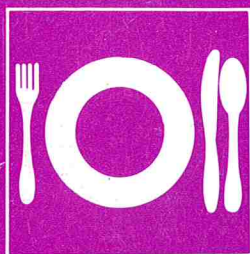
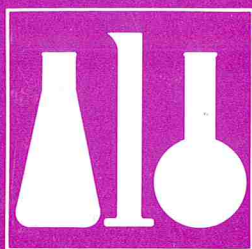


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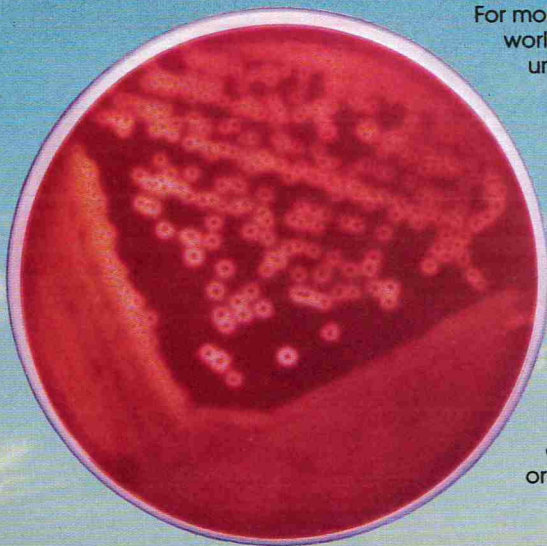
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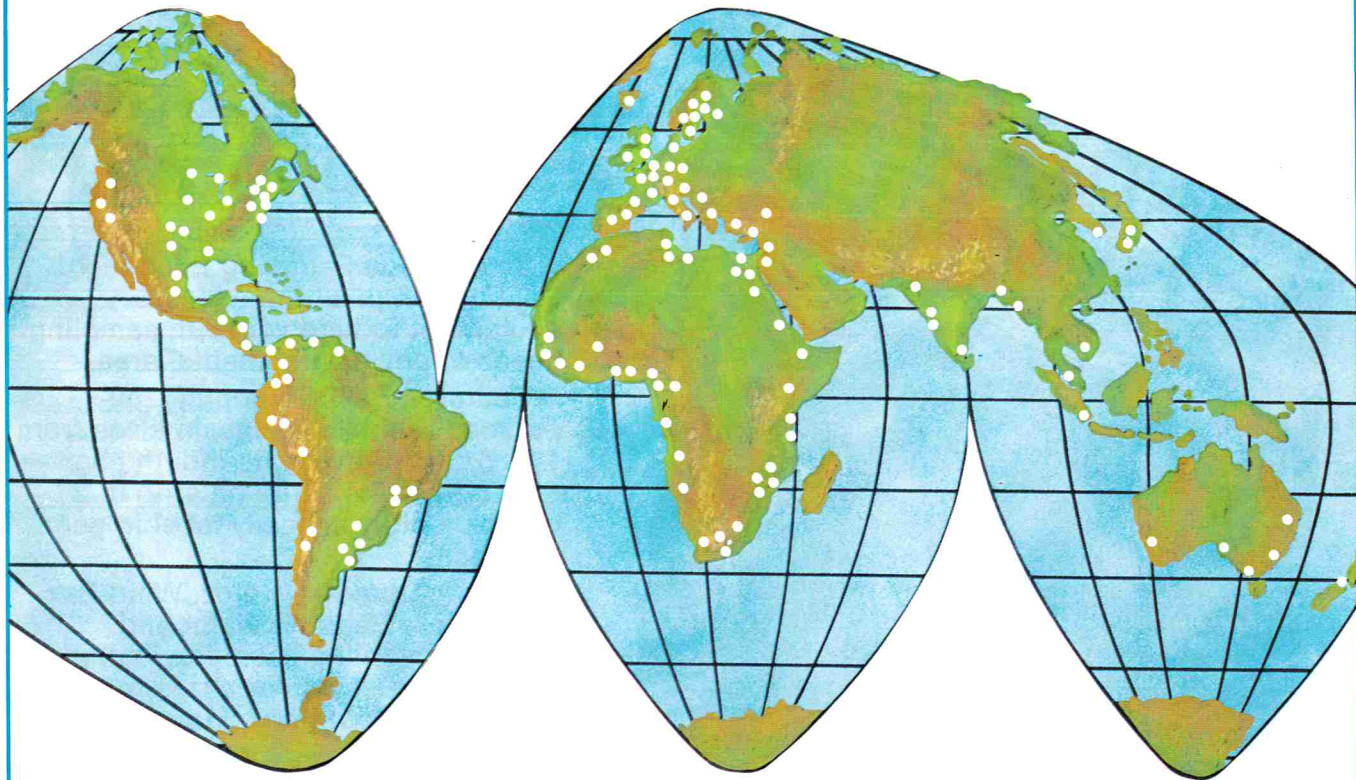
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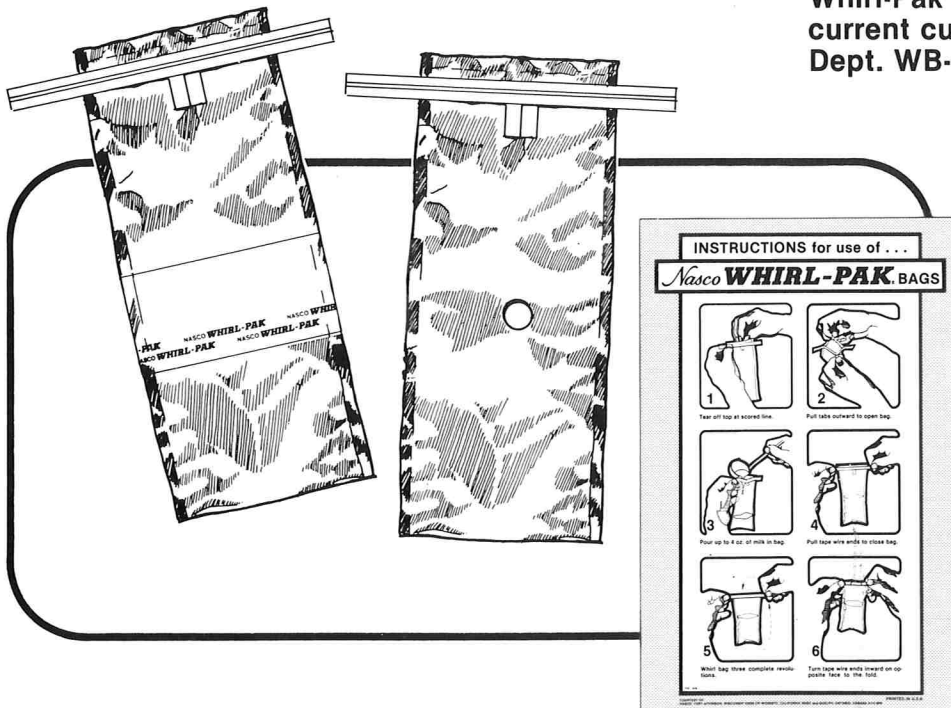
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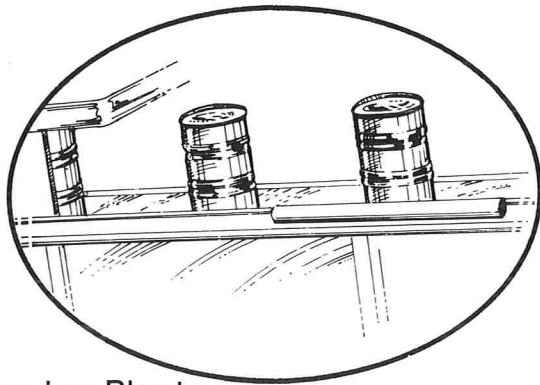


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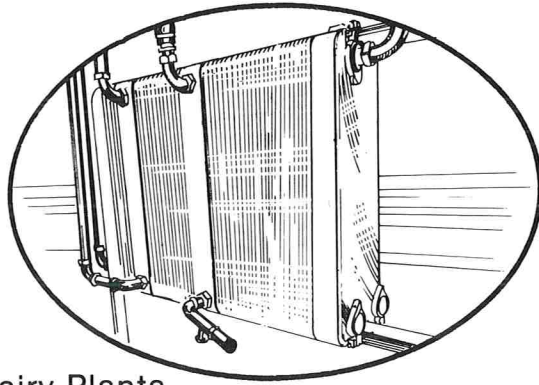
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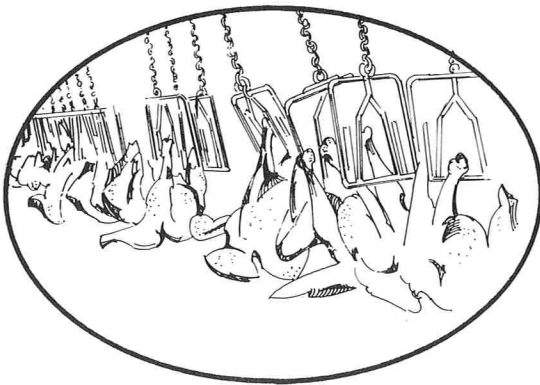
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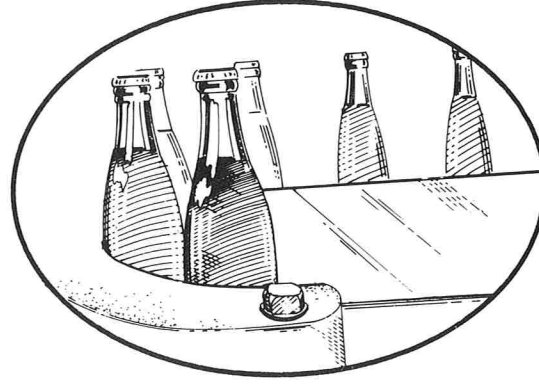
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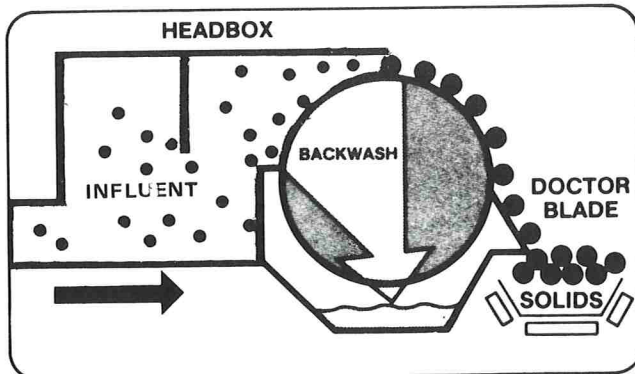
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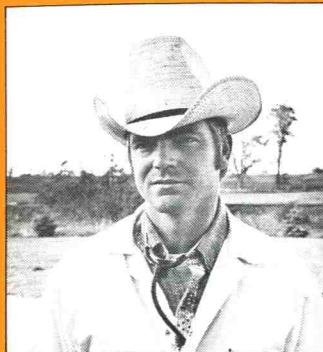
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Dr. Bruce Beachnau, Veterinarian

Dr. Beachnau is an active member of many professional veterinary organizations. He began his current practice, the Portland (Michigan) Veterinary Service in 1967. It has grown to four veterinarians serving more than 600 dairymen and 5,000 cows in a thirty mile radius from Portland. The practice is a three-way partnership with Dr.'s Ken McCrumb and Gerald Segerland and services both domestic and farm animals. It is based on scheduled herd health which has helped dairymen avoid problems through the use of preventive medicine. Dr. Beachnau offers his views on the importance of on-going herd health programs.

Ever since I was a boy and milking cows on my dad's farm, I saw the importance of taking care of them properly. Taking care of them means more than just milking and feeding, and that's even more important with the improved cows and higher efficiency of today's dairy industry. If a dairyman wants to make money, given today's costs, he just can't afford to go without the services of a veterinarian on a regular herd health program. I have had dairymen tell me, "I don't have a herd health problem." Most of these dairymen don't realize they have a problem until we point out certain factors like cows that he thinks are bred and aren't which are costing him money every day. And subclinical mastitis problems resulting in lost milk and slower milking.

What We Do

We get personally involved in the dairyman's operation. Our goal is to catch a problem before it can get a solid foothold on a herd. We look at everything from sanitation to milking equipment, feeding program and record keeping. We also look at the breeding program and give recommendations on improving any part which is lacking. We encourage dairymen to get on a herd health program with visits at least every four weeks. On larger herds of more than 150, we recommend a visit once every two weeks to assure every cow gets enough attention to avoid problems.

Our program includes the following services:

- Checking every cow which freshened since last visit.
- Checking for mastitis and infected udders.
- Checking entire reproductive tract for abnormalities, cystic ovaries, retained placentas, infections, etc.
- Check bred cows for pregnancy.
- Examine cows that are return breeders.
- De-horn calves at four to eight weeks of age.
- Vaccinate for Bangs at two to seven months of age.
- Check feeding program.
- Discuss any problems cropping up since last visit.
- Look at milk production records for sudden drops.

In addition to these other services, we culture mastitis problem cows and recommend dry cow treatment. We also want to find out why these cows have mastitis to make sure there isn't a condition that could spread. Sometimes an inadequate or worn out milking system is a cause. A few years ago, I'd say about 70% of our herds had this problem; today, in our area, it's probably down to about 40% operating with less than capacity systems.

Not An Easy Way To Go But Worth It

If you think a herd health program makes life easier, it's not so. Like anything worthwhile, it takes planning and extra effort to make herd health productive. The first three or four months dairymen become very irritated with the program, but when they start planning for the day of our visit, they get in the groove and realize its importance. An average stop takes about two hours and many dairymen feel it's the most valuable two hours they can spend because it's preventive medicine.

On most herds we see rolling herd production go up at least 1,000 pounds of milk or more by simply clearing up the reproductive tract which all means more milk and more money for the dairyman.

I have seen that every dollar a dairyman invests in a herd health program should return between \$20 and \$30 in higher income. That alone makes the program one of the best investments he can make. A definition of what our ultimate goal is would be something like: To return the most pounds of milk per cow per year and assure that we can raise every calf for the most dollar giving the dairyman the highest return on his investment of labor and time. A dairyman works very hard to make a living, and his returns should be as high as good planning and management can provide. We want to help him make money, and I don't want to see anyone go out of business because I haven't done everything in my power to help. We work closely with other people and organizations in an effort to help the dairyman. For instance, if the milking equipment is causing a problem we work with the dairy equipment dealer to correct the situation. No, it's not easy to coordinate a herd health program, but it can make those long hours in the milking parlor pay bigger dividends.






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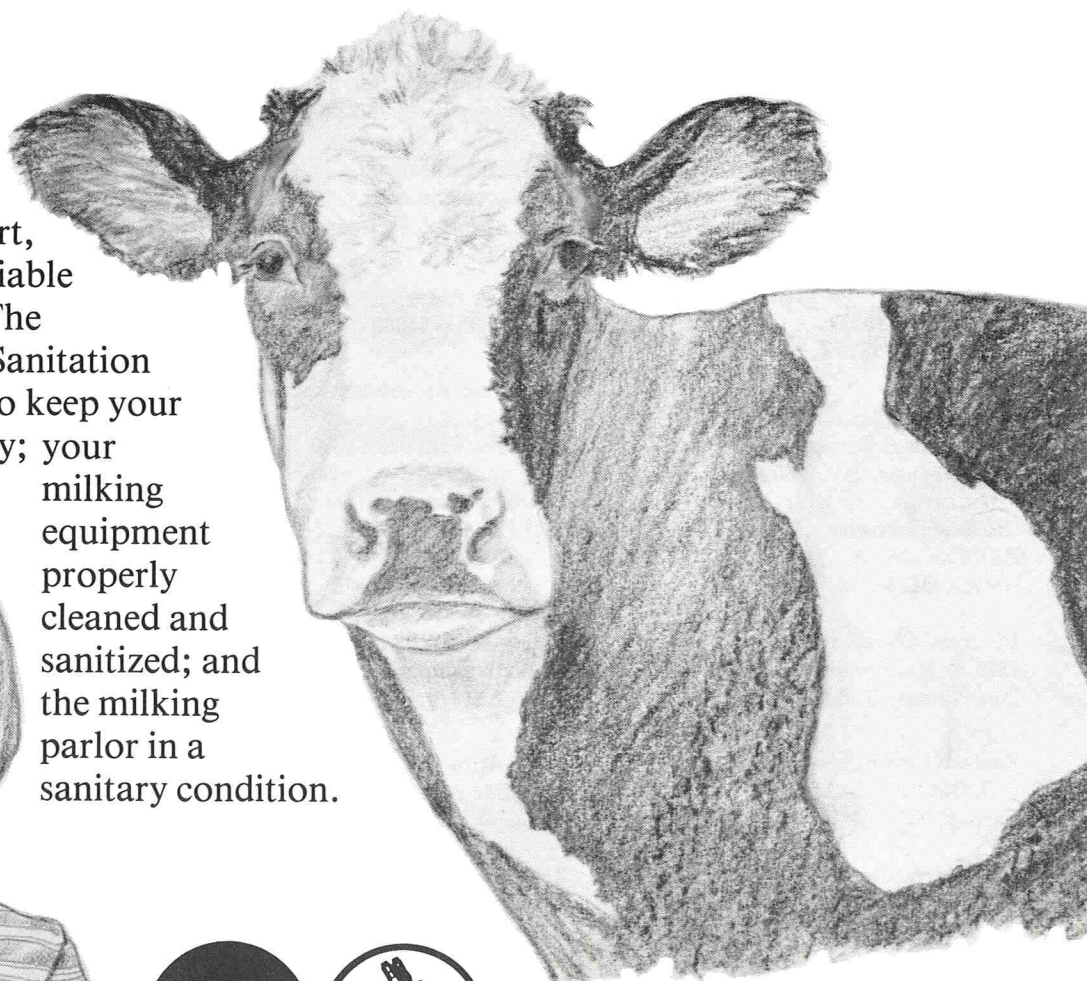
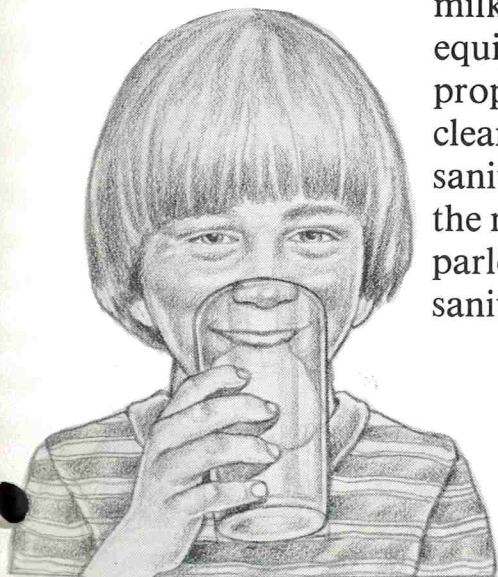
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Whey Ricotta Cheese Manufactured from Fluid and Condensed Whey

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(Received for publication July 31, 1978)

ABSTRACT

Twenty-four different supplies of fresh Mozzarella cheese whey were pasteurized. Twenty-one were evaporated into seven condensed whey product (CWP) categories; three were not evaporated. Each whey and whey product was subsequently manufactured into Ricotta cheese. Average total solids (TS) content ranged from 6.70 to 35.90%. The Ricotta cheeses manufactured from five of the eight categories were judged to be acceptable for the market. Average TS (%) of the acceptable categories were 6.70, 10.31, 14.87, 18.02 and 20.86. Ricotta cheeses manufactured with CWP of average TS contents of 25.10, 28.67 and 35.90% were not acceptable. Flavor defects for Ricotta cheeses that were unacceptable included coarse, unnatural and unclear; body and texture defects included grainy and mealy. We recommend the manufacture of whey Ricotta cheese with approximately 21% CWP. Yield based on total weight for CWP with 20.86 TS averaged 21.32%, more than four times greater than the noncondensed whey. Ricotta cheese from CWP of 20.86% TS tested 69.75% moisture, 7.55% protein, 13.37% lactose, 4.30% fat and 0.72% salt. Large amounts of protein and lactose remained in the Ricotta cheese whey and must be handled properly to prevent pollution.

An estimated 29.5 billion pounds of liquid whey were produced as a byproduct of the cheese industry in 1975, and 81% of that total was sweet whey (6). Strict antipollution requirements (5) and the realization that whey contains protein of excellent nutritional quality (11,14), used in many food products (3,7,9), mandate continued research to improve whey utilization. Manufacture of Ricotta cheese (4,12) is one possible method for reclaiming protein in whey. Currently, this is unattractive to industry because of low yields and high labor costs (12). If yields could be improved significantly and the quality of the Ricotta maintained, the dairy industry might take a closer look at its manufacture from whey. This study was designed to determine the feasibility of manufacturing an acceptable Ricotta cheese from concentrated whey.

MATERIALS AND METHODS

Whey

Fresh Mozzarella whey was obtained from a local cheese plant. Each of 24 different lots was pasteurized at 63 C for 30 min on arrival at the University Dairy Plant and 21 of these were condensed.

Condensed whey

Whey concentrates of varied solids content were manufactured in a Rogers single-effect vacuum evaporator. The evaporator was operated

at 54 C with a vacuum of 660-686 mm. Following concentration to the desired total solids (TS), the condensed whey product (CWP) was stored at 4.4 C until it was manufactured into Ricotta cheese. Average TS content (%) of the CWPs for three trials were: 6.70 (non-condensed), 10.31, 14.87, 18.02, 20.86, 25.10, 28.67 and 35.90.

Manufacture of Ricotta cheese

Each whey supply (three noncondensed and 21 CWPs) was manufactured into Ricotta cheese by the following procedure: (a) One-hundred and fifty-nine kg of whey was placed in a cheese vat equipped with a direct steam injector. (b) The whey was standardized to pH 6.35-6.55 with sodium bicarbonate, then heated to 16-21 C and held 10 min. (c) Heating was continued to 44 C, then 454 g of salt added. (d) Whey was heated to a final temperature of 88 C over a period of 45 min. (e) Emulsion Sag 10 defoamer was added as required to control foaming. (Union Carbide, Hamblet and Hayes Co., Colonial Road, Salem, MA). Granular citric acid dissolved in 2.5 l of hot water was dispersed throughout the whey in amounts necessary to lower the pH of the whey at coagulation to 4.8-5.0. (f) The steam valve was closed slowly when precipitate first appeared (0.5-1.0 min). Jacket steam in the cheese vat was turned on for 5 min. (g) After an additional 15-20 min, whey was drained from the vat through cheese cloth placed over the outlet to prevent curd loss. (h) Remaining curd and whey were stirred and drained into a sanitized plastic bucket. The contents of the bucket were then emptied into perforated plastic containers lined with disposable polyethylene cheese press wraps. (i) Curd was drained for an additional 15 min, covered, then drained overnight at 4.4 C.

Collection of samples

Samples of whey before precipitation were taken directly from the cheese vat after salt had been added. Also, whey samples after precipitation were taken when the vat was partially drained. All whey samples were collected in both 177- and 532-ml Whirl-Pak bags. Cheese samples were collected aseptically in 532-ml bags and in 454-g cardboard containers.

Laboratory analyses

Whey. The pH and titratable acidity of the whey (8) were recorded three times: upon arrival at the plant, before precipitation and again after precipitation in the cheese vat. Samples collected before and after precipitation were analyzed also for TS (8), protein (2), fat (8), and lactose (10).

Ricotta cheese. Chemical tests made on the cheese samples were pH (8), moisture (8), protein (2), fat (8), salt (13) and lactose (10). Microbiological tests (1) were Standard Plate, Coliform, Psychrotrophic and Yeast and Mold Counts.

The palatability of each Ricotta sample was evaluated by two experienced cheese-flavor specialists. Flavor, body and texture were each rated on separate scales from 1.00-5.00. A score of 5.00 points for flavor as well as for body and texture indicated an excellent sample. Deductions in units of 0.25 points were used to rate the severity of criticism. Ricotta cheese with an average score of 4.00 and above for flavor as well as body and texture was established as acceptable for the market.

¹Present address: Borden Company, Syracuse, N.Y. 13217.

RESULTS AND DISCUSSION

Fat was not separated from the 24 fresh Mozzarella whey supplies that were received at the University Dairy Plant. Each supply was obtained from a local cheese plant on 24 different days and was used as received without standardization or fortification. Additional processing was not desirable because we did not want to increase the cost of Ricotta cheese manufacture. Consequently, variations in major constituents for whey, condensed whey products (CWPs), and manufactured Ricotta were expected and evident. Data presented here are average values of three trials for each of the eight whey products.

Quality of Ricotta

Most nutritionists would agree that the proteins, minerals and vitamins in whey Ricotta cheese are excellent quality nutrients. However, if the cheese is not palatable, nutritional value will not be used. Thus, subjective analysis of the finished products was considered first. Data in Table 1 show Ricotta cheeses manufactured from 6.70 (non-condensed) to 20.86% TS are acceptable for the market. CWPs of 25.10, 28.67 and 35.90% TS were not acceptable. Flavor defects for the unacceptable Ricotta cheeses included coarse, unclean, and unnatural; body and texture defects included mealy and grainy. These sensory defects were associated with increased lactose and decreased fat and moisture contents. Ricotta, manufactured with CWP of 20.86% TS content, had a pleasantly sweet taste, and possessed neither a foretaste nor aftertaste other than its natural

TABLE 1. Flavor scores of whey Ricotta cheese manufactured from fluid and condensed whey products (CWP).

Total solids of CWP (%)	Scorecard categories ^a		Average score ^b
	Flavor	Body and texture	
6.70 noncondensed	4.42	4.25	4.34
10.31	4.83	4.58	4.71
14.87	4.33	4.42	4.38
18.02	4.33	3.83	4.08
20.86	3.75	4.25	4.00
25.10	3.83	3.50	3.67
28.67	2.83	4.33	3.58
35.90	2.17	3.17	2.67

^aSamples judged by 2 experienced cheese-flavor specialists on a graduated scale from 1 to 5 for both flavor and for body and texture (5 was excellent quality). Average values for 3 trials.

^bRicotta cheese with average score below 4.00 not acceptable for the market.

flavor. It had a firm body and a smooth and velvety texture. We recommend the manufacture of whey Ricotta cheese from CWP having approximately 21% TS.

Consumer acceptance for this product would depend greatly on its shelf-life. However, this study was not designed to examine the shelf-life of Ricotta cheese. Microbiological data of the 24 Ricotta cheeses indicated they were not grossly contaminated. The cheese manufactured from 20.86% TS contained less than 8,000 organisms per g, less than 10 coliform and psychrotrophic bacteria, and less than 1 yeast and mold. These data suggest that manufacturing Ricotta cheese by the above-described method can produce a product with acceptable shelf-life.

Yield and composition of Ricotta cheese

Yield of Ricotta cheese was calculated as a percentage based on the total weight of solids recovered from 45.36 kg of whey and CWPs. These values are presented in Table 2, column 2. Yield from noncondensed whey was 5.25% and compared to a 6.0% value reported by True (12). As %TS of CWP increased, yield increased correspondingly. Obvious reasons for these increases were higher %TS of the CWPs and recovery of more than these TS in the Ricotta cheeses. As seen in Table 2, yield for the 20.86% CWP averaged 21.32%, more than four times greater than for the noncondensed whey (6.7%).

Federal standards of identity have not been established for Ricotta cheese. Data in Table 2 show that as the yield of Ricotta cheese increased, there was a corresponding rise in percentages of lactose and salt; moisture content decreased uniformly, while levels of protein and fat were variable. Actual percent composition for each of the major constituents in the marketable Ricotta cheeses are shown in Table 2. Ricotta, manufactured from 20.86% CWP, contained the following composition: 69.75% moisture, 7.55% protein, 13.37% lactose, 4.30% fat and 0.72% salt.

Composition of Ricotta Cheese whey

Percent protein, lactose, and fat that remained in the Ricotta cheese whey is reported to show the efficiency of the precipitation process. As seen in Table 3, when the %TS of the CWP increased, percentages of protein, lactose, and fat were variable. The reason for such variability is thought to be caused by the difficulty of controlling an exact make procedure from batch to

TABLE 2. Yield and composition of marketable Ricotta cheese manufactured from fluid and condensed whey products (CWP)^d.

Total solids of CWP (%)	Yield ^b	Composition (%)					Percent protein ^c	Percent fat ^d
		Moisture	Protein	Lactose	Fat	Salt		
6.70 ^e	5.25	79.24	9.29	4.46	5.83	0.41	61.96	62.47
10.31	9.88	78.03	7.67	7.13	3.67	0.50	59.35	57.70
14.87	15.69	75.21	8.10	9.50	3.83	0.57	64.08	59.97
18.02	16.85	71.81	9.06	12.31	2.43	0.70	62.22	37.09
20.86	21.32	69.75	7.55	13.37	4.30	0.72	59.06	56.11

^aAverage values for 3 trials.

^bValues calculated as percentage of total weight of beginning product.

^cPercent protein recovered in cheese from whey containing varied solids concentration.

^dPercent fat recovered in cheese from whey containing varied solids concentration.

^eNoncondensed.

TABLE 3. Percentage of protein, lactose, and fat remaining in the whey after precipitation of the curd for manufacture of marketable Ricotta cheese^{a,b}.

Total solids of CWP ^c (%)	Percentages		
	Protein	Lactose	Fat
6.70	52.71	89.49	10.32
10.31	42.92	80.64	8.03
14.87	38.45	71.81	3.40
18.02	36.87	82.15	10.53
20.86	37.38	69.89	3.63

^aAverage values for 3 trails.

^bPercentage of each constituent calculated by the following equation:

$$\% \text{ of constituent} = \frac{\text{Kg of constituent in whey after precipitation}}{\text{Kg of constituent in whey before precipitation}} \times 100$$

^cCondensed whey products.

batch. This appears to be a general problem in the commercial manufacture of Ricotta cheese.

In conclusion, Ricotta cheese of marketable quality was manufactured successfully from Mozzarella whey that was condensed to a TS content of 20.86%. A four-fold increase in yield, when compared to results obtained from noncondensed whey (6.7%), should make this procedure attractive to the cheese industry.

ACKNOWLEDGMENTS

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Coming Events,

con't. from p. 609

Oct. 14-17--24th ANNUAL ATLANTIC FISHERIES TECHNOLOGISTS CONFERENCE. Danvers, MA. Contact: Fred J. King, 1979 AFTC Secretary, Gloucester Laboratory, Northeast Fisheries Center, National Marine Fisheries Center, National Marine Fisheries Service, Emerson Ave., Gloucester, MA 01930, 617-281-3600, ext. 296.

Oct. 20-25--COMBINED CONFERENCES, EXPOSITIONS: National Environmental Sanitation & Maintenance Educational Conferences, Expositions of Environmental Management Association, The Green Industry Division, Food Sanitation Institute, Health Care Facilities Subsidiary, and Building Service Manager's Institute. Caribbean Gulf Resort Hotel, Clearwater Beach, FL. Contact, for any of the five conferences: EMA, 1701 Drew St., Clearwater Beach, FL, 33515, 813-446-1674.

Nov. 3-6--1979 AMERICAN MEAT INSTITUTE CONVENTION. McCormick Place and The Conrad Hilton, Chicago. Contact: Judi Winslow, American Meat Institute, P.O. Box 3556, Washington, D.C. 20007, 703-841-2431.

Nov. 11-15--FOOD AND DAIRY EXPO '79. McCormick Place, Chicago, IL. Contact: Wes Dibbern, Dairy and Food Industries Supply Assoc., 5530 Wisconsin Ave., Suite 1050, Washington, D.C. 20015, 301-652-4420.

Nov. 27-29--INTERNATIONAL CONFERENCE ON UHT PROCESSING AND ASEPTIC PACKAGING OF MILK AND MILK PRODUCTS. North Carolina State University, Raleigh, NC 27650. Contact: W. M. Roberts, Dept. of Food Science, NCSU, Raleigh, NC, 27650.

Dec. 3-8, 10-15--DAIRY DAYS. Sponsored by University of Nebraska-Lincoln Institute of Agriculture and Natural Resources, Nebraska State Dept. of Agriculture, and Nebraska milk marketing outlets. Cooperating organizations are Nebraska Veterinary Medical Association and Dairy Women of Nebraska. Two programs, one week apart, will be held in the following locations: Columbus, NB---Dec. 3, 10; Beemer, NB---4, 11; Hartington, NB---5, 12; O'Neill, NB---6, 13; Ravenna, NB---7, 14; Beatrice, NB---8, 15. Contact: Nebraska Dairy Women, plant fieldmen, or county extension agents for advance registration.

Mar. 26, 1980--ONTARIO FOOD PROTECTION ASSOCIATION, Annual Meeting. Holiday Inn, 970 Dixon Road, Toronto.

Concerns, Experiences, Attitudes and Practices of Food Market Managers Regarding Sanitation and Safe Food Handling Procedures¹

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ABSTRACT

Managers or owners from 219 randomly selected food markets in Oregon were surveyed concerning their attitudes and practices on sanitation and safe food handling. Completed questionnaires were received from 49.8% of those surveyed. Inquiries were made relative to sanitation procedures used, knowledge of sanitation principles, and food protection and safety. Most indicated a concern for sanitation and felt that the employed procedures were effective. The survey indicated a lack of specific knowledge on basic principles of sanitation and food safety. Few respondents understood elementary principles of food contamination, temperature controls, personal hygiene and food protection. Most responses indicated a need for a training program in sanitation and safe food handling procedures for food retail employees at all levels.

Several programs in retail food market sanitation have been developed recently. The Joint Committee of the United States Department of Agriculture and the National Association of Retail Grocers of the United States have established a check list and guidelines for retail store sanitation (7). These guidelines have been offered as an aid for the retail store employee in achieving sanitary conditions, but no effort is made to educate or train individuals in sanitation procedures within this program.

The Food Marketing Institute has developed a program and a set of training materials for management, the "Uniform Sanitation Training and Certification" or the MUST program (3). This program is designed to give the participants an understanding of the role of retail food store management in public health and safety; significance and need for sanitary food handling practices; good sanitation practices; and principles of good sanitation as good business.

The Food and Drug Administration has published a proposed model ordinance for retail food store sanitation (2). The ordinance sets forth minimum requirements for retail food store compliance. The purpose of the model ordinance is to set uniform standards across the country.

In 1974 a nationwide survey of homemakers' attitudes on food safety was conducted by the United States Department of Agriculture (8). The objectives of this survey were to obtain information on homemakers food

safety practices and knowledge of bacterial contamination of food; to identify those groups of people having the greatest needs for food safety information; and to solicit homemakers' opinions on the most effective ways of disseminating food safety information. Results showed 63% of homemakers sampled conducted at least one high-risk practice relating to handling, preparing and storing selected meat and poultry products. Most homemakers were unfamiliar with conditions and practices allowing bacteria to grow and their potential for foodborne illness. Most of the homemakers were unaware of the effects of food contamination and the role personal hygiene plays in protecting food from contamination. Thirty-two percent of the homes surveyed maintained their refrigerators at or above 45 F.

In 1977, the Oregon Department of Agriculture review committee on meat bacterial standards recommended a continuous education and training program be provided to Oregon retail food store employees (6). The stated purpose of this program was to educate retail store employees in proper sanitation and safe food handling procedures and help them understand and solve food sanitation and food safety problems. However, very little was known about the concerns, experiences, attitudes and practices of food retail personnel on sanitation and safe food handling practices. Therefore, the purpose of this study was to gain some insight into the opinions, practices, knowledge and experiences regarding procedures for sanitation and food safety of food retailers.

METHODS

A questionnaire was used to collect information from food market employees on knowledge, attitude, opinions, experiences and practices regarding sanitation and food safety. The questionnaire was developed, reviewed and approved by the Oregon State University Survey Research Center. The questionnaire was pre-tested and minor changes made in certain questions based upon the findings of the pre-test.

