October, 1983
Vol. 3, No. 10
Pages: 361-404
ISSN:0273-2866
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Ames, Iowa 50010

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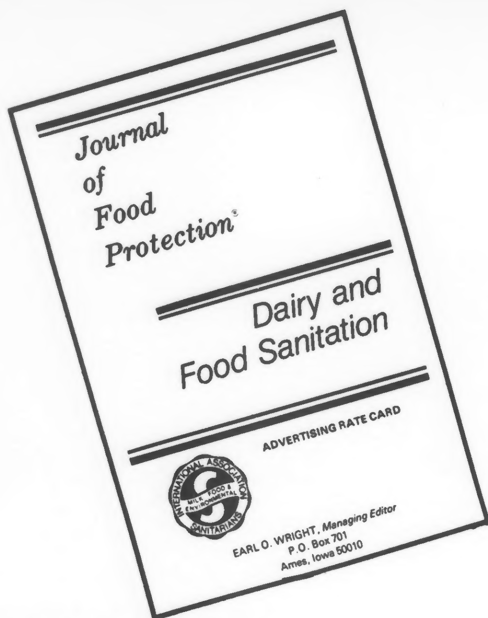

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Dairy and Food Sanitation is published monthly by the International Association of Milk, Food and Environmental Sanitarians, Inc, executive offices at PO Box 701, 413 Kellogg, Ames, IA 50010. Printed by Heuss Printing, Inc, 911 Second St, Ames, IA 50010. **Second-class postage paid at Ames, IA. Postmaster: Send address changes to IAMFES, 413 Kellogg, Ames, IA 50010-0701.**

Manuscripts: Correspondence regarding manuscripts and other reading material should be addressed to Kathy Hathaway, PO Box 701, Ames, IA 50010-0701. 515-232-6699.
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Dairy and Food Sanitation, Vol. 3, No. 10, Pages 364-371 (October 1983)
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Cost/Benefit Analysis of Food Quality Control

GAIL C. (EVANS) HOLLAND

Director Scientific Activities, Canadian Meat Council. Presented February 23, 1983. ABC Research Conference, Gainesville, Florida.

A Quality Control System should be designed to identify the probability of a substandard product. The system should then weigh the costs of distributing this substandard product against the benefits of isolating this product before it enters the market. Quality Control can be applied at any level of the food industry. It should be developed to select a program with the greatest potential to meet the scientific requirements of the corporation, find and identify all alternatives and determine whether more information could improve the existing programs.

Design of Quality Control Processes

As long as a Food Quality Control (QC) system operates on random sampling of processes and/or products, then all products tend to fall into one of six categories:

1. The product is actually acceptable, is sampled and is found (correctly) to be acceptable.
2. It is actually acceptable, and is not sampled.
3. It is actually acceptable, and is sampled, but is found (by error) to be deffective.
4. The product is (by error) actually not acceptable, is sampled, but is found (by error) to be acceptable.
5. It is (by error) actually not acceptable, but is not sampled.
6. The product is (by error) actually not acceptable, is sampled and is found (correctly) to be out of compliance.

It is on these observations that a quality control process should be designed to identify the probability of accepting a substandard lot (categories 4 and 5) for distribution and retail. A QC system should weigh the costs of distribution of a substandard product against the benefits of isolating and receiving substandard products prior to entering the market--and visa versa.

Quality control processes should be designed to measure, on a continuing basis, the percentage of production output which is of unsatisfactory quality, and serve to inform production and marketing management promptly and quantitatively, the percentage of unsatisfactory product.

Since raw materials and production processes are not entirely uniform or precise, there will always be a certain portion of product which is imperfect in some respect. Adequate quality control procedures should prevent the shipment of product which has more than a pre-decided percentage of faulty product.

Quality control procedures can provide for re-inspection and removal of faulty product from unsatisfactory shipping lots before shipment.

Quality control inspection reports should provide production management with quantitative data on the frequency of occurrence of different types of faults and will thereby help to direct their attention to specific parts of the process or raw material selection which are not being adequately controlled.

Theoretically, quality control should be a service to production, sales, purchasing, and ultimately the consumer. It should be active in establishing, maintaining, and controlling product standards and quality such as: weight, consistency, formulation adherence to company specifications and to government regulations, microbiological quality, sanitation and employee hygiene. It should cover every phase and operation-production, storage, product nutritional quality, palatability, and shelf-life.

Benefits and Costs

When effectively applied, a number of benefits can be attributed to quality control (QC) programs. Extended product shelf-life, extended "best before" dates, reduced product returns due to premature off-condition, reduced spoilage, increased product sales, and improved competitive position in the retail market are the benefits most frequently associated with effective QC programs. Additional benefits attributed to QC programs include reduced potential for product seizure or product recall.

With regard to the potential for product seizure and recall, it cannot be overstated that the manufacturing company, including its individual officers and employees, bears full legal responsibility for the safety, labelling, and quality of its products. Product, civil and criminal liabilities may be involved when illegal, unsafe or hazardous products are placed on the market irrespective of prior knowledge, intent or extenuating circumstances.

Based on this list of benefits, it appears that a QC program can provide corporate security--both financial and entity--by guaranteeing a market share. However, actual benefits depend on the application of a program. A quality control laboratory brimming with petri dishes, glassware, bottles, bunsen burners and chemists titrating color changes may impress shareholders, visitors and inspectors. But unless that laboratory generates accurate information and that information is used to adjust operations and to assure that products comply with regulatory and company specifications, then no benefits can be attributed to a QC program.

Before reviewing the perceived costs it is important to remember that a specific QC program must be designed for each company. A QC program which has been acceptable for one company does not necessarily mean it will be effective in another. In other words, there are different costs/risks--benefits/promises for every QC program.

The perceived costs of a QC program as identified by management includes:

1. It costs a lot of money.
2. It never pays a dividend.
3. The results are frequently after-the-fact, and
4. If management tires of it, it cannot be sold.

Because QC programs are time-intensive they become long term efforts--in fact some managements believe that the results should be left in trust to the future generations.

Realistically, the costs of quality can be grouped into three categories:

1. Failure costs - internal and external (Table 1)
2. Appraisal costs - process control and final product control (Table 2)
3. Prevention costs - costs incurred in planning, setting up and maintaining a system which ensures compliance (Table 3)

These tables provide a generalized check list which indicate the major sources of cost in a system. It is the responsibility of each company to determine the significant items to be included in the estimation of the cost of quality control vs. the resulting benefits.

TABLE 1. *Failure costs.*

Activity	Function involved
Internal failure -	
Scrap	Production
Product giveaway	Inspection Material control
Rectification	Production Re-inspection Material control
Downtime (quality reasons)	Production Engineering
Warehouses-inspection of finished products in stock	Stores Inspection
External failure-	
Complaints	Administration
Return of goods	Administration
Investigation and analysis	Production Engineering Quality control
Replacement	Quality control and assurance Administration
Customer liaison and compensation	Sales
Warranty	Buying Administration

TABLE 2. *Appraisal costs.*

Activity	Function involved
Process appraisal -	
Receiving - raw materials, bought-in finished items	Quality control Stores
Line inspection at stages of process	Quality control Production
Inspection equipment maintenance	Instrument engineers Quality control
Final appraisal -	
Finished product inspection	Quality control Production Laboratory
Centrification Tests-destructive Tests-non-destructive Life/reliability Environmental	Laboratories Consultants, etc.
Inspection equipment maintenance	Instrument engineers Quality control

Due to the cost of analyses, QC has historically been a voluntary program of the more progressive, conscientious, relatively large companies. However, in Canada, with the present minimum total protein regulations (in U.S. P.F.F. criteria, etc.) proposed minimum meat content regulations, potential microbiological standards, and increased consumer awareness (some fad, some fallacy, some fact), companies are now more obliged to have active quality control programs.

TABLE 3. *Prevention costs.*

Activity	Function involved
Quality planning -	
Quality investigation within the design specification in respect of:	Quality control and assurance Production/engineers
Raw materials	
Methods of manufacture	
Product characteristics	
Proving, sampling, or other pre-production trials and tests of prototype and processes	Production Quality control R&D technologists
Process control -	
Supplier approval	Quality control Buying
Planning of inspection routines and testing procedures and methods during production/ processing	Quality control Production Laboratory
Design and approval of inspection	Quality control Laboratory Instrument design
Training of inspectors	Quality control Courses
Specifying storage and handling-special conditions	Production Quality control Stores Transport

In addition, the present activities by the U.S. Department of Agriculture (U.S.D.A.) in the develoment of the Total Voluntary Quality Control Program for the meat industry has also motivated the industry to look at and implement QC systems.

The concept of voluntary compliance is used in the U.S.D.A.'s approach to QC regulations. Industry controls its own operations and U.S.D.A. monitors the industry's program. The QC regulations emphasize industry's responsibility to produce safe, wholesome and accurately labelled products.

The regulations, which became effective September 15, 1980, outline the general requirements for plants to participate in Voluntary QC Inspection.

The objectives of the total quality control regulations are to permit the U.S.D.A. to use quality control technology, which in turn will result in a more effective and efficient use of regulatory resources. It is claimed that inspection is based on objective measures; consequently, there is better control of critical points in processing where significant variation can result in unsatisfactory finished products. The U.S.D.A. also indicates that this type of QC also provides a base of knowledge and experience from which future regulatory reform can be evaluated.

The Meat Hygiene Division of Agriculture Canada is presently evaluating the U.S. program and is considering a FOIL (frequency of inspection level) concept for the Canadian federally inspected meat industry.

In the discussion of costs/benefits of quality control, it is imperative to use a logical, practical decision-making mechanism which reflects present economic and regulatory pressures such as: increasing consumer demands for greater supply, for greater consistency (standardization), for more economical supply, for more convenience foods; increasing regulatory activity i.e. protein, moisture, fat, protein fat-free specifications, microbial standards and inflation.

Such decision-making mechanisms require the ability:

a) to identify specific corporate concerns;
b) to realistically assess whether the corporation has the development skills to convert the QC program results into products and services, and
c) to differentiate and assess procedures with potentially large returns in the future vs. projects assuring small returns in the near term.

Interactions and Costs and Benfits

Quality in the food industry may be defined as "a measurement of the degree to which a product meets the expectations of the consumer".

Minimum quality standards are basically defined by the food and drug regulations or by appropriate agricultural regulations. Such standards include the statutory compositional requirements, safety in manufacture (i.e. performance requirements), package protection....Quality standards also address the expectations of the consumer and include image of brand name, meeting promotional claims....

In order to determine the level of quality standard, then it is ncessary to assess the interaction of the value of the quality viz the price the consumer is willing to pay, and the cost of producing it.

Edward Druce of RHM General Products, and David Matthews of Kelloggs Company of Great Britain have fine tuned the concept of cost benefit interactions.

Figure 1 demonstrates the interaction of worth and cost against quality. Particular constraints could be applied to the condition of the raw material. For example, the degree of precision that each piece of raw material should be cut could be specified, with differing tolerances, and classified according to high or low quality standard. If a low standard is chosen, then it will cost a certain amount to produce, because the raw materials will have to be bought and the fixed costs of running the factory still have to be met; hence any quality costs something. To increase the standard of quality, costs little at first. More attention can be given to supervising the activity of the operators, and the slicing machine can be adjusted to cut the material more accurately. However, further increases in the quality standard ultimately results in a limitation beyond which neither the capability of the slicer nor the skill of the operators can be increased. Once this occurs the only recourse is to reject the product, and as the standard of quality increases so the costs escalate due to the increased amount of rejection. This is shown in curve A (Fig. 1).

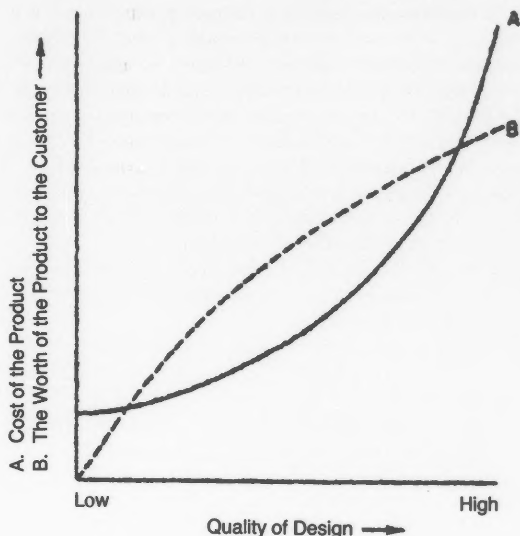

Figure 1. *Relationship between cost and quality of design.*

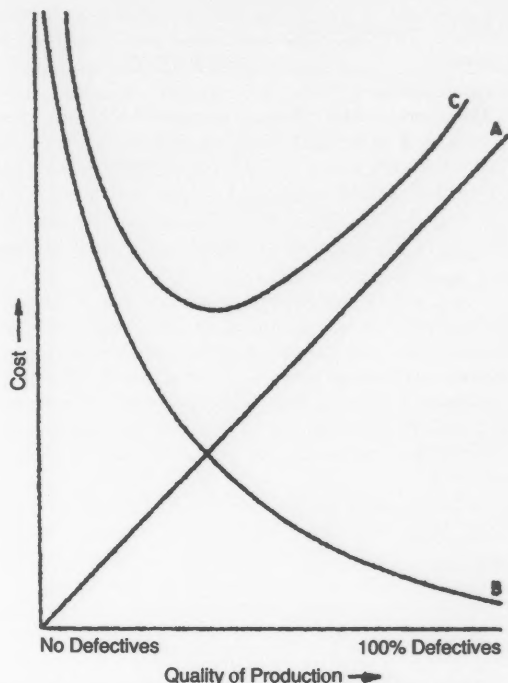

Figure 2. *Costs of maintaining the production specification.*

Next, the value of the improvement in quality of the raw material as perceived by the customer must be assessed, because this influences the price that he or she is willing to pay. When the standard of quality is very low, it has little or no value for the customer. In the example, irregular appearance and variation in the eating texture would be the outcome of having too low a standard. As the quality rises, the product becomes more acceptable and the price the customer is prepared to pay rises. However, there comes a point where the customer is satisfied with the product and would not be prepared to pay more for any improvement which he cannot appreciate. This is shown in curve B (Fig. 1).

Thus, as the interaction of curves A and B show, there is always an optimum of quality. Above this optimum, the increased cost of achieving a higher quality more than offsets the greater market value of the finished product. Below this optimum, any reduction in the cost of manufacture is more than off-set by a still greater reduction in value of the product.

Relationships such as that considered here show very clearly that the selection of quality standards, and particularly the choice of tolerances, is an economic decision of the greatest importance since these greatly influence the manufacturing process which is to be used.

The definition of quality embraces the concept of production at an 'economic cost', and this phrase is of considerable significance of planning quality control in the factory. The overall objective is to achieve the required quality standard as cheaply as possible. Consequently, the interaction of failure, appraisal and prevention costs on the quality of product should be considered (Fig. 2).

The abscissa shows the quality of production expressed as the percentage of work produced in accordance with the quality specifications. Thus, 'no defectives' means that everything was produced 'right first time'. On the right-hand side is the other extreme, where everything that is produced has failed to conform to the standards that have been set for it. The ordinate represents the cost incurred in quality control activities.

Line A represents the failure and appraisal costs, and is approximately a straight line; it is difficult to pull these costs down once they have started to rise. The more defective products that are produced, the higher are the failure costs. The traditional method of meeting higher failure is more inspection. This, of course, results in a higher appraisal cost. This greater degree of inspection does not really have much effect in eliminating the defects. Defective product will still leave the factory and arrive in the hands of complaining customers. Appraisal costs thus remain high as long as failure costs remain high and continue to increase unless there is any successful preventive action.

Curve B (Fig. 2) represents the costs of prevention. Where there are high failure and appraisal costs, little is being spent on prevention, and the curve is very near the abscissa. Therefore, when prevention costs are increased, to pay for the right kind of quality planning, process control, etc., a marked reduction in the number of products which are defective occurs. Much greater effort is required to reduce the defectives further, with an appropriate in-

crease in cost. In the extreme case, to require that a factory would never produce any product that did not conform to the specification in every respect, would demand an enormous expenditure. Thus, raw materials would have to be selected to very tight standards; machines would have to be purchased with infinitely better capabilities than those in use; selection, training, and operating standards of possibly the total workforce would need review; all to save a very small percentage of defectives. Thus, applied to curve B, the cost of attaining 'zero defective work' even by preventive means escalates steeply.

The quality of production obtained should be determined by the minimum overall cost of all control activities, and the addition of the curves for failure and appraisal to that for prevention gives curve C which shows the minimum cost. In such a system, when prevention costs are increased a reduction in the number of defective products occurs. This, in turn, leads to a substantial reduction in failure costs.

A similar sequence of events takes place with appraisal costs. Reduction of defective work in its turn has a beneficial effect on appraisal costs, since defect reduction means a reduced need for routine inspection and other testing.

Finally, when there is an improvement in quality planning, process control, and the performance of personnel (e.g. by better training), an additional reduction in appraisal costs results. The overall result is both a substantial reduction in the total cost of quality activities and an increase in the level of quality. It should, however, be remembered that even within the events that have been described there is a 'minimum cost' of defective work below which it is unprofitable to go.

Figure 3. *More realistic representation of costs.*

There is a common flaw in quality control logic - i.e. the more that is spent on qualified staff, then the lower the cost of scrap or rework. However, Fig. 3 may more fairly suggest that over a certain point the more qualified a staff, the more they will generate a) quality rejects for insignificant faults; b) communications problems; and c) a climate where operators abandon any responsibility for quality and sanitation. In other words, work is undertaken which does not in fact improve the quality of the product.

The concept of cost/benefit interaction can be applied at any level of the food industry-from the relationship of benefits of retail quality (market-ability) vs. the cost to attain the quality, to benefits of accuracy and precision in analytical methods vs. the costs of time and labour.

In light of these points then an accurate cost/benefits - risks/promises assessment of a QC program necessitates:

a) the development of a mechanism to select a program with the greatest potential for the scientific requirements/concerns of the corporation.
b) the effective identification of issues--the identification of alternatives; possible outcome, and factors which could influence future events.
c) the determination of whether more information could improve existing QC programs - at what costs in time and money.
d) the identification of synergistic interactions--technical and commercial--in the existing QC portfolio.

APPLICATIONS OF COST BENEFIT ASSESSMENT IN QUALITY CONTROL PROCEDURES

Chemical Analyses

In the past, chemical analyses (with few exceptions) for meat products, have been limited to determining fat, moisture, dextrose, protein, nitrite and salt. Such analyses have been used to determine product compliance with the company's specifications, operational performance (e.g. process capacity, process variation, product quality vs cost....) and regulatory compliance with Food and Drug Regulations.

Of greatest significance to the industry is the measurement of protein. Accurate and precise analysis is important for two reasons. The first is that the degree of process-control cannot be better than the precision of the analysis; the more precise the analysis, the closer a company can come to the control target. Since protein is usually the most expensive component of a meat product, close control of protein content can give a direct savings to the cost of formulating a product. The second reason for accurate analysis is the law--the potential for prosecution, the potential for product recall, and the resulting damage to consumer confidence. In instances of product seizure or recall, costs include: administrative, labour, materials, facilities, design, service, notification, insurance and others such as loss of goodwill.

