent an average of three trials and show the desorption isotherm, here defined as a pattern of moisture loss to the environment at a constant temperature and humidity, for 12, 50, and 80% RH at 10 and 20 C. It is evident that moisture loss was very rapid at each temperature and at each humidity. Milk dried to a film of constant weight within 2 to 3 hr through moisture equilibration with the atmosphere.

When pre-soiling was included in observations on drying, results indicated little, if any, effect on the amount of water in the film when equilibrated within a given humidity. Observations on the rate of moisture loss, however, indicated considerable influence from pre-soil (Table 4). A five-fold, or more, increase in time necessary for equilibration was observed following the application of four layers of pre-soil. Pre-soil decreased the rate of moisture loss more

at 20 C than at 10 C. The reduced rate of moisture loss associated with pre-soiling was in agreement with the increase in microbial population observed with pre-soiled samples.

Effect of increasing solute concentration on the microenvironment

Nonfat dry milk was added to raw milk in Whirl-Pak bags to obtain various levels of solids and incubated to determine the fate of the microflora. Results of an average of four trials (Table 5) indicated that an increase in solute concentration, or conversely a decrease in moisture, reduced the rate of growth of microorganisms. Without added solids, the count increased from 160 x 10^3 to 250 x 10^7. With 20 g added solids to provide a medium with 29% water the count increased from 100 x 10^4 to 33 10^6, which was considerably less growth than in raw milk alone. The data therefore indicate solute concentration influences the rate of growth of microorganisms and thereby can influence the magnitude of quality problems.

DISCUSSION

The data indicate bacteria could grow in a film exposed to 12-80% RH, which is well below the figure projected by Mossel et al. *(11)*. However, the results are in harmony with their conclusion that nature of substrate influenced available water to the cells at a given humidity.

Dairy equipment constitutes a highly complex ecosystem, which is the product of milk, soil, moisture, humidity of the surrounding atmosphere, physicochemical nature of the surface, temperature, and residual microorganisms. An example of the interdependence of these factors was shown in the presentation of desorption isotherms at 10 and 20 C. Considerably more moisture was retained in films at 10 C than at 20 C with identical humidities of 80% RH.

The complexity of the system is exemplified by failure of microorganisms to grow, over a wide range of humidities, in a film of fresh raw milk on stainless steel. Yet, pre-soiling treatment provided an interaction of the milk film with the surface and microorganisms, retarding the loss of moisture, and thereby improving the environment for the microorganisms. A general explanation of the phenomenon might be retardation of a build-up of solute concentration beyond that tolerated by the cells. Indeed, the extreme sensitivity of the system to humidity of the atmosphere may account for previously unexplained variations in microflora associated with seasonal changes.

ACKNOWLEDGMENTS

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THE EFFECT OF A BIPOLAR-ORIENTED ELECTRICAL FIELD ON MICROORGANISMS IN AIR[1]

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Abstract

A new type of electrode that produced a bipolar-oriented electrical field was used to reduce the viable content of species of bacteria, yeasts, or molds continuously aerosolized into a chamber. With field voltages of 6,000; 10,000; 14,000; and 20,000 measured at 1 m from the electrode, the reduction of *Pseudomonas fragi, Serratia marcescens, Candida lipolytica,* and *Penicillium roqueforti* was largest at 14,000 volts; and of *Bacillus subtilis* spores at 20,000 volts. The mean reductions at the most effective field voltages were 59.2, 49.1, 47.7, 31.0, and 49.1%, respectively. Deposition of viable particles during aerosolizing for 5-7 hr was much higher on the metal door and metal walls of the chamber than it was on the electrode surface.

Recognition of the importance of reducing or eliminating airborne contamination in food plants has increased greatly in recent years. The quality of cultured products can be adversely affected by airborne contamination. Shelf life of cheeses, butter, cultured creams, cultured buttermilk, etc., is influenced by the extent of the contamination from the air, especially during packaging for retail distribution. The expanding market area of individual plants has lengthened the period between packaging and consumption, thus, intensified the seriousness of even small amounts of contamination. Aseptic packaging of foods necessitates the complete elimination of airborne contamination. Health also may be affected by the transmission of pathogenic or toxin-producing airborne microorganisms.

The potential is large for numerous applications in the food industry, as well as others, if an effective and economical means of reducing microorganisms in the air is developed. The objective of this report is to present results of an investigation on reduction of microorganisms in the air by use of a bipolar-oriented electrical field. Variables included in this study were voltage and type of microorganism when evaluated at 21 C and 70% relative humidity. Consideration was also given to deposition of the microorganisms on the electrode, walls, and door of the experimental chambers.

Literature Review

The number of microorganisms in dairy plant air was found by Labots *(10)* to be 18 colonies per liter, by the slit sampler method, and 300 colonies per minute, by sedimentation into a petri plate. Cerna *(2)* reported 1 to 550 colonies per petri plate for a 10-min exposure. Heldman et al. *(7)* observed, using the slit sampler, an average of approximately 6 bacterial colonies, 2 yeasts, and 14 molds per ft^3 in dairy plant air. Hedrick and Heldman *(6)* tested the air in dairy plants in nine states. The mean numbers of bacterial colonies per ft^3, using the slit sampler, were: butter areas, 45; cheese, >116; dry milk, 31; and market milk, 31. Cannon *(1)* reported an average of 14 molds and 32 bacteria, plus yeasts, per 10 liters in ten milk plants.

The common sources of the largest numbers of airborne microorganisms in dairy plants were shedding by people, floor drains while flushing liquid into them, dust in the plant or from the outside, and the ventilation system *(6, 8)*.

Cannon *(1)* reported micrococci; streptococci; gram negative rods, including coliforms; lactobacilli; corynebacteria; and bacilli to be in the air of milk plants. Sunga et al. *(14)* identified species in the following genera shed most frequently into the air from arms and hands of dairy workers: *Alcaligenes, Bacillus, Corynebacterium, Gaffkya, Micrococcus, Peptococcus, Pseudomonas, Sarcina,* and *Staphylococcus.*

Fedorov and Rogov *(3)* observed that viable microorganisms in milk were reduced to zero by treatment with high voltage impulses. The germicidal effect was attributed to cavitation and wave impact.

The influence of air ions on bacterial aerosols was investigated in considerable detail by Phillips et al. *(11)*. The over-all death rates for *Serratia marcescens* aerosols were doubled in the presence of positive ions and tripled in the presence of negative ions.

Sale and Hamilton *(12)* observed that electric fields up to 25 KV/cm applied as direct current pulses to organisms in suspensions had lethal effects. The number and length of pulses correlated with the amount of effect. Yeasts were more sensitive to the field than were bacteria. Additional investigation *(13)* attributed the bacteriocidal effect of the field to an irreversible loss of the membrane's function as the semipermeable barrier between the cell and its environment.

[1]Mich. Agri. Expt. Sta. J. Article No. 5120.

Escherichia coli, *Streptococcus faecalis*, *Bacillus subtilis* spores, and phage specific for *Streptococcus cremoris* ML 1 were destroyed by discharging 8 to 15 KV across an electrode gap submerged in aqueous suspensions *(4)*. The electrohydraulic shock produced oxidation reactions, which inactivated certain organic complexes in the cellular metabolism *(5)*.

EXPERIMENTAL PROCEDURE

The aerosol trials were conducted in two chambers. Each was 64 x 52 x 72 inches, consisting of a stainless steel floor and walls. A 65 x 29 inch aluminum door was fitted with a 12 x 6 inch acrylic plastic panel containing a 6-inch diameter access port, which was fitted with a glove of arm's length. A false ceiling of polyethylene was installed in each chamber.

An electrode[a] (4 x 4 x 32 inches) for producing the bipolar-oriented electrical field was suspended from the ceiling to within 2 ft of the floor in each chamber. One served as the control, so the electrode was not turned "on." The field voltage readings were taken 1 m from the electrode. An oscillating fan dispersed the aerosolized microorganisms uniformly throughout the chamber. Constant temperature was maintained with heating and cooling equipment above the false ceiling. The relative humidity was controlled by a spray, exposed water, and/or silica gel. The temperature and relative humidity were continuously recorded.

A glass atomizer *(9)* operated with air at 20 psi, aerosolized the microorganisms dispersed in water into an acrylic plastic prechamber (20 x 20 x 20 inches). The aerosol flowed into the two chambers through 2 plastic tubes, 0.5 inch inside diameter.

The species used in the trials included: (*a*) *S. marcescens*, grown in nutrient broth (shake culture) at 32 C; (*b*) *Pseudomonas fragi*, similarly grown at 28 C; (*c*) *B. subtilis* spores, grown in Roux flasks with nutrient agar at 28 C; (*d*) *Candida lipolytica*, grown in Sabouraud maltose broth at 28 C (shake culture); and (*e*) *Penicillium roqueforti*, obtained as Blue Cheese Mold Powder from a commercial source. Each species was washed four times in buffered, distilled water and dispersed in buffered, distilled water according to the desired dilution for aerosolization. The ages of the cultures, when used after harvesting, were *S. marcescens*, *P. fragi*, and *C. lipolytica*, 20 hr; *B. subtilis*, 70 hr; and *P. roqueforti*, approximately 12 months.

During the test period of 5-7 hr, a species was continuously aerosolized into the test chamber (electrode "on") and the control chamber (electrode "off"). In a few trials the aerosolization was for 5 min at the beginning of the test period. Airborne bacteria populations were measured with the Casella slit sampler, using standard plate count agar. For the yeast

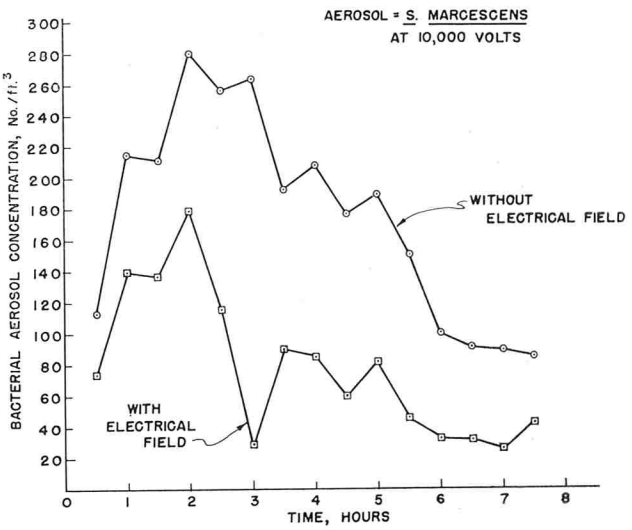

Figure 1. Bacterial aerosol population during a typical trial.

[a]Invented by C. D. Slocum, Sr., and supplied by Envitron Corporation, Royal Oak, Michigan 48067.

TABLE 1. INFLUENCE OF A BIPOLAR-ORIENTED ELECTRICAL FIELD ON THE DISPOSITION OF AEROSOLIZED BACTERIA ON THE ELECTRODE[1] AND SURFACES OF THE CHAMBERS.

Trial No.	Electrode surface (plastic-coated)				Door surface (aluminum)			
		Mean deposition rate				Mean deposition rate		
	Samples	Test	Control	Difference[3]	No. Samples	Test	Control	Difference[3]
		———(ft/hr)———		(%)		———(ft/hr)———		(%)
88	8	0.02890	0.00294	10.17	4	0.29255	0.00211	0.720
89	10	0.00604	0.00150	24.79	6	7.41210	0.00063	0.009
90	10	0.01533	0.00063	4.14	3	1.07600	0.00031	0.030
91	8	0.09833	0.00084	0.85	4	2.07360	0.00038	0.020
92	9	0.04090	0.00611	14.94	5	3.96560	0.00178	0.050
105	5	0.02194	0.01445	65.86	3	3.62910	0.00123	0.030
106	7	0.05631	0.02117	37.60	4	1.40400	0.00240	0.170
107	11	0.06774	0.00431	6.14	6	1.18523	0.00094	0.080
108[2]	10	0.02205	0.00382	14.32	5	0.06163	0.00099	1.600
	Wall Surface (stainless steel)							
126[2]	6	0.22818	0.00568	2.49	6	0.45440	0.00516	1.140
127[2]	6	0.34716	0.00330	0.95	6	0.75895	0.00465	0.610

[1]Field voltage was 14,000 at 1 m from electrode.

[2]*Bacillus subtilis*, otherwise *Serratia marcescens*.

[3]$\frac{\text{Control}}{\text{Test}} \times 100$

or mold, acidified potato dextrose agar was used in the sampler. Each sampling consisted of 1 ft^3 of air. Rodac plates were used to determine the numbers of organisms on the wall, door, floor, and electrode by the contact method in collection of data for Table 1. Casella sampling of air in the chambers was at 0.5-hr intervals.

RESULTS

The influence of the bipolar-oriented electrical field on bacterial aerosol population was determined by comparison of concentrations in two aerosol chambers. Both chambers were operated as identically as possible, with injection of attempted equal amounts of aerosol into each. A bipolar-oriented electrical field was maintained in one (test chamber) of the aerosol chambers throughout the duration of the 5-7-hr experiments.

Results presented in Fig. 1 are typical of those obtained in the other experiments. In the example presented, an aerosol of S. *marcescens* was injected into both chambers during the entire 7-hr experiment. The aerosol concentration in the chamber with a bipolar-oriented electrical field of 10,000 volts was consistently lower than the chamber without the field. In addition, the rather significant gradual decrease in aerosol concentrations after 3-4 hr in both chambers during the 7-hr experiment was attributed to a slowing of the aerosolizing rate. This observation was based upon the similar decline in the control chamber during continuous aerosolization. Trials with *B. subtilis* spores illustrated a similar effect.

All data were analyzed statistically to account for the minor variations of aerosolization between the control and the test chambers and the declining rate after 3-4 hr. The mean percentage reduction values for the five aerosolized test species at voltages of 6,000; 10,000; 14,000; and 20,000 were corrected, using a least squares fitting analysis, to establish the true relationship.

The significant influence of field voltage was evident when using *P. fragi* as a test organism (Fig. 2). The reduction in aerosol population caused by the bipolar-oriented electrical field increased consistently to a mean value of 59% at 14,000 volts and did not show additional effectiveness at 20,000 volts.

The influence of field voltage on the reduction in population of airborne *B. subtilis* spores is illustrated in Fig. 3. The maximum reduction of 63% occurred with 20,000 volts; but the average reduction was 53% at 20,000, or 49% for both 20,000 and 14,000 volts. Since the spores were the more resistant to environmental conditions of the microorganisms tested, these data should be more critical of the ability of the bipolar-oriented electrical field to reduce viable aerosol population.

The influence of field voltage on reduction of a S. *marcescens* aerosol was demonstrated by a mean reduction of about 49% that occurred at approximately 14,000 volts. The evidence seems insufficient to assure that the influence actually diminished above 14,000 volts. Some experiments indicated reduction of airborne bacteria approached 60%. S. *marcescens* is a common test bacterium for aerosol research, and is known not to be highly resistant to environmental stresses. The influence of the bipolar-oriented electrical field on reduction of this species would be expected to be substantial.

Results of trials involving influence of field voltage on reduction of the population of a *P. roqueforti* aerosol were similar to those in the trial shown in Fig. 2. But, in these trials the mean reduction was 31% with 20,000 volts. The greatest effect of any of these experiments indicated a reduction of 50%, and the least was 20%. This species appeared to be more highly resistant to environmental stresses that may have been induced by the bipolar-oriented electrical field.

Reduction of *C. lipolytica* with a field voltage of 14,000 and 20,000 ranged from 34-57%. The mean value was 48%.

In general, the mean statistical reductions attained for all trials of the five test organisms, *P. fragi*, *B. subtilis*, S. *marcescens*, *C. lipolytica*, and *P. roqueforti*, were 59, 49, 49, 47, and 31%, respectively. The average of the lowest figures of five ranges was 36%,

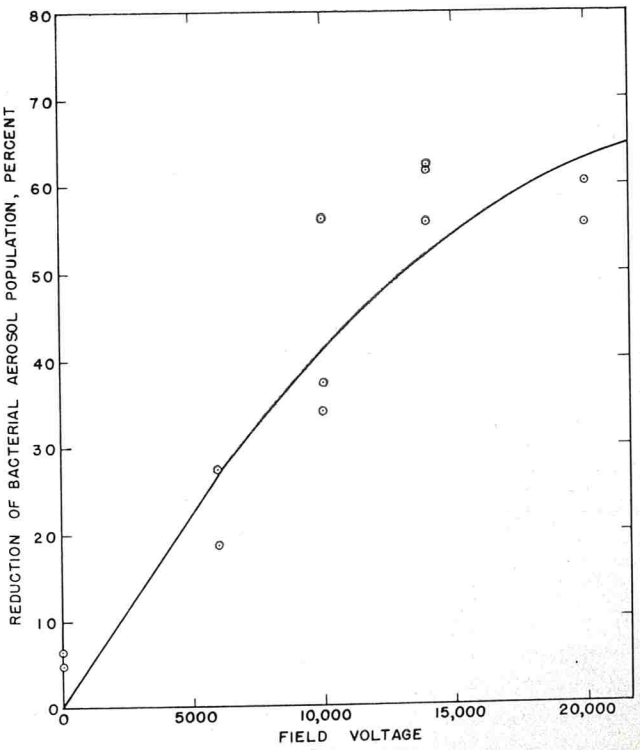

Figure 2. Effect of voltage on reduction of airborne *Pseudomonas fragi* in a bipolar electrical field.