A systematic sample of licensed meat sellers in the State of Oregon was selected from a list provided by a licensing agency, the Oregon Department of Agriculture. Ten percent (219) of the total number of food stores in Oregon was chosen as the sample.

Questionnaires were mailed to the respondents along with a cover letter explaining the purpose of the study, the importance of the cooperation of the respondents and the confidentiality of information obtained. The respondent was asked to return the questionnaire within a 2-week period in the self-addressed stamped envelope provided. If the initial questionnaire was not returned within the 2-week period, a

¹Oregon Agricultural Experiment Station Technical Paper Number 4991. Supported, in part, by funds from the Oregon Retail Council.

follow-up letter and questionnaire were sent. The frequency distributions of the response to each question were examined.

RESULTS AND DISCUSSION

Completed questionnaires were received from 49.8% of those surveyed. The response rate in each category of food store is shown in Table 1. The sample was classified into the following categories: chain supermarkets, convenience stores, independent food markets, meat markets and others (i.e. warehouses, cooperatives, wholesale, produce markets, etc. on the basis of the license list). The survey response was determined by the respondent. Approximately 5.5% of the initial mailing of questionnaires was returned as undeliverable, incomplete address, out of business, changed owners, or refused to answer questionnaire.

TABLE 1. *Categories of food stores in survey.*

	No. in sample	% of sample	% response
Chain supermarket	36	16.4	20.4
Convenience store	27	12.3	29.6
Independent food market	122	55.7	45.4
Meat market	16	7.3	9.3
Other (warehouse, co-ops, produce, wholesale, etc.)	18	8.2	11.4
TOTAL	219	—	49.8

The returned questionnaires indicated 82.4% of those surveyed had a routine sanitation procedure that was being followed by employees and that they were achieving a "good" to "very good" job of keeping the store sanitary. A few (0.9%) of the establishments had no "outside" employees as the store was family-owned and -operated. Only 2.8% of the establishments felt they were not doing a good job in keeping their store sanitary. An attempt was made to determine, from the respondents point of view, the motivating factor for store sanitation. The question was posed to bring forth these attitudes. The answers reflect ambivalence. Such responses as "good for customer relations," "corporate policy," "protect health of customers," "good for business," "required by law," were some of the reasons given.

A substantial percentage (40%) of respondents indicated they do not have any programs for training or educating employees in sanitation and safe handling practices. Table 2 shows sources of information on proper sanitation procedures. The majority (65.7%) seem to learn by experience on the job. Beyond that there doesn't appear to be any other source from which most

TABLE 2. *Sources of information on sanitation procedures.*

Source	% Response
Experience	65.7
Trade publications	42.6
Newspapers - TV	35.2
Company policies	31.5
Company headquarters	27.8
Salesmen	25.9
Formal training	21.3
Other (inspectors, etc.)	16.7

retailers acquire information on sanitation procedures.

A fear of more government regulations and increased control of business was clearly expressed by some of the respondents. Many commented on the confusion and inconsistency in requirements and regulations from the multitude of governmental agencies such as federal, state, county, city, etc. However, when asked if they were aware of proposed federal regulations on sanitation requirements for retail food stores, most (68.5%) responded they had no knowledge of this proposal.

A battery of questions was designed to obtain data about the specific knowledge of food retailers on sanitation and safe food handling practices. As expected, most (72%) judged their knowledge on sanitation as being adequate. The attitude reflected was positive and the individual judged himself as being knowledgeable, doing the right things and confident he would give the right information. The right information was concerned with such things as ability to explain food poisoning to customers, which involves specific knowledge of bacteria, conditions of growth and potential foods involved (Table 3).

TABLE 3. *Self-evaluation of knowledge of food sanitation and safe food handling practices.*

Factor	Response
Adequacy of knowledge	72% - adequate 16.7% - need an up-date 6.5% - inadequate
Ability to explain to customers what food poisoning is	78.7% - could do so
Need for a training program on sanitation and safe food handling practices	67.7% saw a need

The questions purposely did not reflect details such as different types of organisms that can cause illness, foods involved, symptoms, conditions necessary to cause illness, etc. It is obvious from the nature of the response, the respondents attached little importance to this technical information.

In an attempt to evaluate if the individuals did in fact have specific knowledge, a series of "specific knowledge" questions were designed. A group of organisms were listed and the individual was asked to indicate which ones would cause food poisoning. The types of responses varied greatly but only *Salmonella* and trichinia were recognized by the majority (over 50%) as being a causative factor for food-borne illness. Less than 50% of the respondents failed to recognize the potential dangers associated with *Bacillus*, *Staphylococcus*, *Escherichia* and *Clostridium* organisms (Table 4).

The fact that less than 50% of the respondents surveyed ranked *Escherichia* as an organism causing illness is interesting. The food retailers in Oregon should be more familiar with this organism due to problems experienced with the Oregon meat bacterial standards, which were in effect from 1973-1977 (6). Possibly if "*E. coli*" had been the nomenclature for the organism used in the questionnaire instead of "*Escherichia*" a different

TABLE 4. Grouping of organisms as to pathogenicity.

	Food pathogen	Non-food pathogen
Acceptable grouping	<i>Salmonella</i>	<i>Lactobacillus</i>
	<i>Bacillus</i>	<i>Aerobacter</i>
	<i>Trichinia</i>	<i>Streptococcus</i>
	<i>Staphylococcus</i>	<i>Pseudomonas</i>
	<i>Escherichia</i>	
	<i>Clostridium</i>	
	Food pathogen ^a	Non-food pathogen ^b
Survey response	<i>Salmonella</i>	<i>Lactobacillus</i>
	<i>Trichinia</i>	<i>Bacillus</i>
		<i>Aerobacter</i>
		<i>Staphylococcus</i>
		<i>Streptococcus</i>
		<i>Escherichia</i>
		<i>Clostridium</i>
		<i>Pseudomonas</i>

^aRanked by over 50% of respondents.

^bRanked by less than 50% of respondents.

level of response would have been obtained. However, the obtained response may have reflected a "true" level of recognition, in the fact the organism is not considered harmful. Spokesmen for the food retail industry have made this point in an argument against the enforcement of the former bacterial standards on meat products (4,5,10).

To further determine the level of specific knowledge of the respondents, a series of statements related to food sanitation and food handling were listed. The respondent was asked to agree or disagree with a series of statements (Table 5).

Good agreement or proper response was obtained on subject matter questions dealing with simple elementary statements about bacteria such as conditions of growth for bacteria. However only approximately 1/3 of the respondents knew or understood more specific facts about bacteria, such as statements relating to the mode of transport of bacteria and basic principles of food contamination.

A relatively high percentage (77.8%) recognized growth of bacteria can be controlled by keeping foods cold. There was not the same level of recognition or understanding of some of the more complex statements such as "safe temperatures for potentially hazardous foods are 45 F or below and 140 F or above." Only 37% of the respondents agreed that this was a correct statement, which would basically indicate the respon-

dents were unsure of specific temperatures necessary for adequate control of the growth of bacteria.

The response on the statement "frozen food should be held at 10 F or below" is interesting. Seventy-five percent agreed with the statement, but more important, is the fact that such a large number of food retailers agreed with *that* statement. The Oregon sanitary code requires frozen foods be held at 0 F or below; a temperature of 10 F would be unacceptable.

Concerning the statement "food contact surfaces can not be adequately cleaned without the use of sanitizers" - 64.8% agreed with this statement. Concurrently, a combination of 30.6% either disagreed or strongly disagreed with this statement. This statement attempted to gain an insight as to the specific awareness of food retailers on what constitutes "sanitation" and how it can be accomplished. However, based upon the response to this statement, a common reliance on chemical sanitizers is apparent and reflects belief in the "magic of chemicals." The fact that food-contact surfaces must be cleaned before the application of sanitizers is not reflected as a practice by the respondents.

A question was designed to determine how retailers perceive given situations and their relationship to public health. The situations listed in the questionnaire are most common to the operation of food markets.

Table 6 lists the various situations posed in the questionnaire. The respondent was asked to rank them one to ten as to which situations would pose the greatest *public health risk* (one being the greatest and ten the least). Each situation will be discussed separately.

A. Sick employees

One would expect a high ranking for potential public health hazard. Indeed the majority (51.9%) did give it a high (1-3) priority. However, it should be noted this is a much lower response than is acceptable. If the respondents were adequately aware of the real dangers and problems ill workers can cause in handling food, a greater percentage would have recognized this as a "high risk situation."

B. Food stored at 120 F

The temperature of 120 F is at the end of the danger zone, a temperature where many harmful organisms can

TABLE 5. Response to statements related to food sanitation and safe food handling practices.

Statement	Correct response	Survey results	
		Correct	Incorrect
Bacteria need specific conditions to grow and multiply	Agree	82.4%	14.8%
All bacteria are harmful	Disagree	94.5%	2.8%
Frozen food should be held at 10 F or below	Agree	75.0%	24.2%
Bacteria can go from place to place without help	Disagree	39.8%	54.6%
Bacteria do not grow rapidly at refrigerated temperatures	Agree	77.8%	19.4%
Food products containing food poisoning organisms will smell spoiled	Disagree	87.0%	9.3%
Safe temperature for potentially hazardous foods are 45 F or below and 140 F or above	Agree	37.0%	52.8%
Food contact surfaces can not be adequately cleaned without the use of a chemical sanitizer	Disagree	30.6%	64.8%
As long as saw and grinder are kept clean it is not necessary to sanitize them during a day's processing of different cuts of meat such as beef, pork and poultry	Disagree	80.5%	13.0%

thrive and cause serious problems. Again most (55.6%) did recognize the seriousness of that temperature but a fact worthy of concern, is that a significant portion of the sample *did not readily recognize* the dangers of a food product being held at 120 F and the importance of temperature control for microbial growth.

C. Storing fish, poultry and meat in the same cooler room

Storing of fish, poultry and meat together is a practice that should not be tolerated in a food market under any circumstances. In design of the question, the author felt it would receive an overwhelming response as a "high public health risk." In fact, the response was almost the opposite. The situation was ranked as a "low risk" by 59.9% of the respondents. One might argue the practicality of the situation in that a market may only have one cooler room, and therefore the practice would be satisfactory if the products were properly segregated and proper control measures taken. However, as the situation was cast in the question, the practice offers an excellent opportunity for cross-contamination and this apparently was not discerned by many respondents.

D. Smoking and eating by employees in food preparation areas

The author again expected to receive a relatively strong ranking of this situation as a "high risk," since it is a prohibited act; survey results showed just the opposite. Only 7.4% of the respondents gave this situation a one to three ranking. This illustrates a lack of understanding of the sources of food contamination and the importance of proper methods for food protection.

E. Cracks in floors or walls

Cracks in a food establishment do pose a potential source of food contamination, a place for insects to be harbored, filth and mold to accumulate and could lead to many problems in a food market. Floors and walls must be adequately cleaned and food sanitation and housekeeping practices followed. It is recognized that if proper procedures are followed and adequate cleaning and sanitizing accomplished, then cracks in floors and walls are not as critical, therefore a moderate ranking was expected. It was assigned a "low risk" (8 to 10) situation by 70.3% of the respondents, while 4.6% assigned it to a "high risk" (1-3) situation.

F. Meat processing room temperature of 55 F

Most meat processing rooms are set at 55 F primarily for the workers comfort. It is very uncomfortable to work at temperatures much below 55 F for any length of time; however, control procedures are necessary to prevent the temperature of the product from exceeding 35 F. This is usually accomplished by moving the product through the processing room rapidly. This concept was not intentionally made a part of the situation. It was designed to determine the level of knowledge of the temperature factor only. The generated response was uninformative, which may indicate a questionable fact of what the temperature should be.

G. Discolored meats

Many consumers associate the color of fresh meat with its safety and discolored or dark meat is considered spoiled or unsafe. Consumers made this association as they do not understand the role of oxygen and meat pigmentation. The situation was posed to test or determine how well food retailers understand this concept. Fifty-eight and three tenths percent of the respondents correctly assigned discolored meat as a "low risk" situation.

H. Broken cartons of dry foods

This situation specifically included the words "dry foods" to convey to the respondents that the situation concerned foods that were not likely to spoil quickly or would not support the growth of pathogenic organisms (i.e. low-moisture foods). The broken package itself could pose a potential for food contamination however. An expected low risk situation was indicated (62.9%).

I. Products on display beyond the pull-date

A great deal of attention has been given to dates on perishable foods in Oregon. A law is currently in effect requiring an "open date" on all perishable foods and the regulatory agencies are checking for the presence of these dates and noting violations when not in compliance with the law. It was assumed the food industry would be very sensitive to dating requirements, and for this reason the situation was included in the questionnaire. A very low number of respondents, 7.4%, considered products on display past their pull-date as a "high risk" situation,

TABLE 6. Numerical ranking^a of situations as to degree of public health risk.

Situation	Expected groupings	Results		
		1-3	4-7	8-10
Sick employees	high	51.9%	24.1%	24.1%
Food stored at 120 F	high	55.6%	17.6%	26.9%
Storing fish, poultry, and meat in same cooler room	high	12.9%	32.4%	59.3%
Smoking and eating by employees in food preparation areas	high	7.4%	48.1%	44.4%
Cracks in floors or walls	moderate	4.6%	25.1%	70.3%
Meat processing room temperature of 55 F	moderate	30.5%	35.3%	34.2%
Discolored meats	low	11.1%	30.5%	58.3%
Broken cartons of dry foods	low	5.6%	31.4%	62.9%
Product on display past pull date	low	7.4%	45.4%	47.3%
Temperatures above freezing in frozen foods case	low	53.7%	23.1%	23.2%

^a1 = High.

10 = Low.

however the remaining respondents were mixed as to the degree of risk involved.

J. Temperatures above freezing in frozen foods case.

Oregon law requires products to be maintained at 0 F or below and specifies that the product should not be allowed to go above 10 F during the defrost cycle or similar operations. Previous research by investigators at Oregon State University (1) revealed a serious lack of adequate temperature control by food retailers. The results of this research study have been widely disseminated to food retailers and in some organizations definite action has been taken by management. Inspectors of the state regulatory agency devote specific attention to temperature checks as part of their routine inspection procedures. The inspectors are now equipped with electronic thermometers designed to give the temperatures of products within several seconds, without destroying the integrity of the package. As a result of these efforts it can be readily observed that food retailers are sensitive about temperature monitoring in their stores.

The survey data confirm this assumption, however, the respondents did not discern factors of quality vs. safety. Temperatures above freezing would pose a serious public health risk according to 53.7% of the respondents.

There is a common assumption that the people who work in grocery stores do not stay on any given job for a very long time. In fact, a 100% turnover rate is often quoted (9). In planning for any form of training program this fact is always discussed. The respondents were asked how long they had worked in food stores (Table 7). Seventy-four percent indicates they had worked in food stores for over 10 years. This may not be such a notable fact, as most respondents (80.6%) would be classified as managers or owners.

TABLE 7. *Length of time respondents have worked in food stores.*

Less than 1 year	4.6%
0-5 years	12.0%
5-10 years	9.3%
Over 10 years	74.1%

It could be stated that maybe an individual does change jobs and maybe with different companies, but it seems from the survey data a large percentage stay within the food retailing industry. Therefore the value of training that individual has much greater merit. A need for a training program on sanitation and safe food handling practices was indicated by 76.6% of the respondents. The response indicated practically all positions in a store should be trained (Table 8) not necessarily only individuals holding managerial positions.

A question was designed to give the respondents an opportunity to comment freely on factors that in their opinion create insanitary conditions in a food store, such as practices of shoppers. The comments were most interesting. A very frequent comment made was the fact that the public does not exercise good personal hygiene

TABLE 8. *Types of employees recommended for training in sanitation and safe food handling.*

Position	% Response
Managers	47.2
Meat cutters	38.9
Clerks	36.1
Deli-section workers	32.4
Bakers	28.7
Box persons	19.4

and many bring disease, filth, dirt, etc. into stores. Customers are observed opening food cartons, misplacing items in a store, eating bulk displayed foods, etc. But the factor consistently discussed by the respondents has to do with the insanitary conditions created by return of soft drink and beer containers. Handling of these containers by the clerks and holding them in their stores until picked up by distributors created the most serious public health hazard in the opinion of the food retailers.

All respondents were assured a copy of the survey results would be made available to them and 87% indicated they would like to receive a copy of the published results.

SUMMARY

This study indicates a need for training retail food store employees in sanitation procedures and safe food handling. It also points out that individuals surveyed stay within the industry for a relatively long time, which further justifies the need for a sanitation and food safety training program. In industries that experience a rapid turnover of personnel it is sometimes difficult to justify the expense of a training program.

The study showed a distinct lack of knowledge of fundamentals of good sanitation and safe food handling practices. For the food retailers surveyed, a positive response for the merits of good sanitation was received and many readily recognized potential benefits. It is apparent that the necessary training program should be offered by a qualified organization and not left up to the individual store to develop since industry experience seems to be the only identified source of information for sanitation procedures for food retailers.

ACKNOWLEDGMENTS

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Book Review

"Hazardous and Toxic Effects of Industrial Chemicals," by Marshall Sittig. Noyes Data Corporation, Park Ridge, NJ 1979. 460 pp. \$42.00.

This book is a comprehensive encyclopedia of chemicals that are of concern to the industrial hygienist and is an attempt to catalog the hazard status of approximately 240 chemicals or groups of chemicals. The information given in the book was derived mainly from publications from government agencies; i.e., the National Institute for Occupational Safety and Health and the Environmental Protective Agency. Other data came from the conferences and other referenced sources.

Each chemical or group is listed and described as follows: name, description, synonyms, potential occupational exposures, permissible exposure limits, route of entry, harmful effects, medical surveillance, special tests, personal protective methods, and a bibliography. This format provides ready reference for the reader, and no index is necessary. One purpose of the book is that of "preventive medicine" in effect, that is, by presenting an assessment of potential hazard from the chemicals, workers and control personnel can become informed and then take necessary precautions to prevent or minimize hazard.

Since the items are presented in alphabetical list form, there is no grouping with regard to occupation as such. Also, in many instances, permissible exposure limits (federal standards) serve as a regulatory guide, but may not help the worker who does not know what a "ppm" is in his use of the chemicals. This is not a fault of the book, but possibly a shortcoming in the education of handlers of hazardous chemicals. A possible hidden value of the book is the revealing of a paucity of information under the "Special Test" heading, indicating that much analytical research is needed for developing methods for the specific chemicals.

Admittedly, no single volume can be expected to cover all known or potentially dangerous industrial chemicals, but this book is a clear catalog of many of those recognized by government agencies. However, application to food processing is ambiguous in some instances. For example, the permissible exposure limit for phosphoric acid is given as 1.0 mg/m³ (1 ppm), but the Food and Drug Administration regards phosphoric acid as "generally recognized as safe when used in accordance

with good manufacturing practice," with no tolerance set (Code of Federal Regulations, Title 21, Ch. 1, Part 182, 1073, April 1, 1978). The user of the handbook should not take the limits out of context, but should consider the entire text which points out that, in the same example, the mist of phosphoric acid at 1 ppm may be an irritant, not the food additive as such.

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Book Review

Food Microbiology. Third Edition. W. C. Frazier and D. C. Westhoff. McGraw-Hill Book Co., 1221 Avenue of the Americas, New York, NY 10020. 540 pp. 1978. \$19.50.

This book will serve very well as a reference on food microbiology for veteran food scientists and technologists as well as for beginning food microbiology students. This book is not only well written, well organized, and a very up-to-date and complete treatise of food microbiology, but the price is right.

This text is divided into six major sections: Food and Microorganisms; Principles of Food Preservation; Contamination, Preservation, and Spoilage of Different Kinds of Foods; Foods and Enzymes Produced by Microorganisms; Foods in Relation to Disease; Food Sanitation, Control, and Inspection. There are 27 chapters that present these six major parts of the text.

The authors have blended well the microorganism nomenclature of the pre-eighth edition of Bergey's Manual of Determinative Bacteriology with the current

This text will prove useful, both for the student and the practicing food scientist.

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Bacteriological Quality of Ground Beef Prepared from Hot and Chilled Beef Carcasses

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ABSTRACT

The bacteriological quality of ground beef chub packs prepared from beef sides at 2 h postmortem (hot-boned) and opposite sides conventionally chilled for 24 h at 3 C (cold-boned) were compared at the time of preparation and at 3-day intervals up to 45 days of storage at 0 C. Aerobic plate counts (APCs) in ground beef from hot-boned beef were either significantly lower or not significantly different from APCs in ground beef from cold-boned carcasses. There were no significant differences of any practical importance in Most Probable Numbers (MPNs) of coliforms and *Escherichia coli* between hot-boned and cold-boned ground beef stored at 0 C. Ground beef prepared from hot-boned beef offers great potential to the meat industry for energy conservation. The bacteriological quality of ground beef from hot-boned carcasses does not limit and might enhance the feasibility of boning carcasses before chilling.

Fabrication of beef carcasses before they are chilled ("hot" boning) could have several advantages as an alternative to conventional beef fabrication. Removal of excess fat and bone before chilling could save considerable energy in terms of total refrigeration. Additional advantages could include savings in costs of transportation, labor and investment. In recent years researchers investigated characteristics of hot-boned bovine muscle (1,3,5-10,12). Most of these studies were concerned with the effect of hot boning on tenderness and eating quality of meat from Good and Choice grade beef carcasses.

Fabrication of ground beef utilizes a large proportion of the bovine carcass. Few, if any, data have been reported about the feasibility of producing ground beef from hot-boned beef carcasses. Such ground beef might have potential problems, which include textural changes, color differences and shelf-life, and inordinate bacterial counts would be prohibitive. We compared the bacteriological quality and shelf-life of ground beef prepared from hot- and cold-boned beef carcasses.

MATERIALS AND METHODS

Product fabrication

Four USDA Utility grade beef carcasses were used in this investigation. The animals were slaughtered and the ground beef was prepared and stored at a commercial beef slaughter- and further-processing plant. At 2 h postmortem, the top round, strip loin and ribeye cuts were removed from one side of each carcass. At 24 h postmortem, the comparable muscles were removed from the sides that had been chilled at 3 C. The remainder of the meat from the boned carcasses was used immediately (2 and 24 h postmortem) for the ground beef fabrication.

The hot-boned meat was chilled by addition of CO₂ snow (0.1 kg of

CO₂ /kg of meat) during ground beef fabrication. The hot-boned meat from the four sides (about 450 kg) was ground through a kidney plate. Two-thirds of the CO₂ snow was added, and the coarsely ground meat was mixed 3 min. The meat was then ground through a 1.27-cm plate, the remainder of the CO₂ snow was added, and the meat was mixed again for 3 min. The final grind was through a 0.32-cm plate, after which the ground beef was packaged in oxygen-impermeable polyethylene casings to make 5-lb chub packs. The ground beef from the four chilled sides was prepared in the same manner except that CO₂ snow was not used. Fat content of the ground beef was about 21%.

Forty-eight ground beef chub packs from the hot-boned batch and 48 from the cold-boned batch were stored at 0 C. Three chub packs from each batch were transported (45 min) to the laboratory for bacteriological analyses after 0, 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42 and 45 days of storage.

Bacteriological analyses

Three locations within each chub pack were sampled aseptically to obtain a 25-g sample that was blended 2 min in 225 ml of sterile Butterfield's phosphate diluent (11). Serial dilutions of the samples were plated in duplicate on three sets of Plate Count Agar (Difco Laboratories, Detroit, MI) plates. Aerobic plate counts (APCs) were determined after the duplicate sets of plates were incubated 7 days at 5 C, 3 days at 20 C or 2 days at 35 C.

Most Probable Numbers (MPNs) of coliforms and *Escherichia coli* were determined by methods described in the *Bacteriological Analytical Manual for Foods* (4). All EC-broth (Baltimore Biological Laboratory, Cockeysville, MD) tubes showing gas after 24 or 48 h at 45.5 C were streaked onto Levine's eosin methylene blue agar (BBL) for detection of typical *E. coli* colonies.

The logarithms (base 10) of the bacterial counts were treated statistically by analysis of variance (ANOVA) and Duncan's (2) multiple range test.

RESULTS AND DISCUSSION

There were no significant differences in initial APCs (5, 20, or 35 C) between the ground beef prepared from hot-boned and that prepared from cold-boned carcasses (Table 1). With one exception (APC 5 C at 3 days of storage) during the 45-day study, the APCs (5, 20, and 35 C) in ground beef from hot-boned beef were either significantly lower or not significantly different from APCs of ground beef from cold-boned carcasses.

The bacterial counts of the hot-boned ground beef did not increase as rapidly during storage as those of cold-boned. With hot-boned ground beef, APCs at 5 and 20 C did not increase significantly from 0-day counts until day 30 of storage at 0 C; APCs at 35 C were significantly higher than 0-day counts after 33 days. With ground beef from chilled carcasses, APCs at 5, 20 and 35 C were significantly higher than 0-day counts after 18, 21, and 24 days of storage, respectively.

After 45 days of storage, there were no significant

differences in APCs (5, 20, or 35 C) between hot- and cold-boned ground beef, but the APCs were slightly lower in the hot. Both products had reached the end of their microbiological shelf-life. During 45 days of storage, the APCs at 5, 20, and 35 C increased 2.55, 1.78, and 1.65 logs/g, respectively, in the hot-boned ground beef, and 3.08, 2.04, and 1.70 logs/g, respectively, in the cold-boned ground beef. The appearance and odor of both hot- and cold-boned ground beef were acceptable through 42 days of storage, but a slight off-odor was detected at 45 days.

MPNs of coliforms and *E. coli* were very low initially and throughout the 45-day storage study (Table 2). There were no significant differences of any practical importance in numbers of these bacteria between hot- and cold-boned ground beef.

Our data indicate that ground beef prepared from hot-boned carcasses as described above has bacteriological quality and shelf-life that are equal to or better than those of ground beef prepared from chilled carcasses. As an alternate processing method, fabrication of ground beef from hot-boned carcasses offers the meat industry great potential for energy conservation.

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TABLE 2. Effect of storage at 0 C on MPNs of coliforms and *Escherichia coli* in ground beef prepared from "hot" and chilled beef carcasses.

Days of storage	Coliforms		<i>E. coli</i>	
	Hot	Chilled	Hot	Chilled
0	12b ^a	14b	0c	7abc
3	7b	6b	0c	6abc
6	5b	17b	0c	3abc
9	2b	1b	0c	1c
12	9b	1b	9ab	1c
15	6b	0b	0c	0c
18	0b	12b	0c	2bc
21	3b	14b	0c	0c
24	4b	3b	0c	0c
27	22b	4b	0c	4abc
30	8b	10b	0c	10a
33	13b	151a	0c	0c
36	1b	19b	0c	1c
39	0b	5b	0c	5abc
42	0b	5b	0c	4abc
45	3b	4b	0c	1c
Overall average ^b	6a	17a	1b	3a

^aEach value is the mean MPN/g of 3 chub packs.

Values for a given bacterial classification followed by no common letters are significantly ($P \leq 0.05$) different according to Duncan's multiple range test (2).

^bOverall average values for a given bacterial classification followed by different letters are significantly ($P \leq 0.05$) different according to Duncan's multiple range test (2).

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TABLE 1. Effect of storage at 0 C on APCs in ground beef prepared from "hot" and chilled beef carcasses.

Days of storage	APC (5 C)		APC (20 C)		APC (35 C)	
	Hot	Chilled	Hot	Chilled	Hot	Chilled
0	4.30kl ^a	3.941m	5.05g-j	4.96hij	5.13g	5.13g
3	4.171	3.44m	5.06g-j	4.89ij	5.06g	4.99g
6	4.011m	3.981m	5.15g-j	5.06g-j	5.11g	5.18g
9	3.951m	4.35kl	4.90ij	4.96hij	5.01g	5.22fg
12	4.061	4.50jkl	5.09g-j	4.92ij	5.27fg	4.99g
15	4.141	4.47jkl	5.04g-j	4.79j	5.04g	4.92g
18	4.041m	4.81jk	5.14g-j	5.17ghi	5.19g	5.07g
21	4.27kl	5.06hij	4.78j	5.36fg	4.93g	5.34fg
24	4.061	5.94d-g	5.01g-j	6.17e	4.99g	5.97de
27	4.26kl	6.14c-f	5.10g-j	6.22e	5.27fg	6.06d
30	4.95ij	5.73efg	5.58f	5.31fgh	5.31fg	5.91de
33	5.60fgh	6.46a-d	5.56f	6.60cd	5.62ef	6.49bc
36	6.52a-d	6.24b-e	6.38de	6.62cd	6.28cd	6.48bc
39	6.75ab	6.70abc	6.83abc	6.75bc	6.74ab	6.68ab
42	5.40ghi	5.66efg	6.70bcd	7.13a	6.71ab	7.03a
45	6.85a	7.02a	6.83abc	7.00ab	6.78ab	6.83ab
Overall average ^b	4.83b	5.28a	5.51b	5.74a	5.53b	5.77a

^aEach value is the mean log₁₀ count/g of 3 chub packs. Values for a given APC incubation temperature followed by no common letters are significantly ($P \leq 0.05$) different according to Duncan's multiple range test (2).

^bOverall average values for a given APC incubation temperature followed by different letters are significantly ($P \leq 0.05$) different according to Duncan's multiple range test (2).

Blade Tenderization Effects on Cooking and Palatability Characteristics of Steaks from Bullock and Cow Carcasses

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ABSTRACT

Steaks ($n = 240$) from bullock and cow carcasses were studied to determine effects of blade tenderization on cooking and palatability characteristics. After two control ($0\times$) steaks were removed, strip loins, inside rounds, outside rounds and top sirloin butts (all boneless) were blade-tenderized; additional steaks were removed after one ($1\times$) and two ($2\times$) passes through a blade tenderizer. Evaluations included cooking time, cooking loss, visual degree of doneness, Warner-Bratzler shear force and sensory panel evaluation for tenderness, amount of organoleptically detectable connective tissue, flavor, juiciness and overall palatability. Blade tenderization of bullock muscles resulted in steaks which required less time to cook, had decreased amounts of organoleptically detectable connective tissue and had increased tenderness, flavor and overall palatability ratings. Blade tenderization of cow muscles had little or no effect on cooking characteristics, tenderness, flavor, or overall palatability of muscles from the round but increased the tenderness, decreased the shear force value and amount of organoleptically detectable connective tissue, and increased the overall palatability of the longissimus dorsi muscle. Blade tenderization, though it will usually improve tenderness, will not improve the product enough to make beef of unsatisfactory quality comparable to that from high quality beef.

Tenderness is of major importance in determining the palatability of meat. Numerous researchers have demonstrated moderate to large increases in tenderness of beef, pork, lamb, and goat (1-7,9-12,14) associated with use of blade or needle tenderizers. Meat quality limits within which blade tenderization can be used to enhance tenderness have not been clearly defined. At question is whether the procedure can be used to bring the tenderness of muscles from lower quality, less desirable carcasses into the range considered acceptable by most consumer's standards. Two classes of beef for which tenderization might be applicable are bullocks (young intact males) and cows.

The hormonal integrity of the male bovine detrimentally influences tenderness of the meat (7). Cow meat is also tough because of the effects of advanced chronological age on the quantity and/or chemical state of connective tissue in the meat. Procedures used to increase tenderness of bullock and cow beef presently center upon use of tropical plant enzymes; such beef can be effectively merchandised and, in fact, is sold in tremendous quantities to HRI outlets and fast food franchises. However, use of proteolytic enzymes to tenderize meat is beset with numerous problems — off-

flavor, over-tenderization, under-tenderization, etc. The objective of the present study was to determine the effects of blade tenderization on cooking and palatability characteristics of cuts from bullock and cow carcasses.

MATERIALS AND METHODS

Ten bullocks, of the U.S. Good-Bullock grade and ranging in liveweight from 471 to 603 kg, and 10 mature cows, of the U.S. Commercial and U.S. Utility grades and ranging in liveweight from 268 to 389 kg, were slaughtered. Boneless strip loins, inside rounds, outside rounds and top sirloin butts were removed from each carcass approximately 36 h postmortem, frozen and stored at -23 C . The cuts were thawed for 18-20 h at $5-7\text{ C}$ before mechanical tenderization.

Two steaks, approximately 2.5 cm in thickness, were removed from each subprimal cut before mechanical tenderization for use as untreated controls ($0\times$). The remaining portion of each cut was then passed through a reciprocating blade-type mechanical tenderizer (Ross TC 700) with the fat side down either one ($1\times$) or two ($2\times$) times. Two 2.5-cm steaks were removed after each pass through the blade tenderizer. All steaks were then frozen and stored at -23 C until further evaluation was conducted.

One steak from each pair was cut and trimmed to obtain samples of constant size containing only the selected muscle. The biceps femoris (BF), semimembranosus (SM) and gluteus medius (GM) muscles were frozen and trimmed to obtain samples of the dimensions $8.0 \times 8.0 \times 2.5$ cm and weighing approximately 130 g; the longissimus dorsi (LD) muscle was frozen and trimmed to obtain samples of the dimensions $5.0 \times 5.0 \times 2.5$ cm and weighing approximately 80 g. Each sized muscle sample was thawed (24 h at 2 C) and then cooked in a gas oven at 177 C to an internal temperature of 75 C . Cooking time and cooking loss were recorded for each sample. In addition, an internal cross-section of each cooked steak was exposed and a single evaluator assigned a subjective degree of doneness score by the use of a 10-point photographic scale (10 = extremely rare; 1 = extremely well-done). Objective tenderness measurements were made by use of a Warner-Bratzler shear machine and 1.27-cm cores of cooked muscle.

The other steak from each pair was broiled from the frozen state in an electric oven at 177 C to an internal temperature of 75 C . Samples of the longissimus dorsi (LD) muscle from strip loins, the semimembranosus (SM) muscle from top rounds, the biceps femoris (BF) muscle from bottom rounds and the gluteus medius (GM) muscle from top sirloin butts were evaluated by a trained 8-member sensory panel. Each steak was cooked, cut into pieces and served warm to panelists who evaluated samples by the use of 8-point rating scales for tenderness (8 = extremely tender; 1 = extremely tough), juiciness (8 = extremely juicy; 1 = extremely dry), amount of organoleptically detectable connective tissue (8 = none; 1 = abundant), flavor desirability (8 = extremely desirable; 1 = extremely undesirable), and overall palatability (8 = extremely desirable; 1 = extremely undesirable).

Reduction of data was accomplished using analysis of variance (13) and mean separation techniques. When significant ($P < .05$) main effects were observed in the analysis of variance, mean separation was performed by use of the Student-Newman-Keuls test (13).

RESULTS AND DISCUSSION

Mean values for cooking data are presented in Table 1. The time required to cook bullock steaks that had been blade tenderized twice (2 ×) was significantly ($P < .05$) less than that required to cook non-tenderized (0 ×) control steaks, which agrees with some previous studies (6,10 for GM muscles). Blade tenderization did not significantly ($P < .05$) affect cooking time for steaks from cow carcasses, which agrees with certain studies (1,10 for ST muscles, 12). The issue regarding effects of blade tenderization on cooking time remains unresolved; disagreements among research studies might be explained by differential cooking rates and/or failure to adequately monitor end-point temperatures were it not for the fact that results for different muscles within the same study (10 and the present study) do not agree.

No significant differences ($P > .05$) in cooking loss were found as a result of the use of blade tenderization (Table 1). Most published research indicates little or no difference in cooking losses (1,11,12) or processing losses (11) between control and blade-tenderized meat. One report (2) documented increased cooking losses in blade-tenderized cuts as compared to control samples and suggested that the increased cooking losses might be due to moisture losses through the holes made by the blades or by changes in heat transfer properties of the meat.

Steaks from blade-tenderized GM and SM muscles of cow carcasses appeared to be more nearly "well-done" than did steaks from control GM and SM muscles (Table 1). Blade tenderized bullock steaks (2 ×) tended to be more thoroughly cooked at 75 C than did control samples (0 ×) but these differences were not consistent enough for statistical significance ($P > .05$). One advantage frequently cited by promoters of mechanical (blade or needle) tenderization is a greater degree of doneness during a shorter cooking period (8); the data of the present study support this claim.

