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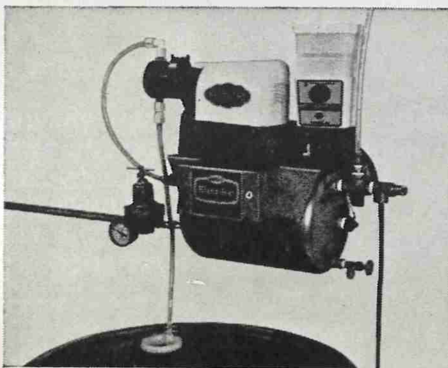

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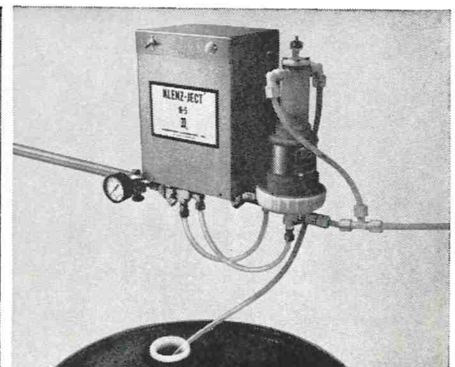

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A SCREENING MEDIUM AND METHOD TO DETECT SEVERAL MYCOTOXINS IN MOLD CULTURES[1]

L. B. Bullerman

Department of Food Science and Technology
University of Nebraska, Lincoln, Nebraska 68503

(Received for publication September 6, 1973)

Abstract

A single culture medium consisting of rice powder (5%), corn steep liquor (4%), and agar (2%) was tested as a substrate for mycotoxin production using 34 known toxinogenic mold strains. Aflatoxins, ochratoxin A, sterigmatocystin, penicillic acid, patulin, citrinin, and zearalenone were each detectable in 4 days of incubation at 25 C using this medium. Extraction of melted agar cultures, in screw cap test tubes, with hot chloroform (55 C) followed by cooling to resolidify the agar greatly facilitated and simplified the extraction process and eliminated the need for separatory funnels. Mycotoxins were detected by treating developed thin-layer chromatographic plates with ammonia fumes, p-anisaldehyde, and phenylhydrazine and then viewing the chromatoplates under ultraviolet and white lights.

The increasing significance of mycotoxins as potential public health hazards has aroused interest in examination of certain foods and feeds for the presence and incidence of toxinogenic molds. While occurrence of toxin producing molds in a product does not necessarily mean that mycotoxins are present, knowledge of the contamination of foods with these types of molds is of interest, and can be significant when making an assessment of potential public health hazards associated with the flora of a product. Therefore, it is often desirable to screen molds isolated from foods and feeds for their ability to produce several mycotoxins.

Screening mold isolates for mycotoxin production is complicated by the fact that toxin production is influenced by substrate. Most workers have used various media, large cultures, and long incubation times *(3)*. This can involve considerable time, work, and expense in screening numerous mold isolates, particularly if it is desirable to screen for several mycotoxins. A single medium that would support production of detectable quantities of several mycotoxins would, therefore, help to reduce the amount of work required. Further, such a test if sufficiently sensitive at the test tube level would require much less media and solvents and would thereby reduce costs as well as simplify methodology. Finally, if incubation times could be reduced to 3 to 4 days, a considerable savings in time would result.

Media that have been used to screen mold isolates for aflatoxin production include rice *(6)*, yeast extract sucrose (YES) broth *(2)*, and shredded wheat *(9)*. Scott et al. *(4)* reported a "semimicro culture technique" using 5 ml cultures of YES broth in 30-ml vials, extraction of the cultures with chloroform, and a thin-layer chromatographic (TLC) method of testing mold extracts for mycotoxins. However, some mycotoxins were not produced on YES broth.

The work reported here describes a single agar medium suitable for production of detectable quantities of several mycotoxins and a simplified extraction process.

Materials and Methods

Preliminary studies compared several solid and semi-solid media in test tube quantities for production of aflatoxin, penicillic acid, and patulin. The media tested included yeast extract sucrose broth + 2% agar, potato dextrose agar (Difco), moistened whole long grain white rice, potato dextrose agar + yeast extract (2%) and corn steep liquor (4%), and several combinations of ground raw rice, corn steep liquor, and agar. These preliminary results showed a rice powder-corn steep agar medium consisting of 5.0% rice powder, 4.0% corn steep liquor (Grain Processing Corp., Muscatine, IA) and 2% agar (Difco) to be the most promising. This medium was then studied further using molds able to produce several additional mycotoxins.

Since raw rice could be contaminated with mycotoxins, a sample of the rice to be used was extracted with chloroform and examined using thin-layer chromatography. Rice powder was prepared by pulverizing dry raw rice in an electric blender. All ingredients were suspended in distilled water and heated to boiling to dissolve the agar. Five-milliter quantities of the medium were then dispensed into 16 × 150 mm screw cap test tubes, fitted with teflon lined caps, and sterilized at 121 C for 15 min. After sterilization each tube was inverted several times to resuspend the gelantinized rice powder, and then laid flat on it's side to form an agar surface that extended the full length of the tube. This technique provides more agar surface area than the conventional agar slant technique. The 5-ml volume was just enough to bring the agar layer flush with the neck of the tube.

This medium was then tested as a substrate for production of aflatoxins, ochratoxins, sterigmatocystin, penicillic acid, patulin, citrinin, and zearalenone using known toxin producing cultures obtained from numerous sources (Table 1). The tubed agar was streaked with a heavy loopful of spores from

[1]Published as Paper No. 3679, Journal Series, Nebraska Agricultural Experiment Station, Lincoln. Research reported was conducted under Project No. 16-22.

TABLE 1. MYCOTOXINS DETECTABLE USING KNOWN TOXIN PRODUCING MOLDS GROWN 4 DAYS ON RICE POWDER-CORN STEEP AGAR AT 25 C.

Mold	Strain numbers	Known toxin produced	Toxin detected
Aspergillus flavus	HS 4[a]	Aflatoxins B_1, B_2	Aflatoxins B_1, B_2
	NRRL A16100, HS10[a]	B_1, B_2, G_1, G_2	B_1, B_2, G_1, G_2
A. parasiticus	NRRL 2999, NRRL 3000, IMI 15957	Sterigmatocystin	Sterigmatocystin
A. versicolor	FDA-M1069[b], FDA M1073[b], IMI 16139	Ochratoxin A and Penicillic acid	Ochratoxin A and Penicillic acid
A. ochraceus	ATCC 18641, ATCC 18642		
	M199[c], NRRL 3174	Ochratoxin A	Ochratoxin A
A. melleus	NRRL 3520		
A. sulphureus	NRRL 4077		
Penicillium cyclopium	NRRL 1888	Penicillic acid	Penicillic acid
P. martensii	NRRL 3612		
P. puberulum	NRRL 3564		
P. urticae	NRRL 1953, M1[d], 6 isolates[e]	Patulin	Patulin
P. patulum	NRRL 1952, NRRL 991, NRRL 992		
	NRRL 994, M108[c]		
P. claviforme	NRRL 1002		
P. citrinum	NRRL 1843	Citrinin	Citrinin
Fusarium roseum (graminearum)	Mapleton 10[f]	Zearalenone	Zearalenone

[a]H. S. Schroeder Texas A & M University
[b]A. F. Schindler, Food and Drug Administration
[c]Food Science & Technology Dept., University of Nebraska
[d]Agronomy Dept., University of Nebraska
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a 10 day old potato dextrose slant culture of the mold to be tested in way to completely cover the surface of the agar and allow for as much growth as possible within a short time. Inoculated slants were incubated at 25 C for 4, 7, and 10 days.

Following each incubation period tubes were given a very short high temperature heat treatment (121 C for 30 sec) to kill the mold and melt the agar. In the extraction process which follows, all operations dealing with chloroform were carried out in an exhaust hood. The molten agar and mold mat were extracted with 20 ml of hot chloroform (55 C) by shaking for 3 min. Following extraction, the tubes were inverted and on cooling the aqueous agar layer came to the surface of the chloroform, and re-solidified. The chloroform extract was then drained off and filtered through Whatman No. 4 filter paper and 1 g of anhydrous sodium sulfate. When teflon lined screw caps were not available and there was danger of leakage, tubes were cooled in an upright position and hardened agar was punctured with a sharp instrument to allow drainage of chloroform. Since the test was intended for a qualitative screening, only one extraction was done and quantitative toxin recovery was not attempted. However, to determine the sensitivity of the test and the amounts of toxins being produced visual estimation of toxin concentrations by comparison with quantitative standards on TLC plates was done.

Extracts were concentrated by evaporation of chloroform on a steam bath in a fume hood to 0.5 ml and analyzed using thin-layer chromatographic (TLC) plates according to the method of Scott et al. *(4)*, modified to include an ammonia treatment *(1, 7, 8)*. The TLC plates containing aliquots of the extracts were examined for colored and fluorescent spots in visible, short wave, and long wave ultraviolet lights before and after treatment of the plates. Treatments, applied to separate TLC plates, included exposure to *(a)* ammonia fumes *(1, 7, 8)*, *(b)* p-anisaldehyde spray *(4)*, and *(c)* phenylhydrazine spray *(5)*. Concentrated ammonium hydroxide was used to provide ammonia fumes in a closed TLC developing chamber *(1, 8)*. The exposure time to ammonia was 6 min. Appropriate standards were included on each TLC plate and no extract was counted positive unless all three observations agreed with a corresponding standard. Sterigmatocystin was obtained from Calbiochem (La Jolla, CA), patulin was produced in our laboratory, and the remaining toxins were obtained from various workers in the field.

