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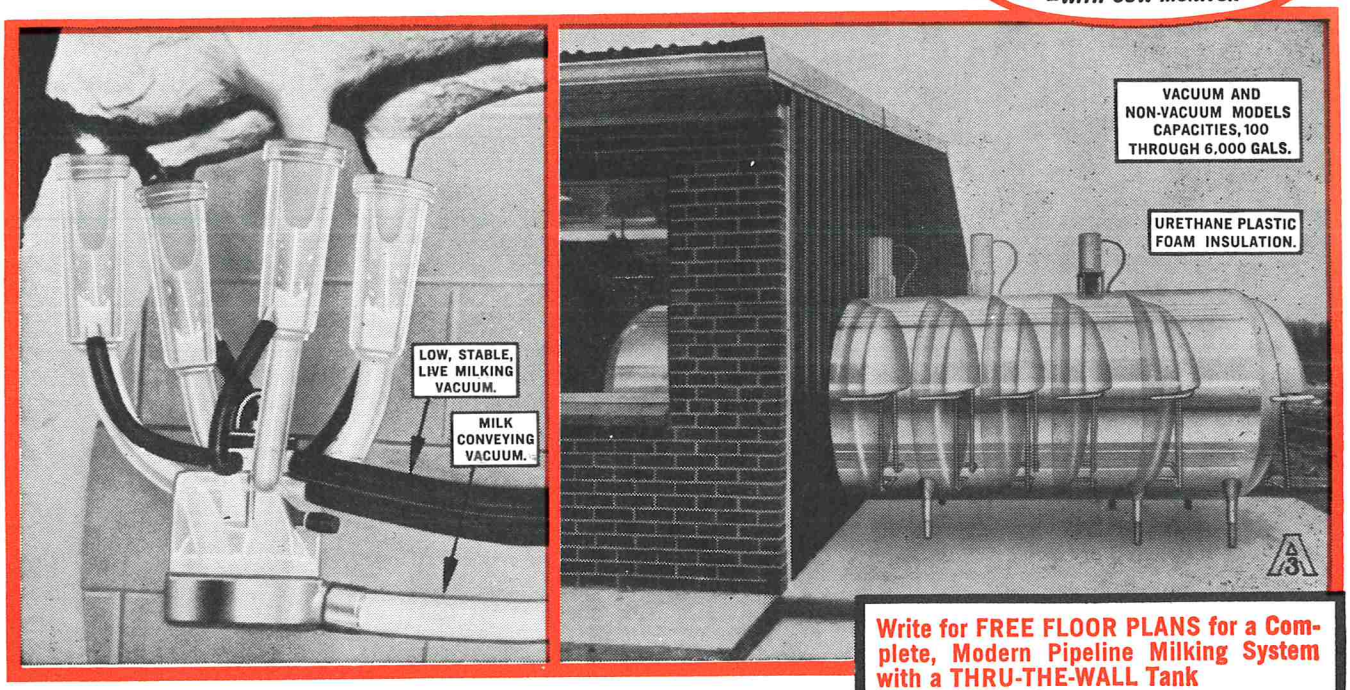

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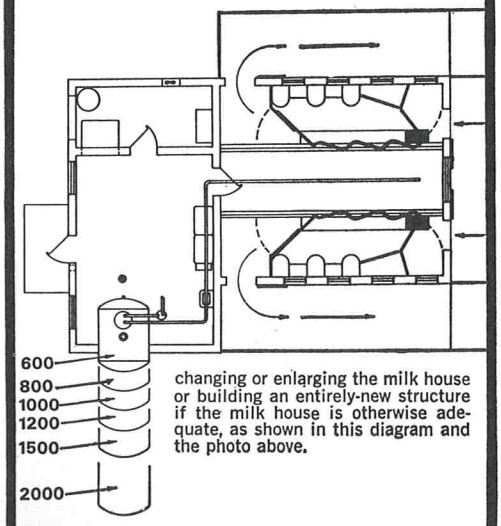

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Vol. 36 June, 1973 No. 6

Viruses in Foods
Norman Potter ---------307

Experimental Survival Studies of Sporothrix Schenckii in a Meat Product
J. H. Scharding, D. C. Kelley, J. E. Cook, and D. H. Kropf ---------311

Incidence of Salmonella in Commercially Prepared Sandwiches for the Vending Trade
N. A. Khan, and McCaskey ---------315

Fate of Bacillus Cereus in Cultural Cheese
E. M. Mikolajcik, J. W. Kearney, and T. Kristoffersen ---------317

Effect of Egg Shell Sweating on Microbial Spoilage of Chicken Eggs
D. V. Vadehra and R. C. Baker ---------321

Utilization of Dairy Ingredients in Other Foods
John J. Jones ---------323

Determination of Lactose in Milk by Gas Liquid Chromatography
H. O. Jaynes and T. Asan ---------333

Red Meat and Poultry Inspection: Microbiology of Equipment and Processing
R. Paul Elliott ---------337

Amendment to 3-A Sanitary Standards for Fittings Used on Milk and Milk Products Equipment and Used on Sanitary Lines Conducting Milk and Milk Products ---------340

3-A Sanitary Standards for Farm Milk Storage Tanks ---------341

Food Regulatory Activities
Virgil O. Wodicka ---------349

Affiliates of IAMFES, Inc. ---------353

Association Affairs ---------355

News and Events ---------357

Index to Advertisers ---------358

VIRUSES IN FOODS[1]

NORMAN N. POTTER
Department of Food Science
Cornell University, Ithaca, New York 14850

(Received for publication October 2, 1972)

ABSTRACT

Many virus-food interrelationships are not yet well understood and hence a meaningful assessment of the health hazard caused by several foodborne viruses cannot be made at the present time. Interest in this area is growing, however, and investigations involving methods for quantitative recovery of viruses are being facilitated by increased commercial availability of animal and human cell cultures and tissue culture media. This paper reviews pertinent literature, discusses some of the problems inherent in studies of viruses in foods, and cites several areas deserving of further research.

Viruses are subcellular entities whose structure, organization, and size are comparable to those of large molecules. These submicroscopic entities can be introduced into specific living cells and will reproduce only inside such cells.

Virus particles contain elements of genetic material in the form of DNA or RNA which reproduces inside the living cells they penetrate. The infecting virus uses the synthetic machinery and energy of the host cell to direct the synthesis of more virus particles of similar genetic makeup. The host cell subsequently disintegrates and liberates numerous new virus particles. This strict parasitism is a fundamental property of viruses. Intracellular parasitism also is a property of some bacteria and protozoa but these forms have their own cellular organization and generally need the living host cell to provide some special nutrient or metabolic intermediate. The relationship between viruses and host cells is more demanding. Viruses divert the synthetic mechanisms and the energy systems of the host to replicate virus nucleic acids and so the relationship has been called "parasitism at the genetic level." This intimate association of virus and host cell, except where the virus may remain dormant, results in an alteration of or ultimate destruction of the host cell.

In addition to viruses of food animals and food plants being responsible for a considerable loss of produce, many animal viruses can cause diseases of man. Among the better known of these are smallpox, yellow fever, poliomyelitis, hepatitis, measles, mumps, rabies, various forms of encephalitis, and others. Many of these virus diseases have never yet been associated with foods, although outbreaks of food-borne poliomyelitis and hepatitis are well known. Other viruses that infect man include such enteroviruses as coxsackieviruses and echoviruses which may produce intestinal disorders, foot-and-mouth disease virus which is more common in cattle but can cause severe blister infections in man, influenza virus, herpesvirus, adenovirus which produces respiratory infections, and several viruses of fowl and egg origin. Ornithosis and Newcastle disease are diseases primarily of poultry but ornithosis is communicable to man producing a pneumonia-like respiratory condition, and the Newcastle disease virus has caused human eye infections. There also are the yet incompletely understood relationships between viruses and tumors. It is still controversial whether any viruses able to induce malignancy can cause tumors in man, but because numerous virus-induced tumors exist in other animal species "cancer virology" is receiving intensive investigation.

At the present time relatively few research scientists are engaged in studies on viruses in foods. At the 1971 National Conference on Food Protection, sponsored by the American Public Health Association, it was again affirmed that foodborne illness of viral origin is not yet adequately understood. It was further pointed out that many technical difficulties remain and hinder progress in this field, among them are problems in epidemiological recognition, methods of virus detection and identification from foods, and sometimes lengthy incubation periods making conclusive relation between disease and a given food very problematic.

It is generally agreed that there is increasing need for research on occurrence of viruses in our overall food supply, and the survival of viruses in contaminated food undergoing common processing procedures. The latter need becomes especially significant with the increased use of milder processing conditions such as high temperature–short time and ultra high temperature–short time pasteurization and sterilization techniques, membrane and other "cold sterilization" treatments, freeze drying and other mild dehydration techniques, ultra quick freezing methods, and use of increasing quantities of pre-prepared convenience foods that require little or no cooking before consumption. Indeed, there is every reason to expect that viruses pathogenic to man, permitted to

[1]Presented at the 49th Annual Conference of the New York State Association of Milk and Food Sanitarians, Binghamton, New York, September 20-22, 1972.

contaminate various food raw materials, would survive many of today's accepted processing and reconstitution regimens.

VIRUS—FOOD STUDIES

There is more than ample evidence that viruses of public health significance occur intrinsically in food raw materials of animal origin, and may be present in or on animal and plant products through contamination of various kinds *(6, 7, 10, 25)*. Outbreaks of poliomyelitis associated with raw milk, and infectious hepatitis from consumption of raw contaminated shellfish have been substantially documented *(10)*. Less clearly defined have been the occurrences of human infection from foods carrying enteroviruses (other than the polioviruses), reoviruses, adenoviruses, and other viral agents spread by infected animals, sewage and fecal contamination, insect vectors, and infected food handlers. While the past record of food-associated viral infections of humans is not overwhelming, it is prudent to assume, until there is evidence to the contrary, that this is caused more by difficulties inherent in proving etiological relationships than by the probability that they do not exist.

Such observations as the following are of further significance. Poliovirus and echovirus have been isolated from farm soils irrigated with sewage *(4)*, and further, ecovirus, coxsackievirus, and poliovirus have survived on vegetables stored under household conditions *(5)*.

Viruses which infect animals may be present in the apparently healthy tissues of a percentage of those used for human food *(6)*. The virus of foot-and-mouth disease, for example, has been isolated from cuts of pork after extended storage; furthermore it has survived for longer than 2 months in infected beef, both uncured and cured *(12, 13, 30)*. Coxsackievirus inoculated into ground beef was found not to be significantly inactivated during storage up to 8 days at both refrigerated and room temperatures, even though proteolytic bacteria were present in high numbers *(21)*. In this same study the coxsackievirus inoculated into ground meat survived both the bacterial fermentation process and subsequent heat treatment of Thuringer sausage preparation. Enteroviruses also have been isolated from market samples of ground beef *(29)*.

Ornithosis and Newcastle disease have occurred in poultry plant workers handling turkeys and chickens *(14, 17)*. Eggs frequently harbor viruses of poultry origin *(8)*.

Viruses generally are more resistant than the vegetative cells of bacteria to adverse conditions, yet many of our major food preservation practices were developed largely on the basis of bacterial control. Temperatures reached within meats cooked to the rare condition are not sufficient to inactivate foot-and-mouth disease virus *(15)* and possibly would be inadequate to inactivate other viral agents that could be present.

Eggs frequently are used in applications where heat is minimal, examples are bakery meringues and glazes. Current egg pasteurization requirements aimed at *Salmonella* destruction were not developed specifically with viruses in mind.

Cheeses commonly made from underpasteurized milk require minimum ageing of 60 to 90 days in the U.S. and certain other countries as a safety measure against survival of pathogenic bacteria. The efficacy of this requirement against viral agents has not been adequately explored. Once introduced, poliovirus and other enteric viruses also have been found to persist in cottage cheese curd *(22)* as well as in sour milk products *(23)*.

Many convenience foods are only partially cooked and then frozen or dehydrated to be reconstituted before consumption. Reconstitution practices frequently employ insufficient heat to assure bacterial destruction. Such practices would not be expected to inactivate the more heat resistant viruses. In this context it is interesting to note that the foot-and-mouth disease virus possesses a different degree of heat resistance depending on whether it is a chance surface contaminant or whether it occurs within the cells of meat tissue. The latter condition imparts considerable protection to the virus, so that it survives more than 4 hr at 80 C (176 F) within tissue *(15)*. This is the same virus that may go unnoticed during antimortem and postmortem carcass inspections and then go into commercial products such as cured meats where the normal processes of ripening, salting, and storage have been found ineffective in rendering the meat virus-free *(12)*. Protective effects of food constituents such as fats and sugars as noted when bacteria are inactivated by heat and chemical preservatives also should be expected to influence virus survival.

Viruses can survive in foods of different compositions, and still be recoverable as infective agents even after the foods have undergone gross decomposition *(24)*. This is highly significant since it demonstrates that the normal microbial flora of such foods does not destroy the virus either directly or through decomposition products.

In the food processing industries there is an increased tendency to use milder preservation processes to minimize product quality loss. This extends to methods of drying, freezing, and other means of microbial control. Economic considerations, and a

tendency of American tastes for blander foods, also are influencing the degrees of fermentation, ageing, salting, smoking, and other practices used to preserve different foods. The above trends have public health significance not yet fully understood.

Milder preservation processes based on heat take many forms, including use of lower temperatures in combination with certain chemicals. In our laboratory we studied the effects of commercial egg pasteurization treatments on the survival of poliovirus and echovirus *(27)*. Results illustrate how processing conditions developed to be effective against one group of organisms, in this instance *Salmonella*, may be less effective against commonly encountered viruses.

With respect to liquid egg processing, currently in the U.S. and certain other countries all forms of liquid egg used commercially must receive a pasteurization treatment to render the product *Salmonella*-negative. Regulations with respect to heat treatment are not rigid, however, and the processor currently may choose from several methods that have been shown to be effective against *Salmonella (1)*. All commercial pasteurization treatments for egg employ a considerably milder heat treatment than is used for milk and various other low acid foods because the functional properties of eggs are highly sensitive to heat. With egg white, which is still more sensitive than yolk-containing products, temperatures as low as 51.7-54.4 C (125-130 F) for 3.5 min or less combined with addition of hydrogen peroxide constitutes effective pasteurization when *Salmonella* is concerned. Without the peroxide slightly more severe heat exposures are required to inactivate *Salmonella* but egg white proteins are easily denatured.

Our studies showed that neither poliovirus nor echovirus inoculated into fresh liquid whole egg and egg white survived the various heat exposures used commercially for egg pasteurization. However, both viruses survived the various milder heat-peroxide treatments applied to egg white. Although commercial equipment was not used in these studies, times, temperatures, and peroxide levels duplicated those currently used commercially. Thus we concluded that commercial egg white rendered *Salmonella*-negative by mild heat plus peroxide can retain viable virus particles.

MORE INFORMATION NEEDED

In his excellent review on the food vehicle in virus transmission, Berg *(6)* suggested three general areas needing more study. These included further search for viruses in foods, increased investigation of the relationship of viruses detected in foods to human disease, and effects of food processing procedures and preparation techniques on survival of viruses in foods. To these must be added further study on methods of virus detection, recovery, and identification from food systems.

With regard to food processing procedures and preparation techniques opportunities for study appear almost limitless. For example, more should be known about the effects on viruses of changing egg pasteurization methods; the effects of making cheese from underpasteurized milk and subsequent ageing of the cheese; freeze drying of eggs, meat and seafoods; curing chemicals in the production of uncooked sausage products; freezing of fruit and vegetable products where chemical treatments replace heat as a means of controlling oxidative changes; approved chemicals such as sulfur dioxide, sorbic acid, sodium benzoate, and high levels of salt, sugar, and acid used as preservatives in appropriate foods; refrigerated storage of pre-prepared salads, cole slaw, and other convenience foods that are not cooked before eating; and mild heat used in reconstitution of selected convenience foods, including hamburger cooked to the rare condition.

In recent years quantitative methods for viral recovery using tissue culture techniques have successfully been adapted to detection of a variety of viruses in food materials *(16, 18, 20, 24, 28)*. Among them have been various types of poliovirus, coxsackievirus, echovirus, reovirus, adenovirus, herpes simplex virus, influenza virus, Newcastle disease virus, simian virus, and others. These viruses have produced cytopathic effects on several susceptible cell lines in the presence of a wide range of contaminating food materials when bacterial and fungal growth was controlled by appropriate addition of antibiotics. Problems of methodology have been markedly eased with the increased commercial availability of animal and human cell cultures and tissue culture media *(2, 3, 11, 18, 26)*.

Provocative questions of public health related to major food commodities are inherent in a number of studies *(4, 5, 6, 8, 9, 12, 13, 14, 15, 17, 24, 30)*, yet investigations specifically directed at effects of processing conditions on virus survival in foods have been remarkably few. A meaningful assessment of the health hazard of food-borne viruses cannot be made at the present time because of inadequate knowledge.

Unlike bacteria, viruses cannot multiply outside of living cells. Certainly this keeps their numbers down in most food products that may become contaminated from animal or human sources. Were it not for this, the role of viruses in food-borne disease surely would be considerably multiplied. Nevertheless, opportunities for viral contamination of a wide

variety of foods are great, and in the opinion of many are increasing as population concentrations increase and as our total environment becomes further assaulted by pollution of various kinds. Nor should it be assumed that large virus populations need be ingested to produce disease in man. Actually very little is known about the minimum infective doses of several viruses for persons of different ages and states of health, and, as with bacterial pathogens, this is one of the more difficult areas in which to develop meaningful data.

Interest in the role of viruses in food-borne disease is growing. One indication of this is the recent establishment of a World Health Organization Committee to assemble the names of all scientific workers studying virus-food interrelationships and to catalog the nature of their specific studies. Certainly opportunities for research in this field are many.

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EXPERIMENTAL SURVIVAL STUDIES OF *SPOROTHRIX SCHENCKII* IN A MEAT PRODUCT[1]

J. H. Scharding[2], D. C. Kelley[3], J. E. Cook[4], and D. H. Kropf[5]
Departments of Infectious Diseases, Pathology, and Animal Science and Industry
Kansas State University, Manhattan, Kansas 66506

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Abstract

The literature includes a few reports on the ability of the fungus *Sporothrix schenckii* to survive at high temperatures, and one suggests that it could survive processing procedures used to manufacture frankfurters. Reported are studies to determine the extent that S. *schenckii* could survive processing procedures used by most manufacturers of commercial frankfurters.

A frankfurter test model was devised to approximate the length, diameter, and cooking characteristics of a commercial frankfurter. Uncooked emulsion was inoculated with the organism and recovery was attempted throughout the experimental cooking process. In 32% of the experimental studies, the maximum times and temperatures for positive recovery of the organism met or exceeded the processing standards used by most manufacturers. Thus, S. *schenckii* may survive in commercial frankfurters and be a potential health hazard.

For nearly 75 years the disease sporotrichosis has been reported in the world literature. Investigations of this cutaneous and systemic fungal disease have ranged from the gross lesions in animals and man to the ultrastructure of the dimorphic organism's cell wall. Hardly any body organ or tissue is exempt from invasion, and all common routes of entry have been used by the organism *(6, 9)*.

Members of the *Sporothrix* (*Sporotrichum*) genus are known to survive at low temperatures since *Sporotrichum carnis* is responsible for "White Spot" on chilled meats *(2, 4)*, and *Sporothrix schenckii* has been reported growing on frankfurters stored at 5 C *(1)*. The organism's ability to survive at high temperatures was first reported in 1898, by Schenck *(8)*. He noted that ". . . the vitality of cultures is destroyed by exposure to a temperature of 60 C for 5 min. Hertoken and Perkins *(5)* found in 1900, that 4 min at 60 C did not entirely kill S. *schenckii*, but that 4.5 min was fatal. De Beurmann *(3)* concluded in 1912, that the ". . . spores can survive temperatures of 0 and 55 C plus." How these early researchers determined these time and temperature limits is not mentioned.

Of several hundred reports in the literature, only one suggests that this pathogenic fungus is capable of surviving in meat products, and this was in commercially processed frankfurters *(1)*. The present study was undertaken to determine the extent that S. *schenckii* could survive the processing procedures employed by most manufacturers of commercial frankfurters by duplicating the processing times and temperatures on simulated frankfurters inoculated with the organism. The frankfurter test model had the approximate length, diameter, and cooking characteristics of commercial frankfurters.

Materials and Methods

Development of a test model

The frankfurter test model was fashioned from a 15.9 × 116 mm polypropylene test tube which had the walls of the lower portion of the tube partially removed. Over this basic model a section of cellulose casing was slipped and held in place with rubber bands. A glass test tube, with a diameter slightly smaller than that of the model, was inserted into the mouth of the model. This glass tube acted as a form upon which to shrink the cellulose casing for a uniform fit when the assembled model was sterilized, and as a plunger when stuffing the model with uncooked, inoculated frankfurter emulsion. It was not a part of the final test model (Fig. 1).

Preparation of stock cultures

A strain of S. *schenckii* isolated from a case of human sporotrichosis (Culture B-958, National Center for Disease Control, Atlanta, GA) was maintained in our laboratory on slants of Mycobiotic Agar (Difco Laboratories, Detroit, MI) in both the mycelial and yeast phases. A pilot study was conducted to determine if this strain, compared to another human and to a canine isolate, was unusally heat resistant. The method of testing was similar to that described later in

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[1]Contribution No. 171, Department of Infectious Diseases, No. 263, Department of Pathology, College of Veterinary Medicine, and No. 440, Department of Animal Science and Industry, College of Agriculture, Kansas Agricultural Experiment Station, Manhattan, KS 66506.

[2]Present address: USAMEDD Veterinary School, Fort Sheridan, IL 60037.

[3]Professor, Department of Infectious Disease, and Research Mycologist, Kansas Agricultural Experiment Station, Kansas State University, Manhattan, KS. Submit reprint requests to Dr. D. C. Kelley.

[4]Professor, and Acting Head, Department of Pathology, and Research Pathologist, Kansas Agricultural Experiment Station, Kansas State University, Manhattan, KS.

[5]Professor, Department of Animal Science and Industry, and Research Meat Scientist, Kansas Agricultural Experiment Station, Kansas State University, Manhattan, KS.

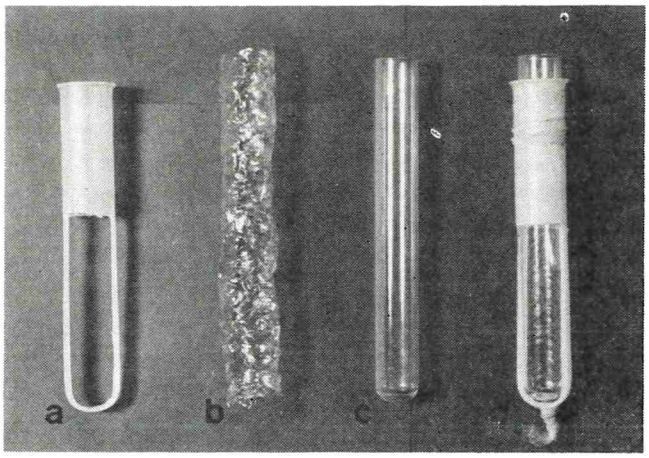

Figure 1. Frankfurter test model: *(a)* Basic test model, *(b)* cellulose casing, *(c)* glass test tube form and plunger, and *(d)* assembled test model with glass tube form in place for sterilization.

this paper.

One agar slant of each phase was flooded with 5 ml of Brain Heart Infusion Broth (BHIB) (Baltimore Biological Laboratories, Baltimore, MD) and harvested by scraping with flamed inoculating needles. Each harvested culture was separately streaked onto Mycobiotic Agar slants with a sterile swab. These two groups of stock cultures were allowed to grow 9 days in incubators at 25 C for the mycelial phase, and 37 C for the yeast phase. By then, fungal growth had totally covered the surfaces of the agar slants. All stock cultures then were maintained in a refrigerator at 5 C.

Inoculation of the emulsion

Several pounds of uncooked, all-beef frankfurter emulsion was supplied by a large Midwest producer, and frozen at −20 C until used for experimental purposes. This emulsion was initially cultured on Mycobiotic Agar slants to determine the presence of any pre-existing fungi, especially *S. schenckii*. For each group of experimental studies, 120 g of the emulsion was thawed and blended in a sterile Waring Blendor with approximately 25 ml of sterile distilled water. The resulting emulsion had a consistency that facilitated hand-filling of the test models. Two stock culture agar slants, of either the mycelial or yeast phase, were each flooded with 5 ml of BHIB and harvested by scraping with flamed inoculating needles. The entire 10 ml of harvested inoculum was added to the 120 g of emulsion and thoroughly blended, yielding an average of 10^7 particles of *S. schenckii* per gram of emulsion, as determined by serial plate counting methods. This concentration of organisms is consistent with other experimental designs *(9)*.