Tenderness data for control and blade-tenderized muscles are presented in Table 2. The amount of

organoleptically detectable connective tissue decreased ($P < .05$) after one pass (1 ×) of SM, BF and LD muscles from bullock carcasses through the blade tenderizer and decreased after two passes (2 ×) of GM from bullock carcasses and LD from cow carcasses through the blade tenderizer. There are other research findings which support the use of blade tenderization for decreasing the amount of organoleptically detectable connective tissue (1,10,14).

Steaks from all four bullock muscles increased significantly ($P < .05$; Table 2) in tenderness after they were passed one time (1 ×) through the blade tenderizer; a second pass (2 ×) of muscles through the blade tenderizer did not significantly ($P > .05$) increase tenderness over that of steaks passed through the blade tenderizer once (1 ×). Among muscles from cow carcasses, only the LD was significantly ($P < .05$) improved in tenderness by use of the blade tenderizer.

Warner-Bratzler shear force values (Table 2) were decreased in magnitude as a result of blade tenderization for all muscles from both bullock and cow carcasses; however, the decrease was consistent enough for statistical significance ($P < .05$) in only four of the eight comparisons. In previous research, blade or needle tenderization was effective in reducing shear force requirements (4,5,6,10,12) and repetitive passes through the tenderizing machine further reduced shear force (1,10,12). Among muscles from bullock carcasses, response to blade tenderization was greater for less tender (SM, BF) than for more tender (GM, LD) muscles. Conversely, in more mature carcasses (those from cows), greater response to blade tenderization in reducing shear force values was observed in those muscles which are expected to be more tender (GM, LD).

Mean sensory panel ratings for flavor, juiciness and overall palatability are presented in Table 3. Flavor desirability of three of the four bullock muscles was increased ($P < .05$) over that of controls (0 ×) by passage

TABLE 1. Cooking data for steaks from control and blade tenderized muscles from bullock and cow carcasses.

Trait	Muscle ^a	Bullocks			Cows		
		0 × ^b	1 ×	2 ×	0 × ^b	1 ×	2 ×
Cooking time, min ^c	GM	69.2 ^e	57.6 ^{ef}	52.0 ^f	63.3 ^e	66.3 ^e	59.3 ^e
Cooking time, min	SM	89.1 ^e	72.6 ^{ef}	58.0 ^f	80.5 ^e	74.7 ^e	63.9 ^e
Cooking time, min	BF	81.9 ^e	73.1 ^{ef}	62.7 ^f	80.2 ^e	67.0 ^e	72.6 ^e
Cooking time, min	LD	69.3 ^e	60.5 ^{ef}	45.1 ^f	63.4 ^e	64.9 ^e	66.2 ^e
Cooking loss, %	GM	38.0 ^e	36.2 ^e	34.7 ^e	36.3 ^e	39.9 ^e	42.5 ^e
Cooking loss, %	SM	48.1 ^e	46.4 ^e	44.7 ^e	44.5 ^e	42.1 ^e	46.2 ^e
Cooking loss, %	BF	44.8 ^e	42.1 ^e	42.4 ^e	42.5 ^e	46.1 ^e	46.0 ^e
Cooking loss, %	LD	38.8 ^e	39.4 ^e	34.6 ^e	45.2 ^e	42.2 ^e	44.4 ^e
Degree of doneness ^d	GM	4.1 ^e	3.5 ^e	2.8 ^e	6.3 ^e	3.5 ^f	3.1 ^f
Degree of doneness	SM	2.6 ^e	2.6 ^e	2.5 ^e	4.8 ^e	3.8 ^{ef}	3.6 ^f
Degree of doneness	BF	4.0 ^e	3.2 ^e	2.9 ^e	4.5 ^e	3.3 ^e	3.5 ^e
Degree of doneness	LD	3.9 ^e	3.3 ^e	3.6 ^e	4.7 ^e	4.0 ^e	3.7 ^e

^aGM = gluteus medius from top sirloin butt, SM = semimembranosus from top round, BF = biceps femoris from bottom round, LD = longissimus dorsi from strip loin.

^b0 × = untreated control, not blade tenderized; 1 × = passed through the blade tenderizer one time; 2 × = passed through the blade tenderizer two times.

^cMinutes required to reach an internal temperature of 75 C.

^d10 = extremely rare; 1 = extremely well-done (by use of a photographic scale).

^{ef}Means in the same row, for the same class, bearing a common superscript letter are not different ($P > .05$).

of muscles through the blade tenderizer one time (1 ×). Most previous research indicates that there is no difference in flavor between tenderized and untreated meat samples (1,3,9); however, Miller (8) reported that improvements in flavor have been claimed for blade- and needle-tenderized meats. It seems likely that sensory panel members rate all palatability traits higher if tenderness is adequate; tough samples may be perceived as generally unsatisfactory in all palatability traits.

Passage of muscles through the blade tenderizer two times (2 ×) decreased ($P < .05$; Table 3) the juiciness of subsequent steaks as compared to that for control steaks (0 ×) for one of four bullock muscles (GM) and for two of four cow muscles (GM and SM). Losses in juiciness due to mechanical tenderization have been reported (9,10) or suggested (1).

Blade tenderization (1 × or 2 ×) increased ($P < .05$) overall palatability ratings for three of four muscles (SM, BF, LD) from bullock carcasses (Table 3), but for only

one of four muscles (LD) from cow carcasses. Mean overall palatability ratings for bullock steaks ranged from 3.3 (moderately undesirable) to 5.5 (slightly desirable); those for cow steaks ranged from 3.1 (moderately undesirable) to 4.2 (slightly undesirable). Even after 2 × blade tenderization two of the muscles from bullock carcasses and all of the muscles from cow carcasses were not considered even "slightly desirable" in overall palatability by the sensory panel. These results substantiate the conclusion that mechanical tenderization, though it will usually improve tenderness and overall palatability, will not improve the product enough to make beef of unsatisfactory quality comparable to that from high quality beef. Identical conclusions were reached in a direct comparison of high quality and low quality beef (14).

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T.A. 14691, Meats and Muscle Biology Section, Department of

TABLE 2. *Tenderness data for control and blade tenderized muscles from bullock and cow carcasses.*

Trait	Muscle ^a	Bullocks			Cows		
		0 × ^b	1 ×	2 ×	0 × ^b	1 ×	2 ×
Connective tissue amount ^c	GM	5.0 ^f	5.6 ^{fg}	5.8 ^g	3.2 ^f	4.0 ^f	3.8 ^f
Connective tissue amount	SM	3.0 ^f	4.2 ^g	4.0 ^g	3.0 ^f	4.1 ^f	3.5 ^f
Connective tissue amount	BF	2.8 ^f	4.3 ^g	4.7 ^g	3.0 ^f	2.7 ^f	2.8 ^f
Connective tissue amount	LD	4.9 ^f	5.7 ^g	5.9 ^g	2.8 ^f	3.3 ^{fg}	4.0 ^g
Tenderness ^d	GM	5.0 ^f	5.7 ^g	5.7 ^g	3.1 ^t	4.0 ^f	4.0 ^f
Tenderness	SM	3.4 ^f	4.1 ^g	4.2 ^g	3.0 ^f	4.1 ^f	3.8 ^f
Tenderness	BF	2.9 ^f	4.3 ^g	4.4 ^g	3.1 ^f	3.0 ^f	3.4 ^f
Tenderness	LD	4.7 ^f	5.6 ^g	5.9 ^g	2.5 ^f	3.4 ^g	4.2 ^g
Shear force, kg ^e	GM	4.5 ^f	4.1 ^f	3.8 ^f	9.7 ^f	7.3 ^g	6.8 ^g
Shear force, kg	SM	8.5 ^f	6.6 ^{fg}	6.1 ^g	10.1 ^f	9.4 ^f	8.5 ^f
Shear force, kg	BF	7.2 ^f	6.0 ^{fg}	5.4 ^g	9.9 ^f	9.8 ^f	8.1 ^f
Shear force, kg	LD	4.0 ^f	3.8 ^f	3.6 ^f	11.9 ^f	8.9 ^{fg}	7.7 ^g

^aGM = gluteus medius from top sirloin butt, SM = semimembranosus from top round, BF = biceps femoris from bottom round, LD = longissimus dorsi from strip loin.

^b0 × = untreated control, not blade tenderized; 1 × = passed through the blade tenderizer one time; 2 × = passed through the blade tenderizer two times.

^c8 = no organoleptically detectable connective tissue; 1 = abundant amount of organoleptically detectable connective tissue.

^d8 = extremely tender; 1 = extremely tough.

^eForce required to shear a 1.27-cm core.

^fgMeans in the same row, for the same class, bearing a common superscript letter are not different ($P > .05$).

TABLE 3. *Flavor, juiciness and overall palatability data for control and blade tenderized muscles from bullock and cow carcasses.*

Sensory panel rating	Muscle ^a	Bullocks			Cows		
		0 × ^b	1 ×	2 ×	0 × ^b	1 ×	2 ×
Flavor ^c	GM	4.9 ^f	5.0 ^f	5.2 ^f	4.5 ^f	4.3 ^f	4.2 ^f
Flavor	SM	4.3 ^f	5.0 ^g	5.2 ^g	4.4 ^f	4.5 ^f	4.0 ^f
Flavor	BF	4.4 ^f	5.1 ^g	5.0 ^{fg}	4.3 ^f	3.8 ^f	4.0 ^f
Flavor	LD	4.8 ^f	5.2 ^g	5.4 ^g	4.3 ^f	4.1 ^f	4.2 ^f
Juiciness ^d	GM	5.5 ^g	4.7 ^{fg}	3.8 ^f	6.1 ^g	4.7 ^f	4.8 ^f
Juiciness	SM	3.9 ^f	3.9 ^f	3.9 ^f	5.5 ^g	4.2 ^f	4.4 ^f
Juiciness	BF	3.9 ^f	4.3 ^f	4.1 ^f	5.4 ^g	4.0 ^f	4.6 ^{fg}
Juiciness	LD	4.3 ^f	4.3 ^f	5.0 ^f	5.2 ^f	4.3 ^f	4.3 ^f
Overall palatability ^e	GM	4.8 ^f	5.1 ^f	5.1 ^f	3.5 ^f	4.0 ^f	3.9 ^f
Overall palatability	SM	3.4 ^f	4.2 ^g	4.4 ^g	3.3 ^f	4.0 ^f	3.5 ^f
Overall palatability	BF	3.3 ^f	4.3 ^g	4.5 ^g	3.3 ^f	3.0 ^f	3.4 ^f
Overall palatability	LD	4.5 ^f	5.2 ^g	5.5 ^g	3.1 ^f	3.5 ^{fg}	4.2 ^g

^aGM = gluteus medius from top sirloin butt, SM = semimembranosus from top round, BF = biceps femoris from bottom round, LD = longissimus dorsi from strip loin.

^b0 × = untreated control, not blade tenderized; 1 × = passed through the blade tenderizer one time; 2 × = passed through the blade tenderizer two times.

^c8 = extremely desirable; 1 = extremely undesirable.

^d8 = extremely juicy; 1 = extremely dry.

^e8 = extremely desirable; 1 = extremely undesirable.

^fgMeans in the same row, for the same class, bearing a common superscript letter are not different ($P > .05$).

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Iowa Sanitarians Honor Two

Two persons were honored at the Iowa Association of Milk, Food and Environmental Sanitarians' annual meeting in late March. Don Jaeger, Klenzade Products, Marshalltown, received the M. P. Baker award for contributions to food processing sanitation. Paul Hartman, professor and chairman of the bacteriology department at Iowa State University, Ames, was presented a 20-year membership certificate.

Bill LaGrange, extension food technologist at Iowa State, was elected President of the Association and Charles Griffith, Des Moines, City Health Department, was elected President-Elect. Other officers elected include Clarence Jellings, Clinton City Health Dept., First Vice-President; Leroy Frericks, fieldman, Mid-America Dairymen, Dyersville, Second Vice President; Hale Hansen, State Health Dept., Des Moines, Secretary-Treasurer. Don Larson, H. B. Fuller Co., Cedar Rapids, is Past President; Earl Wright, IAMFES, Ames, Advisor; Bill LaGrange, Iowa State, Ames, Faculty Advisor.

The program included presentations on investigating foodborne illness outbreaks, water quality, testing dairy foods, dairy fieldmen's responsibilities, milk quality, trends in food service, and pesticide control programs for food processors.



The 1979 IAMFES Annual Meeting is next month, Aug. 12-16, in Orlando, FL, and plans are already well underway for the 1980 Annual Meeting in Milwaukee, WI. Above, members of IAMFES, NEHA, and the Local Arrangements Committee meet to plan that event, a joint meeting with NEHA. Watch the *Journal* this year for details on that meeting, to be held July 26-31, 1980.

Webber Named Dairy Grade Standards Chief

Richard W. Webber has been named chief of the Dairy Standardization Branch, Poultry and Dairy Quality Division, Food Safety and Quality Service, U.S. Department of Agriculture (USDA). He has worked for USDA since 1960, and has been assistant chief of the Poultry and Dairy Standardization Branch, since 1971.

A graduate of the University of

Illinois, Webber worked for Cremix, a division of Bowman Dairy, Chicago, before joining USDA. He began his career at USDA in the Inspection and Grading Branch, Dairy Division, and was assigned to various plants in Wisconsin and Minnesota. Since 1967, he has been with the Standardization Branch in Washington working in the areas of plant and farm requirements, product quality standards and specifications, and working with states in their milk quality and farm programs.

Comparison of the Automated with the Semi-Automated Coulter Counter Method and the Direct Microscopic Somatic Cell Count (DMSCC) on Raw Milk Samples¹

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ABSTRACT

The automatic Milk Cell Counter (MCC) and semi-automatic electronic cell counter (ESCC) of Coulter Electronics were compared with each other and with the direct microscopic cell count (DMSCC) on raw milk samples with various cell counts. The average DMSCC count on 241 samples of milk with Wisconsin Mastitis Test (WMT) results of 22 mm and higher was 55,000 cells/ml above the average MCC count when calibrated to a 4.4- μ m minimum particle diameter. This difference is statistically significant at the 1% level. On 24 different raw milk samples of widely varying somatic cell count analyzed in replicate six times per sample, the standard deviations for replicate samples were 34,300, 34,900 and 136,000 for the MCC, ESCC and DMSCC, respectively. For these tests, the MCC had been calibrated to a 4.3- μ m minimum particle diameter. The average difference between counts by the MCC and ESCC methods was only 6080/ml, but this was statistically significant at the 5% level. The average MCC count with the equipment set at 4.3- μ m minimum particle diameter was 58,000 above the average DMSCC count.

Coulter Electronics Limited has developed a fully automated device capable of analysing milk samples for somatic cell count at a rate of about 210 samples per hour. Previous work (2-6, 8, 9) has shown a similar though semi-automatic method to yield acceptable results for this kind of analysis. While other automated procedures have been developed for this purpose, the Coulter Counter offers the advantage of a calibration technique based upon particle size. It can also be calibrated against a reference test such as the Direct Microscopic Somatic Cell Count (DMSCC). As a particle counter, the automated Milk Cell Counter (MCC) offers some advantage in speed over the semi-automatic counting device (ESCC). The procedures for making the two analyses are identical except for one specific step. The MCC would thus be expected to yield essentially the same results as the ESCC. This work was done to establish the validity of this concept.

MATERIALS AND METHODS

Standardization of Coulter Counters

A semi-automatic Model Z_F Coulter Counter (Coulter Electronics,

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Hialeah, Florida) has been in use in the Dairy Quality Control Institute, Inc. Laboratory for some time. This device was standardized using a Size Distribution Analyzer and latex particles of 3.40 μ m diameter. This technique is explained in a previous paper (4).

The fully automatic Coulter Electronics Milk Cell Counter (MCC) was standardized on organic chicken blood cells (Coulter Electronics, Hialeah, Florida 33010) using the half-count procedure suggested by the manufacturer. Average size of these cells was 4.71 μ m in diameter. In preliminary work the lower threshold setting, below which particles will not be counted, was fixed at 4.4 μ m in diameter. Results of 241 determinations checked against the Direct Microscopic Somatic Cell Count suggested that the equipment was biased on the low side. To bring results into better agreement with the DMSCC, the equipment was re-calibrated to count particles larger than 4.3 μ m in diameter.

The MCC method can be calibrated either on standard particles of matter or against counts of a reference standard such as the DMSCC. Use of particulate matter provides a way of avoiding errors inherent in the reference standard procedure. This is important when the reference standard is less precise than the test method, which appears to be the case with the DMSCC.

The ESCC procedure used in this study was that given in reference (5). The MCC method is capable of making 210 determinations per hour. Up to 50 samples can be accepted at one time on a rotating sample rack. Though done automatically, the basic steps in the MCC analysis are almost the same as for the ESCC procedure. While on the rotating rack, milk samples are stirred, an aliquot is automatically removed, then diluted 1:100 with Somaton fixative (Coulter Electronics, Hialeah, Florida), and dispensed into a reaction tube. Reaction tubes also progress through the counting process in a rotating handling rack. During this time samples are heated to 80 C in a polyethylene glycol bath. Duration of heating is 10 min. At this one point the MCC and ESCC methods vary. The ESCC samples are cooled to room temperature before counting to avoid physical changes in the cells. The MCC counting takes place immediately following heat treatment; therefore cooling is not necessary.

The MCC is programmed to count a diluted sample every 17 sec. The machine takes 0.3 ml of diluted sample, divides the results by three, corrects for coincidence, subtracts the background count, and prints results on a teleprinter.

The method of making DMSCC determinations was the single strip technique as described in *Standard Methods for the Examination of Dairy Products* (1).

Preliminary test

In a preliminary trial extending over a 7-week period, 3,362 raw milk samples were analyzed with the MCC. Samples were taken from the ongoing operation of Dairy Quality Control Institute, Inc. In addition, all samples having a Wisconsin Mastitis Test value of 22 or higher were analyzed by DMSCC, and results compared with MCC analyses. A total of 241 samples were thus compared. Based upon results of this study, both the MCC and ESCC were re-standardized to count particles (somatic cells) of 4.3 μ m and larger in diameter.

Test trial

In the final study, 24 liters of milk were collected, 1 liter each from 24 different farms. Farms were selected based upon past records which indicated a suitably wide range of somatic cell counts. Each milk sample was divided into six sublots and each subplot analyzed by both the MCC and ESCC methods. In addition, samples of each milk supply were analyzed by DMSCC by four different technicians, yielding a total of 96 DMSCC analyses.

RESULTS AND DISCUSSION

In the preliminary trial in which 241 samples of raw milk were analyzed by both the MCC and DMSCC methods, the average difference between the counts by the two methods was 55,000 cells/ml. A t-test showed that difference to be significant at the 1% level. For this reason the electronic devices were re-standardized to a 4.3- μ m minimum diameter.

Data in Table 1 show mean and grand mean results of somatic cell counts made on 24 samples analyzed in replicate six times by MCC and ESCC methods, and four times by DMSCC (once each by each four technicians). These data show good agreement between the three methods over a wide range of somatic cell counts. Grand means were 554,000, 560,000 and 496,000 for the MCC, ESCC and DMSCC methods, respectively. Standard deviations were 34,300, 34,900 and 136,000, respectively.

The average difference between the MCC and ESCC

TABLE 1. Mean and grand mean somatic cell counts of replicate analyses made on 24 milk samples by three different methods.

Sample No.	Method		
	MCC ² ($\times 1000$)	ESCC ³ ($\times 1000$)	DMSCC ⁴ ($\times 1000$)
1	469	458	427
2	550	599	431
3	498	538	425
4	55	51	16
5	295	323	196
6	786	771	893
7	126	150	105
8	325	328	240
9	496	523	412
10	506	531	488
11	1543	1628	1623
12	651	645	611
13	151	151	122
14	207	234	172
15	599	544	570
16	958	948	827
17	1601	1583	1556
18	994	920	667
19	317	269	198
20	231	185	121
21	209	247	161
22	242	267	245
23	500	541	463
24	944	1012	906
Grand mean	554	560	496

¹Samples were analyzed six times by MCC and ESCC, four times by technicians.

²Fully automatic electronic Milk Cell Counter.

³Semi-automatic electronic somatic cell counter.

⁴Direct microscopic somatic cell count.

methods was 6080. An analysis of variance indicated that this difference was significant at the 5% level, but only because the variance within replicates was so small; i.e., 1,200. When DMSCC, MCC and ESCC results were compared, the method, sample and interactions between them were all found to be highly significant at the 0.1% level. The difference between the electronic count means and the DMSCC mean is of the same magnitude, but of opposite sign from the previous test. Thus 4.4- and 4.3- μ m particle sizes bracket the optimum value for standardization of electronic devices.

Except for automation and a single step in the analysis, the MCC and ESCC methods are identical. Results by the two methods were expected to agree rather well, and this work validates that hypothesis. The observed differences are of small magnitude. The data also seemed to suggest that better agreement between MCC, ESCC and DMSCC will be achieved when the electronic devices are standardized at a 4.35- μ m lower threshold value.

A collaborative study of the ESCC method has been previously reported (4). The procedure used in the study was recommended for approval at the International Dairy Federation meeting in June of 1978.

Because of the similarity in the ESCC and MCC methods, the good agreement between the two methods observed in this investigation, and the recommended approval of the ESCC method, the authors wish to urge official adoption of the MCC procedure.

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Role of *Hafnia alvei* and a *Lactobacillus* Species in the Spoilage of Vacuum-Packaged Strip Loin Steaks

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ABSTRACT

A microbiological examination of vacuum-packaged strip loin steaks that were defective (gassy packages, hydrogen sulfide odor) revealed high total counts (10^7 - 10^8 /cm²) with *Hafnia alvei*, *Lactobacillus* and *Pseudomonas* spp. as major isolates. Re-inoculation experiments indicated that *H. alvei* was the likely cause of the hydrogen sulfide odor. Gas formation resulted from the activity of heterofermentative lactobacilli and *H. alvei*. Improvements in plant practices and temperature control eliminated the problem.

In July of 1978, a meat purveying company which distributes hotel, restaurant and institutional meat cuts to a national clientele received complaints from end-users in five states regarding spoilage of vacuum-packaged strip loin steaks (IMPS 1180) packed 10 to the pouch and in fiberboard boxes. According to customer complaints, the vacuum packages were gassy to severely puffed, an odor similar to that of rotten eggs was evident when the pouch was opened and, in some reports, the meat had a green surface color.

Reports in the literature show that some vacuum-packaged beef, usually after extended storage under refrigeration exhibits, upon opening of the pouch, an acid odor sometimes described as sour, lactic, cheesy, milky or butyric. These odors most likely result from the presence of a variety of volatile fatty acids which are produced at least in part by heterofermentative lactic acid bacteria (1,9). Greening of vacuum-packaged meat with or without a hydrogen sulfide odor occurs more frequently in meat with a pH of 6.0 or higher and is often attributed to the activity of *Pseudomonas* spp. (3,5). This report describes the conditions and microbial activities most likely responsible for spoilage of these vacuum-packaged strip loin steaks.

MATERIALS AND METHODS

Product history

By using code numbers on the fiberboard boxes, the production dates were narrowed down to a specific Thursday, Friday and following Monday two weeks before the first complaint. Evaluation of plant records revealed the following chronological history for the product: (a) vacuum-packaged, boxed boneless strip loins (IMPS 180) were purchased from a meat packer in September, 1977 and frozen-stored at -23 C until July, 1978, (b) product was removed from the freezer and placed in a -1 C tempering cooler in the original boxes for 1 to 3 days (exact time unknown), (c) frozen, tempered product was removed from boxes — vacuum packaging material remained intact — and placed into 1.2 × 1.5 × 1.2-m stainless steel vats, and (d) vats were filled with 26

to 30 C tap water and stored in a processing room where the temperature is maintained at 10 C for 19 h/day but which reaches 24 C during a 5-h cleanup period. At this time plant personnel were not certain as to how the product was handled. Under usual circumstances, the product would have been: (a) used the next day, at a time when internal product temperature was 0 to 5 C, or (b) if it was not used the next day, the vat would have been returned to the cooler, drained and held overnight at -2 to 0 C — product would have been moved back to the 10-C processing room and processed during that working day. Plant personnel now suspect that the meat might not have been returned to the -2 to 0-C cooler (as would have been standard operating procedure) after storage in the 10 C/24-C processing room for 2 days; product would then have remained in the 10 C/24-C processing room over the weekend and would have been processed on the following Monday.

Normal fabrication procedure was followed — vacuum packaging materials were removed from the product, the strip loins were passed twice through a blade tenderizing machine, steaks were cut, trimmed, weighed and placed in a vacuum pouch. Workmen would have handled unwrapped product in all of the fabrication steps described above.

Normal packaging-handling procedure was followed, a vacuum was drawn on the pouch, the pouch was heat-impulse sealed, the sealed pouch was placed in a fiberboard box and the box was stored in a -2 to 0-C holding cooler, boxes of product were stored for 3-8 days at the processing plant and shipped as far as 3200 km by refrigerated transport. Complaints were received as early as 14 days following fabrication and cutting; because complaints were received from end-users in several states, the problem is assumed to have originated in the processing plant and not in-transit or after receipt of the product by the customer.

Bacteriological examination of packaged product

Total counts of the meat surface and purge (fluid which accumulates around the cut inside the package) were made by the spread-plate method on tryptic soy agar (TSA, Difco), lactobacilli MRS broth with 1.5% agar (MRS, Difco) and peptone iron agar (PIA, Difco). A 2.5-cm² area of the meat surface was swabbed with a dacron swab moistened in sterile 0.1% peptone. The swab then was placed in 9 ml of 0.1% peptone and shaken 20 times. Appropriate dilutions were made with sterile 0.1% peptone. Plates were incubated for 4 days at 25 C. Representative colonies of countable plates were picked, placed on TSA slants and incubated for 2-3 days at 25 C. Diagnostic schemes and procedures to identify the isolates have been reported by Vanderzant and Nickelson (10).

Reinoculation of steaks with bacterial isolates

In reinoculation experiments, beef steaks were inoculated with the major isolates of the defective steak: a homofermentative *Lactobacillus*, a heterofermentative *Lactobacillus*, two strains of *Hafnia alvei* (lactose +, lactose -) and a *Pseudomonas* sp. Blade chuck steaks (11 × 9 × 2 cm) were fabricated from beef wholesale chucks. Two steaks were inoculated with each test organism and two similar steaks served as controls (non-inoculated). *H. alvei* and the *Pseudomonas* sp. were grown for 24 h at 25 C in brain heart infusion; the homofermentative *Lactobacillus* was grown in MRS broth and the heterofermentative *Lactobacillus* in APT broth. Counts of these cultures (on TSA plates,

incubated for 4 days at 25 C) after incubation ranged from 1.6×10^8 to 2.0×10^9 per ml. A 0.1-ml aliquot of broth was placed on a steak and spread with a sterile glass rod over the entire surface of the steak. Each steak was placed in a laminated nylon/saran/polyethylene pouch (oxygen transmission rate 32 cc/m²/24 h; moisture vapor transmission rate of 0.8-1.8 g/m²/24 h). The pouches were evacuated of air, and heat-impulse sealed with a chamber-type vacuum packaging machine; pouches were then stored at 1-3 C for 3 weeks.

After storage, the vacuum packages were opened with a sterile scalpel and a sterile aluminum template (50 cm²) was placed on the meat. A sterile cellulose sponge (7 × 4.5 × 1 cm), moistened in sterile 0.1% peptone, was drawn across the exposed meat surface. The sponge then was placed in 50 ml of sterile 0.1% peptone and squeezed five times. Appropriate dilutions were made with sterile 0.1% peptone. Agar plate counts were made on TSA, MRS, APT (BBL) and PIA with the spread plate method. Plate incubation was as described earlier.

RESULTS AND DISCUSSION

A pouch containing 10 steaks was opened under aseptic conditions and one steak representative of the defective lot, was obtained for further study. A strong hydrogen sulfide odor was noticed upon initial opening of the pouch; this odor dissipated in a few minutes and was followed by a "sour" odor which persisted for some time. No greening of the meat was observed. A gram stain of organisms on the meat surface and in the purge showed large ($1.2 \times 8 \mu\text{m}$) gram-positive rods in palisades and smaller ($0.8 \times 3 \mu\text{m}$) gram-positive rods in chains. Counts of the meat surface and purge ranged from 3.2×10^7 to 6.5×10^8 per cm² or ml. Nearly all of the isolates from countable plates consisted of *Lactobacillus* spp. Homofermentative types were more numerous (about 5:1) than heterofermentative types. Colonies of homofermentative lactobacilli on MRS agar were 2-3 mm in diameter, convex, white and entire; heterofermentative types were somewhat smaller (0.5-1 mm), raised, white and entire. *Hafnia alvei* and *Pseudomonas* spp. also were isolated but the concentration of these organisms was about 2 logs lower ($3.6 \times 10^5 - 2.0 \times 10^6$ per cm² or ml) than that of the lactobacilli. Based upon the procedures and classification of Sharpe et al. (8) the homofermentative isolates were atypical streptobacteria, resembling *Lactobacillus plantarum*, the heterofermentative isolates were atypical betabacteria, resembling *Lactobacillus viridescens*. Characteristics of *H. alvei*

were as follows: gram-negative rods ($0.5 \times 1.5 \mu\text{m}$); oxidase -; urease -; OF glucose, fermentative, lysine decarboxylase +; arginine dihydrolase -; ornithine decarboxylase +; phenylalanine deaminase -; indole -; MR -; VP +; citrate -; H₂S (PIA) +; gelatin -; TSI K/A; nitrate +; esculin -; motility +; acid from lactose ±; sucrose -; sorbitol -; adonitol -; inositol -; raffinose -; malonate -. *Pseudomonas* isolates were typical motile gram-negative rods ($0.5 \times 1.5 \mu\text{m}$); oxidase +; TSI K/K; NH₃ from arginine +.

The results of reinoculation experiments (Table 1) indicate that *Lactobacillus* spp. were predominant on both the control and inoculated vacuum-packaged steaks stored for 3 weeks at 1-3 C. This is in agreement with numerous reports on the microbial flora of vacuum-packaged beef. Gas production in the pouches was observed only with steaks inoculated with the heterofermentative *Lactobacillus* sp. (weak) and with *H. alvei* (stronger). The sulfide odor of the laboratory steaks inoculated with *H. alvei* was not as strong as that of the commercial meats. Factors which may be in part responsible for this difference include; type of meat sample (differences may exist, for example, in muscle pH between types of steaks), history of the sample (the commercial steaks had been subjected to wide fluctuations in temperature, whereas the laboratory steaks were not temperature-abused) and differences in the composition of the mixed microbial populations on the commercial vs. the laboratory steaks. The results indicate that *H. alvei* most likely was the cause of the hydrogen sulfide odor of the commercial vacuum-packaged meat. Gas production was likely a combination of CO₂ and H₂S generated by heterofermentative lactobacilli and *H. alvei*, respectively.

Production of hydrogen sulfide and sulfide-like odors by microorganisms in meats, poultry and fish has been reported in the literature (2,4,5). *Pseudomonas* spp., particularly *P. putrefaciens*, *P. mephitica*, *P. perolens*, *P. putida* and *P. fragi* are frequently involved. For example, Nicol et al. (5) reported that *P. mephitica* inoculated on packaged beef caused production of sulfmyoglobin if the pH was above 6.0 and if meat was maintained at low

TABLE 1. Agar plate counts and predominant bacterial types isolated from control and inoculated vacuum packaged steaks stored for 3 weeks at 1-3 C.

Inoculum	Plating medium	Plate count per cm ²	Gas production in package ^a	Predominant isolates from countable plates ^b
Control	TSA	5.6×10^7	—	<i>Lactobacillus</i> sp. (Ho); <i>Lactobacillus</i> sp. (He, dextran+)
	APT	3.8×10^7	—	<i>Lactobacillus</i> sp. (Ho)
	MRS	3.4×10^7	—	<i>Lactobacillus</i> sp. (He, dextran-); <i>Lactobacillus</i> sp. (Ho)
	PIA	5.6×10^7	—	<i>Lactobacillus</i> sp. (Ho)
<i>Lactobacillus</i> sp. 3 (Ho)	TSA	6.5×10^7	—	<i>Lactobacillus</i> sp. 3 (Ho)
	MRS	9.8×10^7	—	<i>Lactobacillus</i> sp. 3 (Ho)
<i>Lactobacillus</i> sp. 4 (He)	TSA	7.5×10^7	+	<i>Lactobacillus</i> sp. 4 (He)
	APT	9.4×10^7	+	<i>Lactobacillus</i> sp. 4 (He)
<i>Hafnia alvei</i> 5 (lactose+)	TSA	4.1×10^7	+++	<i>Hafnia alvei</i> 5; <i>Lactobacillus</i> sp. (Ho)
	PIA	4.7×10^7	+++	<i>Hafnia alvei</i> 5; <i>Lactobacillus</i> sp. (Ho)
<i>Hafnia alvei</i> 6 (lactose -)	TSA	2.7×10^7	+++	<i>Hafnia alvei</i> 6; <i>Lactobacillus</i> sp. (Ho)
	PIA	3.4×10^7	+++	<i>Hafnia alvei</i> 6; <i>Lactobacillus</i> sp. (Ho)
<i>Pseudomonas</i> sp. 9	TSA	1.2×10^8	—	<i>Lactobacillus</i> sp. (Ho)
	PIA	1.1×10^8	—	<i>Lactobacillus</i> sp. (He, dextran-)

a+ weak, ++ fair, +++ strong

bHo = homofermentative, He = heterofermentative.

oxygen tensions. At lower pH values the bacteria were unable to produce hydrogen sulfide. At low oxygen tensions, green reduced sulfmyoglobin is formed; at higher oxygen tensions oxidation to the red metsulfmyoglobin occurred. *Hafnia* spp. are reported to come from various sources associated with the animal and may be spread during slaughtering and dressing operations. Patterson and Gibbs (7) reported these organisms in water, hair, soil, feces, on the hands of workers, in air, on carcasses, in chill rooms and on tables in the boning room. Many of these isolates were capable of growing at 4 C. Patterson and Gibbs (6) also reported that *H. alvei* inoculated on meat of high pH (6.15) and stored at 4 C caused "cabbagey" odors when packed exposed to air and that of "slight pickles" when vacuum-packaged. No off-odors were detected when meat of normal pH (5.4-5.5) was inoculated with *H. alvei* and stored at 4 C.

Quality control procedures initiated by the meat purveying company after consultation with university personnel included: (a) discontinuance of water-thawing of cuts, (b) repeated sanitation with chlorinated water of all equipment and utensils, (c) tightened enforcement of use of disposable plastic gloves, and (d) increased surveillance to assure good manufacturing practice and compliance with regard to product temperature constraints. The problem has not recurred.

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Seven Elected to DFISA Board

Four new directors and three incumbent directors were elected by the membership of Dairy and Food Industries Supply Association to terms on the DFISA board of directors at the association's 60th Annual Meeting at Palm Beach, April 2-4, 1979.

New directors are Clyde Monda, president, Waukesha Foundry Div., Abex Corp., Waukesha, Wis., and Leonard Peterson, national dairy products sales manager, Burry Div., Quaker Oats Co., Elizabeth, N. J. New director for the chemicals and refrigerants group is H. Bruce Ellison, marketing manager for food industries, BASF Wyandotte Corp., Wyandotte, Mich. New director for the containers section is James McCullough, dairy industry manager, Soltex Polymer Corp., Houston, Texas.

Re-elected as at-large directors were Peter Miller, vice president, Chester-Jensen Co. Inc., Chester,

Pa., and Leroy Mommsen, president, CREPACO, Inc., Chicago. Re-elected as point-of-sale director was F. Heath Schroeder, regional manager, Kelvinator Commercial Products Inc., Lake Oswego, Ore.