There are many methods for determining protein. Frequently the choice of a method is based on the cost per analysis; accuracy and precision are given relatively minor importance. If analytical results are properly and completely used, however, the analytical costs can be trivial compared to the savings made on formulation costs and the marketing advantages gained by improved product uniformity.

The primary requirement of an analytical method is to provide reliable results. Accurate and precise analysis is

important for two reasons. First, the degree of control cannot be any better than the precision of the analysis; the more precise the analysis the closer you can come to the control target. This control of protein content will provide a direct saving in the cost of formulating a product.

Value of Precision and Accuracy

Precision refers to the reproducibility and repeatability of analytical results that are affected by random or chance errors. Random errors include: sampling errors, as well as intrinsic errors in the methodology (weighing dilution, reading, calibration, operator's skills).

Accuracy is described by the term "bias", which is defined as the "best" value minus the "true" value. The "best" value for a given sample may be the single value at hand or, if one wants to measure bias precisely, one may use the mean of several analyses to reduce random error.

The "true" value is not so easily obtained. In the case of government limits on protein, the "true" value will be the "official" value which is defined as 6.25 times the percent Kjeldahl nitrogen of a sample.

There are two parts to this definition. The official Kjeldahl nitrogen content is that obtained by an official analyst in an official laboratory using the official procedure. Since the official method can suffer from bias, and since an industrial analyst is not an official analyst, following the official procedure is no guarantee that results obtained by your analyst will be the same as those obtained by an official analyst. It takes careful standardization and an experienced analyst to obtain accurate results. One can expect the agreement between labs to have a standard deviation of from 0.2 to 0.3 percent protein.

Bias due to the method and the type of sample are only two sources of bias. There could be differences between laboratories caused by differences in the purity of reagent chemicals used or by differences in temperature or humidity. Bias can arise between individuals through slight differences in technique. These errors can be controlled through training and periodic checks of accuracy with known samples.

The effect of bias on protein analysis can lead to direct loss of profit. If results are always too low, protein is needlessly given away. If results are too high, the products could be below the government limits. Simply stated, bias of any magnitude cannot be tolerated.

The effects of random error are not so clear, since negative and positive errors will cancel on the average and the net effect will be zero. However, there will be odd samples that may be below the government limit (Fig. 4). This is where precision in analysis is important.

The effect of random error on control can be seen most easily by examining the distribution of random error. In a modern well engineered process where ingredients are weighed out accurately and batches are mixed thoroughly, the precision of control will be limited by the precision of the analytical method. The standard deviation for protein by the official method is typically around 0.3% protein.

Since random error is present, one cannot aim for the minimum accepted protein limit as a target but must operate at a higher level. If it is desired to limit the fraction of control units below the limit to 5 percent with a standard deviation of 0.3% protein, the target will have to be 9.50% protein or 9.70% protein for 1 percent below (Table 4).

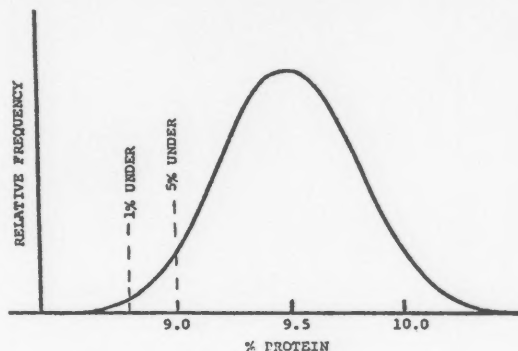

Figure 4. *Distribution of random error.*

TABLE 4. *Protein control targets.*

Protein Control targets for a minimum protein limit of 9%		
	% BELOW LIMITS	
STD. DEV. (% Pr)	5	1
0.3	9.50	9.70
0.1	9.17	9.23
SAVINGS	0.33	0.47
RELATIVE SAVING	3.5%	4.9%

If a more precise method having a standard deviation of only 0.1% is used, the corresponding targets are 9.17 and 9.23% protein. The more precise method allows one to maintain quality at a lower protein level. (The control limit need not be based on the government minimum, but on a higher limit set by internal policy. Nevertheless, the argument remains the same.) Since protein is expensive, the saving can be substantial. The relative savings are 3.5% and 4.9% of protein content at the 5% and 1% defect levels. That is, the more precise method will save $3.50 to $4.90 per hundred dollars worth of protein. Since the cost of most methods is in this $3 to $5 per sample range, this saving will pay for the analysis itself, let alone the difference in cost between the two methods (Table 1).

Meat packers routinely buy quantities of cut, boxed beef and pork in either the frozen or refrigerated state. Using conventional methods, at least 48 h are required before the microbiological quality of the product can be established; but by then the meat has probably been processed and defective raw meat may already be causing economic loss in the finished product. The availability of an enzyme activity test capable of assessing the bacteriological quality of meats within 3 h would essentially eliminate such losses. Poor quality meats could then be termed "unacceptable" and returned to the sender.

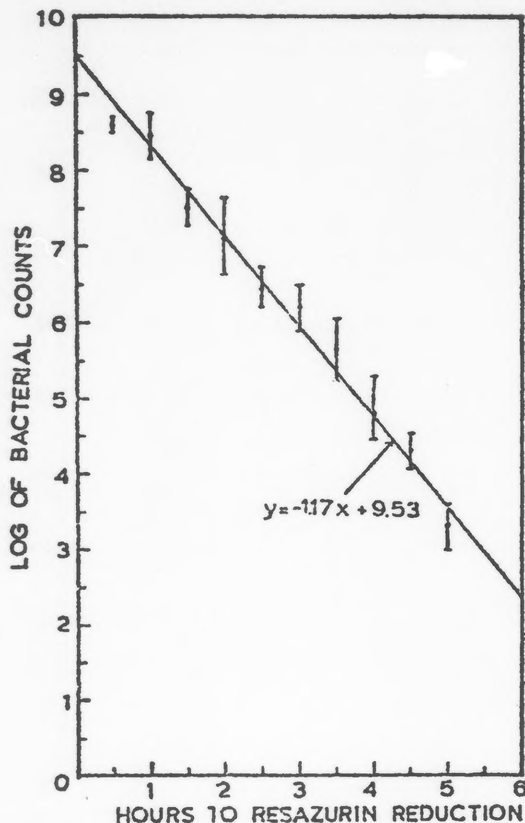

Figure 5. *Relationship used to determine bacterial numbers from resazurin reduction time. Meat ± std. Dev. indicated for each interval, based on 139 direct comparisons.*

The bacteriological quality of fresh meat can be determined rapidly by resazurin reduction. Test mixtures contain 1 ml of decanted supernatant from a Colworth Stomacher preparation of fresh or frozen meat and are added to 10 ml of solution of 10% skim milk and 0.00055% (W/V) resazurin. Unsatisfactory meats reduce the dye within 3 h when tests are incubated at 30°C (Fig. 5). The rate of dye reduction is affected by the number and type of organism, concentration of skim milk and by reagents affecting the redox potential and pH of the test medium. This method is presently not applicable to ground meat because of reducing compounds in animal tissue released during grinding or blending, but works well on boxed manufacturing meats.

The first advantage of this technique is that 10 sample units can be analyzed from every consignment with less labour than was required for 1 plate-count analysis; although some plate counts should still be done to improve and to provide confirmatory results for decisions made on poor consignments. Results are expressed in terms of real numbers which is superior to sensory evaluation. Meat may contain 10^8 - 10^9 bacteria per g and not be rejected by odour, particularly if the product is frozen. Unacceptable consignments, become evident in 1-1.5 h. Substantial savings in storage space and in eliminating the possibility of meat spoiling on the premises are realized by making decisions regarding shelf life within 4 h of purchase. The entire system is portable on a laboratory cart; so that in addition to making decisions at the point of purchase, meat in storage could be examined as required anywhere in the plant. The operator need not have an extensive microbiological background. Media and petri plate costs are reduced, as are preparation and cleanup times. An increase in the shelf life of finished products is anticipated. Although the precise dollar value of the accumulated advantages has not been determined; the ability to evaluate all purchased consignments of meat cuts by international standards has been attained.

The preceding paper is strictly a presentation of concepts for assessing the costs/benefits of a QC program. The assessment procedures can be equally applied at the processing level and at the laboratory level. The costs of QC programs are very real--but so are the benefits.

List of References on QC in the Meat Industry

STATEMENT OF AWARENESS TO REDUCE SALMONELLA CONTAMINATION IN RENDERING OPERATIONS. Canadian Meat Council, 5233 Dundas St. W., Islington, Ontario M9B 1A6.

airborne contamination, water supplies, personnel, insects, rodents, birds, raw materials, plant construction, process failure, cleaning procedures, transport vehicles.

STATEMENT OF GOOD MANUFACTURING PRACTICES FOR THE PREPARATION OF GROUND BEEF AND RELATED PRODUCTS. Canadian Meat Council. (address above)

general employee hygiene, condition of raw materials, frozen storage of trimmings and ground beef, tempering/defrosting frozen beef, final product condition, retail display of ground beef, cleaning procedures, water temperatures, stainless steel maintenance.

CRITICAL CONTROL POINTS IN BACON MANUFACTURE. Canadian Meat Council. (address above)

belly quality; quality, purity, and consistency of curing ingredients; preparation of curing pickle; pumping procedures; cover brine; smoking; cooling prior to slicing; analyses of finished products including selection of samples, lot identification, sampling procedures for injection machine adjustment, confidence levels for pumping gains, graphs of nitrite depletion during preparation and storage, proximate analysis, sample calculations, tables of specific gravity of brines, charts for temperature corrections for Brix Hydrometers.

REVIEW OF MANUFACTURING PRACTICES FOR PROCESSED MEATS. Canadian Meat Council. (address above)

care of spices, seasonings, binders; development of purchase specifications for spices; care of curing

agents; care of frozen meat; tempering -- effect on quality; methods for tempering meat; preblending procedures; care of grinders; review of emulsion production, preparation of curing pickle; care in pumping cured meats; massaging and tumbling technology; smoking; smokehouse maintenance; review of product control; processing room temperatures; detergents, cleaners, and sanitizers; water temperatures; cleaning program design; evaluation of sanitation.

HAZARD ANALYSIS OF MEAT, POULTRY AND FISH IN THE FOODSERVICE INDUSTRY. Canadian Meat Council. (address above)

critical conditions for foodborne illness; hazard analysis of cooking procedures (delayed cookery, oven roasting, water bath, air convection, microwave); examples of foodservice operations and H A C C P.

FAT ANALYSIS. Q C-R & D vol 2 (4)-7. Research Bulletin of the Canadian Meat Council. (address above)

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OFFICIAL METHODS OF ANALYSIS OF MICROBIAL CONTENT AND EXTRANEOUS MATTER. Health Protection Branch. Ottawa, Ontario.

PROCESSED MEATS. W. E. Kramlich, A. M. Pearson, F. W. Tauber, AVI Publishing Company, Westport, CN.

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QUALITY CONTROL IN SMALL PLANTS A GUIDE FOR MEAT AND POULTRY PROCESSORS. Agriculture Handbook 586. U S D A, Food Safety and Inspection Service.

*More detailed lists of texts and publication dealing with QC technology in the meat industry are available on request.

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2. Guidelines for Product Recall. 1974. By Grocery Manufacturers of America, 1010 Wisconsin Ave., N.W., Suite 800, Washington, DC 20007.
3. Emergency Communications: Operating Procedures for Controversial Situations. Bulletin 101-PR, (National Canners Association). Now National Food Processors Assn., 1133 20th St., N.W., Washington, DC 20036.
4. Organizing A Product Recall Program. Bulleting 34-L, (National Canners Assoc). Now National Food Processors Assn., 1133 20th St., N.W., Washington, DC 20036.
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Dairy and Food Sanitation, Vol. 3, No. 10, Pages 372-375 (October 1983)
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SHOULD CHEESE BE REFRIGERATED?

JOHN H. NELSON, Ph.D.

Vice President Quality Assurance
and Regulatory Compliance
Kraft, Inc.
Glenview, Illinois

Cheeses are one of the oldest types of prepared foods. Cheesemaking provided mankind with the means of concentrating and preserving milk at a time when refrigeration was unknown and principles of food preservation were vague empirical concepts at best. Cheeses were included in the diet of early Egyptians and Greeks. Indeed, cheese is mentioned in Greek mythology, including one variety made from the milk of tigers. That cheese must have had real gusto, but pity the poor tiger milkers. Rome imported cheeses from England, France, the Alpine areas and even Asia, all without the benefit of refrigeration.

General Principles

Displays of cheeses out of refrigeration should be conditional upon ambient temperature limits and adequate stock rotation. Display temperatures should not exceed 78°F, and product should not be exposed to localized heat sources, such as sunlight, refrigeration condensers, etc. Effective stock rotation is a must, but is rarely a problem, since most promotions last only a few days.

Mass display should be limited to products in original packages - that is packages of food products filled and sealed under good manufacturing or food handling practices. Thus, delicatessen sales of opened blocks or loaves of cheese should maintain cheese in opened packages under refrigeration, in an enclosure which prevents handling or sampling by curious shoppers.

Some cheese packages bear the statement "Refrigerate after opening", reflecting concern that once a product is exposed to the environment, it should be kept cold to minimize the growth of spoilage organisms that may be introduced into the product.

Often, shippers for products displayed out of refrigeration may bear the statement, "Store under refrigeration" or "Keep refrigerated." Such instruction reflect manufacturers programs to control distribution conditions so that when weeks or months elapse between manufacture and store display, product will remain at optimum quality.

Reasons for Out-of-Refrigeration Display

A major incentive for removing cheese from refrigeration is sales promotion. Attractive mass display of any product, strategically positioned and priced to motivate consumer purchase is a proven technique for increasing sales. The removal of cheese from the confines of refrigerated display cases is essential to this sales strategy.

Foodservice operations may need to have cheese conveniently at hand during food preparation. Buffet food service may include a variety of cheeses or items which incorporate cheese, some of them at ambient temperatures.

Technology of Natural Cheeses

Natural cheeses are fermented foods. Conversion of milk to cheese includes inoculation with very high numbers of harmless lactic culture microorganisms. These lactic organisms multiply as fermentation of the lactose to lactic acid proceeds. Consequently, the pH decreases. The milk is clotted with rennet or acid and the curds separated from the whey under controlled processing conditions. Some natural cheeses are sold freshly manufactured but many are cured or aged, again under controlled conditions for many months or even years.

During the manufacture of semi-soft, hard, and very hard cheeses, the cheese is subjected to relatively long exposure to ideal incubation temperatures for spoilage microorganisms. For example, Cheddar and related varieties are maintained at 88-102°F during manufacture and are formed or hooped at temperatures in the 90's. Cheeses may remain at warm temperatures during overnight pressing, cooling gradually thereafter.

Many Cheddar-type cheeses are cured or aged at temperatures up to 60°F. Swiss cheese is held for a period of four to eight weeks at a temperature of 72°-74°F to develop the characteristic eyes and flavor of Swiss cheese. If storage of Cheddar or Swiss cheeses at room temperature had any in-

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Presented at: State of New York Department of Agriculture and Markets, Division of Food Inspection Services, Annual Inspectors Update, May 3, 1983, May 18, 1983, Sheraton Inn and Conference Center, Ithaca, New York.

herent detrimental effect on the safety of the cheeses, then neither Cheddar nor Swiss cheeses would be safe to consume.

The safety of natural cheeses is "built in" by proper management of the fermentation process. There are two main keys to proper control of cheese fermentation. First, the lactic culture utilized in manufacture must exhibit vigorous fermentation activity. A vigorous lactic fermentation has been demonstrated to inhibit the growth of spoilage microorganisms and pathogens and to inhibit, as well, toxin production by Staphylococci. Second, the fermentation during cheese manufacturing must be carefully controlled to be neither too rapid nor too slow. The key analytical tool is pH measurement, particularly pH of the cheese 24 hours after manufacture. Such freshly made cheddar and related cheese must exhibit a pH of 5.4 or less. Aged cheese may have a pH exceeding 5.4, resulting from chemical changes in constituents.

Display Conditions for Natural Cheeses

Guidelines for the storage of natural cheeses are primarily related to the moisture content of the cheese. Although salt, pH, and gross composition exert some effect, moisture content is by far the most significant determinant of how well a cheese will withstand temperature stress.

For the purpose of assessing susceptability to temperature stress, natural cheese can be divided into four groups - soft cheeses, semi-soft cheeses, hard cheeses, and hard grating cheeses.

Soft cheeses include cottage, bakers, neufchatel, cream, mozzarella and ricotta. Soft cheeses have moisture contents exceeding 50 percent. They spoil readily when temperature stressed. Spoilage may be either organoleptic (flavor) or microbiological. They should always be refrigerated at temperatures of 40°F or less.

SOFT CHEESES
Refrigeration Essential

Variety	Max. Moisture	
Cottage		80
Bakers		(80)
Neufchatel		65
Cook (Koch)		80
Cream		55
High Moisture Jack	50	(44 minimum)
Low Moisture		
Mozzarella, Scamorze	52	(45 minimum)
Low Moisture Park Skim		
Mozzarella, Scamorze	52	(45 minimum)
Mozzarella, Scamorze	60	(52 minimum)
Part Skim		
Mozzarella, Scamorze	60	(52 minimum)
Ricotta		(70)

Semi-soft cheeses include surface ripened Brie, and Camembert, mold-ripened Blue and Gorganzola, and others - Edam, Monterrey, and Muenster. These varieties have moisture contents ranging from 44-52 percent. Although such cheeses are capable of withstanding moderate temperature stress, they should be refrigerated. Flavor deterioration result from prolonged temperature stress.

SEMI-SOFT CHEESES
Refrigeration Desirable

Variety	Max. Moisture
Surfaced Ripened	
Brie	(50)
Camembert	(50)
Brick	44
Limburger	50
Mold Ripened	
Blue	46
Gorganzola	46
Roquefort	45
Other Varieties	
Edam, Gouda	45
Monterrey, Monterrey Jack	44
Muenster, Munster	46

Hard cheeses include Cheddar, Colby and Swiss cheeses and have moisture contents of 36-43 percent. Generally, hard cheeses that are to be cured or aged are manufactured to contain less moisture than mild flavored hard cheeses which may be marketed three months or less after manufacture.

HARD CHEESES
Refrigeration Optional

Variety	Max. Moisture
Cheddar	39
Colby	40
Swiss	41

Hard cheeses readily withstand short-term out-of-refrigeration display, at temperatures of 78°F or less. Good control over ambient temperature is essential, since high temperatures can result in unsightly oiling off of liquified milk fat. Good stock rotation is a must. Out-of-refrigeration display exceeding one week should be avoided.

HARD GRATING CHEESES, GRATED CHEESES
Refrigeration Unnecessary

Variety	Max. Moisture
Parmesan	32
Romano	34
Grated	(18)

The fourth group, hard grating cheeses can be displayed out of refrigeration for extended periods, as can grated cheeses. The moisture content of hard grating cheeses is 34 percent or less while the moisture content of grated cheeses is usually about 18 percent. Consistent with these low-moisture contents, such cheeses can withstand extended out-of-refrigeration display although they will exhibit oiling-off if subjected to temperature stress in excess of 80°-85°F.