A sterile frankfurter test model was stuffed with the inoculated emulsion. A laboratory spatula and the glass tube plunger were alternately used to fill and compress the emulsion inside the model and eliminate air pockets. In each study, another test model was filled with the inoculated emulsion and a dial thermometer inserted to record the internal temperature of the emulsion. Initial pilot studies showed that the internal temperatures within the two test models would be the same, or nearly so, throughout the cooking process. The models then were placed in a refrigerator to equalize beginning internal temperatures at 10 C, before being simultaneously placed in the oven for cooking.

Thermal processing of the emulsion

A large Midwest producer furnished the following scheme and internal temperature reference points for processing their frankfurters in forced-air ovens: Starting internal temperature of the emulsion would be 10 C or lower; at the end of 24 min at an oven temperature of 85 C, the internal temperature of the frankfurters would be about 54 C; and, after an additional 19 min at an oven temperature of 100 C, the final internal temperature of the frankfurters would be approximately 71 C. Though processing schemes vary somewhat, most producers approach this 43 min 71 C standard, and Price and Schweigert *(7)* state that most producers achieve a final internal temperature of 68 to 72 C. Thus, the cooking scheme outlined above, plus an additional 7 min at 100 C, was adopted for the experimental studies. This gave a total experimental processing time of 50 min. A small, gravity convection laboratory oven (Blue M, model SW-11TA, Scientific Products, Evanston, IL) was the experimental processing oven.

Recovery procedures for S. schenckii

At periodic intervals during the cooking process, sterile swabs moistened in BHIB were inserted into the inoculated emulsion and streaked on Mycobiotic Agar slants. A pilot study established the time intervals for attempting recovery

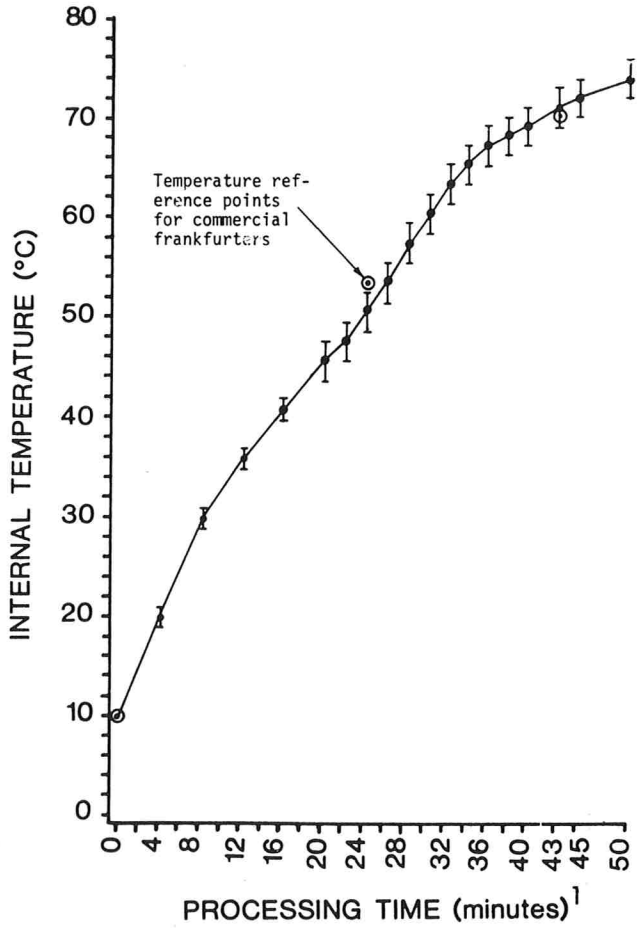

Figure 2. Mean and standard deviation of the frankfurter test model internal temperatures for each processing time, based on 60 experimental studies. [1]Oven temperatures of 85 C from 0 to 24 min, and 100 C from 26 to 50 min of processing time.

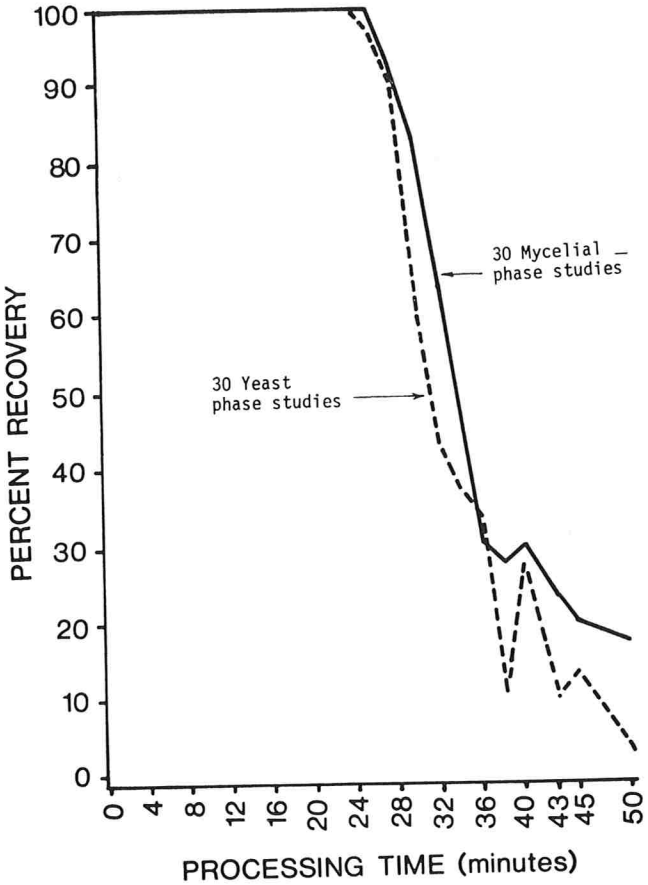

Figure 3. Percent positive recovery of S. *schenckii* from the frankfurter test model at each processing time for the mycelial and yeast phase studies.

of the organism at every 4 min from 0 to 20 min of processing time, every 2 min from 22 to 40 min of processing time, and at 43, 45, and 50 min of processing time. This made a total of 19 recovery attempts in each study. At each timed recovery attempt the internal temperature of the emulsion was recorded from the thermometer in the adjacent test model. The recovery agar slants were incubated 7 days at 25 or 37 C, depending on the fungal phase being studied in each experiment. Positive or negative recovery of S. *schenckii* was determined for each recovery attempt in each study by the presence or absence of colonies of the organism on the recovery agar slants. The number and percentage of positive recoveries for each time interval were also determined. Thirty of the studies used the mycelial phase stock cultures and 30 used the yeast phase stock cultures, for a total of 60 experimental studies.

RESULTS AND DISCUSSION

Test model

Figure 2 shows the mean and standard deviation of internal temperatures recorded for each processing time interval in the 60 studies. A close approximation is seen when the mean internal temperatures of the frankfurter test model are compared with the commercial temperature reference points. Thus, the test model and methods adequately duplicated the processing conditions for most commercial frankfurters and were suitable for the study of the survival of S. *schenckii* in frankfurters.

Experimental studies

All three strains of S. *schenckii* compared in pilot studies for possible heat resistance had similar survival capabilities in relation to exposure times and temperatures. Cultural examination of the emulsion before any experimentation revealed no pre-existing fungi.

For each study the maximum processing time, and the corresponding maximum internal temperature, at which positive recovery of the organism was made using the frankfurter test model are shown in Table 1. For the total 60 studies, the means of the maximum processing times and the maximum internal temperatures with survival and recovery of S. *schenckii* were calculated to be 37 min, with a standard deviation of 7 min, and 67 C, with a standard deviation of 6 C. The range of maximum processing times was 26 to 50 min, and the range of maximum

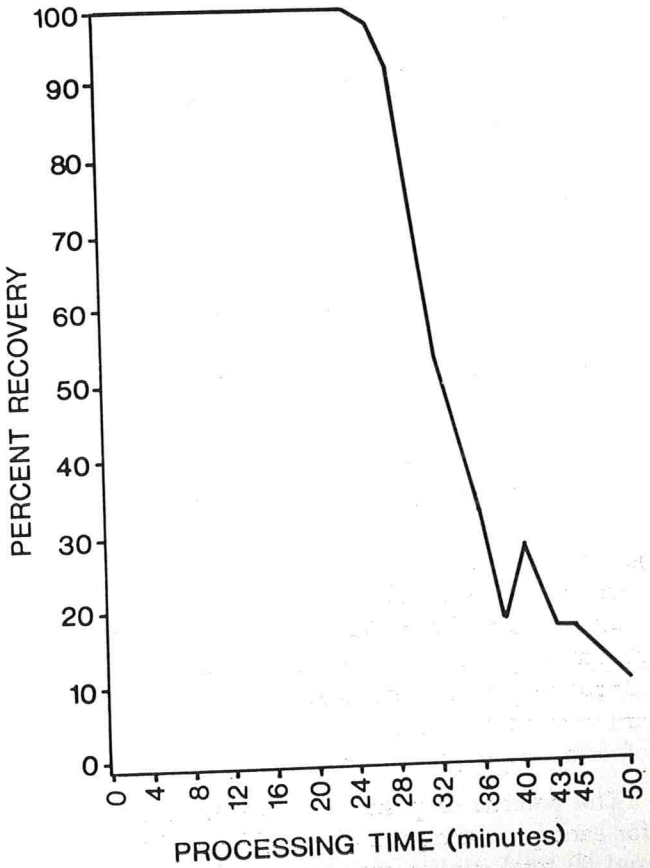

Figure 4. Percent positive recovery of S. *schenckii* from the frankfurter test model at each processing time for the combined 60 experimental studies.

TABLE 1. MAXIMUM PROCESSING TIMES AND INTERNAL TEMPERATURES WITH RECOVERY OF *S. schenckii* FROM THE FRANKFURTER TEST MODEL

30 Mycelial phase studies			30 Yeast phase studies		
Experiment number	Max. time (min)	Max. temp. (C)	Experiment number	Max. time (min)	Max. temp. (C)
1m	45	69	5y	40	71
2m*	50	74	6y	36	68
3m*	45	75	7y*	43	71
4m	40	70	8y*	43	75
9m*	43	74	13y*	45	76
10m	30	62	14y	36	66
11m*	43	75	15y*	43	74
12m	36	69	16y	36	67
17m	34	64	23y	40	68
18m*	50	73	24y	30	60
19m*	50	77	25y	34	64
20m	40	72	26y	32	62
21m*	45	75	27y	40	70
22m*	50	77	28y	36	67
29m	30	63	35y	34	65
30m*	45	77	36y	34	65
31m	34	67	37y*	45	71
32m	32	64	38y*	50	74
33m	30	61	39y	32	66
34m	34	65	40y	26	55
41m*	43	73	47y	34	64
42m*	50	76	48y	26	51
43m	32	62	49y	30	60
44m	40	69	50y	28	56
45m*	43	71	51y	30	60
46m	32	62	52y	32	63
53m	30	61	57y	30	63
54m	30	61	58y*	45	73
55m	28	59	59y	30	64
56m	36	68	60y	38	74
Mean**	39	69		36	66
Standard deviation**	7	6		6	6

*Indicates the 19 studies (32%) that meet or exceed the 43 min, 71 C standard.

**Mean and standard deviation for all 60 studies is 37 ± 7 min, and 67 ± 6 C.

internal temperatures was 51 to 77 C. The mean maximum processing time and internal temperature for recovery of the mycelial phase were only slightly greater than those of the yeast phase, probably because the mycelial phase is hardier. Data in Table 1 also indicate that in 32% (19/60) of the studies, the maximum processing times and internal temperatures for recovery met or exceeded the 43 min, 71 C standard currently approximated by most manufacturers of commercial frankfurters.

The percent of positive recoveries of *S. schenckii* for each processing time in the 30 mycelial, 30 yeast, and 60 total studies are shown in Fig. 3 and 4. In Fig. 3, the mycelial phase showed a slightly greater percent recovery than the yeast phase, especially at later processing times. This was expected since the mycelial phase is hardier and is the phase found exposed to the environment on soil and organic matter.

Percent positive recovery of the organism in Fig. 4 showed a decrease from 98% at 26 min of processing time, to 18% at 38 min. This sharp decrease indicated rapid death of the organism as time and temperature increased. However, after the full 50 min of experimental processing time there was still positive recovery in 10% of the studies. The slight increase in percent recovery, with a following decrease, from 38 to 43 min may have resulted from activation of dormant spores or undetected experimental variation.

Any undetected, diseased carcass containing the yeast phase of the organism, which is processed into various meat products, especially frankfurters, could be a source of preprocessing contamination. Also, as the fungus is found worldwide on soil and organic matter *(6)*, an additional source of both preprocessing and postprocessing contamination with the mycelial phase would exist wherever there is poor sanitation.

Results of our experiments indicate that *S. schenckii* may survive processing procedures used to manufacture most commercial frankfurters and be a potential health hazard to man and animals. These findings are important to manufacturers, public health officials, and other responsible persons and agencies because *S. schenckii* can infect man and animals via the gastrointestinal tract and result in systemic disease *(6, 9)*.

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A Research Note

INCIDENCE OF SALMONELLAE IN COMMERCIALLY PREPARED SANDWICHES FOR THE VENDING TRADE

N. A. KHAN[1] AND T. A. MCCASKEY
Department of Animal and Dairy Sciences, Auburn University Agricultural Experiment Station, Auburn, Alabama 36830

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ABSTRACT

A survey was conducted to determine the incidence of salmonellae in sandwiches prepared in commercial kitchens for distribution through vending machines. A total of 646 samples consisting of 13 different types of sandwiches obtained from five vending firms was analyzed. Salmonellae were not detected in any of the sandwiches. It is concluded that the routine use of mayonnaise and other acid ingredients along with proper maintenance of hygienic conditions and effective temperature control of vending machines play an important role in the prevention of *Salmonella* infection in commercially prepared sandwiches.

One of the contributions of modern technology is mass production of ready-made foods and their sale through vending machines. Sandwiches are one of the most popular single forms of food consumed in the United States. The consumption of sandwiches during 1970 was estimated at 100 to 200 million per day *(2)*.

Sandwiches are prepared almost entirely by hand and the ingredients used for their preparation support bacterial growth. Adame et al. *(1)* reported finding numerous coliform bacteria in commercially prepared sandwiches. The source of contamination might have been the sandwich ingredients or the food handlers. The latter source also may be an important route of foodborne pathogens into sandwiches. The National Academy of Sciences reported that the incidence of *Salmonella* carriers among food handlers is higher than that of the general population in the United States *(7)*. Epidemiological studies of salmonellosis have revealed that food and food ingredients play an important role in the chain of infection.

This study was conducted to determine the incidence of salmonellae in sandwiches prepared in commercial kitchens for the vending trade. Various kinds of sandwiches from a number of vending machines and from kitchens of five distributors of vended foods were examined.

MATERIALS AND METHODS

A total of 646 samples consisting of 13 different types of sandwiches was analyzed in this study. A summary of the samples analyzed according to type of sandwich and the source of collection is shown in Table 1.

A 30-g sample was aseptically cut from the middle third portion of each sandwich and blended with 200 ml of lactose broth in a sterile Waring Blendor. The blended sample was incubated at 37 C for 18-24 hr and 1 ml was transferred to 9 ml of Tetrathionate (TET) broth. The TET broth was incubated at 37 C for 18-24 hr and the broth was streaked on Brilliant Green Agar (BGA) containing 0.016% sodium sulfadiazine. BGA plates were incubated at 37 C for 24 hr and at least five non-lactose fermenting colonies were inoculated into Triple Sugar Iron (TSI) agar slants. The TSI agar slants were examined after 24 hr of incubation at 37 C. Cultures that produced alkaline slants with acid butts with or without gas or hydrogen sulfide in TSI medium were suspected as *Salmonella*. These cultures hereafter will be referred to as TSI-positive organisms.

The somatic antigens of the TSI-positive cultures were typed with polyvalent 0 antiserum (Difco) and also with the individual antisera that comprise the polyvalent 0 group. The cultures were tested further for lysine decarboxylase production and inability to produce indole and urease. Motility was determined on Motility GI medium (Difco) and serological typing for flagellar antigens was accomplished with pooled Spicer-Edwards antisera (Difco).

Studies were conducted in our laboratory to evaluate the sensitivity of the *Salmonella* recovery technique. Various levels of *Salmonella thompson* were added to egg salad sand-

TABLE 1. LIST OF TYPES AND SOURCE OF SANDWICHES OBTAINED FROM FIVE DISTRIBUTORS

Distributor	Kind	No.
A	*From vending machine*	
	Hamburger	9
	Cheeseburger	2
	Sausage & biscuit	4
	Hot dog	2
	Smoked sausage	1
	Pimento cheese	2
	Fish sandwich	2
	Roast beef	1
	Cheese & ham	1
	Ham salad	1
	Bologna & lettuce	29
	Tuna salad	31
	Fresh from kitchen	
	Bologna & lettuce	20
	Tuna salad	30
	Ham salad	50
B	Tuna salad	132
	Egg salad	100
C	Bologna & lettuce	49
	Ham salad	50
D	Ham salad	30
E	Tuna salad	50
	Egg salad	50
		646

[1]Present address TOM'S FOODS LTD, Columbus, Georgia, 31902.

wiches and immediately after preparation the sandwiches were analyzed for S. *thompson* as previously described. Samples inoculated with 1-2 salmonellae per 100 g of sandwich were found positive for salmonellae in 60% of the recovery attempts.

RESULTS AND DISCUSSION

A total of 203 or 31.4% of the samples yielded TSI-positive organisms. These cultures also reacted with polyvalent 0 antiserum. Among the serological subgroups tested, the highest percentage of organisms reacted with somatic antiserum subgroup B (29.5%) followed by C_2 (26.6%) and C_1 (24.1%). On the basis of their negative reaction to H antisera none of the cultures was confirmed to be *Salmonella*. Further identification of the organisms was not attempted.

Results of this study are consistent with the observations of Adame et al. *(1)* and McCroan et al. *(6)*. These two groups of investigators did not recover salmonellae from a total of 850 commercially prepared sandwiches.

Although there are several possible routes whereby salmonellae may enter sandwiches during preparation, there has been, however, only one published report of salmonellosis involving commercially prepared sandwiches *(5)*. That outbreak occurred at an army camp in 1944 and involved 97 persons who ate *Salmonella typhimurium*-contaminated egg salad sandwiches purchased from a vendor.

A few reports indicate that low pH produced by certain sandwich ingredients, especially mayonnaise, and the competition and antagonism by saprophytic organisms probably have played important roles in the prevention of sandwich-borne *Salmonella* infections. Low pH of commercially prepared sandwiches containing mayonnaise and salad dressing was reported by McCroan et al. *(6)* as a significant factor in the prevention of foodborne illness. Wethington and Fabian *(9)* reported that salmonellae failed to survive in commercial mayonnaise and salad dressing because of low pH. Most of the sandwiches analyzed in this study had either mayonnaise or salad dressing as one of the ingredients.

The effect of competition and antagonism from saprophytic organisms in suppressing the growth of *Salmonella* was reported by Dack and Lippitz *(4)*. A profound inhibitory effect on the growth of S. *typhimurium* was noticed by these investigators when the number of saprophytic organisms reached 19,000/g of slurry of pot pies. During our investigation many sandwiches were analyzed that had a considerable population of lactose- and saccharose-fermenting bacteria. These organisms were observed on Brilliant Green Agar after enrichment of the sandwiches in lactose and TET broths.

The important role played by public health authorities in implementing effective hygienic standards and proper temperature control in vending machines have also contributed to prevention of *Salmonella* infection in commercially prepared sandwiches. Thermal death time studies conducted by Angelotti et al. *(3)* have revealed that 45-min exposure at 60 C would reduce 1,000 salmonellae/g of food to a nondetectable level. According to Section V of the Sanitation ordinance and code 1965 *(8)*, potentially hazardous food within the vending machine should be maintained at 7 C or below for cold foods or 60 C for hot served foods. All multiused containers or parts of vending machines which come in contact with potentially hazardous food should be removed from the machine daily and thoroughly cleaned and sanitized. The requirement for daily cleaning and sanitation is waived for those food contact surfaces which are maintained at all times at a temperature of 7 C or below, or 60 C or above, and an approved cleaning program is followed.

In summary it is concluded that the routine use of mayonnaise and other acid ingredients in commercially prepared sandwiches along with proper maintenance of hygienic conditions and effective temperature control of vending machines have played an important role in the prevention of *Salmonella* infection in sandwiches sold through vending machines.

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FATE OF *BACILLUS CEREUS* IN CULTURED AND DIRECT ACIDIFIED SKIMMILK AND CHEDDAR CHEESE[1]

E. M. Mikolajcik, J. W. Kearney, and T. Kristoffersen
Department of Food Science and Nutrition
Ohio Agricultural Research and Development Center, Columbus 43210

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Abstract

Germination, growth, sporulation, and survival of *Bacillus cereus* 7 was determined in cultured (*Streptococcus lactis* C10) and direct acidified (lactic acid) skimmilks. For cultured systems, *B. cereus* increased initially at approximately the same rate in milks with or without streptococci. However, as the acidity of the milk increased, vegetative *B. cereus* cells failed to survive but spore counts remained unchanged. *B. cereus* organisms did not influence acid production or multiplication of the lactic streptococci. In direct acidified skimmilk, spore germination and outgrowth and vegetative cell multiplication decreased as the pH of the system was lowered from 6.5 to 5.0. In skimmilk at pH 5.0, vegetative cells failed to multiply and spore germination ceased. In Cheddar cheese manufacture, *B. cereus* multiplied rapidly during the period from the end of cooking to milling of the curd. *B. cereus* survived in the spore state in Cheddar cheese during 52 weeks curing.

It is becoming increasingly evident that *Bacillus cereus* can be an etiological agent in some cases of food poisoning. Although to date, the actual mechanism(s) by which this occurs is unclear *(3)*.

In some aspects, *B. cereus* food poisoning resembles that of *Clostridium perfringens (3, 11)*. There is convincing proof that food poisoning by *C. perfringens* requires consumption of foods containing large numbers of vegetative cells *(4)*. For *B. cereus* food poisoning, counts in excess of 10^5-10^8/g have been encountered in suspect foods *(3)*.

B. cereus is widely distributed. In our 1961 survey of raw milk from Ohio farms, *B. cereus* spores were present in 37% of 287 samples examined *(7)*. Higher values were reported by European workers *(3)* who found that over 70% of the milk samples contained *B. cereus*. Dried skimmilk and pasteurized milk have been found to be contaminated with *B. cereus (3, 6)*.

As part of a continuing investigation, we have reported on *B. cereus* spore germination and outgrowth *(9)*, proteolytic activity *(1, 2)*, and heat resistance *(8)* in skimmilk. This study reports on the behavior of *B. cereus* in cultured and direct acidified skimmilk and during Cheddar cheese manufacture and curing.

[1]Approved as Journal Series Article No. 111-72 of the Ohio Agricultural Research and Development Center.

Methods

Bacillus cereus 7, originally isolated from a raw milk supply, *(7, 9)* was used. As described previously *(1, 9)*, spores were prepared by the non-heat method and vegetative cells in exponential growth and synchronous division by successive transfer in modified G medium containing 0.2% casamino acids. The skimmilk medium was Matrix Mother Culture Media (Galloway-West Co., Fond du Lac, Wisc.) reconstituted to 11% total solids and sterilized at 121 C for 10 min. Cultured skimmilk was prepared by inoculation at the 0.5% level with *Streptococcus lactis* C10. For the direct acidified samples, the pH of the autoclaved skimmilk was adjusted with sterile lactic acid and incubated at 30° C.

Cheddar cheese was manufactured in the conventional manner from milk pasteurized at 72.2 C for 17 sec and inoculated with 1% Hansen's H-4 mixed culture. Two separate trials were made. For each trial, two lots of cheese were prepared: one was artificially infected with heat-shocked (80 C - 12 min) *B. cereus* 7 spores to yield a final spore count of approximately 4,000/ml of milk and the other lot served as the control.

The mannitol-egg yolk-polymyxin (MYP) medium of Mossel et al. *(10)* was used to enumerate *B. cereus* organisms in the presence of lactic streptococci. This medium has been evaluated and utilized by Kim and Goepfert *(5, 6)* for studies of *B. cereus* contamination of food products. Characteristic colonies appearing on MYP agar were counted following incubation of plates at 35 C for 24 hr. In systems containing only *B. cereus*, Standard Plate Count agar was employed. Spore counts were done on heated samples (80 C - 12 min) using Standard Plate Count agar containing 0.1% soluble starch with incubation at 35 C.

To enumerate lactic streptococci in the presence of *B. cereus*, Standard Plate Count agar was used and counts were corrected by substrating *B. cereus* counts of the same system obtained on MYP agar.

Percent germination, generation time, and number of generations were calculated as previously reported *(9)*.

Curd samples for microbiological analysis were prepared by grinding 11 g of curd with 99 ml of sterile 2% sodium citrate at 40 C in a Waring Blender.