NCI and ABI Elect Officers

The National Cheese Institute held its 52nd Annual Meeting at the Marriott O'Hare in Chicago April 23 and 24 and re-elected the following NCI corporate officers for a one-year term: Harold Steinke, Borden Foods Inc., President; and Vice Presidents, Arthur Jepsen, Land O'Lakes, Inc.; L. W. Arens, Pauly Cheese Co.; R. M. Bush, L. D. Schreiber Cheese Co., Inc.; and G. F. Heisinger, Kraft, Inc.

The American Butter Institute met for its 70th Annual Meeting at the same time. They honored their immediate Past President, John

DFISA is the national trade association of 500 equipment, supply and service firms serving the dairy, food, beverage and related processing industries.

Ringenberg, Mid-America Farms, Inc. and new officers elected for a one year term were: Claude Harper, Jr., Beatrice Foods Co., President, together with Vice Presidents Floyd Harris, Level Valley Dairy Co. and Jim Nieman, Wilsey Bennett of Oklahoma.

R. F. Anderson was re-elected Executive Director of both Institutes.

The theme for the 20th joint ABI/NCI Annual Meeting was "Strategies for the Future". Over 500 attendees heard speakers discuss topics as varied as productivity, strategic planning, butter cultures, low fat cheese characteristics, the future of dairy market orders, and international trade negotiations.

Effects of Some Spices on Acid Production by Starter Cultures

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ABSTRACT

Ginger, red pepper, mustard, mace, cinnamon and clove were examined to determine their effects on growth of and acid production by a starter culture containing *Lactobacillus plantarum* and *Pediococcus cerevisiae* in a liquid medium. At 4, 8, and 12 g/l levels all spices except clove stimulated acid production by the starter bacteria but did not stimulate increases in bacterial population. Clove was inhibitory to the starter bacteria at and above the 4 g/l level, but low concentrations (0.5 - 2.0 g/l) stimulated acid production. High concentrations of cinnamon (8 and 12 g/l) delayed acid production, but bacterial counts were similar to those of the control.

The antimicrobial properties of spices have been investigated for many years (5-7,15,21). Most of the published reports deal with the effect of essential oils of spices and other plant materials on a variety of microorganisms (2,4,16-18). Koedam (14) reviewed the literature on antimicrobial action of essential oils for the period 1960-1976. Reviews of earlier work on spices may be found in references 4, 7, and 20. Considerable variation in resistance of different microorganisms to a given spice and of the same organism to different spices has been observed (4,7). Although much attention has been paid to pathogenic microorganisms (4,6,9,13,20), little information is available on the effect of spices on nonpathogenic microorganisms, particularly those used as starter cultures in the food industry. Recently Salzer et al. (19) reported on the effect of black pepper and its constituents on several species of starter culture organisms and fecal bacteria. *Lactobacillus plantarum* was inhibited the least, *Micrococcus specialis* and *Streptococcus faecalis* were somewhat inhibited and *Escherichia coli* was inhibited the most. These workers showed that fermented sausages can be prepared with encapsulated pepper extract when starter cultures are used. Karaioannoglou et al. (11) found that garlic is inhibitory to *L. plantarum* at concentrations greater than 1%.

Our studies on Lebanon bologna (23) indicate that addition of spices to the sausage formulation enhanced acid production during fermentation by either the natural microflora present in ground meat or by added

starter culture. We employed Lactacel MC starter culture composed of *L. plantarum* and *Pediococcus cerevisiae*. Recently we reported on the effect of Lebanon bologna spice mixture and its major components, black pepper, allspice, and nutmeg, on growth of and acid production by Lactacel MC starter culture in a liquid medium (12). These spices stimulated acid production by the starter culture; however, this effect could not be attributed to increased bacterial population, since the bacterial counts of spice-containing samples (4, 8 or 12 g/l) did not differ significantly from those of the controls.

This paper reports on the effect of the other spices used in our Lebanon bologna formulation, red pepper, clove, cinnamon, ginger, mustard and mace, on starter culture Lactacel MC in a liquid medium.

EXPERIMENTAL

Spices

Sterilized red pepper, clove, cinnamon, ginger, mustard and mace (Griffith Laboratories³, Inc., Union, NJ) were used throughout the experiment.

Liquid medium

Beef extract (Difco Labs, Detroit, Mich.), 3 g; tryptone (Difco), 5 g; sucrose, 20 g; and glucose, 20 g were dissolved in 1 liter of distilled water. The pH of the solution was adjusted to 6.4 with 0.1 N H₂SO₄ to give a post-sterilization pH 5.8-6.1. Aliquots of 250 ml of the medium were dispensed into 500-ml Erlenmeyer flasks and sterilized for 15 min at 15 psi.

Starter culture

Lactacel MC (Merck and Co., Inc., Rahway, NJ) containing *L. plantarum* and *P. cerevisiae* was used in our fermentation work. In some experiments the individual organisms were used: *P. cerevisiae* (Lactacel, Merck and Co.) and *L. plantarum* (Lactacel DS, Merck and Co.).

Fermentation

Sterilized spices were added aseptically to the flasks of sterile medium to provide concentrations of 0.5, 1, 2, 4, 8, or 12 g/l, respectively. Then 2.5 ml of commercial starter culture diluted with 0.5% peptone water was added to each flask and to a control containing no spice to give an initial bacterial population in the range of 1.0-5.0 × 10⁴ cells/ml. The flasks were incubated statically for 4 days at 35 C. Samples for bacterial counts and titratable acidity were taken at 24-h intervals.

Bacterial counts

Bacterial counts were made by conventional pour plate techniques with tryptone glucose extract agar (Difco). Plates were incubated for 48 h at 35 C.

Titratable acidity

Titratable acidity was expressed as ml of 0.1 N NaOH required to titrate to pH 7.0 a 10-ml aliquot of the liquid medium after

¹Presented at the 38th Annual Meeting of the Institute of Food Technologists, Dallas, TX, June 4-7, 1978.

²Agricultural Research, Science and Education Administration, U.S. Department of Agriculture.

³Reference to brand or firm name does not constitute endorsement by the U.S. Department of Agriculture over others of a similar nature not mentioned.

centrifugation and dilution with 50 ml of distilled water. The initial titratable acidities of the liquid media were 0.54-0.75 ml. Addition of all spices except clove did not change the initial value significantly.

RESULTS AND DISCUSSION

The spice concentrations used in this work were chosen to encompass the levels used in Lebanon bologna formulations. The higher concentrations were used to determine possible germicidal effects of spices.

All the spices examined enhanced acid production by Lactacel MC starter culture but did not stimulate bacterial growth. The effect of spice concentration and the extent of stimulation of acid production was characteristic for each spice studied. The amount of acid produced, expressed as titratable acidity, and the bacterial counts for cultures exposed to 4, 8, and 12 g/l of ginger, mace, mustard, red pepper, and cinnamon were measured at 24-h intervals for 4 days as shown in Fig. 1-5, respectively. Bacterial counts for both the control and the spice-containing samples increased from 10^4 to 10^8 cells/ml after 24 h and remained in that range throughout the incubation period. A slight decrease in counts was occasionally observed after 96 h of incubation.

Twice as much acid was produced in samples containing ginger as in the control (Fig. 1). The amount of acid produced was similar for all three concentrations of ginger tested, and no significant differences in bacterial counts were observed until at least 72 h of fermentation.

Mace stimulated acid production by the starter culture only slightly and the acidity produced at the 4, 8 and 12 g/l levels did not differ significantly (Fig. 2). Bacterial counts for all samples were in the 10^8 cells/ml range after 24 and 48 h and decreased slightly during the later stages of incubation.

Acid production by Lactacel MC starter culture increased with increasing concentrations of mustard

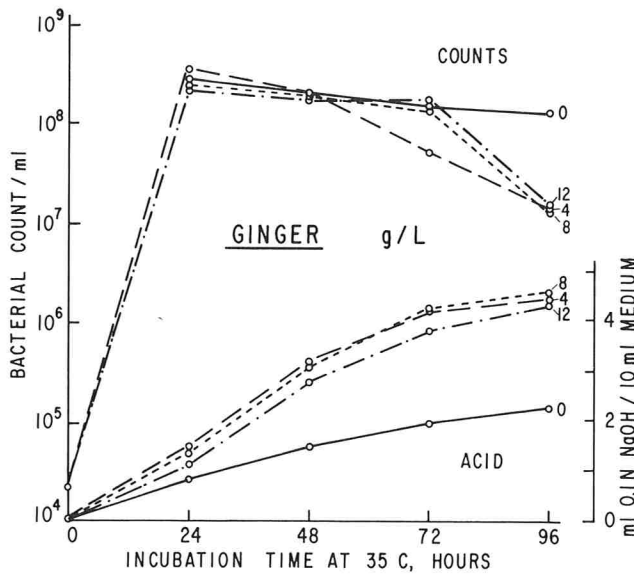


Figure 1. Effect of 4, 8, and 12 g/l ginger on growth of and acid production by Lactacel MC starter culture organisms in liquid medium.

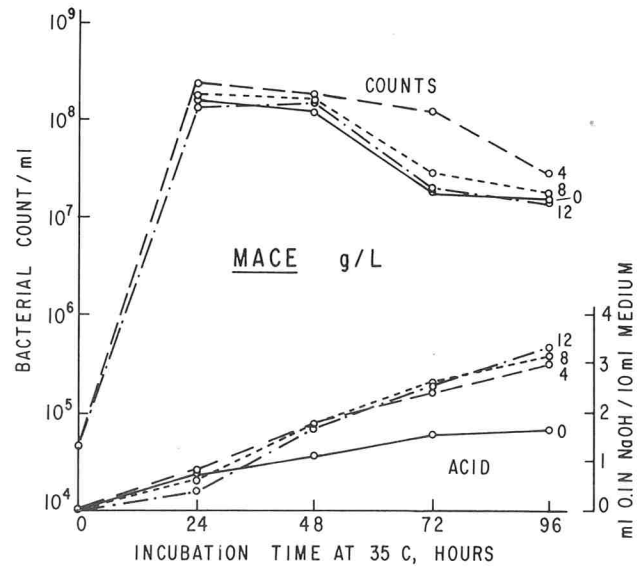


Figure 2. Effect of 4, 8, and 12 g/l mace on growth of and acid production by Lactacel MC starter culture organisms in liquid medium.

(Fig. 3). At the 12 g/l concentration, three times as much acid was produced as in the control sample. Bacterial counts for the control and the samples containing 4, 8 and 12 g/l mustard were similar and were in the range $2.5-4.0 \times 10^8$ cells/ml at 24 and 48 h.

Red pepper (Fig. 4), like mustard, strongly stimulated acid production, particularly in the initial stages of fermentation. Bacterial counts for the control and the samples containing red pepper were practically identical during 4 days of fermentation. Acid production increased with increasing concentration of red pepper at all stages of fermentation. Titratable acidities after 96 h for the control and for samples containing 4, 8 and 12 g/l red pepper were 2.29, 4.15, 5.64 and 6.83 ml, respectively.

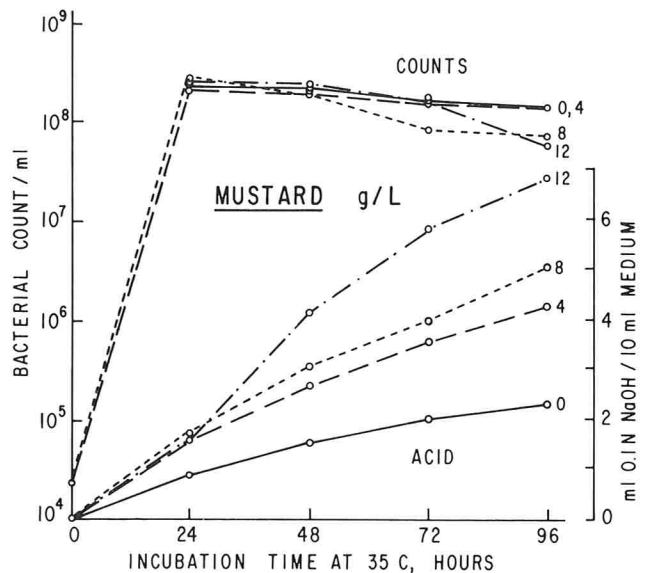


Figure 3. Effect of 4, 8, and 12 g/l mustard on growth of and acid production by Lactacel MC starter culture organisms in liquid medium.

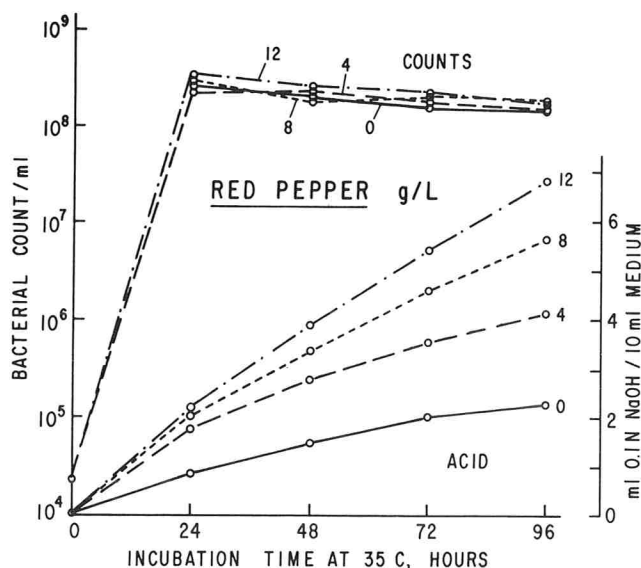


Figure 4. Effect of 4, 8, and 12 g/l red pepper on growth of and acid production by Lactacel MC starter culture organisms in liquid medium.

The effect of cinnamon (Fig. 5) on acid production by the starter culture organisms was different from the effects of the above-mentioned spices. Titratable acidities for all cinnamon-containing samples were greater than for the control after 96 h; however, the amount of stimulation diminished with increasing concentration of cinnamon. There was a definite inhibition of acid production in cinnamon-containing samples in the initial stages of fermentation. After 24 h, the sample with 4 g/l cinnamon had an acidity value similar to that of the control, while no acid was formed in the 8 and 12 g/l samples. In fact, at the 12 g/l level, acid production did not take place until after 48 h of fermentation. However, bacterial growth was not inhibited in any of the cinnamon-containing samples at

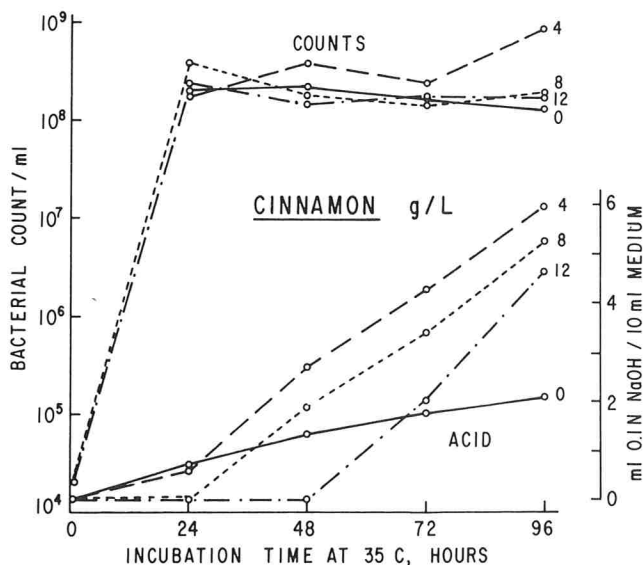


Figure 5. Effect of 4, 8, and 12 g/l cinnamon on growth of and acid production by Lactacel MC starter culture organisms in liquid medium.

any stage in the fermentation, and all counts fell into a relatively narrow range around 3×10^8 cells/ml. This is in contrast to the findings of a number of workers that cinnamon possesses strong antimicrobial properties toward some microorganisms (3,7,10).

To investigate this effect further, cinnamon was added to the liquid medium in concentrations ranging from 0.5 to 8 g/l. Acid production (Fig. 6) increased with increasing concentration of cinnamon, reaching a maximum at the 4 g/l level, and then declined at the 8 g/l level. In the presence of 2 g/l cinnamon or less, acid production was enhanced even after 24 h, while at higher concentrations acid production was initially inhibited but at later stages enhanced. Bacterial counts (Table 1) for samples containing up to 4 g/l cinnamon were in the same range as the control, 10^8 cells/ml throughout the incubation period. In this instance the sample containing 8 g/l cinnamon had a slightly lower count after 24 h, 2.0×10^7 , but the count reached 1.7×10^8 cells/ml after 48 h.

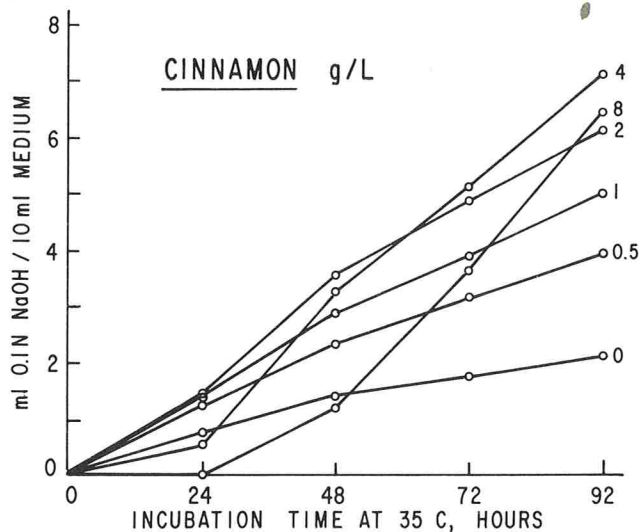


Figure 6. Effect of 0.5, 1, 2, 4, and 8 g/l cinnamon on acid production by Lactacel MC starter culture organisms in liquid medium.

Initial experiments indicated that no acid was produced in samples containing 8 g/l clove. This was expected since clove has been reported to show antimicrobial activity toward various species of microorganisms. Therefore the effect of clove on Lactacel MC starter culture was tested at concentrations ranging from 0.5 to 8 g/l. Bacterial counts (Fig. 7) for samples containing 0.5 g/l clove did not differ significantly from those of the control. However, with increasing concentration of clove, increased inhibitory effects on the starter culture organisms were observed. Clove was definitely inhibitory at the 8-g/l concentration. In spite of its inhibitory effect at higher concentrations, clove stimulated acid production by the starter culture bacteria at low concentrations (Fig. 8). In fact, twice as much acid was produced in samples containing 0.5 g/l clove as in the control. At the 2 g/l level, the amount of acid produced was equal to that of the control, even though the bacterial count was about 2 logs less than that for the

TABLE 1. Effect of cinnamon on growth of starter culture (*L. plantarum* and *P. cerevisiae*) at 35 C.

Cinnamon (g/l)	Bacterial count ^a /ml			
	24 h	48 h	72 h	96 h
0	1.9 × 10 ⁸	2.0 × 10 ⁸	1.2 × 10 ⁸	8.3 × 10 ⁷
0.5	2.3 × 10 ⁸	3.2 × 10 ⁸	2.4 × 10 ⁸	2.1 × 10 ⁸
1	2.4 × 10 ⁸	3.4 × 10 ⁸	3.6 × 10 ⁸	2.2 × 10 ⁸
2	2.9 × 10 ⁸	8.8 × 10 ⁸	9.6 × 10 ⁸	1.0 × 10 ⁸
4	1.7 × 10 ⁸	2.0 × 10 ⁸	3.2 × 10 ⁸	7.6 × 10 ⁷
8	2.0 × 10 ⁷	1.7 × 10 ⁸	2.3 × 10 ⁸	3.0 × 10 ⁸

^aThe initial bacterial count was 3.9 × 10⁴ cells/ml.

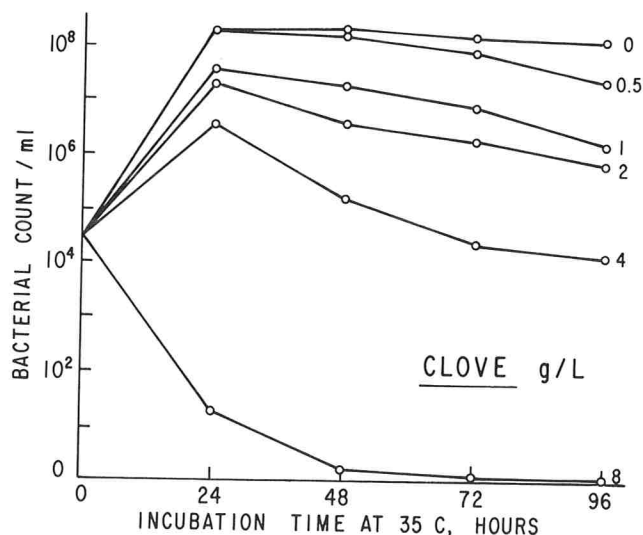


Figure 7. Effect of 0.5, 1, 2, 4, and 8 g/l clove on survival of Lactacel MC starter culture organisms in liquid medium.

control. This indicates strong stimulation by clove of acid production by the starter culture bacteria.

The effect of clove at concentrations of 0.5 to 8 g/l was also tested on the individual components of the mixed starter culture, *L. plantarum* and *P. cerevisiae*. Results for the individual microorganisms (Table 2) were similar to those obtained for the mixed culture. Low levels of clove stimulated acid production by both starter organisms, but to a greater extent by *L. plantarum*. Increasing concentrations of clove were inhibitory to both organisms, and 8 g of clove/l was bactericidal.

TABLE 2. Effect of clove on growth of and acid production by *L. plantarum* and *P. cerevisiae*.

Bacterium	g/l	Incubation time at 35 C							
		24 h		48 h		72 h		96 h	
		TA ^a	count/ml	TA	count/ml	TA	count/ml	TA	count/ml
<i>L. plantarum</i> ^b									
Control	—	0.55	4.0 × 10 ⁷	0.75	1.8 × 10 ⁷	1.00	1.2 × 10 ⁷	1.16	8.0 × 10 ⁶
Clove	0.5	1.12	4.9 × 10 ⁷	3.62	4.1 × 10 ⁷	4.96	2.3 × 10 ⁷	5.33	1.1 × 10 ⁷
Clove	1	1.00	1.7 × 10 ⁷	2.73	1.1 × 10 ⁷	3.39	4.3 × 10 ⁶	3.55	1.8 × 10 ⁶
Clove	2	0.61	1.2 × 10 ⁷	1.64	6.7 × 10 ⁶	2.00	1.7 × 10 ⁶	2.16	6.9 × 10 ⁵
Clove	4	0.40	3.6 × 10 ⁶	0.69	8.4 × 10 ⁵	0.78	6.4 × 10 ⁴	0.78	1.3 × 10 ⁴
Clove	8	0.14	5	0.12	2.0 × 10 ²	0.15	< 1	0.16	< 1
<i>P. cerevisiae</i> ^c									
Control	—	0.62	1.6 × 10 ⁸	1.11	9.3 × 10 ⁷	1.38	3.6 × 10 ⁷	1.49	2.1 × 10 ⁷
Clove	0.5	1.12	1.4 × 10 ⁸	2.59	9.7 × 10 ⁷	3.33	3.8 × 10 ⁷	3.71	1.0 × 10 ⁷
Clove	1	0.85	1.0 × 10 ⁸	2.60	4.7 × 10 ⁷	3.08	9.4 × 10 ⁶	3.27	1.7 × 10 ⁶
Clove	2	0.19	2.5 × 10 ⁷	1.18	1.6 × 10 ⁷	1.77	7.1 × 10 ⁶	1.99	8.2 × 10 ⁵
Clove	4	0.09	8.0 × 10 ⁴	0.18	2.9 × 10 ⁵	0.30	3.0 × 10 ⁵	0.44	1.8 × 10 ⁵
Clove	8	0.14	1.2 × 10 ²	0.22	2	0.24	< 1	0.31	< 1

^aTA = Titratable acidity.

^bAll samples initially contained 3.4 × 10⁴ cells/ml of Lactacel DS starter culture.

^cAll samples initially contained 1.6 × 10⁴ cells/ml of Lactacel starter culture.

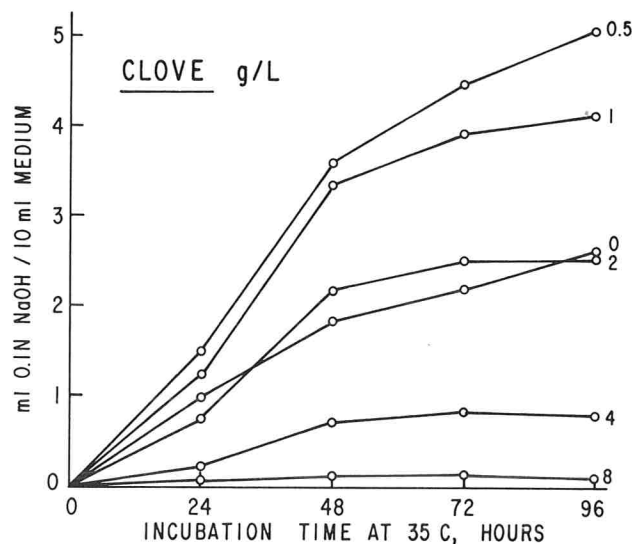


Figure 8. Effect of 0.5, 1, 2, 4, and 8 g/l clove on acid production by Lactacel MC starter culture organisms in liquid medium.

Our data suggest that the starter culture organisms, *L. plantarum* and *P. cerevisiae*, are more resistant to the inhibitory effects of spices than are many of the microorganisms investigated by other workers. Of the spices that we studied, cinnamon and clove have been reported to inhibit a variety of yeasts, molds and bacteria, while the other spices were considered inactive or active only at high concentrations (1,3,5-7,10,21). Mustard was reported to be particularly inhibitory to yeast (5,22). Fabian et al. (7) reported that ground cinnamon and clove inhibited pathogenic bacteria at concentrations as low as 0.1%, while mustard, mace and ginger were inhibitory at 5% concentration. Although we found that the growth of Lactacel MC starter culture bacteria was unaffected by red pepper, Gál (8) found that capsaicin, the hot principle of red pepper, at a dilution of 1:1000, slightly inhibited growth of *L. plantarum*, did not affect *Staphylococcus aureus* or *Escherichia coli*, but prevented growth of *Bacillus subtilis* and *Bacillus cereus*.

There are only a few reports in the literature dealing with stimulatory effects of spices. Webb and Tanner (21)

stated that oils of black and white peppers appear to contain growth stimulants for yeasts; however, they did not present data to substantiate this claim. Corran and Edgar (5), reporting on the preservative action of spices against yeast fermentation, measured by loss of glucose from the medium, suggested that black pepper contains a yeast stimulant. Salzer et al. (19) also reported that black pepper stimulated growth of micrococci, but their findings were inconclusive. Wright et al. (22), however, showed that a number of spices at low concentration, including cinnamon, ginger and mace, exhibited marked stimulation of gas production during yeast fermentation and that the enhanced gas production was not the result of accelerated yeast cell proliferation.

Many investigators were concerned only with screening spices and spice components for antimicrobial properties toward a variety of microorganisms. However, our results indicate that although spices may not affect the population of the starter culture bacteria, they may affect production of metabolites by the microorganisms. Also, the concentration at which spices are used is important; large quantities may be germicidal while low concentrations may stimulate some activity of the microorganism. The stimulatory effects we observed might possibly be attributed to trace metals, co-factors, enzymes or other constituents of spices. Additional information is needed to define the mechanism of interaction between spices and microorganisms.

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Naturally-Occurring Estrogens in Plant Foodstuffs - A Review

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ABSTRACT

A number of non-steroidal estrogenic substances are common naturally-occurring constituents of human foods. Concern over dietary estrogens has focused largely on the consumption of trace amounts of diethylstilbestrol (DES) from tissues of cattle fed the compound as a growth stimulant. Human exposure to naturally-occurring fungal and phytoestrogens in foods is, however, substantially larger than exposure to DES in animal tissues. Occurrence, potency and toxicity of the estrogenic isoflavones, coumestans and resorcylic acid lactones are reviewed.

Numerous chemicals which are tumorigenic or carcinogenic in experimental animals are common naturally-occurring constituents of foods. Nitrosamines, aflatoxins, polycyclic aromatic hydrocarbons and estrogens can all be shown, under appropriate conditions, to be carcinogens and are all commonly consumed in foods. The significance of these compounds in the etiology of various human cancers is, of course, the subject of considerable controversy. The possible significance of naturally-occurring estrogens in foods has been widely publicized in recent years by the public debate and scientific discussion over the presence of diethylstilbestrol (DES) residues in liver or other tissues from animals treated with DES as a growth stimulant. DES is widely used in production of cattle in the U.S. although its use was at one time banned by the FDA (1,2). Amounts of DES present in meat and poultry products which led to the ban were extremely small and it has been frequently suggested that the dietary estrogens to which humans are exposed are predominantly naturally-occurring phytoestrogens rather than residues of feed additives. The significance of this comparison of intake levels is, of course, complicated both by problems in applying dose-response toxicology to carcinogenesis and by the question of whether more stringent standards should apply to regulation of intentional additives than apply to regulation of naturally-occurring substances of a similar kind. Resolution of these issues is beyond the scope of this review. The intent here is to summarize what is known about naturally-occurring non-steroidal estrogens in plants and plant foodstuffs.

ESTROGENS IN PLANTS

Existence of estrogenic substances in plants has been recognized for a considerable time. Bradbury and White in 1954 listed over 50 species of plants which had been

shown to possess estrogenic activity and many more have been reported since that time (15,23,24). As shown by data in Table 1, estrogenic activity has been detected in a wide variety of food products, some of which are of major importance in our food supply. In most instances the chemical constituents responsible for the estrogenic activity of these plants have not been characterized. Reports of estrogenic activity are based most commonly on either evidence of uterine enlargement or of cornification of vaginal epithelium after treatment of experimental animals with plant extracts. Both of these assays are subject to several criticisms and misleading results are possible (22). The effect of the physiological state of the plant has only rarely been considered as an important variable in estrogenicity studies. The estrogen levels in clover are, for example, known to be affected by conditions of growth, climate, variety, stage of growth and other similar parameters (28). Variability in the reported estrogenicity of hops (Table 1) may be due to effects of this kind.

TABLE 1. Estrogenic activity of selected plant foodstuffs.

Source	Amount	Reference
Carrots, fresh	+	26
Cabbage	0.024 $\mu\text{g E}_2/\text{g}^a$	19
Peas	0.004-0.006 $\mu\text{g E}_2/\text{g}$	19
Hops	1-2 $\mu\text{g E}_2/\text{g}$	19
	20-300 $\mu\text{g E}_2/\text{g}$	40
	None	25
Wheat bran	+	12
Wheat germ	+	12
Rice bran	+	12
Rice polish	+	12
Soybean meal	+	55,56
Vegetable oils	+	12,69
Pomegranate seeds	4 $\mu\text{g estrone}/\text{kg}$	21
	17 mg estrone/kg	29
Milk	+	66

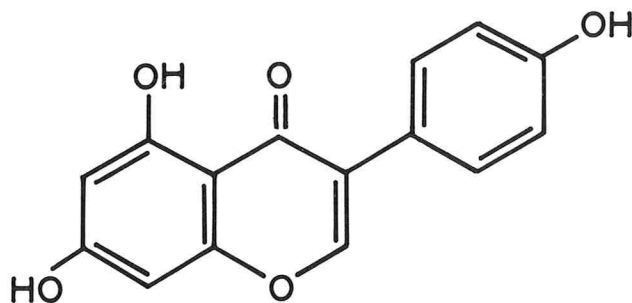
^a $\text{E}_2 = 17\text{-}\beta\text{-estradiol}$.

It is somewhat unfortunate for our purposes that most of the information available on plant estrogens is concerned with estrogenic substances in feeds (clover, alfalfa, fungus-infected grains), rather than concerned specifically with those estrogens of significance in human foods. Nevertheless, most of the information obtained from these feed-directed studies is pertinent and will be discussed in this review of the literature. Those phytoestrogens which have been characterized fit into three general chemical categories: isoflavones, coumestans and resorcylic acid lactones. It should be

emphasized, however, that many other classes of compounds to which man is commonly exposed may possess either uterotrophic or estrogenic properties. Gibberellic acid, for example, is a widely distributed plant hormone which has been reported to possess estrogenic properties (45,46). Several insecticides have estrogen-like activity (63). The estrogenicity of delta-9-tetrahydrocannabinol has been recently debated (60,76).

ISOFLAVONES

Isoflavones are the most common naturally-occurring isoflavonoids. Wong (85) listed over 70 isoflavones and 40 isoflavone glycosides which have been shown to occur naturally. Many of the compounds which have been isolated as free isoflavones may exist in vivo as glucosides. (4,80). Only a limited number of these compounds have been shown to be estrogenic. Genistein (4',5,7-trihydroxyisoflavone) was first isolated from subterranean clover and, though not a steroid, has a structure with



GENISTEIN

some resemblance to that of estradiol and diethylstilbestrol. Genistein stimulates uterine growth in ovariectomized mice (5,86), sheep (16), and rats (59). In mice genistein is roughly 10^5 times less effective than diethylstilbestrol as an estrogen in stimulating uterine enlargement (Table 2) (6,16). Based on competitive binding to human tumor cell estradiol receptors, however, genistein is only 50 times less potent than 17β -estradiol (Table 3). Clearly, affinity for estradiol receptors indicates a much higher potency than is suggested by in vivo uterine weight assays. It is probable that transport and metabolic effects are responsible for

TABLE 2. Relative potency of some naturally-occurring estrogens in mice.^a

	Quantity to produce 25 mg uterus (μ g)	Relative potency
Diethylstilbestrol	0.083	100.000
Estrone	1.2	6.900
Coumestrol	240	35
Coumestrol diacetate	340	24
Genistein	8,000	1.0 ^b
Daidzein	11,000	0.75
Biochanin A	18,000	0.46
Formononetin	32,000	0.26

^aFrom (6).

^bGenistein arbitrarily assigned a value of 1.0.

this difference. It is not clear at this time which method of estimating estrogenicity is of most value in predicting potency in humans.

Other common isoflavones which have been shown to be estrogenic are daidzein (4',7-dihydroxyisoflavone), biochanin A (5,7-dihydroxy-4'-methoxyisoflavone), and formononetin (7-hydroxy-4'-methoxyisoflavone). Based on either relative affinity for estrogen receptors or assays using mouse uterine weight these compounds are very weak estrogens (Table 2, Fig. 1). Other classes of flavonoids have been examined for estrogenic activity but appear to be relatively inactive compared to the isoflavones.

Investigations of the estrogenic isoflavones began in the 1940s as an attempt to explain the causes of "clover disease" which resulted in infertility in sheep grazing on certain forages. The problem was traced to the presence of estrogenic isoflavones in several common clovers. Concentrations of isoflavones in clover can be as great as 5% of the dry matter content of the leaves of healthy plants (73). Genistein and formononetin are the major isoflavones present in clovers responsible for reproductive problems in sheep. Because formononetin is a relatively weak estrogen in mice, whereas genistein is quite active in mice and poultry (18) and in guinea pigs (54), genistein was thought for some time to be the principal cause of 'clover disease' in sheep. However, genistein content of clover varieties does not correlate well with estrogenic activity in sheep, whereas formononetin content correlates quite well (50). The high estrogenic activity in sheep of formononetin compared to genistein has been shown to be a direct result of the metabolism of the two isoflavones. Genistein and

TABLE 3. Relative affinity of phytoestrogens for mammalian estrogen receptors.