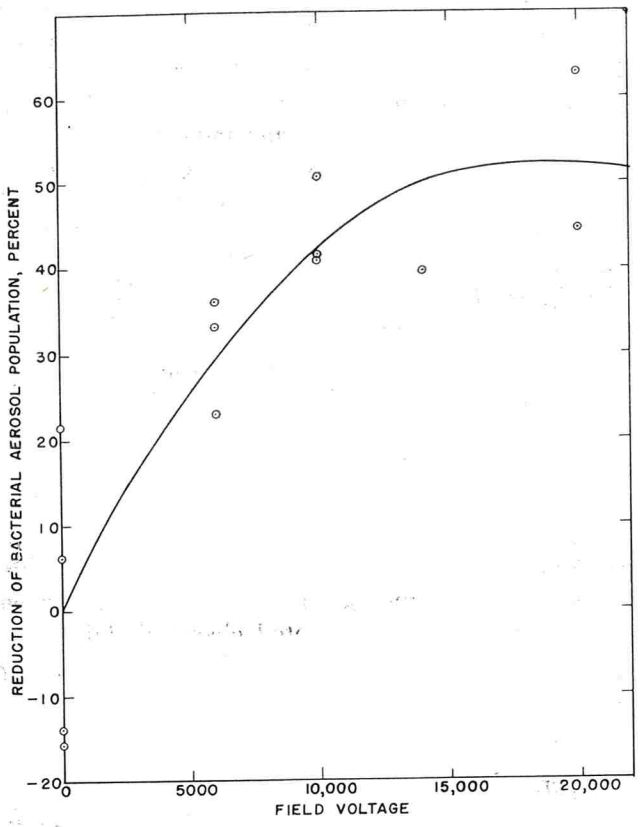

Figure 3. Effect of voltage on reduction of airborne *Bacillus subtilis* spores in a bipolar electrical field.

and the average of the highest figures of the five ranges was 58%.

The nature of reduction of aerosol population caused by the bipolar-oriented electrical field was investigated using Rodac plates with solidified agar for surface contact sampling at selected locations in the aerosol chambers. A high concentration of *S. marcescens* was aerosolized into the chambers during 5 min, and tests were conducted each 30 min for 4 hr. Results of surface population tests were correlated with aerosol populations at the corresponding times. Then, by comparing numbers obtained in the chamber with the bipolar-oriented electrical field and in the control chamber, it was possible to observe the relative influence of the field.

Results of 11 experiments conducted to evaluate chamber with the bipolar-oriented electrical field on deposition are summarized in Table 1. The results are also presented in terms of percentages, which indicate the relative deposition at the same location in the test and control chambers. The mean percentage in the control chamber was calculated by using the deposition in the chamber with the charged electrode as 100%. Thus, the lower percentage values are a definite indication of more significant deposition in the test chamber compared to the control chamber.

Results in Table 1 illustrate the influence of the bipolar-oriented electrical field of 14,000 volts on deposition of *S. marcescens* and *B. subtilis* spore aerosols on the aluminum door of the test and control chambers and on the plastic-coated electrodes placed in the two chambers. Some of the data presented in Table 1 may represent relative rates of deposition. The result of dividing the surface concentration (no. deposited per hr per ft^2) by the corresponding aerosol (no./ft^3) produces a value with units which are indicative of the velocity (ft/hr). In studies of aerosol sedimentation, this parameter has been referred to as an effective sedimentation rate. For purpose of this investigation, the values may be an indication of the rates of deposition remaining viable.

Based on results shown in Table 1, the aluminum door of the chamber with the bipolar-oriented electrical field had the greatest attraction for aerosol particles. Deposition of microorganisms remaining viable on the door may be as much as 100 times greater than on the positively charged electrode which generated the field voltage. The difference in percentage deposition among trials was caused by variation in airborne concentration of microorganisms. However, the higher the number of airborne microorganisms, the less the difference in deposition between charged and uncharged electrodes.

In addition results (Table 1) show relative rates of deposition for an aerosol of *B. subtilis* spores in a voltage field of 14,000. In two experiments rates of deposition are utilized to compare attraction of bacteria to aluminum doors and stainless steel walls of aerosol chambers. There appears to be slightly greater deposition on the door than on the stainless steel wall of the chamber with the bipolar-oriented electrical field, but the difference does not approach the magnitude of the difference between the door and electrode. The mean deposition rate on the door was approximately twice as high as on the wall (0.45440 versus 0.22818). The comparisons confirm previous observations that the door of the chamber in which the bipolar-oriented electrical field was established received the most significant amounts of deposition. Based on these percentage values, difference on the door was 10-100 times greater than on the electrode. In addition, data in Table 1 indicate that deposition on the door was only slightly greater than on the steel wall—approximately double, based on percentage values.

Discussion and Conclusion

Reduction of viable airborne microorganisms under the influence of the bipolar-oriented electrical field was gradual when microorganisms were aerosolized continuously or for a short time at the beginning of

the testing period, which lasted several hours. The effective rate of deposition of the microorganisms also can be considered to be slow. The decrease in viable numbers in the air was substantial, although less than ideal, with a maximum of approximately 60% during continuous aerosolizing. Although the viable bacterial spores decreased in the air about as rapidly as the vegetative cells of non-spore-producing bacteria, it is interesting to observe that the older mold spores were affected much less by the electrical field.

The voltage, as might be expected, had a direct relationship with an increased disappearance of viable microorganisms in the air; but it seemed to reach the "point of diminishing returns" at approximately 14,000 to 20,000 volts.

In considering the application of the bipolar-oriented electrical field to practical conditions of a food plant, hospital, etc., additional information will be helpful. More needs to be known about the specific effect(s) of the field on the microorganisms. Data on the influence of distance of the microorganisms from the electrode on reduction are necessary. This factor has a direct bearing on the amount of electrode surface required per cubic foot of space. This, in turn, has a direct effect on the installation and operating costs, as well as on the safety factor.

In conclusion, the bipolar-oriented electrical field reduced the viable airborne bacteria, yeasts, and molds. Additional studies are needed to determine the mechanisms of the reduction and the practicability of the principle for commercial application in food plants.

ACKNOWLEDGMENT

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LACTIC ACID BACTERIA ASSOCIATED WITH RAW PLANT FOOD MATERIAL[1]

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Abstract

The lactic acid group of bacteria occur on plants with some degree of constancy, but not of consistency, and seldom at high levels of population. Their role on the surfaces of plants is unknown, and apparently passive, for no functional, concrete role in an intimate bacterium to plant relationship has been detected.

The lactic acid bacteria are a family of Gram-positive, catalase-negative rods, or spheres which may occur in pairs, chains, and tetrads. They require carbohydrates for energy, amino acids for nitrogen nutrition, and various growth factors. With only these properties in common, it is not surprizing that some genera and some species within genera can cope with the climatic conditions of nature and are found primarily on plants, whereas others are intimately associated with a warm-blooded host; and some species appear to be almost equally at home in either environment.

When one examines spontaneous or deliberately induced fermentations, such as those of cabbage, cacao pods, milk, and a host of other items, or when one determines the identity of the dominant species on forage grasses, one concludes that relatively few species of the lactic acid bacteria are associated with plants. When one goes directly to the plant, a much wider range of species is encountered. Then one concludes that during fermentations conditions are conducive to the selective enrichment of certain species, to the virtual or even real exclusion of the remainder. One example will suffice: *Streptococcus faecium* var. *casseliflavus* appears to be more prolific, and much more widespread in nature, than is *Streptococcus lactis*. It is an exceedingly active bacterium; it thrives at nature's temperatures; yet it has not ever been reported as an agent in the fermentation of cabbage, cucumbers, or other materials.

Cultivation and Enumeration

The lactic acid bacteria are not difficult to cultivate. Problems arise, however, in attempting enumeration. There are specific sensitivities to the commonly used inhibitors incorporated into selective media; not all members will thrive on the same media; and some members such as *Leuconostoc* have an overwhelming population level as compared with other species. Neither lactobacilli nor pediococci respond quantitatively to enumeration by surface plating, and in fact these may be so few in numbers that they must be enumerated by a liquid, MPN technique. Each of the problems has been overcome, and most of the specific methodologies have been recorded in the literature.

Origin on Plants

The question of origin of the various lactic acid bacteria on plants has preoccupied workers during recent years. Despite intensive study, the problem is generally unresolved. Undoubtedly, many overwinter in soils, although they are seldom isolated from this source, and then only if the plant growing on that soil or adjacent to it, harbors them. Streptococci have been isolated from the ovules of green beans and of corn, and overwintering in the seed is a possibility. They are present in almost astronomical numbers within the bodies of some insects, such as members of the *Coleoptera* and *Hymenoptera*. There may be a continual reseeding onto plants from animal wastes on the part of those associated with the animal body, through the intervention of both insects and wind. Whereas fecal origin is an attractive postulate, it is not entirely compatable with the distribution patterns of some of the lactic acid bacteria in agronomic and wild environments.

Growth on Plants

Lactic acid bacteria possess the potential for growth on the surfaces of plants, whether they are present in pure culture or in a naturally competitive situation. Several species of these bacteria, *S. lactis*, *Streptococcus faecalis* var. *liquefaciens*, and *Lactobacillus plantarum*, are recoverable from the stems, arils, and primary and secondary leaves of beans, cabbage, rye, and corn, when the bacteria have been introduced to either control or to surface-sterilized seeds, and these have been planted into either con-

[1]Presented at a Seminar on Spoilage Bacteria, Indicator Organisms, and Pathogens in Raw Plant Foods at the 70th Annual Meeting of the American Society for Microbiology, Boston, Massachusetts, April 26–May 1, 1970.

TABLE 1. THE FREQUENCY IN RECOVERY OF SPHERICAL LACTIC ACID BACTERIA FROM 156 PLANT SAMPLES AND THE FREQUENCY AS THE SOLE SPECIES RECOVERED

Bacterium	Frequency in recovery		Frequency as sole species
	Number	Per cent	
Streptococcus faecalis	13	8.3	2
S. *faecalis* var. *liquefaciens*	45	28.8	13
Streptococcus faecium	24	15.4	2
S. *faecium* var. *casseliflavus*	44	28.2	12
Leuconostoc mesenteroides	83	53.2	28
Aerococcus viridans	11	7.0	0

TABLE 2. THE IDENTITY AND FREQUENCY IN OCCURENCE OF SPECIES OF LACTOBACILLI RECOVERED FROM THE ORAL CAVITY, THE HUMAN INTESTIONAL TRACT AND PLANTS[1]

Species	Oral cavity	Intestinal tract	Plants
Lactobacillus acidophilus	+	+ (8)*	−
Lactobacillus lactis	−	+ (5)	−
Lactobacillus leichmannii	+	+ (1)	−
Lactobacillus salivarius	+	+ (1)	+ (1)
Lactobacillus cellobiosus	+	−	+ (5)
Lactobacillus casei	+	+ (9)	+ (3)
Lactobacillus plantarum	+	+ (10)	+ (35)
Lactobacillus fermenti	+	+ (12)	+ (23)
Lactobacillus brevis	+	+ (3)	+ (21)
Lactobacillus buchnerii	+	+ (3)	+ (1)
Lactobacillus viridescens	−	−	+ (1)

*Frequency in recovery

[1]Data from three references at end of paper.

trol or heat-sterilized garden soils. Estimated increases in numbers on the plant over those estimated to have been introduced to the seeds range from a low of 40-fold to a high of 750-fold.

The levels of population which the several lactic acid bacteria achieve on plant surfaces undoubtedly are restricted severely by the amount of available nutrients and also by competition with the less demanding, usually Gram-negative, bacteria. Sterilized washing and conveying waters used in vegetable processing have supported the growth of selected species of the lactic acid bacteria to populations in excess of 1 x 10^7/ml, provided such waters contained 0.01 to 0.02% nitrogenous substances. It is felt that these waters reflect reasonably the adequacy of the food material available on the surfaces of plants.

KINDS OF PLANTS

Relatively few species of the lactic acid bacteria are found consistently on plants, and even these are not invariably present. The numbers per gram of plant tissue are highly variable. The average populations of S. *faecalis*, S. *faecalis* var. *liquefaciens*, and S. *faecium* are less than 1 x 10^3/g of plant tissues, when present, with a range from 1.5 x 10^2 to 2.6 x 10^4/g, in a study involving 156 samples of vegetables. *Streptococcus faecium* var *casseliflavus*, while often present in low numbers, has been enumerated at 4 x 10^5/g of summer squash peel and of corn flowers, occasionally exceeding the numbers of the ubiquitous *L. mesenteroides*. *Aerococcus viridans* often is present in low numbers on succulent plants such as summer squash and greens, but it has not been found on the more dry vegetable such as the green bean.

Streptococci

Typical frequency in the occurrence of the genera and species of the spherical lactic acid bacteria on vegetables is shown in Table 1. *Leuconostoc mesenteroides* is the most frequently recovered species, followed by S. *faecium* var. *casseliflavus* and S. *faecalis* var. *liquefaciens*. *Streptococcus faecalis*, S. *faecium*, and *A. viridans* are recovered less frequently, in the range of 7 to 15% of all samples of vegetables included in the survey.

The spherical bacteria occur more often as mixtures on plants than as the sole species. The figures in the last column of Table 1 show that during the study in question, S. *faecalis*, while present on 13 of 156 samples, was the sole species obtained from only 2 samples. *Leuconostoc* was the only species recovered from 28 of the 83 samples from which it was isolated. The simultaneous occurrence of 3, 4, or even 5 species on the same plant is not unusual.

The lactic acid bacteria do not thrive on plants during the cold months of the year. They are recovered rarely from dormant and overwintering plants, and with less frequency from non-succulent plant parts such as leaves, than they are from flowers and fruiting structures. *Streptococcus faecium* var. *casseliflavus* prefers the cooler months during spring and early summer. It is obtained only infrequently, and then usually in low numbers per unit weight of tissue, after mid-July. On the other hand, a direct correlation exists between the advance of the summer season and the frequency in recovery of S. *faecalis* var. *liquefaciens*. The increases in recovery are correlated with increasing average daily temperature beginning with the first isolations in June to mid-September, after which an abrupt decrease in both incidence and numbers occurs. The occurrence of of lactobacilli and pediococci on plants also seems to be correlated to the warmer temperatures, although too few isolations have been made to establish a firm pattern. Pediococci are not isolated from plants (in Tennessee) until the end of May, when small grains are in the milk stage.

Reproduction and the frequency in occurrence of the lactic acid bacteria is influenced markedly by rainfall and relative humidity. During one study,

these bacteria were obtained from all samples of selected vegetables with an average population of 1 x 10^5/g tissue. During the following year, when near drought conditions prevailed, these bacteria were obtained from only two-thirds the samples, with total populations at 10% those of the preceding year.

The majority of the strongly reducing enterococci produce a soft, rennin-like curd which is usually digested rapidly in stratiform fashion, in contrast with the hard curd which is digested vertically, characteristic of the acid-proteolytic streptococci. The amount of rennin which cultures of each type produces is very nearly alike; differences in the nature of the curd and in type of digestion are attributed to differences in rate of fermentation of lactose. The majority of the S. *faecalis*-like streptococci isolated from *Mammalia* other than humans and domesticated animals, *Reptilia*, and plants growing in either agronomic or wild environments, are of the soft curd-producing type. Many of these are also β-hemolytic, but this property has little differential value in the plant setting.

Streptococcus faecium is widely distributed in the plant environment. It appears to be the dominant enterococcus in the intestinal tract of boars and of hogs. For many years, it was difficult to reconcile the properties of cultures of this species taken from plants with the description given for the species by Orla-Jensen. The recognition of the variant, S. *faecium* var. *casseliflavus*, has reduced much of the confusion. The variant is a very active bacterium with properties of both S. *faecalis* and of S. *faecium*. It ferments many more sugars than do either of these species. Most of the cultures are motile. It produces a watersoluble, pale lemon yellow pigment in the cell wall. Especially when first isolated, it is frequently deformed and appears as a swollen rod. Cells of many strains appear to produce buds, and these give rise to crooked, rather than to straight chains of cells. The variant colonizes on plants very readily, and except for *Leuconostoc* it is the most common of the spherical bacteria on plants during late spring and early summer. Despite its abundance, we have not observed it as a primary agent during the deterioration of vegetables in holding situations.

Species of *Leuconostoc* other than *L. mesenteroides* have been encountered extremely rarely in approximately 5,000 identified cultures. As others have reported, about 70% of the cultures produce dextran on sucrose agar. The remainder are detected most easily through the use of the Gibson-Abd-El-Malek gas entrapment technique. Carbon dioxide does not accumulate in the frequently used Smith or Durham tubes, because of its high degree of solubility in water. *Leuconostoc* becomes a problem when raw, succulent commodities like peas are held too long in vats prior to blanching.