Titratable acidity expressed as percent lactic acid was determined by standard procedures utilizing 0.1 N NaOH and phenolphthalein indicator.

Results and Discussion

Cultured skimmilk

The effect of lactic acid streptococci on the rate of outgrowth and germination of *Bacillus* spores in skimmilk was determined (Fig. 1). During the first 4

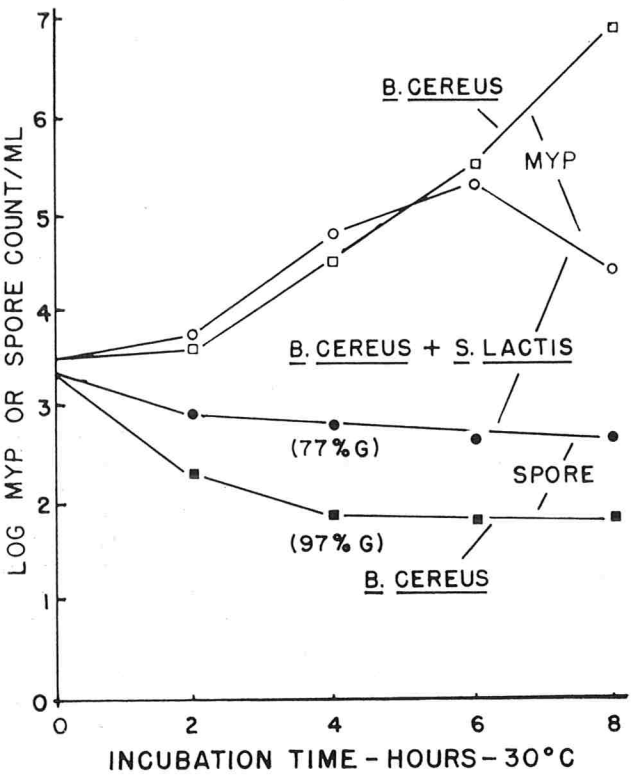

Figure 1. Effect of S. *lactis* C10 on the germination and outgrowth of *B. cereus* 7 spores in skimmilk. The percent germination is shown at 4 hr. (Average of 3 trials).

hr of incubation, outgrowth of *B. cereus* was approximately the same whether or not S. *lactis* was present. Beyond 6 hr, counts of *B. cereus* in the cultured system dropped rapidly, whereas counts of the control milk continued to increase at an exponential rate. At 4 hr, 77% of the *B. cereus* spores had germinated in the cultured system as compared to 97% for the control.

The rate of acid development by S. *lactis* C10 was not affected by the presence of the *B. cereus* organisms (Fig. 2). In fact, during the period of 6 to 8 hr, acid production by S. *lactis* C10 was slightly higher in the presence than in the absence of *B. cereus*. However, the increased acidic environment did decrease markedly the survival of *B. cereus* cells (Fig. 1).

Although not shown, studies with *B. cereus* 7 spores and *Streptococcus cremoris* US3 or Hansen's H-4 yielded similar results.

Direct acidified skimmilk

To determine the effect of acidification on germination and outgrowth of *B. cereus* 7 spores and on *B. cereus* vegetative cells, sterile lactic acid was used to adjust the pH of skimmilk and the systems were inoculated with heat-shocked spores or vegetative cells in exponential growth.

With respect to spore outgrowth (Fig. 3) particularly during the period of 4 to 8 hr incubation, the population level and rate of growth varied with the pH of the skimmilk. As the pH decreased from 6.55 to 5.03, there was a corresponding decrease in the rate of growth and/or in the total count of organisms present at each time interval.

Spore germination was also influenced by pH of the system (Fig. 3). With the exception of pH 5.03, in all other instances, spore numbers decreased gradually with increasing incubation indicating germination. The rate and extent of germination increased with increases in pH. For example, at 6 hr of incubation, the percent germination ranged from 0 for pH 5.03 skimmilk to 97 for pH 6.55 skimmilk. In the later milk, initiation of sporulation was detected at 8 hr.

Results shown in Fig. 4 are for vegetative *B. cereus* cells in exponential growth added to direct acidified skimmilk. Active cell multiplication occurred in all but pH 5.03 skimmilk. As the pH of the skimmilk was decreased to 5.03, there was a corresponding decrease in the rate and extent of multiplication of vegetative cells. At pH 5.03, vegetative cell numbers decreased rapidly indicating that the organisms failed to survive in the acid environment.

For *B. cereus* in a direct acidified system, pH 5.0 appears to be the pH at which inhibition of spore germination and outgrowth and active cell multiplication is manifested. However, spores are not destroyed at this pH. In associated growth systems, as was observed with the lactic streptococci, some

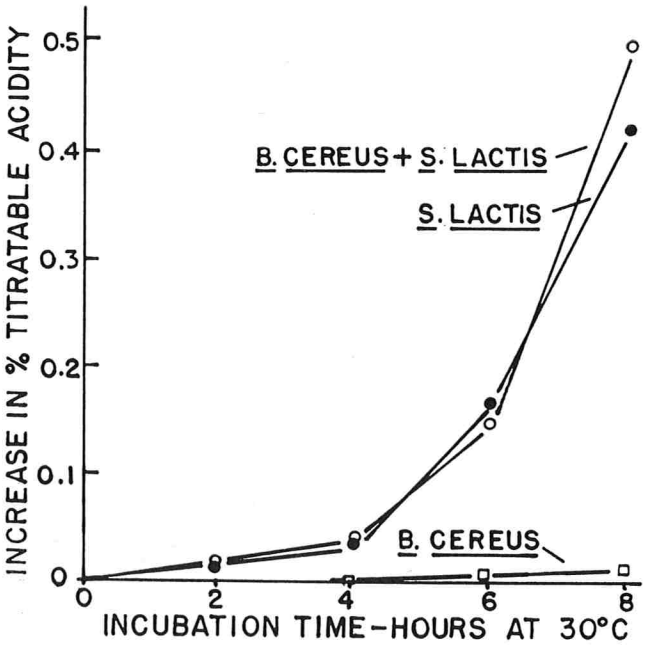

Figure 2. Influence of *B. cereus* 7 on acid production in skimmilk by S. *lactis* C10 (Average of 3 trials).

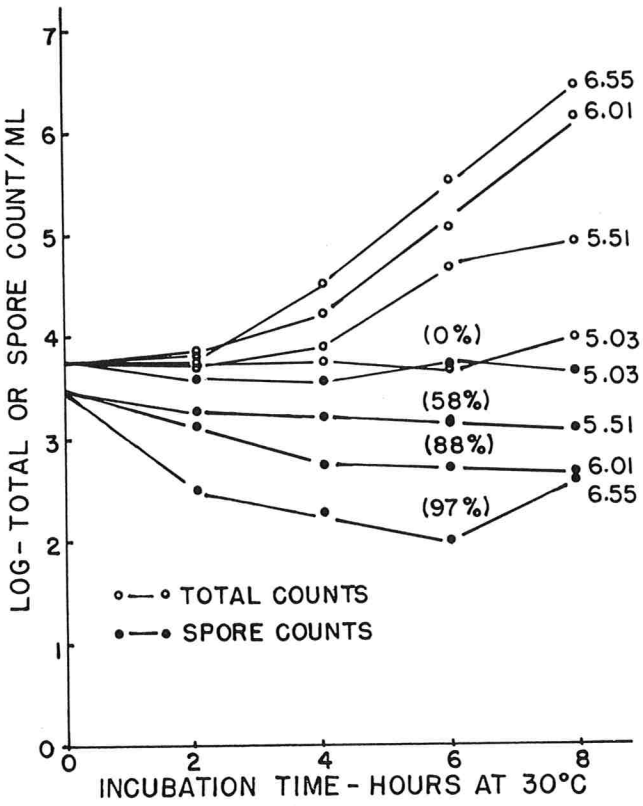

Figure 3. Effect of pH of skimmilk on germination and outgrowth of *B. cereus* 7 spores. The percent germination is shown at 6 hr. and the pH of the skimmilk in the extreme right column. (Average of 3 trials)

inhibition of spore germination and active cell multiplication may occur at higher pH.

Cheddar cheese

To ascertain the fate of the *B. cereus* spore during manufacture and curing of Cheddar cheese, milk was infected with approximately 4,000 heat-shocked spores/ml prior to manufacture. *B. cereus* counts on selective MYP agar and on Standard Plate Count agar were done at each step of the manufacturing process and at selected time intervals during curing at 4 C for 52 weeks.

For the data shown in Table 1, the approximate time for each of the following cheesemaking steps was 1 1/4 hr for ripening and renneting, 1 hr for cooking, and 2 1/2 hr for cheddaring. The total time from the addition of the spores to hooping was about 6 hr.

B. cereus counts increased approximately 5-fold during ripening of the milk with a 10-fold decrease in spore counts. At cutting, the curd contained 19,500 *B. cereus*/g and at milling, the counts had increased to 220,000/g. Following salting and at hooping, the MYP counts had decreased to 42,000/g. However, spore counts of the curd had increased to 6,000/g from a low of 690/g at cutting.

Part of the observed increases in counts may have resulted from physical entrapment of the organisms in the curd coupled with concentration of the curd upon expulsion of the whey.

In one-day old cheese, *B. cereus* counts on MYP agar were 4,300/g, whereas spore counts of the same system were 5,600/g. Apparently, the *B. cereus* organisms survive in the spore state. MYP agar does not differentiate between the vegetative or spore state, enumerating both states. The difference between MYP counts and spore counts is probably related to normal variation in plating techniques and/or to an inability of some of the spores to germinate and outgrow on the selective agar. Spores of species other than *B. cereus* were not a factor in the increased spore count because the control lot of cheese prepared without added spores had counts of only 155/g at 1 day.

As the curing time progressed from 8 to 52 weeks, counts on MYP agar and spore counts varied only slightly from each other and remained relatively constant within the range of 5,500 to 8,200/g.

The flavor, body, and texture quality of both the infected and control lots of cheese were similar and highly acceptable. At 52 weeks, the cheese was

Table 1. Fate of *Bacillus cereus* spores in the manufacture and curing of Cheddar cheese[a]

Sample		Total count[b]	Spores[c]
		(No./g or ml)	
Milk used for cheese manufacture		120	28
Upon addition of *B. cereus* spores		3,600	3,900
End of ripening		21,500	440
End of renneting		6,000	380
At cutting: Whey		1,800	30
Curd		19,500	690
End of cooking: Whey		2,700	30
Curd		44,000	2,600
Curd at milling		220,000	5,600
Curd at hooping		42,000	6,000
Cheese after curing for —	1 day	4,300	5,600
	7 days	5,500	4,200
	14 days	7,000	6,700
	28 days	6,100	5,500
	8 weeks	6,000	5,800
	12 weeks	7,400	7,100
	16 weeks	5,500	5,700
	24 weeks	8,200	5,900
	30 weeks	6,500	5,700
	52 weeks	5,800	6,200

[a]Averages of two separate lots of cheese. Control cheeses prepared with the same milks had 28 spores/ml in cheese milk and the finished cheese had 155, 180, 58, and 80 spores/gram following curing of 24 hr, 12 weeks, 24 weeks, and 52 weeks, respectively.

[b]Total *B. cereus* count on MYP selective agar.

[c]Counts obtained following heat treatment of sample at 80 C - 12 min.

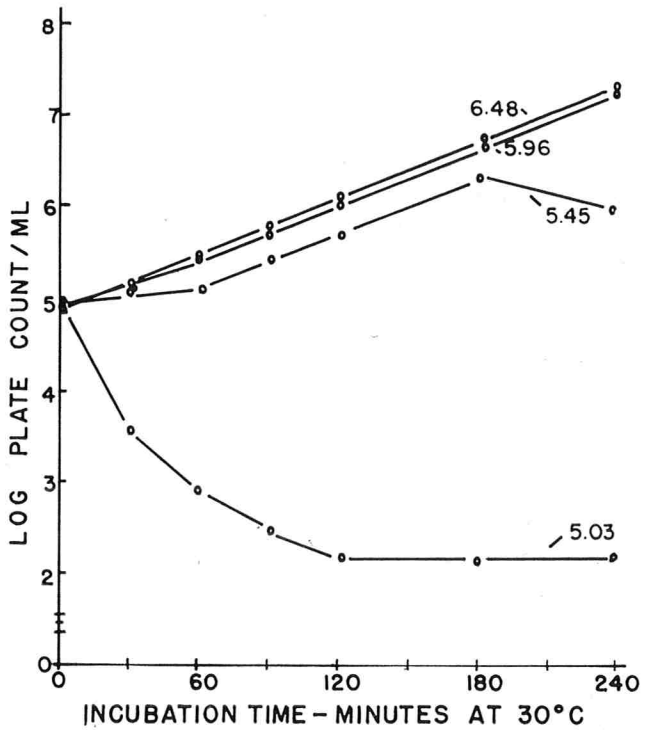

Figure 4. Response of *B. cereus* 7 cells in exponential growth upon inoculation into direct acidified skimmilk of varying pH. (Average of 5 trials)

criticized for slight unclean flavor.

The two major findings of the Cheddar cheese phase of the study were: one, that concentration and rapid proliferation of the *B. cereus* organism can occur in curd particularly after stimulation of the spore during the cooking process and, two, that spore counts of *B. cereus* in some systems do not represent the entire *B. cereus* population especially where large numbers of these organisms are present in the heat-labile vegetative state.

Few or no vegetative *B. cereus* cells were present in the cheese during the curing period substantiating the finding from the cultured and direct acidified study that the pH of properly prepared Cheddar cheese is inhibitory.

It should be noted that if the mechanisms for food poisoning by *B. cereus* involves the pre-formed toxin, then the ability of the organisms to multiply prior to development of sufficient acid by the lactic streptococci should be of concern.

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A Research Note

EFFECT OF EGG SHELL SWEATING ON MICROBIAL SPOILAGE OF CHICKEN EGGS[1]

D. V. Vadehra and R. C. Baker
Department of Poultry Science, Food Science Section
Cornell University, Ithaca, New York 14850

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Abstract

A study was undertaken to show the effect of sweating on microbial spoilage of eggs. Sweating had little effect on the spoilage pattern. The improper washing procedure had a greater influence on spoilage than the sweating treatment. Induced infection studies showed far greater spoilage due to *Pseudomonas* than to *Salmonella* but the sweating procedure did not influence the spoilage pattern.

It is a common belief in the poultry industry and also among research workers that sweating is detrimental to egg quality and enhances the chances of egg spoilage. The term "sweating" refers to the accumulation of water droplets on the egg's exterior when eggs are moved from refrigerated storage to room temperature. The presence of moisture on egg shell is believed to facilitate the locomotion of bacteria and enhance their penetration through the egg shell resulting in egg spoilage.

A review of the literature revealed that little if any work has been done in this area although several reports are available on the effect of humidity and storage conditions on the internal quality of eggs. Extensive works has been done on the oiling of eggs and its effect on egg quality. Korslund et al. (3) studied the effect of washing and oiling on egg weight loss and albumen quality. Sabet et al. (5) showed that an oil-water emulsion for coating of eggs did not increase the microbial penetration rate when eggs were stored at 1 C and a relative humidity (RH) of 75 to 85%. Funk (2) also reported on the effect of temperature and humidity on the keeping quality of shell eggs. Van Wagenen et al. (7) reported that a RH of 60% and a temperature of 7.3 C were satisfactory for short time farm holding of eggs.

This study was undertaken to determine the effect of sweating on the spoilage of eggs.

Materials and Methods

Effect of sweating

Washing treatments. Eggs used throughout this study were from one strain of White Leghorn hens from the Cornell University Poultry Farm and were one day old unless otherwise specified. The eggs were obtained nest clean and were given the following treatments: *Treatment 1*: no washing. *Treatment 2*: proper washing. Washing for 3 min in an immersion type egg washer using a sanitizer-detergent solution at a temperature of 45 C. The eggs were rinsed with water at 40 C to remove any residual detergent on the egg surface. *Treatment 3*: improper washing. The wash water, in addition to the sanitizer detergent, contained 250 g of chicken fecal matter per 30 liters. Other conditions of temperature and time were similar to treatment number 2.

Sweating procedures. The eggs were stored throughout this study in a refrigerator (13 C) in styrofoam egg cartons. To induce sweating, cartons were moved to room temperature and the covers opened. Cartons were left at this temperature until visible water droplets could be seen (1 to 2 hr). The room temperature was 25 to 27 C; the RH was 80 to 85%. The sweating procedures for the eggs were as follows: *(a)* no sweating—stored at 13 C for the length of this study (60 days); *(b)* sweating once—brought to room temperature once, allowed to sweat then returned to 13 C refrigerator for the remainder of the storage study; *(c)* sweating three times—on three consecutive days, brought to room temperature, allowed to sweat, then returned to a 13 C refrigerator; and *(d)* sweating daily for the length of the study.

Table 1. Effect of washing procedure and sweating on percent spoilage of eggs incubated at 13 C for 60 days[1]

Type of washing	Number of sweatings: None	One	Three	Daily
	——(Percent Spoilage)*——			
No washing	6	10	8	10
Proper washing	6	8	6	12
Improper washing	12	12	12	14
Average for treatments	8	10	9	12

[1]60 eggs were used for each treatment.
*Eggs were considered spoiled when they showed greenish fluorescence under U.V. light.

Table 2. Effect of induced infection and sweating on percent spoilage of eggs incubated at 13 C for 60 days[1]

Test organism	Number of sweatings: None	One	Three	Daily
	——(Percent spoilage)*——			
Pseudomonas aeruginosa	74	78	88	76
Salmonella typhimurium	4	0	0	0
Salmonella derby	0	0	4	4

[1]60 eggs were used for each treatment.
*Eggs were considered spoiled when they showed a greenish fluorescence for *Pseudomonas* and positive test for *Salmonella*.

[1]This investigation was supported in whole by PHS Research Grant No. FD 00080 from the Food and Drug Administration.

Effect of induced infection

Method of infection. Eggs were washed as in treatment 2. The rinse water was at 40 C and dip water containing the test organism was 15 C. This provided a temperature differential for entry of bacteria into eggs. The bacterial count of dip water was approximately 10^6/ml. Test organisms used were *(a) Pseudomonas aeruginosa* isolated in this laboratory from a spoiled egg *(b) Salmonella typhimurium* LT 2, and *(c) Salmonella derby.* The organisms were grown in glucose yeast extract broth at 30 C for 24 hr.

Bacteriological examination. Examination for spoilage by *Pseudomonas* infection was done by candling using an ultraviolet light *(1).* Eggs showing greenish fluorescence were considered positive. Eggs infected with *Salmonella* species were prepared for bacteriological examination according to the procedure of Brown et al. *(1).* The albumen was plated on standard plate agar. Plates were incubated at 37 C for 48 hr. Ten to fifteen colonies were randomly picked per plate and tested for *Salmonella* by the standard procedures *(4).*

RESULTS AND DISCUSSION

The effect of the washing and sweating treatments on spoilage of eggs is shown in Table 1. These data indicate that spoilage was not increased by sweating except possibly when sweating was repeated daily, a condition which seldom exists in the industry. Eggs washed improperly (fecal matter in wash water) showed a slight increase in spoilage when compared to eggs washed properly. Results of improper washing were similar to those found with cracked eggs as reported by Vadehra et al. *(6).*

Results of induced infection on spoilage of control eggs and eggs exposed to several sweating procedures are summarized in Table 2. The results indicate that sweating treatments did not influence spoilage of eggs irrespective of type of organism used. Spoilage was far greater when *P. aeruginosa* was used as the test organism than when S. *typhimurium* or S. *derby* was used. The absence of spoilage with *Salmonella* species is probably due to the incubation temperature (13 C) used in this study which is far below the optimum growth temperature for this organism; however, this is a commonly used storage temperature.

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POLYUNSATURATED MEAT AND MILK DESCRIBED BY USDA SCIENTISTS:

Milk with 10 times the normal amount of polyunsaturated fat and beef with 4 times its usual content of such fat were described here today by U. S. Department of Agriculture scientists.

These experimental foods were produced by cattle given feed containing specially treated vegetable oils. Flavor, processing characteristics, and other properties of the polyunsaturated milk and meat were described by chemists Locke F. Edmondson and Joel Bitman of USDA's Agricultural Research Service at the 64th annual meeting of the American Oil Chemists' Society.

Besides increasing unsaturated fats in meat and milk, the experimental cattle-feeding regime also reduced the amount of saturated fats. The idea is that these new livestock products may contribute to a better dietary balance of unsaturated and saturated fats, and thus help to lower the blood cholesterol of some consumers. Medical evidence has indicated that less cholesterol in the blood reduces the risk of heart and circulatory ailments.

The special vegetable oils used by Edmondson and Bitman were prepared by a method, first developed in Australia, in which oil droplets are coated with casein, treated with formaldehyde, and spray dried. The protective coating ensures passage of the oil through the digestive tract of cattle in unsaturated form. Normally, most of the unsaturated fats present in feed become saturated in the cow's rumen before they find their way into milk and meat.

As the cows were fed increasing amounts of safflower oil treated with formaldehyde, the polyunsaturated fatty acids in their milk rose from 3 to 30 percent of the total fat. An oxidized, or tallow-like, flavor characterized the milk, and this off-flavor became more pronounced as the content of polyun-

(Continued on Page 332)

UTILIZATION OF DAIRY INGREDIENTS IN OTHER FOODS[1]

JOHN J. JONAS
Kraftco Corporation, Research and Development Division
Glenview, Illinois 60025

ABSTRACT

This paper discusses the rationale of using various dairy proteins, fats, and carbohydrates in solid, liquid, frozen, and emulsified food systems. Special emphasis is given to sectors of the food industry which offer the best novel opportunities for functionally designed dairy ingredients. Dairy ingredients to be discussed are classified according to their chemical nature into three groups: dairy proteins, fats, and carbohydrates.

INTRODUCTION

Use of dairy ingredients in formulated foods enhances consumer appeal, improves the nutritional value, and supplies functionality features. Modified dairy ingredients, when designed to meet specific functionality requirements of the food manufacturer, could supply not only the inherent benefits of the dairy raw materials but also improve economy and convenience. Introduction of these functionally designed, and industrially oriented, new dairy ingredients into international trade would tend to reduce the economic pressures of overproduction in dairy production areas and be of benefit to the food industries in the non-dairying countries as well.

The industrially oriented products of dairy origin have been traditionally marketed to baby food manufacturers, bakeries, meat processors, confectioneries, and for functionally designed dairy ingredients in the prepared food industries. Manufacturers of pre-packaged foods, frozen foods, and various convenience food items are potential users of dairy ingredients. A close and technologically meaningful working relationship between the industrially oriented dairy producer and the food processor will be the source of new functionally designed dairy ingredients. Because of these developmental processes, the dairy industry will present its industrial products in a diversified form which will be able to cope with the numerous demands of the food manufacturers.

This paper considers the rationale of using the various dairy proteins, fats, and carbohydrates in solid, liquid, frozen, and emulsified food systems. The review is not intended to be comprehensive, rather special emphasis is given to sectors of the food industry which offer the best novel opportunities for functionally designed dairy ingredients.

[1]Presented in part at the 59th Annual Meeting of the International Association of Milk, Food, and Environmental Sanitarians, Milwaukee, Wisconsin, August 21-24, 1972.

FUNCTIONALLY DESIGNED DAIRY INGREDIENTS FOR THE FOOD INDUSTRY

The functionally designed industrial dairy ingredients are products intended for use in conjunction with other foods to: *(a)* provide enrichment in terms of nutrition (i.e., protein and vitamin supplementation), *(b)* contribute certain technical effects in the finished products for the food manufacturer (i.e., consistency, texture, whipability, baking performance, etc.), and *(c)* obtain food products of high consumer acceptance (i.e., flavor, mouthfeel, color, etc). The basic justification for use of functionally designed dairy ingredients in food formulation is to provide the public with manufactured foods of the best overall food values.

Functionally designed dairy ingredients should be produced in such a fashion that the most desirable food value attributes be preserved and developed to the maximum effectiveness and should be available for the food processor in the most economical and convenient way. There is little doubt that the dairy proteins are by far the most unique and give the most opportunity for successful commercial applications. The dairy proteins are enjoying an unchallenged position in terms of intrinsic food values which are not equally shared by some of the other major dairy ingredients such as butter, or lactose. Dairy ingredients selected for discussion are classified according to their chemical nature in three major groups: dairy proteins, fats and carbohydrates.

DAIRY PROTEINS

Various dairy proteins can be made available for the food manufacturer. Tables 1 and 2 illustrate a potential classification of those dairy proteins.