Process Cheeses and Related Products

Processed cheeses and related products are manufactured by comminuting, mixing and heating blends of natural cheese and in some types, other dairy ingredients. Emulsifying salts are incorporated to impart a smooth,

homogenous body and texture. The heat treatments are sufficient to render processed cheeses microbiologically inert, although very low populations of heat resistant organisms are present in some production lots.

Pasteurized process cheeses and related products can be divided into four product groups - process cheese, cheese foods, cheese spreads, and cheese products. Process cheeses are manufactured exclusively from cheeses without any optional dairy ingredients. The moisture content of pasteurized process cheeses is limited to 1 percent greater than the maximum moisture allowed in the natural cheese or cheese blends from which they are manufactured. Pasteurized process cheese foods must have a moisture content not exceeding 44 percent, contain at least 51 percent cheese and therefore may contain up to 49 percent optional dairy ingredients. Pasteurized process cheese spreads must also contain 51 percent cheese but may exhibit a moisture content within the range 44-60 percent. Most pasteurized process cheese spreads on the market contain 52 percent moisture or less.

Pasteurized process cheese products are those products that are all dairy, are pasteurized, but do not fall within the requirements of the three standards just summarized. Presently, there is no federal standard for pasteurized process cheese products although proposals for such a standard have been filled with or proposed by FDA.

The minimum requirements for pasteurization of process cheese and similar products set forth in the Code of Federal Regulations specify heating the product to a temperature of at least 150°F for 30 seconds. This time/temperature combination would not adequately pasteurize milk. However, the same temperature has been proven effective for cheese because the pH of natural Cheddar cheese and most other natural cheeses is much lower than that of milk. Also, the emulsifying salts used in processing as well as added salt increase the level of electrolyte, thereby increasing the lethality of this heat treatment to microorganisms. Therefore, pasteurization of cheese at this time/temperature is considered adequate by FDA and other agencies.

The usual practice in the process industry is to heat the blended ingredients to a temperature substantially above 150°F, usually from 160°F to 170°F, for a period of three to five minutes. Consequently, the heat treatments used in pasteurization of cheese for the manufacture of process cheese and process cheese products are far in excess of that required to kill pathogenic organisms including Salmonella and enterotoxigenic Staphylococci. Moreover these products are packaged and sealed with heat--usually at temperatures not lower than 160°F. Such heat treatment just preceding hot filling and immediate package closure imparts a longer keeping quality than would be the case if minimum heat treatments had been applied for the destruction of pathogens.

When process cheese and process cheese products deteriorate, they do not, as a rule, exhibit microbiological spoilage. Instead, they exhibit the results of lipid oxidation. As is true with all foods containing fat, eventually there is a tendency for oxidized flavors to develop no matter how they are packaged. Cheese products that have received the kind of treatment mentioned above and that are packaged while hot in sealed plastic or glass containers have a shelf life by Kraft standards in excess of 150-270 days. Even when Kraft process cheese type products reached the ''Best when purchased by'' date stamped on the package, they are still suitable for consumption for many weeks thereafter if they have been handled in a reasonable manner.

For pasteurized process cheese and related standard products there need be no hesitation in permitting out-of-refrigeration display at temperature of 78°F or less. Proper stock rotation is again a must and although we believe that a two week display is completely safe, a one week stock turnover is recommended to sales representatives and customers.

Pasteurized process cheese products are presently not a well defined class of products. Consequently, no general recommendation can or should be made on out-of-refrigeration storage or display. However, there is no reason to conclude that they cannot be handled and displayed in a manner similar to other pasteurized process cheese types.

Concerning Mold on Cheese

Despite continuing advancement in cheese packaging technology and the use of antimycotic substances, moldy cheese continues to be a common occurance. Moldy cheese does not present a serious health hazard. The commonst cheese mold - the green or blue-green penicillia and white ''dairy mold'' are not toxin producers. In the unlikely event that mold on cheese is a toxin-producing mold, profuse growth is required before significant toxin production occurs. This remote risk can be eliminated by trimming moldy cheese to a depth of 1/3 in. below the deepest mold growth penetration. This recommendation does not, of course, apply to mold ripened cheeses such as Blue, Gorgonzola, Roquefort and Stilton.

Mold growth under refrigerated conditions presents no known health risk. Common toxigenic molds cannot grow well, if at all, at refrigerated temperatures. The scientific literature records no instance whatsoever wherein growth of toxigenic molds on cheese under refrigerated conditions resulted in toxin production.

Definition of ''Potentially Hazardous Food''

A definition that has caused considerable confusion and misunderstanding in the evaluation of out-of-refrigeration display of cheeses and other foods is that contained in the 1976 FDA Food Service Sanitation Manual for ''Potentially Hazardous Food.''

> ''Potentially Hazardous Foods'' means any food that consists in whole or in part of milk or milk products, eggs, meat, poultry, fish, shellfish, edible crustacea, or other ingredients, including synthetic ingredients, in a form capable of supporting rapid and progressive growth of infectious or toxigenic microorganisms. The term does not include clean, whole, uncracked, odor-free shell eggs or foods which have a pH level of 4.6

or below or a water activity (a_w) value of 0.85 or less."

We believe that natural cheese, properly manufactured via a vigorously controlled lactic fermentation is *not* "in a form capable of supporting rapid and progressive growth of infectious or toxigenic microorganisms." Similarly, pasteurized process cheese and related products that have been subjected to the pasteurization conditions previously described and which have been hot filled and sealed are *not* "in a form capable of supporting rapid and progressive growth of infectious or toxigenic microorganisms."

It is important, of course, that both types of products be in the original, sealed, package. Accordingly, an appropriate legend on the package such as "Refrigerate after opening", is recommended even though the surface of cheeses are not a particularly hospitable environment for pathogens.

Conclusion

Whether or not any cheese should be refrigerated depends upon moisture content and cheese type. Pasteurized process cheeses and related standardized products readily withstand out-of-refrigeration conditions. Natural cheeses may not require refrigeration if they contain a relatively low proportion of moisture. Soft or semi-soft cheese must be refrigerated whether or not they are in intact packages. Hard or hard grating cheeses need not be refrigerated but should not be subjected to temperature stress which could cause oiling off. Open packages of any cheese should be refrigerated. Mold on cheese presents little or no health risk, but moldy cheese should be trimmed and the trimmings discarded.

The definition for "Potentially Hazardous Food" doesn't offer clear guidance on whether to refrigerate cheeses. The definition requires adequate knowledge and proper interpretation of what constitutes those conditions which will support the growth of pathogens and information on whether contamination with pathogenic microorganisms has or may have occurred.

PROCESS CHEESES AND RELATED PRODUCTS
Refrigeration optional, except for cheese products for which no general recommendations can presently be made.

Type	Max. Moisture
Pasteurize Process:	
Cheese	40-42
Cheese Food	44
Cheese Spread	60 (44 minimum)
Cheese Product	(60) ?

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Dr. H. Fernandez
Santiago, Chile

Dairy and Food Sanitation, Vol. 3, No. 10, Pages 376-385 (October 1983)
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DAIRY FARM PRACTICES AND THEIR EFFECT ON PRELIMINARY INCUBATION COUNTS

C. A. GOTTEMOLLER
Environmental Systems Service, Ltd.
5111 College Ave.
PO Box 220
College Park, MD 20740

FINAL DAIRY FARM REPORT

On September 28th and October 19th, 1982, two farm visits were made by the personnel from Maryland Virginia Milk Producers Association and ESS Laboratories. The purpose of this study was to strengthen existing data and conclusions that were obtained from the previous two farm visits.

In the second report, a summary was completed in reference to the first two farm visits. All farms up to this point in the study had Preliminary Incubation problems. The results of the study indicate:

1) the rubber and/or plastic hoses were a major source of bacterial contamination and were directly linked to the Preliminary Incubation count,
2) the gaskets, in conjunction with the milker claws, take-off sensors, and weigh jars, had added significantly to the bacterial load of the milk when these parts were not cleaned or replaced,
3) the drivers' procedures in the handling of the samples were not proper and correct, since the Standard Plate and the Preliminary Incubation counts of the driver samples did increase considerably,
4) thorough preparation of the cows before milking (iodine wash and dry) dramatically decreased the bacterial load entering the milking system.

Though the above statements were deduced validly from the data gathered, additional information was needed to support these conclusions. All facets had to be taken into consideration in order to verify the findings of this Preliminary Incubation study.

On September 28th (third trip), visits were made to two farms that did not have a past history of Preliminary Incubation problems. It should be noted that, unlike the farms involved during the previous trips, the farms on this trip had their milking operation in a barn rather than a parlor. The fourth trip on October 19th was made to two farms in which the preparation of the cow was the only aspect explored. The goals of the visits were to: 1) find which areas in the milking operation had similarities and/or differences in bacterial load contamination in comparison to the previous farms studied, and 2) to further investigate the relationship between cow preparation and Preliminary Incubation count (PI). The data may be found at the conclusion of this report for both the third and fourth trip, respectively. Also, the results and reports prior to the third and fourth trip are included.

The results from the third visit indicated that there were similarities and differences between farms with PI prob-

lems and those that did not have PI difficulties. Though the farms differed in their milking systems, there were some common points of bacterial contamination. In the analysis of equipment, the plastic hoses and milker claws were found to have bacterial plate counts comparable to those at the farms in the first two studies. Contrary to belief, the cow teat samples showed similar bacterial loads, even though outstanding techniques for preparation were used on the farms in the third visit. The difference in the farms was that of the milking system. Certain equipment was not present in the operations to take samples in the third trip, such as the gaskets, weigh jars, and take-off sensors. It is believed that these areas, especially the gaskets, are the major sources of bacterial contamination where the PI is concerned. The equipment in the barns generally does not have as much contact surface area as the parlors, thus there are less cracks and crevices where bacterial build-up can occur.

On the fourth visit, the samples for the preparation of the cow did show the importance of this step in the milking process. On most of the cows, the bacterial plate count decreased after being washed and dried. It should be noted that all the counts were reduced further after milking. This does emphasize the need to properly prepare the udder before milking by thorough cleaning and drying. The teats are believed to be a major source of entry for organisms associated with the PI, although the PI counts for these samples did not increase dramatically. This was probably due to the fact that these organisms do not start to grow rapidly until they are in an enrichment medium, (i.e. milk). The sterile water for these swab samples did not contain any nutrients for these organisms to feed upon, thus growth was limited.

In conclusion, the trouble spots in the milking operation seem to be in the cracks and crevices, as well as in the parts that wear down after use (i.e. gaskets, rubber hoses). Manual cleaning and periodic replacement of the equipment can be the key in decreasing PI problems. Proper cow preparation is essential to limit the amount of bacterial load entering the system to reduce the chance of bacterial build-up.

DAIRY FARM REPORT

On July 23, 1982, a representative of the laboratory was given the opportunity to visit four MVMPA producers to assist the fieldman. Each dairy farmer was currently having a problem with the PI analysis. The purpose of this joint venture was to generalize the bacterial contamination areas in each operation. For the basis of this report, the farms have been referred to as A, B, C, and D.

In the program, bacterial contamination was studied from two aspects: 1) direct sources, and 2) indirect sources. Samples were collected by two methods: 1) the grab sample - Table 4, and 2) the swab technique - Table 5.

The results indicate that the problem with each operation is in the equipment. Outside sources of contamination such as the well water or the dipper do not seem to add significantly to the bacterial load of the system. The build-up of milk on the gaskets, threads, hoses, claws, and weigh jars does show that a high bacterial content is present even after sanitizing. Manual cleaning of these parts is recommended since the CIP systems do not have enough agitation to lift milk particles from the cracks in the operation. Further tests before and after manual cleaning would verify the relationship to the PI count.

TABLE 1. *Swab samples.*

Sample identification	Farm	Bacterial plate count
One teat after wash and dry - Cow #1	F	490/ml
One teat after milking - Cow #1	F	75/ml
Cow teat before washing (very dirty) Cow #2	F	32,000/ml
Cow teat after washing but before drying - Cow #2	F	18,000/ml
Cow teat after wash and dry - Cow #2	F	16,000/ml
Cow teat after milking - Cow #2	F	230/ml
Washer manifold cups (dairy type)	F	7/ml
Teat ends only	F	440/ml
Inflations after milking	F	340/ml
Milker's hand - male	F	5,800/ml
Milker's hand - male	F	47,000/ml
Inflations	F*	1/ml
Plastic milker hose	F*	>5,900/ml
Plastic milker hose	F*	>5,900/ml
Milker claws without threads	F*	410/ml
Milker claws with threads	F*	1,600/ml
Swingline	F*	5,500/ml
Glass pipeline	F*	1,300/ml
Control	G	1/ml
Inflations	G	3/ml
Rubber milk hose	G	28/ml
Plastic milk hose	G	>5,900/ml
Milker claw	G	41/ml
One teat after wash and dry - Cow #3	G	33/ml
One teat after milking - Cow #3	G	13/ml
One Teat before wash (very dirty) Cow #4	G	45,000/ml
One teat after washing only - Cow #4	G	30,000/ml
One teat after wash and dry - Cow #4	G	1,500/ml
Teat ends only	G	46/ml

* - The swab samples were taken after the morning milking, thus the equipment had been cold water rinsed, washed with a hot detergent solution, then rinsed with an acid solution, but not sanitized.

NOTE: It should be noted that Farm F uses a common rag to wash the cows and an individual paper towel to dry while Farm G uses an individual towel to both wash and dry the cows.

TABLE 2. *Grab samples*.

Sample identification	Farm	Bacterial plate count	PI	Coliforms
Tank sample - Day #1	F*	e300/ml	<1,000/ml	
Tank sample - Day #2	F*	e100/ml	<1,000/ml	
Tank sample - Day #3	F*	e400/ml	<1,000/ml	
Filter sock	F	900/sock		
Udder iodine wash after 10 cows	F	3,000/ml		
Well water	F	360/ml		
Teat dip	F	<1/ml		<1/ml
Iodine solution (fresh)	F	450/ml		
Tank sample - Day #1	G	e400/ml	1,000/ml	
Tank sample - Day #2	G	e200/ml	<1,000/ml	
Tank sample - Day #3	G	e300/ml	<1,000/ml	
Teat dip	G	<1/ml		<1/ml
Well water	G	7,000/ml		
Iodine solution (wash)	G	140/ml		
Iodine solution (claws)	G	30/ml		
Tank sample brought thru hauler	F**	7,400/ml	190,000/ml	
Tank sample brought thru hauler	G	e300/ml	1,000/ml	

* - Sample was taken after two milkings.
** - Sample was taken after four milkings.
e - Estimated.

TABLE 3.

Sample identification	Teat before wash		Teat after wash		Teat after dry		Teat after milking	
	SPC	PI	SPC	PI	SPC	PI	SPC	PI
Cow #1	12,000	31,000	3,400	2,400	4,700	6,000	3,100	3,400
Cow #2	600	1,000	100	400	1,400	1,400	190	6,700
Cow #3 (hair needs clipping)	2,900	<1,000	6,400	1,700	770	1,200	420	600
Cow #4 (very dirty)	26,000	>590,000	35,000	69,000	44,000	43,000	6,000	8,600
Cow #5	9,000	32,000	300	300	240	300	55	300
Cow #6	7,200	6,000	100	200	34	100	52	400

NOTE: All of the above plate counts are recorded as Colony Forming Units per milliliter.

DAIRY FARM REPORT

On August 19th and 20th, ESS Laboratories assisted the MVMPA field personnel in visiting five dairy farms where both grab and swab samples were collected. Four of these dairy farms had been analyzed previously in order to generalize the area(s) on each farm where the origin of the Preliminary Incubation problem may be found.

The first trip to the farms provided the necessary information to eliminate certain facets in the dairy parlor and, therefore, allowed the personnel to concentrate on key areas. The milking equipment, excluding the tank, and the preparation of the cow for milking were the major sampling points. Outside sources such as the paper towels, the well water, and the sample dipper were not retested except on farm E (first visit).

For the milking equipment, swab samples were taken at various points in the operation, from the inflations to the swing line (and to the tank on farm E). It should be noted that if the bacterial plate counts of the swab sample are in excess of five bacteria (colonies) per milliliter (ml), it indicates unsatisfactory sanitary conditions. The guideline holds true only for the milking equipment, not the swab samples taken from the cow. The unsatisfactory sanitary conditions exist in the milking equipment.

The major source of bacterial contamination seems to stem from the plastic and/or rubber hoses. The PI count problem is strongly suspected to be linked to both types of hoses. The data from swab samples taken from two different farms support the statement. The genus, *Pseudomonas,* was suspected to be present in the plastic hoses (farm B) and the rubber hoses (farm D). Pseudomonas is not a type of bacteria normally found in the interior of the cow udder; rather, it is an organism associated with unsanitary conditions. The greenish fluorescent pigment observed on the petri dishes strongly indicates its presence.

TABLE 4. *Grab sample.*

Sample source	Farm	Plate count (CFU/ml)
Well water	A	<1
Dip water with chlorine - fresh	A	<1
Dip water with chlorine - old	A	<1
Fresh iodine solution before warm water	A	43
Fresh iodine solution after warm water	A	8
Tank milk sample	A	6,800 PI - 30,000
Paper towel in dispenser	A	<100
Well water	B	380
Paper towel without dispenser	B	500
Well water	C	<1
Tank milk sample	C	3,900 PI - e2,000
Filter sock	C	3,600
Well water	D	790
Dip water with chlorine - fresh	D	<1
Dip water with chlorine - old	D	<1
Equip. sanitized water before cleaning	D	<1
Equip. sanitized water after cleaning	D	<1
Iodine solution after milking 12 cows	D	20,000
Tank milk sample	D	e1,500 PI - e1,000
Fresh iodine solution in bucket	B	5
Fresh iodine solution in bucket	C	4

e - Estimated.

TABLE 5. *Swab sample.*

Sample source	Farm	Plate count (CFU/ml)
Flow meter	A	27,000
Claw	A	>590,000
Claw gaskets	A	>590,000
Pump and swing lines	A	21,000
Inside tank	A	15
Iodine bucket and sponge	B	18,000
Weigh jar and claw	B	>590,000
Gaskets on weigh jar	B	>590,000
Plastic bag	B	14
Inside tank	B	220
Claws	C	>590,000
Claw threads	C	>590,000
Inside rubber hoses	C	>590,000
Gaskets and threads of claw	C	>590,000
Gaskets and threads of claw	D	>590,000
Vacuum trap	D	6,600
Hoses and weigh jar	D	600,000
Cow teats after water wash	D	12,000
Cow teats after iodine wash	D	20,000
Cow teats after drying	D	4,800

>-Greater than.

To further emphasize the plastic/rubber hose role in bacterial contamination, an experiment was completed on farm A. This particular dairy was in the process of replacing the rubber tubing in the parlor. The rubber hoses that were thrown out had a plate count of 300,000/ml. When this figure is compared to the new rubber tubing after two milkings (and sanitizing), the plate count was 600/ml. The dramatic drop does support the fact that the hoses develop cracks where organisms are allowed to flourish. Sanitizing will only reduce the bacterial load on the surface but the CIP systems do not have enough agitation to "lift" or remove the buildup in the crevices. Both types of hoses have the tendency to create these cracks after "wear and tear". For the plastic hoses, this condition is hard to detect and determine when to change the tubing. On the other hand, the condition of the rubber hoses can be readily recognized by taking a knife and scraping the inside of the hose. If the interior is coarse and rough, the tubing needs to be replaced.