TABLE 2. MYCOTOXIN PRODUCTION BY *Aspergillus parasiticus* NRRL 2999 (AFLATOXINS), *Penicillium martensii* NRRL 3612 (PENICILLIC ACID) AND *P. patulum* M108 (PATULIN) ON SEVERAL MEDIA IN 4 DAYS OF INCUBATION AT 25 C

Media	Average amount of mycotoxin detected (μg/g)		
	Aflatoxins (B_1 + G_1)	Penicillic acid	Patulin
Yeast extract sucrose agar	10	4	8
Rice powder-corn steep agar	10	21	3
Potato dextrose agar	2.5	2	70
Potato dextrose agar + yeast extract + corn steep	10	7	0.5
Whole white rice	4.7	4	2.5

TABLE 3. MINIMUM AMOUNTS OF MYCOTOXINS DETECTED USING THINLAYER CHROMATOGRAPHY AND THE AVERAGE AMOUNTS PRODUCED BY SEVERAL MOLD STRAINS ON RICE POWDER-CORN STEEP AGAR IN 4 DAYS AT 25 C

Toxin	Minimum amount detected (μg)	Average amount produced (μg/g)
Aflatoxin B_1	0.0025	29.0
B_2	0.0030	0.3
G_1	0.0025	175.0
G_2	0.0030	1.9
Ochratoxin A	0.01	4.3
Sterigmatocystin	1.0	25
Penicillic acid	0.01	102
Patulin	1.0	106
Citrinin	0.02	79
Zearalenone	0.01	10

Results and Discussion

All of the media tested in the preliminary work, supported production of detectable quantities of the toxins studied (Table 2). Aflatoxins and penicillic acid were produced most abundantly on the rice powder-corn steep agar, but patulin was produced in highest amounts on potato dextrose agar. However, detectable quantities of patulin also were found on the rice powder-corn steep medium. Because this medium supported production of higher amounts of aflatoxins and penicillic acid, it's use as a common screening medium was studied further using additional mold strains.

All of the toxin producing molds tested produced detectable quantities of the respective mycotoxins within 4 days of incubation at 25 C on the rice powder-corn steep medium (Table 3). With the aflatoxins, toxin production sometimes was evident in 3 days. One strain of *A. flavus* (HS-4) was very weakly toxinogenic, but toxin production was still evident in 4 days at 25 C. Incubation beyond 4 days did not seem to offer any advantage and in some instances toxins disappeared with longer incubation. This phenomenon has previously been reported with aflatoxin production during prolonged incubation *(3)*. Of all of the toxins studied, aflatoxins (especially aflatoxin G_1) were produced the most abundantly on this medium. Penicillic acid, patulin, and citrinin were also produced in high amounts and were easily detectable. Sterigmatocystin, ochratoxin A, and zearalenone were produced in lesser but yet detectable amounts.

Extraction of liquid agar and allowing re-solidification of the agar on cooling greatly aided separation of the organic and aqueous phases. Removal of chloroform was simplified since the aqueous phase and mold mat remained in the bottom of the tube while the chloroform phase was drained off, thus eliminating the need for separatory funnels. When it was necessary to cool tubes in the upright position, chloroform removal was still relatively simple after puncturing the agar, and the complete aqueous phase again remained in the tube. Chloroform recovery by either method averaged 94%. Use of tests tubes for extraction reduced both the expense and time required for extraction since several tubes could be shaken simultaneously. Up to 30 separate cultures could be extracted and prepared for TLC analysis in less than 3 h by an experienced worker. Use of technical grade chloroform and the small volume also reduced expense.

Addition of the ammonia treatment to the TLC method of Scott et al. *(4)* increased the fluorescence of ochratoxin A *(8)* and converted penicillic acid *(1)* and patulin *(7)* to bright blue and pale blue fluorescent derivatives, respectively, which could be observed in long wave ultraviolet light. Fluorescence of aflatoxins and sterigmatocystin was evident without ammonia treatment. Aflatoxins were most easily detected because of their intensely fluorescent nature. The aflatoxins could be seen in long wave ultraviolet light using only one TLC plate since the ammonia and spray treatments were not necessary for visualization of this group of toxins.

While rice-powder corn steep agar is not an optimum substrate for formation of all of the toxins studied, it does supply the necessary factors for production of detectable quantities of the various mycotoxins mentioned. The medium and extraction method, when combined with the modified TLC method of Scott et al. *(5)*, represent a cheap, rapid, and convenient method for a preliminary screening of large numbers of molds for mycotoxin production. Positive cultures can be checked further under additional culture conditions and in bio-assays. The method has been used successfully in this laboratory to screen molds isolated from various food and feed products for production of mycotoxins.

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GLUCOSE INHIBITS GROWTH OF *CLOSTRIDIUM PERFRINGENS* IN FOOD PROTEINS[1]

D. J. SCHRODER[2] AND F. F. BUSTA
Department of Food Science and Nutrition
University of Minnesota, St. Paul, Minnesota 55101

(Received for publication August 30, 1973)

ABSTRACT

A study of the effects of food components on *Clostridium perfringens* growth indicated that the addition of D-glucose to sodium caseinate or to isolated soy protein greatly extended the lag phase of growth. A final concentration of 10 g glucose per liter in a sodium caseinate medium containing NaCl, K_2HPO_4, Na_2SO_4, and sodium thioglycollate increased the lag time of *C. perfringens* strain S40 to 3.5 h compared to 2 h for the control with no glucose. Growth was determined by colony count or absorbance (650 nm) measurement, or both. Addition of Trypticase (2 g/1) or Fe^{++}, Ca^{++}, or Mg^{++} cations (1 mM) relieved the glucose inhibition. Similar inhibition by glucose was also observed when amino acids replaced sodium caseinate and the amount of cations was controlled by adding low levels or by adding EDTA. Other sugars tested did not give this inhibitory effect. The extent of the lag time varied with glucose concentration or with level of the cell inoculum. There was a direct linear relationship between the molecules of added glucose per cell and the lag time. The mechanism appears to involve competition by food proteins for cations that affect the glucose transport system(s). These data indicate a potential control or at least delay for initial growth of *C. perfringens* in certain fabricated protein foods.

While studying the effects of food components on *Clostridium perfringens* growth *(18)*, we observed that addition of D-glucose to a sodium caseinate or isolated soy protein medium greatly extended the lag phase of growth. The explanation for this inhibition was not immediately apparent because *C. perfringens* has long been recognized as a saccharolytic heterofermentive microorganism which produces lactate, butyrate, and ethyl alcohol as well as CO_2 and H_2 from glucose *(2, 6)*. This retardation of growth had not been observed in a hydrolyzed casein medium, i.e., the commercial Thioglycollate Medium with Added Dextrose (BBL) which contains Trypticase. Our study was made to characterize the effects of glucose on growth with special attention toward extension of the lag phase in regular sodium caseinate and the stimulatory effect in a hydrolyzed casein medium.

MATERIALS AND METHODS

Test culture

An 18-h culture of *C. perfringens* S40 grown in Thioglycollate Medium without Added Dextrose (BBL) was centrifuged, washed in 6.25×10^{-4} M potassium phosphate buffer (2x), and inoculated at 10^7 cells/ml for absorbance studies or 10^4 organisms/ml for colony count measurements.

Sodium caseinate medium

Sodium caseinate solution (Domestic sodium caseinate, Land O'Lakes, Inc., Minneapolis, Minn.) was autoclaved separately (30 g/1).

The 10 $\times$ strength salts solution: 2.5 g NaCl (Merck & Co.), 1.5 g K_2HPO_4 (J. T. Baker Chemical Co.), 0.6 g sodium thioglycollate (BBL), 0.02 g sodium sulfite (Allied Chemical Corp.), in 100 ml H_2O was autoclaved separately.

Concentrated sugar solutions used in this study were filter sterilized. The test cation solutions: 0.1 g $MgSO_4 \cdot 7H_2O$/100 ml (Merck & Co.) and 0.05 g $CaSO_4 \cdot 2H_2O$/100 ml (Merck & Co.) were autoclaved separately; the solution of 0.05 g $FeSO_4 \cdot 7H_2O$/100 ml (Mallinckrodt) was filter sterilized. The ethlyenediamine tetraacetate (EDTA) solution consisted of 50 mg disodium and 80 mg tetrasodium EDTA (Eastman Organic Chemicals) in 100 ml H_2O, final pH 7.0, and was autoclaved. Trypticase solution consisted of 20 g Trypticase (BBL) in 100 ml H_20 and was autoclaved.

Colony count determinations

The apparatus and method of determining the growth of *C. perfringens* were described earlier *(5)*.

Absorbance measurements

Growth in the test media was followed by periodically measuring absorbance at 650 nm with a G. K. Turner spectrophotometer model 330 (G. K. Turner Associates, Palo Alto, California).

Test solutions

In absorbance studies, 6.7 ml sodium caseinate and 1.0 ml salts solution were added aseptically to 19 $\times$ 150 mm sterile tubes. To this, when appropriate, were added: 0.1 ml or specified amount of specific sugar solution, 0.1 ml or specified amount of each cation solution, 0.1 ml or specified amount of EDTA, or 1.0 ml Trypticase solution. The volume was adjusted to 10 ml with sterile water. The contents were mixed and steamed for 15 min before inoculation. In colony count studies, the same proportions of the ingredients were used with a total volume of 500 ml.

An amino acid medium was used to determine the effect of cation concentration in the absence of sodium caseinate. The amino acid solution of the same composition as casein *(11)* consisted of glycine 0.27 g, alanine 0.30 g, valine 0.72 g, leucine 0.92 g, isoleucine 0.61 g, proline 1.13 g, phenylalanine 0.50 g, cysteine 0.34 g, methionine 0.28 g, tryptophan 0.17 g, arginine 0.41 g, histidine 0.31 g, lysine 0.82 g, aspartic acid 0.71 g, glutamic acid 2.24 g, serine 0.63 g, threonine 0.49 g, and tyrosine 0.63 g per 100 ml H_20 (Calbiochem). This mixture was steamed 20 min. The composition of the growth factor solution was *(17)*: riboflavin 0.5 mg, Ca-D-pantothenate 1.0 mg, pyridoxamine 0.5 mg, biotin 0.005 mg, nicotinic acid 1.0 mg, thiamine 1.0 mg, adenine sulfate 17.4 mg, and

[1]Paper No. 8261 Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul, 55101.
[2]Present address: Food Technology Section, Canada Department of Agriculture Research Station, Kentville, Nova Scotia, Canada.

uracil 10 mg per 100 ml H_2O (Calbiochem). The mixture of growth factors was steamed 20 min.