Use and rationale of dairy proteins in foods

Technological innovations in manufacturing milk proteins have created new products with wide range of adaptability to food systems. This new orientation relegates to the past the traditional dairy industry approach which processed surplus skim milk to non-edible casein for the adhesives industry. The new trend calls for processing skim milk to yield a new line of proteinaceous products with specific, food technologically valuable functional properties. The present market demand clearly indicates a trend for using more dairy proteins in foods. This increased

TABLE 1. DAIRY PROTEINS AS FUNCTIONALLY DESIGNED FOOD INGREDIENTS

1. Isoelectric caseins
2. Whey proteins
3. Coprecipitated dairy proteins
4. Modified dairy proteins by means of chemical, physical or microbiological methods
5. Dairy by-products

TABLE 2. MODIFIED DAIRY PROTEINS FOR FOODS (SUBGROUP OF ITEM 4 OF TABLE 1)

a. Caseinate salts
b. Lactalbumin phosphates
c. Microbiologically or enzymatically modified proteins:
   i) cottage cheese, cheese powders
   ii) quark
   iii) rennet-treated milk or proteins
d. Protein concentrates prepared by membrane processes and gel filtration
e. Dairy protein hydrolysates

demand will be satisfied at the expense of non-edible skim milk allocations and will require production of edible caseins, milk protein coprecipitates, microbiologically or chemically modified dairy proteins, and an efficient whey protein recovery system.

The current importance of dairy proteins to the food industry in America is illustrated by the complete change in the market for imported casein *(12)*. Mr. Borst, a prominent businessman in the international trade, writes: "In 1960, New Zealand and Australia constituted only a little over 29% of the total imports which were nearly all consumed in industrial applications, whereas, in 1969 these two countries accounted for 68.5% of the imports, most of which found their way into food uses of one kind or another. Overall, it is estimated that the market for edible milk protein in America is currently running about 65 million lb. per year. This is an increase of something over 50 million lb. greater than the usage just 10 years ago which is indicative of the important role these materials have now assumed in the food industry."

Uses of edible isoelectric casein

The old fashioned edible casein produced by acid precipitation without proper purification is easily manufactured, but has a gluey flavor which imposes limitations on use in some foods. However, use in the less flavor-sensitive food applications, such as bread and cereal fortification, is suggested by Clausi et al. *(14)*.

Casein also can be converted to a fine fibrous form which when bonded together results in a texture resembling meat *(55)*. In processing of beer and wine, casein is employed to adsorb natural polyphenols *(65)*.

Borst *(12)* has reported that the main reason for the growth in use of casein in foods lies in its functionality. The fast growth of casein uses might become self-limiting because of exhaustion of the supply and consequent price increases. There is a significant tendency in Scotland, Australia, and New Zealand to initiate increased production. It is advisable to tap the casein resources in Argentina by upgrading the quality of the production *(39)*.

Whey proteins

Traditionally produced lactalbumin is water insoluble, but is of high nutritional value. Its established uses have been limited to non-functional applications, or simple protein supplementation. For example, addition of 4% lactalbumin to common cereals will double the protein efficiency ratio of the cereal protein. In spite of these nutritional benefits, its food technological applicability is limited because of its gritty texture. However, undenatured whey proteins, recovered under controlled heat treatment, are dispersible, have excellent whip imparting properties, are efficient water binders, and are useful in many foods *(71)*.

Native lactalbumins can interact with other proteins when heated. Such interactions might result in a great increase in the water binding capacity of the lactalbumin. The theoretical background and practical application of complexes formed between lactalbumin and other proteins is discussed by Wingerd *(72)*.

Lactalbumins and lactoglobulins in the future will be produced by the currently developing membrane technology. These products are very promising as to their colloid chemical functionalities.

By controlling the ash content of the whey proteins, using electrodialysis, demineralized and delactosed whey concentrates have been made available commercially for food use in the United States *(3)*. Further developments include using whey proteins as additives to sweet cream for improved whipping performance *(48)*, and as functional additives in ice creams to achieve slow meltdown features *(49)*. Reference is made to an excellent review on the use of whey proteins by Mann *(42)*.

Dairy protein coprecipitates

The highest nutritional efficiency in the dairy protein field can be obtained by balanced blends of casein and whey proteins. Such preparations possess an excellent amino acid profile and render highly nutritious protein supplements.

Depending on the method of preparation, the solubility, water binding, and viscosity building capability of the products can be regulated for the best food technological performance. The first attempts to produce coprecipitates for food use were made by

D'yachenko et al. in the U.S.S.R. *(18)*. This work considered coprecipitation of casein and serum proteins in the presence of calcium chloride and envisioned use of the recovered proteins in bread baking, macaroni products, soups, vegetable purees, and other locally important food items. In the U. S., Engel and Singleton worked out *(23)* a continuous process for producing a dairy protein coprecipitate.

In Australia, Muller and Hayes *(46)* systematically studied the effects of pH, and calcium and sodium tripolyphosphates on the coprecipitation process and reported recovery of products which are excellently suitable for production of a milk biscuit. This application uses spray dried coprecipitated milk proteins in a dry blend with flour and other additives to prepare a hot biscuit mix for home use. The Japanese food industry is very active in introducing coprecipitates for the manufacture of recombined dairy products *(67)*. Another Japanese work reports on a coprecipitate which is stable at low pH values, such as those occurring in natural fruit juices. This development opens up the possibility of developing protein fortified fruit drinks *(13)*. Coprecipitates are important in preparation of lactose-free baby food formulations, useful in the diets of lactose intolerant infants. Recently, Russian scientists combined dairy proteins with blood proteins and suggested a milk-blood coprecipitation process *(58)*. The resulting product is dark in color, but according to the reports has a pleasant flavor and is useful in a variety of foods.

The above data attempt only to illustrate a few highlights. Detailed review articles have been published in France by Genin *(27)*, in the U. S. by Fox *(25)*, and most recently by Muller in Australia *(47)*.

In the manufacture of marshmallows and nougats, milk proteins or coprecipitates are important because of their whip imparting properties. In caramels, fudgies, and similar candies, milk proteins contribute to flavor, body, and color. To obtain a smooth textural quality, milk protein characteristics must be such that during cooking conditions of candy, when coagulation of the milk protein takes place, protein aggregates formed will be small.

Color formation is controlled by the simultaneous presence of reducing sugars and proteins. Similarly, the characteristic milk caramel flavor is developed as a result of chemical interactions between reducing sugars and proteins.

The significance of milk proteins in chocolate manufacturing is highly complex and processing details are kept confidential. Apparently, the most essential feature in this application is development of flavor stabilizing compounds which might be powerful antioxidants.

In the meat industry, dairy proteins can be used to increase the water binding capacity of chopped meats. In sausage processing, the finely dispersed milk protein curd also acts as a binding agent, yielding the desirable chewy texture. Additional attributes of dairy proteins in sausage formulations include the control of shrinkage during storage and deformation under slicing.

Modified dairy proteins

The modified dairy proteins have been listed in Table 2. Included are caseinate salts, lactalbumin phosphates, microbiologically and enzymatically precipitated proteins, membrane and gel filtration processed milk protein concentrates and, finally, protein hydrolysates.

Caseinate salts. Among the caseinate salts, sodium caseinate is by far the most significant as a food additive. The caseinate salt group also has a unique standing from the legal point of view, because in the United States it is declared as a food chemical derived from milk, rather than a dairy product. The caseinate salts enjoy an exempt position with regard to the Filled Milk Act and, consequently, can be used in conjunction with vegetable fats without violating the above Act.

The best quality of sodium caseinate is made from freshly precipitated casein, followed by solubilization with sodium carbonate or sodium hydroxide. The resulting colloidal solution of sodium caseinate is then spray dried.

In this form it has an acceptable flavor and possesses excellent water binding, whip imparting, and emulsion stabilizing capabilities. Sodium caseinate disperses well in water or melted fats. Upon addition of warm water during processing, sodium caseinate dispersions hydrate and the resulting colloidal solution forms a base for subsequent emulsions.

CASEINATES IN EMULSION TECHNOLOGY. The rationale of sodium caseinate application in emulsion technology is based on its manifold chemical reactivity. The reactivity of caseinates resides in the unique distribution of the electrical charges on the polymeric molecule, its hydrogen bonding capability, and its richness of hydrophilic and lipophilic bonding sites. The complex colloid chemical performance of caseinate can be accentuated by its reactivity with lecithins and carrageenans. In homogenized emulsion systems the caseinate molecule is anchored to the surface of fat droplets, and acts synergistically with synthetic emulsifiers contributing to formation of encapsulating layers. The encapsulating layers on the outside surface of emulsified fat particles are instrumental in stabilizing emulsions toward heat effects, or toward detrimental effects of freezing. In this way, emulsions prepared with sodium caseinate are resistant against the heat shock of pasteurization

and will show increased freeze-thaw tolerance during frozen storage. The structure of encapsulating layers remains unharmed by heat during the spray drying process. This property of caseinates is essential to prepare dried emulsions.

Dried emulsions are rehydratable without the coalescence of fat particles. On the other hand, caseinate layers of dried emulsions in the rehydrated state are sensitive to the mechanical shearing action of whipping devices commonly used in food processing such as kitchen mixers, wire whips of Hobart mixers, Oakes mixers, or to dashers of ice cream machines. This shearing action causes whipping in the presence of air. On whipping, the caseinate encapsulating layer rearranges to a foam lamella system which possesses high tolerance and stability under many conditions. In this highly complex mechanical and physico-chemical process, very fine textured whips are formed. These whipped forms of fat, or protein-rich food formulations are highly palatable and suitable for many commercial applications. This concept is widely used in the preparation of toppings, cream substitutes, and numerous desserts.

CASEINATES IN MEAT PRODUCTS. Use of sodium caseinate in the meat industry is in the most advanced stage of development in Germany and in several other European countries. The rationale for use of caseinates is based on the water binding and fat emulsifying capability of the caseinate salts in sausage meat emulsions *(63a)*.

The stabilizing and texture building properties of caseinate salts are recognized as effective meat binders. The subject of meat binders was very thoroughly reviewed by Saffle in 1968 *(60)*. He concluded that there are no guidelines which would clearly indicate and predict the useful effects of the various non-meat additives on formulation and stability of meat emulsions. In recent years vegetable proteins have gained more emphasis as meat binders than the dairy proteins. It is very likely that the relative high price of dairy ingredients compared to functionally designed vegetable protein products has tipped the balance unfavorably for the dairy industry.

Another problem connected with use of dairy proteins in meats has been a legal one. Most food control authorities require that the added dairy proteins be quantitatively detectable in the meat products. Active research work was instituted towards this goal in Europe. Successful development of practical analytical methods in West Germany lead to approval for use of sodium caseinates in sausage products. In 1970 Olsman *(54)* described an analytical method which differentiates between casein and meat proteins by means of a urea-starch gel eletrophoresis technique. By this method 0.25% casein can be readily determined in various heated, mixed, and processed meat products.

Recently in Norway, further new analytical developments have been published for the detection of sodium caseinate in raw and heated meat products. A method by Nordal and Rossebo *(52)* distinguishes between sodium caseinate and dry milk powders in meat products. This paper gives guidance to distinguish sodium caseinate in meat products from additives such as dry milk powders. Caseinate addition levels in the range of 0.2 - 0.4% can be determined in processed meats.

Lactalbumin phosphates. The colloidal effectiveness of lactalbumin is greatly enhanced in lactalbumin phosphate products which have been developed mainly in America. Between 1966-71 several patents were issued to McKee and Tucker *(45)* and Ellinger and Schwartz *(19, 20, 21, 22)* which describe the preparation and application of these chemically modified dairy proteins. The authors recommend broad usage of these products in cake mixes, meats, self-raising flour, and bread and pizza doughs as a replacement for non fat milk solids. Further applications are also suggested for replacement of sodium caseinates in coffee whiteners, mellorines, and whipped toppings.

Lactalbumin phosphates are precipitated from whey under acid conditions in the presence of certain condensed phosphates. Although there is some evidence that this precipitation involves chemical reactions, it is presently thought to be mainly one of cation-anion interaction. The lactalbumin phosphates contain both the lactalbumin and the beta lactalbumin of the milk in undenatured form and, thus, is highly advantageous over the denatured non-hydrating whey protein.

Microbiologically and enzymatically modified dairy proteins. As we have seen in Table 2, Item c, cottage cheeses, cheeses and cheese powders, the highly popular *Quark* of Germany and rennet-treated milks are the topic for discussion in this category.

In recent years, demand for high protein foods gained wide publicity, mainly because of their alleged value in limited calorie foods. Medical and regulatory aspects of protein fortified foods are in the process of development.

COTTAGE CHEESE AS A NEW RAW MATERIAL. The different cottage cheese types occupy a key position in this application area. Dairy proteins recovered as cottage cheese can vary in a broad spectrum with respect to flavor and consistency, depending upon starting material and treatment used.

In Anglo-Saxon countries, creamed cottage cheese is the most popular item of this class; however, the European dairy industry has explored a wider range of products in this category. *Quark* and *Frisch Käse*

are used in Germany, while *Fromage Frais* is used in France. Annual per capita consumption of these cheese varieties is 5.2 kg in Germany and 3.4 kg in France. The high nutritional value and the extensive versatility of cottage cheeses await a more pronounced use of this product by the food industry *(43)*.

The basic idea for introducing microbiologically precipitated dairy proteins hinges on the possibility of improving the rather pasty and occasionally bland tasting characteristics of the *Quark* and *Fromage Frais* dairy protein concentrates. By suitable modifications and processing, these raw materials become smooth and creamy, and light textured. Their blandness can be considered an advantage because the microbiologically precipitated dairy proteins are compatible with many balanced sweeteners and fruit flavors. Furthermore, their mouthfeel and body can be readily modified by addition of homogenized fat emulsions. Light textured qualities can also be introduced by whipping.

The perishable nature of cottage cheeses was considered as a major disadvantage in formulated food use; however, by suitable formulations, freeze-thaw stable features can be created, thereby rendering these products as valuable ingredients in frozen food systems.

An entirely different approach to the texturized cottage cheeses has been recommended by chemists at U.S.D.A. *(6)*. This group developed a new milk food ingredient by frying milk curd. This high protein-containing, modified milk ingredient is reported to have meat-like texture and can be flavored and sweetened to suit various tastes. The product can thus be used in a meat flavored gravy. Further application research was reported on use of this modified milk ingredient in snacks, hors d' oeuvres and confections *(7, 73)*. Pinkstrom further elaborated on this concept *(57)* and proposed puffed snacks from milk curd using starch containing formulations. Flavor of the oil fried dough can be enhanced by dusting the bite size puffed material with cheese powders or barbecue flavor.

THE USE OF QUARK. *Quark*, or *quarg*, is a new word entering the English language. Webster does not recognize it, except as an archaic word meaning "to croak." However, in its original German meaning, it refers to a fresh uncured cheese in bulk form, without the familiar form of our cottage cheese. *Quark* is widely used in Germany because of its versatility and ease of preparation. To produce *quark*, milk is coagulated exactly the way cottage cheese is made, but instead of cutting, cooking, and washing the curd particles, the whole coagulum is passed through a specially designed centrifuge. In this step whey is separated from the solidified protein curd. It is then cooled and packaged in bulk. When the operation is carried out under good sanitary practices, the product has good shelf life under refrigeration until further processing takes place by the food manufacturer.

Outside the European Economic Community (EEC), in Eastern European countries, the U.S.S.R. is the leader in *quark* production for the food industry. It is estimated that 30-40 different food items, which are based on *quark* are commercialized in significant quantities. The *quark* is blended in these items with dairy or vegetable fat emulsions, it is salted and mixed with spices or herbs *(38)*. Preservation and formulation experiences with *quark* have been reviewed by Schultz *(63)*. The Australian dairy industry also recognized the utility of *quark* and extended its applications in conjunction with seafoods and tangy dips beyond its sweetened versions.

According to a survey conducted by Claydon *(15)* at Kansas State University, the American consumer will accept this product. Based on a limited market study it was concluded that *quark* has considerable potential. As with yogurt, advertising and promotion would be necessary.

RENNETED MILK PROTEINS. Solubilized renneted milk proteins are used in Germany to a limited extent in some meat products.

Protein concentrates prepared by membrane and gel filtration processes. The newly developed technology of reverse osmosis and gel filtration when applied to milk or whey results in recovery of entirely new dairy protein concentrates. These concentrates are basically different from the heat or microbiologically separated products.

It is expected that when reverse osmosis and gel filtration techniques are brought to commercial use in the dairy industry, they will replace many of the existing processes now used to produce dairy protein concentrates and make available to food processors concentrates with improved functionality properties. The utility of these products for the food industry is now actively pursued, but has not yet reached commercial maturity. However, there have been many speculative aspects discussed in the literature during the last several years, concerning potential uses of products made by membrane processes. Because of the complexity of this subject, the reader is referred to the reviews of McDonough *(44)*, Porter et al. *(59)*, and the dissertation of Fenton-May *(24)*.

Dairy protein hydrolysates. Milk protein hydrolysates, produced by either mineral acids or enzymes, have been used in the food industry for 30-40 years. Chemically, these products represent amino acid mixtures and, depending on the extent of the hydrolysis, contain a great variety of peptides. After hydrolysis

the reaction mixture is neutralized, purified, and in many instances the inorganic salts are removed by filtration or ion exchange.

Often carbon treatments are also employed to remove color or undesirable flavors. The flavoring spectrum of the hydrolysates covers a very wide range. Use levels are generally low and highly specific.

Organoleptically, there is a highly desirable appetite-increasing flavor or odor associated with these products. Because of the complex processing and sophisticated purification methods employed, the cost of dairy protein hydrolysates might be high. However, certain unique flavor qualities can be obtained with the specially treated hydrolysates and this might justify the price.

The use of hydrolysates in the diets of patients sensitive to protein intake has some practical and clinical value. Casein hydrolysates have been used for intravenous feeding of humans. Baker and Bertok *(10)* found that certain peptides of casein which form stable foams tend to be antigenic.

With regard to meat flavorings, Germany has special regulations *(56)* for use of dairy protein hydrolysates. Oberg et al. *(53)* proposed hydrolysing casein by means of trypsin. Nestlé developed a patent for other enzymatic hydrolysates *(50)* of dairy proteins with proteolytic enzymes and phosphatases.

The physical characteristics of the hydrolysates leave much to be desired, and adjustments to commercial requirements might be beneficial for their more general acceptance by the food industry. Most of the hydrolysates are highly water soluble, but are also extremely hygroscopic and therefore have limited storage stability features.

Dairy by-products in foods

The dairy industry, for some time, has enjoyed an already existing channel to the food processing industry by means of merchandising its dried skim milk, whey, butter milk, and cheese powders. These by-products of excellent functional qualities and nutritional values are facing an increasing competition from the vegetable protein sources, especially from soya products. The dairy industry will be able to retain this business sector only when high quality products are maintained and the best efforts are put into practice to tailor-make products for specific applications.

Illustrative examples indicate development of patented products of high versatility from whey, such as whey powders with high oil adsorbing capabilities, by Collins *(16)* and its adaptation to specific product areas *(17)*. According to these patents, whey processed in a flowable particulate form is suitable to hold liquid fats. Its adaptation results in dry salad dressing with whey powder as carrier. Factors affecting use of dairy ingredients in baking have been thoroughly studied by Singleton and Robertson *(64)*.

Recently, Kinsella of Cornell University, wrote on this subject *(34)*. He proposed widening the functional uses of dairy by-products with respect to baking performance and their fortification with industrially accepted surfactants.

The chemistry of dairy powders with reference to baking also has been discussed in depth by Kinsella *(33)*. This work elucidates the scientific background of numerous functional features of dried milk, butter milk, or whey ingredients in baked food systems. To insure the food industry's satisfaction with the dairy powders, Kinsella proposes intensive research activities in specific areas.

Cheese powders and cheese flavored dairy powders

The industrial use of cheeses in foods has been favorably advanced by the production of cheese powders. These ingredients make it convenient for food manufacturers to put cheese flavors into baked goods, and convenience items, and their use is widening considerably. Cheese powders are produced by dispersing the selected cheese type in skim milk, or preferably in whey, as a 50% slurry *(31)*.

This slurry is heat treated for emulsification, homogenized, and finally spray dried. The expected storage life is about 1 year under suitable conditions. Spray dried cheese powders can be produced at various flavor levels and with salt addition to suit the food manufacturers.

Starting in 1960 cheese flavored powders were developed. These products have gained broad acceptance by the food manufacturers because of good flavoring strength and relatively lower costs in comparison to cheese powders. Many foods such as salad dressings, soups and various kinds of baked goods are flavored by cheese. For this purpose, usually aged cheese is used, but this item is expensive because of long storage.

Disclosures of U. S. patents by Watts and Nelson *(67a)* and Knight *(34a)* demonstrate the possibility of creating a low-cost composition with high flavoring strength which can be produced without aging. The products are made by inoculating a fluid, aqueous culture medium, based on homogenized milk, skim milk and whey, with spores of *Penicillium roqueforti* and fermenting the mix for a few days. The fermentation liquid is then heat treated, condensed or dried, and used in a liquid or solid form, respectively.

DAIRY FATS

With regard to the utility of all dairy products in the food industry, butter occupies the least enviable position. This, however, does not reflect on the

TABLE 3. DAIRY FATS FOR FOODS

Commercial forms:	1. Butter
	2. Butter oil
	3. Anhydrous milk fat
Potential new dairy fat varieties	4. Fractionated butter fat
	5. Cultured emulsified dairy and vegetable fat blends
	6. Spray dried butter
	7. High heat-treated butter

versatility of this excellent food raw material, but it is more the result of economics.

At present, conventional butter, butter oil, and anhydrous milk fat are essentially the only commercialized forms of this important food resource, and this may be the heart of the problem.

However, in the last 10 years, new technological developments have emerged which might propose new options for its use (Table 3). An attempt will be made to highlight some of these new developments and to generate ideas towards new application opportunities.

Butterfat fractionation

Butterfat can be separated into high, medium, and low melting fractions. This is achieved by melting butter oil and letting crystallization take place first at a higher, and then at a somewhat lower temperature. At the selected temperature, the solidified part of the fat can be easily separated from the liquid portion by pressing. The liquid portion, on further cooling, will again exhibit partial crystallization. Repeated separation of the solidified portion will result in a lower melting solid fraction. Because these subsequent fractions have different compositions and functional properties, their applicability in food formulations will be wider than that of the unfractionated butter oil.

The high melting butter components are superior for use in chocolate and ice cream manufacture, and spray dried butter emulsions, whereas, the lower melting fractions blended with unfractionated butter will increase spreadability in table use. Swedish investigators *(8)* described the manufacturing operations of the fractionation process both for butter oil and for fresh cream processing *(9)*.

Anhydrous milk fat is suitable for bulk distribution and has favorable storage characteristics. It can be used for reconstituted liquid dairy products, and its reformulation for special purpose butters or shortenings is envisioned.

The butter fractionation process might be the starting point of making milk fat just as versatile to the food industry as the vegetable fat producers made their various raw materials. A recent review on milk fat fractionation was issued in Germany *(66)*.

Cultured emulsified vegetable and dairy fat blends

Recently, the Swedish milk fat industry has taken the initiative on this controversial step. By the end of 1969, a new milk fat-vegetable fat blend called *Bregott* was launched. *Bregott* is a butter-like product with a ratio of 80% milk fat to 20% high quality polyunsaturated vegetable oils. It is spreadable even at refrigerated temperatures, and is standardized to contain about 80% fat, 16% maximum water, and 1.4% salt. *Bregott* is fortified with vitamins A and D and its storage stability is satisfactory for retail distribution *(5)*.

Spray dried butter

Spray dried butter brings convenience to the bakery since it is supplied in a storage stable, free flowing form. Furthermore, it gives the dry cake mix industry the opportunity to use butter fat *(2)*. Recent work on this product was done at the University of Wisconsin. Spray dried butter can be produced from heavy cream and butter oil in the presence of milk solids *(11)*.

The moisture content has to be reduced to 0.1% in spray dried butter *(61, 62)*. Spray dried butter rehydrates readily to an emulsion which is organoleptically indistinguishable from cultured cream butter. The origin of the spray dried butter goes back to Hansen in Australia *(29)*. His product was made from butter oil by adding sodium caseinate, emulsifiers, and citrate salts. Subsequent German and U. S. developments avoided use of non-dairy additives. Evaluation of these products in cake baking gave satisfactory results; however, addition of suitable emulsifiers might be useful for better baking performance.

High heat treated butter

This approach was studied in Russia and in the U. S.; its final utility remains to be seen. Heat treated butters have better keeping qualities than ordinary butter. In Eastern European countries such products are used in conjunction with processed meat products.

DAIRY CARBOHYDRATES

The single major dairy carbohydrate is lactose. Lactose can be modified chemically to result in closely related products with different physical or food technological properties (Table 4). Upon hydrolysis, lactose can be transformed to a glucose-galactose mixture which is usually recovered as a syrup of somewhat sweeter taste and of higher solubility than lactose. Lactose, on alkaline inversion, can be transformed into lactulose which is a 4-0-β-D-galactopyranosyl-D-fructose; this product has different nutritional properties than lactose and is considerably sweeter.