The second source of bacterial contamination in the milking equipment seems to be in the milker claws, the take-off sensors, and the weigh jars. Four farms, A, B, C, and D all exhibited plate counts in excess of five colonies per milliliter in most of these areas (depending on dairy system). It is possible to reduce the bacterial load in the dairy system and to have a plate count close to the 5/ml limit in these areas, as shown in farm B and C. The take-off sensors in farm B had a plate count of 8/ml and farm C had a plate count of 1/ml (with the gasket, the plate count was 48/ml). Manual cleaning and periodic replacing of the gaskets can be attributed to these low bacterial counts. Manual cleaning helps to remove the milk (bacterial) build-up in the areas where it is difficult to properly clean and sanitize with the CIP systems. Replacement of the gaskets is as essential as changing the plastic/rubber hoses. The gaskets have the same tendency to develop crevices.

It should be noted that farm E does not have the bacterial contamination in the above mentioned areas of the milking equipment. However, farm E's tank is the site for the buildup problem. The plate count of 10,000/ml and >590,000/ml are extremely high when compared to farm A which had a plate count of 15/ml (first report and data).

In reference to the preparation of the cow for milking, the laboratory data revealed that this is an important first step in the milking process to reduce the bacterial load. On farm B, an experiment was completed to emphasize the

statement. One teat before washing had a plate count of 71,000/ml. After the iodine wash, this same count dropped to 1,100/ml and was further reduced to 150/ml after drying. Not only is it essential to wash the cow with a santizing solution, but it is equally imperative to dry the cow teats thoroughly. To support the drying of the cow, two swab samples were taken from cows that had not been dried off completely. One plate count was 7,800/ml (farm A) and the other was 7,300/ml (farm D).

Three tank samples were taken at each of the dairy farms (except farm E) so that comparisons could be made as to whether the SPC and the PI count were affected by the age of the milk. The laboratory results indicated that there was no significant change in either counts after one, two or three days. There was a significant difference between the samples hand carried to the laboratory and those sent to the laboratory through the hauler; however, it should be noted that the hand carried sample represented two milkings and the hauler sample four milkings. While the SPC remained consistent in both the hand carried and the hauler sample, the PI was not. In farm samples A and B, there was a dramatic increase in the PI from the hauler sample. Farm A went from an average PI of 3,100/ml to >590,000/ml and farm B went from an average of 19,000/ml to >590,000/ml. These results do raise the question as to the proper sampling procedures. A slight rise in temperature would greatly affect the Preliminary Incubation count. Normal milk refrigeration temperatures range from 37°F to 42°F. An increase of 5°F would bring the milk samples closer to the optimal temperature (55°F) for organisms associated with the PI.

In conclusion the data reveals that there are key areas that may affect the Preliminary Incubation count. There are four points in the milking operation that require periodic monitoring. They are: 1) the plastic/rubber hoses, 2) the milker claws and gaskets, 3) the take-off sensors, and 4) the weigh jars. These are the areas in the operation where bacteria seem to thrive if they are not cleaned/replaced. The preparation of the cow for milking was not directly linked to the PI count; however, reducing the bacterial load can help in maintaining sanitary milking equipment. Since the organisms associated with the PI count are naturally found in the environment, the cow teats may serve as a good source in introducing these organisms inside the

TABLE 6. *Swab samples.*

Sample identification	Farm	Bacterial plate count
Milker claws and gaskets	A	>5,900/ml
Synthetic inflations	A	<1/ml
New rubber hose (never used)	A	20,000/ml
Milk tubes	A	>5,900/ml
Weigh meters rinsed with acid	A	530/ml
Pulsator air hoses	A	>5,900/ml
Plastic milk hoses	A	>5,900/ml
Stainless steel swing line	A	3,500/ml
Rubber hose (new/used in 2 milkings)	A	600/ml
Rubber hose (old/thrown away)	A	300,000/ml
Milk equipment after sanitizing	A	63/ml
Teat ends (after washing and drying, but not stripping)	A	65/ml
Teat ends (after washing, drying, and stripping)	A	2,400/ml
Teat ends with a water drip	A	7,800/ml
Teats after milking	A	14,000/ml
Milker's hands - female	A	33,000/ml
Milker claws and claw threads	B	>5,900/ml
Take off sensors and cap area	B	8/ml
Inflations	B	1/ml
Black rubber hoses	B	350,000/ml
Weigh jar	B	>5,900/ml
Weigh jar fittings	B	>5,900/ml
Plastic hose	B	>5,900/ml*
Vacuum lines	B	>5,900/ml
Teats after wash and dry Cow #1	B	45/ml
Teats after milking Cow #1	B	62/ml
Left front teat before washing Cow #2	B	71,000/ml
Left front teat after iodine rag wash Cow #2	B	1,100/ml
Left front teat after drying Cow #2	B	150/ml
Milker's hands - male	B	2,200/ml
Milker's hands - male	B	60/ml
Teat ends	B	120/ml
Milker claws	C	>5,900/ml
Take off sensors and gaskets	C	48/ml
Inflations	C	1/ml
Rubber hose (one end)	C	630/ml
Take off sensor without gasket	C	1/ml
Low line	C	1,200/ml
Swing line	C	270/ml
Teats after washing - Cow #2	C	980/ml
Milker's right hand - male	C	260/ml
Milker's left hand - male	C	1,300/ml
Teats after milking Cow #3	C	160/ml
Teat ends (very dirty - after wash and dry)	C	26,000/ml
Teat dip solution	C	<1/ml
One inflation after milking	C	550/ml
Iodine wash solution after milking 35-40 cows	C	65/ml**
Milker claws	D	1,400/ml
Inflations	D	2/ml
Take off sensors	D	>5,900/ml
Weigh jars	D	>5,900/ml
Weigh jar fittings	D	>590,000/ml
Rubber hoses	D	>590,000/ml*
Teats after washing (cow was very dirty to begin with)	D	2,100/ml
Glass pipeline	D	2/ml
Plastic hose	D	>5,900/ml
Water puddle around teat in the inflation	D	7,300/ml
Hand - male - holds the hose	D	1,400/ml
Hand - male - washes the teats	D	1,700/ml
Teat ends	D	720/ml
Hands - male	D	330/ml
Swab water control	D	<1/ml
Teats after water wash and dry	E	3,900/ml

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Seventy-First Annual Meeting of IAMFES

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Aug. 5-9, 1984

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Teats after milking	E	1,600/ml
Inflations after milking	E	1,600/ml
Rubber air hose	E	41/ml
Sample dipper	E	<1/ml
Inside tank	E	10,000/ml
Drain	E	<1/ml
Inflations after sanitizing	E	3/ml
Swing line	E	27/ml
Tank lid inside (where swing line comes in)	E	>590,000/ml

>-greater than.
*-*Pseudomonas* suspected due to greenish color on agar in petri dish.
**-Grab and swab sample from same container; difference in count is due to sample collection technique.

milking system. If these bacteria are at a reduced state on the outside of the cow teats, the farmer can be assured that a low number of these organisms will be finding their way into the system during milking.

TABLE 7. *Grab samples*.

Sample identification	Farm	Bacterial plate count	P.I.
Tank sample #1 - one day	A	e2,800/ml	2,300/ml
Tank sample #2 - two days	A	e1,100/ml	3,000/ml
Tank sample #3 - three days	A	e1,300/ml	4,000/ml
Dip solution	A	23/ml	
Tank sample #1 - one day	B	e1,500/ml	10,000/ml
Tank sample #2 - two days	B	3,200/ml	8,000/ml
Tank sample #3 - three days	B	e600/ml	39,000/ml
Milk from cow #4	B	36/ml	e100/ml
Milk from cow #4 - weigh jar	B	300/ml	e100/ml
Milk from cow #4 - receiver	B	420/ml	e600/ml
Rag	B	22,000/rag	
Iodine solution after 10 cows	B	40,000/ml	
Tank sample #1 - one day	C	4,200/ml	6,000/ml
Tank sample #2 - two days	C	2,200/ml	4,000/ml
Tank sample #3 - three days	C	3,900/ml	5,000/ml
Tank sample #1 - one day	D	180,000/ml	>590,000/ml
Tank sample #2 - two days	D	190,000/ml	>590,000/ml
Tank sample #3 - three days	D	220,000/ml	>590,000/ml
Milk from cow #5	D	930/ml	17,000/ml
Milk from cow #5 - weigh jar	D	3,000/ml	17,000/ml
Milk from cow #5 - receiver	D	3,200/ml	7,000/ml
Iodine solution after 4-8 cows	D	8,500/ml	
Rag	D	11,000/rag	
Iodine solution after 35-40 cows	C	7,000/ml**	
Tank sample #1 - one day	E	30,000/ml	140,000/ml
Water from washing hose	E	>5,900/ml	
Tank sample brought thru hauler	A	e2,200/ml	>590,000/ml
Tank sample brought thru hauler	B	e1,400/ml	>590,000/ml
Tank sample brought thru hauler	C	3,300/ml	18,000/ml
Tank sample brought thru hauler special tag	D	100,000/ml	>590,000/ml
Tank sample brought thru hauler	D	130,000/ml	>590,000/ml

e - estimated.
> - greater than.
** - Grab and swab sample from same container; difference in count is due to sample collection technique.

Dairy Quality

Capsule Laboratories Newsletter, Dairy Quality Update, St. Paul, MN.

IDENTIFYING SOURCES OF POST-PASTEURIZATION CONTAMINATION -- PART II THE USE OF RAPID METHODS OF ENUMERATING PSYCHROTROPHIC BACTERIA

A previous DAIRY QUALITY UPDATE pointed out that the initial Standard Plate Count (SPC) has its limitations in reflecting microbiological quality of fluid milk. This newsletter also pointed out that the initial SPC has its limitations when used in analyzing line samples for identifying post-pasteurization contamination. It pointed out that when the SPC is used for analyzing lines analyses, the samples must be incubated at 45 F for 5-7 days before useful data can be generated; therefore, this procedure has the disadvantage of taking 7-9 days before data can be generated.

Obviously when serious contamination is being experienced, a 7-9 day delay in obtaining results is a problem. Therefore, various rapid methods have been proposed to determine the microbiological quality of fluid milk and sources of post-pasteurization contamination. Many of these procedures are based on the fact that gram negative bacteria are very heat sensitive, and when found in pasteurized milk are due to post-pasteurization contamination. Many of these methods use inhibitory agents to inhibit gram positive bacteria and allow the growth of gram negative bacteria. Agents used to inhibit gram positive bacteria include surfactants, dyes, and antibiotics. Smith and Witter (*8*) evaluated 17 gram positive inhibitory agents and found crystal violet at 2 mg/l and neotetrazolium chloride at 2 mg/l to be the most effective in inhibiting gram positive bacteria and not affecting the growth of gram negative bacteria.

Another method for analyzing gram negative bacteria in pasteurized milk was proposed by Hankin and Dillman (*2*). This procedure involved the flooding of SPC plates with a solution of a-naphthol and p-aminodimethylaniline oxalate. Those colonies containing the enzyme cytochrome oxidase appeared blue in color. This test is a good indicator of *Pseudomonas* sp. in pasteurized milk. *Pseudomonas* sp. are common post-pasteurization fluid milk contaminants.

Other rapid methods of screening milk for psychrotrophic bacteria involve the use of electrical impedance (*1*) and automated pyruvate (*3*) methods. The electrical impedance method involves noting the time required to bring about changes in the media brought about by microbial metabolism and growth. This test is useful when initial levels of 10,000 organisms/ml are found in fluid milk. A similar situation exists with the automated pyruvate method. This method measures the change in pyruvate acid in milk due to microbial metabolism. Again, this test is only positive at concentrations of 1,000 to 10,000 organisms per ml. Because of the high levels of contamination required, both the automated pyruvate and electrical impedance methods may be more significant in determining raw milk microbiological quality.

Other methods used as rapid enumerators of psychrotrophic bacteria include...attempts to accelerate colony formation by surface inoculations and/or by pre-incubation of plates at higher temperatures and finishing the incubation at lower temperatures (*4,7*). There is disagreement on the effectiveness of these methods, however, these tests have been used successfully in determining raw milk quality.

In 1976, Oliveria and Parmelee (*5*) reported a plating method to enumerate psychrotrophic bacteria in raw and pasteurized milk. This test used the Standard Methods Agar and an incubation temperature of 21 C for 25 hours. Their work found that in 190 pasteurized milk samples, a correlation coefficient of r=0.996 was obtained between this rapid method and standard psychrotrophic counts. However, from this study only 58 of the 190 samples were fresh products and only 38 of the 58 samples were commercially pasteurized products. All of these samples showed psychrotrophic counts greater than 10 per ml, therefore, the sensitivity of this test at the lower levels of post-pasteurization contamination may be questioned.

Violet Red Bile (VRB) agar is used extensively in the dairy industry for enumeration of coliforms in milk and milk products (*4*). VRB agar will permit the outgrowth of gram negative coli-aerogenes type bacteria and will inhibit the growth of gram positive bacteria as well as other gram negative bacteria. However, it should be pointed out that when conducting line analyses, the presence of coliforms and atypical colonies on VRB plates would indicate post-pasteurization contamination. The absence of organisms on VRB plates, however, would not indicate the freedom from post-pasteurization contamination.

Dye reduction tests have been used in the dairy industry for many years as quality indicators. Parmelee (*6*) has used a combination of resazurin and sodium desoxycholate (a gram positive inhibitor). Parmelee suggested that the test is more rigorous than a coliform count and the test is completed in 16 hours. This test, however, will only indicate those psychrotrophs that will reduce resazurin.

While several rapid methods have been proposed, none have received wide acceptance. The primary reason for this is that none of these procedures are reliable when low levels of post-process contamination (i.e. contamination level less than 1/ml) exist. Secondly, many of these tests are selective for specific organisms and, therefore, do not reflect the total microbiological quality of a fluid milk product. Capsule Laboratories does not propose the use of rapid methods in determining fluid milk quality, however,

several of these tests may be useful for obtaining rapid information and determining sources of post-pasteurization contamination. Also, when using rapid methods one must keep in mind the limitations of these tests.

(1) Cady, P., et al. 1978. Automated impedance measurements for rapid screening of milk microbial content. J. Food Protection. 41:277-283.

(2) Hankin, L., and W. F. Dillman. 1968. A rapid test to find "potentially" psychrophilic organisms in pasteurized dairy products. J. Milk Food Technol. 31:141-145.

(3) Marshall, R. T., and C. C. Harmon. 1978. The automated pyruvate method as a quality test for Grade A milk. J. Food Protection. 41:168-177.

(4) Marth, E. H. 1978. *Standard Methods for the Examination of Dairy Products*. 14th Edition. American Public Health Association, Washington, D.C.

(5) Oliveria, J. S., and C. E. Parmelee. 1976. Rapid enumeration of psychrotrophic bacteria in raw and pasteurized milk. J. Milk Food Technol. 39:269-272.

(6) Parmelee, C. E. 1974. Early detection of psychrotrophs in pasteurized milk. Dairy and Ice Cream Field.

(7) Punch, J. D., and J. C. Olson, Jr. 1964. Comparison between standard methods procedure and a surface plate method for estimating psychrophilic bacteria in milk. J. Milk Food Technol. 27:43-47.

(8) Smith, T. L., and L. D. Witter. 1979. Evaluation of inhibitors for rapid enumeration of psychrotrophic bacteria. J. Food Protection. 42:158-160.

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Thanks from the Missouri Milk, Food and Environmental Health Assn.

Dear Kathy:

I would like to acknowledge and thank everyone for the compliments we all received during the recent 70th Annual Meeting of the Association in St. Louis, Missouri. We certainly feel the meeting was successful and enjoyable because the compliments sounded as if they were truly sincere.

Please publish this letter along with the enclosed copy of my letter to the many members and friends of the Missouri Milk, Food and Environmental Health Association who worked so hard before and during the meeting.

Also, please publish the enclosed list of contributors. It is submitted with my extreme apology to anyone missed. The placard posted during the meeting and the banquet program might have omitted some last minute benefactors but I'm quite sure this list is complete. The people and companies listed all are extended our sincere gratitude.

Very truly yours,
John C. Schilling, Chairman
Local Arrangements Committee

Dear...

Each of us who assisted in hosting the recent 70th Annual Meeting of the International Association of Milk, Food and Environmental Sanitarians have reason to be extremely proud. From all indications it was an outstanding success. Each of you were instrumental in the success through your devotion of personal time and effort.

Unfortunately in situations such as this one person gets most of the plaudits and comments. Please be assured that whenever I had the opportunity to publicly and privately say so, I let it be known that putting on a meeting such as the one just completed is not a one man job. I am well aware of how much so many other people helped and I will make every effort to let each of you know on an individual basis.

Sincere appreciation and many, many thanks.

Very truly yours,
John C. Schilling, Chairman
Local Arrangements Committee

LIST OF CONTRIBUTORS

IAMFES and the Missouri Milk, Food and Environmental Health Association gratefully acknowledge the generous support of the following organizations:

Abbey Winery
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News and Events

Newly Elected IAMFES Secretary-Treasurer, Leon Townsend, Expresses Thanks

My selection as the 1983-84 IAMFES Secretary-Treasurer was indeed a humbling and gratifying experience.

When one contemplates the stature of those who are presently serving on the Executive Board and the Past Presidents of the association, I can't keep from wondering if I deserve this honor.

I do express my sincere appreciation to the 1982 nominations committee for selecting me as a candidate and to all who supported me in my election.

I look forward to serving you, to the best of my ability, as a member of the Executive Board for the next several years. You have an outstanding group of officers, editors of our two publications, and Executive Secretary. The association is financially sound and I believe much will be accomplished in the future.

Ideas and suggestions as to ways the Executive Board and the Association may better serve you as a member will be appreciated.

Candidates sought for 1984 Harold Macy Award

The Minnesota Section of IFT is seeking nominations for suitable candidates from all IFT sections for the 1984 Harold Macy Food Science and Technology Award.

The award, which was established in 1981, is to be given annually for an outstanding example of food technology transfer or cooperation between scientists or technologists in any two of the following settings: academic, government, and private industry. The purpose of the award is to advance the profession and practive of food technology and to honor Harold Macy, dean emeritus of the University of Minnesota and a founding member of IFT. Awardees will be invited to address the Minnesota Section. The award consits of a $500 honorarium and travel expenses.

Nominations for the award should be made on an appropriate form and are due by December 15, 1983. Nomination forms are available from Dr. Larry McKay, Chairperson, Macy Award Committee, Department of Food Science and Nutrition, University of Minnesota, 1334 Eckles Avenue, St. Paul, MN 55108.

Nominations for '84 Awards Now Due

Awards nominations are due for the 1984 IAMFES Awards. The success of the IAMFES Awards Program depends on organizations which generously and regularly fund the program, but also on you, for nominating persons you know who are worthy of the awards.

Contact Harry Haverland, State Training Branch, FDA, 550 Main St., Room 8002, FOB, Cincinnati, OH 45202 with information on your nominees. Present Executive Board members are not eligible for the 1984 awards.