The succulent plant seems to be the reservoir of *A. viridans*. It has been isolated also from processing equipment and from spontaneously fermenting vegetables in holding situations, but not, however, as the dominant agent of deterioration.

Figures giving the incidence and levels of population of S. *lactis* on plants may be deceptive, because many strains of this species are sensitive to the sodium azide incorporated into selective culture media. Hirsch has postulated that S. *lactis* as it is known to the dairy bacteriologist is a recently evolved, highly specialized member of a much wider complex. Current work in our laboratory indicates this to be true. In nature, neither lactose fermentation nor deamination of arginine appear to be of paramount value. Differentiation through the ability to grow in broth with 4%, but not 6.5%, NaCl, appears questionable; we are able to train many cultures to growth in broth with 6.5% NaCl with relative ease. Members of the wider complex, frequently those unable to ferment lactose, have been observed in frozen vegetables by workers in England and in the United States.

Lactobacilli

Studies of the lactobacilli associated with fresh plant material are few. There is a popular conception that certain species are "plant" types, others are "dairy" types, and still others are "animal" types. The conception probably arose, because specific properties and selective environments have given preference to species most adaptable to that environment. The ability to ferment lactose, for example, enables milk and its products to serve as enrichment agencies for *Lactobacillus casei*.

A list of the species of the lactobacilli isolated from the human mouth, the intestinal tract of man, and from plants is presented in Table 2. The figures in the second column indicate the frequency with which each species was isolated from 21 healthy humans, and those in the third column the frequency in isolation from 160 plants. The most interesting feature of the data is the frequency with which the plant and dairy species were isolated from the normal human intestinal contents: *Lactobacillus fermenti*, *L. plantarum*, *L. casei*, and *Lactobacillus brevis* exceeded *Lactobacillus acidophilus* in the frequency of recovery. Several of the plant species have been implanted into the human intestinal tract by ingestion. In view of the low numbers of lactobacilli on plants, quite often less than 10/g tissue, the postulated ternary cycle, from intestinal discharge to nature to reimplantation via the oral cavity appears tenable.

There is no reason to believe that one survey,

conducted in a limited geographic area, expresses definitively the range of species or their numbers occurring on plants. Plants grown in more temperate climates may be the natural habitat for several mesophilic species such as *Lactobacillus frigidus*, *Lactobacillus malefermentans*, and *Lactobacillus parvis*, which have been isolated from beers. A recently rediscovered species, *Lactobacillus intermedius*, initially isolated from wines low in acid, occurs as frequently as any species of *Lactobacillus* on plants in Tennessee.

Lactobacilli are able to colonize in the sludges of expressed vegetable juices on processing equipment. They can be enumerated in terms of millions per gram of sludge at sites such as the carton filler and the gate valve at the end of prolonged packing operations.

Pediococci

With an overall incidence of 8.7% on plants in our studies, pediococci are not numerous, with a recorded maximum of 23/g fresh plant tissue. There is no evidence at this time that they colonize on plants; they grow, however, at the expense of expressed juices on harvesting equipment and in masses of fermenting materials. The primary habitats and sources to the plant are as yet unknown. It is questionable as to whether there is a reseeding from animal waste, since we have been able to isolate them only infrequently from dairy cattle fed corn silage, but not from the intestinal discharges of poultry, beef cattle, sheep, or hogs.

The genus *Pediococcus* includes three diverse species groups: those found in beers, typified by *Pediococcus cerevisiae*, the halophilic *Pediococcus* which is encountered extensively in the Orient, and the plant group. Only members of the latter group, *Pediococcus acidilacti* and *Pediococcus pentosaceus*, have been isolated from plants. Both species accompany *Leuconostoc*, the streptococci, and aerococci on fermenting wet vegetables prior to blanching.

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CONTAMINATION OF DAIRY FEEDS BY AIR POLLUTION

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ABSTRACT

Air pollution of forage for dairy cattle is already a serious problem where industry is encroaching upon land used for production of feed and forage crops. In Pennsylvania, lead poisoning and serious metabolic disease resulting from lime plant stack effluents have caused losses on dairy and beef cattle farms. Evidence of intoxication and other metabolic disturbances in cattle in areas close to industries warrants search of pastures or stored forage crops for toxic air pollutants. Pasture areas close to heavily travelled highways may contain appreciable quantities of lead. This situation appears to justify immediate concern by health and agriculture regulatory agencies.

Growth of cities and industry in Pennsylvania continues to present problems for those who manage livestock and poultry enterprises. Water pollution of surface streams and ground water is nothing new. In recent years, air pollution contamination of feeds has presented serious problems in the state. There have been problems associated with application of herbicides and pesticides which have caused major herd disasters, but the purpose of this paper is to discuss problems caused directly by industrial air pollutants.

LIME

Lime plants have been a major source of air pollution for many years in Pennsylvania and we have experienced severe nutritional problems in herds grazing pastures or consuming hay or ensilage from land in close proximity to lime plants. Nutritionists generally agree that calcium-phosphorus ratios for dairy cattle should approximate 1.5:1. It is virtually im-

Continued On Page 561

THE INDUSTRIAL SIGNIFICANCE OF THE LOW TEMPERATURE MICROBIOLOGICAL PRESERVATION OF FOODS[1]

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ABSTRACT

The U. S. food industry grosses approximately 100 billion dollars annually and is serviced by more than 25,000 firms. By 1975, the frozen food portion of this industry will represent approximately 8% of the total retail sales. The microbiological stability of low temperature foods is contingent on variables such as: raw materials, processing conditions, packaging and storage conditions, consumer use, and abuse.

Inevitably, a design in governmental regulatory control becomes apparent. Steps which may be taken by industry to protect the public include: the establishment of a Quality Assurance program, Microbiological Referee Task Force and Vendor Assurance program; the statistical application of test designs; the implementation of valid, rapid microbiological test methods; and the management decision on the degree of risk inherent in any statistical plan with a course of action should a potential health problem arise.

SCOPE OF FOOD INDUSTRY

As the sciences advance in technology, there is an increasing complexity and sophistication in food technology with an ensuing development of new products and processes. These have resulted in 600 varieties of new foods reaching the consumer-public each year. Today, there are over 8,000 grocery items available to the consumer.

There has been a proportional increase of food service establishments approximating one-half million, employing three million people, serving 15 billion meals, equaling 34 billion lb. of food which represents 25% of the total foods produced in the United States on a yearly basis *(29)*.

Dr. E. M. Foster, Director of the Food Research Institute of the University of Wisconsin, addressed a symposium on microbiological contamination at the University of Minnesota in February, 1969 *(6)*. Dr. Foster cited *Fortune Magazine* as describing the food processing industry as a 78 billion dollar a year business. Similarly, a study by the USDA showed that the food service industry grosses approximately 22 billion dollars annually and, consequently, these combined industries amount to 100 billion dollars annually, or by far the largest industry in the U. S. This giant industry is serviced by more than 25,000 firms in food processing alone.

These are certainly impressive figures. Their application to frozen and/or low temperature storage foods was magnified by Mr. Robert Mueller, Publisher of *Progressive Grocer*, who stated at the National Fisheries Institute Meeting in New Orleans in 1970 that the retail increase for frozen foods will easily represent 8% of the total retail grocery market by 1975. We are truly in the advent of the convenience food.

AN INCREASE IN HAZARDS

If there has been an increase in the development and production of convenience foods, the recent past has also produced an increase in reportable cases of food poisoning outbreaks *(29)*.

The weekly publication of the National Communicable Disease Center, entitled *Morbidity and Mortality*, has reported the number of *Salmonella* cases in the United States at approximately 20,000 per year for the last several years *(29)*. However, at the 13th Joint Educational Conference of The Food and Drug Law Institute of the F.D.A., Dr. Foster placed the number of cases of food-borne salmonellosis in the United States at approximately 2 million with an annual cost in human productivity of over 300 million dollars *(7)*.

The significant microorganisms in low temperature storage convenient foods should be categorized by the industrial microbiologist into two groups: *(a) the potential pathogens* used as sanitary indices and *(b) the overt pathogens.*

Those organisms of *industrial significance* are: The Standard Plate Count organisms, thermophiles, molds, yeasts, and bacterial spore formers. The following microorganisms are recognized as being overt public health *pathogens*: salmonellae, coagulase-positive staphylococci, beta-hemolytic streptococci, *Escherichia coli, Clostridium perfringens, Clostridium botulinum,* and toxigenic molds.

Organisms which are presently considered as sanitary *indices* are: The Standard Plate Count, as a crude index of sanitation, coliform organisms, and fecal enterococci.

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[1]Presented at the 57th Annual Meeting of the International Association of Milk, Food, and Environmental Sanitarians, Inc., Cedar Rapids, Iowa, August 17-20, 1970.

Those organisms which are becoming increasingly *suspect* are: *Vibrio parahaemolyticus*, viruses, *Pseudomonas enteritis*, and *Bacillus cereus*.

These microbiological problems in convenience foods have arisen, in part, from: *(a)* more extensive choice of raw materials; *(b)* development of synthesized foods; *(c)* advances in food processing such as dehydration, freeze-drying, drum drying, and spray drying; and *(d)* innovations in packaging procedures such as aerosols, vacuum pouches, and the "completed meal."

Data in Table 1 list the specific etiology of confirmed outbreaks of food-borne illnesses from January to June 1969 as reported by the National Communicable Disease Center Annual Summary *(28)*. It should be significant to the industrial food producer that while regulatory agencies have, for years, stressed the epidemiological significance of salmonellae, the data repeatedly demonstrate that this microbiological agent is not—and has not been—the major cause of foodborne disease in the U.S. for a number of years. These data demonstrate again that coagulase-positive staphylococci and *C. perfringens* have produced approximately the same number of confirmed outbreaks but that *C. perfringens* has traditionally produced a higher number of confirmed patient illnesses. It traditionally has a much higher "attack rate" and is often associated with meats and meat-type products.

Table 2 shows the number of people reported ill from outbreaks of foodborne illnesses of specific etiology between January and June in a comparison between 1968 and 1969. These data again demonstrate that coagulase-positive staphylococci have produced the largest number of foodborne outbreaks in both years and *C. perfringens* is again second in epidemiological significance with salmonellae third in etiological significance *(28)*.

As an industrial food microbiologist, I find data in Table 3 of particular importance. They demonstrate those areas where food has been mishandled in foodborne outbreaks and reported by specific etiology by the National Communicable Disease Center for the period ranging from January to June 1969 *(28)*. Data in Table 3 did not originally contain the totals now included. But as industrial food producers I think it is important for us to realize the relationships for the occasion of foodborne outbreaks.

Whereas food *processing* establishments were responsible for 13% of the outbreaks, food *service* establishments were responsible for 25% of the outbreaks, and *consumer abuse* in the home caused 10% of the outbreaks. This relatively high ratio of almost 3:1 of foodborne outbreaks in service establishments and homes as compared to food processing establishments demonstrates the significance of potential consumer abuse over which the food producer has little control.

TABLE 1. SPECIFIC ETIOLOGY OF CONFIRMED OUTBREAKS OF FOODBORNE ILLNESS JANUARY TO JUNE, 1969

	Outbreaks confirmed		Patients confirmed	
	No.	%	No.	%
Bacterial agents	66	81.5	4,078	97.2
Staphylococcus	20	24.7	1,329	31.7
C. perfringens	20	24.7	1,829	43.5
Salmonella	14	17.3	713	17.0
C. botulinum	5	6.2	10	0.2
Shigella	3	3.7	133	3.2
E. coli	1	1.2	26	0.6
Streptococcus	1	1.2	3	0.1
B. cereus	1	1.2	5	0.1
Multiple etiologies	1	1.2	30	0.7

TABLE 2. SIZE (NUMBER OF PEOPLE ILL) OF OUTBREAKS OF FOODBORNE ILLNESS OF SPECIFIC ETIOLOGY JANUARY-JUNE 1968 AND 1969

Bacterial agent	1968 Number of outbreaks	1969 Number of outbreaks
Staphylococcus	29	35
C. perfringens	21	32
Salmonella	14	16
C. botulinum	4	5
Shigella	1	3
E. coli	4	2
Streptococcus	5	2
B. cereus	0	1
Brucella	1	0
Multiple etiologies	0	1

TABLE 3. PLACE WHERE FOOD WAS MISHANDLED IN FOODBORNE OUTBREAKS REPORTED BY SPECIFIC ETIOLOGY JANUARY TO JUNE, 1969

Bacterial agent	Food processing establishments	Food service establishments	Homes	Unknown-Unspecified	Total
	(No. of outbreaks)				
Staphylococcus	2	9	4	20	35
C. perfringens	5	10	1	16	32
Salmonella	3	4	1	8	16
C. botulinum			3	2	5
Shigella	1			2	3
E. coli	1	1			2
Streptococcus	1	1			2
B. cereus				1	1
Multiple etiologies			1		1
Totals	13	25	10	49	97

FACTORS IN PRODUCT STABILITY

As an industrial microbiologist, one becomes aware

that the microbiological stability of low temperature foods becomes contingent on a number of variables. To me, there are four principal phases which affect the microbiological stability of a product, and these are:

The primary phase: Raw materials

A discussion of raw materials necessitates a definition of terms. What is one manufacturer's raw material is another producer's final product. The supplier must determine the extent of his liability in terms of his raw material *and* his finished product. Dr. Fred Thatcher, Director of the Canadian Food and Drug Directorate, stated in *Microbiology of Frozen Foods* that, ". . . . ultimately, the source of contamination must be identified and corrective measures taken. Cooperation becomes important between the various phases of industry association with the *sequential* production of susceptible products. Strict attention must be paid to analysis of raw materials and finished product from each manufacturer's viewpoint" *(23)*.

The intermediate phase: Processing conditions

It is inevitable, that the problems in processing are closely related to the raw materials used. It goes without saying, that product handling by people or contamination by air or unsanitary equipment are additional sources of contamination. These hazards apply to almost all food processing techniques and require no further elaboration here.

There always exists the dangers of recontaminating a product during the packaging operation. To many, the packaging process is considered "the final phase." To me, it is not.

The ultimate phase: Consumer abuse

To me, the ultimate phase of microbiological protection of foods for human consumption is the inherent and/or designed protection against consumer abuse. Table 3 has demonstrated the relatively high incidence of food-borne outbreaks associated with food service establishments or home abuse of a product. Certainly, one of the least controllable aspects in the handling of convenience foods is consumer abuse. The conscientious manufacturer has taken all reasonable precautions to deliver a wholesome product. But this does not, in itself, provide complete protection. The housewife, in her kitchen, may contaminate the product or prepare it improperly and thereby create new problems. The ingredients the housewife adds to her foods, the insufficient heating times, the possibility of poor sanitation, and the inevitable danger of elevated refrigerated storage temperatures are uncontrollable factors leading to the consumer abuse type of food poisoning outbreaks.

STANDARDS AND STATISTICS

Among the major considerations in the production of convenience foods are: mass production techniques, need for refrigerated or frozen storage, and the gigantic transportation complex which distributes products throughout the country in a matter of days.

Some may think that it would be desirable to develop the techniques of food processing to that point where no bacteria are present when it reaches the consumer. This is neither attainable nor desirable.

As industrialists, we have heard of microbiological levels of "zero." However, this may not be feasible. We may have to learn to live with reasonable, non-hazardous levels. In interpreting microbiological test results, we would distinguish between the use of the term, "non-detected" as opposed to, "zero." Whereas, "zero" is an absolute value, the phrase, "non-detected" indicates the sensitivity and limitation inherent in the particular test employed.

In a presentation to the Food Protection Committee, Dr. Foster explained that ". . . . standards (are) based on the presence of indicator organisms (and) serve . . . . to reflect the adequacy of processes and sanitation procedures (and) reflect adherence to good manufacturing practices" *(8)*. The Food Protection Committee deals with the technical feasibility of microbiological criteria; that is, standards should be attainable under good commercial practices. *This* is a realistic assessment. Dr. Foster asked that, " . . . . If we accept this premise, we come to the task of determining what is feasible under conditions of good commercial practices (and) from the results we can determine if there is a microbiological relationship to the conditions of production and, if there is, a standard can be set."

The Food and Drug Administration has recently published results of microbiological incidence studies for four frozen food items. These items were carefully chosen because of their potential microbiological significance. They were: frozen cream-type pies, frozen breaded raw shrimp, potato products, and frozen breaded fish.

The design is reasonable and well chosen. It is simply this: *(a)* potentially significant microbiological food prototypes and/or processes are selected for incidence studies; *(b)* a statistically significant number of samples representative of the foods and/or processes are collected and evaluated by standard microbiological procedures; *(c)* the incidence data from these studies depict what might be considered normal operating ranges for the microbiological population for these foods; *(d)* these data are made available to the industry at large with the suggestion that the results indicate the range for production within "good manufacturing practices;" *(e)* a reasonable

period of time is permitted for the industrialists to evaluate the data, consider improvements, and, where possible, adopt modifications which permit implementation of good manufacturing practices; and *(f)* as a final step, we can only assume that the purpose of "guidelines" are to set criteria for future action.