A commercially feasible process to produce lactu-

TABLE 4. DAIRY CARBOHYDRATES AND DERIVATES FOR FOODS

1. Lactose
2. Hydrolyzed lactose
3. Lactuiose
4. Lactobionic acid, lactic acid and salts
5. Naturally occurring oligosaccharides of milk
6. Whey as source of lactose

lose was patented by Guth and Tumerman *(28)*. Lactobionic acid is obtained from lactose by chemical or biological oxidation. Lactic acid and salts are produced from lactose or whey by fermentation. These products find limited use in the food and pharmaceutical industries.

Among the minor carbohydrates of milk, several oligosaccharides have been found which are of physiological importance. However, these have not yet been explored as to their commercial utility. The subject of the various oligosaccharides and lactulose in milk products has been reviewed by Adachi and Patton *(1)*.

At present, lactose is the target of a considerable nutritional controversy, relating to its intolerance by certain individuals. It is very likely that the question of the lactose intolerance is somewhat over-exaggerated now, but the present state of affairs certainly does not add to the commercial desirability of this sugar *(30)*.

Nevertheless, lactose deserves to be discussed from the food technological point of view, because it has valuable properties when used with discretion by the food technologist. Dry whey powder, as an item for the food industry, has to be mentioned at this point because it contains 70% lactose and many of its food technological properties are common with those of lactose.

Lactose makes possible a controlled browning reaction in baked goods. In confections and sweet dessert items lactose is frequently used in balancing the sweetness level of formulations. Lactose in whey powder is used to support the fermentation in development of lactic acid in microbiologically cultured foods. Lactose is widely used in infant foods, to make them more like human milk which is richer in lactose than cow's milk. Lactose as flavor enhancer finds many applications in foods. Lactose is less sweet than sucrose or glucose and, consequently, it does not dominate the sweetness levels in formulations.

In products such as certain dressings, toppings, puddings, or fruit pie fillings 10-20% replacement of sugar with lactose significantly improves the sweet taste appeal *(51)*. In dry whipped toppings lactose-containing formulations render a favorable encapsulating layer around the emulsified fat globules *(26)*.

Lactose, because of its nonhygroscopic and free flowing properties, is a favored dispersing agent. In candies and caramels, lactose influences the crystallization habits of other sugars and controls the body of these goods. In yeast raised doughs of the bakery industry, lactose is a preferred browning agent, because it is not fermented by the yeast.

Whey as a source of lactose and its use in foods

The predominance of lactose in whey is the only reason why this highly versatile industrial food ingredient of dairy origin is being discussed in the dairy carbohydrate section. Whey, as an industrial dairy ingredient, is much more than a source of lactose; it is even much more than a dairy by-product in the eyes of the food technologist. Dried whey is really a family of products with many food technological features, some of which are native, others developed by the whey processor with food industrial utility in mind.

It can be said that the diversification of whey powder for many food uses is one of the best examples of how a dairy ingredient with proper functionality can obtain an important raw material position in manufactured foods. "The production and marketing of edible grade whey"—writes Weisberg *(70)*—"has been one of the real successes in the past decade. This product has moved from a very small volume production on the order of a few million pounds, to a few hundred million pounds."

The successful graduation of dried whey from the status of an obscure dairy waste product to a profitable, functionally designed dairy ingredient targeted for food use was the result of many factors. A study of this development is enlightening for bringing other dairy ingredients along the same road to full acceptance. The elements of this development were: *(a)* basic processing improvements to obtain a sanitary product; *(b)* rigorous quality control for uniformity; *(c)* establishment of a diversified line of products in response to realistic needs; *(d)* imaginative application research conducted in cooperation with the various branches of the food industry; *(e)* increasing the functionality features by additives; and *(f)* realistic pricing policy. Descriptions of the many successful applications of the various whey products in the food industry are so numerous that, for reasons of practicality, reference is made to the most important recent major reviews of the subject *(4, 32, 35, 36, 37, 40, 41, 68, 69)*.

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POLYUNSATURATED MEAT AND MILK

(Continued from Page 322)

saturated fats increased. The flavor defect was negligible in the raw milk immediately after it was taken from the cow, but it became more intense with refrigerated storage. However, adding the antioxidant tocopherol (vitamin E) to the fresh milk suppressed the off-flavor.

Butter made from cream containing a high level of polyunsaturated fats exhibits a much softer texture than normal butter. If the polyunsaturated fat content is as high as 16 percent or more, the butter spreads much more readily at refrigerator temperature. Polyunsaturated cream has to be aged longer than normal cream for satisfactory churning. Rapid cooling partially overcomes this problem.

Natural Cheddar cheese made from milk high in polyunsaturated fat exhibits some body and flavor defects. It has a characteristic off-flavor, which becomes less noticeable on aging. However, a processed cheese with as much as 10 to 12 percent fatty acids (linoleic acid), made by blending normal cheese with polyunsaturated cheese, was liked as well as commercially processed cheese by a consumer taste panel.

The polyunsaturated milk was also used in calf feeding, where it helped to increase the polyunsaturated-fat content of the meat. Calves were fed this milk for 10 weeks, then received dry feed supplemented with protected safflower oil for the next 8 weeks. They produced meat about 4 times as high in polyunsaturated fat as meat from control animals. Oxidative instability in such meat can be controlled by including tocopherol in the calves' rations.

Supplementing animal feeds with protected safflower oil to increase the level of polyunsaturated fats in milk and meat is still experimental. Among many questions not yet answered are the economy of the scheme, how to overcome the tendency of highly unsaturated fats to change flavor through oxidation, and what effects the special feeds have on animal health. Further studies of how fats affect human health are also needed.

DETERMINATION OF LACTOSE IN MILK BY GAS LIQUID CHROMATOGRAPHY

H. O. Jaynes and T. Asan
Department of Food Technology and Science,
Institute of Agriculture
University of Tennessee, Knoxville, Tennessee 37901

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Abstract

A method was adapted to determine lactose in milk by gas liquid chromatography (GLC) of trimethylsilyl ethers. Quantitation was accomplished by comparison to an internal standard, sorbitol. The standard deviation was 0.132% lactose, and the procedure was compared to a recognized method which employed chloramine-T. The GLC method worked well with either milk or skimmilk.

The common traditional methods for determining lactose in milk have utilized polarimetry, paper chromatography, or the reducing power of lactose. Usually, some type of clarification is necessary to remove interferring substances which also entails a volume correction for the materials removed.

Gas liquid chromatography of trimethysilyl ethers has been used extensively as a method to quantitate sugars and mixtures of sugars *(1, 2, 3, 4, 8, 9, 10)*. Since derivatives of anomers have different retention times, distribution between optical isomers can also be measured. Reineccius et al. *(8)* applied the technique to freeze dried milk dialyzates and determined lactose, as well as the small quantities of glucose and galactose which are normally present in milk. Quantitation has been made directly from peak areas *(2, 3)* or by using an internal standard *(1, 8)*. Brobst and Lott *(2)* were able to derivatize the sugars in corn syrup with some water present. We thought that this procedure might lend itself to the analysis of lactose in milk without extensive preliminary sample cleanup.

Materials and Methods

Preparation of trimethylsilyl ethers.

The method of Brobst and Lott *(2)* was followed. Up to 50 mg of aqueous lactose solution or milk was weighed into a small glass vial equipped with a ground glass stopper. One milliliter of pyridine (Anal. Reagent Grade) was added and the sample was dissolved. Then 0.9 ml of hexamethyldisilazane was added, followed by 0.1 ml of trifluoracetic acid. The stopper was replaced and the mixture was shaken vigorously for 30 sec. After 30 min, the material was ready for gas chromatographic analysis.

Lactose solutions in concentrations similar to milk were prepared by dissolving 5 g of α-lactose monohydrate in water. Before final dilution to volume with water in 100-ml volumetric flasks, a drop of concentrated NH_4OH was added. With the elevated pH, equilibrium mutarotation was achieved in <30 min.

Gas chromatography

An F and M Model 810 gas chromatograph was used which was equipped with a disc integrator, a flame ionization detector, and a temperature program module. Several columns were tried; best results were achieved with 92 × 0.218 cm copper column packed with 3% SE-52 on 100-120 mesh Gas-chrom Q (Applied Science Labs, Inc.). Nitrogen carrier gas flow rate was maintained at 60 ml/min. The injection port and detector were heated to 300 C, and the column was programmed from 170 C to 240 C at 15 C/min. after the sorbitol peak emerged. In most instances, 5 μl of sample was injected, and the instrument sensitivity was adjusted to give peaks of about 75% full scale deflection. The retention times were sorbitol-4.5 min, α-lactose - 14.5 min, and β-lactose - 15.8 min.

The chloramine-T method devised by Hinton and Macara *(5)* was used for comparison. The normality of the $Na_2S_2O_3$ and chloramine-T was 0.05. A 25-ml aliquot of lactose solution or clarified milk serum was employed. To calculate lactose concentration in milk, a correction was made for the volume of fat and protein removed by clarification. This was done using 0.93 as the density of milkfat and a volume exclusion of 1.11 ml/g for protein *(7)*. Lactose in the aliquot was calculated by the equation:

$$\% \text{ lactose} = \frac{(\text{ml blank titr.} - \text{ml sample titr.}) \times N_{Na_2S_2O_3} \times 360.31 \times 100}{2 \times \text{ml sample} \times 1000}$$

Results and Discussion

Development of the gas chromatographic method

Replicate samples of derivatives injected into the gas chromatograph did not give reproducible peak areas, but the ratio of the response from α-lactose to that from β-lactose was fairly constant. Thus, an internal standard could be used to calculate lactose concentrations. Sorbitol was chosen for the reference material. Silylation of sorbitol by the method employed for lactose was straightforward, it gave only one derivative, and that was well separated from the two lactose peaks. The response to a given weight of sorbitol was not the same as that for lactose. It was found that a sorbitol concentration of 2.5% in milk or 5% lactose solutions gave peaks which were easily integrated.

Four solutions of lactose containing 5% α-lactose·HOH and 2.5% sorbitol were prepared, derivatized, and analyzed by gas liquid chromatography. Table 1 shows the results. The mean ratio of the response

TABLE 1. GLC RELATIVE RESPONSE TO SORBITOL, α-LACTOSE, AND β-LACTOSE

Sample		Integrator counts			Ratios	
No.	Replicate	Sorbitol	α-Lactose	β-Lactose	α/β	Sorbitol / α + β
1	a	990	600	900	0.667	0.660
	b	1080	665	985	0.675	0.675
2	a	785	450	700	0.643	0.683
	b	800	490	730	0.671	0.656
3	a	1220	710	1070	0.664	0.685
	b	1280	805	1185	0.679	0.643
4	a	1290	790	1180	0.669	0.655
	b	1460	870	1315	0.662	0.668

ANALYSES OF VARIANCE

1. Ratio of α-Lactose to β-Lactose

Source	d.f.	Sum of squares	Mean squares	F	Sign
Samples	3	0.0002725	0.0000908	0.65	N.S*
Error	4	0.0005610	0.0000140	-	-
Total	7	0.0008335	-	-	-

2. Ratio of Sorbitol to α-Lactose + β-Lactose

Source	d.f.	Sum of squares	Mean squares	F	Sign.
Samples	3	0.00007638	0.0000254583	0.07	N.S*
Error	4	0.00144350	0.0003609	-	-
Total	7	0.00151988	-	-	-

*N.S = Not significant at 5% level.

of α-lactose to β-lactose was 0.6663 with a standard deviation of 0.0118, while the mean ratio of the response of sorbitol to the sum of the responses to α-lactose and β-lactose was 0.6656 with a standard deviation of 0.0189. The experiment was repeated with five solutions. Those results showed a mean ratio of α-lactose to β-lactose of 0.6813 and a mean ratio of sorbitol to the sum of α- and β-lactose of 0.6541. A "t" test *(6)* was done on the difference in the mean ratios of response from sorbitol to the response from α- plus β-lactose. The calculated value of t was 0.33, and the tabular $t_{0.025,1^0} = 2.2$. This indicated that the two means were not significantly different at the 5% level, so the numerical average of the two means, 0.6598, was used to calculate the lactose content of milk samples.

If use of sorbitol as an internal standard was valid, then the relative response to sorbitol and lactose should be linear over a range of weight ratios. Five solutions of 5% lactose containing 1, 2, 3, 4, and 5% sorbitol were prepared, derivatized, and analyzed. Ratios of peak areas of sorbitol and total lactose were calculated and a regression analysis was performed. The results are shown in Table 2. Only linear effects were significant. The regression equation which was generated, R = −0.0156 + 0.2694 (sorbitol), gave a value of R = 0.6579 for a 2.5% sorbitol level.

Calculation of lactose concentrations from gas chromatographic data

Since the relative response of the gas chromatograph detector was constant, within statistical limits, to sorbitol and the lactose anomers, the concentration of lactose could be calculated in an unknown sample to which a known amount of the internal standard, sorbitol, was added. The relative response ratio, 0.6598, was established with solutions containing 2.5% sorbitol and 5% lactose, or 1 part sorbitol to 2 parts lactose. Reasoning from a simple proportion showed that the lactose content of an unknown sample could be calculated by:

$$\% \text{ lactose} = \frac{2 \times 0.6598 \times 2.5}{R}$$

where R is the ratio of the response from sorbitol to the response from α- and β-lactose when 2.5% sorbitol was added to the unknown sample before derivatization.

TABLE 2. GLC RELATIVE RESPONSE TO SORBITOL IN 5% LACTOSE SOLUTION

Sorbitol		Integrator counts		Ratio
g./100 ml	Replicate	Sorbitol	Lactose[a]	S/L
1	a	510	1985	0.2569
	b	440	1760	0.2500
2	a	980	1810	0.5414
	b	970	1870	0.5187
3	a	1245	1635	0.7615
	b	1500	1870	0.8021
4	a	1400	1325	1.0566
	b	1550	1445	1.0727
5	a	2285	1710	1.3363
	b	2115	1590	1.3301

[a]Sum of α- and β-lactose peaks.

ANALYSIS OF VARIANCE OF S/L

Source	d.f.	Sum of Squares	Mean squares	F	Sign.
Concentrations of Sorbitol	4	1.4519828	0.3629957	1446.77	V.S.*
a. Conc. Linear	1	1.4516350	1.4516350	5785.71	V.S.
b. Conc. Quadratic	1	0.0000321	0.0000321	0.13	N.S.*
c. Conc. Others	2	0.0003157	0.0001579	0.63	N.S.
Error	5	0.0012545	0.0002509	-	-
Total	9	1.4532373	-	-	-

*N.S. = not significant, V.S. = very significant at the 5% level.

TABLE 3. GAS CHROMATOGRAPHIC ANALYSIS OF SKIMMILK WITH 2.5% SORBITOL ADDED

Replicate	Integrator counts		Sorbitol / α + β-Lactose	% Lactose
	α + β-Lactose	Sorbitol		
1	3980	2955	0.742	4.446
2	3440	2445	0.711	4.640
3	2865	2030	0.708	4.660
4	3340	2395	0.717	4.601
5	3130	2370	0.757	4.358

TABLE 4. LACTOSE DETERMINED IN MILK BY THE CHLORAMINE-T METHOD

Replicate	% Lactose
1	4.874
2	4.737
3	4.658
4	4.934
5	4.829
6	4.746
7	4.778
8	4.751

Note: A volume correction of 7.30 ml/100 ml was made for fat and protein.

TABLE 5. LACTOSE DETERMINATIONS BY GLC AND CHLORAMINE-T

Sample	% Lactose	
	GLC	Chloramine-T
Skimmilk	4.54	4.63
Skimmilk	4.93	4.94
Whole Milk	4.75	4.79
Whole Milk	4.68	4.63

Five replicate samples of a skimmilk were analyzed by this method and the results are in Table 3. The estimated variance was 0.0175, the mean was 4.54% lactose, and the standard deviation was 0.132% lactose. The concentration of lactose determined in the same sample by the chloramine-T method was 4.63%.

The reference method

Replicates of a sample of milk were analyzed by the chloramine-T method to establish the variation to be expected in that technique. Analysis of data in Table 4 showed a standard deviation of 0.087% lactose with eight replicates. The volume correction was made from the fat and protein content of the milk. Data comparing the two methods is given in Table 5.

DISCUSSION

Derivatization of lactose and sorbitol in aqueous solutions or in milk was straightforward. A flocculent precipitate formed when milk was used, but it did not interfere with the analyses. Brobst and Lott *(2)* noted a limiting sample size with the method which concerned the amount of water in the reaction mixture. We encountered the same thing. Silylation was incomplete when samples larger than 50 mg were used, but this was not a real problem since measurable peaks were obtained with as little as 25 mg of milk or 5% lactose solutions.

In contrast, the silylation method employed by Sweeley and co-workers *(10)* was sensitive to water in the carbohydrates derivatized. Using that method, Reineccius et al. *(8)* lyophilized their samples before preparing silyl ethers of the milk sugars.

It was recognized that milk contains small amounts of compounds other than lactose, particularly glucose and galactose, which form trimethylsilyl ethers. However, at the instrument sensitivity levels used to give easily measured peaks for sorbitol and lactose, these materials did not produce detectable peaks. Reineccius et al. *(8)* reported 11.7 mg galactose and 13.8 mg glucose per 100 ml milk which would constitute 0.0117% galactose and 0.013% glucose, respectively. These sugars could be measured by increasing the instrument sensitivity and using a much lower level of internal standard. In the quantitation of lactose in milk they were ignored because they did not produce measurable peaks and the standard deviation of the method was 0.132% lactose.

The gas chromatographic method was found to give comparable results when compared to a recognized method for determining lactose. No special apparatus is required for forming the trimethylsilyl ethers, and no clarification of milk, with the concurrent volume correction, is necessary. The method worked equally well for milk or skimmilk. Mutarotation of sugars in pyridine is extremely slow and the trimethylsilyl ethers are not free to rotate *(9)*. Thus, as well as determining lactose, the method should be useful for measuring the distribution of lactose between its anomers in various milk products.

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NATURE COMPLICATES POLLUTION CONTROL

At a time when specialists are learning to handle man's water pollution, Mother Nature frequently makes things more difficult.

Run-off from woodlands and grasslands has been washing plant nutrients into lakes and streams since long before man began contributing sewage, laundry detergents, animal manure and storm water from city streets, say University of Minnesota soil scientists. All of these materials are sources of phosphorus which can be dissolved in water. Excessive concentrations of this nutrient may encourage overgrowth of acquatic plants. Phosphorus input from natural sources is called "eutrhophication," or nutrient enrichment, and input of this element from man-made sources is called "pollution."

Now scientists and engineers are developing ways to manage man's contribution of plant nutrients to waterways, but seem to be baffled about how to tackle nature's. Part of the problem is that woodlands and grasslands are not well defined points to which man can apply control measures. Things like sewage plants are point sources of phosphorus and are easier to handle. Also, natural eutrophication is more complex and more unpredictable than a waste treatment plant.

"One ironic aspect of phosphorus pollution is that we may be able to hold loses to very low levels on heavily fertilized fields and from feedlots with well designed lagoons or manure pits but we do not know how to intercept in a practical, economic manner phosphorus coming off large areas of natural grasslands," says Lowell Hanson, University extension soil scientist.

Grasslands release nutrients into the environment when plant cell walls rupture, says John MacGregor, University soil scientist. This happens during freezing and thawing or after the plant matures. If phosphorus comes in contact with soil particles, it is held firmly and very little can be carried away in surface run-off.

The nutrient enrichment problem develops when phosphorus doesn't have a chance to contact the land surface and is whisked into lakes and streams during periods of heavy rains and/or rapid snow melt. "Spring is the worst time for phosphorus run-off," says MacGregor. "When the ground is frozen, except for the top two inches, the infiltration rate of water into the soil is zero. All the water from rains and melting snow has to run off, if the land is sloping." Some soil scientists call this the "spring flush," notes Hanson.

Many farmers are attempting to reduce water pollution by using soil conservation practices, like contour plowing and terracing. But these techniques don't keep plant nutrients from frozen vegetation out of run-off during the spring flush.

RED MEAT AND POULTRY INSPECTION: MICROBIOLOGY OF EQUIPMENT AND PROCESSING[1]

R. Paul Elliott
Microbiology Staff, Meat and Poultry Inspection Program, Animal and Plant Health Inspection Service
U. S. Department of Agriculture, Washington, D. C. 20250

Abstract

The Federal Meat and Poultry Inspection Program (MPIP) requires that equipment be properly designed and cleaned frequently. Cooked ready-to-eat foods must be physically separated from raw foods and held below 40 F or above 120 F except for short periods. Microbiological plant inspections form the basis for microbiological criteria which MPIP is now considering for several commodities. Final product objective surveillance has recently begun on these. Sampling and analysis of final product as a means of protecting the consumer against an infrequent hazard is not feasible. Even hundreds of determinations give unacceptably low protection when the hazard is severe. Control at the source—i.e., at the processing plant—is the practical way to protect consumers with the limited resources available in laboratory programs. The MPIP microbiological sanitation program is a combination of investigation, surveillance, and correction. For example, the 1971 investigations of staphylococcal food poisonings from fermented sausages developed rapidly from final product tests, to investigations of cause, and to bacteriological inspections and corrections.

The Federal Meat Inspection Act and the Poultry Products Inspection Act require that meat and poultry be processed under sanitary conditions. The Meat and Poultry Inspection Program (MPIP) is heavily committed to that end *(2)*.

Requisites for good sanitation

The first requisite for good sanitation is to install equipment that is properly designed and constructed. Any new equipment, therefore, must receive formal acceptance by the Equipment Staff of Technical Services. It must be of acceptable materials that will not stain or migrate to the product and that are nontoxic, smooth, corrosion and abrasion resistant, shatterproof, and non-absorbent. Equipment must be designed and installed so that it can be readily cleaned. Acceptance is by letter, followed by listing in the "List of Equipment Accepted for Use in Federally Inspected Meat and Poultry Plants" *(3)*. Inspectors will permit installation of only accepted equipment.

The next requisite for good sanitation is good practice on the part of plant employees to prevent or reduce contamination. This applies to all products, but especially to cooked, ready-to-eat foods. Paragraph 308.16 of the *Manual of Meat Inspection Procedures (4)* requires separation of cooked from raw product, and cleaning and sanitizing of hands and equipment before handling the cooked product. It forbids persons with sores and boils from handling product. This paragraph also requires a mid-shift cleanup in cooked product areas, except that a continuing formal bacteriological monitoring system may be used in lieu of mid-shift cleanup.

The idea of such a monitoring system is based on the concept, "Show us!" Industry tests should demonstrate what is a reasonable level of bacteria on equipment, and what happens to them during processing. Our Technical Services will review and approve such programs for effectiveness. Failure on the part of the establishment to maintain the approved system will require return to the mid-shift cleanup.

A third requisite for good sanitation is control of time and temperature during processing and storage to stop or reduce microbial growth. Many products must be held below 50 F. However, because pathogenic bacteria grow between 40 and 120 F, cooked products are permitted to be in that temperature range no more than 2 hr.

Evaluation of sanitation

The usual tools used to evaluate the sanitation of equipment surfaces are swabs or contact plates. These are useful when their method of application is fully standardized, when specific surfaces are repeatedly examined to establish a norm, and when the commodity under study is uniform. Swabs and contact plates are much less valuable for regulatory work. The factors stated do not apply, and the sample is very small, so that the organisms sought may not appear in the culture. Instead, in our bacteriological inspections, we depend on inspectional observations coupled with representative samples of product that we can weigh for accurate bacterial quantitation.

First the bacteriologist-inspector team observes equipment in the early morning before work starts, then watches as employees arrive to see whether they begin the shift with sanitary hands and utensils. The team takes samples of ingredients and final product

[1]Presented at the 59th Annual Meeting of the International Association of Milk, Food, and Environmental Sanitarians, Milwaukee, Wisconsin, August 21-24, 1972.

as well as line samples to bracket critical processing steps. Sampling continues throughout a shift. The team freezes all samples for transport to the laboratory. The report of observed conditions and laboratory findings becomes the basis for correcting plant practice not only in the specific plant in question, but also in similar plants throughout the nation. Data, pooled with those from many other firms, also become the basis for articles in scientific publications and for microbiological criteria *(1, 5)*.

We intend to use these data to judge the quality of final product of individual firms. Even now, we are beginning limited surveillance of final product in some commodities, and will return for full bacteriological inspections of firms producing high count product.

Our Sanitary Microbiology Section has conducted microbiological surveys of beef and poultry pot pies, raw pork sausage, chicken fryers, and precooked meat and gravy products. Some of this work has been published and the rest is in preparation for publication. These surveys will be expanded in years to come, and will eventually cover all classes of meat and poultry products.

Microbiological guidelines

At this time, the Statistical Staff is working on the data to come up with appropriate criteria. Specific numbers will be published in the *Federal Register*. We are at this time trying to decide whether a new approach, developed by the International Commission on Microbiological Specifications for Foods (ICMSF) is applicable to U. S. production. The ICMSF is mostly concerned with evaluating acceptability of imported lots at ports of entry. They assume the importing authority has *little or no knowledge* of the production and processing conditions, and *no* authority to control such conditions.