The amino acid growth medium was made up as follows: amino acid solution, 1.0 ml; growth factor solution, 1.0 ml; salts solution, 1.0 ml; cation solution (Fe_2SO_4-$MgSO_4$), 0.1 to 1.0 ml; EDTA, 0.1 to 1.5 ml (optional); glucose or lactose, 0.15 ml; and the volume was adjusted to 10 ml with sterile deionized water. All solutions were added aseptically to 19 × 150 mm sterile tubes, mixed, and steamed for 15 min before inoculation. The initial inoculum of *C. perfringens* cells was approximately 2 × 10^7/ml and growth was monitored by absorbance at 650 nm. Lack of contamination was verified by control samples.

The lag time was estimated from the intercept of the exponential growth slope with the initial inoculation level.

Lactic acid was determined by a modification of the method of Ling *(14)*. To 5.0 ml of sample the following ingredients were added in order and mixed thoroughly with each addition: 2.0 ml of $BaCl_2$ (Fisher Scientific Co., 98.8 g/1), 1.0 ml $ZnSO_4$ (Mallinckrodt, 225 g/1), and 1.0 ml NaOH (0.66 N). This mixture was filtered, and 4.0 ml of the filtrate was combined with 0.4 ml of a 1% $FeCl_2$ solution (Fisher Scientific Co.). Color change was read at 425 nm (Beckman Acta III). The readings were converted to percent lactic acid from a standard curve (0.01% to 0.2% lactic acid in a sodium caseinate solution).

The extent of protein hydrolysis was measured by a modification of the method of Hull *(10)*. Four milliliters of the sodium caseinate solution were treated with 4.0 ml of 0.72 N Trichloraectic acid (TCA), (Fisher Scientific Co.) and filtered. To 1.0 ml of the filtrate, 3.0 ml of 7.5% Na_2CO_3, (Merck and Co.) and 1.0 ml of a 1:3 dilution of Folin-Ciocalteau Phenol Reagent (Fisher Scientific) were added. The color change was measured at 650 nm (Beckman Acta III Spectrophotometer, Beckman Instruments, Inc., Fullerton, California). The readings were converted to mg/ml tyrosine from a standard curve.

RESULTS AND DISCUSSION

Characterization of glucose inhibition of C. perfringens in sodium caseinate

Addition of glucose, lactose, sucrose, mannose, or fructose to a Trypticase medium considerably decreased the generation time (Table 1). This is consistent with studies by Fuchs and Bonde *(7)* describing carbohydrates utilized by *C. perfringens.*

The effect of carbohydrate added to food proteins had not been determined. It was expected that addition of a carbohydrate source would also decrease generation times and increase the extent of growth. Initial studies demonstrated an inhibitory effect by glucose in a sodium caseinate or an isolated soy protein medium. This effect was more pronounced in the sodium caseinate medium, so all subsequent studies were done with sodium caseinate medium. Mannose appeared to have the same inhibitory effect as glucose. Other carbohydrates, sucrose, lactose, and fructose, were not inhibitory to growth of *C. perfringens* (data not presented).

The effect on colony count of *C. perfringens* of glucose added to sodium caseinate is shown in Fig. 1. Addition of glucose resulted in a lag time of 4.25 h compared to 2 h with the control. Addition of Trypticase (0.2%) to the sodium caseinate medium resulted in immediate growth without a measurable lag phase. The inhibitory effect of glucose in sodium caseinate is negated by the addition of 0.2% Trypticase to the medium (Fig. 1).

Further characterization of the glucose-sodium caseinate inhibition is shown in Fig 2. Addition of Fe^{++} cation (1 mM $FeSO_4 \cdot 7H_2O$) relieved the glucose-sodium caseinate inhibition. Addition of Fe^{++}

TABLE 1. THE INFLUENCE OF DIFFERENT CARBOHYDRATES ADDED TO TRYPTICASE ON *C. perfringens* GENERATION TIME.

Carbohydrate[a]	*C. perfringens* Generation time (min)
Trypticase Control	22.5
Raffinose	21.4
Sucrose	12.9
Lactose	15.4
Melibiose	22.6
D-Glucose	12.6
Mannose	13.6
D-Fructose	14.1
Rhamnose	22.7
Inositol	24.2

[a]Carbohydrate concentration 10g/l.

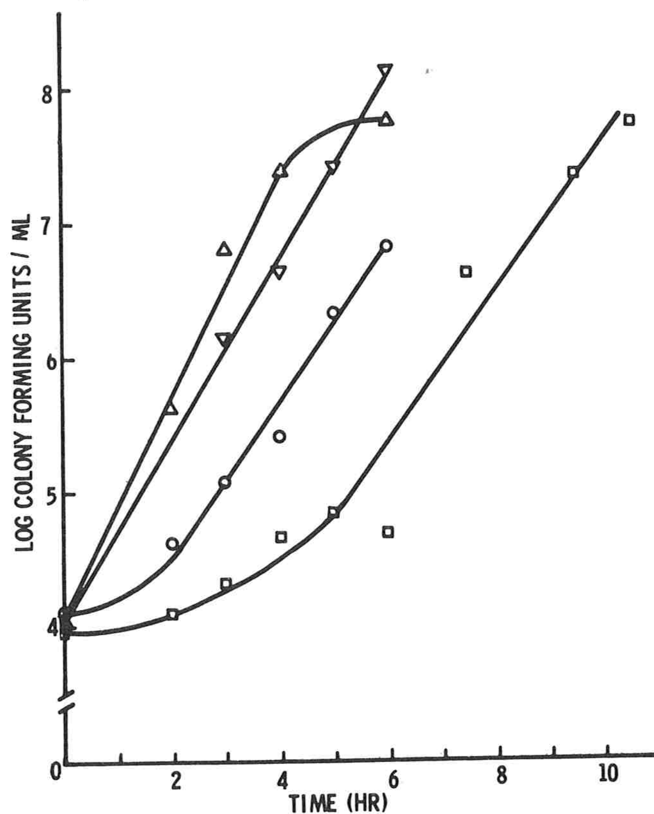

Figure 1. Effect of glucose added to sodium caseinate on the growth of *C. perfringens*. Symbols: open circles, sodium caseinate control; open squares, glucose + sodium caseinate; open inverted triangles, 0.2% Trypticase + glucose + sodium caseinate; open triangles, 0.2% Trypticase + sodium caseinate. Glucose concentration = 10g/1.

had no effect on *C. perfringens* growth in a sodium caseinate medium without added glucose. Addition of fructose or lactose to sodium caseinate did not give the same increased lag as was observed with glucose (data not presented). The inhibitory effect apparently was caused solely by glucose (or mannose) and relieved by addition of peptides (Trypticase) or Fe^{++}. These data imply that glucose had some effect on the proteinase system. This is consistent with other studies that have shown that Fe^{++} stimulated proteinases of *C. perfringens (4, 20).*

Pappenheimer and Shaskan *(15)* noted that if the Fe^{++} content of a medium was low, catabolism of glucose by *C. perfringens* shifted from a predominantly acetic-butyric acid type fermentation with production of large amounts of CO_2 and H_2 towards a purely lactic acid fermentation. Hauschild *(9)* observed that by lowering the pH, the exocellular protein production by *C. perfringens* was greatly reduced. This mechanism may have been involved in the glucose-sodium caseinate inhibition. A limited supply of Fe^{++} would result in a homolactic fermentation, thus lowering the pH. This could cause a decrease in the proteolytic enzymes produced and result in a longer lag in utilization of sodium caseinate as a nitrogen source.

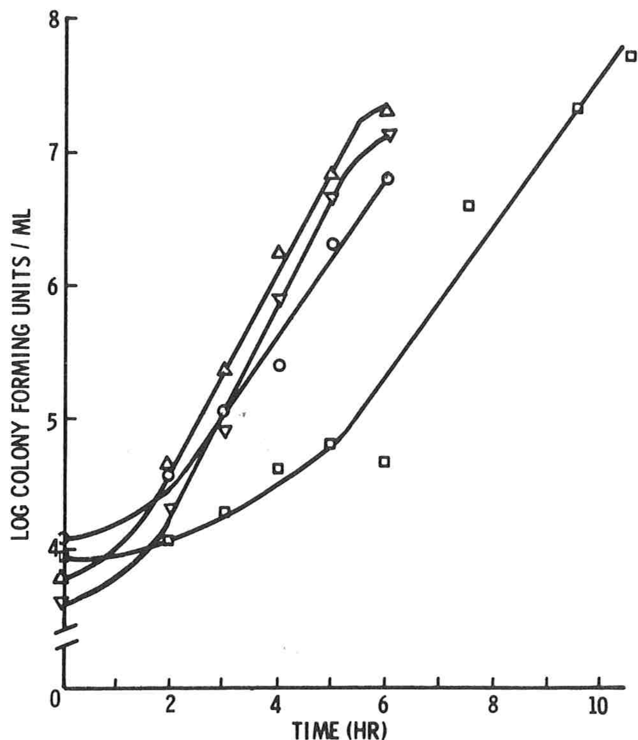

Figure 2. Effect of glucose added to sodium caseinate on the growth of *C. perfringens*. Symbols: open circles, sodium caseinate control; open squares, glucose + sodium caseinate; open inverted triangles, Fe^{++} + glucose + sodium caseinate; open triangles, Fe^{++} + sodium caseinate. Glucose concentration = 10g/1.