In keeping with this approach, in the statistical evaluation of microbiological data, Dr. Keith Lewis, Director of the Office of Food and Nutritional Science of the Food and Drug Administration, presented a review paper on refrigerated and frozen foods at the 30th annual meeting of the Institute of Food Technologists in San Francisco *(17)*. Dr. Lewis suggested that there is "pressure" for establishing microbiological standards for food products but commented that "guidelines" might be best. As an example of these guidelines, Dr. Lewis described the results of microbiological analyses on 2,600 samples of frozen cream-type pies, frozen shrimp, and dry gelatin which were conducted by standard analysis at the FDA National Center for Microbiological Analysis. Without our discussing the ranges of microbiological counts obtained, Dr. Lewis explained that "It would be reasonable . . . . to expect these products not to exceed . . . . :

Frozen cream-type pies:
1. Aerobic plate count of 50,000 per gram.
2. Coliforms <15 per gram.

Frozen shrimp:
1. Aerobic plate count of <500,000 per gram.
2. Coliforms should be non-detectable.

Dry food-grade gelatin:
1. Aerobic plate count of 5,000 per gram.
2. Coliforms should be <3 per gram.

If it is difficult to make an objective distinction between official microbiological standards for foods and a "guideline", I believe it is equally difficult to dispute statistically valid microbiological data.

PROBLEMS WITH FROZEN FOODS

In approximately 1952, the wholesale manufacturing distribution of frozen foods began to spiral with public acceptance. Almost inevitably, a series of problems arose in this infant industry which, unfortunately, are not totally eliminated today. Some of these problems were: *(a)* inadequate low temperature storage for bulk inventory, *(b)* the inability to obtain and maintain the necessary low temperatures for product stability, *(c)* lack of mechanically refrigerated delivery trucks, *(d)* the practice of the delivery and sale of partially thawed product at "distress" prices, *(e)* failure to recognize the perishability and sensitivity of frozen products as a prototype, *(f)* the lack of sufficient display case space proportional to the volume of business, and *(g)* the practice of overloading the display case resulting in cycling storage temperatures *(5)*.

In 1955, when frozen foods had been accepted as a convenience household item, there were reported 193 associated food-borne disease outbreaks involving 9,633 people. The Disease Outbreak Summary of the Public Health Report *(1)* states " . . . . this probably represents only a small portion of such cases occurring in the United States. There are doubtless many individual cases and family-size outbreaks of non-fatal illnesses which are not reported and never come to the attention of a physician."

There are a number of inherent product distribution and storage problems associated with low temperature storage foods. Clark has demonstrated that it is possible for a number of "microclimates" to exist in stacked frozen products in a display case. This can result in varying microbial proliferation rates from front to back and from top to bottom in the stack *(5)*. The humidity in a carton of frozen foods is at the saturation point. Consequently, when freezer cabinets contain various microclimates, a film of moisture may develop over the surface of the product and create an environment for the slow multiplication of microorganisms although the interior of a product may be frozen *(8)*.

We feel that we have demonstrated the significance of the role of the consumer in microbiological abuse. Perhaps one of the most significant problems is the use (or abuse) of low temperature food storage by the consumer herself. The home refrigerator often ranges from 45 to 50 F. This temperature, acting on products such as chicken-a-la-king would allow for proliferation of such overt pathogens as staphylococci and salmonellae *(20)*.

FOOD POISONING AND FROZEN FOODS

An often overlooked potential hazard for food poisoning results from the inadvertent lack of application of the manufacturer's recommended times and temperatures for cooking pre-cooked frozen foods. Studies by Canale-Parola and Ordal *(4)* on frozen poultry pies indicated that the center of pies baked under what the authors assumed to be comparable home conditions did not reach a temperature high enough to reduce the bacterial count to a safe level. Coliform organisms and other non-spore formers were detected in the baked pies *(16)*. Canale-Parola and Ordal express the opinion that the baking time is more significant in the destruction of the microbial flora than is the oven temperature *(4)*.

Effects of freezing on bacteria and their survival depend on various factors such as: rate and type of freezing which controls the size of the ice crystal possible rupture of the cell wall dependent upon ice crystal structure, temperature and duration of storage, initial microbial populations, the microbial

flora itself, and various stages of growth in which the microflora may be found at the time of freezing. Other factors are the number of cyclical defrostings and thawings, as well as the time allowed at ambient temperatures before the housewife bakes the product.

A temperature of 0 F or lower is considered desireable for holding frozen foods at all stages from packer to consumer *(5)*. As might be expected there is ambiguity among the results of various investigators. The work of Clark *(5)* has shown that various types of poultry and processed poultry products gave evidence of deterioration when kept short periods of time at temperatures at about 0 F and developed rancid flavors at 10 F. Yet, Burr et al. *(3)* stated that " . . . . one or two brief exposures to higher temperature, a few days at 10 F or a few hours at 20 F, do not cause appreciable harm." For all of the aforementioned factors which influence the stability of low temperature storage foods certainly, protection offered by the sanitary quality of the food itself is most critical *(21)*.

Food prototypes

Pre-cooked frozen foods. Certainly, there are a wide variety of low temperature storage foods which have been affected adversely by improper handling and/or storage. The literature is replete with references. Several will be cited here to demonstrate the range of food prototypes affected. Among these are the precooked frozen foods which, in a study by Canale-Parola and Ordal *(4)*, it was found that poultry pies had a higher degree of bacterial contamination than did other types of pre-cooked frozen foods which were obtained on the retail market. In documented cases of food-borne outbreaks involving this type of product, total counts have listed at 30 million per gram, coliforms at 1,100 per gram, and *Staphylococcus aureus* at 340,000 per gram.

Meats. In December 1969, there were four related outbreaks of salmonellosis in Los Angeles County involving persons who ate meals catered by food service establishments in which 62% of the persons reported clinical symptoms *(29)*. While the roasting temperature reported by the caterer appeared to be sufficient to destroy salmonellae, the refrigerator temperature of 50 F appeared to be inadequate to prevent stored, undercooked foods from microbial proliferation and contamination of the foods served the guests. Between 1967 and 1968 there were 91 isolations of salmonellae from turkeys alone in the United States *(29)*.

Certainly it becomes apparent that the various food prototypes intended for low temperature storage require attention proportional to their incrimination in food-borne disease. From 1961 to 1963, shipments of veal, beef, and mutton imported and intended for human consumption were found to be contaminated at a rate from 5 to 90% *(23)*.

Fruits. Commercially packaged frozen strawberries were studied to determine flavor and color changes in relation to time - temperature changes. At a temperature of 20 F and after storage at 2 weeks, they were found to have undergone change. Storage of between 4 to 6 weeks produced deterioration and consumer rejection. The significance of the time-temperature relationship is well stated by Guadagni *(10)* ". . . . for each 5 F increase in temperature, the rates of deterioration were increased two to threefold." Interestingly enough, these investigators found that the type of package used was the single most significant factor affecting the storage life of strawberries held at temperatures above 0 F.

Beverage concentrates. Whereas our previous concern has been almost totally with microbiological protection by the suitable low temperature storage of foods, work of McColloch et al. *(19)* indicates that the 0 F storage of frozen, unheated orange concentrates becomes critical for product degradation may be caused by the phenomenon of enzyme reactivation rather than by microbiological activity.

Frozen vegetables. There is some indicated apparent inherent protection demonstrated in the thawing cycles of frozen vegetables by the work of Hucker et al. *(14)*. In this study a thawing temperature range of 35 F to 44 F with an 8 hr holding time before refreezing, was used to determine the effects of alternate freezing and thawing on frozen vegetables In this study, no significant rise in microbiological counts was noted after 5 freezing-thawing cycles. After consecutive freezing-thawing cycles of the frozen vegetables, the results indicated that the total flora did not increase when the thawing phase did not exceed a period of 10 hr at 38 F to 44 F. Again, the significance of the food prototype may be a prime factor.

Bacteria of specific importance

The general classes of bacteria of significance in low temperature storage foods are shown in Table 4 *(23)*. The organisms of greatest epidemiological significance, and of greatest interest to the food producer, at this time are the salmonellae and staphylococci.

In a study conducted by Goepfert and Chung *(9)*, luncheon meats were inoculated with salmonellae, vacuum packaged, and stored at 41 F for six weeks. During the first two weeks a 30 to 90% reduction of cells was detected. However, after this time, the salmonellae ceased to decline and their numbers stabilized for the remainder of this study. Obviously, salmonellae will survive under well func-

TABLE 4. GENERAL CLASSES OF MICROBIAL TEMPERATURE RANGES

Group	Temperature ranges in °F		
	Minimum	Optimum	Maximum
Psychrophilic	36 - 40	59 - 69	86
Mesophilic	50 - 77	86 - 104	95 - 122
Thermophilic	77 - 113	122 - 131	158 - 194

tioning home-use refrigerator temperatures.

Work by Sorrells et al. *(22)*, using injured *Salmonella* cells subjected to freezing, indicated that the injured cells had the ability to regain their capabilities when grown on nutritional media after abusive freezing temperatures of —4 F. There was no evidence of a different effect of injured to uninjured cells on chicks suggesting that metabolic injury caused by freezing did *not* alter pathogenicity.

Data produced at the Taft Sanitary Engineering Center (27) offered refrigeration temperatures which prevented the outgrowth of salmonellae and staphylococci in what were described as readily perishable cooked foods. Whereas 5 days were required to produce perishability in these foods stored at 40 F, only one day was required to produce perishability at 50 F.

Weiser *(31)* demonstrated that *S. aureus* and *Salmonella typhi* could be frozen in liquid air at —182 F to —190 F for 20 hr without destroying the viability of these organisms.

Abrahamson et al. *(2)* clearly demonstrated the relationship between staphylococcus and food poisoning outbreaks in meats and meat products associated with human contamination and improper low temperature storage.

In a joint study using salmonellae and staphylococci in custards as the food vehicle, work at the Taft Center *(27)* demonstrated that staphylococci grew at 44 F and above, whereas the salmonellae underwent a gradual decrease at temperatures from 40 F to 50 F.

Again, the significance of the food prototype manifests itself when the same study demonstrated that both salmonellae and staphylococci grew at temperatures of 44 F and above in chicken-a-la-king. However, neither organism grew in a ham salad at temperatures from 40 F to 50 F.

Harrison *(12)* used *Lactobacillus fermenti* to demonstrate the effects of the initial freezing and thawing on cell concentrations. Of particular interest was the fact that regardless of the length of storage interval between successive freezings, the lethal effect of the second freezing was greater than that of any subsequent freezing or of the initial freezing itself. This may be caused by the rate of ice crystal formation and their size in disrupting cell wall membranes.

To substantiate this, the work of Raj et al. *(21)* demonstrated that *E. coli* in fish homogenate survived through the fifth cycle in sufficient numbers to constitute a public health hazard.

The work of Guadagni et al. *(10)* with *Streptococcus faecalis* demonstrated that this organism survived almost 100% when inoculated into chicken meat pies baked at 425 F for 20 min. However, when baked at this temperature for 30 and 40 min, respectively, survival rates decreased to 3.6% and 0.1%, respectively.

From these data it should be apparent that, for the sake of public health, low temperature storage of frozen and cold storage products cannot be depended upon solely as the means to reduce or eliminate the presence of epidemiologically significant microorganisms in foods. The industrial significance of the low temperature microbiological preservation of foods should be based upon the ability to control reasonable levels of microbiologically tolerable microorganisms in food products produced under good manufacturing practices.

DISCUSSION

Acceptable microbiological populations are those levels of bacteria in a specific food which are attainable by reasonable production techniques, established by valid microbiological tests, and defensible with regard to public health and quality requirements. Analyses are necessary to guarantee consumer safety within a reasonable storage time, reduce the risk of hazards from consumer abuse, promote wholesomeness and product stability, and assure repeated sales.

These objectives may be accomplished, in part, by the formation of a Microbiological Quality Assurance program, the functions of which are: development of valid microbiological procedures and establishment of workable embargo levels for implementation in the event of microbiological hazard. There are various aspects in a quality assurance program which may be erected as protective measures for any organization. Primarily, it is important to understand the inherent microbiological hazards in the commodity. Defense against vendor abuse is a control mechanism. Full utilization of inherent "kill steps" within the processes is a reasonable adjunct. Full utilization of careful recipe preparation is reasonable. And inevitably, a knowledge of expected consumer abuse, preferably obtained from market studies, and the fate of the microflora under specific conditions, is necessary.

In assessing the microbiological problems in low

storage convenience foods, the industrial microbiologist should institute a microbiological protection survey of each product to consider the following: *(a)* microbiological hazard inherent to the raw agricultural commodity through the vendor, *(b)* problems arising from inprocess conditions, *(c)* establish freedom from potential microbiological hazards, and *(d)* develop defensible microbiological specifications based on a knowledge of the product augmented by product research.

The risk of error in accepting or rejecting a lot of material, based on the quality of the representative's samples drawn, is best defined in terms of an operating characteristic curve. If we apply this concept to the microbiology of convenience foods, we have to consider that regulatory agencies have taken the position that one organism—such as *Salmonella*—detected in a lot of material is cause for regulatory action. To be 95% confident that the true level of contamination in any given lot of material is less than 1% would require 300 consecutive negative analyses. No statistical assurance can be given for "zero defects" unless the entire lot is destructively analyzed.

If the true *average* value is: 1 *Salmonella* organism in 2500 g of convenience food, the probobility of obtaining at least one positive result from 100 random samples is 63%. There is no statistical approach to non-uniform contamination; therefore, we feel that the best method of protection is to rely on the quality control of raw materials and inspect heavily those which are especially suspect. If we concentrate our efforts on suspect raw materials, the number of analyses is reduced to workable levels and offers the same statistical assurance, if we assume that the other raw materials not suspect are truely free from salmonellae.

SUMMARY

The microbiological aspects of convenience foods require many avenues of approach by the industrial microbiologist. The pre-established course of events has been outlined as: *(a)* The establishment of the increased incidence of foodborne outbreaks. *(b)* It has been established that these problems are essentially raw material problems with need for in-process control. *(c)* Industries should make efforts to establish vendor assurance programs. *(d)* The problems which bind industry at this time are: the "zero tolerance" for salmonellae, need for extensive microbiological testing for statistical protection, and existence of complicated and prolonged tests. *(e)* There is a vital need for rapid microbiological test methods. *(f)*. Protection in depth for any food industry requires the extensive control of: raw materials, in-process conditions, final product quality, and anticipated consumer abuse. *(g)* Management must be made to understand and to decide on the degree of risk that any given statistical method offers when adopted. *(h)* Statistics do not protect against a contamination, but merely point out the degree of risk involved. *(i)* Management must be assisted by the industrial microbiologist in preparing to make the advance decision as to the course of action to follow *if* a potential health problem does arise.

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CONTAMINATION OF DAIRY FEEDS

Continued From Page 553

possible to adjust the remainder of the ration to compensate for all of the lime dust intake in such herds. Dairy cattle have a very high incidence of milk fever, infertility, and bone abnormalities. In one large purebred beef cattle herd in southeastern Pennsylvania, a large percentage of the brood cows experienced ovarian cysts and osteopetrosis (a type of arthritis characterized by excess deposition of bone) was common in cows over 8 years of age. Lime dust also affects the pH of the digestive tract to a great extent limiting digestion and absorption of some components of the diet. Elimination of all calcium supplementation from the diet and supplementation with phosphorus has been helpful for these herds. Harvesting corn silage before it gets into the tough dough stage has been helpful. The more acid silage has certainly brought about better feed utilization and performance in at least one dairy herd.

LEAD POISONING

In the past 14 years, the author has been involved in a number of lead poisoning situations in Pennsylvania caused by forage contaminated from materials discharged from lead smelter stacks. Lead poisoning problems are never very simple, but lead is an accumulative poison and in some cases poisoning did not accur until after several years of contamination. Although it has been shown that lead content of plants grown in soil thus contaminated does increase, the poisoning problems occur from lead dust which contaminates the plants at harvest time. In two farms in Berks County pastures close to lead smelters contained enough lead dust contamination on grass to kill cows. One herd was wiped out by lead poisoning 3 years after the smelter went into operation. In the other herd owned by a cow dealer, cattle which were on pasture a short time were not affected; those which were not sold within about 60 days developed lead poisoning. The only approach to lead poisoning of cattle from air or water pollution is tight control of the lead plants. Effluents must be constantly monitored and the attitudes of the offenders must be changed by stiff penalties. Some of the smaller lead plants do a good job of washing out lead dust from stack effluents during the daytime, but after dark they allow the smelter smoke to go without any attempt to control air pollution. Lead poisoning is just as subtle and dangerous for humans. In poorly managed plants the workers are certainly worse off than the cattle in the immediate vicinity.

Continued On Page 567

FIELD EVALUATION OF AN OPTICAL SOMATIC CELL COUNTER FOR MILK

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ABSTRACT

The Technicon Optical Somatic Cell Counter (OSCC) was studied for its utility in determining the somatic cell concentration in raw milk. Over the range of 30,000 to 1,600,000 cells per milliliter, dilutions of a milk sample or a stabilized turkey erythrocyte standard elicited a smooth but slightly curvilinear instrument response. Thirty milk samples of cell concentration clustering closely around 1,500,000 cells per milliliter were analyzed in triplicate. From an analysis of variance of the uncorrected instrument readout we computed an $LSD_{.01}$ of 1.48 major chart scale divisions, which is a sensitivity of 2.0% at 1,500,000 cells per milliliter.