If we apply the ICMSF approach, we will alter the plans slightly, to take into consideration the fact that we have control over production.

We first establish a figure, m, beyond which one should not expect a bacterial level to fall in good commercial practice. This value is based on the hundreds of samples analyzed in the nationwide surveys mentioned previously. If the bacterial level on all sample units falls below m, we would have no cause for concern. However, in the knowledge that there is variation among sample units we will permit a specified number of units (c) to surpass m. This is the area of transitional concern. If too many units of those analyzed surpass m, we will return to the establishment and make immediate changes to correct the situation for further production. Except under unusual circumstances, we would take no action against the particular lot sampled. This type of approach has been termed a "microbiological guideline":

> "A microbiological guideline is that level of bacteria in a final product, or in a shipped product that requires correction . . . . of current and future production or . . . handling . . . . " *(1)*.

To put the picture into perspective, we may decide that 10 packages (units) should be examined to evaluate a lot (i.e., n=10), that m should be 50,000 per gram, and 3 units can exceed 50,000 per gram (c=3).

However, we are not yet finished. There is for each type of test a limit, M, beyond which no one could permit even a single sample unit to fall. That is, above M we have an area of positive concern. M has little or no relationship to attainability in commerce, but rather to a hazard of some kind. Perhaps the hazard is overt spoilage, perhaps it is a health risk of a minor, moderate, or severe nature.

This is a 3-class sampling plan. However, if we were to permit none of the sample units to fall between m and M (that is, c=O), m and M would then be the same level, and we would have a 2-class plan. This approach could apply to bacterial numbers, but more frequently it would apply to tests for presence or absence of a particular organism.

Obviously, the choice of n, c, m, and M varies with the commodity, the test performed, and the relative seriousness of the hazard. If, for example, the hazard is simply reduced shelf-life, the sample units examined can be few, the values for m and M can be relatively high, and there can be considerable leniency toward the number of samples (c) higher than m. If, on the other hand, the test measures a severe hazard such as the presence of *Salmonella*, the numbers of sample units tested must be high, and the permissible limits low, perhaps even undetectable.

In addition, ICMSF has considered the nature of the food and the likelihood that in the normal course of events the subsequent treatment of the food before consumption will "reduce," "not change," or "increase" the measured hazard.

Using the two criteria, i.e., the nature of the test, and the likelihood of future change in hazard, the ICMSF is developing multiple sampling plans. Complete information on this system must await the new ICMSF book to be published in late 1973.

We can, however, consider one commodity and develop a hypothetical sampling plan for it. For example, a frozen ready-to-eat product would, in the normal course of events, remain frozen until shortly before serving. Thus, any hazard would remain unchanged. If our concern is shelf-life after thawing, our measurement might be for psychrotrophic spoilage bacteria. We might analyze five packages, (n=5), permit no more than 3 (c=3) to exceed 60,000 per gram (m) and none to exceed 10,000,000 per gram (M).

If our concern is sanitation, our measurement might be the coliform group, and the criteria would be a little tighter. Of ten units analyzed, only two could exceed 100 coliform bacteria per gram, and none could exceed 10,000 per gram.

If our concern were a severe health hazard, we might analyze 300 units per lot, and permit no positives. Obviously, such a heavy sampling program is impractical and even this would be inadequate protection against a severe hazard. The statisticians tell us that if all of the 300 are negative, we have 95% certainty that the defect is present in fewer than 1% of the units—not acceptable for something like botulism. Analysis of final product samples is therefore not the best way to protect against a severe low frequency hazard. Control of production and processing is the only sure and practical method.

The correctional approach

We in the Meat and Poultry Inspection Program recognize that control at source is the way to reduce microbial problems. Analysis of the final product is only one tool. We will use it primarily to point up problems for correction.

All of you have heard about the *Staphylococcus* outbreaks from Genoa salami. For this problem, we applied both a final product sampling program, and a correction-oriented bacteriological inspection procedure.

When the outbreaks occurred, we sampled and analyzed incriminated lots, related lots, and unrelated lots of the brands in question for *Staphylococcus* enterotoxin.

At this point all lots of incriminated brands were tied up, and released only after the owners had analyzed them exhaustively to sort out toxic from nontoxic lots. The only acceptable test was presence or absence of the toxin. Each test took several manhours of laboratory work, and required special reagents not available from commercial sources. The statistical aspect proved an awesome hurdle. To attain a high degree of certainty that a lot was acceptable required many dozens—even hundreds of tests. A single positive among these numerous tests incriminated the entire lot as well as adjacent lots. Hundreds of thousands of pounds of salami were destroyed.

It became quickly apparent that control of production practices was the only practical answer. The firms involved spent thousands of dollars to investigate the reasons for toxin formation. They were only moderately successful. However, they each changed several plant practices, and introduced careful microbiological control tests during production. These companies were able to assure us of the complete safety of their current and future production by this means.

In the meantime, our own laboratories monitored the work of these private plant laboratories by parallel sampling on a smaller scale. We also analyzed other brands. But in the knowledge that sampling the final product for a low incidence hazard is not a feasible way to control the hazard, we quickly reverted to bacteriological inplant inspections. We had one thing going for us. We knew that enterotoxin could not occur at detectable levels unless the numbers of toxigenic staphylococci approached or exceeded about one million per gram at some point in production. The obviously critical period was in the fermentation or "green room" operation, and in the early stages of drying. We could therefore use a simple quantitative method for coagulase-positive *Staphylococcus* instead of the laborious enterotoxin method. *Staphylococcus* levels are now not excessive in fermented products under production. The problems that occurred in 1971 with two companies were the exception and not the rule. Good practice dictates (1) that the numbers of *Staphylococcus* in the meat ingredients be low, and (2) that acid formation —the principal deterrent to *Staphylococcus* growth— be helped along by an acid chemical, or by an active lactic starter.

Our bacteriological sanitation program is a combination of investigation, surveillance, and correction. We try to improve consumer protection with minimal disruption of production.

REFERENCES

1. Elliott, R. P. 1970. Microbiological criteria in USDA regulatory programs for meat and poultry. J. Milk Food Technol. 33:173-177.

2. United States Department of Agriculture, Consumer and Marketing Service. 1970. Sanitation handbook of consumer protection programs. C&MS, USDA, Washington, D. C. 20250.

3. U. S. Department of Agriculture, Consumer and Marketing Service. (Latest edition). List of equipment accepted for use in federally inspected meat and poultry plants. C&MS, USDA, Washington, D.C. 20250.

4. U. S. Department of Agriculture, Consumer and Marketing Service. Manual of meat inspection procedures. (Latest edition). U. S. Government Printing Office, Washington, D.C. 20402, $9.25 per year.

5. U. S. Department of Agriculture, Consumer and Marketing Service. 1968. Establishment of microbiological criteria to supplement regular sanitary inspections, Etc. Federal Register 33(247):19042-19043.

AMENDMENT TO 3-A SANITARY STANDARDS FOR FITTINGS USED ON MILK AND MILK PRODUCTS EQUIPMENT AND USED ON SANITARY LINES CONDUCTING MILK AND MILK PRODUCTS

Serial #0813

Formulated by
International Association of Milk, Food and Environmental Sanitarians
United States Public Health Service
The Dairy Industry Committee

The "3-A Sanitary Standards for Fittings Used on Milk and Milk Products Equipment and Used on Sanitary Lines Conducting Milk and Milk Products, Serial #0809" is further amended as follows:

Add the following to section C. *MATERIALS*:

C.1.7

In a processing system to be sterilized by heat and operated at a temperature of 250°F or higher, all materials having a product contact surface(s) used in the construction of fittings, valves, tubing, gaskets and non-metallic component parts shall be such that they can be (1) sterilized by saturated steam or water under pressure at a temperature of at least 250°F and (2) operated at the temperature required for processing.

Add the following to section E. *SPECIAL CONSIDERATIONS*:

E.8

In a processing system to be sterilized by heat and operated at a temperature of 250°F or higher, fittings, valves, tubing, gaskets (if used) and non-metallic component parts shall comply with the following criteria in addition to other criteria in this standard.

E.8.1

The construction shall be such that they can be (1) sterilized by saturated steam or water under pressure at a temperature of 250°F and (2) operate at the temperature required for processing.

E.8.2

The fittings and valves used in such a system not designed so that it automatically is shut down if the product pressure in the system becomes negative and cannot be started until the system is re-sterilized, shall have a chamber for steam or other sterilizing medium surrounding the portion of a pipeline fitting, joint, valve, etc., adjacent to the product.

These fittings and valves shall be constructed so that the steam or other sterilizing medium chamber may be exposed for inspection.

E.8.3

Where steam or other sterilizing medium is used, the connection(s) on the fitting shall be such that the steam or other sterilizing medium lines can be securely fastened to the fitting .

This amendment is effective September 22, 1973.

3-A SANITARY STANDARDS FOR FARM MILK STORAGE TANKS

Serial #3000

Formulated by
International Association of Milk, Food and Environmental Sanitarians
United States Public Health Service
The Dairy Industry Committee

It is the purpose of the IAMFES, USPHS, and DIC in connection with the development of the 3-A Sanitary Standards program to allow and encourage full freedom for inventive genius or new developments. Specifications for Farm Milk Storage Tanks heretofore or hereafter developed which so differ in design, material, fabrication, or otherwise as not to conform with the following standards, but which in the fabricator's opinion are equivalent or better, may be submitted for the joint consideration of the IAMFES, USPHS, and DIC at any time.

A.
SCOPE

A.1
These standards cover the sanitary aspects of tanks in which bulk milk is stored on dairy farms. They do not pertain to storage tanks nor to silo type tanks for milk and milk products used in dairy processing plants nor do they pertain to farm milk cooling and holding tanks.

A.2
Tanks made in conformance to these standards will prevent a significant increase in the temperature of the milk stored in the tank by the insulation or by the combination of the insulation and refrigeration. These tanks will not provide the means for cooling the milk.

A.3
In order to conform with these 3-A Sanitary Standards, farm milk storage tanks shall comply with the following design, material and fabrication criteria.

B.
DEFINITIONS

B.1
Products: Shall mean milk.

B.2
Farm Milk Storage Tank: Shall mean a cylindrical, rectangular, oval or other equally satisfactorily shaped tank having a capacity for product of at least 1,500 gallons.

B.3
Surfaces

B.3.1
Product Contact Surfaces: Shall mean all surfaces which are exposed to the product and surfaces from which liquids may drain, drop or be drawn into the product.

B.3.2
Non-Product Contact Surfaces: Shall mean all other exposed surfaces.

B.4
Lining: Shall mean all surfaces used to contain the product, including the ends, sides, bottom and top.

B.5
Shell: Shall mean the material covering the exterior of the insulation and, if provided, the refrigerated surface.

B.6
Breast: Shall mean that portion of the metal used to join the top of the lining to the top of the shell on an open top type tank.

B.7
Outlet: Shall mean the opening in the lining and the passage for milk to the exterior of the tank. The outlet passage starts at the opening in the lining and terminates at the connection for the outlet valve.

B.8
Mechanical Cleaning or Mechanically Cleaning: Shall denote cleaning, solely by circulation and/or flowing chemical detergent solutions and water rinses onto and over the surfaces to be cleaned, by mechanical means.

C.
MATERIALS

C.1
All product contact surfaces shall be of stainless steel of the AISI 300 series[1] or corresponding ACI[2] types (See Appendix, Section E.), or metal that is non-toxic and non-obsorbent, and which under conditions of intended use is at least as corrosion re-

[1]The data for this series are contained in the following reference: AISI Steel Products Manual, Stainless & Heat Resisting Steels, April 1963, Table 2-1, pp. 16-17. Available from: American Iron and Steel Institute, 633 Third Avenue, New York, New York 10017.

[2]Alloy Casting Institute Division, Steel Founders' Society of America, 21010 Center Ridge Road, Rocky River, Ohio 44116.

sistant as stainless steel of the foregoing types except that:

C.1.1
Rubber and rubber-like materials may be used for slingers, drip shields, agitator seals, agitator bearings, protective caps for sanitary tubes or fittings or vents, O-Rings, seals, gaskets and parts used in similar applications. These materials shall comply with the applicable provisions of the "3-A Sanitary Standards for Multiple-Use Rubber and Rubber-Like Materials Used as Product Contact Surfaces in Dairy Equipment, Serial #1800."

C.1.2
Plastic materials may be used for slingers, drip shields, agitator seals, agitator bearings, protective caps for sanitary tubes or fittings or vents, O-Rings, seals, gaskets, direct reading gauge tubes, moisture traps on vacuum lines, in sight and/or light openings and parts used in similar applications. These materials shall comply with the applicable provisions of the "3-A Sanitary Standards for Multiple-Use Plastic Materials Used as Product Contact Surfaces for Dairy Equipment, Serial #2000," as amended.

C.1.3
Except for the protective caps provided for in C.1.1 and C.1.2, sanitary fittings shall be made of materials provided for in the "3-A Sanitary Standards for Fittings Used on Milk and Milk Products Equipment and Used on Sanitary Lines Conducting Milk and Milk Products, Revised, Serial #0809" as amended and supplements thereto.

C.1.4
Glass of a clear heat resistant type may be used for direct reading gauge tubes and in sight and/or light openings.

C.1.5
Where materials having certain inherent functional properties are required for specific applications, such as bearing surfaces and rotary seals, carbon[3], and/or ceramic materials may be used. Ceramic materials shall be inert, non-porous, non-toxic, non-absorbent, insoluble, resistant to scratching, scoring, and distortion when exposed to the conditions encountered in the environment of intended use and in cleaning and bactericidal treatment.

C.2
The materials used for lining shall not be less than 18 U. S. standard gauge.

[3]Carbon which is specifically in compliance with the Food, Drug and Cosmetic Act, as amended, is that which is included in "V Fillers" in the food additive regulation for rubber articles intended for repeated use, 121.2562 of Sub-part F, Code of Federal Regulations, Title 21 - Food and Drugs.

C.3
All non-product contact surfaces shall be of corrosion-resistant material or material that is rendered corrosion-resistant. If coated, the coating used shall adhere. All non-product contact surfaces shall be relatively non-absorbent, durable and cleanable. Parts removable for cleaning having both product contact and non-product contact surfaces shall not be painted.

D.
FABRICATION

D.1
All product contact surfaces shall be at least as smooth as a No. 4 finish on stainless steel sheets. (See Appendix, Section F.) The measuring rod of an immersion type measuring device, if made of stainless steel, may have a dull finish to facilitate reading.

D.2
All permanent joints in product contact surfaces shall be welded except that rolled on sanitary pipeline ferrules or flanges may be used on connections beyond the shell. All welded areas of product contact surfaces shall be at least as smooth as the adjoining surfaces.

D.3
All product contact surfaces shall be easily accessible for cleaning, either when in an assembled position or when removed. Removable parts shall be readily demountable.

D.4
All product contact surfaces shall be self draining except for normal clingage. The tank shall be designed and constructed so that when it is level or when it is in the position in which it was calibrated or when it is in position for calibrating, the bottom shall pitch at least 1/4 inch per foot toward the outlet; or if the tank is a vertical tank designed for mechanical cleaning, the bottom shall pitch at least 3/4 inch per foot toward the outlet. The lining shall be constructed so that it will not sag, buckle or become distorted in normal use. If the tank is designed for use on a vacuum system, the construction shall be such that the lining will not be distorted when the internal pressure is 20 inches of mercury below atmospheric pressure. Horizontal tanks shall be so constructed that they will not prevent complete drainage of water when the tank has a pitch of not more than 1 inch in 100 inches.

D.5
Gaskets shall be removable. Any gasket groove or gasket retaining groove shall not exceed 1/4 inch in depth or be less than 1/4 inch wide except those for standard O-Rings smaller than 1/4 inch.

D.6

All internal angles of 135° or less on product contact surfaces shall have minimum radii of 1/2 inch, except that:

D.6.1

The minimum radii for accessories, appurtenances, or bridges that are welded to product contact surfaces shall be not less than 1/4 inch.

D.6.2

The minimum radii in agitator shaft bottom guide bearings and in gasket grooves or gasket retaining grooves other than those for standard 1/4 inch and smaller O-Rings shall be not less than 1/8 inch.

D.6.3

The minimum radii in grooves for standard 1/4 inch O-Rings shall be not less than 3/32 inch and for standard 1/8 inch O-Rings shall be not less than 1/32 inch.

D.6.4

The minimum radii of covers and agitator assemblies shall be not less than 1/4 inch.

D.7

There shall be no threads on product contact surfaces.

D.8

All sanitary fittings and connections shall conform with the applicable provisions of the "3-A Sanitary Standards for Fittings Used on Milk and Milk Products Equipment and Used on Sanitary Lines Conducting Milk and Milk Products, Serial #0809," as amended and supplements thereto except that materials conforming to C.1.1 or C.1.2 may be used for caps of sanitary design for the protection of terminal ends of sanitary tubes, fittings or vents.

D.9

The breast shall be integral with or welded to the lining, and shall be sloped so that drainage is away from the lining. The junction of the breast and the shell shall be welded or effectively sealed.

D.10

Covers

D.10.1

Main Covers for Open Top Type Tanks.

Main covers (1) shall be sufficiently rigid to prevent buckling (2) shall be self draining, (3) shall be provided with an adequate, conveniently located and durable handle(s) of sanitary design, which is welded in place or formed into the cover material, (4) unless gasketed, shall have downward flanges not less than 3/8 inch along all edges and (5) shall be close fitting. If the cover is not gasketed, the clearance between the surface of the cover and the surface of the tank it is designed to contact shall not exceed 3/32 inch. Covers not exceeding 24 × 30 inches or 30 inches in diameter may be removable and shall be designed to be self draining in the closed position.

D.10.2

Non-removable Covers for Open Top Type Tanks.

Non-removable covers (1) shall be of a type that can be opened and maintained in an open position, (2) shall be designed to be self draining when in the closed position, (3) shall be designed so that when the covers are in any open position liquid from the exterior surface will not drain into the lining and (4) shall be designed so that when in their fully opened position, drops of condensation on the underside will not drain into the tank. Covers of openings that will be held in place by gravity or vacuum may be of the lift off type and may be provided with a clamp(s) or other device to maintain them in position.

D.10.3

Bridges and Fixed Covers for Open Top Type Tanks.

Bridges and fixed covers shall pitch to the outside edge(s) of the tank for complete drainage, and shall have a raised flange not less than 3/8 inch in height where the edge(s) meets the main cover(s). Bridges and fixed covers shall be integral or welded to the lining, and shall be installed so the underside is accessible for cleaning and inspection without completely entering the tank. Bridges shall not exceed 24 inches in width.

Generally horizontal fixed covers, located at ends or sides of an open top type tank (or segments of cylindrical open top type tanks) with generally vertical side walls, shall not extend more than 12 inches over the surface of the product.

D.10.4

Manhole Covers for Closed Type Tanks

Covers for manholes in side walls shall be either the inside or outside swing type. If the cover swings inside, it shall also swing outside, away from the opening. Threads or ball joints employed to attach the manhole cover(s) and its appendages shall not be located within the lining. Covers for manholes in the top of tanks shall be of the outside swing type or be of a removable type.

D.10.5

All openings in the lining or in fixed covers or in bridges, or main covers of open top type tanks not continually in use shall be provided with removable covers, which are designed to make close contact with the upper edges of the opening or cover surface, and when in the main cover the removable cover(s) shall remain in position when

the main cover is in an open position.

D.10.6
An umbrella or drip shield of sanitary design that can be raised or dismantled, to permit cleaning of all of its surfaces, shall be provided to protect against the entrance of dust, oil, insects and other contaminants into the tank through the space around the agitator shaft.

D.10.7
The water compartment of a tank designed for refrigerated water cooling shall have a cover. The clearance between surface of the cover and surface of the water compartment it is designed to contact shall not exceed 1/16 inch.

D.11
Openings
The edges of all openings into the lining that are upward or horizontal, shall extend upward or outward at least 3/8 inch beyond the shell or be fitted with a permanently installed sanitary pipeline fitting.

D.11.1
The main opening(s) of tanks shall be of sufficient number, adequate in size, and so located that all product contact surfaces are easily accessible and, except for the product contact surfaces of parts removable for cleaning, can be inspected visually without entering the tank.

D.11.2
An exception to the requirements of D.11.1 is made for closed top type tanks, having product contact surfaces that cannot be manually cleaned and inspected without entering the tank.

D.11.2.1
The minimum inside height of this type of tank shall be 42 inches and if the inside height exceeds 96 inches, means shall be provided (see Appendix, Section G.) that will facilitate manual cleaning and inspection of all product contact surfaces or means shall be provided for mechanically cleaning the product contact surfaces of the tank and all non-removable appurtenances thereto. This type of tank shall have a manhole opening(s) complying with the provisions of D.11.5.

D.11.3
An inlet sanitary pipeline connection shall be at least 1 1/2 inches or the inlet opening shall accommodate at least 1 1/2 inch 3-A sanitary tubing.

D.11.4
Agitator openings: Agitator shaft openings through the bridge or top enclosure shall have a minimum diameter of 1 inch on tanks which require removal of the agitator shaft for cleaning or be of a diameter that will provide a 1 inch minimum annular cleaning space between the agitator shaft and the inside surface of the flanged opening on tanks which do not require removal of the agitator for cleaning.

D.11.5
Manhole openings: A manhole opening, if provided, shall be located at the outlet end or side of the tank or the top of the tank. The inside dimensions of the manhole opening shall not be less than 15 × 20 inches oval, 12 × 27 inches elliptical, or 18 inches diameter.

D.11.6
Sight and Light Openings: Sight and light openings shall be provided when no other opening is available for viewing the surface of the milk and shall be of such design and construction that the inner surfaces drain inwardly, and if the tank is designed for mechanical cleaning, the inner surface of the glass (or plastic) shall be relatively flush with the inner surface of the lining. The inside diameter of the opening, if only one is provided, shall be at least 5 3/4 inches. If two openings are provided, the inside diameter of each shall be at least 3 3/4 inches. The external flare of the opening shall be pitched so that liquid cannot accumulate.

D.11.7
Thermometer openings: Two connections or openings which will accommodate thermometer sensing elements shall be provided. Connections and/or openings shall be located in the top enclosure, cover, bridge or through an end or sidewall. Thermometer wells may be used. The bulb of the temperature sensing element shall be located so as to permit registering the product temperature when the tank contains no more product than 10% of its capacity and if the tank has provisions for cooling, it shall be located so that the sensing element is not influenced by the cooling medium. All connections and/or openings shall conform to one of the following:

D.11.7.1
The applicable fittings found in the "3-A Sanitary Standards for Instrument Fittings and Connections Used on Milk and Milk Products Equipment," Serial #0900 as amended and supplements thereto.

D.11.7.2
Fittings for temperature sensing devices which do not pierce the tank lining, but which have temperature sensing element receptacles securely attached to exterior of the lining.

D.11.8
The vacuum connection for a tank designed to be

operated under vacuum shall be standard stainless steel tubing not less than 1 1/2 inch in diameter and not longer than 4 inches (See Appendix, Section H.)

D.12

Outlet: The outlet shall provide complete drainage of the tank and shall have an outside diameter conforming to that of 2 inch or larger 3-A sanitary tubing and a wall thickness no greater than 1/8 inch. The terminal end of the outlet passage shall have a rolled-on or a welded sanitary pipeline ferrule or flange. The ferrule or flange shall not be below the bottom of the shell. The distance between nearest point on the shell to the face of the ferrule or flange on the terminal end of a horizontal type outlet shall not be more than the smaller of (1) twice the nominal diameter of the outlet passage or (2) five inches. The outlet shall be one of the following types:

D.12.1

Horizontal type. The bottom of the outlet passage shall be at least as low as the low point of the lining at the outlet. The outlet passage shall be pitched downward toward the terminal end.

D.12.2

Vertical type. The vertical centerline of the outlet passage shall be as close as practical to a side wall of the tank. The outlet passage shall be a generally horizontal extension of an elbow which is a part of or is welded to the lining.

The outlet passage shall not pass through the bottom of the shell if product will be held in the passage.

D.13

Outlet valves: Valves, when provided, shall conform to D.8 or if the valve is within the lining or in the outlet passage, and the seat is an integral part of the lining or the outlet passage, a compression-type valve conforming to the applicable provisions of D.13.1 may be used. A cap conforming to D.8 shall be provided for the outlet end of valves furnished with tanks.

D.13.1

Compression-type valve in the tank or outlet passage. This type of valve shall have a metal to metal or rubber or rubber-like material to metal seat. The rubber or rubber-like material may be either removable or bonded. The handle or valve operating rod shall extend above the bridge or main cover or the handle shall be outside the shell.