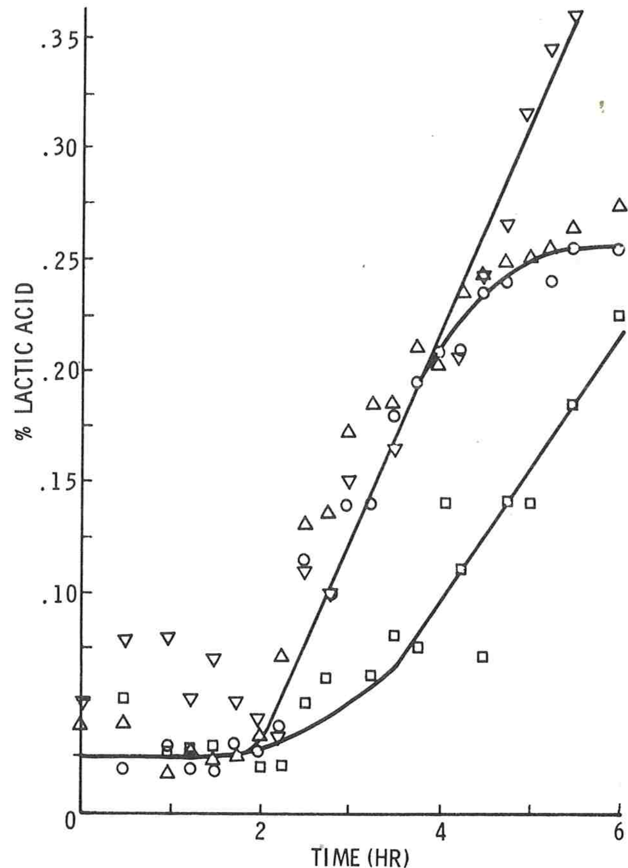

Figure 3. Lactic acid production by *C. perfringens.* Symbols: open circles, sodium caseinate medium; open squares, glucose-sodium caseinate medium; inverted open triangles, glucose-sodium caseinate-Fe^{++} medium; open triangles, sodium caseinate-Fe^{++} medium. Absorbance read at 425 nm and converted to percent lactic acid from a standard curve. Glucose concentration = 10g/1.

Production of lactic acid with and without added glucose was determined throughout growth of *C. perfringens* to evaluate the glucose-sodium caseinate inhibition. Data on production of lactic acid in a sodium caseinate medium supplemented with Fe^{++} or glucose or glucose + Fe^{++} are shown in Fig. 3. Lactic acid production closely paralleled growth of *C. perfringens.* That is, lactic acid was produced slowly in the presence of glucose and was produced faster when iron was added with glucose. These data suggested that lactic acid production in a glucose-sodium caseinate medium was not the cause of the glucose inhibition; or if lactic acid inhibition occurred in the micro-environment early in the growth of *C. perfringens,* the increase in lactic acid was not detectable by the method used.

A subsequent test was made to determine the effect of glucose on the ability of *C. perfringens* to hydrolyze sodium caseinate. Partial hydrolysis was determined by measuring the TCA solubles with Folin-Ciocalteau Phenol Reagent. To obtain a mea-

TABLE 2. THE EFFECT OF GLUCOSE CONCENTRATION ON LAG TIME OF *C. perfringens* IN SODIUM CASEINATE MEDIUM. GROWTH MEASURED BY ABSORBANCE AT 650 NM.

Glucose concentration (g/l)	*C. perfringens* lag time (h)
0 (Control)	3.0
0.3	1.5
1.0	1.5
2.5	1.5
5.0	2.5
10.0	4.0
30.0	6.0

surable effect, *C. perfringens* was inoculated at a level of 10^9 cells/ml. The effect of a glucose-sodium caseinate medium is shown in Fig. 4. Contrary to expectations, addition of glucose resulted in rapid hydrolysis of sodium caseinate. The glucose-sodium caseinate medium facilitated immediate hydrolysis without the lag in hydrolysis given by the control. The extent of hydrolysis was nearly two-fold that of the control.

These results in conjuction with a review of earlier preliminary findings in our laboratory suggested that glucose added to sodium caseinate was more inhibitory when the initial cell inoculum was low. The previous experiment showed that an inoculum of 10^9 cells/ml overcame the glucose inhibition. In further preliminary studies, a low glucose concentration stimulated growth of *C. perfringens* as much as had addition of higher glucose concentrations to a hydrolyzed protein source. Therefore, the effect of glucose concentration in a sodium caseinate medium was investigated.

Effect of cell and glucose concentration on growth of C. perfringens

Glucose-sodium caseinate inhibition was negated by increased cell concentrations in previous studies. In this study glucose was added to sodium caseinate in concentrations ranging from 0.3 to 30 g/l. Parallel studies were done substituting lactose for glucose. The effect of concentration is shown in Fig.. 5 and Table 2. Glucose concentrations of 10 g/l or higher resulted in increased lag times while 5 g/l or less shortened the lag time over that of the control. Concentrations of 2.5 g/l or less resulted in minimum lag times. Addition of 30 g/l glucose extended the lag to 6 h. These results confirmed a glucose concentration effect. This effect was evident only in the period of the lag, after which all growth rates in a glucose-sodium caseinate medium were similar. Lactose did not show this concentration effect. Lactose in concentrations of 2.5 to 30 g/l showed no effect in a sodium caseinate medium on growth of *C. perfringens*. The addition of lactose to glucose-sodium caseinate medium had no effect on relieving the extended lag (data not presented).

The effect of glucose concentration became more apparent when both cell inoculum and glucose concentration were varied (Table 3). The combination of 20 g/l added glucose and 2 × 10^7/ml cell inoculum resulted in a lag time of 8.5 h; 10 g/l added glucose and 2 × 10^7/ml cell inoculum resulted in a lag time of 4.25 h. Similarly, doubling the cell inoculum (from 2 to 4 × 10^7) with a glucose concen-

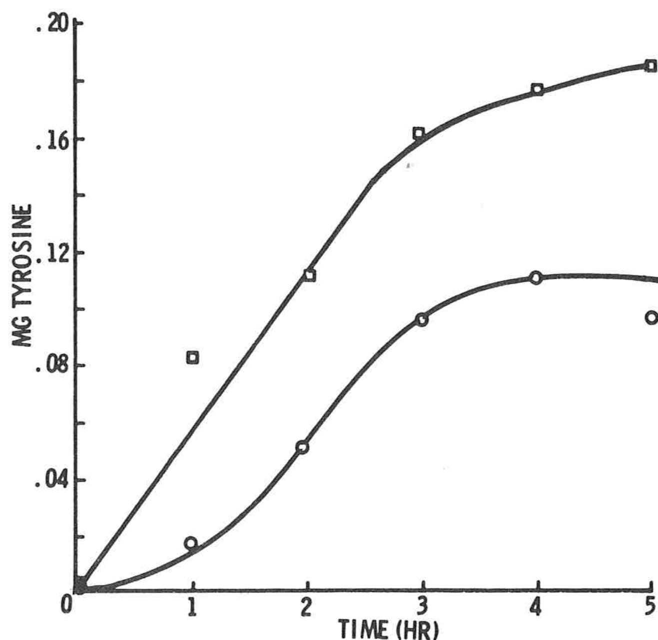

Figure 4. Sodium caseinate hydrolysis by *C. perfringens* in a sodium caseinate medium with and without added glucose. Symbols: open circles, sodium caseinate medium; open squares, sodium caseinate + glucose. Hydrolysis determined by Folin Ciocalteau Phenol Reagent, measured at 650 nm and converted to mg tyrosine/ml from a standard curve. Glucose concentration = 10g/l.

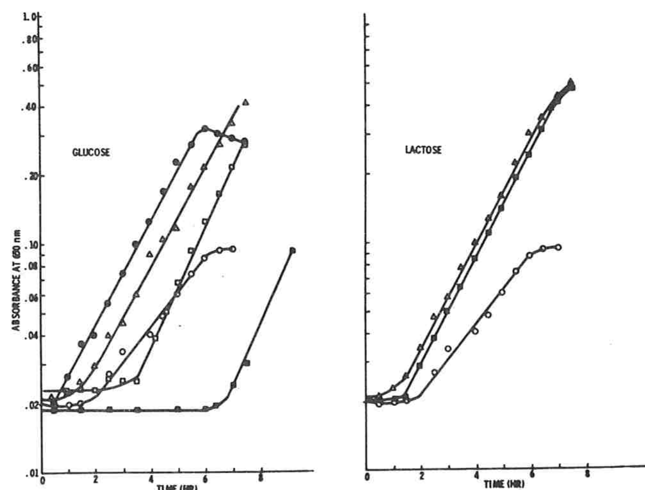

Figure 5. Effect of sugar concentration in a sugar-sodium caseinate medium on the growth of *C. perfringens*. Left, glucose; right, lactose. Symbols: open circles, no sugar; closed squares, 30 g/l sugar; open squares, 10 g/l sugar; open triangles, 5 g/l sugar; closed circles, 1 g/l sugar.

TABLE 3. THE EFFECT OF GLUCOSE CONCENTRATION AND CELL INOCULUM ON THE LAG TIME OF *C. perfringens* IN SODIUM CASEINATE MEDIUM. GROWTH MEASURED BY ABSORBANCE AT 650 NM.

Glucose concentration (g/l)	Inoculum (Cell concentration)	Lag time (h)
0	2×10^7	3.00
10	2×10^7	4.25
20	2×10^7	8.50
10	4×10^7	3.00
20	4×10^7	4.75
10	8×10^7	1.75
20	8×10^7	3.50
20	1.6×10^8	1.50

tration of 20 g/l halved the generation time from 8.5 h to 4.75 h. In all instances, within limits, doubling of the cell concentration had effects similar to halving the glucose concentration. These cell-glucose concentration combinations indicate a direct relationship between the glucose added/cell and the extent of the lag period.

The log of the number of molecules of glucose added/cell of inoculum versus the lag time was plotted. The averages of three tests are shown in Fig. 6. There was a direct straight line relationship. The glucose inhibition was relieved by an increase in the cell-glucose ratio. This could account for the equivalent growth rate after the extended lag in high glucose concentrations or low inoculation levels. Eventually the cells doubled or went through sufficient doublings until the cell-glucose ratio was high enough to overcome the inhibition. However, these findings did not explain why glucose and mannose caused this effect and other sugars did not.

It was not known at this time why intact food proteins, especially sodium caseinate, exhibited this inhibition when glucose was added, while glucose did not cause inhibition but instead was stimulatory when added to hydrolyzed casein *(19)*. The reasons why Fe^{++} counteracted inhibition were not determined.