Determinations were made on bulk tank milks ranging from 100,000 to 1,600,000 cells per milliliter. Chart peak values and Direct Microscopic Somatic Cell Counts (DMSCC) were highly correlated (0.96) when operating at either 30 or 60 samples per hour. Apparent inadequacies of the turkey erythrocyte calibration system may account for the discrepancy between the slope of the calibration curve and the regression lines. The discrepancy was much greater at the faster sampling rate. In a comparison of split samples of milk by both OSCC and DMSCC in three laboratories, the OSCC averaged 20% higher than the DMSCC counts but yielded a much lower standard deviation.

In recent years there has been increased research interest in improved methods for enumerating somatic cells in milk. The program for control of abnormal milk adopted by the National Conference on Interstate Milk Shipments *(3, 4)* is based on exclusion from sale of farm raw milk containing more than 1,500,000 somatic cells per milliliter. Farm milk supplies are periodically screened in the laboratory by one of several indirect tests. All samples giving rise to a high screening test score must be confirmed by the direct microscopic leucocyte count or the electronic method.

Among the many variations on the original Prescott-Breed microscopic counting method, the Direct Microscopic Somatic Cell Count (DMSCC) *(5)* is rigorously defined in procedural details and has been evaluated for precision repeatedly in several laboratories *(8, 9)*. The method is, however, time consuming and visually fatiguing. Several methods have been published for utilizing electronic gating instruments in counting cells in milk. Correlations of 0.97 have been reported between one method under evaluation in the United States and a manual microscopic count using 48-hr bulk tank milk samples *(7)*. The electronic procedure is reported to have higher precision than individual manual counts *(6)*. It is not automated, however, and considerable time must be devoted to sample preparation.

The Technicon Corporation has developed a fully automated procedure which is based on the optical properties of the milk sample. Several laboratories were loaned equipment to evaluate the procedure. Except as noted, the information reported here is from studies conducted in the USDA Mastitis Laboratory at Beltsville, Maryland.

MATERIALS AND METHODS

Principles and function of the Optical Somatic Cell Counter

The OSCC system *(10)* consists of five modules in series: the automatic sampler; the proportioning pump with special manifold; a heated incubation bath; the optical cell counter; and a potentiometric recorder with strip chart display.

Initial fixation of the somatic cells with formaldehyde at a final concentration of 0.2% can be done at room temperature overnight, or equally well at 55 C in a water bath for 45 min. Samples are then poured into individual sample cups and placed in the sampler.

The sampler rotates a tray of sample cups through 40 positions at an interval which can be set for either 30 or 60 samples per hour. At two positions in the cycle milk is mechanically agitated and at the second of these positions a probe is introduced to aspirate the sample into the analytical system. The sample volume is 0.32 ml at 30 per hour and 0.16 ml at the 60 per hour sampling rate. Between each two milk samples, the probe aspirates liquid from a wash reservoir to provide physical separation of the samples in the reaction train. The motive force for aspiration is supplied by the proportioning pump. Each liquid or air component of the system is introduced continuously and at constant flow rate by aspiration through one or more parallel pump tubes, the inside diameter of which determines the volumes of fluid introduced. The flow diagram is shown in Fig. 1.

Milk samples are diluted with 0.25% aqueous glutaraldehyde and then clarified of noncellular particles by a mixture of hydroxylamine in alcoholic potassium hydroxide, Triton X-100, and ethylenedinitrilo-tetraacetic acid (EDTA). The first two components disrupt the fat globule membranes and saponify the fat; the EDTA complexes the calcium salts. The stream is mixed by passage over a series of vertical coils and is incubated at 60 C during traverse of two 40 ft glass coils within an oil bath.

The detection system consists of an optical train which first focuses light from a lamp source in a small, sharply defined region of a flowcell and then blocks the beam from energizing a photomultiplier tube by interposing a dark field disc. If any particles, such as somatic cells, are dispersed in the liquid

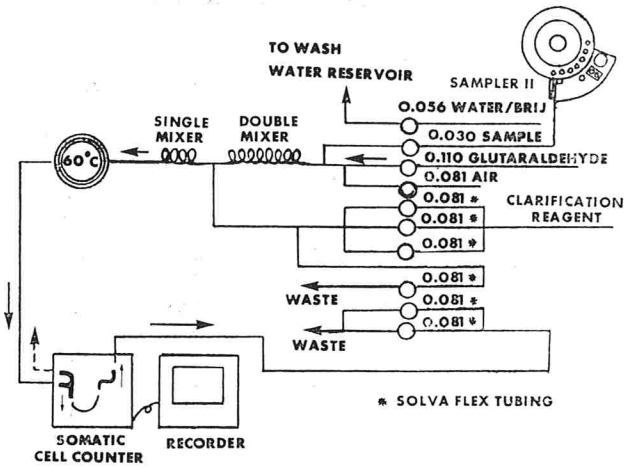

Figure 1. Flow diagram of the Optical Somatic Sell Counter.

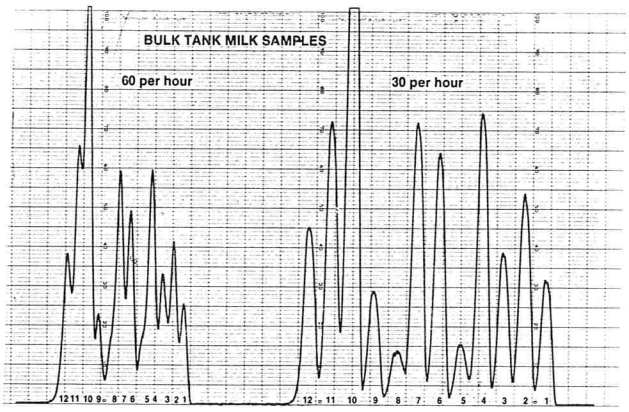

Figure 2. Strip chart recording of milk somatic cell concentration analyses by Optical Somatic Cell Counter at two sampling rates.

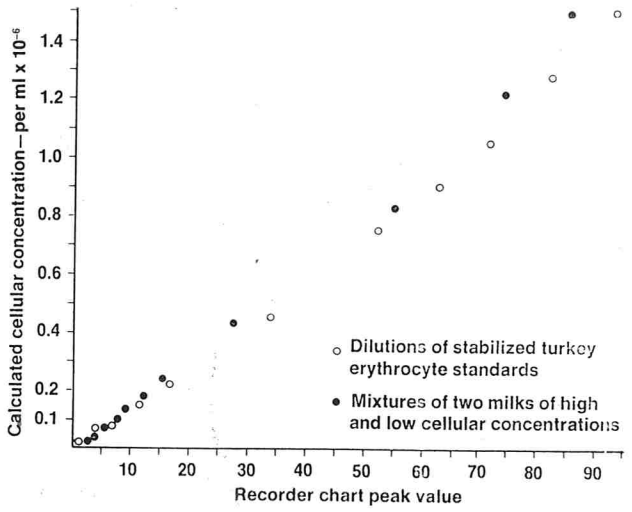

Figure 3. Response of Technicon Optical Somatic Cell Counter to a wide range of cell concentrations.

stream as it passes through the illuminated area of the flowcell these act as secondary sources of near-forward scattered light. The resulting flashes impinge upon the photomultiplier tube where each generates an electrical impulse. The physical principles have been reviewed by Martens *(2)*. The pattern of pulses is displayed on a small oscilloscope screen. These nonuniform current pulses are amplified and converted to voltage pulses. A threshhold detector removes those small pulses which were generated by particles of less than the minimum volume desired and clips and converts the remaining pulses to square wave forms. Pulses are of nonuniform width, so the signal is fed into a monostable multivibrator. Finally a count rate, or time averaging, circuit provides an analog voltage output whose level is a direct function of particle flow rate through the flowcell.

A single pen recorder traces the output signal on a continous strip chart to produce a single peak for each sample. The paper is imprinted with 200 equally spaced lines and is scaled at intervals from 0 to 100. Figure 2, taken from the analysis for a series of milk samples, shows such peaks. By introducing among the milk samples certain standards one obtains peaks of height relative to known cell concentrations. The standards supplied by the Technicon Corporation consist of stabilized suspensions of turkey erythrocytes. A plot of these points defines a calibration curve, from which can be found the OSCC cell concentrations, corresponding to chart peak values of the unknown milks.

Routine operation of the OSCC

All liquid lines of the OSCC must be flushed with the reagents for 15 min at the beginning of a day's operation. Several replicate samples of a high cell concentration standard are placed in the first positions on the sampler tray and then other standards and unknowns as desired. At the end of the tray, standards are repeated as a check on drift in the circuitry. After about 12 min running time the first sample arrives at the flowcell, causing a response of the recorder pen. A calibrated potentiometer, labeled "Sensitivity", is set into the face of the cell counter and permits adjustment of the peak height of the first standard during its passage through the flowcell. Since the OSCC was designed primarily with bulk tank samples in mind, for which the maximum permissible cell concentration is presently 1,500,000 per milliliter, most of our testing of the instrument has been done with the maximum scale reading of 100 set equivalent to a concentration of about 2,000,000 cells per milliliter. At the end of a day's operation, the aspiration tubes are placed in wash reagents which are permitted to circulate through the system for 20 min.

RESULTS AND DISCUSSION

Pattern of instrument response

Several series of samples were prepared for analysis with the OSCC by diluting either stabilized turkey red cells with glutaraldehyde reagent or a milk of high cell concentration with virtually cell free milk. Cell concentrations of the diluted samples were calculated from the labeled value of the standard or the DMSCC on the original milk. Figure 3 shows the results of typical trials over the range 1,500,000 to 30,000 cells per milliliter. Open circles mark turkey erythrocyte samples; solid dots mark milk samples. The position of each point is determined by the recorder chart peak value and the cal-

TABLE 1. COMPARISON OF ANALYSES ON SPLIT SAMPLES OF MILK BY DMSCC AND TECHNICON OSCC

Sample	OSCC[a]				DMSCC[a]					
	Lab 1	Lab 2	Lab 3	Stand. dev'n	Lab 1	Lab 2	Lab 3	Stand. dev'n	DMSCC mean	OSCC as % of DMSCC
A-1	1,740	1,650	1,760	48	1,670	1,790	1,116	273	1,540	111.3
A-2	1,700	1,790	1,780	40	1,560	1,780	1,210	235	1,520	115.7
B-1	1,720	1,700	1,830	57	1,540	1,640	1,750	86	1,640	107.0
B-2	1,780	1,730	1,710	30	1,800	1,690	1,450	146	1,650	105.7
C-1	2,800	2,960	2,800	76	2,540	2,920	2,510	187	2,660	107.0
C-2	2,760	2,920	2,840	65	2,550	2,800	2,700	103	2,680	106.0
D-1	1.870	1,960	2,590	321	1,960	2,050	1,320	325	1,780	120.3
D-2	1,900	2,640	2,510	322	2,010	2,590	1,520	437	2,040	115.0
E-1	1,360	1,290	1,430	57	1,120	1,500	820	278	1,150	118.0
E-2	1,380	1,240	1,320	57	1,130	1,480	880	246	1,160	113.3
F-1	2,890	2,750	2,800	58	2,340	2,430	2,380	37	2,380	118.3
F-2	2,600	2,770	2,720	71	2,480	2,780	2,430	155	2,560	105.3
G-1	930	630	550	164	500	600	370	94	490	143.7
G-2	940	720	540	164	540	760	420	141	570	128.7
I-1	830	840	800	17	760	820	240	260	610	135.0
I-2	800	830	750	33	780	860	310	243	650	122.0
J-1	1,220	1,390	1,380	78	970	1,290	550	303	940	141.7
J-2	1,240	1,340	1,290	41	1,100	1,180	550	280	940	137.3
Overall				15.8				28.7		119.5

[a]Somatic cells x 10^{-3} per milliliter.

culated cell concentration of that sample. For both types of sample there is a consistent but slightly curvilinear relation.

Accurate determination of low cell concentrations is a particularly difficult problem. Although concentrations below 300,000 per milliliter are of little consequence in abnormal milk control, their precise measurement can be of importance in mastitis research. We have studied such low cell concentrations by increasing the sensitivity of the OSCC. Manipulation of the "Sensitivity" control to increase amplifier gain accomplishes a contraction of the scale to the extent that chart peak height for a given cell concentration can be increased about threefold. With full scale pen deflection set for about 800,000 cells per milliliter, the instrument response to series of dilutions of standards and known milk samples was essentially linear down to 30,000 cells per milliliter. This is illustrated in Fig. 4. In replicate determinations, none of the lower peaks deviated by more than one-half a major scale division.

Although these data imply that the OSCC will yield accurate results at cell concentrations as low as 30,000 per milliliter, we are not completely satisfied. The analysis of groups of independent milk samples in the concentration range 30,000 to 100,000 by both OSCC and DMSCC has produced nearly random scatters of points. This may not be the fault of the OSCC. The variance of a cell count is ideally equal to the mean particle count, and this relation is approached in practice with the DMSCC *(8, 9)*. Thus at low cell concentrations, in which only a few cells are encountered in all four strips across the milk film, the per cent error in manual counts will be very great. In such a range, the DMSCC is necessarily an imprecise tool for evaluating the OSCC, for which far greater numbers of particles participate in the resulting count.

Instrumental precision is much easier to determine than absolute accuracy. I prepared a series of 30 samples of high but slightly varying cell concentration, as follows. A batch of milk of about 1,500,000 cells per milliliter was refrigerated overnight and then shaken only 10 times before decanting 30 samples. The series was run on the OSCC three times in succession. From an analysis of variance of the chart peak values, in which the samples were considered as treatments, we estimated the error variance as 0.4633, and from this computed the $LSD_{.01}$ to be 1.48 major chart scale divisions. Since the sensitivity setting was such that 1,500,000 cells per milliliter produced a peak height of 75, the LSD indicates that the instrument was operating to detect with great reliability a minimum difference in concentration of 30,000 cells per milliliter, or 2.0% of the nominal concentration in the milk. The great precision of the OSCC would thus commend its use in studies of the adequacy of currently accepted procedures for sampling dairy products *(1)*.

Results of testing bulk tank milk samples

Figure 5 illustrates results of determinations on a typical series of 60 bulk tank milk samples. The heavy black line is the calibration curve derived from

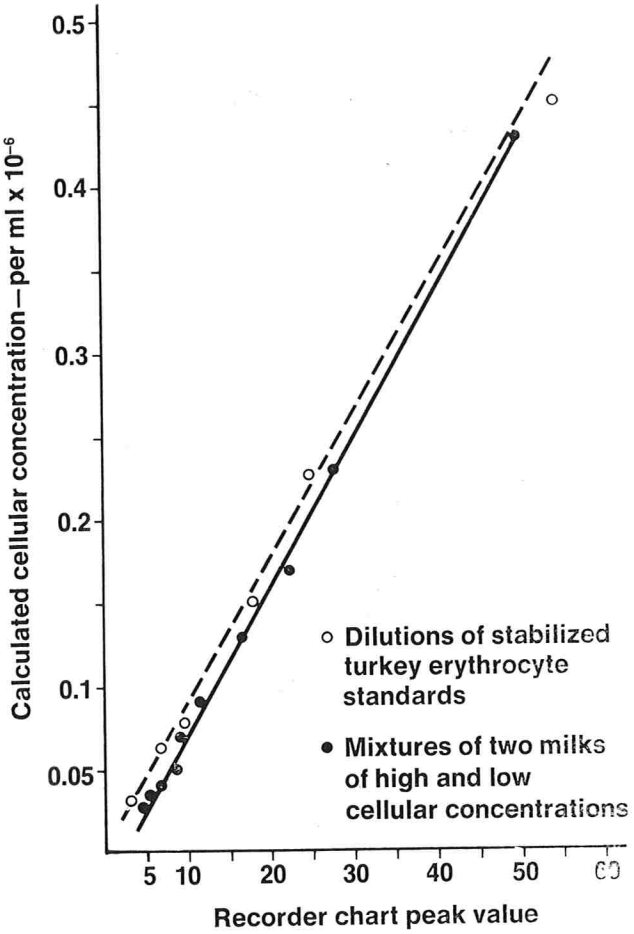

Figure 4. Response of Technicon Optical Somatic Cell Counter to a restricted range of low cell concentrations.

chart peak values of the turkey cell standards. In routine practice, chart peak values of the unknown milks would be projected up from the abscissa to the curve and then to the left, where the analogous cell concentrations can be read from the ordinate scale. We performed the DMSCC on each sample, however, and plotted the points using these counts. For each count a vertical line depicts the 95% confidence interval of its DMSCC. Since for most of the determinations the confidence interval of the manual count meets the curve, the count interpretations from OSCC chart peaks match pretty well the DMSCC counts. Deviation is most apparent at higher cell concentrations, where the turkey cell calibration curve reads high in terms of the DMSCC. This sort of comparison measures not only instrument performance but our ability to interpret it. The latter appears to be the limiting factor at present, for when we considered the unconverted data from the OSCC, namely chart peak values, the calculation of simple linear correlation against DMSCC yielded a coefficient of $r = 0.964$.