D.14

Agitators: Means for mechanical and/or air agitation shall be provided that will result in a variation in milk fat content of the product in the tank of not more than plus or minus 0.1% as determined by an Official AOAC Milk Fat Test[4], when the tank is filled to at least 50% of its capacity with product and the agitator has been in operation for 10 minutes. Agitators, if not designed for mechanical cleaning, shall be readily accessible for manual cleaning and inspection either in an assembled position or when removed. A seal for the agitator shaft, if provided, shall be of a packless type, sanitary in design with all parts readily accessible for cleaning. A sanitary seal for the agitator shaft shall be provided for (1) a horizontal agitator, (2) a vertical agitator when it is specified that the tank is to be located so that the portion of the shaft outside the tank is not in the milk house or milk room, (3) a tank designed to be operated under vacuum and (4) an agitator in a tank having means for mechanically cleaning the tank. The means for agitation shall be one of the following:

D.14.1

Mechanical, top entering, non-removable type.

There shall be at least a 1 inch space between the non-removable agitator and the bottom of the lining, unless the agitator is mounted on a hinged type cover. A bottom shaft bearing shall not be provided for a non-removable type agitator.

D.14.2

Mechanical, top entering, removable type.

This type of agitator shall be provided with an easily accessible, readily demountable coupling of either a sanitary type located within the lining or a coupling located outside of the lining provided that it is above the shield provided to protect the annular space around the shaft. All product contact surfaces of the agitator shall be visible when the agitator is removed. A bottom support or guide, if used, shall be welded to the lining, shall not interfere with drainage of the tank, and the inside angles shall have minimum radii of 1/8 inch. When the agitator shaft has a bearing cavity, the diameter of the cavity shall be greater than the depth. The agitator shall be easily demountable for cleaning of the bearing and any shaft cavity.

D.14.3

Mechanical side entering type.

This type of agitator, shaft and complete seal, if not designed for mechanical cleaning shall be readily demountable for manual cleaning. Non-removable parts having product contact surfaces

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[4]The method of making these tests will be found in the following reference: Official Methods of Analysis: Available from the Association of Official Analytical Chemists. P. O. Box 540, Benjamin Franklin Station, Washington, D.C. 20004.

shall be designed so that the product contact surfaces are readily cleanable from the inside of the tank.

D.14.4

Air agitation.

The means for air agitation shall comply with the applicable provisions of D.15.

D.15

Air for Agitation or Movement of Product: Means for applying air under pressure shall conform to the applicable provisions of the "3-A Accepted Practices for Supplying Air Under Pressure in Contact with Milk, Milk Products and Product Contact Surfaces Serial, #60403," and the following:

D.15.1

Clamp type fittings shall not be used within the lining.

D.15.2

Tubing and related fittings within the tank shall be readily and easily removable for cleaning outside the tank or be designed for mechanically cleaning. If designed for mechanically cleaning, the tubing and all related fittings shall be self-draining.

D.15.3

Permanently mounted air tubing shall be constructed and installed so that it will not sag, buckle, vibrate or prevent complete drainage of the tank or tubing and shall be located so that the distance from the outside of the tubing to the lining shall be at least two inches, except at point of entrance.

D.16

Mechanical Agitator Driving Mechanism Mounting: The driving mechanism when above the lining shall be securely mounted in a position that will provide a minimum distance of 4 inches measured vertically downward from the bottom of the driving mechanism housing, excluding bearing bosses and mounting bosses to the nearest surface of the tank; and in such a manner that all surfaces of the tank under or adjacent to the driving mechanism shall be readily accessible for cleaning and inspection.

D.17

Thermometers: Each tank shall be provided with an indicating thermometer and/or a recording thermometer complying with the applicable specifications for indicating and recording thermometers in Appendix Section I.

The temperature sensing element of the thermometer shall fit one of the connections or openings provided for in D.11.7.1 and D.11.7.2.

D.18

Vents: A vent(s), if provided, shall be of a hooded type of sufficient free opening area to prevent back pressure during filling and to prevent vacuum during emptying of the tank. It shall be in the front head near the top of the tank or in the top of the tank. The vent(s) shall terminate in the milk house or milk room. It shall be provided with a perforated cover having openings not greater than 1/16 inch diameter, or slots not more than 1/32 inch wide. Woven wire mesh shall not be used for this purpose. It shall be so designed that parts are readily accessible and readily removable for cleaning.

D.19

Cleaning: Tanks having an inside height of more than 96 inches shall be provided with means (see Appendix, Section G.) that will facilitate manual cleaning and inspection of all product contact surfaces or means shall be provided for mechanically cleaning the product contact surfaces of the tank and all non-removable appurtenances thereto.

D.20

Sample Cock: A sample cock must be provided when a sample cannot be readily obtained from a top opening or a sample port opening in the tank. It shall be of a type that has its sealing surface relatively flush with the product contact surface of the tank and have an inside diameter no less than that of one inch 3-A sanitary tubing.

D.21

Tank Supports: The means of supporting a tank designed to be installed wholly within the milk house or milk room or the means of supporting the portion of a tank that will be in the milk house or milk room shall be one of the following:

D.21.1

With legs: Adjustable legs shall be of sufficient number and strength and so spaced that the filled tank will be adequately supported. Legs shall have closed bases. Exteriors of legs and leg sockets shall be readily cleanable. Legs shall be such that will provide (1) the minimum distance between lowest interior surface of the outlet connection and the floor will be 4 inches and (2) a minimum clearance of 6 inches between the floor and the bottom of a tank 72 inches or less in diameter or width, except in the case of a V-bottom or a rounded bottom tank of which the outer shell slopes continually upward from the outlet centerline, in which case the minimum clearance may be 4 inches if it increases to 6 inches within a horizontal distance of not more than 12 inches on each side of this centerline. On a tank more than 72 inches in diameter or width, the minimum clearance shall be 8 inches. (Where Weights and Measures Codes require that a seal be placed on the

legs to detect height adjustment after the tank has been leveled or calibrated, the holes for the seals shall be designed and located, or sealed, to prevent entrance of moisture into the legs.)

D.21.2

Mounted on a Slab or Island: The base of the tank shall be such that it may be sealed to the mounting surface (see Appendix, Section J.)

D.22

Prevention of a Significant Product Temperature Increase. The tank shall be capable of preventing, in 18 hours, an average product temperature increase greater than 3° F in a tank filled to 100% of its capacity with product when the average difference between the temperature of the atmosphere surrounding the tank and temperature of the product in the tank is 30°F. This may be accomplished by one of the following methods:

D.22.1

Insulation

If the prevention of a significant product temperature increase is to be accomplished solely by insulation, the insulating material over non-refrigerated areas of the tank shall have an insulating value equivalent of not less than:

D.22.1.1

Two inches of cork on

(a) tanks to be installed wholly within a building

(b) the portion of the tank within a building on tanks to be installed partially outside of a building

D.22.1.2

Three inches of cork on the portion of the tank outside of a building on tanks designed to be installed partially outside of a building

D.22.2

A combination of insulation and sufficient refrigerated surface.

D.23

Insulation: Shall be of a nature and installed in a manner that will prevent shifting or settling.

D.24

The tank shall have a measuring device. If it is of the immersion type or of the direct reading gauge type, it shall comply with D.24.1 or D.24.2.

D.24.1

Immersion Type: An immersion measuring device shall comply with the applicable provisions of the code entitled "Farm Milk Tanks" in the National Bureau of Standards Handbook 44—Fourth Edition 1971.

The measuring rod shall have graduation marks not less than .005 inch in width and not exceeding .008 inch in depth. The measuring rod consists of a graduated portion, a seat to engage the measuring rod supporting bracket or other supporting means and a handle. It does not include the supporting bracket or other supporting means. The measuring rod may be two or more parts welded together or may be one piece. The handle shall extend above the bridge or main cover, or shall be located outside of the outershell. The tank serial number stamped or etched on the rod shall be located as high on the rod as is practicable. The opening through which the measuring rod extends shall be protected against liquids or other contaminants entering the tank from that portion of the measuring rod outside the tank.

D.24.2

Direct Reading Gauge: A direct reading gauge of the glass or plastic tube type shall be sanitary in design and construction and shall be readily accessible for cleaning or shall be designed for mechanical cleaning. It shall be designed and constructed so that product in the gauge will automatically be discarded. The valve shall be close coupled. The distance, measured along the passage for the product in the tank to the gauge valve, from the nearest point on the shell to the ferrule or flange for the valve shall not be more than the smaller of (1) twice the nominal diameter of the passage or (2) five inches.

D.25

Non-Product Contact Surfaces: Non-product contact surfaces shall comply with the following:

D.25.1

They shall be smooth, free of pockets and crevices and be readily cleanable.

D.25.2

Surfaces to be coated shall be effectively prepared for coating.

D.25.3

The shell shall be effectively sealed against moisture and vermin at all joints and at junctions with the breast, manhole openings, outlets and other openings.

D.25.4

A vent or weep hole may be provided in the shell. If provided, it shall be located in a position that will provide drainage from the shell and shall be vermin proof.

D.25.5

Outside welds need not be ground.

APPENDIX

E.

STAINLESS STEEL MATERIALS

Stainless steel conforming to the applicable composition ranges established by AISI[1] for wrought

products, or by ACI[2] for cast products, should be considered in compliance with the requirements of Section C.1. herein. Where welding is involved the carbon content of the stainless steel should not exceed 0.08%. The first reference cited in C.1 sets forth the chemical ranges and limits of acceptable stainless steels of the 300 series.

Cast grades of stainless steel corresponding to types 303, 304, and 316, are designated CF-16F, CF-8, and CF-8M, respectively. These cast grades are covered by ASTM[5] specifications A296-68 and A351-70.

F.

PRODUCT CONTACT SURFACE FINISH

Surface finish equivalent to 150 grit or better as obtained with silicon carbide, is considered in compliance with the requirements of Section D.1 herein.

G.

MANUAL CLEANING

If the inside height of a tank exceeds 96 inches, one means for manual cleaning is to weld a stainless steel rung on each end of the tank to support a removable platform at a height which will facilitate cleaning and inspection.

H.

VACUUM PIPING

When vacuum piping is provided, the piping downstream from an elbow connected to the vacuum connection on the tank (see D.11.8) should pitch downward from the tank to a moisture trap. The piping between the tank vacuum connection and the moisture trap should be stainless steel and have a pitch of not less than 1 inch in the first 12 inches.

I.

INDICATING THERMOMETERS USED IN STORAGE TANKS

Scale Range.—Shall have a span not less than 50°F. including normal storage temperatures plus or minus 5.0°F. with extension of scale on either side permitted; graduated in not more than 2.0°F. divisions.

Temperature Scale Divisions.—Spaced not less than one-sixteenth of an inch apart between 35°F and 55°F.

Accuracy.—Within 2° F. plus or minus, throughout the specified scale range.

Stem Fitting—Shall conform to the 3-A "Sanitary Standards for Instrument Fittings and Connections Used on Milk and Milk Products Equipment" Serial #0900 as amended and supplements thereto or shall be a stem fitting that does not pierce the lining or means shall be provided to permit securely fastening the temperature sensing element to the outer surface of the lining.

RECORDING THERMOMETERS USED IN STORAGE TANKS

Case.—Moistureproof under operating conditions in a milk house or milk room.

Scale.—Shall have a scale span of not less than 50° F, including normal storage temperature plus or minus 5°F., graduated in not less than 2°F. divisions with not more than 40° F. per inch of scale; graduated in time scale divisions of not more than 1 hour having a chord or straight line length of not less than one-eighth of an inch at 40°F. Chart must be capable of recording temperatures up to 180° F. (Span specifications do not apply to extensions beyond 100° F.)

Temperature Accuracy.—Within 2° F. plus or minus, between specified range limits.

Pen-Arm Setting Device.—Easily accessible; simple to adjust.

Pen and Chart Paper.—Designed to give line not over one-fortieth of an inch thick when in proper adjustment; easy to maintain.

Temperature Sensor.—Protected against damage at 212° F.

Stem Fitting—Shall conform to the 3-A "Sanitary Standards for Instrument Fittings and Connections Used On Milk and Milk Products Equipment" Serial #0900 as amended and supplements thereto or shall be a stem fitting that does not pierce the lining or means shall be provided to permit securely fastening the temperature sensing element to the outer surface of the lining.

Chart Speed.—The circular chart shall make one revolution in not more than 7 days and shall be graduated for a maximum record of 7 days. Strip chart shall move not less than 1 inch per hour and may be used continuously for 1 calendar month.

J.

SLABS OR ISLANDS

When a tank is designed to be installed on a slab or an island, the dimensions of the slab or island should be such that the tank will extend beyond the slab or island at least one inch in all horizontal directions. The slab or island should be of sufficient height so that the bottom of the outlet connection is not less than 4 inches above the floor. The surface of the slab or island should be coated with a thick layer of waterproof mastic material, which will harden without cracking. The junction of the outer shell of the tank and the slab or island should be sealed.

These standards shall become effective September 22, 1973.

[5]Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103

FOOD REGULATORY ACTIVITIES[1]

VIRGIL O. WODICKA
Bureau of Foods, Food and Drug Administration
Washington, D. C. 20204

ABSTRACT

Current regulatory activities at the Food and Drug Administration cluster about several main lines of thrust. *(a)* More informative labeling. Examples are nutrient labeling, ingredient labeling on standardized foods, percentage declaration of characterizing ingredients, and on new foods, the definition of generic names. *(b)* Increasing emphasis on effective cooperation between State and Federal authorities. *(c)* Increased emphasis on food plant inspection. *(d)* More emphasis on inspection of quality assurance instead of only production. This includes quality assurance procedures applied to plant sanitation. *(e)* Increased attention to environmental contaminants, such as toxic metals and industrial organic chemicals. *(f)* Review of the safety of food ingredients with initial emphasis on the GRAS list.

The old adage that "You are what you eat" has enough truth in it to give each of us an intense and personal interest in food. There are few subjects for discussion that generate such universal interest or strength of opinions. The fact that these strong opinions vary widely among the consuming public makes life especially interesting for the purveyor or regulator of food.

The discussion in this paper is largely brought about by two trends in our economy: The first of these is the long-term rise of productivity resulting in a state of affluence which gives the consumer an opportunity to make choices as to what he consumes. When the consumer must choose, he wants the ability to make an informed decision.

The second of these trends is the increasing transfer of food preparation activities from the household kitchen to the food processor or food service establishment. As time becomes more precious than gold to more and more people, they become willing to give some of their gold in return for the time freed by the delegation of household chores.

It has been a long time since most consumers in this country produced their own food. Now in increasing numbers they not only do not produce it but do not prepare it. As a result, they are getting the feeling that they are no longer masters of their destiny in this area and are casting about for some way to regain control.

There is a theory of government that says that government should do for the people what they cannot do for themselves, or what it can do better and cheaper. This obviously assumes that the activity in question is something that the people want done.

There seems to be little doubt that a large segment of our people want more control over what they eat without losing the freedom of choice and low cost that they now have. In large numbers they are looking to government to achieve this control.

IMPROVED COMMUNICATION—LABELING

One of the major activities of the Food and Drug Administration currently has been and will continue to be the improvement of communication from purveyor to consumer so the consumer can make informed choices among foods. The communication medium for which we are responsible is the label. In recent years we have carried out our mandate under the Fair Packaging and Labeling Act to see to it that the statement of quantity of contents in the package of food was large enough to read and uniformly located. We are now proposing a regulation that would gather together essentially all the mandatory information and some optional information that is not on the principal display panel and put it in a single additional location. This is the so-called "information panel." A proposal along this line was set forth for comment and the comments are now being analyzed. I think it is likely that some regulation along this line will be issued, although the form it will take is yet uncertain.

List of ingredients

One of the pieces of information consumers are demanding is the list of ingredients in the food. This is now required on all foods that are not standardized, but at the time this requirement was imposed it was assumed that the standards would serve this purpose for standardized foods. If this assumption was ever valid it certainly is not today. When the law was amended to provide for ingredient statements and standards, however, it did not give the Food and Drug Administration authority to require the declaration of mandatory ingredients on standardized food labels. Accordingly, the Food and Drug Administration can only encourage such a declaration, which it has done. It has also requested amendment of the Act to provide the necessary authority to require it.

[1]Presented at the 59th Annual Meeting of the International Association of Milk, Food, and Environmental Sanitarians, Milwaukee, Wisconsin, August 21-24, 1972.

Nutritional information

Another packet of information widely demanded by consumers is the nutritive value of the food. This is a set of properties that has not been given serious attention by most purveyors, and as a consequence development of new plant varieties, development of food processing methods, and development of packaging unguided by any such consideration may or may not deliver to the plate of the consumer the nutritive value that his grandfather could count on. The Food and Drug Administration has proposed for comment a format for declaring nutritive value for those purveyors who choose to do so. It has made the point repeatedly, however, that it expects the food offered to contain the nutritive values declared on the label. Anything else would be misbranding and actionable.

There is a separate facet of ingredient and nutrient declaration that is now being covered by regulations. Previously, in many instances, fat contained in foods could be declared generically as animal or vegetable. It will now be required that the specific source of the fat be declared, although to permit market forces to operate in choosing fat sources it will not be required that they always be stated in order of decreasing abundance. Also for foods that are significant sources of fat in the dietary, label statements will be permitted that declare the percentage of saturated and polyunsaturated fatty acids in the fat along with the amount of fat in the food. A format has been provided for such declarations, and this is sufficiently compatible with the format for general nutrient labeling that the two may be combined.

Defining foods

The law provides a mechanism for establishing definitions and standards of identity, quality, and fill. In most instances where such standards have been established there has been a certain amount of controversy because otherwise there would be no need for a standard. The consequence of this has been that the procedures for establishing standards are quite cumbersome, and the time required is usually best measured in years rather than weeks. One of the major elements of this standardization process is to establish an official name for the defined food. The law requires that this be the common or usual name if there is one. In these days of rapid technological progress, however, there is an increasing number of foods being offered which do not have a common or usual name because they are completely new. In many instances it would avoid confusion to have a standard name for such products but the problems are not sufficient to warrant undertaking the cumbersome process of standardization. Accordingly, a procedure has been proposed for comment by which the Food and Drug Administration would promulgate a standard name for such a product, including, where appropriate, the declaration on the principal display panel of the percentage in the product of one or more characterizing ingredients. Such a procedure would serve many of the purposes of a standard but would be much simpler and faster. It would not provide much of the detail that is now contained in the standard, however, and therefore would not be a complete replacement. It should be looked upon rather as a supplementary mechanism of the same type.

Overseeing Food Production and Processing

All these activities and others I have omitted in the interest of space are intended to facilitate communication between purveyor and consumer to permit informed choice on the part of the consumer. Many of these are in specific response to expressed consumer demand. There remains, however, the activity of representing the consumer in overseeing the production and processing of foods to make sure that these are accomplished cleanly and safely. The government here can and must provide the capability for technical examination of foods that the consumer cannot realistically maintain and must also serve as the eyes and nose of the consumer in checking on operating conditions from which the consumer is far removed in distance and often in time.

Cooperative efforts

The primary responsibility for the quality, including the safety, of food lies with the purveyor. In the event of processed foods, of course, this means mostly the processor. The regulatory agencies cannot assume this responsibility; they can only check up to see whether the processor is carrying it out properly. With our highly developed agriculture and food technology, however, effective quality control is a demanding professional specialty, and the conscientious workman though still very necessary is no longer sufficient. If the job is to be done properly, there are not enough trained or even trainable people available to allow for unnecessary duplication of effort among industry and state and federal authorities. One of the steps being taken by the Food and Drug Administration to give recognition to this fact is to put increasing emphasis on coordination and cooperation between state and federal activities. For the last two years there have been specific contracts between the Food and Drug Administration and several states for work in connection with the Fair Packaging and Labeling Act. The results of this have been sufficiently satisfactory to both parties that this relationship is now being extended to cover other aspects of regulation during the current fiscal year.

We are trying to find ways in which the State regulatory agencies can act on behalf of the Federal government as well as their own with shared costs and shared benefits. We would hope that this would result in reduced overall costs to the taxpayer by elimination of duplicated effort and at the same time would accomplish more effective control.

Federal activity

The attempt to enlist the assistance of the States in carrying out the federal mission, however, does not imply any reduction of effort at the federal level. The opposite is true. Within the past year the General Accounting Office, which is an investigative agency of the Congress, made a study of the food industry and the activities of the Food and Drug Administration showing that the state of sanitation of the food industry is on the average not very good. It has issued a report number B-164031 (2) entitled *Dimensions of Insanitary Conditions in the Food Manufacturing Industry.* This is available from the Superintendent of Documents for $5.00. It includes dramatic color pictures of insanitary conditions illustrative of its statistics showing that 40% of the plants sampled were insanitary, with 24% seriously so. This report reenforced the position taken by Commissioner Edwards of the Food and Drug Administration that when the resources available permitted inspection of food establishments on the average of once every 6 years, not enough pressure could be put on the food industry to maintain sanitary conditions. This message has now been heard where it needed to be, and as a consequence this year's appropriation provides for more than doubling the FDA inspection force for food establishments.

Although this increase in the FDA forces was essential and is as large as could be managed in a single year, it should be obvious that increasing frequency from once every 6 to 7 years to once every 3 years does not constitute a basis for complacency, even with augmentation by state efforts. Something more than this is necessary. Here I return to the need for avoiding redundancy. The responsibility for a clean and wholesome product lies with the processor, not with the government. The government can only provide guidance and check up to see if the processor is doing his job.

Inspectors

In the past, the activities of the government inspector have been to check on plant operations to see if they were likely to result in a clean and wholesome product. On the assumption that the inspector is thoroughly competent in the technology involved in the plant he is visiting, he can then identify those improper practices that are carried on habitually or which just happen to be going on that day. If we now assume that there is some serious infraction that takes place in that plant 10% of the time, he has one chance in 10 of catching it. If he now gets around every 3 years this means that in an average of 30 years he is likely to find it, if the company is still in business and still doing things the same way. It would seem that there should be a better way.

The Food and Drug Administration is now proposing to train its inspectors in the procedures of modern quality control. They will then start placing their emphasis on the inspection of the quality control of the plant rather than the production. Of course it is impossible to inspect the quality control without at the same time inspecting the production, but the converse is not true. With knowledge of what the company itself is doing to assure a clean and wholesome product, the regulatory agency can draw much better conclusions about what is going on on the days when the inspectors are not around.

The limitation to this approach is that there is no legal requirement for the processor to disclose his quality control system to the inspector. Fortunately, a large and increasing number of companies is willing to do this voluntarily, so that the agency would be remiss in not taking advantage of this opportunity. I return now to the point that the inspection frequency of once every 3 years is an average. Some plants will be visited more often, and others less. When a plant's quality control has been inspected and found satisfactory, it will obviously qualify for less frequent inspection. This will permit concentration of effort on those plants where the quality control is inadequate or unknown.

ENVIRONMENTAL CONTAMINATION

There are two areas of food regulation where the Food and Drug Administration has an obligation to both the consumer and the industry. The first I would touch upon is the area of environmental contamination. This focuses on two major aspects of our industrial economy. The first of these is the increasing practice of mining ores which contain metals in very small percentages of the total environment and converting these into essentially pure metals which therefore exist in the environment in high concentration. When these metals have served their intended purpose they are returned to the environment in the form of "junk" where they now present the opportunity for contamination of various things, including foods. The process of converting the ore to metal also may result in contamination of the air or streams nearby and consequently of the food produced in the area.

The second facet of this problem lies in the development in the last century or so of a synthetic

organic chemicals industry which can produce natural materials in unnatural quantities, or with equal facility can produce in large quantities materials which have never existed before. It would be expected that this latter category is a particular problem because nature has not had an opportunity to develop enzyme systems to cope with these unfamiliar insults. In both these areas the government is increasingly recognizing its obligation to identify those situations in which there may be public hazard and to bring these under control. In view of the fact that food is one of the major media through which this hazard may be presented, the Food and Drug Administration has an obligation to monitor the food supply for public protection.

Here again, it is obvious that the Food and Drug Administration, and in fact all the state and federal agencies put together cannot accomplish the total job. The active and informed participation of the industry is essential. The Food and Drug Administration, however, feels that there are certain responsibilities that it is in best position to assume. One of these is to provide adequate analytical methods to characterize the problems. This does not imply that the methods must be developed by the Food and Drug Administration, but the Agency does have the obligation to determine that they are feasible and appropriate. The second obligation is to make the affected industry, and where necessary the public, aware of the fact that there is a problem requiring action. Where problems of this sort have arisen, the Food and Drug Administration has shown its willingness to coordinate the activities of the industry and to serve as an information center to promote quick and effective action. The third obligation, of course, is to impose regulatory limits on environmental contaminants whenever survey information, together with toxicology, shows that such action is needed. Within relatively recent months, all these actions have been taken on such contaminants as mercury, lead, asbestos, and polychlorinated biphenyls. Others are under study.