Estrogen	Receptor			
	Rabbit uterine cytosol (71)	Sheep uterine cytosol (74)	Human cancer cell line MCF-7 (47)	Rat uterine cytosol (84)
17β -estradiol	100	100	100	100
HMP zearalanol	—	—	20	21.3
Coumestrol	1.4	5	10	5.0
Zearalenone	—	—	3.3	3.4
Genistein	0.6	0.9	2	1.3
LMP zearalanol	—	—	1.3	0.6
Daidzein	—	0.1	—	0.09
Formononetin	—	<0.01	<0.01	—
Biochanin A	—	—	—	0.07

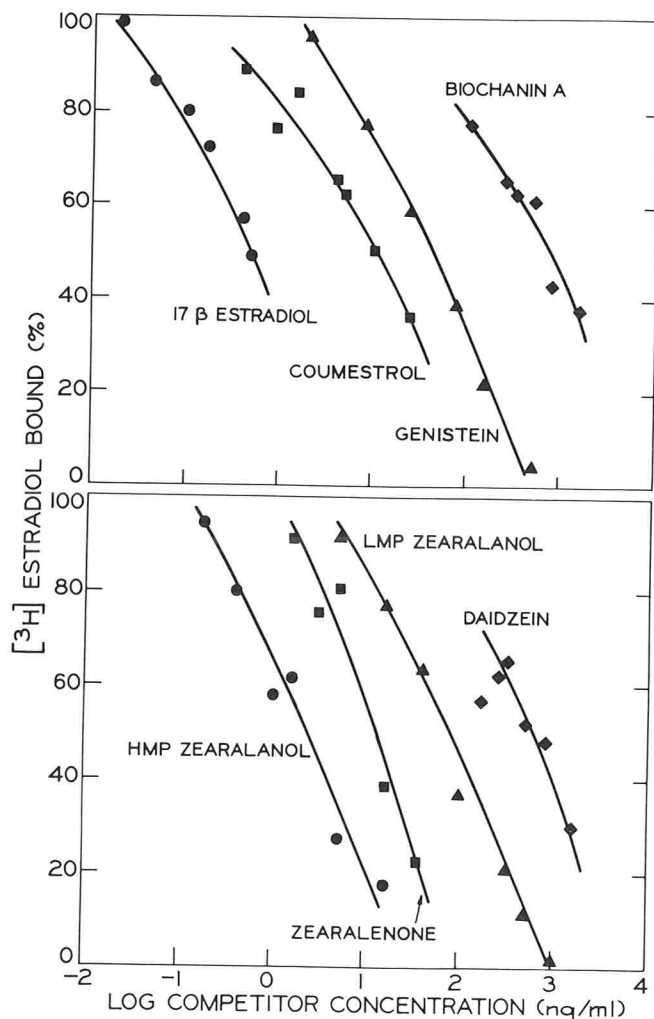


Figure 1. Competitive binding of plant and fungal estrogens to ^3H -estradiol binding proteins from rat uterine cytosol. From Verdeal (84).

biochanin A are degraded (Fig. 2) in the rumen to give p-ethyl-phenol and a phenolic acid, neither of which are estrogenic. The primary pathway for degradation of formononetin, however, is demethylation to give daidzein and subsequent reduction to give equol, an estrogenically active compound (3,75). The relative estrogenicity of genistein and formononetin in sheep is therefore the opposite of the situation in mice.

The pathway for degradation of genistein and

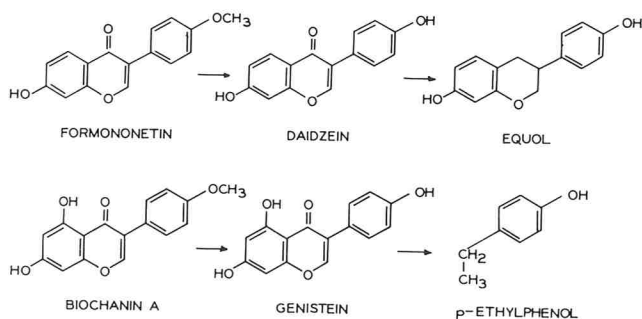


Figure 2. Metabolism of estrogenic isoflavones in the rumen of the sheep. Adapted from Shutt (73).

biochanin A appears to be induced in sheep only after several days of ingestion of feed rich in isoflavones. In contrast, metabolism of formononetin to equol does not change significantly with time. The estrogenicity of genistein and biochanin A, then, appears to depend on the feeding history of the animal while the estrogenicity of formononetin does not exhibit such a dependence (20,73). The ability of an animal to develop metabolic pathways to inactivate estrogenic isoflavones, then, can have a decisive effect on the overall significance of the presence of these substances in foods. It is extremely difficult for this reason to draw conclusions about a compound's estrogenicity in one species from experiments with another species. Unfortunately very little is known about the metabolism of estrogenic isoflavones in non-ruminants in general and in man in particular (41).

Several isoflavones appear to possess antifungal or antibacterial properties and coordinate derepression of isoflavonoid biosynthesis may be responsible in part for the hypersensitive resistant response of plant tissue to invasion by pathogens. For example, daidzein accumulates to high levels in soybeans after infection with either *Phytophthora megasperma* or *Phytophthora glycinea* (36,38). Daidzein also accumulates in ozone-injured soybean leaves (37). Other isoflavones which have been shown to accumulate after fungal infection of various plants include genistein (10), 2',4',5,7 tetrahydroxyisoflavone (10) and formononetin (61). Free isoflavones have been shown to have higher fungistatic activity than the corresponding glycosides (55) and a glycosidase from the invading fungus may be responsible for activation of the isoflavonoids synthesized by the plant (62). Biosynthesis of isoflavones in response to physical damage or fungal infection could be one reason for variations in isoflavone content of foods.

COUMESTANS

A second class of isoflavonoids that contains compounds which possess estrogenic activity is the coumestans (coumaranocoumarins). Over 20 naturally-occurring coumestans have been reported (85). The coumestans which have been most thoroughly studied are the estrogenic coumestans from alfalfa (*Medicago sativa*) and ladino clover (*Trifolium repens*) (Table 4). The dominant estrogen in alfalfa appears to be coumestrol (9).

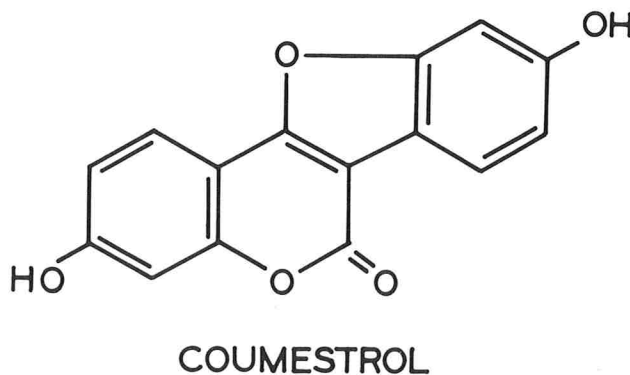


TABLE 4. Naturally-occurring coumestans isolated from alfalfa.

Common name	Trivial name	Reference
Coumestrol	7,12-Dihydroxy-coumestan	5
Trifoliol	7,10-Dihydroxy-12-methoxy-coumestan	42
Medicagol	7-Hydroxy-11,12-methylene-dioxy-coumestan	43
4'-Methoxycoumestrol	7,12-Dihydroxy-12-methoxy-coumestan	7
3'-Methoxycoumestrol	7,12-Dihydroxy-11-methoxy-coumestan	8
Lucernol	6,7,12-Trihydroxycoumestan	77
Sativol	7-Methoxy-8,12-dihydroxy-coumestan	77
—	7-Hydroxy-11,12-dimethoxy-coumestan	78

Coumestrol has been detected in several clovers as well as in many other plant products more commonly consumed by man (Table 5). Based on the dosage required to produce a uterine weight of 25 mg in mice, coumestrol has been estimated to be 30-100 times more active as an estrogen than are the isoflavones (Table 2). The affinity of coumestrol for mammalian estradiol receptors is only roughly 10 to 20 times lower than the affinity of 17 β estradiol (Table 3) (Fig. 1). Coumestrol binds to high-affinity estradiol-binding proteins in DMBA-induced rat mammary tumor tissue and in human mammary tumor tissue (84).

TABLE 5. Coumestrol content of plant products.^a

Product	Coumestrol, $\mu\text{g/g}$ dry weight
Alfalfa sprouts (fresh)	5.0
Soybean sprouts (fresh)	71.1
Soybean (dry)	1.2
Soybean meal defatted (dry)	0.4
Soybean concentrate (dry)	0.2
Soybean isolate (dry)	0.6
Green beans (frozen)	1.0
Snow peas (frozen)	0.6
Green peas (frozen)	0.4
Brussell sprouts (frozen)	0.4
Red beans (dry)	0.4
Split peas (dry)	0.3
Spinach leaf (frozen)	0.1

^aFrom (39).

As was true with the isoflavones, the coumestrol content of clover and other plants is influenced by conditions of growth, climate, varietal and genetic differences and stage of growth (28). Germination of soybeans appears to increase coumestrol content by a factor of nearly 60 (Table 5). A considerable amount of evidence has accumulated which demonstrates that synthesis of coumestrol in plants is affected by disease or insect infestation. For example, accumulation of coumestrol occurs in hypocotyls of soybeans infected with a fungus (38) and has been associated with the hypersensitive resistance response in lima beans (65). White clover does not normally exhibit any estrogenic activity, but after fungal infection it can produce estrogenic effects in sheep (57). Concentrations of coumestrol as high as 2362 ppm have been reported in leaves of severely infected plants (44). High coumestrol

contents of alfalfa extracts may be a problem in use of alfalfa leaf protein concentrate on a large scale (39).

RESORCYLIC ACID LACTONES

The third class of estrogenic substances which occur in plant foodstuffs are derivatives of resorcylic acid lactones. Zearalenone [6 (10-hydroxy-6-oxo-trans-1-undecenyl)- β -resorcylic acid lactone] and its derivatives (Table 6) are mycotoxins synthesized by the mold

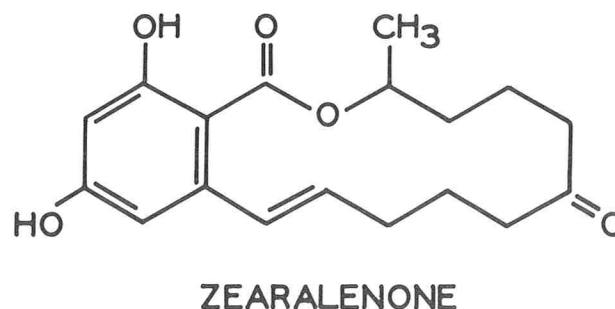


TABLE 6. Naturally-occurring derivatives of zearalenone.

Name	Reference
8'-hydroxyzearalenone	35
8'-epi-hydroxyzearalenone	35
5 formylzearalenone	11
7'Dehydrozearalenone	11
6'8'Dihydroxyzearalenone	51

Fusarium roseum which can infect corn, wheat, barley, sorghum or hay (33,51,53,72). Zearalenone has been referred to as "fermentation estrogenic substance (FES)" or as F-2 toxin. *Fusarium* infection is very common. Surveys of the U.S. corn and wheat crops show a 10-20% incidence of zearalenone contamination of marketable corn and wheat with contamination as high as 10 ppm zearalenone (30,79). High concentrations of zearalenone occur generally only after storage of infected grains; however, zearalenone has been identified in freshly harvested corn (17). A derivative of zearalenone, zearalanol, has been patented for use as a growth stimulant in animals by Commercial Solvents Corporation under the trade name Ralgro. Its use as an ear implant in cattle has been approved by the FDA (13,64,70).

Numerous effects of zearalenone in experimental animals and in model systems have been observed. Swine, which are particularly sensitive to zearalenone, develop several reproductive disorders on diets containing *Fusarium*-infected feeds. Approximately 1-5 ppm zearalenone (4 mg cumulative total dose) is sufficient to cause signs of vulvovaginitis in gilts (51). Miller and co-workers have shown that sows and gilts receiving 5 mg of purified zearalenone daily throughout the last month of pregnancy produced litters with stillborn pigs or pigs with a "spayleg" incoordination of hind limbs (49). When administered subcutaneously, zearalenone is less active in the assay for mouse uterine enlargement than when administered by gavage, suggesting that some

metabolic intermediate more active than zearalenone may be involved (52). Both zearalenone and zearalanol bind to estradiol-binding sites from several mammalian tissues (Table 3) (Fig. 1) (14,27,47,84). Zearalenone has been suggested to be mutagenic by Ueno and Kubota (81) who used a recombination-deficient mutant cell line of *Bacillus subtilis*. The cytotoxic effect of zearalenone in various monolayer cell cultures has been investigated (83). Dietary zearalenone has also been suggested as a possible cause of spontaneous tumors in laboratory animals (38,67) although no solid evidence to support this suggestion has been provided. Hobson et al. have examined the effects of zearalenone on serum gonadotropins in ovariectomized rhesus monkeys and shown that zearalenone is only slightly less potent than estradiol or DES when administered by subcutaneous injection but is substantially less potent when administered orally (34).

In addition to the numerous effects which have been observed in experimental animals and in model systems, zearalenone appears to be estrogenic in humans. At a dose of 75-100 mg/day zearalenone appears to be effective in treatment of symptoms of postmenopausal syndrome in women (31,82). Both zearalanol and zearalenone have been reported to be effective oral contraceptive agents in humans and have been patented for this use (32). Zearalenone and its derivatives are the only naturally-occurring non-steroidal estrogens which have been shown to be estrogenic in vivo in man. Amounts of zearalenone to which humans are likely to be exposed in foods are several orders of magnitude lower than the amounts necessary for contraception. The significance of low-level long-term exposure to these compounds either in the etiology of hormone-dependent tumors or in the responsiveness of hormone-dependent tumors to hormone therapy is not known.

HUMAN EXPOSURE TO DIETARY ESTROGENS

Table 7 lists estimates of the extent of human exposure to estrogens of various kinds measured in DES equivalents. Examples of exposure to phytoestrogens given in this table are on the basis of quantitative analysis of specific phytoestrogens. Estimates of total estrogen content of plant foods could be considerably higher. Unless phytoestrogens are metabolized to more potent estrogens, however, it is clearly not likely that humans are exposed to dietary doses sufficient to cause any major physiological response. The possibility of metabolic alteration to more or less active forms should not be ignored, however, since effects of this kind have been demonstrated in experimental animals. Likely human exposure to phytoestrogens when measured in DES equivalents is considerably higher than likely human exposure to DES in liver from cattle treated with DES as a growth stimulant. This is particularly true since 0.5 ppb DES in liver is a large overestimate of actual DES levels and would only occur in liver from improperly treated cattle. It seems probable, then, that actual

TABLE 7. Human exposure to exogenous estrogens.

Source	Estimate of possible daily dose (μg /DES equivalents) ^a	Reference
Morning-after pill	50,000	2
Birth control pill	2,500	2
Post-hysterectomy replacement therapy	500-1,000	2
Post-menopausal therapy	500	2
100 g beef liver with 0.5 ppb DES	0.05	2
100 g wheat with 2 ppm zearalenone	0.2	30
20 g (dry weight) soybean sprouts with 70 ppm coumestrol	0.5	39
100 g beans (<i>P. vulgaris</i>) with 2-10 ppb estradiol	0.03-0.15	87

^aBased on relative potencies shown in Table 2, a relative potency of 100 for zearalenone and the assumption that the oral potency of estradiol is 15% that of DES.

human exposure to phytoestrogens is substantially higher than human exposure to DES residues.

Considerable controversy exists over the significance of long-term dietary exposure to amounts of estrogen smaller than physiological or pharmacological doses. Relatively large doses of estrogens can induce mammary tumors to develop de novo (58) but can also inhibit growth of some established tumors (48). Smaller amounts in the range of physiological doses of estrogen, however, can stimulate tumor growth. Since human exposure to dietary estrogens is below physiological levels, resolution of questions about the importance of dietary estrogens in the etiology of human cancers must in all probability await the resolution of more general questions relating to the applicability of dose-response considerations to carcinogenesis.

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Ultrafiltration and Reverse Osmosis in the Dairy Industry - An Introduction to Sanitary Considerations

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ABSTRACT

The general applicability of ultrafiltration and reverse osmosis in the dairy industry is reviewed. Consideration is given to the problems of hygienic design and operation of membrane systems, particularly from the point of view of cleanability and sanitation. Recent technological advances which may accelerate acceptance of ultrafiltration and reverse osmosis as unit operations in the dairy industry are also discussed.

The membrane separation processes, ultrafiltration (UF) and reverse osmosis (RO), have found considerable application in the dairy industry, principally for concentration and fractionation of skim milk and whey (3,8). These operations offer both technological and economic advantages over conventional processing methods, and are now becoming increasingly accepted and used commercially on a world-wide basis (1). The requirement of UF and RO equipment to operate under hygienic conditions has been a continual challenge to both design and process engineers. In this review, the objective is to briefly summarize the principles and applications of UF and RO, and to then consider the design and operation of membrane systems from a sanitary standpoint. In addition, an outline of current developments aimed at advancing the state of the technology will be given.

PRINCIPLES

UF and RO (or hyperfiltration) are processes concerned with filtration of components of solutions or suspensions at the molecular level, using selectively permeable membranes to effect the separation. Most frequently, the fluids are aqueous in nature. Trans-membrane flow of water, together with solutes to which the membrane is permeable, takes place under the action of a pressure gradient force. The areas of separation to which UF and RO processes apply are indicated in Fig. 1.

Membranes

The key technological advance which led to commercialization of UF and RO processes in the late 1960's was centered around the membrane itself (7). Membranes used in both UF and RO are uniquely structured films, typically 100 μm in total thickness, based on synthetic organic polymers such as cellulose esters, polyamides and polysulphones. These films are prepared by solution casting methods, and consist of an ultra-thin skin layer (0.2 μm) superimposed on a coarsely porous matrix. The

whole structure is integrally formed and is frequently referred to as an asymmetric membrane. Separation takes place at the skin-layer which contacts the pressurized feed solution. Because of the extremely thin nature of this skin, sufficiently high filtration rates to make the process viable in relation to competitive technologies can be attained.

In RO, the skin-layer of the membrane is non-porous, and it may be treated as a water-swollen gel. Water is transported across the membrane by dissolving in this gel and diffusing to the low pressure side. Dissolved ions such as chlorides or calcium, and most molecules greater than about 100 in molecular weight, e.g. sugars, amino-acids, or proteins, cannot permeate the gel-layer and are retained by the membrane. A measure of control over the degree of retention of inorganic salts is possible by varying the casting conditions for the membrane, and partial demineralization can often be accomplished at the expense of greater losses of organic material (16).

In UF, the skin layer of the membrane contains ultra-fine pores, generally in the 2-10 nm size range. This enables macromolecules and colloids to be retained by UF membranes, while allowing the permeation of water and small molecules or ions e.g. sugars, inorganic salts, by a pore-flow mechanism. Retention of components is based essentially on a sieving-type mechanism and depends on molecular size and shape.

For convenience, however, UF membranes are frequently characterized with respect to their retention capabilities by specifying a molecular weight cut-off, i.e. the minimum molecular weight which the membrane will retain.

Under appropriate operating conditions, RO membranes are characterized by sodium chloride retentions in excess of 90%. It is extremely difficult to manipulate polymers into high-flux structures which will exhibit retention capabilities of this order. For this reason, commercial-scale RO in the dairy industry is currently limited to one membrane type, viz., cellulose acetate. On the other hand, UF membranes, as characterized by molecular weight cut-off values in the 5000-500,000 range, are readily available in a variety of polymeric materials.

Operating pressures

In RO, the trans-membrane pressure must exceed the osmotic pressure difference across the membrane before

water will flow from a high to a low pressure region. A four-fold whey concentrate will exhibit an osmotic pressure of about 500 psi (35 bar). This means that operating pressures significantly above this value, and typically 700-800 psi, are necessary to achieve economic permeation fluxes at this concentration level. This requirement imposes a further condition on the membrane in that it must be capable of withstanding plastic creep (compaction) under the severe pressure conditions of the RO process.

Osmotic pressure decreases with increasing solute molecular weight, such that when larger solutes of the type retained by UF membranes are considered, the osmotic pressure difference developed across the membrane is negligible, even at high concentrations. Much lower operating pressures, typically in the range 10-100 psi, can therefore be used in UF systems, and membrane compaction is not a serious problem.

Concentration polarization

In the course of membrane separation processes, as permeate is being withdrawn through the membrane, a boundary layer of retained components will tend to build up on the membrane surface. This phenomenon is frequently referred to as concentration polarization, or, if the surface layer becomes adherent to the membrane, the term 'fouling' is more appropriate (4,9). In RO, polarization reduces separation efficiency by increasing the trans-membrane osmotic pressure difference, thereby reducing flux. Flux also decreases in UF, but in this instance, it is as a result of increased hydraulic resistance

to flow created by the boundary layer. Polarization effects must be controlled in magnitude if the separation processes are to operate satisfactorily, and this is achieved by creating tangential flow of pressurized feed solution across the membrane surface. The membrane must therefore be mounted in a suitable flow channel. As a result of this requirement, several commercial equipment designs, differing principally in the size and shape of the flow channels, have emerged (14). Typical membrane surface cross-flow velocities range from 3-6 ft/sec in RO, to 3-12 ft/sec in UF, and the flow is generally turbulent.

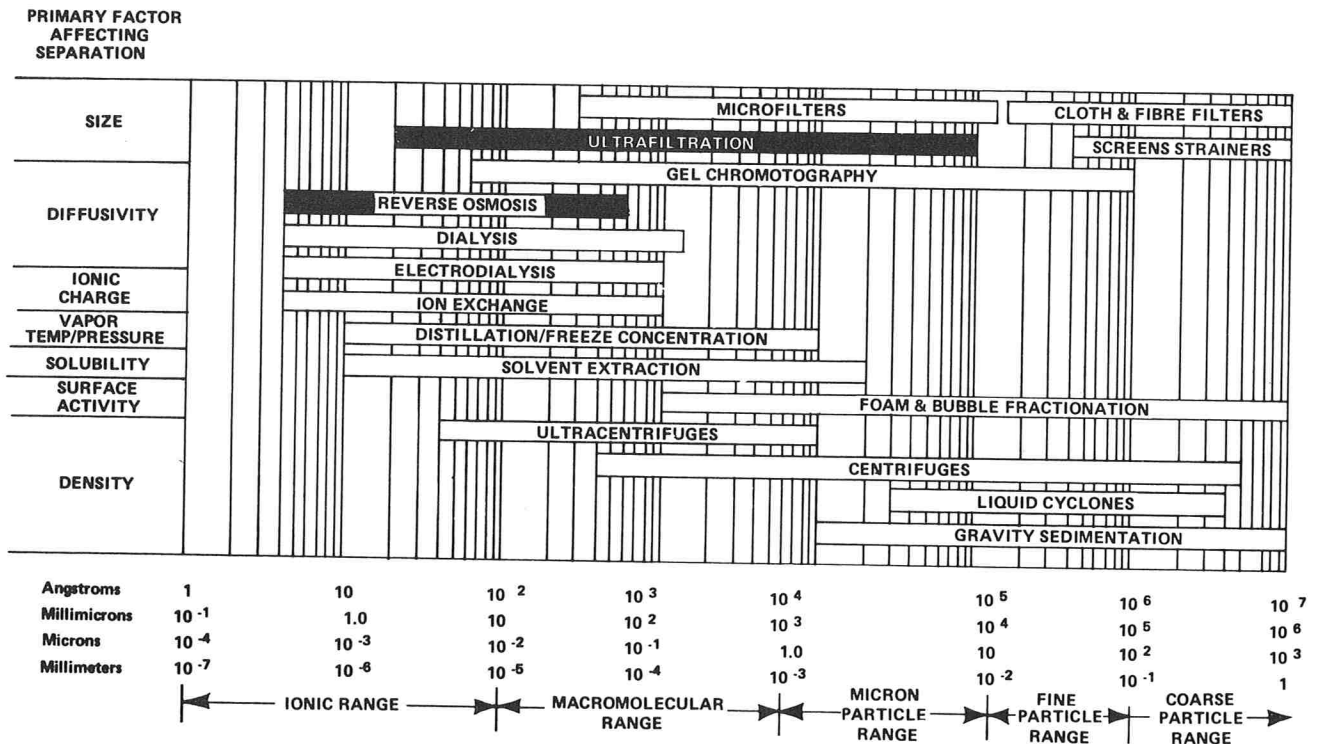
Membrane characteristics

The important characteristics of membranes from the point of view of separation efficiency and process economic viability, and the dependence of these characteristics on operating conditions can be summarized as follows:

Retention. In RO, retention of inorganic salts increases with increasing pressure and increasing flow velocity, whereas in UF, retention is largely pressure independent, but is affected by flow to some extent.

Process flux. In both RO and UF, flux increases with increasing velocity and increasing temperature. RO flux is generally much more sensitive to pressure than UF flux. This is due to concentration polarization being much more severe in the latter case, and the boundary layer rather than the primary UF membrane becomes flux limiting.

Membrane life. In both RO and UF, life decreases



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Figure 1. The place for ultrafiltration and reverse osmosis as separation processes.

with increasing temperature and is usually determined by the time/temperature conditions of exposure to cleaning/sanitizing agents. With RO, life decreases with increasing pressure due to compaction effects. Current operating lifetimes are generally 6-15 months for RO membranes and 9-24 months for UF membranes.

APPLICATIONS

In general terms, membrane processes offer the capability of concentrating and fractionating liquid dairy products without thermal denaturation or degradation of heat sensitive constituents such as proteins or vitamins (3). The separations are also accomplished without change of phase, thereby offering the possibilities for considerable economies in comparison with processes such as evaporation. In addition, separation of milk constituents can be achieved which hitherto had proved to be impossible in one operation. In UF, separation efficiency can be simply controlled by a procedure known as diafiltration, which involves addition of water to the feed material at the same time as permeate is being removed. This enables permeable components of a mixture, e.g. lactose in a protein-lactose stream, to be separated from retained components to the degree required.

The separation capabilities of UF and RO membranes with respect to the principal constituents of milk are indicated in Table 1. While UF membranes retain fat and protein components, with separation of lactose, ash, and water in the permeate, RO membranes are, by and large, permeable only to water. Some partial demineralization can be obtained with more open RO membranes, but only at the expense of greater lactose permeation (16). RO is therefore used principally as an adjunct to thermal dewatering. UF, on the other hand is used to concentrate and fractionate fat and protein constituents of liquid milk products before evaporation/drying or culturing to make cheeses. The principal applications of UF and RO, and the potential uses for the resultant

TABLE 1. Membrane retention of milk constituents.

Milk constituent	Typical dimensions (nm)	Molecular weight	Membrane type ^a able to retain constituent
Fat globule (non-homogenized)	1000-10,000	—	UF/RO
Fat globule (homogenized)	100-3,000	—	UF/RO
Casein micelle	40-300	—	UF/RO
Casein proteins	2-4	20,000-35,000	UF/RO
Immunoglobulins	2-5	150,000-200,000	UF/RO
Blood serum albumin	2-4	70,000	UF/RO
β -Lactoglobulin	2-4	36,000	UF/RO
α -Lactalbumin	1-2	15,000	UF/RO
Protease-Peptone	1-2	4000-20,000	UF or RO
Lactose	1.0	360	RO
Amino-acids	0.5-1.0	100-500	RO
Inorganic ions (Unbound)	0.2-0.4	10-100	RO
Water	0.2	18	—

^aRO - Reverse osmosis membrane; UF - Ultrafiltration membrane.

products are summarized in Table 2.

Typical flux rates experienced in the membrane processing of dairy products lie within the range 5-50 U.S. gal/ft²/day, under operating conditions appropriate either to RO or to UF. In general, UF fluxes tend to be in the higher part of the range. Since flux decreases with increasing concentration of membrane-retained solids, there are limits to the levels of various species which can be attained. In RO, this limit is determined by the increase in the osmotic pressure of the concentrate, which reduces the driving force for mass transport. The maximum whey concentration economically attainable by RO corresponds to about four-fold concentration or 25% total solids. Operating pressures cannot be increased appreciably due to an increasing rate of membrane compaction. In UF, the maximum protein concentration is 20%, at which point the concentrate stream becomes too viscous for polarization to be controlled. With non-homogenized fat, UF concentration up to about 40% is practicable, at least, in the presence of other milk constituents.

TABLE 2. Applications of RO and UF in the dairy industry.

Product processed	Process	Typical volumetric concentration factor	Process application	Products derived from RO/UF concentrates
Whole milk	RO	2	Concentration	Liquid milks, fermented milk products
Skim milk	RO	3	Concentration	Liquid milks, fermented milk products, skim milk powder
Cheese whey or casein whey	RO	2-4	Concentration	Whey powder
UF permeate	RO	2-4	Concentration	Lactose
Whole milk	UF	2-4	Fat/protein concentration	Fermentation substrate
Skim milk	UF	2-6	Lactose/ash reduction Protein concentration Lactose/ash reduction	Liquid milks Cheese products (Cheddar, etc.) Liquid milks and products Cheese products (Camembert, Danish, cottage, etc.), fermented milk products (yogurt, etc.)
Cheese/casein wheys, or lactose crystn, mother liquor	UF	5-20	Protein concentration	Whey protein concentrates
Whole milk/cream mixture	UF	1.5-3.0	Lactose/ash reduction Fat/protein concentration Lactose/ash reduction	Whey protein powders Cheese products (cream)
Adsorbed whey protein eluates	UF	To 10-15% protein	Protein concentration	Fermented milk products High purity protein powders

ECONOMICS

As far as RO is concerned, the process competes directly with evaporation. For example, the total cost of three-fold whey concentration by RO is projected to lie in the region of \$4 per 1,000 gal. of water removed, which represents a saving of at least some 25% over evaporation costs.

In the application of UF to whey, there is no directly competing process. Protein powders containing from 35 to 80% protein can be produced by a combination of UF and spray drying. It is on the available markets for such products that the degree of UF utilization will depend. A typical powder containing 50% protein could be produced for about \$500 per ton of product, with the UF stage costing some \$100 per ton product.

It is perhaps in the application of UF to milk as a first stage in the manufacture of fresh, soft and other cheeses that the greatest economic impact of UF in the dairy industry will be made. In this approach, concentrates prepared by UF are cultured directly, with no whey separation. The principal economic incentives come from the additional cheese yield associated with the incorporation of whey proteins in cheese, together with a greater degree of control over cheese composition. The UF process (5.5-fold concentration of skim milk) is operated commercially for Camembert production in France, where savings of 3 cents per lb. cheese are indicated. Numerous pilot investigations into the application of the UF concept to cheese such as cream, cottage, Danish blue or Italian are currently in progress (2, 6, 10, 12).

SANITARY EQUIPMENT DESIGN

Membrane equipment is fundamentally different from most equipment used in the dairy industry and presents special challenges to the hygienic design engineer (11, 15). The requirements, in the conventional sense, for smooth, non-absorbent materials, have to be waived for the membrane material and also for porous support materials, where employed. It is largely necessary to rely on in-situ cleaning and sanitation of the membrane and its substrate by means of appropriate chemical agents. Disassembly of equipment for manual cleaning, even if possible, which is not always true, is impractical because of the high surface areas involved. Systems must therefore be amenable to clean-in-place (CIP) procedures. In any event, it is improbable that manual cleaning would prove satisfactory in the long-term, due to the ease with which membranes can be subjected to abrasive damage.

Design requirements

Construction of a sanitary CIP membrane device or cartridge is a complex design problem in which close attention is given to such areas as:

(a) Adhering, whenever possible, to the principles of hygienic engineering, with respect to crevice-free structures and absence of flow stagnation points.

(b) Selection of inert, non-toxic, generally-regarded-as-safe (GRAS) materials for fabrication of membranes and

other plastic components used in mounting and supporting the membranes. Materials in contact must frequently be mutually compatible as far as bonding or thermal expansion is concerned.

(c) Design of mechanically - stable hygienic bonds or seals between high and low pressure areas, capable of withstanding the necessary shear, temperature, pressure and environmental conditions encountered in RO and UF.

(d) Design of pressure - sustaining membrane support structures, with sufficient permeability to allow permeate extraction without excessive resistance to flow, while at the same time preventing the membrane from becoming deformed. Membranes themselves possess little mechanical strength.

(e) Design of interfacing supports on which to mount the membrane for handling. At the same time, this support protects the membrane against direct contact with coarsely-porous or slotted pressure-sustaining supports into which the membrane would intrude under pressure.

Commercial equipment suppliers have attempted to comply with these design principles to the best of their ingenuity. Much of the information relating to detailed design and material selection is, understandably, of a proprietary nature. While a detailed account of the various device designs available lies beyond the scope of this article, a brief description is warranted at this point.

Design concepts

A number of membrane equipment designs have been developed in which membranes are contacted with a pressurized feed stream under the cross-flow conditions necessary for polarization control (14). The principal design concepts are as follows:

(a) Large (3/8-1 inch internal diameter) membrane-lined porous or perforated support tubes. The permeate flows through the walls of the tube.

(b) Plate-and-frame devices, incorporating flat-sheet membrane mounted on porous or grooved support plates. Spacer plates separate adjacent membranes and create feed flow channels with dimensions from 0.5 to 3 mm.

(c) Spiral-wound devices, in which flat-sheet membrane is attached to both sides of a flexible porous support, with one end of the membrane-support sandwich being sealed into a permeate withdrawal tube. An open-mesh material is placed on top of this sandwich, and both the mesh and membrane-support assembly are wound round the permeate tube. During winding, the open mesh acts as a spacer between adjacent parts of the membrane-support material, and a spiral-shaped flow channel is created. The whole assembly is mounted in a pressure vessel.

(d) Hollow-fibre design (UF), consisting of fine fibres (0.5-1.0 mm i.d.), used with tube-side feed, and which are self-supporting at the pressures required for UF. To form a cartridge, a large number of fibres are potted at each end into a plug of resin.

In most designs, provision is made for a flooded permeate collection facility to ensure that all areas downstream of the membrane are continuously flushed with permeate, and are fully wetted by the cleaning and sanitizing solutions. In some tubular systems, spray-rinsing of the outside of the support tubes is possible.

It is apparent that several significantly different design concepts are available for membrane equipment. Some operate with laminar flow, others with turbulent flow. The size of the feed flow channels ranges from 0.5 to 250 mm. The reason that the choice in ultrafiltration equipment continues to be wide is that no one design can accommodate all desirable attributes. For example, a high membrane packing density, i.e. low system hold-up volume, which is necessary for design of a compact plant with low fluid residence time, is not compatible with a high suspended-solids handling capability and resistance to channel blockage.

While each design concept has its advocates, and all types have found application in the dairy industry, there is some justification for arguing that fully turbulent flow systems with moderately wide flow channels, say 3-10 mm, and offering fluid residence times of 30-60 min might represent the best compromise. Frequently a user will be attracted towards a particular design not only because of sanitary considerations but also because of factors such as ease of maintenance or membrane life, which will impact on the overall profitability of the operation.

Complete installations

To build up a complete membrane installation, in some designs, a number of single membrane elements or cartridges are frequently combined, sometimes within the one pressure vessel, to form an assembly referred to as a module. Modules can be connected together either in parallel or in series, depending on the type of equipment, continuous or batch operation and size of plant. For connection in series, the maximum number of modules permitted is determined by the maximum and minimum allowable system pressures, and the pressure loss per module, which depends on the flow conditions for the particular design configuration. A complete UF or RO plant is assembled by connecting the modules to suitable pressurizing and flow recirculation pumps, and by incorporating ancillary components, such as heat-exchangers, control valves and instrumentation. One such complete UF system, incorporating Dorr-Oliver sanitary-design equipment is shown in Fig. 2. Ancillary equipment can represent up to 80% of the total investment in a membrane installation and standard components developed for dairy service are employed whenever possible.