It is possible that addition of Trypticase merely supplied sufficient available cations to produce the same inhibition relief observed by direct addition of Fe^{++}. According to the BBL analysis *(3)*, Trypticase contains 0.35% Ca^{++}, and 0.65% Mg^{++}, and 0.03% Fe^{++}. In combination the amount of cations in Trypticase were approximately 50% of the amount of cation added in relieving the glucose-sodium caseinate inhibition. Hydrolysis of casein (i.e. Trypticase) may affect the availability of the cations present in casein. The mechanism(s) of Fe^{++} relief of the glucose-sodium caseinate inhibition were characterized in the following study.

Cation relief of glucose inhibition

Cations (Mg^{++}, Ca^{++}, and Fe^{++}) were added separately or in combination to determine their effect on the growth of *C. perfringens* in a glucose-sodium caseinate medium. Parallel studies were carried out in a lactose-sodium caseinate medium. The cations alone or in combination relieved the glucose inhibition (Table 4). A minimum lag was observed with a combination of Mg^{++} and Fe^{++}. Presence of cations negated the inhibitory effect of a glucose-sodium caseinate medium. Addition of ferric ions (Fe^{3+}) did not relieve the glucose-sodium casinate inhibition (data not presented).

The effect of cations in a lactose-sodium caseinate medium is shown in Table 5. Lactose reduced the lag period in the absence of cations. Fe^{++}, Mg^{++} or Ca^{++} added singly or in combination had little effect on the lag time of *C. perfringens*.

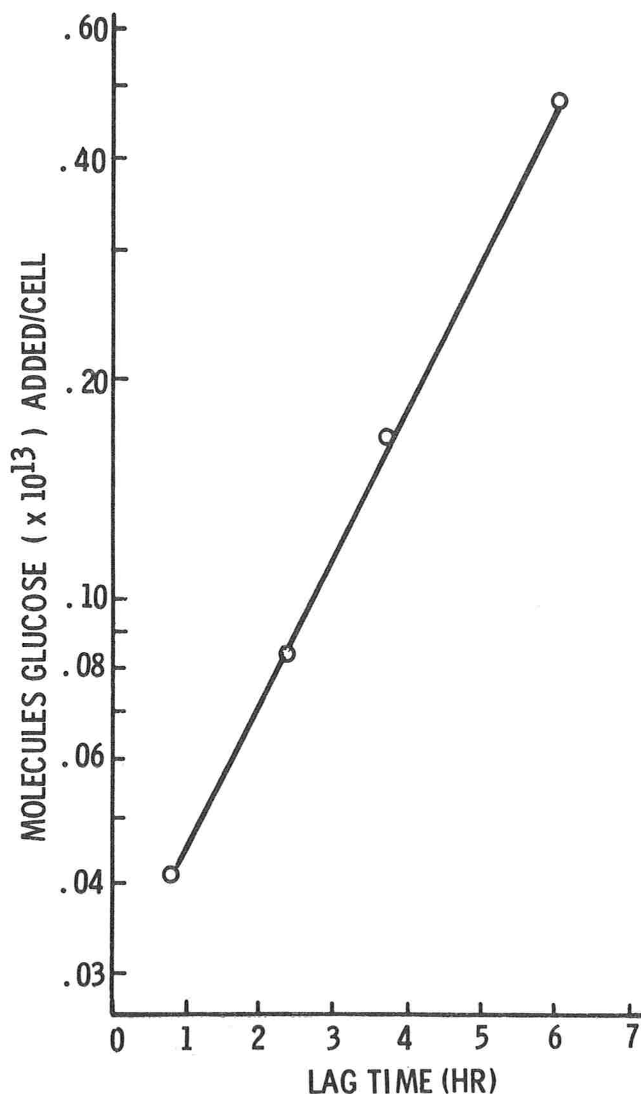

Figure 6. Relationship of the number of molecules of glucose added/cell of *C. perfringens* on the lag time in hours. Lag time estimated from intercept of exponential growth slope with initial inoculum level. Growth measured by absorbance at 650 nm.

TABLE 4. EFFECT OF CATIONS ADDED TO A SODIUM CASEINATE-GLUCOSE MEDIUM ON *C. perfringens* LAG TIME. GROWTH MEASURED BY ABSORBANCE AT 650 NM.

Cations (1 mM/ml) Glucose (10g/l)	*C. perfringens* lag time (h)
Control (glucose-sodium caseinate medium)	4.00
Mg^{++}	2.50
Ca^{++}	2.00
Fe^{++}	1.75
Mg^{++}, Ca^{++}	2.50
Mg^{++}, Fe^{++}	1.25
Ca^{++}, Fe^{++}	2.75
Mg^{++}, Ca^{++}, Fe^{++}	1.75
Sodium caseinate no glucose	3.00

TABLE 5. EFFECT OF CATIONS ADDED TO A SODIUM CASEINATE-LACTOSE MEDIUM ON *C. perfringens* LAG TIME. GROWTH MEASURED BY ABSORBANCE AT 650 NM.

Cations (1 mM/ml) Lactose (10g/l)	*C. perfringens* lag time (h)
Control (lactose-sodium caseinate medium)	1.25
Mg^{++}	1.00
Ca^{++}	1.15
Fe^{++}	1.25
Mg^{++}, Ca^{++}	1.25
Mg^{++}, Fe^{++}	1.75
Ca^{++}, Fe^{++}	1.00
Mg^{++}, Ca^{++}, Fe^{++}	1.25
Sodium caseinate no lactose	3.00

Due to the concentration effect of glucose in the glucose-sodium caseinate medium, the possibility existed that glucose was combining with an unknown compound in sodium caseinate thus producing an inhibitory substance. Also, it was possible that a low availability of cations in sodium caseinate was causing this inhibition. To rule out this hypothesis, sodium caseinate was replaced by amino acids of the same composition as casein *(11)*. To determine if sodium caseinate was a poor source of cations, the effect of cation concentration and EDTA chelation was studied in the amino acid medium. Parallel studies were carried out with lactose added to the amino acid medium. Amino acid medium without added cations served as the control. Results are in Fig. 7. In the glucose-amino acid medium a decrease in the cation concentration (Fe^{++} + Mg^{++}) resulted in an increase in the lag period of *C. perfringens.* A further increase in the lag time was caused by addition of EDTA. These data show that a low cation concentration or chelation of cations results in an extended lag when glucose is added to the medium. This phenomenon was not observed when lactose was added to the medium.

Replacement of a sodium caseinate medium with an amino acid medium of the same composition produced the same glucose inhibition when the concentration of cation was controlled. A low cation concentration or cation chelation by EDTA in the amino acid solution produced the glucose inhibition. These data indicated that a shortage of available cations in sodium caseinate was a major factor in the glucose-sodium caseinate inhibition effect on *C. perfringens.*

The following relevant literature may explain why glucose caused an inhibition with sodium caseinate while other sugars did not. Groves and Gronlund *(8)* observed that resting cell suspensions of *C. perfringens* transported glucose and mannose as phosphorylated derivatives, not as free carbohydrates. Specificity data indicated that phosphorylation occurred at the transport level rather than via the soluble hexokinase. Other carbohydrate sources accumulated as free carbohydrates in the cell. Groves and Gronlund *(8)* proposed the presence of a phosphotransferase system analagous to that described for *Escherichia coli (12, 13).* This transport system is composed of two enzymes E_I and E_{II}, and a heat-stable, low molecular weight protein, HPr, which functions as a phosphate carrier in the overall reaction. The phosphate is supplied by phosphoenol pyruvic acid (PEP) via the glycolytic pathway. This phosphate transfer catalyzed by enzymes E_I and E_{II} is Mg^{++} dependant. A low Mg^{++} concentration would therefore slow glucose transport.

In our study, only glucose and mannose were inhibitory in the presence of low cation concentrations while other sugars tested were not. Since Groves and Gronlund *(8)* have shown that only glucose and mannose are transported as phosphorylated derivatives and propose the existence of a PEP phosphotransferase system, we suggest that this glucose-ca-

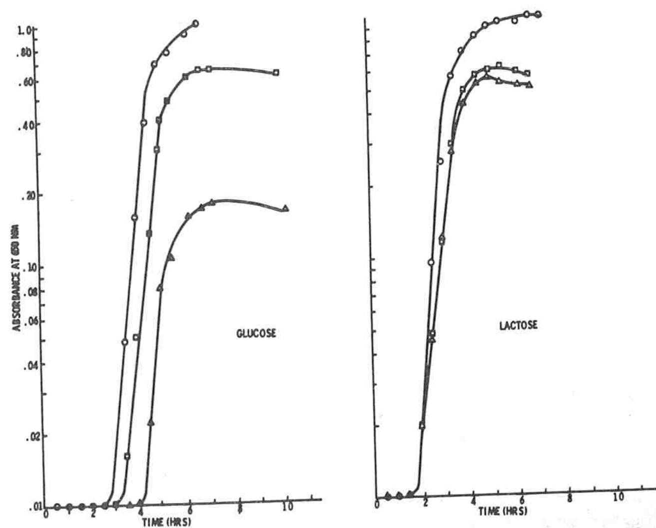

Figure 7. Effect of cation concentration and EDTA on the growth of *C. perfringens* in a sugar-amino acid medium. Left, glucose; right, lactose. Symbols: open circles, 1 ml Fe^{++} Mg^{++}; open squares, 0.1 ml Fe^{++} Mg^{++}; and open triangles, 0.1 ml Fe^{++} Mg^{++} + 0.1 ml EDTA. Growth measured by absorbance at 650 nm.

sein inhibition is associated with the PEP phosphotransferase system. Also, Bard and Gunsalus *(2)* found that the enzyme aldolase was extremely sensitive to low Fe^{++} concentrations, and hence Fe^{++} is indispensable to growth and glycolysis of *C. perfringens*. A low Fe^{++} concentration thus may also slow up transport by depriving the PEP phosphotransferase system of PEP. Low availability of cations in sodium caseinate may account for the glucose-sodium caseinate inhibition.