The awards are as follows:

*Sanitarian's Award. This is a $1000 award presented to any Sanitarian who has made outstanding professional contributions during the past seven years.

*Harold Barnum Award. This $500 award will go to an industry representative in 1984. It is presented to a person who has shown outstanding service to food safety and sanitation.

*Educator Award. This $1000 award will be presented to an educator. It is presented to a person who has shown outstanding service to food safety and sanitation.

*Citation Award. This award will be presented to an IAMFES member who has given outstanding service to the Association in helping fulfill its objectives.

*Shogren Award. This award will go to the affiliate organization with the best state or regional program.

*Honorary Life Membership. This is presented to a member who has shown long and outstanding service to IAMFES.

*Certificate of Merit. This is presented to members who are active within their state and international group.

IAMFES Secretary-Treasurer Nominations Due

Nominations are open for the IAMFES Secretary-Treasurer. This year an academic representative will be elected.

Send a biographical sketch and photograph of your nominee to the Nominating Committee as soon as possible, but no later than November 8, 1983.

Send the information to: Erwin Gadd, Nominating Committee, IAMFES, 2700 Garden View, Jefferson City, MO 65101.

Abstracts of Papers Presented at the Seventieth Annual Meeting of the IAMFES

St. Louis, Missouri, August 7-11, 1983

Abstracts of most papers given at the 70th Annual Meeting of the IAMFES appear on this and the following pages. The complete text of many of these papers will appear in future issues of the Journal of Food Protection and Dairy and Food Sanitation.

CONTRIBUTED PAPERS

Aerobic Versus Anaerobic Incubation for Recovery of Salmonella. J. S. Bailey, J. O. Reagan, N. A. Cox and J. E. Thomson. *Richard B. Russell Research Center, USDA-ARS, PO Box 5677, Athens, GA.*

The effect of aerobic and anaerobic incubation of selenite cystine and TT enrichment broth incubated at 37 and 43°C on the growth rate of four *Salmonella* serotypes (*S. typhimurium, S. montevideo, S. johannesburg, S. newington*) were determined both in pure cultures and in the presence of extraneous organisms. The solid differential plating media (brilliant green sulfa and bismuth sulfite agar) were also incubated aerobically and anaerobically at 37 and 43°C. There were no significant differences in the recovery rate of *Salmonella* when the liquid enrichment media were incubated aerobically or anaerobically at 37 or 43°C. The solid differential plating media, anaerobic incubation resulted in less *Salmonella* recovery. In addition to offering no advantage from the standpoint of *Salmonella* recovery, anaerobic culturing is much more troublesome and time consuming.

Evaluation of a New Miniaturized System, Spectrum-10, for Identification of *Enterobacteriacea*. J. S. Bailey, N. A. Cox and J. E. Thomson. *Richard B. Russell Agricultural Research Center, USDA-ARS, PO Box 5677, Athens, GA.*

A total of 136 cultures of *Enterobacteriaceae* representing 12 genera obtained from clinical and food sources was examined. The 36 clinical and 20 of the food isolates were previously identified organisms. The other 80 organisms from food were fresh isolates from raw oysters, pork sausage, ground beef and onions. Each culture was inoculated into a new system (Spectrum-10) and two other miniaturized identification systems (API-20E and Micro-ID), the accuracy of which had been previously documented. API and Micro-ID were in agreement for identification of all 136 cultures and were, therefore, used as the standard for comparison to determine the accuracy of Spectrum-10. The Spectrum-10 accurately identified 92% of the clinical isolates to species and 91% of the food isolates to genus and 72% to species. The lower accuracy of species identification was due to a false positive lysine reaction. The Spectrum-10 accurately identified 97% of the salmonellae tested. The predominant organism encountered in each food was *Hafnia alvei* (oysters), *Escherichia coli* (pork sausage), *Enterobacter agglomerans* (ground beef) and *Enterobacter cloacae* (onions).

Bacterial Quality of Store-Purchased Milk Samples. Sidney E. Barnard and Cecelia E. Putman. *Food Science Department, The Pennsylvania State University, 9 Borland Lab, University Park, PA 16802.*

A total of 1,720 fluid milk samples were purchased from stores in Pennsylvania during 1982 as part of a continuing program. They were transported in iced, insulated cases and tested within 48 h. Milk temperature was 40°F or less in more than 50% of the stores, but over 45°F in almost 10% of the stores. The average age of open-dated samples was about 7 d at the time of testing. Samples represented 103 dealers and 110 juggers. More than 73% of the samples had <1 coliform/ml, while only 14% had more than 10 coliforms/ml. More than 81% of the Standard Plate Count were less than 5,000/ml, while less than 10% were above 20,000/ml. Results were sent to processors with the general comment that most milk in stores is of good to excellent bacterial quality. Processors should aim for bacterial counts of <1 coliform and <5,000 Standard Plate Count/ml for samples held at 45°F for up to 10 d.

Flavor of Store-Purchased Milk Samples. Sidney E. Barnard and John L. Foley. *Food Science Department, The Pennsylvania State University, 9 Borland Lab, University Park, PA 16802.*

The flavor of 1,720 store-purchased milk samples was evaluated by a dairy judging panel. This was part of a continuing educational program in Pennsylvania, which has widespread cooperation and support from all segments of the dairy industry. Flavors of samples are classified as good, acceptable and poor. Flavors of samples in the latter category are those to which many consumers would object. Twenty-eight percent of the samples were of good flavor, while 36% were acceptable. The area of concern to the dairy industry should be the 36% of samples with objectionable flavor. Of thc 623 poor-tasting samples 58% were

rancid, 18% light-induced and 15% had a strong medicinal or vitamin A flavor. The latter were skim or lowfat samples fortified with vitamin A. Only a few samples lacked freshness, or had putrid or spoiled flavors. Most rancidity can be corrected by proper handling of raw milk by farmers and processors. Light-blocking agents in plastic containers would almost eliminate light-induced flavors found in up to one half of the samples in plastic containers. A change in the vitamin A carrier would seem to reduce the medicinal flavor.

Inhibition of Patulin Production by Postassium Sorbate. Lloyd B. Bullerman. *Department of Food Science and Technology, University of Nebraska, Lincoln, NE 68583-0919.*

The effects of potassium sorbate on growth and patulin production by a strain of *Penicillium patulum* isolated from cheese were studied. Potassium sorbate at 0.05, 0.10 and 0.15% delayed or prevented spore germination and initiation of growth, and decreased the rate of growth of this organism in potato dextrose broth at 12-13°C. Increasing concentrations of sorbate caused more variation in the amount of total mycelial growth and generally resulted in a decrease in total mycelial mass. Potassium sorbate also greatly reduced or prevented production of patulin by *P. patulum* for up to 70 d at 12-13°C. At 0.10% of sorbate, patulin production was essentially eliminated, but at 0.15% low and variable amounts of patulin were produced late in the incubation period. At 0.05% sorbate, patulin production was greatly decreased over the control, except at 14 and 16 d of incubation, when amounts of patulin similar to those produced by the control were detected. Other than that occurance, any patulin production that occured in the presence of sorbate at all was very low and variable.

Effect of Molecular Weight and Dispersibility of Soybean Protein on the Capacity of Surface Film Formation. R. H. Chen and C. K. Rha. *Department of Marine Food Science, National Taiwan College of Marine Science Technology, Keelung, Taiwan, Republic of China.*

The objective of the study was to elucidate the effect of molecular weight and dispersibility of protein on surface-concentrated film formation to understand the mechanism of surface-concentrated film formation. Dispersability of protein was determined by Biuret method from supernatant liquid after removing any precipitates caused by pH adjustment and/or heating. Molecular weight was determined by gel-filtration chromatography. Soybean protein at 5 to 20 mg/ml in constant ionic strength varied film formation capacity with pH 3 and 8. Film formation capacity was inhibited between pH 3 and 5. A minimum of 4.5 mg of heat stable soluble protein/ml was required to form surface-concentrated film. Solubility effect by pH was found to be concentration-dependent. Decreases of solubility with pH were more pronounce at high concentration ranges of 15 and 10 mg/ml than at 5 and 7.5 mg/ml. Minimum molecular weight of acid-hydrolyzed soybean protein that still possessed film formation capacity was 91,000 daltons. It was 58,000 daltons for alkaline-hydrolyzed soybean protein. Molecular weight larger than 240,000 daltons was found 14% in control protein visavis 7% in 5 min acid-hydrolyzed protein that lost its film-formation capacity. Percentage of molecular weight less than 67,000 daltons was 64% in control protein as compared to 96% of 2 min alkaline-hydrolyzed protein that lost its film-formation capacity.

Effect of Lipid Content of Fish and Temperature-Time of Drying on Functional Properties and Nutritional Value of Fish During Dehydration. R. H. Chen, Y. W. Wu and S. S. Wang. *Department of Marine Food Science, National Taiwan College of Marine Science Technology, Keelung, Taiwan, Republic of China.*

The effect of lipid content of drying fish and temperature-time of drying on the protein qualities of fish were studied to evaluate a rational approach of choosing dehydration conditions and methods suitable for food materials of different characteristics. The protein qualities studied were water holding capacity, water soluble protein, salt soluble protein, and available lysine. Forced hot air dehydration had an adverse effect on water holding capacity of both fish flesh, and the higher the lipid content, the greater the loss. Forced cold air dehydration decreased water holding capacity of fish flesh of high lipid content; however, it had no adverse effect on fish flesh of low lipid content. Water soluble protein of fish flesh showed no adverse effect upon forced cold air dehydration and was slightly affected by forced hot air drying. Salt-soluble protein was affected severly by both forced cold and hot air dehydration. The higher the lipid content, the higher the retention of salt-soluble protein. Available lysine of both types of fish flesh was severely damaged by dehydration. Loss of available lysine after 75°C for 8 h and 25°C for 16 h of drying was more than 90% and more than 80%, respectively.

Evaluation of Five Miniaturized Multitest Systems for Identification of Stock Cultures and Food Isolates. N. A. Cox, J. S. Bailey and J. E. Thomson. *Richard B. Russell Agricultural Research Center, USDA-ARS, PO Box 5677, Athens, GA.*

Fifty-gram samples of ground beef and raw shrimp were blended for 1 min with 450 ml of sterile 0.1% peptone solution. Processed broiler carcasses were vigorously shaken for 1 min in a bag with 100 ml of sterile water. Serial dilutions were plated using violet red bile agar with 1% glucose and incubated for 24 h at 35°C. Typical colonies were randomly selected and transferred to brain heart infusion agar plates to determine purity. These isolates plus a selection of organisms from known stock cultures were then inoculated into five miniaturized identification systems (API-20E, Enteric-Tek, Enterotube II, Micro-ID and Minitek) according to the manufacturer's instructions. In addition, each isolate was identified using the conventional procedures described by Edwards and Ewing. In descending order, the accuracy of identification to genus was Micro-ID (98%), Minitek (95%), Enteric-Tek (94%), API-20E (92%) and Enterotube II (86%), and to species was Micro-ID (97%), Minitek (94%), Enteric-Tek (93%), API-20E (91%), and Enterotube II (79%). Eleven genera of *Enterobacteriaceae* were represented among the 124 organisms tested. All systems accurately identified the most pathogenic organisms (*Arizona, Salmonella, Shigella*). Most of the observed errors in identification occurred with *Enterobacter* and *Serratia* species.

Efficacy of Various Media for Detection of *Salmonella* in Poultry Products. N. A. Cox, J. Y. Chiu, J. S. Bailey, G. W. Krumm, J. E. Thomson and R. W. Johnston. *Richard B. Russell Agricultural Center, USDA-ARS, PO Box 5677, Athens, GA.*

Fifty samples of commercial mechanically separated cured chicken and 50 of mechanically separated turkey meat were ob-

tained. Twenty-five g of each sample were stomached for 1 min with 225 ml of selenite cystine broth, then incubated at 35°C for 24 h (procedure A). Also, 25 g were stomached for 1 min with 225 ml of lactose broth and incubated at 35°C for 24 h, then 1 ml was transferred to 9 ml of TT broth and incubated at 43°C for 24 h (procedure B) or to 9 ml of selenite brilliant green broth and incubated at 43°C for 24 h (procedure C). In procedures A, B and C, one loopful was streaked on brilliant green sulfa agar (BGS), xylose-lysine- desoxycholate agar with novibiocin added (XLDN) and modified lysine iron agar (MLIA). One loopful from procedure B and one loopful from procedure C was streaked onto a plate of BGS, XLDN and MLIA (procedure D). After 24 h incubation at 35°C, one typical colony was picked from each plate and analyzed for *Salmonella* by biochemical and serological tests. Fifty broiler carcasses were each shaken for 1 min in a bag with 100 ml of sterile rinse water. Concentrated selenite cystine or lactose broth was added to portions of the rinse to yield a single-strength medium. Procedures A through D were then followed. With cured chicken, there were no significant differences among the four procedures. With turkey, procedures A, B and D yielded significantly (P = 0.01) more positive recoveries than C; procedure B yielded the most positives. With carcass rinsings, procedures A, B and D were not significantly different, and were significantly (P = .05) better than C. There were no significant differences among plating media with the turkey or carcass rinse samples, but with cured chicken, MLIA and BGS were significantly (P = .01) better than XLDN. Overall, *Salmonella* were more frequently recovered from MLIA than from BGS or XLDN. *Salmonella* were found in 92% of the cured chicken samples, 72% of the turkey and 98% of the chicken carcasses.

Consumer Acceptability of Cottage Cheese Containing a Sodium Substitute. B. J. Demott and O. G. Sanders. *Food Technology and Science Department, The University of Tennessee, Knoxville, TN 37901-1071.*

Medical advice to reduce sodium intake has prompted many individuals to limit their consumption of dairy products and other foods which contain added sodium. This experiment was conducted to determine the acceptability of a sodium substitute in cottage cheese. Direct-acid-set cottage cheese curd was obtained from a commercial source. The creaming mixture containing sodium chloride and/or sodium substitute was then added to the curd. Four samples of cottage cheese containing 0 and 1%, 1.26 and 0%, 0.63 and 0.63%, and 0 and 1.26% sodium chloride and/or sodium substitute were evaluated for flavor acceptability by a sensory panel using an 8-point hedonic scale. The sample containing 1% substitute and no sodium chloride was frequently described as being too bland. There was not flavor difference between the sample containing 1.26% substitute and the sample containing 1.26% sodium chloride. The data indicate that an acceptable cottage cheese can be produced using a sodium substitute.

Toxicological Evaluation of *Cellulomonas flavigena* for a Possible Source of Single Cell Protein. B. P. Dey and M. L. Fields. *USDA, FSIS, Science, Pathology & Epidemiology Division, Bldg 322, BARC- East, Beltsville, MD 20705 and Department of Food Science and Nutrition, University of Missouri, Columbia, MO 65212.*

To determine the suitability of a microorganism as a source of single cell protein (SCP), one important factor to consider is its non-toxicity to humans or animals. Based on guidelines suggested by the Protein Advisory Group of the United Nations (PAG/UN) and other researchers, biological tests were conducted on five strains of *Cellulomonas flavigena* to evaluate their toxicity. Cell-free extracts of each strain suspended in water or in peanut oil failed to produce hemolysis or any pathological changes in human blood. Injection of these extracts into fertile chicken egg did not cause death of chicken embryo or abnormality in chicks. Also, these extracts injected subcutaneously did not produce hypersensitivity in rabbits previously fed *C. flavigena.* The viable cells of all the strains when inoculated intramuscularly in rats, subcutaneously in mice and intraperitonealy in rabbits were unable to produce local or generalized infection and had no effect on the growth rate of the test animals. The histology of the vital organs and the fertility rate of rats were not affected by prolonged feeding of any strain. Additionally, there was no evidence of birth defects in their progeny as a result of such feeding. Results of the tests indicate that all five strains of *C. flavigena* are non-toxic to animals and could be potential sources of SCP.

Milky Spoilage and Reduced Shelf Life of Commercially Prepared Hot Dog Wieners. F. A. Draughon and N. G. Nisbett. *Department of Food Technology & Science, University of Tennessee, PO Box 1071, Knoxville, TN 37901-1071.*

Commercially prepared wieners often have shelf lives of 30 to 60 d. A type of spoilage termed "milky spoilage" due to the white discoloration of the wiener and an accumulation of milky colored liquid in the package was reported by a commercial producer in wieners held 30 d or less at 4°C. Experiments were undertaken to determine the major type(s) of bacteria associated with a milky spoilage problem in commercial wieners and to isolate the steps in production of the wieners which were contributing the spoilage microorganisms. Samples were taken for microbiological analysis from the meat emulsion, the cooling brine, the peeler and the packaging equipment. Total counts were taken and microorganisms were identified. The emulsion brine had less than 10 bacteria/ml. Before the smokehouse, the meat emulsion (10^6 bacteria/g) had a large variety of bacteria which included *Streptococcus* (42%), *Lactobacillus* (27%), *Corynebacterium* (2%), *Enterobacteriaceae, Acinetobacter, Pediococcus, Micrococcus* and *Streptococcus*. The cooling brine included all the above and yeast (14%). Counts were reduced to 10^3/gram after smokehouse treatment (pH = 6.3) and included *Streptococcus* (50%), *Lactobacillus* and *Pediococcus*. Counts from the peelers were 10^6 per cm^2 and were also predominantly lactic in character. Shelf life was increased to 60+d without milky spoilage by strict sanitation of equipment including peelers and by moving product promptly to refrigerated storage.

Selecting a Miniaturized System for Identification of *Enterobacteriaceae*. D. Y. C. Fung, N. A. Cox, M. C. Goldschmidt, J. S. Bailey and J. E. Thomson. *Department of Animal Sciences and Industry, Kansas State University, Manhattan, KS; Russell Research Center, Athens, GA and Dental Branch, Dental Science Institute, University of Texas Health Center at Houston.*

The most commonly used commercially available diagnostic kits for identification of *Enterobacteriaceae* are API, Enterotek, Enterotube II, Micro-ID, Minitek and Spectrum-10. The accuracy of identification by all systems does not vary significantly, and falls within an acceptable range. A microbiologist who is consid-

ering the use of one or more of these products should therefore evaluate factors other than accuracy. Twenty-three professional microbiologists who had previous experience with these systems evaluated their advantages and disadvantages and compared them with conventional identification procedures. Our analysis and tabulation indicated that versatility, time required for inoculation, conditions of incubation, manipulation after incubation, possible difficulties in determining positive or negative reactions, potential safety factors for laboratory personnel, shelf-life and price are important factors. Cost of per isolate identification of each system, which included the identification kit, the identification manual, any additional reagents, and other incidental expenses, was also calculated. This in-depth examination and discussion of these criteria will greatly aid microbiologists in choosing a commercially available diagnostic kit.

Video Tape Training - The Future is Now. Robert B. Gravani. *Department of Food Science, 8A Stocking Hall, Cornell University, Ithaca, NY 14853.*

Traditionally, sanitation training has been accomplished through in-person lectures, supplemented by the use of overhead transparencies, slides, filmstrips and films. Field trips to food processing operations, warehouses, retail stores and food service facilities also served to impart "real-world" practical knowledge to the audience. Today, the technology has progressed to where video tape can be effectively used to convey concepts, issues and realism to training programs. Available in a variety of formats, this "new" medium allows for tremendous flexibility in sanitation or industry training programs. Not only can scientific subjects be covered, but important issues such as inspector attitude, employee awareness and crisis management can be effectively taught. Interactive video using both video and computer technologies can be used for teaching complicated and/or comprehensive material. A series of good quality and practical video-tapes illustrating the concepts above will be shown.