SANITARY PROCESS CONDITIONS

The objective of sanitary operation is to control the degree of contamination of product with microorganisms, principally bacteria. The degree of contamination in a concentrate from UF or RO process operations is

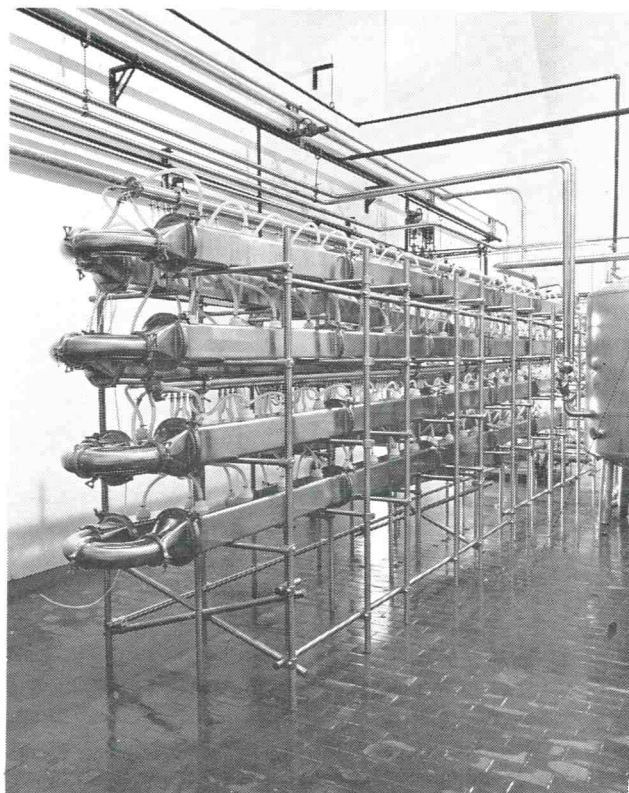


Figure 2. Flat-leaf sanitary ultrafiltration system (2880 ft²).

determined by the following factors (11):

Feed product quality/process volume reduction

Generally, for optimum feed quality, membrane process feed streams are pasteurized, stored cold (< 40 F), and processed with minimum delay. Pretreatment of some feeds by heating, centrifugation or pH adjustment is often beneficial in controlling the degree of membrane surface fouling. Process flux rates are higher, fluid residence time in the plant becomes shorter, and sometimes cleaning is easier to accomplish.

Bacteria present in the feed stream are retained by the membrane and are concentrated along with other constituents of the feed. The population of those bacteria surviving at the process temperature will therefore increase in proportion to the volume reduction attained in the process.

Hygienic condition of the plant

Plants are cleaned, sanitized, and rinsed immediately before processing, thereby ensuring good initial process conditions from the microbiological standpoint.

Process temperature

Whenever possible, within the constraints imposed by the temperature resistance of available membranes and the susceptibility of the process fluid to thermal denaturation, processes should be operated outside temperature regions of high bacterial growth rate. Since the predominant group of organisms are mesophilic, operation within their growth region, viz. 15-45 C, is to be avoided if possible.

In UF, the ranges 5-10 C and 50-60 C are normally employed. The higher temperature range is preferred since the flux is approximately double that obtained at the lower temperatures. With RO, however, cellulose acetate membranes are incapable of extended operation above 40 C. Operation at 10 C is therefore preferable from a sanitary viewpoint, but to improve flux, plants are often operated at 30 C, with more frequent plant shutdowns to clean and sanitize the system.

Fluid residence time in the system

Membrane systems can be operated either on a batch or on a continuous basis. In a batch operation, as shown in Fig. 3(a), processing takes place over the complete range of concentration levels, from initial feed to final concentrate. Since flux decreases with increasing concentration, advantage can be taken of the fact that separation always takes place under the optimum concentration conditions, and the maximum average flux is realized. However, the whole batch must be maintained at the process temperature, and the fluid residence time becomes equal to the length of the process cycle. Thus, except for low temperature operation, or for short batch times, say up to 4 h, batch operation is unacceptable, principally due to high growth rates of thermophilic organisms.

The minimum residence time would be attained in a single-pass continuous plant, but this is generally not an option because the minimum cross-flow requirement for polarization control is much greater than typical process feed rates. A recirculation loop is therefore necessary to control the velocity independently of the throughput of the plant.

Use of a single stage recirculation loop is inefficient, since the recirculation loop contains the product at maximum concentration, and process flux is at its lowest level. The fluid residence time in the system is therefore high. The preferred approach is to adopt a multi-stage

approach, as shown in Fig. 3(b), with two to six stages being typical. As the number of stages increases, the fluid residence time decreases, and the process flux approaches that of a batch operation.

Typical residence times range from 0.2 to 2 h, depending on system hold-up volume per unit area of membrane, and process flux (5). At 50 C, in the processing of skim milk by UF, the maximum allowable residence time is considered to be about 4 h. Under the same conditions, for short residence times under 1 h, a net kill has been observed (8).

CLEANING AND SANITATION

During operation, the surface of membranes becomes fouled with a variety of materials such as fat, bacterial cells, protein or colloidal inorganic matter. A visible gel-like film is formed. To removed surface films of this type, membrane systems are subjected to high velocity CIP procedures using chemical cleaning solutions. The chemical cleaner is frequently tailored to meet the requirements for removing specific foulants, e.g. non-ionic detergents (0.1%) to remove fat deposits, acids to remove inorganic precipitates, alkaline detergents (0.1-0.5%) to remove protein deposits. Proteases, lipases or enzyme detergents, which hydrolyse proteins and fats, are sometimes used to supplement or replace alkaline detergent cleaning, particularly when less alkali-resistant cellulosic UF membranes are present. Most UF equipment incorporating non-cellulosic membranes can be cleaned with solutions in the pH range of 2-12, at temperatures up to 60 C, and even more aggressive chemical environments are sometimes allowed.

Cellulose acetate reverse osmosis membranes are subject to loss of performance at pH values lying outside the range of 3-8 and at temperatures above 40 C. Enzyme detergent, or pure enzyme soak cleaning, is therefore widely practiced. Complexing agents such as EDTA and sodium hexametaphosphate are useful supplementary cleaners for removal of inorganic deposits such as insoluble calcium salts.

Sanitation of many UF membranes is commonly accomplished by use of solutions of sodium hypochlorite containing 100-200 ppm of available chlorine. Chlorine is freely permeable to the membranes and will also sanitize the downstream side of the system. Cellulose acetate reverse osmosis membranes can tolerate only brief exposure to chlorine at the 10-50 ppm level. Other common dairy sanitizers can often be used if required (13).

A typical UF cleaning and sanitation cycle can be completed in 1-2 h, whereas RO systems require a minimum of 3-4 h, and frequently longer, mainly because an enzyme cleaner soak is required. Before cleaning, the system is normally rinsed twice with water at the process temperature. Further water rinses are carried out after both cleaning and sanitation cycles. Water flux measurements are generally taken after cleaning since this represents a measure of the degree of

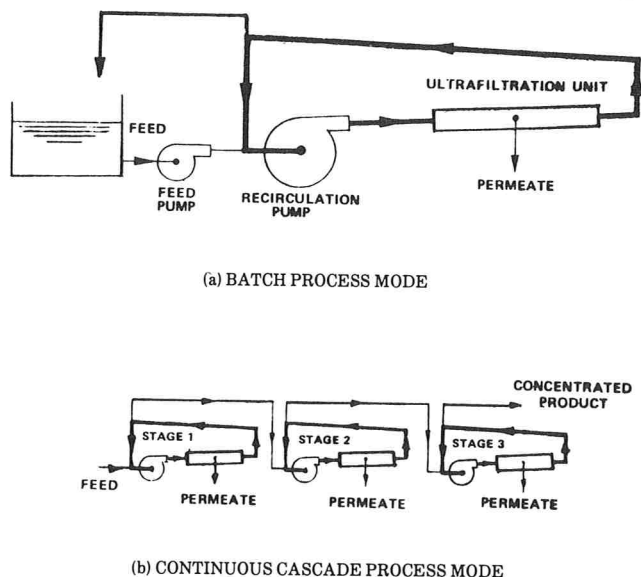


Figure 3. Membrane system flowsheets: (a) batch operation (b) continuous multi-stage operation.

cleanliness of the membranes. Water of a quality comparable to that generally accepted as suitable for direct contact with milk products should be used for all cleaning and rinsing operations.

It is possible to demonstrate physical cleanability in membrane systems by coagulating milk within the equipment. In the Dorr-Oliver UF cartridge, for example, the bulk of the curd could be removed by rinsing with water and the full capacity of the system could be restored by cleaning procedures of the type indicated above. An illustration of the UF cartridge before cleaning, showing the coagulated milk, is given in Fig. 4.

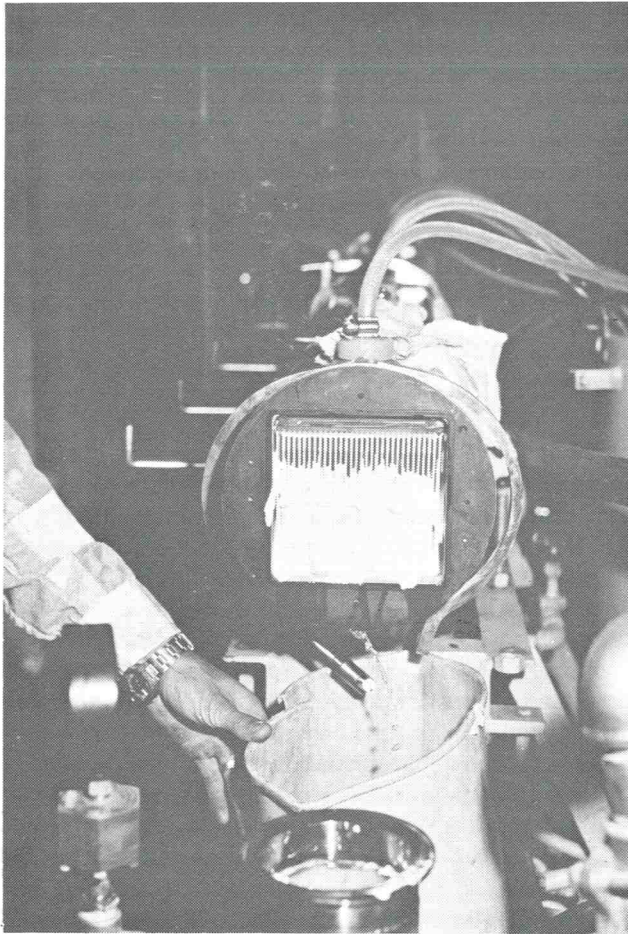


Figure 4. Milk coagulation in ultrafiltration cartridge to demonstrate cleanability.

TECHNOLOGICAL DEVELOPMENTS

Several areas of current development, both product and process related, may be identified, which may assist in accelerating the acceptance UF and RO:

(a) Development of non-cellulosic membranes for reverse osmosis, which would be capable of operating continuously at temperatures up to 55 C, and within the pH range of 2-12 for one year or more.

(b) The understanding of fouling mechanisms in UF and RO, minimization of fouling by feed pre-treatment, and optimization of cleaning procedures.

(c) Development of improved equipment offering extended operating lifetimes at higher process fluxes.

The degree of utilization of UF in particular will be extended as a result of numerous on-going developments aimed at using the process as the first stage in the manufacture of a variety of cheeses.

UF systems containing up to 5000 ft² of membrane area and capable of processing some 100,000 GPD of whey are currently in operation in the dairy industry. RO whey concentration systems up to 50,000 GPD in capacity are also in commercial operation. The processes can now be operated with a level of reliability approaching that of many other dairy industry operations. The objective of using any novel process is generally to realize economic benefits without in any way sacrificing the safety and quality of the products. It is probably fair to say that the incorporation of membrane processes in production operations can now meet this objective.

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Sanitary Processing of Egg Products

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ABSTRACT

The egg products industry has gone through dramatic changes in recent years as influenced by regulations requiring pasteurization of egg products, mandatory USDA inspection, establishment of E-3-A Standards for equipment, and tight customer specifications. Quality control for egg products includes: (a) procurement of good raw materials, (b) use of adequate pasteurization, processing and sanitary procedures, (c) microbiological testing, including *Salmonella* and (d) safeguards against recontamination. Pasteurization methods have been developed which substantially reduce the hazard of potential pathogens and still retain the heat-sensitive properties of the raw egg. Present egg products have very good functional and microbiological quality.

Egg products - liquid, frozen, and dried - are an important part of our food supply, being very useful as an ingredient in many other food products, such as bakery goods, mayonnaise and salad dressings, and egg noodles. Egg products also make possible certain convenience foods which require the unique functional properties of eggs. Fifteen percent of all eggs consumed are consumed as egg products. In 1977, for example, the per capita consumption of eggs was 272, of which 37 were represented as egg products.

Following are some changes that have had considerable influence on the sanitary standards of the egg products industry in the United States.

- (a) Governmental regulations requiring pasteurization of all egg products and mandatory inspection of egg products plants by USDA.
- (b) Tighter customer specifications.
- (c) Development and E-3-A Standards and Practices for equipment and processes used in the industry.
- (d) Desire for the egg products industry to improve.

GOVERNMENT REGULATIONS

The egg products industry once struggled with the problem of *Salmonella*. However, this concern has been greatly reduced because of pasteurization as well as certain sanitation measures. Actually, work started with the pasteurization of egg in 1936, but it wasn't until the middle 1960's that the Food and Drug Administration came out with the regulations requiring that egg products must be pasteurized in such a way that rendered them *Salmonella*-negative as determined by specified sampling and testing procedures. Shortly after this a law was passed requiring that all egg products plants must come under mandatory U.S. Department of Agriculture inspection. Before this time, USDA already

had regulations setting forth minimum requirements for plants under voluntary inspection, and there were a number of plants under this program. Through the years these requirements have been refined. USDA regulations are set forth in *Regulations Governing the Inspection of Eggs and Egg Products* (3). This covers such things as sanitary construction of the plant facilities, construction of equipment (now covered by E-3-A Standards), minimum requirements for processing of egg products, including holding temperatures and holding times, and pasteurization requirements for every type of egg product. Also, an important part of the inspection procedure is the sampling and testing of egg products, requiring that every batch is *Salmonella*-negative.

CUSTOMER SPECIFICATIONS

Companies that purchase egg products have become very aware of the need for specifications. Most customers now have their own requirements, and many of these are extremely tight. They also have their own sampling and testing program to make sure that these specifications are met. Although USDA requires that egg products are *Salmonella*-negative, many customers have other standards such as values for total plate count, coliform, yeast, mold, *Escherichia coli*, coagulase-positive staphylococci and *Clostridium perfringens*. Typical specifications call for less than 10,000 total plate count, less than 10 coliform, less than 10 yeast and mold, and negative for *Salmonella*.

Egg products must also meet certain chemical, physical and functional specifications, which include moisture, fat, protein, ash, glucose, acidity of ether extract, reconstituted viscosity, whipping ability, and performance of egg products in the customer's finished goods.

The product liability question has had some influence on quality of egg products. Many customers now require a continuing product guaranty which places responsibility for any liability case that may involve an egg product on the manufacturer of the egg product.

E-3-A SANITARY STANDARDS AND PRACTICES

Following is a list of E-3-A Sanitary Standards and Practices for equipment used in the egg products industry (2).

E-0100; E-3-A Sanitary Standards for Storage Tanks for Eggs and Egg Products. (3/72)

- E-0200; E-3-A Sanitary Standards for Pumps for Liquid Egg Products. (3/70)
 E-0201; Amendment to E-0200. (4/71)
 E-0401; E-3-A Sanitary Standards for Homogenizers and Pumps of the Plunger Type for Liquid Egg and Liquid Egg Products. (3/72)
 E-0500; E-3-A Sanitary Standards for Automotive Transportation Tanks for Liquid Egg Products. (11/75)
 E-0600; E-3-A Sanitary Standards for Egg Breaking and Separating Machines. (9/76)
 E-0800; E-3-A Sanitary Standards for Fittings Used on Egg and Egg Products Equipment and Used on Sanitary Lines Conducting Egg and Egg Products. (11/71)
 E-0900; E-3-A Sanitary Standards for Instrument Fittings and Connections Used on Egg Products Equipment. (3/70)
 E-0901; Amendment to E-0900. (8/71)
 E-0902; Supplement to E-0900. (8/71)
 E-1100; E-3-A Sanitary Standards for Plate Type Heat Exchangers for Egg Products. (4/75)
 E-1200; E-3-A Sanitary Standards for Tubular Heat Exchangers for Liquid Egg Products. (11/75)
 E-1300; E-3-A Sanitary Standards for Liquid Egg Products Cooling and Holding Tanks. (8/76)
 E-1400; E-3-A Sanitary Standards for Inlet and Outlet Leak Protector Plug Valves for Batch Pasteurizers. (5/71)
 E-1500; E-3-A Sanitary Standards for Shell Egg Washers. (9/76)
 E-1700; E-3-A Sanitary Standards for Fillers and Sealers of Single-Service Containers for Liquid Egg Products. (8/76)
 E-1800; E-3-A Sanitary Standards for Multiple-Use Rubber and Rubber-Like Materials Used as Product Contact Surfaces in Egg Processing Equipment. (3/71)
 E-2400; E-3-A Sanitary Standards for Non-Coil Type Batch Pasteurizers. (10/71)
 E-2600; E-3-A Sanitary Standards for Sifters for Dry Egg Products. (3/70)
 E-60400; E-3-A Accepted Practices for Supplying Air Under Pressure in Contact with Liquid Eggs and Egg Products and Product Contact Surfaces. (3/71)
 E-60500; E-3-A Accepted practices for Permanently Installed Sanitary Product Pipelines and Cleaning Systems. (3/71)
 E-60700; E-3-A Accepted Practices for Liquid Egg and Liquid Egg Products Spray Drying Systems. (12/71)

These were developed through the cooperation and efforts of the International Association of Milk, Food and Environmental Sanitarians, the Dairy and Food Industry Supply Association, equipment manufacturers and the Poultry and Egg Institute of America. Many of these standards were adopted from the 3-A standards used in the dairy industry, but some are unique to the egg products industry. For example, the standards for egg washers and egg breakers took considerable time and effort to develop because there was nothing similar being used in the dairy industry, and there were certain sanitation problems that had to be resolved.

Equipment used for pasteurization of egg products is similar to that used in the dairy industry, but because of the properties of egg products, their viscosity and heat-sensitive nature, the equipment has to be specifically designed for the egg products and for the particular egg product for which they are used. Because of this it has been difficult to develop a meaningful E-3-A pasteurization practice. The guide for pasteurization has been a *Manual for Egg Product Pasteurization* published by USDA in 1969 (1).

INDUSTRY EFFORT

There has been much effort within the industry itself to improve egg products. Most companies now have quality control and testing programs. Much help has been given by the Poultry and Egg Institute of America. The institute has conducted Quality Control Schools for the egg products industry every year since 1949. It was about this time that the egg industry began a concerted effort to control *Salmonella* in egg products by working with the Institute, government agencies and universities. Through this effort standard procedures for sampling and determining *Salmonella* in egg products were developed and well-defined pasteurization procedures were established.

EGG BREAKING AND SEPARATING

The three types of egg products - liquid, frozen and dried - and different products coming under each of these categories are listed in Table 1. They all have a common beginning in the egg breaking and separating operation.

The quality of shell eggs used for egg products has improved in recent years. At one time all eggs were from small farm flocks of 100 birds or less. Now most eggs are produced by commercial flocks of 30,000 birds or more, where eggs are gathered daily and refrigerated. USDA regulations prohibit shipment of loss eggs, such as rots and leakers. There are still some dirty eggs, but these must be cleanable and have a sound shell. There are also eggs that become checked or cracked. These can be broken only if they are clean and have the shell membrane intact. Because of these USDA requirements there are a relatively large number of eggs that do not

TABLE 1. *Egg products.*

LIQUID PRODUCTS

Egg white
 Egg yolk
 Whole egg

FROZEN PRODUCTS

Egg white
 Whole egg
 Whole egg with yolk added (fortified)
 Plain egg yolk
 Fortified whole egg with corn syrup
 Sugared egg yolk
 Salted egg yolk
 Salted whole egg

DRIED PRODUCTS

Egg white
 Spray-dried egg white solids
 Flake albumen
 Instant egg white
 Plain whole egg and yolk
 Standard whole egg solids
 Stabilized (glucose-free) whole egg solids
 Standard egg yolk solids
 Stabilized (glucose-free) egg yolk solids
 Free-flowing whole egg solids
 Free-flowing egg yolk solids
 Blends of whole egg and yolk with carbohydrates
 With sugar
 With corn syrup

qualify for use in human food. These egg products, though not considered to be fit for human consumption are of relatively good quality and are used in animal products, such as dog food.

A system for handling, washing, and breaking and separating the eggs is shown in Fig. 1. An automatic loader picks eggs from the filler-flat and deposits them onto the conveyor of an egg washer. The eggs pass through the washer where they are scubbed by brushes and, at the same time, flushed with wash solution containing a cleaning compound. They are then rinsed and sanitized with either a chlorine or iodine solution. Next they pass through a candling and inspection area before being fed to the egg breaking and separating machine. This machine cracks and opens the shell, depositing the contents onto a device which separates the whites from the yolks. These machines operate at a rate of between 16,000 and 24,000 eggs per hour (4.5 to 6.5 eggs per second) and require three persons: one loader, who presents the shell eggs to the automatic loader and, at the same time, inspects and removes any eggs which cannot be broken; one inspector of the washed shell eggs, who removes any eggs which were not properly cleaned, cracked eggs or those having any other obvious defects; one egg breaking and separating machine operator, who inspects eggs that have been broken and separated and controls the speed and operation of the entire system. Three components - whites, yolks, and mix - flow away from the breaking machine to inspection vats. After inspection the liquids are pumped through filters or

centrifugal clarifiers and are then cooled for holding until they are processed further.

PASTEURIZATION

Pasteurization procedures are similar for all types of egg products. USDA pasteurization requirements are shown in Table 2. These minimum requirements are based on the bacterial kill obtained when heating whole egg to 140 F for an apparent holding time of 3½ min. Because of laminar flow of egg products, holding time of the fastest particle is only one half the time of the average holding time.

When pasteurizing egg products, one must also be concerned about the effect of pasteurization on functional properties. Proteins of eggs can be denatured by heat, which will damage their ability to whip, emulsify, and coagulate. There is thus a relatively low limit as to how high eggs can be heated. There are a number of different types of egg products, all of which are different in their sensitivity to heat and the ease by which bacteria can be destroyed within them.

Egg products containing whole egg and yolk are all pasteurized by heating the liquid egg material in its natural state or when mixed with certain functional ingredients. Although egg white can also be pasteurized in this way, other methods are also used:

1. Heat treatment of heat-stabilized egg white at not less than 140 F for a holding time of 3½ min. Heat stabilization is accomplished by adjusting the pH to

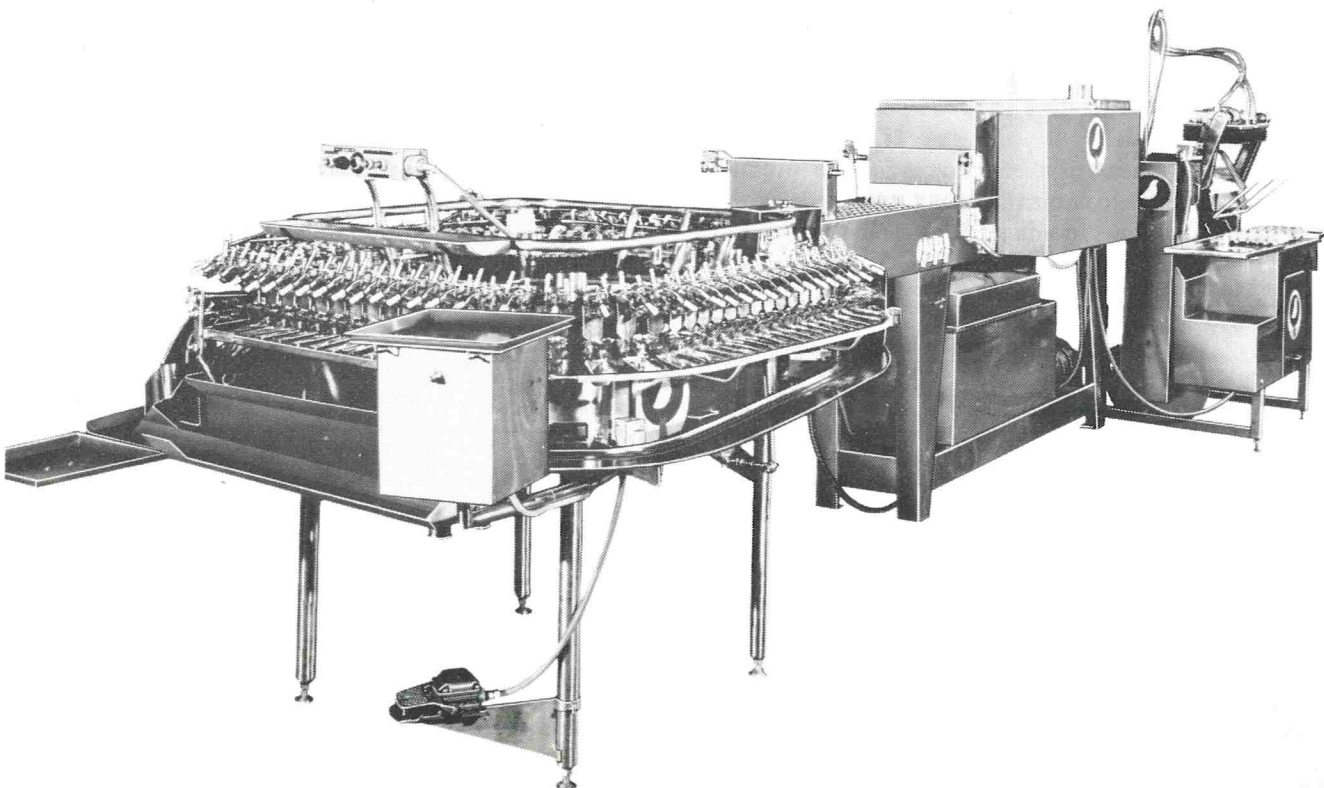


Figure 1. Automatic egg handling and breaking/separating system.

TABLE 2. *USDA Pasteurization requirements (3).*

Liquid egg product	Minimum temp requirements (°C)	Minimum holding time requirements	
		Fastest particle (min)	Average particle (min)
Albumen (without use of chemicals)	57	1.75	3.5
	55	3.1	6.2
Whole egg	60	1.75	3.5
	Whole egg blends (less than 2% added non-egg ingredients)	61	1.75
60		3.1	6.2
Fortified whole egg and blends (24-38% egg solids, 2-12% added non-egg ingredients)	62	1.75	3.5
	61	3.1	6.2
Salt whole egg (with 2% or more salt added)	63	1.75	3.5
	62	3.1	6.2
Sugar whole egg (2-12% sugar added)	61	1.75	3.5
	60	3.1	6.2
Plain yolk	61	1.75	3.5
	60	3.1	6.2
Sugar yolk (2% or more sugar added)	63	1.75	3.5
	62	3.1	6.2
Salt yolk (2-12% salt added)	63	1.75	3.5
	62	3.1	6.2

7.0 with lactic acid and adding aluminum sulfate. Adjustment of pH increases the stability of the proteins ovalbumin, lysozyme, ovomucoid and ovomucin. Aluminum sulfate stabilizes conalbumin, which is normally not stable at pH 7.0. The aluminum ion forms a heat-stable complex with conalbumin.

- Heat treatment of plain egg white above 125 F in the presence of hydrogen peroxide. Heating of the liquid serves to inactivate the natural catalase and also makes the bacterial killing power of hydrogen peroxide more effective. After heat treatment, catalase is added back to decompose the hydrogen peroxide.
- Heat treatment of the dried egg white product, sometimes in combination with one of the liquid pasteurization procedures. Dry heat treatment of

egg white powder is effective in destroying *Salmonella* at temperatures above 130 F. Dried egg white with natural glucose removed is quite stable and can be heat-treated for extended periods without noticeable effect on functional properties. USDA requires that dried egg white be heat-treated at not less than 130 F for not less than 7 days.

Other methods for pasteurizing egg products have been studied but, as far as I know, are not now in use.

Equipment used for pasteurizing liquid eggs is similar to the high-temperature-short-time equipment used in the dairy industry. This is a continuous process in which liquid is heated to a specified temperature and held for a specific period before it is cooled and/or dried. Component parts include safety devices to insure that these requirements are met.

Batch pasteurization was one of the first methods to be applied to egg products. This method is again being used to a limited extent, especially for small egg processing operations. Temperatures of 132 F for 35 min and 135 F for 15 min are considered to be equivalent to 140 F for 3 1/2 min.

PROCESSING AND SANITATION PROCEDURES

Cleaning procedures and compounds used for cleaning and sanitizing equipment are similar to those used in the dairy industry, although certain compounds are tailored for this specific use. CIP systems are also commonly used.

Unit operations and processing used for egg products are: cooling, mixing with other ingredients, pasteurization and removing the natural glucose by fermentation or enzyme method for stability purposes in dried egg products. Holding conditions used for egg products are specified by USDA and shown in Table 3. Liquid egg products are usually transported in tank trucks, the same as those used for milk. It is sometimes necessary to refrigerate these tank trucks to maintain proper temperature. Liquid eggs are also transported in smaller

TABLE 3. *Minimum cooling and temperature requirements for liquid egg products (3).*

Product	Unpasteurized product temperature within 2 h from time of breaking			Temperature within 2 h after pasteurization	Temperature within 3 h after pasteurization
	Liquid (other than salt product) to be held 8 h or less	Liquid (other than salt product) to be held in excess of 8 h	Liquid salt product		
White (not to be stabilized).	55 F or lower	45 F or lower		45 F or lower--	
Whites (to be stabilized). 70 F or lower		55 F or lower		55 F or lower--	— ^a
All other product (except product with 10% or more salt added)	40 F or lower	40 F or lower		If to be held 8 h or less, 45 F or lower. If to be held in excess of 8 h, 40 F or lower	If to be held 8 h or less, 45 F or lower. If to be held in excess of 8 h, 40 F or lower.
Liquid egg products with 10 percent or more salt added			If to be held 30 h or less, 65 F or lower. If to be held in excess of 30 h, 45 F or lower.	65 F or lower ^b	

^aStabilized liquid whites shall be dried as soon as possible after removal of glucose. The storage of stabilized liquid whites shall be limited to that necessary to provide a continuous operation.

^bThe cooling process shall be continued to assure that any salt product to be held in excess of 24 h is cooled to and maintained at 45 F or lower.

containers. A refrigerated vat with about 100-gal. capacity has recently been introduced.

The common container for frozen eggs is still a metal can which holds 30 lb. of product. This can is filled with chilled liquid egg to be frozen and is placed in a blast freezer at -20 F to -40 F for up to 72 h. After freezing the product it is held at about -10 F.

In drying egg products it is important to maintain dry conditions in the equipment used for drying and handling the finished product. Wet conditions caused, for example, by condensation within the drying system can result in microbiological problems.

SAFE GUARDS AGAINST RECONTAMINATION

An important part of maintaining egg products as negative for *Salmonella* is the use of safeguards to assure against recontamination after pasteurization. We know that recontamination or cross-contamination can occur via such carriers as people, equipment and utensils, and contaminated air.

For example, to prevent recontamination in a spray-drying operation, we have found that it is better to draw air into a drying system from the outside rather than from the inside of the drying room. When drawing air from inside, a vacuum is created which allows unfiltered air to be drawn into the drying room from the outside. It is also important to maintain the environment around the inlet duct free of contaminating sources, such as birds. Duct work is kept clean and sanitized, and

high-efficiency filters are used for air entering the system. Many dryers for egg products now use absolute filters having an efficiency of 99.97% by the D.O.P. test.

TESTING PROGRAM

As indicated before, sampling procedures and *Salmonella* testing methods are now specified by USDA; the agency also requires that every batch of egg product must be found *Salmonella*-negative. Some egg processors also test each batch for total plate count, coliform, yeast and mold and do any other test required by customer specifications.

CONCLUSION

The egg products industry has made considerable progress in the sanitary processing of eggs through the years. This is reflected in the good sanitary, functional, and overall quality of present day egg products.

ACKNOWLEDGMENT

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Food Protection for the 80's¹

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ABSTRACT

New social, economic and political demands for conservation of energy, water and consumable products coupled with changes in lifestyle including more meals eaten away from home will require new approaches to food handling. These modifications may increase or uncover new hazards and potential opportunities for foodborne illness. Microbial hazards will remain a major problem but will be only one of the many concerns of the consumer about food. Increases in awareness of newly identified pathogens, carcinogens, mutagens and the like will demand greater efforts but will also increase cost of foods. Acute sensitivity to escalating costs will in turn bring about more objective evaluations of benefit/risk ratios on all programs. Education of producers, handlers, processors and consumers will be required so that they may monitor and serve as protectors of the food system thus minimizing regulatory costs and placing responsibility at the point of action. This process will be successful only with appropriate educational and research support to evaluate and implement modified programs.

New social, economic and political demands for a variety of changes make it imperative that those individuals working with food protection be extremely alert to change if they are to be successful. These various new demands, in turn, will frequently require new approaches to satisfy these needs and produce appropriate end results.

Most of the changes that are anticipated may be presently underway and should continue through the 1980's. A shifting age distribution in the population is one of these changes. Anyone who reads news magazines or daily newspapers is well aware of the shifting age distribution that is resulting in the closing of elementary schools and in requiring services by various expanding age groups. Modifications in social attitudes are evident and are an ever-present aspect of our life (12). Social attitudes have recently made a greater impact on food protection than earlier and will continue to do so. Changing consumption patterns have been evident for years, and consumption of various types of nutrients will continue to shift (7). Current economic concerns for inflation, for taxes and for general consumer spending do not show evidence of decreasing in the next decade. No short-term solutions to economic problems appear to be imminent. In general, a new awareness by all towards food, nutrition, safety and quality will result in changes in food protection activity. An expanding use of foodservice establishments will allow the foodservice market to continue to grow beyond its \$100 billion level

in 1978 (10). This foodservice increase must be accompanied by increases in food protection activities directed at that aspect of our industry (6).

Consumer concerns will increase, and consumers will evaluate closely the relationships between benefits, risks and costs. Consumer attitudes remain very positive in relation to safety but are increasing in their intensity toward value and conservation. These general consumer attitudes must be reflected in the food protection programs of food processing industries, in foodservice and in the home.

NEW CHALLENGES

Examples of new challenges for food protection programs include the need to reduce water consumption and energy use in cleaning and sanitizing of processing equipment, of foodservice dishes and of other materials and equipment associated with food. Constant modification of technology in the area of food preparation and processing results in new and different prepared foods stored and preserved in a variety of ways. Examples include prepared and stored entrees and use of special ovens, including microwave, that cook in a variety of different ways. Another challenge is removal of traditional components from specific foods; for example, removal of nitrite, salt, or other food additives to produce a natural food, or substitution of a specific "natural" component for an "artificial" component in foods, poses a continued challenge to food protection.

Some of the questions that must be answered in the next decade follow. Who will set the risk/benefit ratios that we will live by? Who will enforce regulations? Who will verify the safety of foods? What approaches can be expected in answering and solving our problems? Consider some of the current and future directions for food protection in research, in education, in regulation that might speak to these questions.

RESEARCH

In research, government appears to be emphasizing more compliance and less research in the areas of food protection and sanitation, and will continue to follow this path. The food industry appears to be reducing the amount of effort it is expending on developmental research and is increasing its auditing activities. There is no indication that this trend will diminish. In academic areas, applied studies will continue to play a great role in research, but there are indications that there will be more

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funding for certain basic, more fundamental research. This is indeed needed.