An observation similar to ours was made by Ashton et al. *(1)* with *Bacillus stearothermophilus*. They found that growth was inhibited by sodium caseinate added to Dextrose Tryptone Agar. This inhibition was relieved by addition of iron, calcium, and magnesium. Although not yet elucidated, the mechanisms in *B. stearothermophilus* and *C. perfringens* may be similar.

There was a direct relationship between the log of the glucose concentration added/cell versus lag time. The glucose-sodium caseinate inhibition effect resulted only from higher glucose/cell ratios. The opposite effect was observed by Rao and Bhargava *(16)*. In a non-growing population of *Escherichia coli* the rate of transport of ^{14}C glucose/organism decreased with increasing bacterial concentration.

In our study, a high concentration of glucose apparently interfered with transport at the membrane level. Thus, with low cation concentrations, glucose can only be transported slowly until an increase in cell numbers is sufficient to lower the glucose/cell ratio and no further glucose inhibition exists. In the presence of an adequate supply of cations, the rapid uptake of glucose combined with cell division quickly lowers the glucose added/cell ratio with no noticeable inhibition of growth. These results demonstrated the importance of the relationship between the initial *C. perfringens* population and the glucose concentration in a sodium caseinate medium in the absence of added cations. Addition of glucose to a sodium caseinate medium could prolong the lag period in the presence of low numbers of *C. perfringens*.

These findings may indicate that glucose is an influential ingredient that could control, delay, or at least affect the initial growth of *C. perfringens* in certain fabricated protein foods.

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MICROBIOLOGICAL EVALUATION OF YOGURT PRODUCED COMMERCIALLY IN ONTARIO

D. R. Arnott, C. L. Duitschaever, and D. H. Bullock
Department of Food Science
University of Gelph, Guelph, Ontario, Canada

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Abstract

One hundred and fifty-two commercially-produced yogurts were subjected to microbiological examination for lactobacillus/streptococcus ratio, staphylococcus count, coliform count, enterococcus count, yeast and mold count, and psychrotrophic count. These yogurts were produced by 13 different manufacturers and sold in Ontario. The desired 1:1 ratio of lactobacillus to streptococcus was found in 15.1% of the samples. Streptococci were predominant in 40.8% and lactobacilli in 44.1% of the samples. Staphylococci were found in 27.6% of the samples, enterococci in 36.2%, and coliform in 13.8%. Yeast counts in excess of 1000/g were noted in 26.3% of the samples and mold counts >10/g in 17.8% of the samples. Psychrotrophs at levels >1000/g were found in 11.8% of the yogurts examined.

The increasing popularity of yogurt has to some degree been a consumer response to the appearance of yogurts containing added sugar, fruit, and flavorings. Unfortunately these additions improve yogurt as a medium for growth of yeasts and molds and may also contribute to microbial contamination even though most bacteria, particularly those of public health significance, soon die out because of the marked antagonism exerted by the lactic acid bacteria and the acid pH *(2, 4, 5)*.

In respect to yogurt technology it is generally agreed that yogurt should contain approximately equal proportions of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* to achieve the characteristic pleasant but sharp acid flavor in high quality mature yogurt.

For these reasons fruits and flavors added to yogurt must be subjected to a rigorous quality control program as well as control of cultures and sanitation during manufacture. Results of a study reported here are intended to acquaint the dairy industry and regulatory agencies with the microbial quality of yogurt appearing on the Ontario market.

Materials and Methods

Products

One hundred and fifty-two commercially-produced yogurts were obtained from retail outlets in Ontario during the months of June, July, and August of 1971. The samples which represented 13 different manufacturers included 15 plain and 137 fruit or fruit-flavored yogurts (Swiss style). All products were transported to the laboratory within 2 hr of purchase, held at 5 C, and analyzed within 48 h.

Analyses

Yogurt samples were subjected to seven microbiological analyses: *(a)* lactobacillus-streptococcus ratio; *(b)* staphylococcus count; *(c)* coliform count; *(d)* enterococcus count; *(e)* yeast count; *(f)* mold count; and *(g)* psychrotrophic count.

Approximately 170 g yogurt were transferred to a sterile Waring blendor and mixed thoroughly for 3 min at high speed. A sample was diluted by similarily mixing 11 g with 99 ml of buffered sterile water (pH 7.2). Further dilutions were made as required. Smears were prepared from the original mixed sample.

(a) Lactobacillus-Streptococcs ratio. Following staining with L-W modified stain *(3)* the lactobacillus-streptococcus ratio was determined microscopically.

(b) Staphylococci. The presence of staphylococci was determined by spreading 1 ml of the original sample over 4 plates and 0.5 ml and 0.1 ml of the diluted sample on single plates of Baird-Parker egg yolk tellurite agar. Plates were examined following incubation at 37 C for 24 and 48 h. Typical staphylococcal colonies were picked for confirmation by gram staining and a coagulase slide test *(1)* using lyophylized bacto-coagulase plasma (without EDTA, Difco).

(c) Coliforms. Violet red bile agar (Difco) was used for the detection of coliform organisms with incubation at 37 C for 24 h.

(d) Enterococci. Enterococci were enumerated on Reinbold's blue tetrazolium-citate azide medium *(5)* with incubation at 37 C for 48 h.

(e) Yeasts and molds. Acidified potato dextrose agar was used for yeast and mold determinations. Incubation was at 25 C for 5 days.

(f) Psychrotrophs. Standard plate count agar was used to detect psychrotrophs with incubation at 5 C for 10 days.

Results and Discussion

Samples were grouped according to brand names. Each of the groups from A to H inclusive represented one brand of yogurt and contained from 15 to 27 samples while Group I included 5 different brands and contained 20 samples. Results are summarized in Table 1.

Lactobacillus-Streptococcus ratio

As noted in Table 1, the desired 1:1 ratio of lactobacillus-streptococcus cells occurred in 15.1% of the samples. The remaining samples were divided almost equally with streptococci being predominant in 40.8% and lactobacilli in 44.1% of the samples. The high incidence of undesirable ratios could be due to poor culture control at point of manufacture or to handling and storage conditions during manufacture

TABLE 1. MICROBIOLOGICAL ANALYSES OF YOGURTS SHOWING RANGE OF COUNTS/GRAM AND PERCENTAGES OF SAMPLES FALLING WITHIN SELECTED RANGES

	Group									
	A	B	C	D	E	F	G	H	I	Total samples
No. samples	15	16	16	17	17	17	17	17	20	152
Plain samples	0	0	0	2	1	0	3	2	7	15
L:S ratio[a]										
% 1:1	13.3	12.5	18.8	11.8	11.8	5.9	35.3	11.8	15.0	15.1
% S >L[b]	0.0	75.0	18.8	70.6	11.8	82.4	17.7	64.7	25.0	40.8
% L >C[c]	86.7	12.5	62.4	17.6	76.4	11.7	47.0	23.5	60.0	44.1
Staphylococci										
range	<1-3	<1-960	<1-62	<1	<1-240	<1-5	<1-3	<1-45	<1-380	<1-960
% <1	93.3	66.7	68.8	100	11.8	76.5	88.2	82.4	70.0	72.4
% >1	6.7	33.3	31.2	0	88.2	23.5	11.8	17.6	30.0	27.6
Coliforms										
range	<1-10	<1-110	<1-2	<1-5	<1-12	<1-4	<1-5	<1-55	<1-5	<1-110
% <1	93.3	75.0	93.8	82.3	82.4	88.2	82.4	88.2	90.0	86.2
% >1	6.7	25.0	6.2	17.7	17.6	11.8	17.6	11.8	10.0	13.8
Enterococci										
range	<1-2	<1-2,200	<1-41	<1-15	<1-400	<1-6	<1-2	<1-100	<1-110	<1-2,200
% <1	86.7	18.8	68.8	70.6	41.2	52.9	88.2	70.6	75.0	63.8
% 1-100	13.3	56.2	31.2	29.4	35.3	47.1	11.8	29.4	20.0	30.3
% >100	0.0	25.0	0.0	0.0	23.5	0.0	0.0	0.0	5.0	5.9
Psychrotrophs										
range	<10-170,000	<10-240,000	<10-1,200	<10-7,000	<10-1,200	<10 8,200	<10-10	<10-18,000	<10-200,000	<10-240,000
<10	73.3	50.0	81.3	70.6	88.2	58.8	94.1	76.5	45.0	70.4
10-1000	13.3	31.3	12.5	23.5	5.9	23.5	5.9	11.7	30.0	17.8
>1000	13.4	18.7	6.2	5.9	5.9	17.7	0.0	11.8	25.0	11.8
Yeasts										
range	<2-30,000	<2-320,000	<2-240,000	<2-1,800	<2-3,000	<2-11,000	<2-20	<2-100,000	<2-300,000	<2-320,000
<100	46.7	50.0	68.8	88.2	82.4	47.1	100.0	64.7	40.0	65.1
100-1000	6.6	6.2	12.5	5.9	5.9	29.4	0.0	11.8	0.0	8.6
>1000	46.7	43.8	18.7	5.9	11.7	23.5	0.0	23.5	60.0	26.3
Molds										
range	<2-550	<2-30,000	<2-610	<2-6	<2-30,000	<2-190	<2-4	<2-2,000	<2-900	<2-30,000
<2	53.3	31.3	62.6	88.2	64.7	53.0	94.1	64.7	60.0	63.8
2-10	40.0	43.7	25.0	11.8	5.9	23.5	5.9	0.0	15.0	18.4
>10	6.7	25.0	12.4	0.0	29.4	23.5	0.0	35.3	25.0	17.8

[a]Lactobacillus - Streptococcus ratio
[b]% of samples in which streptococci are predominant in numbers
[c]% of samples in which lactobacilli are predominant in numbers

and marketing. Regardless of cause, the large proportion of samples with undesirable ratios indicates a need for more care in processing and handling of yogurt in Ontario.

Staphylococci

Eight of the nine groups of samples contained staphylococci with counts ranging from <1 to 940/g. More than one quarter of the samples analyzed contained staphylococci. Fifteen of the 17 samples in Group E were contaminated with staphylococci and two of these contained coagulase-positive staphylococci. The only other instance where coagulase-positive staphylococci were present was in Group B.