Operation at increased sampling rate

Analysis of the 60 bulk tank milk samples discussed above was repeated at the 60 per hour rate. Figure 6 shows a plot of the chart peak values against DMSCC. In comparison with the previous figure, there is a similar magnitude of spread among the points but they describe a more gentle slope. The slope of the new calibration curve diverges much more from positions of milk samples, and so a greater error would be introduced through conversion of chart peak values to cell concentrations. Whereas at the slower operating rate the divergence in slope of the calibration curve and the linear regression coefficient for chart peak values on DMSCC was 0.017, the divergence at the 60 per hour rate was 0.055. The fault was entirely in the calibration curve, for the correlation coefficient of $r = 0.965$ was not different from that at the slower sampling rate.

There are minor operational problems in running the OSCC at 60 samples per hour. The volumes of samples and alternating wash fluid are halved, and since the chart drive on the recorder has constant speed the peaks appear at half the usual distance from each other. The shortness of sampling and washing periods apparently provides insufficient time for the detection system to respond fully to great differences in cell concentration between successive samples. Figure 2 shows a strip chart recording of certain milk samples run at 30 per hour and then repeated for comparison at 60 per hour. The low concentration samples numbered 5 and 8 were lost at 60 per hour because the pen had not recovered sufficiently from tracing the high peaks of samples 4 and 7. In routine operation, however, existence of these samples would be detected from double spacing of visible peaks, and these sample cups would be shifted to the end of the run for reanalysis. In sum, it would seem that the calibration problem is not insoluble and that operation at the faster rate is both feasible and preferable in routine laboratory monitoring of large numbers of milk samples.

Results of a split sample trial

The five laboratories involved in the field evaluation recently participated in a split sample trial arranged by the U. S. Food and Drug Administration as part of their research collaborative studies. Such a trial necessarily introduces as a variable the effects on the milk samples of transport by the postal service. Indeed, results from two of the laboratories were so erratic that we can only assume that the milk samples had deteriorated in shipment. Therefore these results have not been included in the analysis. Table 1 shows the cell concentration determinations for each sample in each of the other three laboratories. Ten samples were sent out in blind duplicate with identification numbers coded separately for each laboratory. Results are shown for only

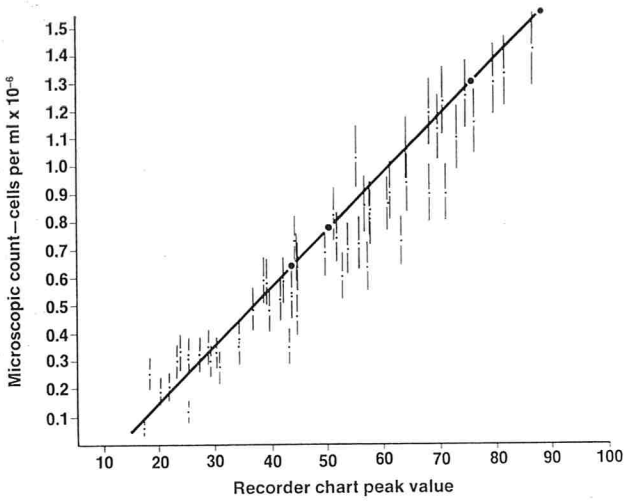

Figure 5. Results of Optical Somatic Cell Counter analyses at 30 per hour on bulk tank milk samples.

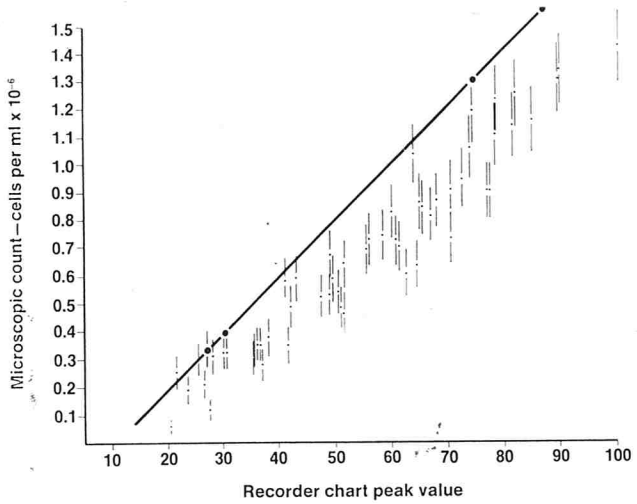

Figure 6. Results of Optical Somatic Cell Counter analyses at 60 per hr on bulk tank milk samples.

nine samples because one laboratory reported the tenth to a minimum rather than an exact value. Each sample was analyzed twice by OSCC, with the mean value reported, and once by DMSCC. Among the 54 OSCC analyses run in duplicate among the three laboratories, only four replicate pairs failed to agree within 10%. Converted OSCC counts were closely proportionate to the mean concentrations determined by manual counting but averaged higher by 19.5%. In view of the possibly different histories of the split samples, the mean of only three DMSCC determinations provides a poor reference for evaluating another analytical method. In fact, laboratory 3 commented when submitting its data that the milk films did not appear typical of unaltered milk. There was in almost all instances considerably greater dispersion of results by the DMSCC, as can be seen in the tabulated standard deviations for each sample. Overall standard deviations, computed from the partitioned within-sample sums of squares, were 15.8 and 28.7 $\times 10^3$ cells per milliliter for the OSCC and DMSCC counts, respectively.

Four of the ten sets of split samples received were in excess of the maximum cell concentration for which we routinely set the OSCC. We chose to deal with them by diluting the fixed milks with one or three equal portions of glutaraldehyde diluent. Samples C, D, and F were so treated before analysis, with completely satisfactory results. It also should be possible to expand the range of the OSCC electronically, by decreasing the amplifier gain. Although the zero to 2,000,000 cell range seems optimal for control in an abnormal milk program, operation at a chart scale range up to 8,000,000 is conceivable.

Problems in use of the OSCC.

The response of the OSCC is not quite linear over the full cell concentration range of interest, but is satisfactorily so below 800,000 cells per milliliter. Actually, the assumption of a single flex point at about this concentration would reflect the true concentration quite well. To utilize this approach, the analyst would require standards at three concentrations: about 100,000; about 800,000; and in the neighborhood of 1,500,000 cells per milliliter. Chart peak values determined on these would permit construction of a control curve of two intersecting linear segments.

The discrepancy between response to turkey erthrocyte standards and to milk samples increased with cell concentration and could reflect merely inaccurate determination of the concentration of the standard. The use of turkey cell suspensions derives apparently from their prior satisfactory use to standardize optical cell counters for clinical hematology. In our laboratory, use of internal standards for each day's operation has proven a feasible alternative, as follows. Three high and three low reading samples are identified as they appear on the strip chart early in the run, are reanalyzed at the end, and are also counted by DMSCC. Average peak heights for each sample are then plotted against their DMSCC, forming a high and a low concentration triangle of small area. A standard curve is obtained by connecting the centers of these triangles, and from it the chart peak values of the other milk samples are converted. Counts converted in this manner in several trials were consistently closer to the DMSCC determinations than were those obtained through use of the turkey cell standards. The objection to this method is that each laboratory using it must also be capable of performing the DMSCC reliably.

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CONTAMINATION OF DAIRY FEEDS

Continued From Page 561

OTHER TOXICANTS

Molybdenum and fluorine have been involved in problems which have caused severe losses in a few cattle herds. The presence of any powdered material on pasture plants in the vicinity of industrial operations should be thoroughly investigated when cattle herds become ill or experience lower productivity. Tons of sulfur dioxide are being introduced into the atmosphere by the stacks of huge coal burning power plants in western Pennsylvania. Sulfur dioxide damage to trees miles away from these plants is already apparent. The possibility of serious effects on humans and animals is not remote. Deposition of lead from gasoline exhaust may be an important factor influencing the health of animals living on farms along heavily traveled highways. The author collected samples of fresh forages at points 5 ft distant from the edge of the berm of three heavily traveled Pennsylvania highways. Levels of lead in the ash of these samples ranged form 15 to 50 ppm. One sample taken from a pasture 100 ft from the edge of the Pennsylvania Turnpike revealed 15 ppm in the ashed sample.

It appears safe to say that effects of industrial and other air pollutants on animals should merit careful study because the animal problems resulting from consumption of contaminated forage might be useful monitors for preventing less apparent problems in humans. The future of all of us demands that we take air pollution seriously.

Editor's Note: This report raises the question of whether meat and milk of abnormal composition is produced by cows exposed to air-borne toxicants. Research to answer this question would seem to be in order.

ROLE OF THE DAIRY AND FOOD INDUSTRY IN ENVIRONMENTAL POLLUTION CONTROL[1]

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ABSTRACT

The scope and extent of environmental pollution is reviewed. The roles of the dairy and food industry in environmental pollution—polluter, educator, community leader—are explained. Examples of how the industry pollutes the environment, how it can help educate its employees and the public about pollution, and how industry personnel can provide community leadership to study and solve local environmental pollution problems are cited. The industry is urged to become involved in the campaign to abate pollution and to be committed to improving environmental quality.

This past year, Americans all across the country suddenly became aware of the environmental crisis. They began to realize that our water, air, and land had become a dumping ground for our wastes to the extent that usefulness of these resources had been impaired and that pollution posed a very real threat to our health and comfort.

Many people began pointing fingers at those whom they thought were responsible for the mess. And when they finished analyzing the situation, they found that everyone had a role in correcting the problems and abating the pollution.

If we accept these conclusions, then we must examine the role of the dairy and food industry in environmental pollution and how it can contribute to pollution control.

There are three roles which I feel the dairy and food industry assumes—the role of a potential or actual polluter, the role of an educator, and the role of a community leader.

Before I expand on these roles, let's briefly examine some espects of environmental pollution.

ENVIRONMENTAL POLLUTION

Water, air, land—all have become engulfed by pollution. Our lakes, streams, and oceans have become fouled with municipal sewage, industrial wastewaters, silt from the land, refuse, oil, radioactive wastes, and heated effluents. Such pollution threatens our drinking water supplies, fouls our bathing beaches, and destroys our favorite fishing spots.

The air we breathe is fouled with smoke, gases, particles, and odors from a wide assortment of municipal, industrial, institutional, and private sources — power plants, steel mills, home heating facilities, automobiles, trucks, airplanes, incinerators, refuse dumps, cement plants, paper mills, and chemical plants. Such pollutants damage our health, destroy vegetation, corode building materials, and soil clothing.

The land is polluted with municipal refuse, litter, industrial solid wastes, junk automobiles, and agricultural wastes. These disfigure the landscape and create breeding places for vermin.

Environmental pollution poses a health hazard, destroys our natural resources, costs us money, and diminishes the quality of life.

Now let's examine the roles of the dairy and food industry in environmental pollution control.

FOOD INDUSTRY AS A POLLUTER

First, let's look at the industry's role as a polluter. Dairy and food companies have often been cited for pollution of water. In St. Lawrence County, New York, one of the largest dairy counties in the country, the New York State Health Department, in its initial water pollution survey of that region conducted in 1960 cited no less than 15 dairies as polluters *(1)*.

The industry also contributes to air pollution, and it indirectly produces significant quantities of solid waste and, hence, contributes indirectly to land pollution. In the area of water pollution, dairy farms, milk plants, food processing plants all are potential polluters of water. Wastewater from milk houses and milking parlors and sanitary sewage from farm houses constitute potential pollutants on dairy farms, as does wastewater from milk and food processing plants in rural and urban areas.

As for air pollution, boilers and heating facilities in milk and food processing plants are potential sources of pollutants. Diesel trucks used to haul milk and other foods to processing plants and to retail stores are another important source of pollutants. Most supermarkets and many food warehouses have incinerators to burn combustible refuse. Such incinerators usually have no pollution control devices

[1]Presented at the Annual Meeting of the New York State Association of Milk and Food Sanitarians, Syracuse, New York, September 23.

and smoke and particles from these create pollution and nusiances.

The industry, both directly by its production of refuse and indirectly by use of non-reuseable packaging materials, contributes significantly to the solid waste problem.

Dairy and poultry farms produce enormous tonnages of manure, much of which is allowed to accumulate or which may be disposed of in such a way as to cause water pollution and odors. Processing plants, especially food plants, produce much solid waste such as vegetable and fruit trimmings and spoiled food. Broken bottles and discarded packaging materials also contribute to the volume of refuse from such plants.

Present-day food packaging trends, especially use of no-deposit no-return bottles, plastic bottles, and containers are responsible for much of the solid waste produced in this country. The food and dairy together with the beverage industry accounted for over 55% of the total packaging produced in the nation *(2)*.

In food service operations, the growing use of single service utensils, both plastic and paper, has increased the volume of refuse from such establishments. In hospitals this has resulted in an increase in solid waste of up to 4%, whereas in schools paper service may contribute an extra 12 lb. of refuse per 100 lunches *(3)*.

Thus, we see that the dairy and food industry does contribute in a variety of ways to environmental pollution, and as such, it has a responsibility to do all it can to achieve abatement of such pollution.

The industry must comply with government pollution control laws and it must take the initiative in helping solve these problems. In some areas, such as the packaging-solid waste dilemma, the industry must take the lead in developing ways of recycling wastes and of using biodegradable packaging materials.

FOOD INDUSTRY AS EDUCATOR

Next, let's look at the role of the dairy and food industry as an educator. To some, this idea may sound far-fetched, but I feel that the industry has numerous opportunities to educate its employees and the public about environmental pollution.

Take for example the use of packaging as an educational medium. Dairies can print statements and suggestions about pollution control on milk cartons. This also can be done on packages of other types of foods such as cereal boxes and bread wrappers. Restaurants could have messages about pollution control printed on their place mats. Trucks used to deliver foods to stores and restaurants could carry signs on their sides urging people to fight pollution.

Television and radio messages sponsored by dairy and food companies could include words of advice about pollution control. The dairy and food industry could sponsor television specials about pollution control, or companies could support financially the efforts of national, state, and local groups working to educate the public about pollution problems.

Dairy and food companies also can be instrumental in educating their employees about the need to protect our environment. Posters on bulletin boards, messages in paycheck envelopes, and other means could be used to get the word across. Articles in trade journals are another excellent way of educating industry personnel.

The education of school children about environmental pollution is another area in which the industry can be of service. Consider the potential for educating children by printing information about pollution on milk cartons used by millions of school children each day in this country. Such industry organizations as the National Dairy Council, which publishes educational materials for schools, might prepare materials about pollution for use in the schools.

Inspection personnel, both industry and government sanitarians and inspectors, with their knowledge and understanding of environmental issues, can help educate the public by volunteering their services as speakers at meetings of local civic organizations.

FOOD INDUSTRY AS COMMUNITY LEADER

Next, let's take a look at the role of the dairy and food industry as a community leader in environmental matters. Maybe many people don't envision the industry in this role, but in many communities the dairy and food industry is a major business and employer. Every civic organization and professional group concerned about environmental pollution needs men with business and public relations experience and know-how. Supervisory personnel in the dairy and food industry are a source of such expertise in most communities.

Administrative and supervisory personnel with these skills should participate in Chamber of Commerce programs which now include pollution control activities. They're needed in the Jaycees and other civic groups interested in environmental quality, they're needed in professional groups interested in pollution, they're needed wherever people are working to fight pollution and improve the quality of our environment.

Plant managers and laboratory technicians, many of whom are college graduates, possess a knowledge of science and, hence, can be very helpful to civic and conservation groups in studying and evaluating local environmental problems. Dairy fieldmen are acquainted with farmers and can be instrumental in

helping solve their individual and community pollution problems by providing leadership to get these problems solved. Sanitarians and other inspection personnel who have knowledge of pollution control laws and programs can be of great service to community groups in planning environmental improvement projects. Dairy and food company executives, public health sanitarians, and others employed in administrative capacities can serve on government advisory and study committees concerned with environmental issues.

These are, as I envision them, some of the major roles which the dairy and food industry has in environmental pollution control. The industry has the responsibility, as a potential or actual polluter, to abate pollution which it may create, has the opportunity to educate both its personnel and the public about pollution issues, and can provide the leadership needed by state and local organizations working to abate pollution.

Often our potential for helping to solve the problems of society and to improve living conditions is unrecognized or underrated. Such, I believe, is true with the dairy and food industry in the area of environmental pollution control. It's time we recognized and realized that potential.

The President of the United States, in his message to Congress about environment, stated that: "The task of cleaning up our environment calls for a total mobilization by all of us. It involves government at all levels; it requires the help of every citizen. It cannot be a matter of simply sitting back and blaming someone else. Neither is it one to be left to a few hundred leaders. Rather, it presents us with one of those rare situations in which each individual everywhere has an opportunity to make a special contribution to his country as well as his community *(4)*.

The dairy and food industry must accept this challenge and become involved in the struggle to prevent environmental degradation and become committed to improving the quality of our environment.

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1971 NATIONAL EXPOSITION FOR FOOD PROCESSORS

There will be at least 22% more exhibits presented at the 1971 National Exposition for Food Processors (NEFP) than when the trade show was last presented in Chicago in 1967.