Misleading Inhibitory Substances Test Results. M. Leuther and Ronald Glass. *Leuther Laboratory, Rt. 1, Box 140, Coon Valley, WI 54623 and University of Wisconsin - LaCrosse.*

Test results for inhibitory substances in milk may be misleading due to bacteria that produce inhibitory substances or β-lactamase. Bacteria from samples testing positive for an inhibitory substance other than a beta-lactam were tested to determine if they were producing inhibitory substances. Samples initially testing positive for beta-lactam and later testing negative were retested with the addition of penicillin. β-lactamase free milk was inoculated with suspected β-lactamase producers. It was determined that bacteria in the milk sample can produce inhibitory substances in amounts sufficient to give a positive test and that β-lactamase producers can make the β-lactam undetectable.

Growth of Indicator, Pathogenic and Spoilage Bacteria in Mechanically Separated Beef, Ground Beef and Red Bone Marrow from Steers. Bibek Ray and R. A. Field. *Division of Animal Science, University of Wyoming, University Station, PO Box 3354, Laramie, WY 82071.*

Growth of *Escherichia coli, Salmonella anatum, Staphylococcus aureus, Clostridium perfringens,* and naturally occurring mesophilic aerobes and psychrotrophs in mechanically separated beef (MSB), ground beef (GB) and red bone marrow (BM) was studied. Six good grade steers were slaughtered and samples of MSB, GB and BM were mixed with 600 ml of sterile water, distributed in 20-g portions in sterile vials and frozen at -20°C within 6 h postmortem. For growth studies, vials of MSB, GB, and BM were thawed and inoculated with *E. coli* or one of the pathogens, incubated at 37°C up to 24 h and enumerated for colony forming units (CFU) on specific selective agar plates. Growth of mesophilic aerobes and psychrotrophs were enumerated by incubating the materials at 37°C for 24 h and 7°C for 12 d, respectively. During the first 8 h of incubation, *E. coli* and *S. anatum* multiplied rapidly in MSB and GB but rather slowly in BM. By 24 h both species had multiplied to the same population level. Initial growth of *S. aureus* was rapid in MSB and GB, but by 24 h its number was higher in GB than in MSB or BM. *C. perfringens* grew faster in GB and slower in BM during the 24-h period. Both mesophilic aerobes and psychrotrophs grew fastest in MSB and slowest in GB during the incubation periods. Differences in growth rate of various bacteria in MSB vs. GB might be considered in its production and storage.

Radiometric *Salmonella* Screening. Dean Reed. *Ross Laboratories, 625 Cleveland Avenue, Columbus, OH 43216.*

An automated method was evaluated to assess its potential as a replacement for the conventional BAM procedure for *Salmonella* screening. This method uses radioactively labelled selective enrichment broths (tetrathionate and selenite cystine) and a BACTEC® 460 instrument manufactured by Johnston Laboratories. Fifty-one isolates representing over 98% of all serotypes were evaluated for their ability to grow and be detected in ^{14}C-labelled conventional selective enrichment broths. All were detected except for one *Salmonella paratyphi* A isolate. *S. paratyphi* A accounts for less than 0.15% of the outbreaks in the United States. Pre-enrichment preparations of eight powdered nutritional products containing low levels of five stressed *Salmonella* were inoculated into the selective enrichment broths. Thirty-eight of the 40 combinations resulted in detection. Negatives were due to insufficient outgrowth in pre-enrichment preparations. *Escherichia coli* and *Klebsiella pneumoniae* gave false presumptive results. The method proved both selective and sensitive, offering a much quicker (48 h) alternative to conventional *Salmonella* screening of ingredients or products with low enteric populations.

Economic Impact of Food Spoilage and Foodborne Disease. Ewen C. D. Todd. *Bureau of Microbial Hazards, Health Protection Branch, Tunney's Pasture, Ottawa, Ontario, Canada K1A 0L2.*

Food spoilage and foodborne disease are thought to be very costly to food producers, foodservice operators and the public, but very few studies have been carried out to show this. Information, such as 60% of dates from Iran and Iraq were rejected at port of entry in the United States in 1977 because of insect contamination and mold growth, indicates perhaps the extent to which spoilage can occur in some countries. Vomitoxin in the 1982 Ontario winter wheat crop cost farmers and government $42 million. Records of recalls, seizures and fines show that mistakes made through ignorance or negligence have to be paid for by companies and tax payers. The Aberdeen typhoid outbreak from Argentinian canned corned beef in 1964 cost producers $50 million; no costs were calculated for the hundereds of persons hospitalized and out of work. In 1971, the Campbell Soup Company

recalled two of its soups because of the danger of botulism at an estimated cost of $10 million. A Quebec company recorded a $27 million loss and went bankrupt in 1974 when *Salmonella*-contaminated chocolate candies caused illness. The economic impact of several outbreaks involving foodservice establishments has been determined. Where illness was severe, hospitalization expenses and loss of patient earnings were important; in other incidents, the economic loss to food suppliers was significant. More economic assessments are required before such data are extrapolated to indicate annual costs of food spoilage or foodborne disease at national or international levels.

INVITED PAPERS

Regulation of Goat Milk Production and Processing. Henry V. Atherton. *University of Vermont, Burlington, VT 05405.*

Delegates to the 1981 National Conference on Interstate Milk Shipments recommended the appointment of a Goat Milk Task Force to review available information to determine if separate standards should be established for cow's milk and goat's milk. Regulations concerning maximum somatic cell counts and minimum milkfat percentages were identified as major areas of concern. Basic differences are noted in milk produced by caprine and bovine species. Cytoplasmic particles appear to be a normal component of goat milk. Regulations dealing with somatic cell counts in goat milk must clearly state that only nucleated cells, as opposed to cytoplasmic particles, should be counted in official methodology. Current standards for DMSCC are acceptable if this is done. Low seasonal milkfat percentages appear common and normal in goat milk. Also, goat milk appears to give much lower freezing points than is common for cow's milk. Only six states have distinctive regulations for goat milk. Thirteen states permit sale of raw goat milk, thirteen do not.

Net Contents of Packaged Foods. Carroll S. Brickenkamp. *Office of Weights and Measures, National Bureau of Standards, Washington, DC 20234.*

The consuming public generally assumes that the net contents declaration appearing on labels of packaged food is "correct" or "accurate" (if they notice it at all). There are legal requirements, however, at Federal, State and local government levels, for these net contents statements - what they mean and how they are to be interpreted. The general requirements for food and nonfood products, as well as the concurrent authorities of several levels of enforcement agencies in the United State are described. A new inspection manual, National Bureau of Standards Handbook 133, "Checking the Net Contents of Packaged Goods" has been published that covers test methods, sampling, and data analysis. The handbook's present and potential effects on food packaging and on regulatory inspection are discussed in terms of cost savings and efficiency.

Risks of Salmonellosis in Consumption of Processed Egg Products. Owen J. Cotterill. *Food Science & Nutrition, University of Missouri, T-14, Room 107, Columbia, MO 65211.*

During World War II, of 400 egg product samples tested, 28% were positive for salmonellae. Due to a large interstate outbreak caused by *Salmonella derby* in 1963, 39% of those involving animal products were due to eggs. Since about 1974, very few outbreaks have been attributed to eggs. Better sanitation, refrigeration, pasteurization, testing and removal of high risk shell eggs have virtually eliminated eggs as a source of salmonellae. The interior of most fresh eggs is sterile. A good commercial egg breaking plant can expect a raw product to contain a total count of less than 100 cells/g. All egg products are pasteurized and tested to assure that they are salmonellae-negative.

Applied Visual Aids Program. Joseph E. Edmondson. *Food Science & Nutrition, University of Missouri, 201 Eckles Hall, Columbia, MO 65211.*

Use of visual aids has become commonplace for most presentations. Without these aids, most teachers or extension personnel would be at a loss in preparation of today's programs. One constantly searches for the best approach or method to present data or graphics. Use of the computer has opened an entirely new approach to this problem. One can prepare three to six different formats from the same data, store them in the computer and then select the one which will best present the topic for a specific audience. Examples of this type of operation will be presented using slides, transparencies or handouts.

Soluble Fiber in Human Nutrition. Dennis T. Gordon. *Food Science & Nutrition, University of Missouri, 224 Eckles Hall, Columbia, MO 65211.*

Dietary fiber is defined as the remnants of plant foods that resist digestion by the elementary enzymes of man. An insoluble residue is implied. The increased intake of dietary fiber is reported to prevent or retard many intestinal disorders. Other positive effects include the lowering of blood cholesterol and better management of glucose levels in the diabetic. A more complete discription of the dietary fiber content of foods would be total dietary fiber, the sum of the insoluble residue (fiber) and soluble residue (fiber). This soluble fiber, although comprising only approximately 20% of total dietary fiber, may be equally important to human health. The soluble fiber components of plants are not easily recovered or characterized by analytical means. These include such water-soluble polysaccharides as gums, pectins and soluble hemicelluloses. The gel-forming properties of these soluble fiber components change the viscosity within the gut. Insoluble fiber components act as bulking agents, have binding capacity for dietary components and intestinal metabolites, and may alter the physical nature of the intestinal mucosa. The mechanism of action of total dietary fiber is the basis for suggesting it be viewed as a nutritional adjunct.

Quality Control and Instrumental Analysis in Dairy Laboritories. Remy Grappin. *Institut National de la Recherche Agronomique, Station Experimentale Laitiere, 39800 Poligny, France.*

In most countries with a developed dairy industry, milk supplies are tested regularly for milk payment or regulatory purposes, by specialized laboratories using mainly automated equipment. The infra-red method is now widely used for measuring fat, protein and total solids content, and electronic equipment has replaced the microscope for somatic cell counting. Standard plate count is still used for the evaluation of bacteriological quality of raw milk, but several new methods (fluorescence, impedance, A.T.P. measurement, etc.) might be used shortly. Because indi-

rect instrumental methods require calibration against reference methods or materials, the overall accuracy is closely associated with the ability of the laboratories to perform correctly reference methods, or with the availability of standard reference materials. High quality results can be achieved, provided that the laboratories are aware of the limitations of the methods, and apply a quality control program. Internal control should include regular checking of precision, accuracy and stability of the instruments. An external surveillance is also essential to ensure homogeneity of results between laboritories.

How to get a Million Bacteria in a Product without Really Trying. Paul R. Hocking. *Eskimo Pie Corporation, 530 E. Main Street, Richmond, VA 23219.*

As dairy and frozen dessert production plants become larger and more complex, the challenge becomes enormous to have adequate sanitary procedures to keep control of our operations. Even more critical is the communication of these procedures to the responsible production people, who ultimately must actually follow the instructions. Motivating these people to act as instructed and following through to oversee that the quality standards are met is an ever increasing challenge to us all. Our plants are modernizing and automating at a rapid pace, due to tax relief measures, increased labor costs, and higher overhead costs. How do we cope with these changes and keep bacterial counts within written quality guidelines? How can we motivate production and plant personnel on the line to make them well aware of the sensitivity of quality guidelines? These issues and other related topics will be discussed from the dairy and frozen novelty plants' point of view.

Actions of the 1983 NCIMS Conference. James I. Kennedy. *Missouri State Milk Board, 915-C Leslie Boulevard, Jefferson City, MO 65101.*

Program convened May 9-13, 1983, at Stouffers' Riverfront Towers, St. Louis, MO. Overall, 104 problems and proposals were submitted for consideration. Council I was assigned 57 of the problems, Council II 34 and Council III 13 plus five constitution revision proposals. Problems assigned by the Program Committee to each of the Councils were based on subject matter. Some excellent committee reports were presented. These included outstanding reports from the NCIMS History and Accomplishments Committee chaired by Donald H. Race, the Goat Milk Task Force chaired by Henry Atherton, and the Farm Cleaning Procedures Task Force chaired by Don Kimball. Other committees having input at the Conference were the Laboratory Committee, Methods of Making Sanitation Ratings, Resolutions, Joint Committee on Coded Memoranda, Constitutional Revision, Single Service Containers and Closures, Foot-and-Mouth Disease and Program Committee. Seven resolutions were adopted by the Conference. From Council I the voting delegates took 17 positive actions including acceptance of three minority reports where Council had no recommended action. Council II also had 17 positive actions approved by the voting delegates along with the acceptance of six positive actions of Council III including four constitution revisions. Most profound among actions of the Conference was the lowering of acceptable somatic cell count for raw milk for pasteurization from 1.5 million to 1 million to be effective July 1, 1986, making use of PI count in lieu of SPC optional with the state regulatory authority, allowing the feeding of recycled animal waste to lactating dairy cows, and the acceptance of step dam gravity flow gutters on dairy farms.

Problem Areas in Cleaning and Sanitizing RO and UF Equipment. Gerald Luss, Don Vegoe, Leo Bohanon and Jeanne Dahl. *H. B. Fuller Company, Monarch Chemical Division, 3900 Jackson St. NE, Minneapolis, MN 55421.*

A short survey of the types of RO and UF equipment prevalent in the food processing industry is presented. The different membrane configurations are discussed. The types of cleaning and sanitizing regimes commonly used for each type of equipment are discussed. Examples drawn from typical problems encountered in the field will be presented and discussed. Corrective steps in terms of both process modifications and cleaning/sanitizing regimes will be presented.

Microenvironment of the Surface of Food Processing Equipment. R. Burt Maxcy. *Department of Food Science and Technology, University of Nebraska, 134 Filley Hall - East Campus, Lincoln, NE 68583.*

The microenvironment of the surfaces of food processing equipment is unique and strikingly different from the microenvironment normally considered in the study of microorganisms. To study the microenvironment, 1-cm^2 pieces of stainless steel were used with pure cultures and mixed cultures in known menstrua and with controlled environmental factors. Bacteria on a hard surface with limited suspending menstruum are extremely sensitive to alterations in available water, nutrients, temperature and surface-active forces. Cells may be arrested or injured so that recovery in selective media is limited, thereby influencing the usefulness of commonly used tests for sanitation. Vigor of individual elements of a mixed culture from contamination determines the nature of the microorganism contaminating foods subsequently processed over such equipment surfaces. Study of the fate of microorganisms in the microenvironment of surfaces of food processing should aid in decision-making on sanitary practices.

Mutagens in Cooked Foods. Michael W. Pariza. *Food Research Institute, University of Wisconsin, Madison, WI 53706.*

What we call "food" is an extremely complex medium containing many chemicals capable of exerting various pharmacological effects, some of which may influence the process of carcinogenesis. This lecture will consider such factors which are associated with the cooking of foods. Data on the purification and identification of the major mutagens associated with the cooking of proteinaceous foods will be presented. New data on mutagenesis inhibitors in food will also be discussed. The possible role of such factors in food safety assessment will be considered.

Cleaning Large Bulk Tanks and Pipeline Systems. Phillip W. Parsons. *Maryland & Virginia Milk Producers Association, Inc., PO Box 9154, Rosslyn Station (1530 Wilson Blvd), Arlington, VA 22209.*

Proper cleaning procedures are essential to produce a quality raw product. The wash cycle temperature should start at approxi-

mately 160°F, 170°F if several plastic parts are in the milk system, followed with a rinse of an acid solution and a sanitizing solution just before milking. The milk truck driver must manually rinse the tank to remove the heavy residue of milk and foam before washing. The orifices on the spray stick must be maintained open so that proper water coverage is achieved. The average milking system being installed in my area is a double-slope, 3-in. low line with 12 milk units, inplace washers and automatic take offs. To clean a milking system such as this we connect a 1.5 in. water pick up line to the 3-in. line. A restrictor is installed in this line with an air injector; in this way we can build a 3-in. slug of water and maintain coverage through out the 3-in. system.

New Development in Near-Infrared Technology in Food Analysis. Jim Psotka. *Technicon Industrial Systems, 511 Benedict Avenue, Tarrytown, NY 10591.*

The expansion of Near-Infrared Reflectance Analysis (NIRA) technology from its commercial introduction in the grain industry has resulted in the rapid development of applications in other agricultural areas, including the dairy industry. New samples presentation hardware and sample handling protocols are enabling food processors to obtain rapid reliable analyses without elaborate sample preparation for a wide range of products - from liquids to soft solids to hard solids to powders. Some examples of such applications of NIRA will be presented.

A Yersiniosis Outbreak. J. Carroll Sellers. *U. S. Food and Drug Administration, 297 Plus Park Blvd., Nashville, TN 37217.*

Yersinia enterocolitica was isolated from 172 patients ill with enteritis from July 11 to July 29, 1982, in a three-state area. Epidemiological evidence collected by Arkansas and CDC officials implicated milk produced at a West Tennessee plant as the vehicle of infection. FDA's Nashville District was informed on July 15 and began inspection of the plant July 16 to determine if the plant's products were the vehicle, how it may have happened, and how to prevent reoccurrence. Thorough investigation including equipment testing, product samples and environmental samples did not reveal an obvious source of contamination. Samples scraped from two milk crates on a farm which fed hogs with "returned milk" from the plant yielded *Y. enterocolitica* of the outbreak serotype. Therefore, there is ample reason to suspect the plant's product to be the vehicle. The milk industry and milk regulatory people should again be reminded not to let down in efforts to provide milk of the best sanitary quality, starting with the cow and following through to the consumer.

Problem Areas in Installation and Operation of Milking Equipment. Barry J. Steevens. *Department of Dairy Science Extension, 125 Eckles Hall, University of Missouri, Columbia, MO 65211.*

The current trend is to install 3-in. milk lines, larger vacuum lines and pumps. Automation and electronics are being included. Electricity and moisture are not very compatible. Some of the problems associated with milking systems include incorrectly installed vacuum pumps; leaky exhaust pipes allow oil fumes to cause problems with other equipment. Many air controllers are located in areas where dust, dirt and oil fumes tend to gum them up. Three-inch milk lines need to be correctly installed to allow for adequate washing. Self-draining valves and cracks in hoses can allow air leaks which result in poor washing. Hose support arms are essential in parlors, especially with low milk lines. Vacuum guages tend to corrode and become sticky. It is essential that dariymen change liners adequately to prevent distortion and deterioration from milkfat or excessive liner slippage can occur. Milking cows with wet udders can cause major problems in producing quality milk. Large spray nozzles on hoses should not be used to wash cows. Stray voltage is sometimes confused with equipment problems.