Coliforms and enterococci

Coliform counts ranged from < 1 to 110/g. The counts were not large but were surprising when one considers that the data of Davis et al. *(2)* and Goel et al *(4)* indicated that yogurt was not a good medium for coliforms. Davis found no coliforms in the samples he analyzed whereas Goel et al. found that the numbers of coliforms introduced by inoculation decreased rapidly and were almost extinct after 4 days. Both groups of workers used yogurt of the same pH range as were found in the work reported here. Results of Goel et al. may be explained by the findings of Walker et al. *(7)* who worked with staphylococci and observed that naturally occurring pathogenic staphylococci were better adapted to adverse conditions than were laboratory cultures.

Approximately one-third of the samples had enterococcus counts ranging from 1 to 100/g. Four groups had yogurt samples with counts of 100/g or more. The relatively high incidence of coliforms and enterococci is disturbing because it is considered to be indicative of unsanitary processing conditions.

Yeasts and molds

Presence of yeasts or molds in yogurt also is indicative of poor sanitary practices in manufacturing or packaging. Yogurts with added sugar or fruits are especially susceptible to yeast growth. Data in Table 1 for both yeasts and molds indicate a problem area for manufacturers of yogurt in Ontario. If one uses the standards suggested by Davis *(2)* of < 10 yeasts and < 1 mold/g as being satisfactory and > 100 yeasts or > 10 molds/g as being unsatisfactory, then one quarter of the samples analyzed were unsatisfactory owing to yeast contamination and almost one-fifth were unsatisfactory owing to mold contamination. Another 8.6% of the samples tested for yeast would fall into a doubtful classification. Group G shows no doubtful or unsatisfactory samples with reference to yeast and no unsatisfactory samples in the case of mold. This indicates that yeast and mold contamination can be controlled in commercially produced yogurt.

Psychrotrophs

Eighteen of 152 samples had phychrotrophic counts > 1000/g. Five of the 18 samples registered counts in excess of 100,000/g. Although high psychrotrophic counts are indicative of poor quality, the problem is not serious in Ontario yogurt as 90% of the samples fell within acceptable limits.

CONCLUSION

The overall picture of yogurt quality in Ontario as measured by microbiological evaluation appears to indicate a need for emphasis on quality control within processing plants. The level of coliform, staphylococci, yeast and mold counts indicates that excessive contamination occurs during manufacture and packaging of the product. The relatively high temperatures (80 to 90 C for 15 to 30 min) used in processing milk for yogurt manufacture precludes survival of these organisms.

The large number of samples containing an excess of either streptococci or lactobacilli indicates poor culture control or improper storage conditions of yogurt in merchandising channels.

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CAREER OPPORTUNITIES[1]

Harold E. Calbert
Department of Food Science
University of Wisconsin-Madison, Madison, Wisconsin 53706

Abstract

The role and responsibilities of the sanitarian have changed drastically in the last two decades. Now he must be concerned with many aspects of the total environment that go far beyond those of interest to the traditional milk inspector or dairy plant fieldman. There are many career opportunities for the environmental sanitarian with federal, state, and local regultory agencies; industry; trade associations; and public service organizations. It has been necessary for colleges and universities to revise and update curricula to assure the proper training of students to be able to meet the challenges and responsibilities of the professional environmental sanitarian. Sanitarians already in the profession must take action continuouly to be professionally qualified There are more environmental sanitarian positions open than there are graduatng students available to fill them. Possibly some procedures must be devised to train individuals from other occupations and professions to enable them to become qualified environmental sanitarians. As our society becomes more complex and technology continues to change, the need for qualified environmental sanitarians will continue to increase. Who will be available to fill these positions?

The role and responsibilities of the sanitarians have changed greatly in the last several decades. When some of us became engaged in this activity, our concept of a sanitarian was relatively limited.

To some of us a sanitarian was a person working for a municipality or state health or agriculture department. His main concern was with development and maintenance of a Grade "A" milk supply. A common term applied to him, frequently in a derogatory manner, was that - - - - - - - milk inspector.

Early Sanitarians

The early milk sanitarians had an uphill battle. Their technical assistance, and often their technical training, were limited. Changes were coming fast. Development of the milking machine, pipeline milking and bulk milk handling, CIP, free stall and loose housing of dairy cattle were but a few of the changes that introduced new problems in milk sanitaton.

These problems were overcome by the hard work and perseverance of many people—mainly sanitarians. This success story is taken for granted today—so much that the proportion of many municipal budgets devoted to milk sanitation programs has been decreasing rapidly. It has now reached the point where some cities have eliminated these programs and turned them over to some state agency.

If loss of financial support can be used as a measure of a program's success, milk sanitation programs have been extremely successful. Needless to say, there are many other ways to measure the success of these programs in a more positive manner.

Another concept of a sanitarian was a person employed as a dairy plant fieldman. This fellow had contradictory responsibilities. On one hand he had the responsibility to maintain and to improve the quality of a milk supply. To do this he had to work with the milk producer and assist him in any way possible so that the producer could and did comply with the sanitary requirements of his market. On the other hand, he was responsible to his plant management for milk procurement and assuring an adequate supply of milk, often in a very competitive market. I am sure that these diverse types of responsibilities presented a quandary to many fieldmen.

Their success in meeting these responsibilities in a proper manner can be attested to by the fact that in many markets the inspection activities of the dairy plant fieldman now serve as one of the official inspections meeting regulatory requirements. This certainly represents progress in trust and understanding between the regulatory agency and the industry being regulated.

Other types of positions sometimes carried the title of sanitarian. The inspection and regulation of sanitary conditions in eating establishments, the safety of water supplies, and, in a few instances, the regulation of housing conditions were the responsibility of sanitarians. Some trade associations had staff members listed as sanitarians. Their main function was to assist members with quality control problems, meeting regulatory requirements, and interpreting regulations as they applied to various aspects of sanitary processing operations.

To be sure, there were other types of positions that carried the title of sanitarian. I'm sure that I have not exhausted the list by any means. The above examples are given to illustrate how some sanitarians were employed, and the types of responsibilities they had.

[1]Presented at the 60th Annual Meeting of the International Association of Milk, Food, and Environmental Sanitarians, Rochester, New York, August 13-16, 1973.

The background and training of these persons varied considerably. In more instances than we care to recall, their main qualifications for the position that they held was that they were related to the local city alderman, or had been active in the mayor's campaign. A few of the dairy plant fieldmen were former dairy farmers who for various reasons were no longer dairying. However, these examples represented a very small minority. The large majority of sanitarians were dedicated people doing the best with whatever background and training they had. A few had completed a vocational agriculture course in high school. Most of those with a college degree had been trained in either dairy husbandry or dairy industry. A few had degrees in public health. Very few held advanced college degrees.

No matter what their background, training, or level of education, they did have certain things in common. For the most part the terms environmental sanitation, air pollution, noise pollution, urban sprawl, environmental impact statements, radiation standards, thermal pollution, inner core, disadvantaged persons, mass feeding, compactors, shredders, sanitary landfills, and instant replay were not part of their vocabulary and had not become an integral part of their lives.

The New Sanitarian

What I have been leading up to, in a rather lengthy but not very devious manner, is the fact that the title of sanitarian in 1973 carries a much different connotation than it did a few decades ago. Today a person interested in a career as a professional sanitarian has a much greater diversity of employment opportunities than did the sanitarian of the preceding generation. At the same time the training and educational needs are different, and the complexity of the challenges and problems he will face are much different.

Where are the opportunities in the profession today? Many of them are with federal and state agencies. The past few decades have seen a proliferation of these agencies and a vast expansion of existing agencies. A brief look at the expansion of the Department of Health, Education, and Welfare will illustrate this point. New agencies have been created. The Environmental Protection Agency is a good example at the federal level. The same is true in state govenments. All of these agencies employ sanitarians of various types. My office frequently receives employment notices from many of these agencies indicating that they have openings for sanitarians. They are asking us to suggest qualified applicants for these positions. I am sorry to say that often I cannot respond to these requests as I know of no available qualified person at the time. I am sure that this same situation exists in similar departments in other universities.

There are many opportunities for employment as sanitarians in the food industry. Sometimes they list the position as being in quality control, but the specific duties are those of a sanitarian. As it becomes necessary for food processors to meet good manufacturing practice standards, it also becomes necessary that they have available the services of professional sanitarians. If the industry is of sufficient size, they employ the sanitarian as part of its staff. If not, this service may be hired from an organization operating for this purpose or the industry may call on its trade association for this service.

With the increasing public interest in air and water pollution, agencies, both public and private, are hiring sanitarians for investigative and control work. Waste disposal, both solid and liquid, is a major problem facing most communities in our country. Sanitarians are being hired as part of the teams of experts coping with these problems. With the proliferation of health care facilities and an increasing awareness of these needs there will be an increasing need for sanitarians to service these facilities. There seems to be no lack of opportunities for careers as sanitarians. The problem is to find enough qualified personnel to fill these positions.

Training for the New Sanitarian

What type of formal training should a sanitarian have to qualify for the profession. By this I mean formal training in an educational institution. The continual upgrading and updating of the profession by means of short courses, on-the-job training, conferences, and seminars are other matters that I will touch on later.

There are very few educational institutions in this country that have a complete curriculum and are training sanitarians *per se*. It appears that the young person desiring a career as a professional sanitarian should work toward the initial degree in either food science, public health, or sanitary engineering. No matter which curriculum he chooses to follow, he should enroll in an institution that would permit him to take courses in the other pertinent areas. This is a slow process requiring 4 to 5 years of college level training, followed by a period of on-the-job training and experience before the individual can perform in a manner expected of a professional sanitarian. In the meantime, the need for sanitarians has been increasing at a much faster rate than the

number of people being trained for this profession. This has made it necessary for many agencies needing sanitarians to employ persons trained in some other discipline and then attempt to give specific training by on-the-job experience.