Safety of Food Ingredients

The other major area where the government has a responsibility of leadership is in the safety of food ingredients. There is, of course, no such thing as a completely safe material. Accordingly, safety is always conditioned by circumstances and therefore to some extent a matter of opinion. When actions become guided by opinion, it becomes necessary to have an official opinion. For foods, the Food and Drug Administration is the official focus of such opinions.

The law divides components of foods into a number of categories that are separately regulated. The first two are food additives and color additives. I shall discuss them together because they are similarly handled. Ever since 1958, the introduction of a substance to the food supply as a food additive or color additive requires that the person who proposes to introduce it must file a petition with the Food and Drug Administration for a regulation permitting its use. Before the regulation may be issued, the Food and Drug Administration must be satisfied that the material is safe for its intended purpose and that there is an analytical method satisfactory for its regulation. No more of the substance may be used than is necessary to achieve its intended effect. Accordingly, the Food and Drug Administration must know how much this is in making its safety decisions. The approval of the Food and Drug Administration in the form of a regulation, therefore, is necessary before the material may be legally used.

A third category of component is that of the so-called prior sanction. In other words, materials in this category were made the subject of official opinions or permits given by either the Food and Drug Administration or the U. S. Department of Agriculture in commodities under its jurisdiction before passage of the Food Additives Amendment to the Food, Drug and Cosmetic Act in 1958. Materials which have prior sanction status are not, strictly speaking, subject to any provisions of the Act governing food additives but their use may be controlled by general authority given to the Food and Drug Administration by other provisions of the Act. There are relatively few materials covered by prior sanction of record in the Food and Drug Administration.

The final category consists of substances generally recognized as safe by experts qualified through training and experience to judge their safety. This includes most of the food supply. When the Food Additives Amendment was passed, however, the Food and Drug Administration listed something just short of 500 materials on which frequent questions were arising which it had determined through questionnaire were generally recognized as safe by experts. This became the so-called GRAS list. The turmoil arising from the banning of cyclamates which were on this list caused the Food and Drug Administration to be directed to review the safety of all the items on the list. Accordingly, a multi-million dollar program is well along to do just that. All the published literature on the toxicity of these materials for the last 50 years has been gathered. A contract with the National Academy of Sciences to ascertain use levels for each of these materials is now almost complete. A program is now launched to write a monograph for each GRAS material on the list based on the literature survey and the use survey. Finally, it will be necessary for the Food and Drug Adminis-

tration to make a decision on each substance based on these monographs with the advice of an expert committee assembled by the Federated American Societies for Experimental Biology. We are targeting for decisions on 300 substances within the next year.

IN CONCLUSION

From this review I am sure you can see that this has been a period of great activity on the part of the Food and Drug Administration, and the early future does not promise any diminution in level of effort but rather an increase to the extent permitted by available resources. This effort, on the other hand, does not take the place of the efforts of state and local agencies or the affected industry in meeting the needs of the consumer for information and for safety. The increase in level of effort is rather called for on the part of all of us. In view of the fact that we shall all be busy along the same lines, we all have the corresponding obligation to see to it that our efforts reenforce each other instead of working at cross purposes.

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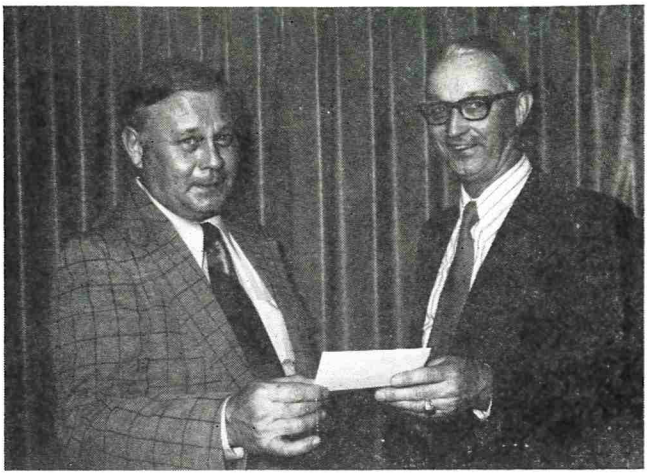
ASSOCIATION AFFAIRS

MISSOURI SANITARIAN OF THE YEAR AWARD

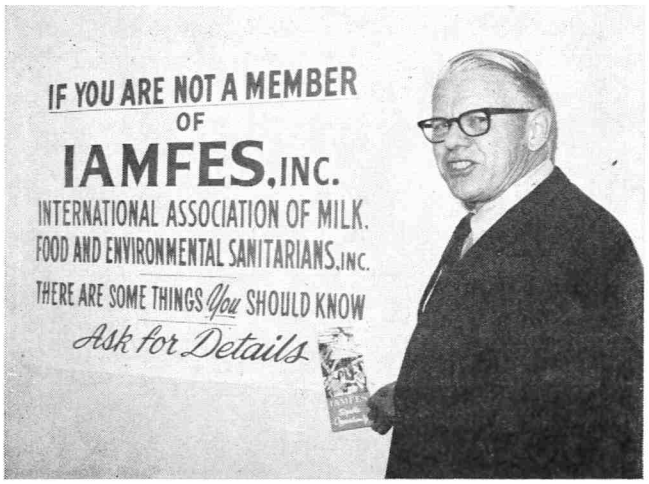
James I. Kennedy, left, being presented the Missouri Sanitarian of the Year Award by President Charles VanLanduyt. Mr. Kennedy has been an employee of the Missouri Division of Health since 1958 serving as a nursing home sanitarian for several years. He has served as a milk sanitation survey officer for the past eight years and as Chief of the Milk Sanitation Program, Missouri Division of Health since 1968.

IAMFES, INC. 60TH ANNUAL MEETING

Contributions toward the expense of 60th annual meeting are coming in well according to Dick Wolcott of Upstate Milk Cooperative, Rochester, N.Y., a member of the Local Arrangements Committee. The fund is still short of its $6000 goal and it is hoped that many more milk and food related businesses will want to make contributions to help assure the success of the meeting which is being hosted by the New York State Association of Milk and Food Sanitarians August 13-16 in Rochester. Local Arrangements Chairman, Al Lahr, President of Antical Chemicals Inc. of Rochester, reports that entertainment plans include a trip to Widmers Wine Cellars, Naples, N.Y., two cocktail receptions, favors, and an attractive program for the ladies, all complimentary to conference attendees. Contributions to the conference fund should be made payable to IAMFES–NYS Meeting Fund and sent to Richard Wolcott, Upstate Milk Cooperatives, 45 Fulton Ave., Rochester, N. Y. 14608.



Albert J. Lahr, 1973 Annual Meeting Local Arrangements Chairman, presents contribution to Richard Wolcott, Finance Chairman.



Charles G. Ashe, President, New York State Association of Milk and Food Sanitarians is saying "cheese" as he poses to illustrate the new brochure promoting International and the poster which will be used to recruit new members for IAMFES.

AMERICAN INTERSOCIETY FOR CERTIFICATION OF SANITARIANS

By John G. Todd, Dr. P.H., *Chairman*

The Academy, dedicated to the recognition of professional competence and achievement among Sanitarians, was incorporated on March 14, 1966. This was the culmination of plans developed over a period of several years by the Sanitarian's Joint Council which is composed of representatives of the Interna-

tional Association of Milk, Food, and Environmental Sanitarians; the National Environmental Health Association; and the American Public Health Association. All sponsors of the Sanitarian's Joint Council had given early support and development to an "Academy" and encouraged its creation. As an outgrowth of numerous conferences and deliberations, the American Inter-society Academy was formalized with a twelve (12) member Board of Directors. Although its implementation required financial support from the Associations forming the Joint Council, the Academy is now a completely independent autonomous sanitarian group and does not compete with nor duplicate the activities of any sanitarian association.

The Academy has continued to progress over the past six years and currently has a roster of 313 certified diplomates. Day-to-day operations of the Academy are carried out by the Chairman, Vice Chairman, and Secretary/Treasurer, elected by and from the twelve member Board of Directors. The Directors are elected from and by the full membership of the Academy for a three year term. Beginning in 1973 the Academy will hold its annual meeting concurrently with the Annual Educational Conference of the National Environmental Health Association.

Through certification, the Academy provides to the individual a close professional relationship with his peers and provides tangible evidence that he has achieved excellence and is outstanding in his chosen field. Employing agencies, academic institutions and other professional associations are demonstrating increasing awareness of the implications of Diplomate status.

To be eligible for Academy certification, applicants must:

1. Be of good moral character and of high ethical and professional standing.
2. Possess a baccalaureate degree with thirty semester hours in the physical, biological sciences.
3. Possess a Masters or higher degree in Public Health, the environmental health sciences or in an area of scientific or administrative specialization bearing upon environmental management.
4. Give evidence of accepting the Academy's concept of the Sanitarian Diplomate "He is a public health professional uniquely qualified through education and experience to manage environmental factors for the purpose of protecting and promoting the health and quality of life of man."
5. Be a legally registered sanitarian or meet the criteria of the model act for registration of sanitarians.
6. Have completed at least 7 years of acceptable environmental health experience (5 years of full time work on a professional level and two years above the staff level).
7. Furnish proof of applicant's acceptability through one or more of the following:
   a) A written examination;
   b) Submission of an essay as specified by the Board;
   c) An oral interview as specified by the Board.

The Academy objectives are:

1. To improve the environmental health status of man;
2. To enhance the Sanitarian's professional development; and
3. To recognize the excellence of Sanitarians through certification.

The Academy welcomes and invites your consideration. Additional information may be obtained by contacting Mr. Richard F. Clapp, Secretary, AIACS, Training Program, Center for Disease Control, U.S. PHS, Atlanta, Georgia 30333.

DR. H. E. RANDOLPH HONORED BY TEXAS A&M UNIVERSITY DAIRY SCIENCE CLUB

The Texas A&M University Dairy Science Club announced the selection of Dr. H. E. Randolph, Associate Professor of Dairy Science, Texas A&M University as an "Honorary Member" at its annual Awards Banquet April 24, 1973. This honor is presented to individuals who have made significant contributions to the dairy industry and who have provided unusual assistance and support of the educational activities of the Dairy Science club. Dr. Randolph serves as advisor to the Dairy Club and was recog-

nized for his many contributions to the educational goals of dairy students and support of the club's cheese projects. Dr. Randolph received a B.S. degree in Dairy Science from Tennessee Tech in 1957, and the M.S. and PhD. degrees in Dairy Technology from Ohio State University in 1959 and 1962. He held a joint appointment in extension and research at the University of Kentucky prior to joining the staff at Texas A&M University in 1967.

Dr. Randolph is a member of the American Dairy Science Association, Institute of Food Technologists, International Association of Milk, Food, and Environmental Sanitarians and the Dallas-Fort Worth Dairy Society. He received the Dallas-Fort Worth Dairy Society's Charles Galyen Award in 1972 for outstanding service to the dairy industry. Dr. and Mrs. Randolph have two sons (Kenneth and David) and two daughters (Marsha and Beth).

NEWS AND EVENTS

ZERO CELEBRATES INSTALLATION OF 500TH ZERO BULK MILK COOLER IN THE NETHERLANDS

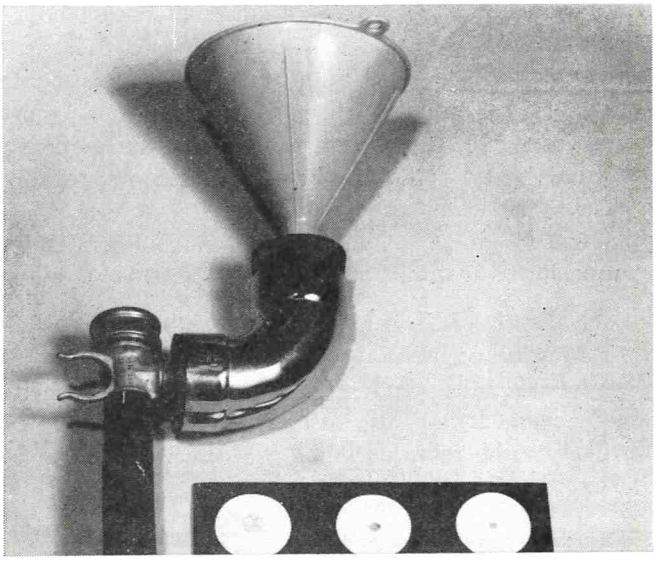
A celebration to commemorate the delivery of the 500th ZERO Bulk Milk Cooler to DOMO MELK-PRODUKTEN BEDRIJVEN, one of the largest dairy cooperatives in The Netherlands—and its installation on the farm of R. van Gijssel at Beilen, The Netherlands—was held recently on the van Gijssel farm. Mr. van Gijssel is a member of DOMO. The celebration was sponsored by DOMO and International Koeling, N.V. of Bleskensgraaf, Holland. Internationale Koeling—a joint venture of ZERO Manufacturing Company of Washington, Missouri and A.M. van Duinen of Bleskensgraaf—is Distributor of ZERO Products in the Netherlands. The 1,000-gallon ZERO Tank was turned over to DOMO by A. J. Ader—President of the Supervisory Board of Internationale Koeling—for the installation.

During the celebration, ZERO Manufacturing Company—represented by O.K. Backhaus, Co-Managing Director of Internationale Koeling—extended its best wishes to the farmers and to K.de Boer, General Manager of DOMO, for the continued association which began in 1969 when the first bulk tank for DOMO, a ZERO, was put into use. Since that time, bulk tank milking has grown steadily by DOMO's producers. In 1969, the average bulk tank size was approximately 400-gallons—with a herd size of about 30 cows. This has risen to 1,000 gallons for about a 60-cow herd.

By the end of 1973, DOMO will have disposed of approximately 620,000 pounds of bulk tank milk. This will be about 20% of the total yearly supply to all DOMO firms as compared to the national average of 10% to 15% at the end of 1972.

As an example of DOMO's rapid advancement—a visit was paid to one of the three Benning Brothers farms where a 2,000-gallon ZERO Tank is installed in connection with a carousel rotary parlor which can handle 125 to 150 cows. It is estimated that within the next few years milk production on the three Benning farms will achieve 795,000 pounds.

JET SEDIMENT TESTER

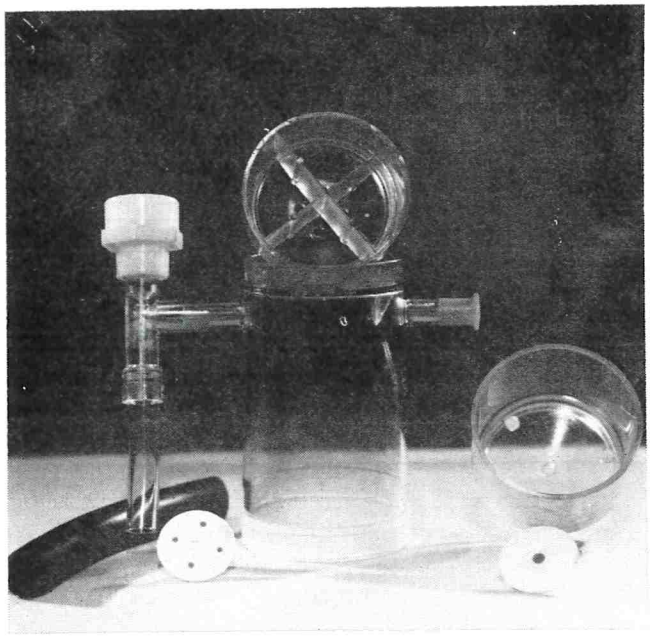


Portable adapter kits quickly convert the patented Jet Sediment Tester to provide for smaller test diameters for use in cleanliness screening of universal milk samples.

The 1-pint—0.4" diameter test is standard with this water aspirator type tester. The adapter kits for insertion into the tester provide for additional test diameters of 0.2" and 0.14" for sediment screening of 4 and 2 ounce universal milk samples.

The Jet Sediment Tester is adapted for field use in milk and other food testings, weighs only 1½ lbs. and sells for $19.95 postpaid and complete with the two adapter kits thus providing for 3 different sized tests. It is available from: Jet Milk Cleanliness Co., Lowville, New York 13367.

MILK QUALITY GAUGE



A practical invention for rapid and simultaneous testing for sediment of four 1-ounce milk samples has been developed for sanitarian, laboratory and dairyman's use. The Milk Quality Gauge is comprised in part of a 4-section sample cup and a filter test area of 0.1" diameter for each sample. Four separate test results appear on a single test disc. The standard volume-area mixed sample sediment test relationship is maintained in the one-ounce–0.1" test.

Such testing of collected universal milk samples by the sanitarian or laboratory serves as an indicator of those whose milk production cleanliness is in need of improvement and also instances of abnormal milk are likely to be revealed when the disc is fouled and the sample resists passage.

The dairyman can use the invention in monitoring for clean milk production by before-straining testing of the milk and also use it as an aid in abnormal milk detection by individual quarter sample testing at cowside.

The MQG is also supplied with an interchangeable single compartment cup for use in testing a 4-ounce sample through a 0.2" diameter test area. Vacuum from a water faucet aspirator supplied with the MQG can be used in its operation or milking machine vacuum if the testing is done at cowside.

The apparatus is priced at $19.95 plus $1.00 for handling and postage and is available from: MQG Division, New York Laboratories, 901 E. New York Ave., Brooklyn, N. Y. 11203.

LETTER TO THE EDITOR

What does the Standard Plate Count really tell us?

DEAR SIR:

In recent years many publications have appeared which describe the pros and cons of lowering the plate incubation temperature for the Standard Plate Count (SPC) when assessing raw milk quality. Unfortunately, I haven't kept score, and therefore I am unable to say whether the pros or the cons are in the lead at the present time. Nearly all of these reports claim victory on the basis that "their" temperature for determining SPC produced the highest counts, and this makes me wonder what we are trying to do.

I believe that our goal is to evaluate not only the quality of raw milk as such, but also the quality of raw milk *production.* The ideal test would tell us the number of those undesirable microorganisms present in milk as a result of unsatisfactory production procedures. (I am *not* suggesting that we disregard pathogens or other abnormal conditions which may affect milk quality.)

Unfortunately, the ideal test hasn't been invented yet, and all of our present methods are more or less successful compromises. However, I must confess that I fail to see why some people stress the importance of obtaining a "highest count" at any given temperature. We should *not* look for an incubation temperature at which the majority of samples produce maximum counts, but rather for a temperature at which we can detect most of those organisms which either affect the quality of bulk-cooled milk or which indicate faulty production. The SPC in its present form only tells us how many organisms can grow to a visible colony on a certain medium within 48 hr at 32 C, a temperature at which milk is never stored. In my opinion there is little value in enumerating this group of bacteria since most of them neither affect the quality of refrigerated milk nor do they provide an accurate index of its production. The most frequently heard argument for the SPC is the fact that "results" are available after two days. Wouldn't it be more sensible to obtain meaningful counts, even if it would involve waiting for a few extra days?

G. BLANKENAGEL
Department of Dairy and Food Science
University of Saskatchewan
Saskatoon, Saskatchewan
Canada

INDEX TO ADVERTISERS

Babson Bros., Inc. ----------Back Cover
Difco Laboratories ----------IV
IAMFES, Inc. ----------I
Technicon Industries ----------II
The Haynes Mfg. Co. ----------Inside Back Cover
Whitmire Research Laboratories ----------346
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SANITARY METHOD OF APPLYING
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TO DAIRY & FOOD
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The Modern HAYNES-SPRAY *Method of Lubrication Conforms with the Milk Ordinance and Code Recommended by the U. S. Public Health Service*

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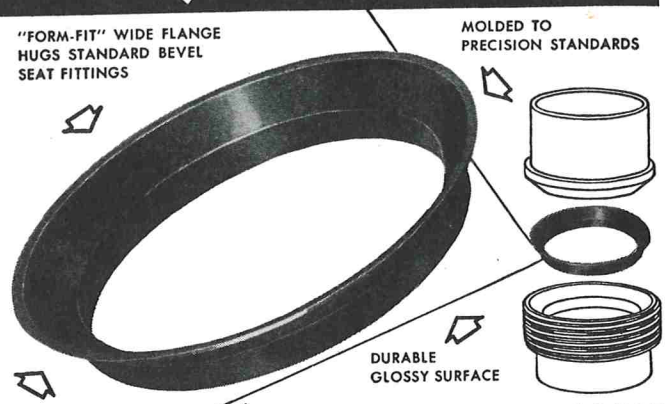

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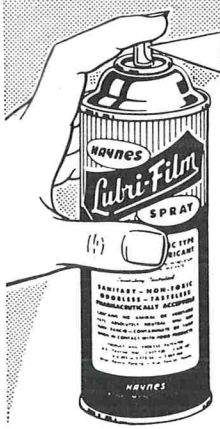

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ESPECIALLY DEVELOPED FOR LUBRICATION OF FOOD PROCESSING AND PACKAGING EQUIPMENT

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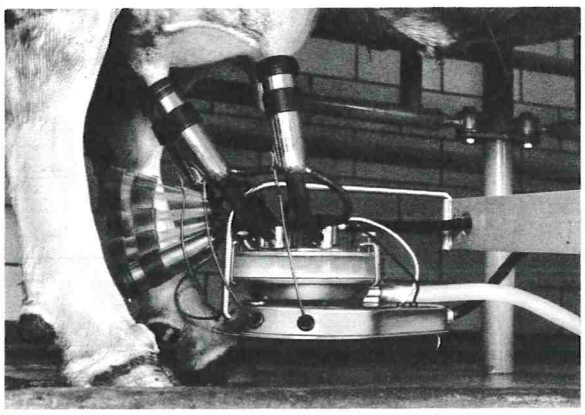
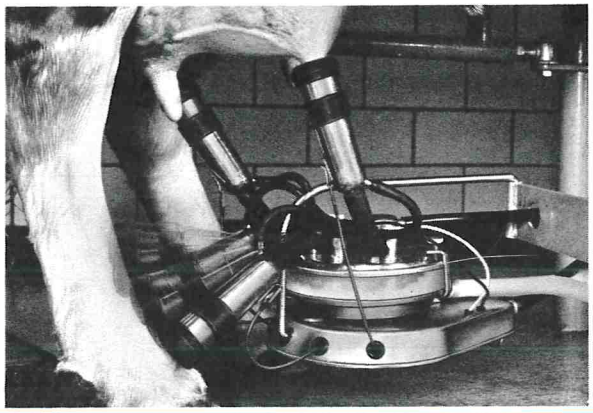
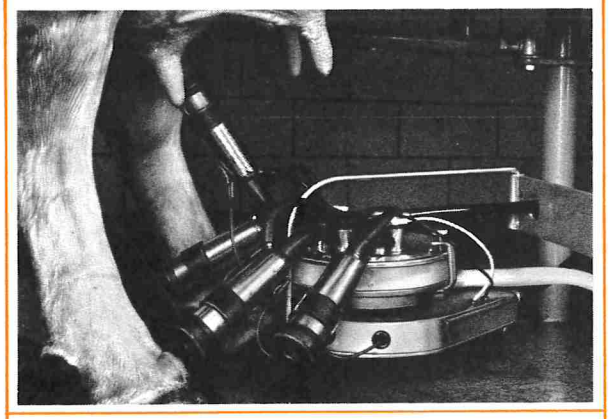


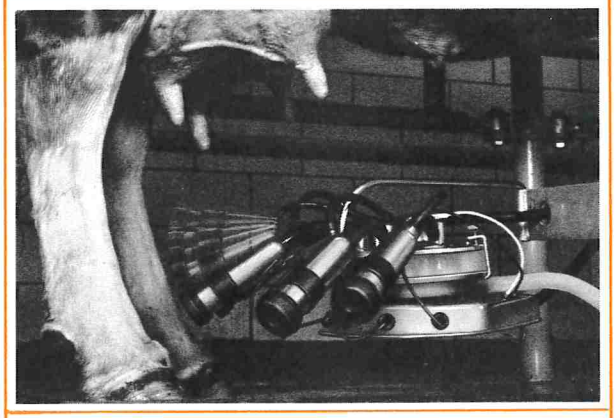
:0220 Two minutes and twenty seconds after unit is attached, left front quarter milks out. QTO teat cup is automatically removed. All other quarters continue milking.



:0254 Thirty-four seconds later, right rear quarter has finished. Milk flow stops and second teat cup is taken off.



:0329 Right front quarter milks out thirty-five seconds later and teat cup is removed automatically.



:0417 Last quarter milks out four minutes, seventeen seconds after unit is attached. Time difference between first and last quarter: one minute and fifty-seven seconds.*

you've got to see it to believe it!

Push a button and attach the QTO milker. As each quarter of the udder milks out, that teat cup is removed automatically. When the last quarter has been milked, the machine signals that it's ready for the next cow. It's that easy.

Automatic teat-cup removal is controlled by reliable solid-state milk flow sensing circuits. The circuit boards plug into the control panel. Only low voltage current goes to the milking units. The QTO milking units themselves are rugged and simple. They use the SURGE Breaker cup principle and adjustable Randel support arms for tug and pull milking action.

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*Average based on 160,000 individual quarter timings.