Role of IAMFES in the International Dairy Federation. Harold Wainess. *Harold Wainess & Associates, 464 Central Ave, Northfield, IL 60093.*

The International Dairy Federation (IDF) was founded in 1903 to establish an international forum for the exchange of technical and scientific subjects. IDF has published over 300 Technical Manuals, Guides, Monographs, Standards and Seminar Proceedings. Recently this has included such topical subjects as "A Technical Guide to Packaging" and "A Monograph on UHT Processing" that have become current texts. In 1982, for the first time, the U.S. became a member and the U.S. National Committee of the IDF (USNAC) was formed to encourage U.S. participation in IDF and a sharing of scientific information. The IAMFES was a founding member of this highly successful venture and many of its members are currently sharing in this two-way exchange of knowledge. The author will describe how more IAMFES members can actively participate in over 98 Groups of Experts in five different categories. These include: Production, Sanitation and Quality of Raw Milk; Technology and Engineering of Plant Processes, Controls and Packaging; Compostion, Nutrition and Chemical Contaminants; Analytical Standards and Laboratory Techniques (Microbiological and Chemical); The Application of Science and Education to the Dairy Industry. Seminars and Symposia to be held in the U.S. and other countries will be discussed, including the role to be played by IAMFES.

Retail Food Store Sanitation Code--an Update. Robert L. Winslow. *Food Technology Div, Safeway Stores, Inc, Fourth and Jackson Streets, Oakland, CA 94660.*

This is an update of the status report on the Model Retail Food Store Sanitation Ordinance presented to the 1979 Annual Meeting of the International Association of Milk, Food & Environmental Sanitarians by FDA's K. J. Baker. This document has since been jointly revised by FDA and the Association of Food and Drug Officials (AFDO) and was published in 1982 by AFDO. Training programs have been developed by FDA for regulators and by the Food Marketing Institute for the retail food industries. The Code has been officially adopted by a few jurisdictions and is under consideration by others. It has served as the basis for formal sanitation programs developed by much of the food retailing industry. The Code is being kept current through FDA's issuance of interpretations covering extensions of our understanding of potential food hazards (such as sulfiting of foods) or changing merchandising practices in retail food stores (such as bulk display of unpackaged foods for customer self-service). The primary benefit of this document probably lies more in mutual agreement amongst regulators and industry as to the relative sanitation hazards in food retailing than in the actual reduction of foodborne disease.

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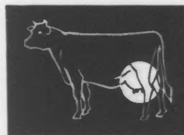

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A proper and complete sanitation program could probably be stated by listing several necessary steps: 1) Sanitizing of the equipment, 2) Pre-milking udder washing and drying, 3) Sanitizing of teat dip clusters between cows, 4) Post-milking teat dipping and 5) Cleaning of the equipment.

The milking equipment needs to be properly sanitized before every milking operation. Especially important, are the teat cups, and in fact the entire teat cup assembly which could serve as a source of infective organisms. Inflations which are cracked even with hairline cracks, can be difficult to clean and sanitize, and as a result are good sources for mastitis pathogens. Certainly the entire claw assembly could be a source of pathogens that could be transmitted to the teat end. According to some research, milk droplets containing mastitis pathogens can impinge on the end of the teat with the possibility of gaining entrance into the canal under certain circumstances associated with the milking process. Contamination from this source can be readily controlled by using the known sanitation technology that is available at the farm level.

Proper washing and drying of the cows is important both for cleanliness and for stimulation of milk let down. Unless properly done, udder washing procedures may tend to spread pathogens rather than to destroy them. The Pasteurized Milk Ordinance, requires that an udder wash containing an appropriate germicidal agent is necessary at recommended concentration and temperature. The use of single service paper towels is recommended and important. The teats and the base of the udder should be well dried with a clean paper towel after each washing. The teats and the udder should be completely dry in order to eliminate any accumulation of washing solution that will result in residuals in the milk.

The NMC in their "Current Concepts of Bovine Mastitis", recommends that smooth rubber gloves be worn by the milkers and that the gloves be dipped in a sanitizing solution between cows. In this way the transfer of organisms may be minimized.

The recommendation of dipping teat cup clusters between cows is open to debate according to the NMC "Current Concepts". The procedure of back flushing the teat cups and claw assembly, is a practice that will help to reduce the mastitic pathogens.

Teat dipping is probably the most important of the hygienic procedures in regard to reducing infection. Some studies have shown a 50% reduction in new infections during lactation, as a result of dipping teats in an effective teat dip after milking. According to Dr. W. Nelson Philpot, "teat dipping does not exert a rapid effect on the level of infection in a herd because it does not affect existing infections, but its importance in a long term program of mastitis prevention cannot be over emphasized."

All evidence proves that a complete sanitation program is necessary in order to keep new infections to a minimum.

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AFFILIATE NEWSLETTER . . .

PENNSYLVANIA DAIRY SANITARIANS - LABORATORY DIRECTORS CONFERENCE

More than 250 persons participated in the annual three day conference at the Pennsylvania State University, May 23-25, 1983. Among the three panel discussion was a spirited one on quick tests for antibiotics. Twenty-seven other presentations covered a wide variety of topics. These included the cholesterol story, future of cooperatives, training field staff, stray voltage, dairy situation, water testing, handling milk in schools, calculating a blend price, and causes of fat test variations.

Both the sanitarians and laboratory directors association held annual meetings. Ivan Redcay, Eastern Milk Producers, will serve as president of the PA Dairy Sanitarians for the coming year. James Barnett, Interstate Milk Producers, will be president elect, while Audrey Hostetter, Hershey, and Patricia McKenty, PA Department of Agriculture, continue as secretary-treasurer and assistant secretary, respectively.

The PA Approved Dairy Laboratory Directors Association elected the following officers: President, Daniel Hamilton, Penn Daires; Vice President, Linda Knotwell, Green's Dairy; Secretary, Charles Livak; and Treasurer, Kay Fontenoy, Hershey Chocolate.

Allen Murray, Fike's Dairy, received the 1983 Sanitarians Award from the PA Dairy Sanitarians Association at the banquet. The Distinguished Service Award was given to Sidney E. Barnard, Extension Specialist at the Pennsylvania State University. Certificates of service were presented to five retired members of the sanitarians association.

MISSOURI MILK, FOOD & ENVIRONMENTAL HEALTH ASSN. MEETING HIGHLIGHTS

The Missouri Milk, Food and Environmental Health Association held their annual meeting at the Marriott Pavilion in St. Louis, MO, in conjunction with the International's Annual Meeting, on August 8, 1983.

Bill Goldman was awarded the Sanitarian of the Year Award, John J. Nahlik was given the Monarch Dairy Sanitarians of the Year Award and Brian J. Draves was presented with a $100.00 scholarship Award.

New officers elected were: Conn R. Roden, President; Erwin P. Gadd, President Elect; Barry Drucker, Vice President; David Strull, Secretary and John Norris, Treasurer.

Case History

Outbreak of *Campylobacter enteritis* Possibly Caused by Ingestion of Raw Milk

Vernon R. Cups
April 20, 1982

PRELIMINARY DATA:

Thomas M. Foy, M.D., of the Community Health Center in Hillsboro, Missouri, reported the Campylobacter organisms were isolated from stool specimens of an adult male, hospitalized on March 7, 1982, and his 2½ year old daughter, hospitalized on March 8, 1982.

The above information was related to the Milk Control Service of the City of St. Louis on March 17, 1982, by the Jefferson County Health Department. An investigation of a milk producer that had sold raw milk to the family referred to in Dr. Foy's report to the Jefferson County Health Department on the 17th of March, 1982, was initiated.

The milk producer possessed a valid permit to sell Grade "A" raw milk for pasteurization under regulations enforced by the City of St. Louis, Division of Health, Milk Control Service.

Early the morning of March 18, anal swabs of six of the twelve cows in the milking herd, a milk sample from the bulk tank, a strainer pad, and cheese distributed by the Department of Agriculture, were submitted to the City of St. Louis, Public Health Laboratory for confirmation of Campylobacter contamination. Information obtained on the farm also indicated that the producer had sold raw milk to 10 other families in the community. Six people in three of the 10 families who consumed raw milk had diarrhea in the last week of February and the first week in March. No stool specimens were tested. Laboratory reports of anal swabs, cheese sample, and the milk sample analyzed did not confirm the presence of Campylobacter.

An interview with the adult male patient established the following data:

1. He had no contact with pets prior to the illness.
2. He had eaten only cheese, cereal, prepackaged cornbeef, 72 hours prior to the illness.
3. No poultry or eggs were eaten 72 hours prior to the onset of the illness.
4. Family had not eaten in a restaurant one week before becoming ill.
5. His spouse had consumed no raw milk and was not ill.
6. The 2½ year old daughter had consumed the raw milk and became ill.
7. The two month old baby had diarrhea, but did not consume the raw milk. The stool specimen from the baby did not grow Campylobacter on March 8, 1982. The baby improved, but had diarrhea again and Campylobacter grew from stool specimen on March 23rd, 1982.
8. The family did not drink water from an unapproved source.
9. Raw milk was purchased on March 4, 1982, and the adult patient became ill on the 7th of March, 1982, around noon, and the child, on March 8, 1982.

DISCUSSION AND CONCLUSION

1. *Campylobacter enteritis* in most cases is a self-limited illness and is an example of a disease that can be transmitted to man by vertebrate animals.
2. The organism is inhibited at a pH of 5 and below and should present no problem in cultured milk products.
3. Washing udders of the cows and exposing all milk contact surfaces to 200 ppm of chlorine just prior to milking is recommended because the organism is inhibited at this chlorine concentration.
4. The Organism will survive in temperature of 1°C to 4°C for at least two weeks but is inhibited to 55°C for 5 minutes; therefore, if the milk is pasteurized, pursuant to the Pasteurized Milk Ordinance, it is unlikely to present a problem.
5. Campylobacter is widely distributed in nature and the stream that meanders through the farmstead should be viewed as a possible source of contamination. The stream is accessible to the cows for drinking and wading; therefore, the cows could become infected with the organism or transport the organism on the skin and hair of the flanks and udders to the milk supply. Located upstream from the farm there is a sewage disposal system that discharges into the stream and malfunction of the system could increase the possibility of stream contamination.
6. Since two weeks passed between ingestion of the milk and the collection of the milk and anal swabs from the cows, Campylobacter might no longer be present from the cows or their milk when the tests were taken.
7. The positive stool specimen from the baby on March 23, 1982, could have resulted from close association with the members of the family who were originally infected.
8. For the above reasons, I am of the persuasion that the original allegation of a milk-borne disease caused by consuming raw milk has merit.

ACKNOWLEDGEMENTS

1. Thomas M. Foy, M.D., Community Health Center in Hillsboro, Missouri.
2. Wilma W. Claseman, M.D., City of St. Louis, Communicable Disease Control.
3. Jefferson County Health Department, Hillsboro, Missouri, especially Mrs. Margie Long, R.N.
4. Mr. Vernon Nickel, Dairy Sanitarian, City of St. Louis, Health Division.

REFERENCES

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2. Christopher, F. M., Smith, G. C., and Vanderzant C. Effect of Temperature and pH on the Survival of Campylobacter Fetus. *Journal of Food Protection* 1982; 45:253-259.
3. Christopher, F. M., Smith, G.C., and Vanderzant. C. Examination of Poultry, Goblets, Raw Milk and heat for Campylobacter fetus ssp. jejuni. *Journal of Food Protection* 1982; 45:269-262.

Calendar

1983

Nov. 2-4, 1983 9TH ANNUAL FOOD MICROBIOLOGY RESEARCH CONFERENCE, Chicago, IL. For more information contact: Dr. J. M. Goepfert Canada Packers, Ltd., 2211 St. Clair Avenue West, Tornonto, CN M6N 1K4.

November 3-4, 1983, DAIRY PRODUCTS FOR THE CEREAL PROCESSING INDUSTRY, An AACC Symposium. Held at the Hyatt Regency Hotel, Kansas City, MO. For more information contact: Dotty Ginsburg, AACC Headquarters, 3340 Pilot Knob Road, St. Paul, MN 55121, 612-454-7250.

Nov. 7-10, 1983---UCD/FDA BETTER PROCESS CONTROL SCHOOL. University of California. For more information contact: Robert C. Pearl, Dept. of Food Science and Technology, University of California, Davis, CA 95616, 916-752-0980.

1984

February 15-16, 1984, DAIRY AND FOOD INDUSTRY CONFERENCE, The Ohio State University. For information contact: John Lindamood, Dept. of Food Science and Nutrition, 2121 Fyffe Road, The Ohio State University, Columbus, OH 43210.

March 19-23, 1984, MID-WEST WORKSHOP IN FOOD SANITATION, The Ohio State University. For information contact: John Lindamood, Dept. of Food Science and Nutrition, 2121 Fyffe Road, The Ohio State University, Columbus, OH 43210.

April 16-18, 1984---MIAMI INTERNATIONAL SYMPOSIUM ON THE BIOSPHERE. For more information contact: Ms. Grace Mayfield, Miami International Conference on the Biosphere, Clean Energy Research Institute, University of Miami, PO Box 248294, Coral Gables, FL 33124.

April 25-27, 1984 SOUTH DAKOTA ENVIRONMENTAL HEALTH ASSOC. ANNUAL MEETING. Staurolite Inn, South Dakota State University, Brookings, SD. For more information contact: Morris V. Forsting, Secretary-Treasurer, 1320 S. Minnesota Ave., Room 101, Sioux Falls, SD 57105.

May 7-11, 1984---INTERNATIONAL MILK PROTEIN CONGRESS. For more information contact: International Milk Protein Congress, Congress Secretariat, PO Box 399, 5201 AJ's-Hertogenbosch, The Netherlands.

June 10-14, 1984, 50th ANNUAL EDUCATIONAL CONFERENCE of the Canadian Institute of Public Health Inspectors. For information contact: J. Dunlop, CPHI (C), 1984 National Educational Conference Committee, Canadian Institute of Public Health Inspectors, 444 Sixth Street N.E., Medicine Hat, Alberta, Canada T1A 5P1.

August 5-9, 1984---IAMFES ANNUAL MEETING, Edmonton, Alberta, Canada.

Nov. 22-24, 1984---14th ANNUAL SYMPOSIUM ON THE ANALYTICAL CHEMISTRY OF POLLUTANTS, 3rd International Congress on Analytical Techniques on Environmental Chemistry-Expoquimia, Barcelona Spain. For more information write: Av. Reina Ma. Christina Palacio No. 1, Barcelona-4 Spain.

1985

May 20-23, 1985, FOODANZA '85, joint convention of the Australian and New Zealand Institutes of Food Science and Technology. To be held at the University of Canterbury, Christchurch, New Zealand. For more information contact: D. R. Hayes, Convention Secretary, 394-410 Blenheim Road, PO Box 6010, Christchurch, New Zealand.

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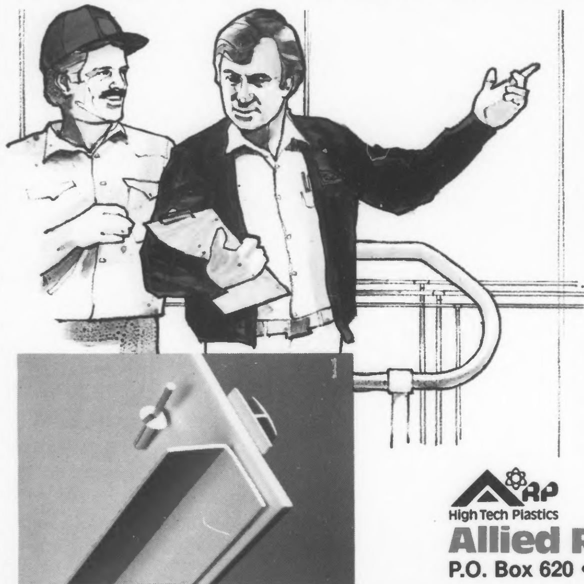

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JFP Abstracts

Abstracts of papers in the October Journal of Food Protection

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Colony-Forming Unit Enumeration by a Plate-MPN Method, S-T. Tan, R. B. Maxcy and W. W. Stroup, Department of Food Science and Technology; Biometrics and Information Center, University of Nebraska-Lincoln, Lincoln, Nebraska 68583-0919

J. Food Prot. 46:836-841

Concepts of the standard surface plate method and the most probable number method (MPN) were combined to provide a new enumeration technique (plate-MPN). Three discrete 0.01-ml samples of an appropriate decimal dilution were inoculated onto each quadrant of a pre-dried petri plate. The discrete spots from the inoculum were then observed for growth after incubation. Results were interpreted analogous to a 3-tube MPN test using presently available tables. Application of the test to pure cultures and mixed flora provided no evidence to indicate the plate-MPN technique to be any less accurate than the standard technique for microbial counts. The plate-MPN technique was less precise than the standard technique. However, the plate-MPN technique has many advantages over traditional methods.

Effects of Wholesale and Retail Contamination on the Case Life of Beef, G. Gordon Greer, L. E. Jeremiah, and G. M. Weis, Agriculture Canada, Research Station, Lacombe, Alberta, Canada, T0C 1S0

J. Food Prot. 46:842-845

To determine effects of wholesale and retail contamination on steak retail case life, rib steaks were fabricated from wholesale beef ribs using laboratory-simulated extremes of retail processing sanitation. Steak retail case life was more highly correlated with the psychrotrophic bacterial load on the surface of wholesale ribs and retail steaks than with the level of retail processing sanitation. Although steak case life could be predicted as a function of both steak and rib bacterial loads or rib and retail equipment bacterial loads the, following is recommended as the most useful predictor of case life: Steak Case Life (days) = 3.97 − 0.19 (log bacteria/cm^2 on wholesale ribs) − 0.14 (log bacteria/cm^2 on retail processing equipment). This equation could also be used by the retailer to assess the quality of wholesale product received from different suppliers.

Effect of Polyphosphates in Combination with Nitrite-Sorbate or Sorbate on *Clostridium botulinum* Growth and Toxin Production in Chicken Frankfurter Emulsions, K. A. Nelson, F. F. Busta, J. N. Sofas and M. K. Wagner, Department of Food Science and Nutrition, University of Minnesota, St. Paul, Minnesota 55108

J. Food Prot. 46:846-850

Sodium nitrite, sorbic acid, potassium sorbate and polyphosphates (sodium acid pyrophosphate, SAPP; sodium hexametaphosphate, SHMP; and sodium tripolyphosphate, STPP) were tested at similar preadjusted (before cooking) pH levels (in the range of pH 5.78 to 6.19 after cooking) to determine effective combinations capable of controlling *Clostridium botulinum* growth and toxin production in mechanically deboned chicken meat frankfurter emulsions incubated at 27°C. In combination with low levels of nitrite (40 ppm), potassium sorbate (0.26%, pH 6.06) was more effective than sorbic acid (0.20%, pH 6.03) in delaying toxin production (>27 d vs. 6 d) and in controlling growth. In formulations containing combinations of nitrite (40 ppm) and sorbic acid (0.20%) or nitrite (40 ppm) and potassium sorbate (0.26%), the addition of polyphosphates (0.4%) resulted in a greater delay of toxin production (8 to 25 d for nitrite-sorbic acid-SAPP vs. 28 d for nitrite-potassium sorbate-SAPP) at similar pH levels. Under these conditions, SAPP delayed production of detectable toxin longer (25 d) than did either SHMP (6 to 11 d) or STPP (4 to 14 d). The addition of polyphosphates to nitrite-free emulsions containing sorbic acid (0.20%) or potassium sorbate (0.26%) did not delay the development of botulinal toxin when the pH was essentially equivalent in the range of 5.78 to 6.07.