Some examples of research that are going on at present can be readily used to predict the kinds of research efforts that should be expanded and emphasized in the next decade. Research must be conducted on the evaluation of all facets of new processes. For example, the long-time low-temperature (LTLT) roasting of beef has recently undergone much evaluation and will be discussed in more detail later. There will be a need to test the removal of various preservatives and other food additives that have traditionally been present in foods. Alternative adjuncts to these foods also must be tested. An example of this would be removal or reduction of concentration of sodium nitrite added to cured meats and the inclusion of sorbic acid or potassium sorbate as an alternative preservative. Research of this type will be discussed later. Furthermore, there will be a demand for study of newly identified potential hazards. These would include microbial pathogens, as well as carcinogens, mutagens and the like. Rapid, simple test methods to identify potential problems in foods will continue to be a needed area for development in research. Finally, it will be essential to respond to the needs identified for specific educational efforts to support adequate food protection in the 1980's.

As an example of research evaluating an entire process, recent work in our laboratory (17,18) has been directed at studying the effects of constantly rising temperatures on growth and survival of *Clostridium perfringens* and salmonellae in beef. Studies on salmonellae supported a recent rule for the LTLT cooking of beef published by the USDA in July. The data that we obtained also indicated that *C. perfringens* could in fact grow to a reasonable population if the rate of heating a piece of beef during cooking was sufficiently slow to permit growth. Our current studies on *C. perfringens* growth and survival in these systems indicate that if one controls *C. perfringens*, one will also control the salmonellae. These findings also indicated that in the future the rate of heating of the product should be considered as well as the time at a given final temperature if the entire process is evaluated for control of unwanted bacteria. It is evident that there is a need to conduct an overall evaluation of any processes that are developed. A simplistic approach based on evaluation of one-time and one-temperature relationship may not be sufficient. It may be necessary to evaluate the overall cooking process just as we evaluate the overall thermal process in canned foods. One must identify which problem organism must be controlled, evaluate the entire cooking temperature profile for the process and use these with computer assistance to verify the safety of a variety of processes whether they be industrial, institutional or in the home.

Another example of research that we feel will be important in the next decade is the study which we are doing on reduced concentrations of nitrite in chicken

frankfurter emulsions and the influence of the addition of sorbic acid combined with reduced amounts of nitrite to control *Clostridium botulinum* toxin production under elevated temperature abuse conditions (16). Our data indicate that when the concentration of nitrite is reduced from the customary 156 $\mu\text{g/g}$ to 40 $\mu\text{g/g}$ (ppm) in the chicken emulsions, the protection is reduced to a level essentially the same as that of a product with no nitrite at all. However, if 0.2% sorbic acid is combined with this low level of 40 μg of sodium nitrite/g, the margin of safety is extended 4- to 8-fold beyond that observed at the current level of 156 μg of sodium nitrite/g. This is an example of the kind of research that will be needed for each situation where the removal, decrease in concentration or substitution for a traditional food additive or food preservative are proposed and the safety of the product comes under question. Testing of alternative adjuncts for potential hazards from changes of traditional adjuncts is an absolute future research demand.

Foodborne microbial threats also require extensive research. The Center for Disease Control in Atlanta frequently lists over 60% of foodborne outbreaks occurring in a year as "etiology unknown." For example in 1975, 306 of 497 foodborne disease outbreaks were listed as "etiology unknown" (3). In 1976, 306 or 438 outbreaks were of unknown etiology (4). Obviously, there is a need to identify various potential foodborne hazards. Common foodborne microbial hazards that are readily recognizable include *Staphylococcus aureus*, *Salmonella* sp., *C. botulinum*, *C. perfringens*, enteropathogenic and enterotoxigenic *Escherichia coli* and mycotoxins.

Other foodborne microbial threats that may or may not increase in importance in the next decade include *Yersinia enterocolitica*, *Bacillus cereus*, *Vibrio parahaemolyticus*, *Vibrio cholerae*, *Campylobacter* sp., viruses and a host of foodborne parasites. Beyond this, the potential danger from carcinogens, mutagens and other dangerous materials emphasizes the real need to study potential hazards. This is not intended to be alarmist. Whether it be a mutagen or a known microbial agent, one must constantly weigh the risks and benefits of the situation. The risk of death from inhalation or ingestion of food *excluding* foodborne intoxications and infections is 2,200 deaths per year in the United States, far in excess of the reported hazard from foodborne infections or food poisonings (11). What risk in the future will the public be willing to take in regard to foodborne intoxications and infections when benefits appear high and the risk is relatively low? Smoking of 20 cigarettes per day generates a risk of death of 5,000 per million persons per year (15). How does one compare that risk to a potential hazard of consuming a slightly mutagenic substance that happens to be a food additive used at a very low concentration (13)? Obviously, there will be no shortage of needs for research to support intelligent decisions in an adequate food protection program.

EDUCATION

Directions in education are as difficult to forecast as directions in research. Some examples where education must meet challenges include responding to the increase in numbers of students from a variety of curricula entering the food area, whether it be foodservice, food processing or food regulation. The expansion of information and scientific knowledge on food results in a greater demand for proper education and training. Thus, there will be a need for more continuing education for a greater variety of students and this continuing education will undoubtedly continue to be offered by a great variety of organizations and institutions. Not only will the universities and the private colleges be active in continuing education, but also a greater number of private organizations and individuals will be highly visible in this needed area of instruction. Education must and will have greater interaction with economic and socio-political activities. We see such increased need for interaction today in our relationships between government, industry and the consumer. Accordingly, food protection education must use the latest information obtained frequently from various research groups to assist students in making intelligent decisions for appropriate regulatory approaches.

REGULATORY ACTIVITY

What type of regulatory directions are anticipated? Increased economic, social and political pressures will result in a greater need for a broader use for the Hazard Analysis-Critical Control Point (HACCP) approach (1) to food protection. The identification of specific items, functions, and activities within food processing, foodservice, food handling and food distribution which can be monitored and used to verify that the product is not hazardous must be regarded as one of the most promising approaches to food safety. This can be expanded beyond food safety to monitoring of general quality assurance and to many operations in foodservice. Expansion of the foodservice industry (14) would indicate that a need exists for a program based on HACCP identification. Snyder has recently developed a program for quality assurance which bases many of its premises on the critical control point approach (9). Coupled with an appropriate educational program, this should relieve regulatory personnel of certain routine responsibilities and free them to make maximum use of their expertise.

After much discussion and study, selection of microbiological criteria will be placed more in the hands of international groups (5). Industry and government operations will also continue to set or establish their own microbiological criteria for food purchasing specifications (8). The critical control point approach coupled with appropriate education of producers, handlers, processors and consumers will permit them to monitor and serve as protectors of the food system while minimizing regulatory costs and placing the responsibility at the location where action can be taken and

where discrepancies can be corrected. Obviously this process will be successful only with appropriate educational and research support to evaluate and implement modified programs.

To paraphrase a comment in a recent address by Bauman (2), we as an organization must approach food protection in the 1980's in a positive dimension, emphasizing our capability of providing America and the world with very safe and readily available food in many forms and at a variety of locations. This can only give us new opportunities for renewed efforts and for innovative approaches to insure adequate protection.

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A Field Topic

Opportunities to Improve Milk Quality

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ABSTRACT

Many opportunities exist to improve the bacterial quality of milk, particularly of manufacturing-grade milk. Test results, using plate counting procedures by 10 Iowa dairy laboratories, reflect a gradual improvement in recent years in manufacturing-grade milk quality. In recent months, 70 to 84% of 3,000 to 5,000 individual Iowa farm's manufacturing-grade milk samples tested each month were placed in Class I (plate-loop count of less than 500,000/ml). Problems still exist in farm milking equipment sanitation, undersized bulk tanks with inadequate cooling capacities, and delays in processing raw milk. USDA DMCC results on milk samples obtained from milk-storage tanks in Iowa dairy manufacturing plants reveal that in 1977-78 only 5.8 to 13.1% of the commingled raw milk would be classified as Class I. These results reflected a deterioration in bacterial quality of raw milk from the time milk leaves the farm until held in the plant storage system. Part of the quality deterioration can be blamed on failure to empty and clean plant storage tanks often, allowing too much time before milk is processed, and on milk not at 40 F or less. Cheese and butter exhibits reveal that poor milk quality has a negative influence on product flavor quality. Quality assurance programs for dairy farms, milk transportation, and plant storage must stress sanitation, cold temperatures and minimum times before processing to obtain good bacteriological quality milk and pleasing-flavored dairy foods.

There still are many opportunities to improve milk quality in general and manufacturing-grade milk quality in particular. Based on observations of laboratory test results, efforts by fieldmen, laboratory personnel, and milk sanitarians are starting to pay off in improved bacteriological quality of manufacturing-grade milk marketed from

individual Iowa dairy farms. Hopefully, this situation is occurring on dairy farms in other midwestern states where volumes of manufacturing-grade milk are significant. The seven midwestern states, including Iowa, produced 76% of the 21.8 billion pounds of manufacturing-grade milk marketed in the U.S. in 1977 according to data from the USDA (4). Nearly 50% of Iowa's milk supply is of manufacturing-grade.

While improvements in milk quality from individual dairy farms can be documented by tests on the individual farm milk samples, the quality of milk going into the cheese vat or milk separators is not always of the quality conducive to manufacturing high quality cheese, butter, and nonfat dry milk. Results from USDA evaluation of commingled milk in dairy plant storage tanks sent to plant managers support this contention that there has been no significant improvement in the quality of commingled milk in Iowa in recent years. Results of flavor evaluation of butter and cheese samples during product evaluation exhibits in Iowa reveal that poor milk quality does have a negative influence on product flavor quality.

Apparently there is a breakdown in bacteriological quality of this milk from the time milk leaves the farm until processing starts in the cheese vat or separator. The problem revolves basically around time and temperature — too much time and too high a temperature before pro-

cessing the milk. These two factors are constantly at work hurting milk quality. In addition to cold-storage temperatures and minimal storage times, basic equipment sanitation is very important to milk quality. There is little new technology that can in any way substitute for milking and milk storage equipment sanitation, for rapid cooling and cold storage of the milk, and for minimizing the time milk is stored before processing.

FARM MILK QUALITY

During the past several years, ten Iowa dairy laboratories, including regulatory, private, and dairy processing plant laboratories, have summarized the plate-loop count results they obtained each month on 3,000 to 5,000 individual manufacturing-grade milk samples. The samples were obtained by bulk milk haulers during their routine farm milk pickup. The samples were analyzed by these dairy laboratories, using plate counting procedures. Each month these results are summarized and a chart prepared to illustrate the percentage of manufacturing-grade milk samples classified the previous month in three designated grades — Class I, II, and Undergrade. The chart is included in the *Dairy Industry Report*, a monthly newsletter prepared for the people of Iowa's dairy industry.

The compiled data from the Iowa laboratories show that the trend in manufacturing-grade milk quality is for more individual farm milk samples qualifying for the Class I grade. Figure 1 illustrates the results of this testing program over the past 6 years. One can see that gradually over these years, a higher percentage of milk samples have qualified for the Class I designation. Also, fewer samples are assigned to Class II. The percentage of samples in the Undergrade category is a bit less each year.

In Iowa, to qualify for this top bacterial Class I grade, the milk samples must not contain more than 500,000 bacteria per milliliter. Class II is for milk containing between 500,000 and 3 million bacteria per milliliter. The Undergrade classifi-

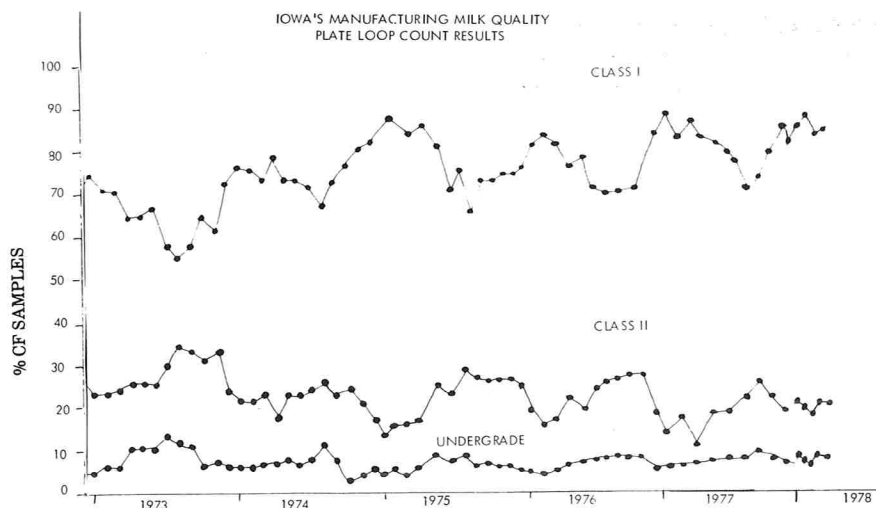


Figure 1. Iowa's manufacturing-grade milk quality determined by plate count testing on three to five thousand individual farm samples each month. Class I represents samples containing 500,000 bacteria per ml or less. Class II samples contained between 500,000 and 3 million per ml. Undergrade samples contain over 3 million per ml.

cation is assigned to milk that contains over 3 million per milliliter. The farm milk samples must be tested once each month according to Iowa law, using the Standard Plate Count or the plate loop count. Microscopic and reduction tests can not be used to evaluate the bacterial quality of milk in Iowa. Most milk testing laboratories in Iowa evaluating manufacturing-grade milk quality use the plate loop count procedure (1).

These trends in milk quality improvement are encouraging. They illustrate how persistent laboratory and fieldwork efforts, with periodic nudges from regulatory authorities, can be effective in milk quality improvement. Part of this overall improvement trend can be credited to some quality problem dairy farmers dropping out of the dairy business. During this same time, however, many dairy farms qualified for the Grade A market and were lost from the ranks of manufacturing-grade milk producers. A large portion of these dairy farms were probably qualified for Class I status. So both "good" and "bad" milk quality farms were lost from the manufacturing-grade market. How these changes balanced out in the overall quality scene would be hard to quantify. But the trend in improved milk quality is good news for modern dairy food processors.

Seasonal trends

Seasonal trends in bacterial quality of Iowa's manufacturing-grade milk are obvious from the data plotted in Fig. 1. The warmer months each year are highlighted by a reduction in the percentage of samples of Class I quality with an increase in samples placed in Class II and Undergrade. Warmer temperatures will speed up the growth of bacteria on milking equipment stored between milkings. If such equipment is not cleaned properly and sanitized before use, the bacteria remaining on the equipment can reproduce rapidly and the next milk passing through the equipment becomes contaminated with large numbers of these bacteria. So equipment sanitation is still important for marketing quality milk, in spite of cold milk storage temperatures associated with bulk tanks. Dairy farm milking equipment sanitation continues to need major emphasis in fieldwork and regulatory programs.

Bulk-tank cooling

Bulk tanks are not the only answer to milk quality, but rapid cooling is an important factor in milk quality. Also, initial levels of bacteria in milk, milking equipment sanitation, and the time before processing are other critical factors. Many people have relied too heavily on the cooling capability of bulk tanks to take care

of milk quality.

Problems exist with bulk tanks being overloaded with the quantity of milk they are required to cool at one time, especially in the milk flush of spring and early summer months. Some bulk tanks currently in use may be too small and/or too old for rapid cooling of current production volumes. So milk production in the early warmer months may stress the cooling capabilities of undersized or older bulk tanks.

An added problem to the general level of milk quality is that during these high production months, the total volume of poorer quality milk may be larger which has also a negative influence on overall milk quality — as does any volume of poor milk. Note in Table 1 the influence a high bacterial count in the milk of producer number 3 had on the bacterial count of the bulk truck load of milk.

TABLE 1. Bacteriological quality of manufacturing-grade bulk tank milk from several producers on one route.

Producer No.	SPC/ml	% Of total milk delivered
1	39,000	6.9
2	29,000	15.1
3	12,000,000	8.7
4	190,000	6.5
5	26,000	21.3
6	410,000	5.2
7	520,000	8.4
8	39,000	13.5
9	18,000	14.4
Truck comp. Calculated comp.	1,100,000	100.0
	1,100,000	

Time

The third important factor influencing the bacterial quality of milk is time. Problems do exist on frequency of milk pick-up from 100.0" milk volume dairy farms, thus extending the age of this milk before processing. This situation doesn't help improve the general quality of milk.

Obviously there are three areas that continue to need improvement relative to individual dairy farm milk quality: (a) milking and equipment sanitation to minimize the initial bacterial load in milk, (b) rapid cooling of milk to less than 40 F in adequate-sized bulk tanks, and (c)

minimizing the time between milking and processing.

COMMINGLED MILK QUALITY

Now for the bad news concerning milk quality. The USDA, as part of its dairy manufacturing plant evaluation program, obtains samples of milk from plant storage tanks, and using the Direct Microscopic Clump Count (DMCC), evaluates the bacterial quality of the milk plant's commingled milk. The results of this test influence the plant's status with the USDA.

The results of these DMCC tests as sent to plant managers indicate that raw milk storage in dairy plants is an area where great opportunity exists for improvement in milk quality. The USDA microscopic test results of dairy manufacturing plant's commingled raw milk frequently show bacterial counts in the millions per milliliter. In fact many of these commingled samples would be placed in the Undergrade class according to the Iowa law designation for manufacturing-grade milk bacterial quality.

Table 2 illustrates the results of recent USDA microscopic testing of commingled milk samples from Iowa dairy manufacturing plants. Note that 26.6 to 50.7% of the samples tested, based on summaries of 3-month periods throughout the year, had DMCC results exceeding 3 million per milliliter. Contrast this poor milk quality with that of the plate loop count results of the Iowa labs on individual farm samples where only 2 to 6% of these samples were placed in this Undergrade category.

Looking on the positive side of milk quality, 70 to 84% of the individual Iowa farm's manufacturing-grade milk samples, in recent

months, were placed in Class I (plate loop count of less than 500,000 per milliliter) according to reports from the Iowa dairy laboratories. Contrast this with USDA commingled sample test results where 0 to 13.1% were placed in Class I. The USDA commingled milk results, when compared to the plate-loop count results of individual producer samples tested by the Iowa laboratories, indicate that the commingled milk in the plants is not of as good quality.

Before discussing the possible reasons for this breakdown in milk quality from the farm to the processing vat, we know that there may be some differences in results obtained in the microscopic and the plate-loop count test results. But experience shows that with plate counting procedures, particularly with the standard plate count, the bacterial count results are usually higher than those obtained with the DMCC (2).

Evidently more of the bacterial clumps are broken apart during dilution procedures of the plate counting test than in making the DMCC, resulting in more countable colonies. With the plate-loop count procedure, there may be less tendency for the bacterial clumps and chains to break up and these results may be more comparable with the DMCC. Some plant personnel insist that a major reason for the high USDA DMCC on commingled milk is because of the break-up of bacteria clumps and chains during pumping of the milk. Studies of milk quality indicate that pumping is not an important cause of high bacteria counts in milk (3).

INFLUENCES ON COMMINGLED MILK QUALITY

The bacterial quality of com-

mingled milk in the dairy plant is influenced primarily by four factors - time, temperature, the bacterial load of the milk delivered to the plant, and any additional bacterial contamination of the milk contributed by the bulk tank truck, pumps, piping and milk plant storage equipment. Abuse any one or a combination of these factors and the milk bacterial count will be high as it enters the processing system. Table 3 illustrates counts obtained on loads of milk arriving at the plant and in the storage tanks.

Time

An important enemy of milk quality is time. Frequently the time factor is abused in our methods of marketing raw milk.

We know that a major portion of the microflora of bulk tank milk has psychrotrophic characteristics. This means these bacteria will continue to metabolize, reproduce, and increase in numbers even at refrigeration temperatures. So time is a major enemy of milk quality. This factor is all too often abused by storing milk too long on the farm, transporting it long distances, and storing it too long in a pump-over station or in the milk plant before processing begins.

Even under cold storage, many psychrotrophic bacteria can double their numbers in 24 h. Milk with a bacteria count of 500,000 per milliliter coming into the plant can be at one million per milliliter the next day. So bacterial contamination of the milk and the length of time before processing work directly against milk quality and the resulting products' quality.

Temperature

Another major influence on raw milk quality, and one that is frequently abused, is temperature. Anyone in the fluid milk business will testify to the importance of cold temperatures on the shelf-life of fluid milk products.

Unless milk has been held at temperatures below 40 F and comes into the processing plant at 40 F or below, milk quality is in jeopardy. Milk bacteria at 42 to 45 F will have

TABLE 2. Results of USDA microscopic evaluation of dairy plant commingled milk samples obtained from Iowa dairy manufacturing plants.

Period	No. samples	% Samples with DMCC		
		Class I < 500,000/ml	Class II 500,000-3 million/ml	Undergrade > 3 million/ml
April-June 1977	84	13.1	47.6	39.3
July-Sept. 1977	69	5.8	43.5	50.7
Oct.-Dec. 1977	109	11.9	61.5	26.6
Jan.-March 1978	69	11.6	42.0	46.4

a significantly shorter generation time than if stored at less than 40 F. Any one who has check-tested the temperature of milk along the route from the farm to and including the plant storage tank knows that milk is frequently at temperatures exceeding 40 F during this route. Data from Table 3 illustrate this temperature problem of milk entering the processing plant. Usually there is no opportunity to cool the milk back down below 40 F after leaving the farm bulk tank before being processed in the plant.

Milk plant storage

A major problem facing the dairy industry regarding raw milk quality is the influence of plant milk storage facilities. As milk processing plants have expanded their processing volume, so too have they expanded their raw milk storage facilities in the form of larger but fewer storage tanks. These large storage tanks seem to be an important part of the milk quality problem.

Because of the large milk plants' demand for large volumes of milk to satisfy their production requirements, milk may be purchased from a large area from the plant. This situation usually means that the milk has some age on it as well as a questionable temperature profile before delivery to the plant. As large volumes of milk come into the plant storage tanks, there may be little opportunity or time to clean and sanitize the large storage tanks

between fills. New milk is mixed with the old milk in the plant storage tanks and the dynamic bacterial metabolic chain is not broken and the counts build up to several million per milliliter. Flexibility in dairy plant operations has been lost to bigness and milk and product quality sacrificed for efficiency in milk plant operations.

Plant managers must be made aware of this situation and be committed to schedule milk receiving and product processing so as to assure that the storage tanks are emptied and cleaned between use.

INFLUENCE ON PRODUCT QUALITY

The high bacterial counts of the milk in the plant storage tanks have a direct influence on the quality of dairy products. The milk going into the cheese vat or being separated for buttermaking and for manufacturing skim milk powder may contain large numbers of bacteria as well as the enzymes and the by-products of bacterial metabolism.

Pasteurization will destroy most of the flavor and milk-chemistry-changing bacteria, but the results of their metabolic activity remain in the milk as do some of the heat-resistant bacteria protein and fat splitting enzymes that can further damage milk and product flavor.

These bacterial metabolic by-products do influence the flavor of the products being manufactured. Results of butter and cheese exhibits

held each year in Iowa illustrate this problem. In 1977 and 1978 five cheese exhibits were conducted in Iowa. Of the 73 American-type cheese samples involved in these five exhibits evaluated for flavor, approximately 2 months after manufacture, 35 samples had flavor defects that appeared to be related to poor milk quality. Most of these defects were designated as unclear, bitter, rancid, and sour milk flavors. Table 4 includes the results of one American cheese flavor exhibit and illustrates the general poor flavor quality of most of the exhibit samples. Other production problems, of course, can cause these flavor defects, but poor milk quality is considered to be very significantly related to cheese flavor defects.

The 111 butter samples involved in four 1977-78 exhibits were also evaluated for flavor quality. Thirty-two of the samples were criticized for flavor defects that appeared to be related to poor milk quality. High raw milk bacteria counts also have a negative influence on yield of cheese and on the production of low count skim milk powder.

IMPROVEMENT OPPORTUNITIES

Since raw milk quality does have a significant influence on the quality of all dairy foods, efforts do need to be continued to improve milk quality not only on the farm but especially in the processing plant. Quality assurance programs should include care-

TABLE 3. *Bacterial evaluation of manufacturing-grade milk in truck and silo tanks at one Iowa manufacturing dairy plant.*

Bulk truck	Delivery time (July 16)	% of Milk in silo	Milk temp.	DMCC/ml	SPC/ml
1	5:15 a.m.	4.5	43°	1,000,000	910,000
2	10:25 a.m.	13.1	40°	2,400,000	7,400,000
3	10:45 a.m.	5.3	44°	56,000	43,000
4	2:00 p.m.	8.0	45°	390,000	1,400,000
5	3:00 p.m.	6.4	43°	6,200,000	17,000,000
6	4:00 p.m.	19.6	42°	1,000,000	4,300,000
7	4:00 p.m.	9.8	42°	220,000	62,000
8 Truck			49°	790,000	1,700,000
8a Trailer	5:30 p.m.	15.2	46°	1,600,000	2,300,000
9 Truck			46°	680,000	300,000
9a Trailer	7:30 p.m.	18.3		69,000	280,000

Silo tank sample	Sample time (July 17)	Lbs. milk	DMCC/ml	SPC/ml
1	9:00 a.m.	240,600	2,900,000	10,000,000
2	1:00 p.m.	160,000	5,500,000	9,700,000
3	3:00 p.m.	100,000	4,900,000	12,000,000

TABLE 4. Results of flavor evaluation of an American cheese exhibit in Iowa, July 1978.

Sample number	Flavor score	Flavor evaluation
1	36.0	Acid, bitter
2	36.5	Bitter, slight unclean, slight salty
3	39.5	Very slight acid
4	38.5	Slight bitter
5	35.5	Unclean, whey taint
6	37.5	Slight bitter, slight unclean, slight whey taint
7	37.5	Acid, slight unclean
8	36.0	Acid, slight bitter, salty
9	36.0	Fermented, slight unclean
10	35.0	Acid, bitter, slight rancid
11	39.0	Very slight acid and bitter
12	38.0	Slight acid, very slight bitter, slight fermented

ful evaluation of initial numbers of bacteria in individual farm milk samples coupled with studies of the

time and temperature profile of milk from the farm to the processing vat. Testing milk for bacterial numbers

at critical points in the chain from farm to within the plant will reveal links where opportunity exists for improvement.

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New Cheese Monograph Available

The sixth volume of the Pfizer Cheese Monograph Series, *Lactic Starter Culture Technology*, is now available.

Author of the 55-page hard-cover book is Dr. William E. Sandine, Professor of Microbiology at Oregon State University, Corvallis. Included in the monograph are the following chapters: History of Lactic Starters; Types of Culture Systems; Bacteriophages for Starter Bacteria; Controlling Bacteriophages, and Testing of Starter Cultures. The monograph concludes with a call for further research into phage-related problems which constitute the greatest economic hardship to the dairy products industry.

The book is illustrated with photographs, electron photomicrographs, charts and tables. Copies can be purchased by sending a check or money order for \$2.00 per book to Pfizer Inc. at its Milwaukee Operations, 4215 North Port Washington Ave., Milwaukee, WI 53212.

Previous titles, also available from Pfizer at \$2.00 per copy, deal with the technologies involved in making specific types of cheeses. They include:

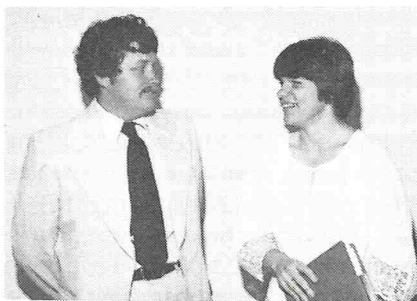
Swiss Cheese Varieties, by Dr. George W. Reinbold; *Ripened Semi-soft Cheeses*, by Dr. Norman F.

Olson; *Cottage Cheese and Other Cultured Milk Products*, by Dr. Stewart L. Tuckey and Dr. Douglas B. Emmons; *American Cheese Varieties*, by Harry L. Wilson and Dr. George W. Reinbold, and *Italian Cheese Varieties*, the first volume in the series also written by Dr. Reinbold.

The Pfizer Cheese Monographs

are published on a non-profit basis as a service to the dairy industry.

Pfizer Milwaukee produces enzymes, culture media, colors and other ingredients for the dairy industry. Pfizer Inc. is a worldwide manufacturer of pharmaceutical and hospital products, specialty organic chemicals, agricultural, consumer and materials science products.



SD Names New Officers

The 31st Annual Education Conference of the South Dakota Environmental Health Association was held May 16-18, in Rapid City, S.D. Newly elected officers for 1979-80 are Calvin Halvorson, R.S., City Health Department, Sioux Falls, President, and Cathy Meyer, R.S., Mitchell, Secretary-Treasurer.

Interested in Writing a Field Article?

But you want a little help with it? If you have notes and an outline of presentations you've made or have heard, or if you have enough information for a field article on a single subject, send an outline and materials to Jan Richards, IAMFES, P.O. Box 701, Ames, IA 50010. She'll work with the material you provide and if the subject is one of interest to the *Journal* readership, she'll write the article for use in the *Journal of Food Protection*.

A Field Topic

Solar Energy on the Dairy Farm

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ABSTRACT

Dairymen now have an alternative source of energy to assist them in efficient production of milk. Solar energy is being used to heat water and to space-heat milk houses and milking parlors. Used in conjunction with standard heating systems, solar systems can supply from 30 to 70% of the water- and space-heating requirements on a dairy farm. Tax incentives and rising costs of electricity and fossil fuels are making solar energy systems economically feasible for the modern dairyman. During the 1970s the world has come to recognize the reserves of fossil fuels used for energy are limited. The "energy crisis" caused these sources of energy to spiral in cost. Today, alternate sources of energy are being investigated and some are proving to be economically feasible.

Solar energy is the energy we receive from the sun via radiation. It is the most abundant source of energy on earth and it is free. Enough solar energy reaches the United States every 20 min to satisfy the country's power needs for 1 year. In 1 day the earth receives solar energy equal to the burning of 550 billion tons of coal.

Solar energy plays a key role in photosynthesis and the beginning of the food chain. Solar radiation is responsible for everything from a painful sunburn to a romantic moon. Since the beginning of time we have depended on the sun for our existence.

In recent years, efficient methods have been developed to capture solar energy and put it to man's use. This discussion will address methods to collect solar energy and convert it to space- and water-heating.

SOLAR HEATING SYSTEM

A solar system is relatively simple

in design. It contains two basic components: (a) collector panels and (b) heat storage unit.

A solar heating system is essentially heat transfer equipment. Heat is absorbed by the collector panels and transferred to the heat storage unit by means of air, water or an anti-freeze solution. Systems using air as a heat transfer medium are most common in Wisconsin. Air models are not subject to the problems associated with freezing, boiling and corrosion. As a result, service and maintenance costs are reduced as compared to liquid systems.

The collector panel is approximately 3 ft. x 7 ft. It contains a black absorber plate that can capture 95% of the solar spectrum and 94% of the infrared radiation.

The plate is encased in an insulated pan which is covered with double-glazed glass to retain the heat. A solar panel this size will capture 6,000 to 19,000 BTUs per hour, depending on available sun light. Air is admitted at the bottom of the collector and moves upward at the rate of 2 cfm. Air entering at 70 F and traveling through two panels would exit at 140 F. Collector panels are installed facing true south. The angle of tilt recommended is latitude plus 5 to 15°. We are at 43° north latitude (Wisconsin) so collectors installed here would be at an angle between 48 and 63°.

The heated air is moved to various parts of the system through duct-work similar to that used in conventional hot-air heating systems. Solar duct-work is carefully insulated to prevent heat loss.

An air handling unit connects the various air ducts together. This unit contains a blower and dampers and regulates the various cycles of the heating system.

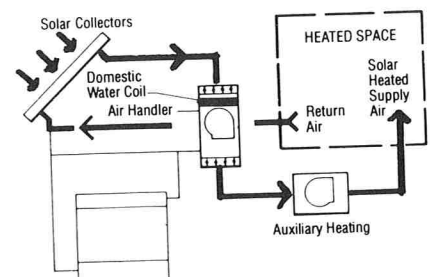
A rock bed is a common method used to store solar heat. The heat storage unit is a box-like structure. It can be built of reinforced concrete, wood frame or concrete blocks. The box must be insulated to an R-11 factor to retain the heat. A typical size heat storage unit would measure 6 ft. wide, 8 ft. long and 5 ft. deep. This unit will handle an average milking parlor. The heat storage box is filled with rocks 3/4 to 1 1/2 inches in diameter. Any type of rock found locally will work satisfactorily. The rock size is important as it determines the pressure drop in the solar air system. One half cubic foot of rock is required for each square foot of collector plate. This is equal to approximately 50 lb. of rock.

The heat storage unit can be located either above or below ground level. The rock bed is normally sized for 1 day's carry-over of heat during the winter months. The hot air from the collectors is blown through the rocks. The heat stratifies in the rocks. The top of the rock bed will retain temperatures up to 150 F while the bottom rocks are 70 F.

OPERATION OF THE SOLAR AIR HEATING SYSTEM

A solar air heating system operates on four cycles.

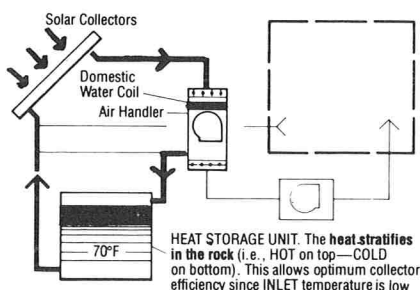
(a) Heating from the collector



Air, the circulating heat transfer medium, is drawn through the collector where it is normally heated to about 120 to 150 F. When the milk house or parlor requires heat, the solar-heated air is drawn through the

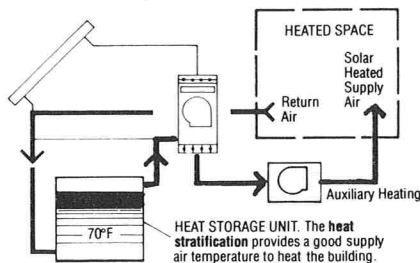
air handling unit in which motorized dampers are automatically opened to direct the hot air to the space. The air then returns to the collector where it is again heated and the cycle repeats itself.

(b) Storing heat



When the space temperature is satisfactory, the automatic control system diverts air into the heat storage unit where heat is absorbed by the rock bed. The air returns to the collector where it is heated and the cycle is repeated.

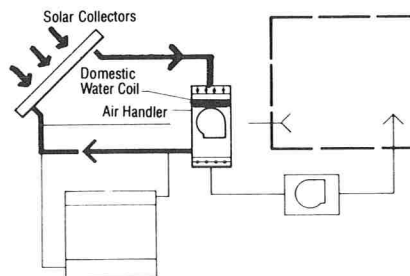
(c) Heating from storage



At night or on cloudy days when solar energy is unavailable and heat is needed in the parlor or milk house, the automatic control directs the building return-air into the bottom of the heat storage unit, up through the rocks where the air is heated, through the air handling unit and into the space. When the solar-heated air does not maintain the

space thermostat setting, the automatic control turns on the auxiliary heater to add to the required heat.

(d) Summer water heating



In summer, when space heating is not required, air is drawn through the collector where it is heated and then through the water heat-exchanger coil. The solar-heated air transfers its heat to the water which is being circulated through the coil and the air is then returned back to the collector inlet.

ECONOMICS OF SOLAR HEATING

Whether or not solar heating is economical in a particular area depends on several factors: (a) cost of equipment, (b) amount of solar radiation available during the heating season, (c) heating load of the proposed building, (d) cost of conventional heating energy and (e) State and Federal tax incentives.

It is expected that non-solar energy sources will increase greatly in cost in future years. For example, authorities are predicting natural gas rates to rise about 17% per year, fuel oil costs by 15% per year, electricity 7% per year and propane 20% per year, for an indefinite period. Eventually it is predicted that propane, natural gas and fuel oil will not be available at any price for space

heating, and electricity only at prices much higher than today.

The cost-effectiveness of solar heating for a particular building in a specific geographic location can be determined by carrying out a simple preliminary design study of the building and proposed solar heating system. Most solar systems in this area (Wisconsin) are designed to handle 60% of the heating load. The heating load of the building and size of the solar heating system are calculated, and from them the cost is determined. The solar system cost is then compared with the predicted heating energy savings to determine: (a) the pay off period on the solar investment and (b) when the annual energy savings may be expected to balance the annual cost of the investment.