According to a spokesman for the Food Processing Machinery and Supplies Association (FPM&SA), sponsor of the largest annual trade show in the food processing industry, 184 firms have already reserved space in the newly rebuilt McCormick Place and additional applications are being processed. It will be the largest NEFP held in Chicago. The 1971 NEFP will be presented January 24-27 and will be one of the first shows in the new McCormick Place. Exhibiting firms will use the upper level 301,000 square foot hall to display the supplies, equipment, and services used to produce the Nation's processed food supply. Since the exhibits cover every aspect of food production, from the field to the factory to the grocer's shelf, the NEFP has been referred to as "the backbone of the Food Processing Industry."

Each year, thousands of processors from canning, freezing, dehydrating and beverage operations, agribusiness interests, plus many volume feeding and fastfood operations, attend the Exposition to see what new equipment and applications they can adopt to improve their production and to curtail costs.

Complete information about the 1971 NEFP is available from the Food Processing Machinery and Supplies Association, 7758 Wisconsin Ave., Washington, D. C. 20014.

MICROBIOLOGY OF RAW AND PROCESSED WILD RICE[1]

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Abstract

Raw wild rice was tested for its microbiological condition and was found to contain, per gram, up to 21 x 10^8 total aerobic count, 63 x 10^6 coliforms, 98 x 10^7 psychrotrophs, 16 x 10^6 streptococci, 26 x 10^4 yeasts, and 83 x 10^5 molds. Although the product was free of coagulase-positive staphylococci, *Salmonella infantis* and *Escherichia coli* were found in some samples.

Rice was parched at 51.7 C (125 F) for 8 hr, 65.6 C (150 F) for 180 min, 79.4 C (175 F) for 180 min, and 121.1 C (250 F) for 105 min. Parching reduced the number of viable organisms and greatest changes appeared when the higher temperatures were used. Unhulled rice parched at 79.4 C contained, per gram, 40 x 10^6 total aerobic count, 33 x 10^3 psychrotrophs, 46 x 10^2 coliforms, 100 x 10^3 streptococci, <10 yeasts, and 62 x 10^4 molds. Most organisms present in parched rice were associated with the hulls rather than the kernels after rice was hulled. Boiling of parched wild rice, as might be done when it is prepared for consumption, reduced the total aerobic count to 140 per gram. Other microorganisms for which tests were conducted could not be recovered from cooked wild rice.

Samples of wild rice obtained from local supermarkets contained, per gram, up to 10^6 total aerobic count and 10^4 coliforms. Other types of microorganisms for which tests were made, could not be recovered from most samples.

Rice, one of the oldest food crops known to man, is the most important field crop in the world and serves as the basic food for more than one-half of the world's population *(2, 3)*. In contrast, wild rice is not well known; only 3% of the people in the United States are familiar with this grain and only 2% have actually tasted it.

Wild rice *(Zizania aquatica)* is a wild aquatic plant grown in Canada and in the Great Lakes region of the United States. It grows best in slowly moving water which is a few inches to not more than 3 ft deep. Wild rice seldom becomes established in landlocked stagnant waters or in swift streams. Its grain is long, slender, and nearly cylindrical and is contained within a bristly brown hull that elongates into a long, stiff, twisted, barbed awn. The kernel is about 0.5 to 0.75 inch long, grooved, and purplish black *(1)*. Wild rice is a costly retail item and is most often served with wild game, particularly with geese, ducks, and pheasants.

Procedures for growing and processing wild rice are not well known and hence will be briefly described. Cultivation and harvesting are done by rather primitive methods. Most of the wild rice is harvested by Indians in Minnesota, Wisconsin, Michigan, and Canada. In small boats they travel among the rice plants and with small sticks beat the plants so the rice is loosened and falls into the boat. The mature grain falls from the plant easily and often up to 50% of the crop is lost. Harvested full-moisture wild rice is often stored in small piles in the open (refrigerated storage is sometimes used) so that a natural fermentation can proceed. After fermentation rice is parched (dried) by the sun or artificial means until it contains 8 - 14% moisture. Dried rice is hulled (manually by pounding or mechanically) to remove the outer coat (hull) from the kernel. After hulls and other debris are separated from the kernels they may be scarified. Scarification entails removal of the outer black coat from the kernel. This is done to minimize the time required for preparing wild rice in the kitchen since the outer coat is rather impervious to water and its presence requires that the rice be soaked for 0.5 - 1 hr before it can be cooked. Finally, the rice can be graded according to kernel size and then is packaged.

Processing of wild rice is an art which is not well known or understood. Consequently a study was initiated to learn about microbiological, chemical, and organoleptic changes which occur when the rice is processed in different ways. This paper reports results on changes in the microflora of wild rice when parched at different temperatures. Results on other aspects of wild-rice processing will be presented in subsequent papers.

Materials and Methods

Wild rice

Raw wild rice with approximately 50% moisture was obtained from Chief Industries, Hayward, Wisconsin. After sampling it was packed into cans which were evacuated,

[1]Published with the approval of the Director of the Research Division of the College of Agricultural and Life Sciences, University of Wisconsin.

flushed with nitrogen, and sealed. Canned raw wild rice was held at −20.6 C (−5 F) to minimize microbial and other changes in the product before it could be processed. When an experiment was to be conducted, a sufficient number of cans were removed from cold storage, opened, and rice was allowed to warm briefly before it was parched and hulled. Samples for microbiological tests were taken immediately after cans were opened.

Parching and hulling

Raw wild rice was parched in a warm-air dryer at 51.7 C (125 F) for 8 hr, 65.6 C (150 F) for 180 min, 79.4 C (175 F) for 180 min, and 121.1 C (250 F) for 105 min. In each instance rice contained 7-8% moisture after parching. Parched rice was hulled with a laboratory-scale huller which was equipped with two hard rubber rolls. Samples for microbiological analyses were taken at intervals during parching and also after the rice was hulled.

Microbiological examination

Eleven grams of wild rice or hulls were weighed aseptically into a sterile Waring blendor jar. Ninety-nine milliliters of sterile phosphate buffered distilled water were added and the mixture blended for 1 min. Preliminary trials indicated that more organisms were recovered when rice was blended rather than shaken in the diluent. Serial dilutions were made in sterile phosphate buffered distilled water and duplicate plates were inoculated with the appropriate dilutions. Plates were then prepared and incubated as described in the next paragraph. After incubation suitable duplicate plates were selected, colonies were counted, and average values were calculated. When necessary, colonies were then picked for use in tests described later. The original blended sample also served as inoculum for detection of salmonellae.

Most samples of raw and parched rice, hulled rice, and hulls were tested as follows: *(a)* total plate count: plate count agar (Difco) and incubation at 30 C for 48 hr; *(b)* psychrotrophic plate count: plate count agar and incubation at 7 C for 10 days; *(c)* yeast and mold count: acidified (to pH 3.5 with sterile tartaric acid) potato dextrose agar (Difco) and incubation at 22 C for 3-5 days; *(d)* coliform count: violet red bile agar and incubation at 32 C for 24 hr followed by picking typical colonies and determining their IMViC pattern; *(e)* staphylococcus count: mannitol salt agar (Difco), and incubation at 37 C for 48 hr followed by picking typical colonies and testing them for coagulase production; *(f)* streptococcus count: KF agar (Difco) and incubation at 37 C for 48 hr followed by picking colonies and testing them for ability to grow in litmus milk, milk plus 0.1% methylene blue, nutrient broth at 10 and 45 C, broth at pH 9.6, and broth with 6.5% sodium chloride; and *(g)* salmonellae: preenrichment in lactose broth at 37 C for 24 hr, enrichment in tetrathionate and selenite broths at 37 C for 24 hr, streaking on brilliant green (Difco) and SS (Difco) agars, picking typical colonies into triple sugar iron (TSI) agar slants, testing TSI-positive isolates for urease and lysine decarboxylase production, and serotyping of positive cultures. Serotyping was done at the Wisconsin State Laboratory of Hygiene.

RESULTS AND DISCUSSION

Raw wild rice

Data in Table 1 indicate that raw wild rice contained high numbers of the common groups of microorganisms. The total plate count of most samples tested exceeded 10^9 per gram. Numbers of coliforms, psychrotrophs, streptococci (colonies on KF agar), and yeasts and molds also were high but they were lower than the total plate count. Tests on colonies isolated from violet red bile agar plates indicated that *Escherichia coli, Enterobacter aerogenes,* and intermediate forms were present on the rice. Pyogenic, viridans, and enterococcus streptococci were isolated from KF agar inoculated with the raw wild rice. Although coagulase-positive staphylococci were not detected, one sample of rice yielded *Salmonella infantis.*

Presence of high numbers of a variety of microorganisms is not surprising when one considers that the rice is high in moisture, harvested under primitive conditions, and stored to permit microbial growth before it is dried.

Changes in microflora caused by parching

Parching reduced numbers but did not eliminate microorganisms from wild rice (Tables 2 and 3); the extent to which numbers were reduced depended on the temperature of parching. Parching at 51.7 C for 8 hr was least detrimental to microorganisms of any treatments studied. Hulled rice contained approximately 10^7 organisms per gram, whereas the count for hulls exceded 10^8 per gram. Psychrotrophs, coliforms, and yeasts were markedly reduced by this process but streptococci and molds persisted in substantial numbers both in the processed rice and hulls. *Enterobacter aerogenes* and pyogenic streptococci were recovered from parched rice and hulls although coagulase-positive staphylococci and salmonellae could not be detected.

The greatest proportion of the microorganisms which survived parching remained with the hulls during the hulling operation. This could be expected

TABLE 1. MICROBIAL QUALITY OF RAW WILD RICE BEFORE AND AFTER REFRIGERATED STORAGE.

Microorganisms	Average (No./g)	Range (No./g)
	(x 10^5)	(x 10^5)
Before refrigerated storage[a]		
Total plate count	16,000	13,000-20,000
Coliforms	3.1[b]	1.2-4.7
After refrigerated storage[c]		
Total plate count	15,000	4,000-21,000
Coliforms	360[d]	5-630
Psychrotrophs	5,000	100-9,800
Streptococci	60[e]	10-160
Yeasts	1.1	0.4-2.6
Molds	31	9-83

[a]Three samples were examined, *Salmonella infantis* recovered from one sample.

[b]*Enterobacter aerogenes* recovered.

[c]Four samples were examined.

[d]*Enterobacter aerogenes, Escherichia coli,* and intermediate forms recovered.

[e]Pyogenic, viridans, and enterococcus streptococci recovered.

TABLE 2. MICROBIOLOGICAL CONDITION OF RAW, PARCHED (51.7 and 65.6 C), AND HULLED WILD RICE.

Group of microorganisms	Parched at 51.7 C for 8 hr				Parched at 65.6 C for 180 min			
	Before hulling		After hulling		Before hulling		After hulling	
	Before parching	After parching	Rice	Hulls	Before parching	After parching	Rice	Hulls
	(x 10^3)							
Total plate count	1,700,000	200,000	10,000	110,000	1,800,000	130,000	1,400	34,000
Psychrotrophs	450,000	350	7.7	100	980,000	410	1.6	80
Coliforms	43,000	57	5.7[a]	36[b]	63,000	64	1.7[c]	37[c]
Streptococci	3,900	910	30[d]	570[d]	16,000	1,200	3.0[e]	500[e]
Yeasts	41	9.0	0.06	0.21	73	1.0	0.03	1.4
Molds	960	730	23	450	8,300	3,400	3.9	1,100

[a]*Enterobacter aerogenes* and an intermediate form (—+——) recovered.
[b]An intermediate form (—+—+) recovered.
[c]*Enterobacter aerogenes* recovered.
[d]Pyogenic streptococci recovered.
[e]Viridans streptococci recovered.

TABLE 3. MICROBIOLOGICAL CONDITION OF RAW, PARCHED (79.4 AND 121.1 C), AND HULLED WILD RICE.

Group of microorganisms	Parched at 79.4 C for 180 min				Parched at 121.1 C for 105 min			
	Before hulling		After hulling		Before hulling		After hulling	
	Before parching	After parching	Rice	Hulls	Before parching	After parching	Rice	Hulls
	(x 10^3)							
Total plate count	2,100,000	40,000	120	18,000	430,000	—	620	1,100
Psychrotrophs	560,000	33	3.3	87	12,000	—	4.6	4.3
Coliforms	37,000	4.6	0.80[a]	4.5[a]	450	—	0.94	0.64
Streptococci	2,800	100	1.9[b]	110[c]	1,400	0.5	12	2.3
Yeasts	260	<0.01	<0.01	0.06	65	<0.01	<0.01	<0.01
Molds	860	620	2.6	290	2,200	2.8	1.8	24

[a]*Enterobacter aerogenes* recovered.
[b]Viridans streptococci recovered.
[c]Viridans and enterococcus streptococci recovered.

since the hulls are on the outside and hence initially are probably more heavily contaminated than the kernels contained within the hulls. The same observation also was made when other parching treatments were used.

Parching at 65.6 C for 180 min (Table 2) yielded a product with a microflora similar to that noted with the previous treatment. Again *E. aerogenes* but not *E. coli* was detected in both parched rice and hulls. Viridans streptococci also were present in both materials but coagulase positive staphylococci and salmonellae could not be found.

Further increases in temperature to 79.4 C for 180 min and 121.1 C for 105 min (Table 3) reduced further numbers of microorganisms which survived the process. Yeasts appeared most vulnerable to destruction under these conditions but numbers of psychrotrophs, coliforms, and streptococci also were greatly reduced. Salmonellae and coagulase-positive staphylococci were not detected in rice processed at these two temperatures but *E. aerogenes* and viridans streptococci were recovered from the product parched at 79.4 C.

TABLE 4. MICROBIOLOGICAL CONDITION OF RETAIL SAMPLES OF WILD RICE.

Group of microorganisms	Brand			
	A	B	C	D
	(No./g)			
Total plate count	56 x 10^3	60 x 10^4	34 x 10^5	32 x 10^2
Psychrotrophs	<10	<10	<10	90
Coliforms	34 x 10^2	38 x 10^3	53 x 10^3	<10
Streptococci	<10	<10	<10	20

Commercial wild rice

Tests were conducted on four brands of commercial wild rice obtained from local grocery stores and results are presented in Table 4. The total plate count of these products ranged from 3200 to 3,400,000 per gram. Although the samples were almost free of psychrotrophs and streptococci, three of the samples

contained $>10^3$ coliforms per gram.

When these results and those discussed earlier are evaluated, it must be remembered that this product receives a substantial heat treatment during the cooking process needed to make it suitable for consumption. Limited tests on wild rice parched at 150 F and cooked as might be done in the home showed that the product had a total plate count of 140 per gram and that yeasts, molds, psychrotrophs, streptococci, and coliforms could not be recovered.

ACKNOWLEDGMENTS

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ASSOCIATION AFFAIRS

NOTICE TO MEMBERSHIP

In accordance with our Constitution and By-laws which requires our Second Vice-President and Secretary-Treasurer to be elected by mail ballot, you are hereby notified that President Milton E. Held, at the anual meeting in Cedar Rapids, Iowa, August, 1970, appointed Ray Belknap, Dept. HEW, Public Health Service, FDA, Federal Office Bldg., 550 Main St., Room 4106, Cinn. Ohio. 45202, as chairman of the Nominating Committee for 1971.

Nominations for the office of Second Vice-President and Secretary-Treasurer are now open and any member wishing to make a nomination should send a picture and biographical sketch of his nominee to Ray Belknap not later than March 1, 1971.

R. P. March, Secretary-Treasurer
IAMFES, Inc.

WINTERS RE-ELECTED BISSC CHAIRMAN THIRTY-THREE SANITATION STANDARDS PROMULGATED

Mr. Philip E. Winters. The Kroger Company, Cincinnati, Ohio was unanimously re-elected Chairman of the Baking Industry Sanitation Standards Committee. The meeting just held at the Americana Hotel in New York City is the 47th since the organization was founded in November of 1949. The meeting was well attended with representatives from bakery equipment manufacturers and health departments nation wide. Mr. Winters, who has served as the BISSC Chairman longer than any other, sought to turn over the leadership reigns. He responded to the urging of his colleagues to continue in office for another year and thus complete a decade of service as BISSC chief executive.

Mr. Paul E. Laughlin, National Biscuit Company, New York City was elected Vice Chairman. Raymond J. Walter, Attorney At Law, New York City is the permanent Secretary-Treasurer. The following new members of the Board of Directors were elected:

William D. Baird, Mrs. Baird's Bakery, Dallas, Texas

Mrs. Roy J. Rasco, Overland Park, Kansas

E. V. Waack, Baker Perkins Inc., Saginaw, Michigan

Edwin H. Leedy, Ekco Products, Inc., Chicago, Illinois

W. E. Lanham Machinery Company, Inc., Atlanta, Georgia

Horton Genung, Latendorf Conveying Corporation, Kenilworth, N. J.