Rapid Cultural Methods for Detection of *Salmonella* in Feeds and Feed Ingredients, J.-Y. D'Aoust, A. Sewell and A. Boville, Health Protection Branch, Health and Welfare Canada, Sir Frederick Banting Research Centre, Ottawa, Ontario, Canada K1A 0L2

J. Food Prot. 46:851-855

Efficacy of standard, 6-h standard and direct enrichment methods for detection of *Salmonella* in naturally contaminated feeds and feed ingredients was compared. Analysis by the standard method involved preenrichment of feed slurries in nutrient broth, selective enrichment in tetrathionate brilliant green (43°C) and selenite cystine (35°C), and isolation of presumptive isolates on bismuth sulfite and brilliant green sulfa agar media. Sample analysis by the 6-h standard method was identical to the above except that incubation of enrichment broths was reduced to 6 h; for direct enrichment, preenrichment in nutrient broth was omitted. Of 287 samples tested, 75 were found to contain salmonellae by the three methods combined. Ability of the standard and 6-h standard methods to identify the same 58 contaminated samples underlines the reliability of the 6-h standard method for the more rapid detection of *Salmonella* in animal feeds. Identification of 68 positive samples by direct enrichment presumably resulted from equilibration (3 to 4 h) of feed slurries at reduced water activity before analysis. Addition of novobiocin (40 μg/ml) to selective enrichment broths did not facilitate isolation of *Salmonella* through repression of competitive flora. Productivity of the six enrichment-plating combinations used in this study was comparable, and no single medium played a determinant role in recovery.

Pathogenicity of *Yersinia enterocolitica* Demonstrated in the Suckling Mouse, Calvin C. G. Aulisio, Walter E. Hill, John T. Stanfield and J. Anthony Morris, Division of Microbiology, Food and Drug Administration, Washington, D.C. 20204 and Bell of Atri, Inc., College Park, Maryland 20740

J. Food Prot. 46:856-860

An experimental suckling mouse intraperitoneal injection test was compared with four plasmid-associated tests (adult mouse peroral exposure, adult mouse intraperitoneal injection, autoagglutination and plasmid detection by gel electrophoresis) to measure *Yersinia enterocolitica* pathogenicity. Of eight Vwa plasmid-harboring strains (O:3; O:4,32; O:5,27; O:8; O:9; O:13; O:21; and O:Tacoma) and one isogenic plasmidless strain (O:8), all Vwa plasmid-harboring strains gave identical results in all tests except the two adult mouse tests. In studies of 35 clinical strains of *Y. enterocolitica* recently isolated during two foodborne outbreaks, a comparison of the autoagglutination, gel electrophoresis for Vwa plasmid detection and suckling mouse tests showed that 29 strains (83%) gave identical results in all three tests. The other six strains produced different reactions in the plasmid detection and autoagglutination tests, indicating that neither test alone is sufficient to evaluate the virulence of *Y. enterocolitica*. To compare the sensitivity of these in vitro tests with a biological assay (the suckling mouse intraperitoneal injection test), a mixture of plasmid-harboring (P+) and plasmidless (P−) isogenic *Y. enterocolitica* cells was examined. The suckling mouse test was more sensitive and consistent in detecting the Vwa plasmid (as evidenced by mouse lethality). A bacterial population containing 0.1% P+ cells induced a lethal infection in the suckling mouse, whereas the other two tests required at least 10% P+ cells for detection of the Vwa plasmid. The 50% lethal dose (LD_{50}) in the suckling mouse was directly proportional to the number of Vwa-harboring cells in the culture.

Extraction of Botulinum Toxin with Urea-Buffer, Yinchun Wang and Hiroshi Sugiyama, Food Research Institute and Department of Bacteriology, University of Wisconsin, Madison, Wisconsin 53706

J. Food Prot. 46:861-863

Portions of wieners and soybean foods (tofu and tempeh) remaining from inoculated pack studies using *Clostridium botulinum* spores were extracted with buffers which differed in having or not having 2 M urea. More samples had botulinum toxin when tested with extracts made in urea-buffer. Based on the LD_{50} of toxin extracted from wieners, urea-buffer extracted 30 to 100% more toxin than normal buffer.

Cryoprotectants Protect Lipopolysaccharide Molecules of the Outer Membrane of *Escherichia coli* B. from Freeze-Damage, Bibek Ray, Department of Animal Science, University of Wyoming, Laramie, Wyoming 82071

J. Food Prot. 46:864-867

Lipopolysaccharide (LPS) molecules of the outer membrane (OM) of *Escherichia coli* B were damaged by freezing and thawing as evidenced by lysozyme lysis of cells frozen in water and their inability to adsorb LPS-specific phages. Permeating cryoprotectants, i.e., glycerol and dimethylsulfoxide (DMSO), protected this damage effectively, as the frozen cells were resistant against lysis by lysozyme and were able to adsorb phages. In contrast, non-permeating cryoprotectants, i.e., polyvinylpyrrolidone (PVP) and dextran, protected LPS molecules so that frozen cells were resistant against the lytic effect of lysozyme but were not able to adsorb specific phages effectively. Although all four cryoprotectants protected cells against viability loss due to freezing, survival was much higher with glycerol and DMSO than with PVP and dextran. The non-permeating cryoprotectants likely formed a physical barrier around the cell surface, whereas the permeating cryoprotectants did not form such a barrier.

Prevalence of *Campylobacter jejuni* at Different Sampling Sites in Two California Turkey Processing Plants, H. I. Yusufu, C. Genigeorgis, T. B. Farver and J. M. Wempe, Department of Epidemiology and Preventive Medicine, School of Veterinary Medicine, University of California, Davis, California 95616

J. Food Prot. 46:868-872

A prevalence survey for *Campylobacter jejuni* from 12 sites was made in two turkey processing plants. Both plants are federally inspected but differ in the age of birds slaughtered (18 and 24 wk for plant A and B, respectively) and scald water temperatures (2.5 min at 60°C and 3 min at 57.2°C for plants A and B, respectively). A total of 594 samples were taken during the period May to July 1982. Isolation rates for individual sites and plant A and B, respectively, were as follows: feathers 23.3 and 3.3%, scald water overflow 5.7 and 5.6%, feather picker drip water 66.7 and 94.4%, recycled water for cleaning gutters 77.8 and 77.8%, ceca 86.7 and 93.3%, final carcass wash water 61.1 and 27.8%, neck skin before chiller 36.7 and 10%, chiller water overflow 0 and 44.4%, neck skin after chiller, hearts, livers, wings and mechanically deboned meat 0 and 0%. These isolation rates were based on detection levels of >10 cells/ml or g for all water samples, skin and deboned meat, >100 cells/g for feathers, heart, liver or wing and >1000 cells/g for fecal samples. Mean cell counts per gram of feces were $\log_{10}$ 5, with a range of $\log_{10}$ 3.4 to $\log_{10}$ 6.8. The defeathering equipment contributed significantly to cross-contamination. Use of chlorinated water in the chillers at 14 to 18 ppm levels may be responsible for the absence of *C. jejuni* in the edible turkey parts.

Keeping Quality and Flavor, and Microorganisms, Proteases and Lipases in Raw Cow and Goat Milk at Collection and After Storage, Lester Hankin and Donald Shields, Department of Biochemistry and Genetics, The Connecticut Agricultural Experiment Station, New Haven, Connecticut 06504 and Dairy Division, Connecticut Department of Agriculture, Hartford, Connecticut

J. Food Prot. 46:873-877

Raw cow and goat milks for retail sale in Connecticut were examined at collection and after storage at 4.4 and 7.2°C for 7 d for keeping quality, flavor, microorganisms, protein degradation on storage, and protease and lipase activity. Some milks were bottled at the farm, others were placed in containers supplied by the customer. Goat milk retained a satisfactory flavor significantly longer than cow milk. There was no correlation of keeping quality with any microbial count made at collection except for

number of coliform bacteria. Significant differences were found in enzyme activity and protein degradation between cow and goat milk. No significant difference was found between milk bottled at the farm and that collected in sterile containers. Over 82% of raw milk samples met the 30,000 per ml state standard for total aerobic count (SPC) and 72% met the coliform standard of 50 per ml.

Storage and Display-Life Characteristics of Beef as Affected by Prerigor Pressurization, Mohammad Koohmaraie, Walter H. Kennick, Elgasim A. Elgasim, Robert L. Dickson and William E. Sandine, Clark Meat Science Laboratory, Department of Animal Science, Oregon State University, Corvallis, Oregon 97331

J. Food Prot. 46:878-882

Top round cuts were obtained from sixteen sides of utility cows. Eight sides were randomly assigned as control (CON) and the remainders were prerigor pressurized (PRP) at 15,000 psi for 2 min. The top round from each side was divided into 4 wholesale cuts, vacuum packaged, heat-shrunk and randomly assigned to 0, 3, 5 or 7 weeks of storage at -1.6 ± 1°C. Upon completion of each storage interval, wholesale cuts were removed from the storage area, purge losses determined and samples for microbial counts obtained. Two boneless steaks were prepared from each wholesale cut and displayed for 5 d at 1-3°C with 1076 lux fluorescent lighting for 12 h each day. Purge loss differed ($P<0.05$) only for the 5th week of storage. Wholesale cuts from PRP and CON had similar microbial counts at 0 and 3 weeks, while CON samples had higher microbial counts at 5 and 7 weeks. For all storage intervals, muscle color of the displayed steaks was improved ($P<0.05$) for the first 4 d of the display period by the PRP treatment. PRP steaks were consistently less discolored for all storage intervals. PRP improved the overall desirability of the displayed steaks throughout the experiment. Steaks prepared from PRP and CON wholesale cuts had the same microbial counts at 0 and 3 weeks of storage while CON steaks had higher and in most instances significantly higher microbial counts for 5 and 7 weeks. PRP had no apparent detrimental effects on the storage or display-life characteristics of meat, instead it beneficially influenced most of the parameters that were examined in this experiment.

Prevalence of Viable *Lactobacillus acidophilus* in Dried Commercial Products, Merry Brennan, Bahijah Wanismail and Bibek Ray, Department of Animal Science, University of Wyoming, Laramie, Wyoming 82071

J. Food Prot. 46:887-892

Samples of 27 dried acidophilus products used as dietary adjuncts for *Lactobacillus acidophilus* in humans, were enumerated for viable cells on plate count agar (PCA), MRS broth plus 1.5% agar (MRSA) and MRSA plus 0.15 % oxgall (MRSOA). Colony-forming units did not differ greatly on plating media because most viable cells formed colonies aerobically, anaerobically or in the presence of bile salts. Health food samples had very low numbers of viable cells and counts varied between samples from different lots. Only one of four brands from the health food group had viable *L. acidophilus* cells. Samples from this group had organisms other than lactobacilli, including coliforms and gram-negative, lactose-negative, motile rods. Most pharmaceutical and milk culture samples had high numbers of viable cells, but only two brands from pharmaceutical samples had viable cells of *L. acidophilus*. *L. acidophilus* strains were susceptible to drying, with vacuum drying being more lethal than freeze drying.

Organochlorine and Organophosphorus Residues in Fat of Bovine and Porcine Carcasses Marketed in Ontario, Canada from 1969 to 1981, R. Frank, H. E. Braun and G. Fleming, Agricultural Laboratory Services, Provincial Pesticide Residue Testing Laboratory, Ontario Ministry of Agriculture and Food, % University of Guelph, Guelph, Ontario N1G 2W1 and Livestock Inspection Branch, Ontario Ministry of Agriculture and Food, Toronto, Ontario, Canada

J. Food Prot. 46:893-900

Between 1969 and 1981, 2482 bovine and 554 porcine carcasses were sampled at provincially inspected abattoirs across Ontario. Abdominal fats were composited into 505 bovine and 122 porcine samples for analyses of organochlorine insecticides and industrial chemicals. Mean ΣDDT residues decreased from 257 μg/kg in 1969-70 to 12 μg/kg in 1981 for bovine fats and from 356 μg/kg in 1971-72 to 5 μg/kg in 1981 for porcine fats. Similar decreases in residue levels were observed for PCB. Dieldrin, with lower initial residues (i.e. 33 μg/kg in bovine fat and 12 μg/kg in porcine), decreased an order of magnitude over this same period. All decreases fitted first order logarithmic regression equations. Chloradane and heptachlor epoxide were rarely observed in bovine or porcine fat; however, the incidence in bovine fat increased after 1973 following the removal of aldrin, dieldrin and heptachlor in 1969 for soil insect control and the subsequent increased use of chlordane. Chlordane appeared at low levels (1-2 μg/kg) in bovine fat during the mid 1970s and remained detectable through 1981. Lindane residues in both bovine and porcine fat fluctuated from year to year and appeared to vary with the need to control insect pests. While present (2 to 39 μg/kg) in the early 1970s, lindane residues disappeared by mid 1970 but reappeared in fatty tissues in 1981 (3-13 μg/kg). A limited number of samples were analyzed for organophosphorus insecticides between 1973 and 1980 and residues were occasionally found. In 1981, the analyses became routine and 3.6% of bovine samples were found to contain detectable residues of fenthion; only 2 of 197 bovine samples exceeded the maximum residue levels permitted under the Food and Drug Act.

Bacteriological Quality of Fresh Seafood Products from Seattle Retail Markets, Carlos Abeyta, Jr., U.S. Department of Health and Human Services, Food and Drug Administration, Seafood Products Research Center, Seattle, Washington 98174

J. Food Prot. 46:901-909

A microbiological survey of 287 (fresh) seafood products from Puget Sound retail markets was conducted over a period of 1 year. The microbiological quality of fresh seafood was high, with only 2.1% of the samples exceeding the maximum limit for acceptability as suggested by the International Commission on Microbiological Specifications for Foods (ICMSF). The overall microbiological data of positive units given as arithmetic means were: coliforms MPN/g, 199; *Escherichia coli* MPN/g, 21;

coagulase-positive *Staphylococcus aureus* MPN/g, 66; enterococci/g, 9121; *Clostridium perfringens*/g, 18; *Bacillus cereus*/g, 100; and *Vibrio parahaemolyticus* MPN/g, 3.7. The standard plate count means 1.0×10^3 to 2.5×10^7 colony-forming units (CFU)/g, giving a mean value of 2.0×10^5 CFU/g. The percentages of seafood samples positive for pathogens were *S. aureus*, 37.6; *Yersinia enterocolitica*, 3.8; *V. parahaemolyticus*, 2.8; *C. perfringens*, 2.4; and *B. cereus*, 0.7. *Vibrio cholerae*, *Clostridium botulinum*, *Salmonella* and *Shigella* species were not isolated.

Behavior of Aflatoxin M_1 During Manufacture and Storage of Queso Blanco and Bakers' Cheese, Dana W. Wiseman and Elmer H. Marth, Department of Food Science and the Food Research Institute, University of Wisconsin-Madison, Madison, Wisconsin 53706

J. Food Prot. 46:910-913

Queso Blanco and bakers's cheese were prepared from milk naturally contaminated with aflatoxin M_1 (AFM_1), and then were stored at 4°C and at -23 ± 6°C for 2 months. AFM_1 was found in both curd and whey. There was a 2.84-fold increase of AFM_1 in curd of Queso Blanco cheese over the amount present in milk from which the cheese was made. The AFM_1 content of the cheese varied during refrigerated and frozen storage, but AFM_1 was present near initial levels at the end of storage. Bakers' cheese was prepared with and without added rennet. More AFM_1 was found in cheese and whey than in milk from which cheese was made. AFM_1 tended to be concentrated in curd. Cheeses made without rennet had greater enrichment (4.24-fold increase over that found in milk) than those made with rennet (2.97-fold increase over that found in milk). The AFM_1 content in both types of cheese was variable but toxin remained in cheese through 1 month of refrigerated and 2 months of frozen storage.

Evaluation of Five Miniaturized Systems for Identifying *Enterobacteriaceae* from Stock Cultures and Raw Foods, N. A. Cox, J. S. Bailey and J. E. Thomson, United States Department of Agriculture, Agricultural Research Service, Richard B. Russell Agricultural Research Center, Athens, Georgia 30613

J. Food Prot. 46:914-916

Five miniaturized systems (API, Enteric-Tek, Enterotube II, Micro-ID and Minitek) were compared to conventional procedures for identification of *Enterobacteriaceae* from stock cultures and freshly isolated from food sources. The accuracy of identification to genus was 98% for Micro-ID; 95%, Minitek; 94%, Enteric-Tek; 93%, API; and 86%, Enterotube II. Accuracy of identification to species was 97% for Micro-ID; 94%, Minitek; 93%, Enteric-Tek; 91%, API; and 79%, Enterotube II. The 124 organisms tested in this study were from 11 genera of the *Enterobacteriaceae* family. All systems accurately identified to species the most pathogenic members of the family (*Arizona hinshawii*, *Salmonella typhi*, *Salmonella typhimurium* and *Shigella flexneri*). Most of the inaccuracies in identification occurred with *Enterobacter* and *Serratia* species.

Sterol Oxides in Foodstuffs: A Review, E. Terry Finocchiaro and T. Richardson, Department of Food Science, University of Wisconsin-Madison, Madison, Wisconsin 53706

J. Food Prot. 46:917-925

The toxicological significance of oxidized cholesterol has been well documented in numerous studies. This review focuses on the analysis of dietary sterol oxides in the foodstuffs examined to date with particular emphasis on isolation and characterization techniques. Eight common oxidation products of cholesterol have been identified in certain cholesterol-rich foods subjected to oxidative stress during food processing and/or storage. These products include 25-hydroxycholesterol, α or β 5,6-epoxycholesterol, α or β 7-hydroxycholesterol, 7-ketocholesterol, cholesta-3,5-dien-7-one and cholestane-3β, 5α, 6β-triol. A limited number of studies on the biological effects of dietary phytosterol oxides indicate these products may also be of nutritional concern. Four common autoxidation products of β-sitosterol have been identified in edible oils; these include α or β 7-hydroxysitosterol, 7-ketositosterol and setosta-3,5-dien-7-one. Few quantitative data are available on the sterol oxide content of foods. Moreover, studies without apparent precautions against the artifactual formation of sterol oxides may be flawed. Additional research is necessary to adequately identify and quantify the sterol oxides which most likely exist in certain foods.

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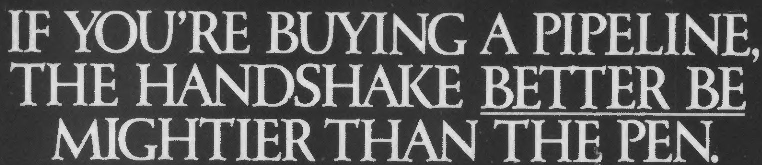

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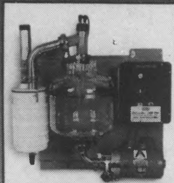

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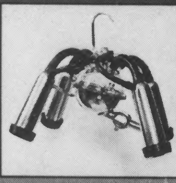

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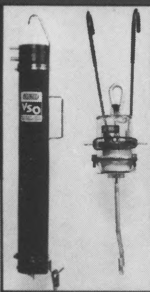

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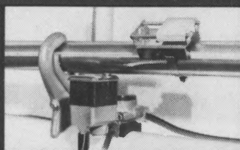

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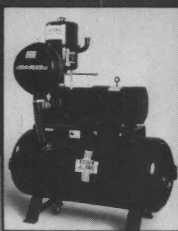

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