In summary, the "Energy Crisis" of the 1970's has challenged the ingenuity and imagination of the American people. The dairy industry is meeting this challenge. Manufacturers have designed and marketed numerous energy-saving devices for use in the dairy industry. Products that capture waste heat from bulk tank compressors and heat water are now in common use throughout the Americas. Tube coolers that cool milk and heat water simultaneously are also popular. In the years ahead, solar energy systems will be commonplace.

ACKNOWLEDGMENT

Presented at the joint Annual Meeting of the Wisconsin Association of Milk and Food Sanitarians, Wisconsin Section of the Institute of Food Technologists, Wisconsin Association of Dairy Plant Fieldmen, and the Wisconsin Dairy Technology Society, Fond du Lac, Wisconsin, September 12 and 13, 1978.

E-3-A Sanitary Standards for Pressure and Level Sensing Devices

Number E-3700

Formulated by
International Association of Milk, Food and Environmental Sanitarians
United States Department of Agriculture
Poultry & Egg Institute of America
Dairy and Food Industries Supply Association

It is the purpose of the IAMFES, USDA, PEIA, and DFISA in connection with the development of the E-3-A Sanitary Standards program to allow and encourage full freedom for inventive genius or new developments. Specifications for pressure and level sensing devices which are developed and so differ in design, material and construction, or otherwise, as not to conform to the following standards but which, in the fabricator's opinion are equivalent or better, may be submitted for the joint consideration of the IAMFES, USDA, PEIA and DFISA at any time.

A.

SCOPE

A.1

These standards cover the sanitary aspects of elements used on liquid egg products equipment for sensing pressure and/or product level.

A.2

In order to conform with these E-3-A Sanitary Standards, pressure and level sensing devices shall comply with the following design, material and fabrication criteria.

B.

DEFINITIONS

B.1

Product: Shall mean the liquid egg product, inert gas, air, vapor, or steam that is in contact with or flows over the egg or egg product.

B.2

SURFACES

B.2.1

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

B.2.2

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

B.3

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.

¹The data for this series are contained in the following reference: *AISI Steel Products Manual, Stainless & Heat Resisting Steels, December 1974, Table 2-1, pp. 18-19. Available from: American Iron & Steel Institute, 1000 16th Street, NW, Washington, DC 20036.*

²Alloy Casting Institute Division, *Steel Founders' Society of America, 20611 Center Ridge Road, Rocky River, OH 44116.*

C.

MATERIALS

C.1

Product contact surfaces shall be of stainless steel of the AISI 300 series¹ or corresponding ACI² types (See Appendix, Section E.), or metal which under conditions of intended use is at least as corrosion-resistant as stainless steel of the foregoing types, and is non-toxic and non-absorbent, except that:

C.1.1

Rubber and rubber-like materials may be used for probe insulators, probe holders, gaskets, diaphragms, coatings and coverings, and parts used in similar applications.

C.1.2

Rubber and rubber-like materials when used for the above specified applications shall comply with the applicable provisions of the E-3-A Sanitary Standards for Multiple-Use Rubber and Rubberlike Materials Used as Product Contact Surface in Dairy Equipment, Number E-1800.

C.1.3

Plastic materials may be used for probes, probe insulators, probe holders, gaskets, diaphragms, bonded coatings and coverings and parts used in similar applications.

C.1.4

Plastic materials when used for the above specified applications 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, as amended, Number 20-08.

C.1.5

Rubber and rubber-like materials and plastic materials having product contact surfaces that are a bonded coating or a covering shall be of such compo-

sition as to retain their surface and conformation characteristics when exposed to the conditions encountered in the environment of intended use and in cleaning and bactericidal treatment.

C.1.6

The final bond and residual adhesive, if used, of bonded rubber and rubber-like materials and bonded plastic materials shall be non-toxic.

C.2

Materials having a product contact surface(s) used in the construction of pressure and level sensing devices designed to be used in a processing system to be sterilized by heat and operated at a temperature of 250°F (121.11°C) or higher shall be such that they can be (1) sterilized by saturated steam or water under pressure at a temperature of at least 250°F (121.11°C) and (2) operated at the temperature required for processing.

C.3

Non-product contact surfaces shall be of corrosion-resistant material or material that is rendered corrosion-resistant. If coated, the coating used shall adhere. 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

Product contact surfaces shall be at least as smooth as a No. 4 ground finish on stainless steel sheets free of imperfections such as pits, folds and crevices in the final fabricated form. (See Appendix, Section F.).

D.2

Permanent joints in metallic product contact surfaces shall be continuously welded. Welded areas on product contact surfaces shall be at least as smooth as a No. 4 ground finish as described in D.1 above.

D.3

Product contact surfaces not designed to be mechanically cleaned shall be easily accessible for cleaning and inspection either when in an assembled position or when removed. Removable parts shall be readily demountable.

D.4

Sensing devices that are to be mechanically cleaned shall be designed so that the product contact surfaces can be mechanically cleaned, and are accessible for inspection.

D.5

Product contact surfaces shall be self-draining except for normal clingage.

D.6

Connections having product contact surfaces shall conform to the E-3-A Sanitary Standards for Fittings Used on Egg and Egg Products Equipment and Used on Sanitary Lines Conducting Egg and Egg Products,

Number E-0800, and/or to the applicable provisions for welded sanitary product pipelines found in the E-3-A Accepted Practices for Permanently Installed Sanitary Product Pipelines and Cleaning Systems, Number E-60500.

D.7

Rubber and rubber-like materials and plastic materials in applications having product contact surfaces that are a bonded coating or covering shall be bonded in such a manner that the bond is continuous and mechanically sound, and so that when exposed to the conditions encountered in the environment of intended use and in cleaning and bactericidal treatment, the rubber or rubber-like materials or the plastic material does not separate from the base material.

D.8

Gaskets having a product contact surface shall be removable or bonded.

D.9

Gasket retaining grooves in product contact surfaces shall be no deeper than their width.

D.10

Internal angles of 135° or less on product contact surfaces shall have radii of not less than 1/16 inch, except where smaller radii are required for essential functional reasons, such as those in sensing devices for high pressure gauges.

D.10.1

When the radius is 1/32 inch or less, the product contact surfaces of this internal angle must be readily accessible for cleaning and inspection.

D.10.2

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

D.11

There shall be no threads on product contact surfaces.

D.12

Pressure and level sensing devices used in a processing system to be sterilized by heat and operated at a temperature of 250°F (121.11°C) or higher shall comply with the following additional criteria:

D.12.1

The construction shall be such that all product contact surfaces can be (1) sterilized by saturated steam or water under pressure at a temperature of at least 250°F (121.11°C) and (2) operate at the temperature required for processing.

D.12.2

Devices that have a product contact surface(s) to be used in such a processing system, not designed so that the system is automatically shut down if the product pressure in the system becomes less than that of the atmosphere and cannot be restarted until the system is reesterilized, shall have a steam or other sterilizing medium chamber surrounding the joint at

the product contact surface between the fitting and the device.

D.12.3

The connection(s) on steam or other sterilizing medium chamber(s) for the steam of other sterilizing medium lines shall be such that the lines can be securely fastened to the connection(s). The lines shall be connected in a manner that they may be disconnected to allow the sterilizing medium chamber to be inspected and cleaned if necessary.

D.13

Non-product contact surfaces shall be free of pockets and crevices and be readily cleanable and those to be coated shall be effectively prepared for coating.

APPENDIX

E.

STAINLESS STEEL MATERIALS

³Available from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

Stainless steel conforming to the applicable composition ranges established by AISI¹ for wrought products, or by ACI² 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 steel of the 300 series. Cast grades of stainless steel corresponding to type 303, 304, and 316 are designated CF-16F, CF-8, and CF-8M, respectively. These cast grades are covered by ASTM³ 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.

These standards shall become effective May 4, 1979.

Coming Events

July 16-18--BASIC PRINCIPLES OF QUALITY ASSURANCE SEMINAR. American Institute of Baking, 1213 Bakers Way, Manhattan, KS 66502. Contact: Darrell Breising, AIB, 913-537-4750.

July 23-24--FOOD INDUSTRY CERTIFICATION/RECERTIFICATION WORKSHOP. Sponsored by the Food Sanitation Institute. Fee: \$150. Riviera Hyatt House, Atlanta, GA. Contact: H. C. Rowe, Food Sanitation Institute, EMA, 1701 Drew St., Clearwater, FL 33515.

July 30-Aug. 3--ADVANCES IN FOOD AND APPLIED MICROBIOLOGY. Massachusetts Institute of Technology, Cambridge, MA 02139. Program is under the direction of Anthony J. Sinskey, MIT, Professor of Applied Microbiology. Contact: Director of Summer Session, Rm. E 19-356, Massachusetts Institute of Technology, Cambridge, MA 02139.

July 30-Aug. 10--BAKING FOR ALLIED PERSONNEL. American Institute of Baking, 1213 Bakers Way, Manhattan, KS 66502. Contact: Darrell Breising, AIB, 913-537-4750.

Aug. 6-7--PESTICIDE CERTIFICATION COURSE. American Institute of Baking, 1213 Bakers Way, Manhattan, KS 66502. Contact: Darrell Breising, AIB, 913-537-4750.

Aug. 12-14--SANITATION THROUGH DESIGN. Sponsored by Food Sanitation Institute. Fee: \$225. Sheraton-Ritz Hotel, Minneapolis, MN. Contact: H. C. Rowe, Food Sanitation Institute, EMA, 1701 Drew St., Clearwater, FL 33515.

Aug. 12-16--IAMFES ANNUAL MEETING. Sheraton Twin Towers, Orlando, FL. Contact: E. O. Wright, IAMFES Exec. Sec., P.O. Box 701, Ames, IA. 50010, 515-232-6699, or see registration form in this *Journal*.

Aug. 13-17--WORKSHOP ON EDUCATIVE PROCESSES IN FOOD MICROBIOLOGY. Sponsored by the Joint American Society for Microbiology/Institute for Food Technologists Committee on Food Microbiology Education. Quadna Resort, Hill City, MN. Contact: E. A. Zottola, Dept. of Food Science and Nutrition, 1334 Eckles Ave., University of Minnesota, St. Paul, MN 55108.

Aug. 13-Dec. 21--BAKING SCIENCE AND TECHNOLOGY. American Institute of Baking, 1213 Bakers Way, Manhattan, KS 66502. Contact: Darrell Breising, AIB, 913-537-4750.

Aug. 20-22--FREEZING OF BAKED AND UNBAKED PRODUCTS. American Institute of Baking, 1213 Bakers Way, Manhattan, KS 66502. Contact: Darrell Breising, AIB, 913-537-4750.

Aug. 29-31--FOURTH INTERNATIONAL IUPAC SYMPOSIUM ON MYCOTOXINS AND PHYCOTOXINS. Co-sponsored by World Health Organization and Swiss Society for Analytical and Applied Chemistry. Lausanne, Switzerland. For participation and poster presentation, contact: Prof. P. Krogh, Dept. of Veterinary Microbiology, School of Veterinary Medicine, Purdue University, West Lafayette, IN 47907 or Prof. D. Reymond, IUPAC, Case postale 88, 1814 La Tour de Peilz, Switzerland.

Sept. 9-11--FOOD WAREHOUSE SANITATION WORKSHOP. Sponsored by Food Sanitation Institute. Sheraton Post Inn, Cherry Hill, NJ. Contact: H. C. Rowe, Food Sanitation Institute, EMA, 1701 Drew St., Clearwater, FL 33515.

Sept. 10-13--2nd INTERNATIONAL CONFERENCE ON FOOD SERVICE SYSTEMS DESIGN. Harrogate, England. Contact: G. Glew, Catering Research Unit, Procter Dept. of Food Science, The University of Leeds, LS2 9JT, England.

Sept. 10-14--FOOD PROCESSORS ADVANCED MICROBIOLOGY SHORT COURSE. University of California, Davis. Fee \$200. Contact: John C. Bruhn, Dept. of Food Science and Technology, University of California, Davis, CA 95616, 916-752-2192.

Sept. 11-12--AMERICAN CULTURED DAIRY PRODUCTS INSTITUTE, Annual Meeting and Conference. Southeast Holiday Inn, Madison, WI. Contact: C. Bronson Lane, ACDPI, P.O. Box 7813, Orlando, FL 32854.

Sept. 11-14--MAINTENANCE MANAGEMENT. American Institute of Baking, 1213 Bakers Way, Manhattan, KS 66502. Contact: Darrell Breising, AIB, 913-537-4750.

Sept. 13-14--INTERNATIONAL SYMPOSIUM ON ANIMAL AND HUMAN INFLUENZA. Ecole Nationale Veterinaire D'Alfort, 7, avenue du General de Gaulle, 97 704 Maisons-Alfort cedex, France. Contact: Ch. Pilet, Secretariat of the Dept. of Microbiology, Ecole Nationale Veterinaire d'Alfort.

Sept. 17-19--BAKING PRODUCTION TECHNOLOGY SEMINAR. Dallas, TX. Sponsored by American Institute of Baking, 1213 Bakers Way, Manhattan, KS 66502. Contact: Darrell Breising, AIB, 913-537-4750.

Sept. 18-20--WESTPACK '79. Convention Center, Anaheim, CA. Contact: Clapp & Poliak, Inc., 245 Park Ave., New York, NY 10017.

Sept. 19-20--NEW YORK STATE ASSOCIATION OF MILK & FOOD SANITARIANS, Annual Meeting. Holiday Inn Arena, 2-8 Hawley Street, Binghamton, NY 13901. Sponsored by NYSAMFS, Cornell University Food Science Dept., New York State Dept. of Health, New York State Dept. of Agriculture and Markets. Contact: R. P. March, 124 Stocking Hall, Ithaca, NY 14853, 256-4550.

Sept. 19-20--WISCONSIN ASSOCIATION OF MILK AND FOOD SANITARIANS, Annual Meeting. Madison, WI. Sponsored by WAMFS, Wisconsin Dairy Plant Fieldmen's Association, Wisconsin Dairy Tech Society, Wisconsin Environmental Health Association, and Wisconsin Institute of Food Technologists. Contact: Don Raffel, 4702 University

Sept. 23-29--XV INTERNATIONAL CONGRESS OF REFRIGERATION. Venice, Italy. Contact: XV International Congress of Refrigeration, American Express Co. S.A.I., Conventions Service Italy, Piazza Mignanelli, 4, 00187-Rome, Italy.

Sept. 26-27--SOUTH DAKOTA STATE DAIRY CONVENTION. Downtown Holiday Inn, Sioux Falls, South Dakota 57100. Contact: Shirley W. Seas, Secretary, Dairy Science Department, South Dakota State University, Brookings, South Dakota 57007, 605-688-5420.

Sept. 28--SYMPOSIUM ON THE PRACTICAL APPLICATIONS OF MICROWAVE ENERGY. Kansas State University Union, KSU, Manhattan, KS 66506. Contact: D. Y. C. Fung, Chairman, or F. E. Cunningham, Co-Chairman, Call Hall, KSU, Manhattan, KS 66506, 913-532-5654.

Oct. 1-3--ADVANCED FOOD PLANT SANITATION COURSE. New Orleans, LA. Sponsored by American Institute of Baking, 1213 Bakers Way, Manhattan, KS 66502. Contact: Darrell Breising, AIB, 913-537-4750.

Oct. 9-11--FOOD SAFETY AND QUALITY ASSURANCE IN FOOD SERVICES, Seminar sponsored by Capsule Laboratories. Radisson Hotel, St. Paul, MN. Contact: Darrell Bigalke, Capsule Laboratories, 840 Sibley Memorial Highway, St. Paul, MN 55118, 612-457-4926.

News and Events

Virginia Association Sponsors Dairy Industry Workshop

The Donaldson Brown Continuing Education Center on the VPI&SU Campus in Blacksburg, VA was the setting for the Virginia Dairy Industry Workshop, March 6 and 7.

The Workshop was sponsored by the Virginia Association of Sanitarians and Dairy Fieldmen and featured four symposia. They were: New Developments in Milking Equipment, PI Counts and Their Effect on Milk Quality, The Antibiotic Problem---How to Handle On-farm Concerns, and What Type of Records Does a Dairyman Need? Presentations made as part of these symposia included milking systems installation, pulsation systems and vacuum regulators, methods of handling dairy farm wastes, the environ-



Virginia Officers, left to right, D. E. Henderson, Marshall Cooper, Charles Worley, J. Gwyn Hampton, Richard Smith, and Lyle Morgan.

mental impact of dairy farm wastes, tissue residues and dairy animals, and testing suspect samples at a dairyman's request.

Officers elected to provide leadership for VAS&DF for the coming year are the following: President, Richard Smith, Mt. Airy, MD; First

Vice-president, J. Gwyn Hampton, Galax; Second Vice-president, Charles H. Worley, Greenville, TN; Secretary-Treasurer, Marshall Cooper, Port Republic; Past President, Lyle Morgan, Bedford; and International Chairman, D. E. Henderson, Marion.

Ontario Affiliate Adopts a New Name

The Ontario affiliate adopted a new name, the Ontario Food Protection Association, at its annual meeting March 28 and the OFPA Executive Board sponsored a competition within its membership to design a letterhead reflecting the new name and broader image.

Highlights of the annual meeting included a panel discussion, "Microbiological Specifications -- Function in Food Protection." Panel participants included Dr. Charlie Davidson, Silliker Labs, Mississauga; Ursula Purvis, Health Protection Branch, Toronto; Dr. David Collins-Thompson, University of Guelph, Guelph; Dr. Bill Humphreys, John Labatt Ltd., London; and Dr. Mac Goepfert, Canada Packers Ltd., Toronto.

C. A. Gracey, Manager of the Canadian Cattlemen's Association provided the keynote address. Featured in an afternoon seminar,



"Food Protection in the Food Service Industry," were Linda Johns, Cara Flight Kitchens, Toronto; Byng Cunningham, Beaver Foods/Signet, London; Terry Lack, Swiss Chalet Bar B Q/Harvey's; and Chris Rice, Abell-Waco Co.

The OFPA Sanitarian of the Year is Dr. Bill Humphreys, John Labatt Co. Doug Varnell, Klenzade Pro-



Left, Roger Wray, 1978-79 President of the Ontario affiliate, presents the gavel to the group's new President, Gail Holland. In photo to the right, Doug Varnell, left, of Klenzade Products congratulates Dr. Bill Humphreys, winner of the 1979 OFPA "Sanitarian of the Year" Award.

ducts, presented the award to him. Elected to lead the OFPA for 1979-80 were Gail Holland, President; Ralph Abell, Vice-president; and Jeanne Bernard, Secretary. Roger Wray became Past President, and new Directors are Bruce Hamilton, John Stearns, Ron Osborne, Nick Jennery, David Collins-Thompson, and Allan Fernandez.

At a May 17 Executive Board meeting the positions of secretary and treasurer were combined and Brenda Chelsey was elected to that office.

PLEASE LOOK FOR additional News and Events items throughout this issue. You'll find these items on pages 566, 571 and 603.

Hertz Offers Discount for IAMFES Meeting

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If you do not need the car 7 days, Hertz will give you a 15% discount when you tell them you are with IAMFES and use ID# 03090 when placing your reservations. Place reservations as early as possible.

Food Processing Report Available

"Controlling Microorganisms in Food Processing", Special Report No. 31, April 1979, is available upon request from D. L. Downing, NYS Agricultural Experiment Station, Geneva, NY 14456. This publication is a result of the Thirteenth Annual Symposium, sponsored by the Western N.Y. Section of the Institute of Food Technologists; the Institute of Food Science, Cornell University; and New York State Cooperative Extension.



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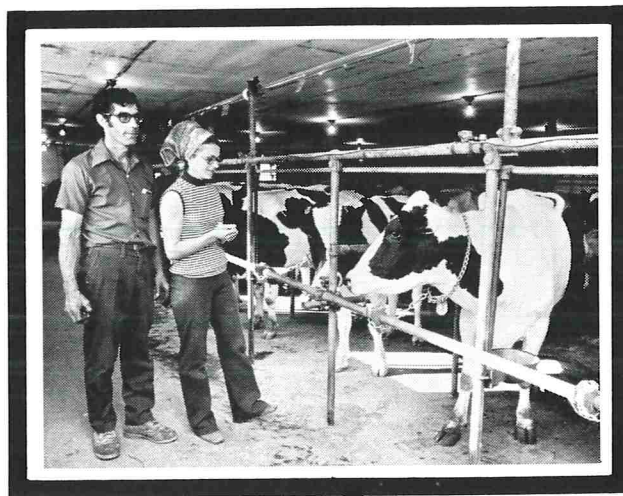
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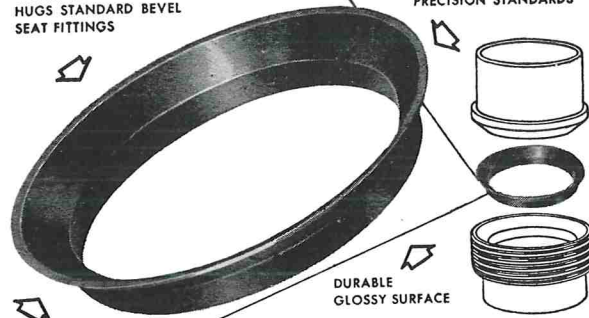
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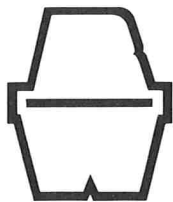
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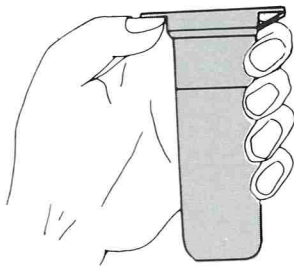
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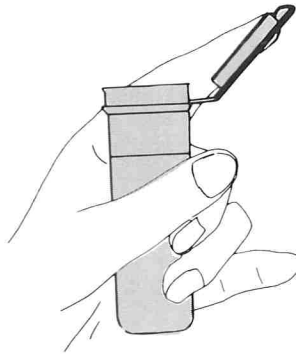
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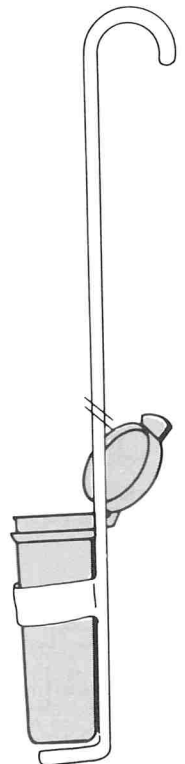
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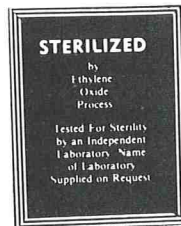
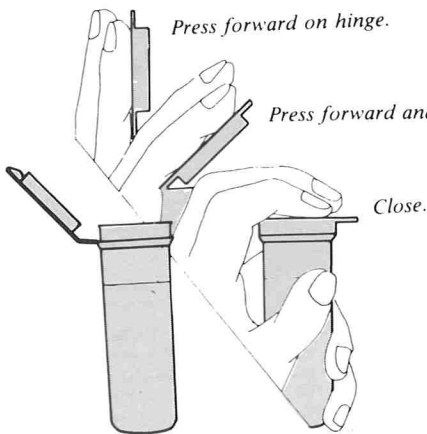


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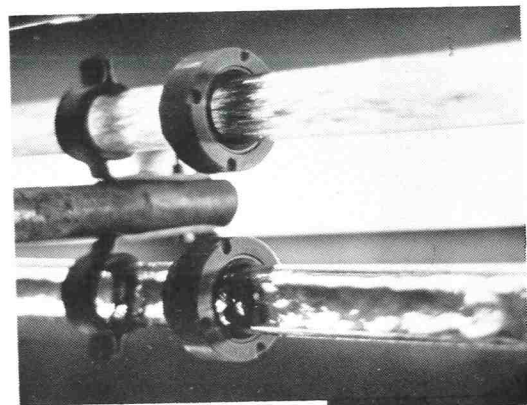
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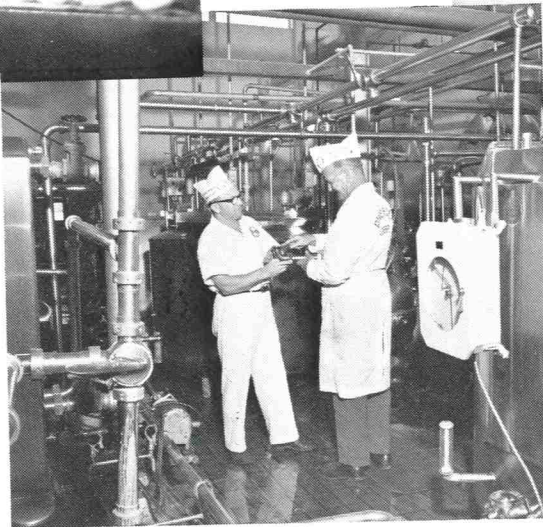
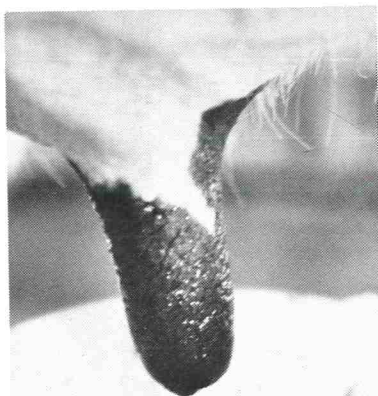
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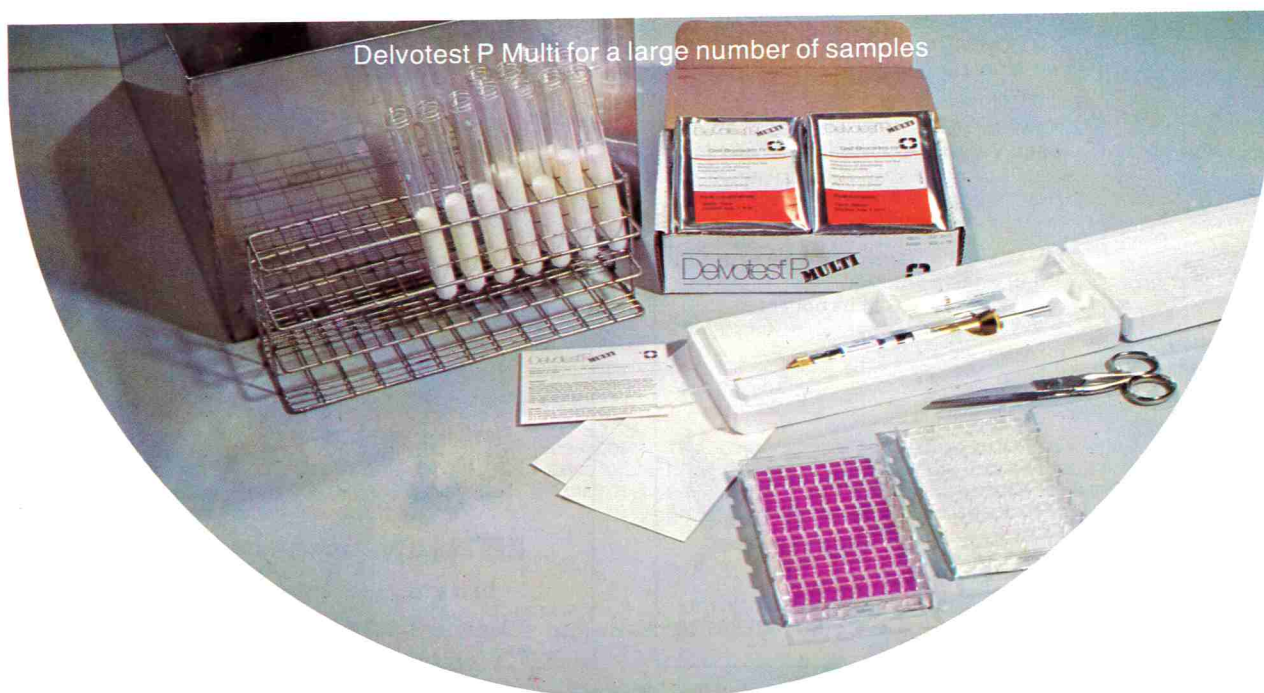
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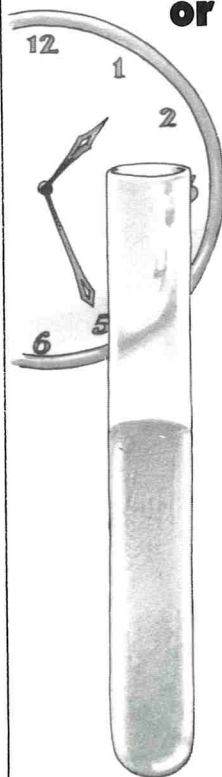
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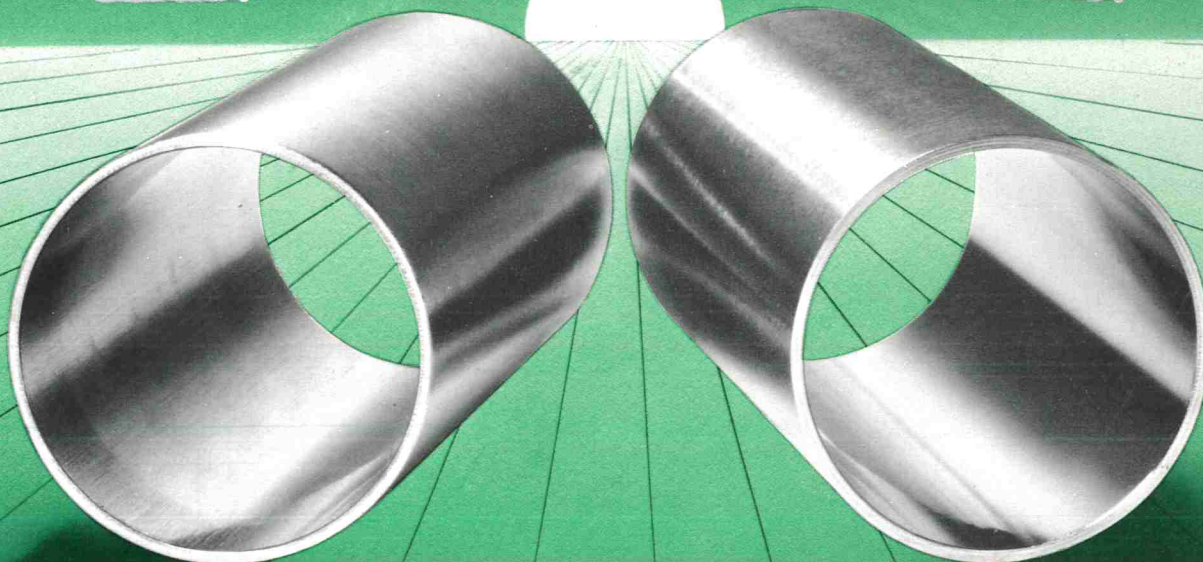
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Both of the tubing samples shown above are AISI-300 series stainless steel designated as ASTM-A270. One has been processed according to the surface finish standards set down by the 3A standards committees. The other contains pits, folds and crevices—surface imperfections not easily detected in bright-light visual inspection.

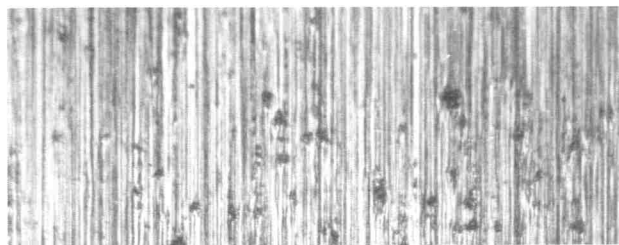
Surface finish and product contact surfaces are included in the 37 separate standards



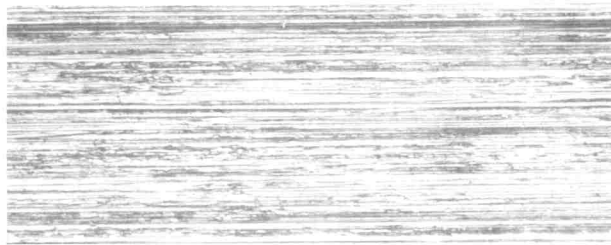
regulating sanitary equipment design as set down by the 3A standards committees—a voluntary collaboration of dairy processors, equipment manufacturers, sanitarians and public health officials. This unique industry-regulated program has, for over 30 years, successfully blended the interests of its participants toward one goal; safeguarding the public health.

At LADISH CO., Tri-Clover Division, sanitation integrity is, and always has been, our first, rather than our last, design and manufacturing criteria. Look for the 3A symbol on Tri-Clover products. You'll find a larger selection here than elsewhere.

*Macrographs of polished I.D. surface of 2" O.D. tubing samples taken at 100X magnification reveal:



Brand X, using a rotary bob, *circumferential* polish, does not provide sufficient metal removal to smooth out weld bead or remove imperfections shown above—prime sources for microbial growth and corrosion attack. (Left, above)



Tri-Clover, using a *longitudinal* polishing method, removes weld bead, pits, folds and crevices. This method takes more time and equipment, but it is your assurance of sanitary integrity and protection against corrosion attack. (Right, above)

Send for our new series of 3A compliance bulletins on:
Sanitary Fittings (TCT-7) and Gaskets (TCT-8).



LADISH CO.
Tri-Clover Division
Kenosha, Wisconsin 53141

Stimulation: The First Step Toward A Better Harvest

*Dr. Richard D. Mochrie
Professor, Animal Science
No. Carolina State University*



It's milking time, and you are ready once more to harvest that milk crop you continue to work so hard for. You have provided the best nutrients to these dairy animals, and the best housing. You have raised them from calves and provided them with every benefit at your disposal to assure that they will be good producers. And now, they have just entered your milking parlor or are ready to be milked in the barn. Your next step, stimulation, will either make all your work worthwhile, or negate much of the effort you have put in.

Oxytocin Means Let Down

Stimulation is more than cleaning the udder before milking. Properly done, stimulation substitutes completely for the natural signal provided by the calf to tell the cow she is hungry. Oxytocin, a hormone released into the blood stream after stimulation, signals the milk making glands (alveoli) to release the milk they have produced. This squeezing out of tiny droplets of milk from each of the millions of alveoli is called "let-down." The let-down is directly related to the amount of oxytocin in the blood stream, and the amount of oxytocin present is directly related to the thoroughness of the stimulation.

Complementary Milk: Profits Left in the Udder

In tests conducted on a number of herds, we found that from three percent to twenty percent more milk was present in the udder than was being harvested, partly due to inadequate stimulation. The animals

were first stimulated and milked in the normal way, by their regular milker, and production recorded just before complementary was obtained. Later, the cows were stimulated as usual and then, just before attaching the milking machine, they were injected with an adequate amount of oxytocin. The average cow gave in the area of ten percent more milk after receiving maximum stimulation with the additional oxytocin. This ten percent as complementary milk (instead of being part of the normal) represents profit lost for three reasons: First, this milk would not have been harvested during a normal milking. Second, the last of the milk is always richer in fat, and so the fat test would be lower. And last, with the complementary milk remaining in the alveoli, the cells become less active in producing milk. Over a normal lactation period, this can make a good cow produce far less than she is capable of. With proper stimulation, the amount of complementary can be reduced to about the same minimum as injecting oxytocin.

Thirty Seconds of Profitable Time

All results point to the fact that about thirty seconds is the amount of time necessary to achieve maximum stimulation and proper cleaning. This should be a vigorous massage—preferably with a disposable paper towel. Less time fails to provide the amount of needed oxytocin, and more than thirty seconds of stimulation does not increase the level. Time spent stimulating the animal will determine if she has received an adequate natural signal to allow maximum let-down. The thirty seconds you spend on each cow to assure proper stimulation may well be the most profitable time you use on the farm.



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