Quentin R. Russeth, The Pillsbury Company, Minneapolis, Minnesota

BISSC was created to develop sound sanitation standards for bakery equipment and machinery. This is a joint effort on the part of the six (6) national baking industry organizations namely:

American Bakers Association
American Institute of Baking
American Society of Bakery Engineers
Associated Retail Bakers of America
Bakery Equipment Manufacturers Association
Biscuit & Cracker Manufacturers Association

The members of these organizations together with sanitation officials as Consultants from the American Public Health Association, International Association of Milk and Food Sanitarians, U. S. Food and Drug Administration, U. S. Public Health Service and the National Environmental Health Association have to date painstakingly developed and promulgated thirty-three (33) Sanitation Standards for Bakery Equipment as follows:

1. Flour Handling Equipment
2. Dough Troughs
3. Mechanical Intermediate Proofers

4. Mechanical Pan, Rack & Utensil Washers
5. Cake Depositors, Fillers and Icing Machines
6. Horizontal and Vertical Mixers
7. Conveyors
8. Dividers, Rounders and Bun Machines
9. Bread Moulders
10. Prefabricated Enclosures and Air Conditioning Equipment For Fermentation, Proofing, Cooling and Retarding
11. Ingredient Water Coolers and Ice Makers (Atmospheric Type)
12. Coating Equipment
13. Bread, Cake and Roll Slicing, Wrapping and Bagging Machines
14. Mechanical Ovens
15. Caster Assemblies and Wheels
16. Doughnut Equipment
17. Pan Greasers
18. Emulsifiers and Homogenizers
19. Spindle Mixers
20. Liquid Ferment and Continuous Mix Processing Equipment
21. Dough Chutes, Dough Hoppers, Dough Trough Hoists, and Automatic Dough Trough Dumps
22. Depanners and Delidders for Bakery Products
23. Floor Scales and Ingredient Scales
24. Racks, Pan Trucks, Dollies, Skids and Reusable Pallets
25. Kettles and Kettle Agitators
26. Liquid Measuring Systems
27. Facilities for Handling and Storing Refined Liquid and Dry Sweetening Products
28. Facilities for Handling & Storing Bulk Edible Fats
29. Electric Motors
30. Distribution Cabinets and Containers
31. Pie Make-Up Equipment
32. Icing and Glazing Machines
33. Coolers for Bakery Foods

These standards are published in a complete booklet. Complimentary copies are disseminated to and made available, without charge, to officials of concerned Government agencies—Federal, State and municipality. The booklet is also being made available to all others for a charge of $5.00 a copy to partially cover production cost and mailing. BISSC as a sponsored instrumentality of the national baking industry organizations comprising its membership, does this as an industry and public service from its executive offices located at 521 Fifth Avenue, New York, New York 10017.

Two additional standards are now undergoing development. These are for "Baking Pans" and for "Portable Small Batch and Ingredient Containers."

In order to promote the public health through the use of bakery equipment of sanitary design and to appropriately identify such equipment, BISSC has established an Office of Certification. Manufacturers who build equipment meeting the sanitation requirements as specified in a standard, may register with the "Office" and receive a certification symbol.

To further the progress being made in the development of sanitary electric motors and to facilitate use by all equipment manufacturers whose products require electric motors, the BISSC Board of Directors has directed that BISSC permit certification of equipment using electrical motors above 20 horse power which do not conform to all of the requirements of Standard No. 29, until March 1, 1973, provided the motor is mounted to permit at least two (2) inch clearance between the motor housing and the mounting surface and is totally enclosed.

Further, it has been directed that Registrations and Certifications be placed on a calendar year basis. Renewals thereof will be made the beginning of each calendar year.

Through the cooperative efforts of the baker, engineer, equipment manufacturer, and their respective Associations, together with government and industry health and sanitation officials, great strides have been made in bakery equipment sanitation.

The next regular meeting of BISSC is scheduled to be held at the Pick-Congress Hotel, Chicago, Illinois, March 5-6, 1971.

3-A COMMITTEES SIGN HOMOGENIZER REVISION

One of the first projects of the 3-A Sanitary Standards Committees—the homogenizer standard—has been completely revised. The historic standard, first published in 1949, has served the industry well but was updated in keeping with 3-A policy.

Signed officially on September 15, 1970, the revision was designated serial number 0403. It will become effective on September 15, 1971. The revision will be published in the June 1971 issue of the Journal of Milk and Food Technology, with reprints available as usual.

One feature included in the Revision is provision for plunger-type pumps other than homogenizers.

On and after the effective date, the 3-A Symbol Administrative Council will entertain applications for use of the 3-A Symbol on homogenizers which are in compliance with the new Revision.

MINNESOTA HONORS SANITARIAN

The Minnesota Sanitarians Association made its Outstanding Sanitarian award for 1970 to Arnold Ellingson at their annual banquet on September 24,

1970. Mr. Ellingson is city sanitarian and assistant health officer for the city of Fergus Falls. He has been very active in the state Sanitarians Association, as well as carrying out an extensive community program in the Fergus Falls area.

His activities include milk inspection, evaluation of air pollution, housing evaluation, planning and conducting food handlers' clinics, and the development of projects on such diverse subjects as dog control ordinances and the handling of derelict cars. His many years of service and his active participation in the field of sanitation and community affairs is an outstanding example of public service and exemplifies the type of individual the Sanitarians Association should make effort to recognize.

DOOR PRIZE WINNERS IAMFES 57TH ANNUAL MEETING

Indiana Assn. of Sanitarians—Mr. Arthur Steinberg, 794 No. 1st, Cherokee, Iowa 51012.

Florida Assn. Milk & Food Sanitarians—Mr. Virgil D. Grace, 103 E. Lincoln Ave., Glentale Heights, Ill. 60137.

Central Ontario Milk Sanitarian Assn.—Mr. Irvin Marx, Dyersville, Iowa 52040.

California Assn. of Dairy & Milk Sanitarians—Mr. Harry Meyer, 304 2nd Ave., N.E., Waukon, Iowa 52172.

Kansas Assn. of Public Health Sanitarians—John C. Schilling, 6623 Neosho, St. Louis, Mo. 63109.

Missouri Assn. of Milk & Food Sanitarians—Mr. J. Lloyd Grannan, 1413 Roseway Drive, Indianapolis, Ind. 46219.

Virginia Assn. of Sanitarians—Mr. Charles E. Langland, 406 2nd St. N.E., Waukon, Iowa 52172.

Wisconsin Assn. of Milk & Foods Sanitarians, John B. Frailinger Jr., 1323 1st Ave., S.E., Cedar Rapids, Iowa 52400.

ELMER OLIN ANDERSON

Those connected with the dairy industry have lost a friend and colleague through the sudden death on October 18, 1970 of Professor Elmer Olin Anderson at St. Petersburg, Florida.

He was born in Dassel, Minnesota on August 18, 1897. The B.S. and M S. degrees were awarded to him in dairy bacteriology and biochemistry by the University of Minnesota. He did advanced work at Cornell University. After teaching positions at Minnesota and Nebraska he came, in 1925, to the College of Agriculture at the University of Connecticut. From then until he became Professor Emeritus in 1955 he taught and conducted research there in the Department of Dairy Manufacturing. A large part of this time he was chairman of the Department. In 1952 and 1953 he was on leave, working for the U. S. Mutual Security Agency in France as a dairy science consultant for ten European countries. From 1955 to 1961 he was called as a consultant to the University of Punjab in Pakistan to help organize a Dairy Manufacturing Department. In 1961 he returned to the United States and first organized, and then headed, the Connecticut Milk Flavor Improvement Program. He retired in 1969 and subsequently moved, with Mrs. Anderson, to Florida.

While his work in such diversified fields as milk product judging, dairy bacteriology, fat testing, and bacteriology of bovine mastitis is well known, the role he enjoyed most was his association with students. "Andy" was one of those rare individuals who was able to communicate effectively and teach students. Not only was he able to convey the academic work but he had the innate ability to inspire his students and associates to achieve greater heights of competence. Those of us who knew him well will long remember how he played the "devil's advocate" to elicit the utmost understanding of the problem under discussion. All who came into contact with him over the years—students, colleagues, people in the dairy industry and those seeking advice and counsel benefitted. Professor Anderson will be missed by all for his wide influence in his science and the people who were privileged to know him.

NEWS & EVENTS

LATEST TECHNICAL ADVANCEMENTS DISPLAYED AT EXPO

Applications of reverse osmosis, aseptic and pouch-type packaging, electronic measurement, egg breaking, high capacity homogenizers and plate heat exchangers and automated C-I-P equipment highlighted Food & Dairy Processing Expo '70.

Held Nov. 1-5 in the Houston, Tex., Astrohall, Expo featured 280 booths displaying the latest equipment, supplies, systems and services for the food processing industries. All exhibitors were members of Dairy & Food Industries Supply Assn., sponsor of the biennial trade show. Thematic throughout the equipment was the emphasis on aseptic processing and packaging. Intended essentially for long shelf-life, the aseptically-handled package can be shipped great distances without refrigeration until it goes into the retail outlet, where it is then refrigerated for better merchandising and acceptance. Aseptic system components—fittings, pumps and fillers designed for aseptic control—were shown. Aseptic processing has dictated the need for many new designs in conventional

equipment. Steam seals for rotating shafts was just one aspect of this approach displayed. Total liquid packaging systems, installations which blow mold, fill and seal, also showed themselves applicable to aseptic packaging.

Pouch or sachet-types of packaging appeared at Expo for the first time. Aimed primarily at the fluid milk market, in which the consumer is supplied with a plastic pitcher to retain the non-rigid pouch, this flexible package may find other applications in the retail beverage market.

Another innovation in packaging was induction heating for sealing of thermoplastic bonds.

Emphasis was observed on equipment for bagging, bundling, wrapping and boxing of products, including automatic cartoning machines.

Materials handling, that difficult area of lost efficiency, offered advances in conveyor and palletizing techniques. Integral truck-loading devices made the shipping operation surprisingly simple and almost effortless.

Special attention was devoted to environment. Three exhibitors had displays of reverse osmosis, with applications for disposal of cheese whey. Food Engineering Forum, co-sponsored by DFISA and American Society of Agricultural Engineers, dealt with this subject in a major way, devoting two of its three afternoon sessions directly to the subject of the environment and the food processor.

Among ingredients, products for use in acidulated products and non-dairy bases, food grade phosphates and protein bases were on view.

In the flavor field, methods of volatile essence recovery were demonstrated. This is important for the restoration of delicate favors lost in thermal processing. Refrigeration equipment illustrated novel applications to continuous shelf freezing.

Processor interest was apparent in demonstrations of water removal for food preservation. One freeze-dryer was presented for specialty use where flavor protection is especially acute.

Piston-type viscous food pumps for flavor injection into bakery and confectionery products were shown. Controlled environment cabinets were offered for use in fermentation and enzymatic reactions.

Of particularly new interest was a precision mixer for dry and/or dense foodproducts, which made use of counter-rotating paddles and mechanical unloading. Food mixers and blenders illustrated improved techniques for batching of dry and liquid ingredients, as well as dispersion of suspended materials.

Dense product handling equipment included sanitary auger feeds and degassing troughs. Sanitary centrifuges for product separation, with in-place cleaning capability, were evident.

High-capacity homogenizers and plate heat exchange units represented an apparent trend toward very large processing plants. A tubular exchanger for cooling milk on the farm was a notable new development. Brought about by increasing herd sizes, large milk house installations which use storage tanks in excess of 1,500 gallon-capacity have shown some indication of going to pre-cooling of milk. Tubular heat exchangers for this purpose utilize a chilled water system, resulting in the need for minimal refrigeration in the storage tank. As herds increase in size, pre-cooling of milk can become a very effective tool for control of raw milk quality.

Refrigeration techniques demonstrated more sophistication than ever, with continuous freezing in tunnels and shelf freezers, air conditioning, automatic defrost devices, air curtains, clean room air treatment and continuous over-the-road truck refrigeration.

Potential use for commercial measurement created great interest in sanitary volumetric flow meters, all demonstrated in positions of application. Another electronic means for measurement and inventory control, the load cell, based on the strain gauge principle, was shown under vessels for batching operations.

The formerly wasteful and unpleasant wash-up operation has evolved into a highly controlled technology. C-I-P equipment has reached nearly the ultimate in automation and its concepts are applied to cases, lab glassware and the washing of shell eggs. Sanitation control in liquid egg processing is dependent on the availability of clean eggs. One exhibitor offered an egg washer.

Two exhibitors presented egg breakers, a highly sophisticated device for protection of liquid eggs in a strongly regulated industry.

An automatic butterfat tester, which could represent substantial savings in the time required for fat determinations of milk—especially producers' samples, which serve as a basis for payment—attracted attention.

EAST TENNESSEE STATE UNIVERSITY OFFERS GRADUATE ENVIRONMENTAL HEALTH PROGRAM

East Tennessee State University, through the Department of Environmental Health, College of Health, offers a program of study leading to the degree Master of Science in Environmental Health. Students may choose emphasis in Environmental Health Administration or General Environmental Health. Federal Traineeships are available to qualified students.

For further information contact Dr. Monroe T. Morgan, Chairman, Department of Environmental Health, East Tennessee State University, Johnson City, Tennessee 37601.

JOURNAL OF MILK AND FOOD TECHNOLOGY

Index To Volume 33

AUTHOR INDEX

SUBJECT INDEX

CONTENTS, VOLUME 33

JANUARY (NO. 1)

FEBRUARY (NO. 2)

MARCH (NO. 3)

APRIL (NO. 4)

MAY (NO. 5)

JUNE (NO. 6)

JULY (NO. 7)

AUGUST (NO. 8)

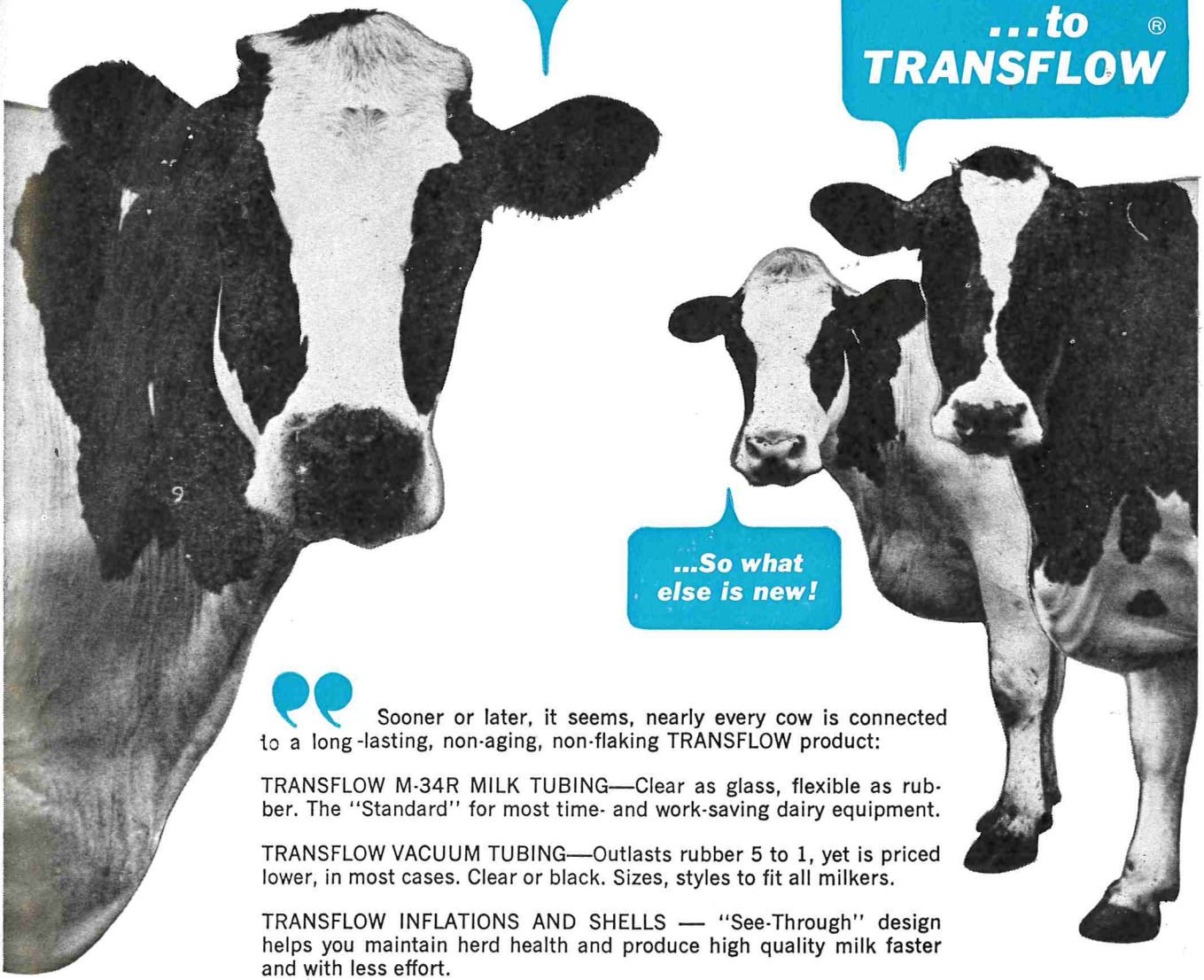
SEPTEMBER (NO. 9)

OCTOBER (NO. 10)

NOVEMBER (NO. 11)

DECEMBER NO. 12)

Guess what! Daisy's getting hitched!



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*International Association of Milk, Food and Environmental Sanitarians; U. S. Public Health Service; The Dairy Industry Committee.

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