An example to illustrate this point has been the situation confronting the Federal Food and Drug Administration (FDA). As many of you know, the FDA has been expanding its field staff during the last several years. For the past 5 years the Department of Food Science of the University of Wisconsin, under a contract with FDA, has offered a special short course entitled "Bacteriological Sanitation Course for FDA Inspectors." The aim of this course is to give specialized instruction relating to problems associated with bacteriological sanitation and inspection in food processing plants. At the start it was a means of professional improvement for some of the FDA field staff. Many of the persons in the original session of the course had been employed in field activities for several years. In the last few years, most of the participants in the course have been employees with limited field experience. In reviewing the educational background of persons enrolled in this short course we find that approximately 60% received their basic training in the biological sciences, 13% in chemistry, 11% in agriculture, 3% in food science, and the remaining 13% in such diverse fields as the social sciences, humanities, education, and the physical sciences.

Basically, these people are regulatory sanitarians. Their main mission is protection of the health and welfare of the consumer. They are doing an excellent job. However, to fill the needs it has been necessary for the FDA to hire people with various educational backgrounds and then depend heavily on on-the-job training and special courses to give these employees the technical expertise needed to perform their field activities. I believe that the FDA is to be commended for taking action such as this in attempting to meet the challenge of the responsibilities that are assigned to this agency of the federal government.

TRAINING AFTER COLLEGE

This brings me to the final point that I would like to make. It appears that there are not enough young people being trained for the many career opportunities open to the professional sanitarian. These opportunities are many and varied. I do not believe that there is one particular curriculum that will adequately train an individual so that he is qualified to meet the needs of all of these professional opportunities. As mentioned previously, I believe that training in food science, public health, and sanitary engineering supplies much of the basic training needed, but this is only the basis or foundation for additional training.

Since it is obvious that employers must turn to persons with other types of training if they are to meet their needs for sanitarians, this may be the time to make a few suggestions. Colleges or universities having the proper expertise and facilities in different geographical areas of our country should be encouraged to develop short courses, conferences, and seminars to give specialized training to meet the needs of the professional sanitarian. These would be either credit or non-credit courses that would enable a person with a sufficient background to concentrate and specialize on a study of subject matter that is essential if he is to be professionally qualified as a sanitarian.

There are educational institutions that are now doing this in some form or other but it has been on a rather piecemeal and unorganized basis. Many educational institutions would be willing to cooperate in a venture of this kind, but need the encouragement and backing of a professional group to get it started. *This is where the International Association of Milk, Food, and Environmental Sanitarians can perform a valuable service. This organization, through an educational committee, could help develop the necessary type of specialized courses and curricula. This committee could work with the institutions that are interested. It could help the concerned departments get the backing of their administration for courses and conferences of this type. It could help recruit students and, if necessary, could sponsor scholarships. Also, the Association could serve as liaison between the potential employers and employees.*

Just as the problem of sanitation registration was a great concern to this group several years ago, professional development should be of great concern now. There will be an increasing need for qualified sanitarians. We cannot depend on chance to fill this need. It is time for IAMFES to become active in finding a solution to this ever-increasing problem. *I urge this organization in its Board and business meetings to give this problem serious consideration. It should take the leadership in search for solutions to the problem.* I am sure that I can speak for my colleagues in various colleges and universities when I say that we are willing to meet with you, explore with you, and work with you in finding ways and means to meet this challenge.

NUTRITION LABELING[1]

Richard P. Farrow
National Canners Association
1133 20th. St., N.W., Washington, D.C. 20036

Abstract

The final form of the nutrition labeling regulations published in March 1973 is the result of more than 2 years of study and debate by the food industry and academic and regulatory communities. Their implementation presents many challenges to food processors, in particular those packaging foods essentially as they are harvested. Their enforcement by the Food and Drug Administration during the first few years will call for exercise of a measure of administrative discretion to permit industry to gain experience with them. Most food processors have committed at least a portion of their production to nutrition labeling. Some food packages with nutrient content statements in general accord with the new regulations are already visible in the market place, and more will appear as the 1973 harvest reaches supermarket shelves later this year.

"The most significant change in food labeling practices since food labeling began," was how Charles C. Edwards, then Commissioner of the Food and Drug Administration (FDA), described the nutrition labeling regulations when they were published on January 19 of this year (1973). No action by the FDA has generated more interest and debate throughout the food industry. During the last 2.5 years, it has been the subject of much study and experimentation and the debate over the proposals and counter proposals has been intense and often emotional. As the result of the new regulations, there are very few food labels in the United States that will escape extensive change during the next 2 years. Some may be changed several times as they adjust to accumulating nutritive content data and the requirements of the mandatory information panel.

The subject was given birth at the White House Conference on Nutrition in December 1969. Label declaration of nutritive values was one of the most publicized of the numerous recommendations to emerge from the Conference.

In the period immediately following the Conference, professional nutritionists were surveyed to catalogue their attitudes toward nutrition labeling; the Consumer Research Institute sought to identify and measure the relevant desires of the consuming public; and several nutrition labeling programs were carried out on an experimental basis in major chain stores in various parts of the country.

[1]Presented at the 60th Annual Meeting of the International Association of Milk, Food, and Environmental Sanitarians, Rochester, New York, August 13-16, 1973.

Proposed Regulation, March 30, 1972

The FDA issued its initial *proposed* regulations on March 30, 1972. They precipitated an enormous volume of comments. The FDA received a total of 3,140 comments, including 2,863 from individual consumers, 71 from consumer groups and dietetic associations, 57 from professionals, 24 from representatives of governmental agencies including state and local groups, 84 from food manufacturers and distributors, and 41 from trade associations.

We at the NCA filed comments in June of last year, in a document that ran to more than 30 pages of text and tabular material. Our principal difficulty with the original proposal was the requirement indicated in the preamble that nutritonal information declared on the label must be based on *analytical values* for each *individual* container of food, rather than on values from averaged or pooled product data. We made a strong case for the use of average values, pointing out the wide variations in nutrient content that occur naturally and are completely beyond the control of canners and other food processors.

Tentative Final Order January 19, 1973

The "tentative final order" appeared only 7 months ago on January 19 of this year (1973). The compliance provisions were a significant feature of this publication. They provided that the compliance sample is to consist of a *composite* of 12 consumer size units or containers, each container to be taken from a different randomly chosen shipping case. Thus the emphasis shifted from a single container in the original proposal to a composite of 12 cans or packages chosen to be representative of the lot to be sampled.

Another significant change was the designation of two classes of nutrients with different compliance requirements for each. Added nutrients, such as those in fortified or fabricated food, were designated as Class I. Naturally occurring or indigenous nutrients were designated as Class II.

For Class I nutrients the value obtained on the composite must be at least equal to the value of the nutrient declared on the label.

For Class II nutrients, the analytical value must be at least equal to 80% of the value declared on the label. In the case of fats, carbohydrates, and calories

the proposal provded for maximum permissible excesses rather than minimum permissible shortages. It indicated that fats, carbohydrates, and calories must not exceed the declared value by >20%.

The preamble to the January 19 regulation made it clear that sampling would be at the manufacturers, wholesalers, or chainstore warehouse, and not focused on single container samples selected at the retail shelf.

Another important feature of the tentative final order was the provision regulating advertising claims insofar as they affect the mandatory nature of nutrition labeling. Any nutrition claims on the label or in advertising trigger nutrition labeling on the product.

The NCA again filed extensive comments on the "tentative final order." We welcomed the improvements in the compliance formula which shifted the focus of regulatory attention from the individual container to a composite of 12 cans. We also advocated the use of the word "portion" instead of the term "serving."

On the matter of advertising that might trigger nutrition labeling, the NCA recommended that it only be triggered by *specific* nutritional claims in labeling or advertising which related to a particular packer's product, and not by advertising making generalized references to the nutritive value inherent in a natural product. The preamble to the January 19 order had indicated that such statements as "orange juice is a good source of vitamin C" would trigger nutrition labeling. NCA suggested that this was too broad. Many food processors presently provide consumer educational materials in terms of such general statements. We pointed out that they might have to forego this desirable activity if it inevitably triggered nutrition labeling.

THE FINAL REGULATIONS, MARCH 14, 1973

The Final Regulation issued on March 14, 1973, had only minor changes from the "tentative final order" published on January 19.

On effective dates the final decision was that, "all labeling ordered after December 31, 1973, and all labeling used for products shipped in interestate commerce after December 31, 1974 shall comply with this regulation." However, if the labeling is not otherwise changed following the date of publication of this regulation, the packer has until December 31, 1975 to comply on the information panel.

In reference to its compliance formula, the FDA made no basic changes, but it did seem to leave the door slightly ajar for consideration of the many special problems that will arise as food processors adjust to the new regulations. The preamble indicates, "The Commissioner cannot and does not expect full and complete adherence to the exact compliance requirements established in 1.17 on an immediate basis. It is entirely likely that, acting in the best of faith, deviations will occur. The Commissioner concludes that the most equitable approach to this matter is to retain compliance requirements of the regulation as published on January 19, 1973, but to exercise substantial discretion in their enforcement during the first few years in which they are in use . . . The principal factor that will guide enforcement policy will be the action taken by the manufacturer or the distributor to obtain the quality control procedures, and the testing programs necessary to achieve compliance with the regulation. The Commissioner does not anticipate taking regulatory action during this initial period where a good faith attempt has been made to achieve compliance, even though exact compliance has not been achieved . . . ".

On the matter of using handbook data in nutrition labeling the Commissioner " . . . concluded that the industrywide or representative data presently available from such sources as USDA Handbook No. 8 is not sufficiently reliable or accurate to be a basis for nutrition labeling at this time . . . In time, the use of standard representative data, backed up by periodic analytical spot checks, will undoubtedly be possible in achieving compliance . . . "

REGULATIONS PUBLISHED AUGUST 2, 1973

On August 2, 1973, still another extensive package of regulations devoted primarily to nutrition labeling and closely related topics appeared in the *Federal Register*. There were 19 documents occupying 49 of the three-column *Federal Register* pages. Eleven documents promulgate final regulations, three are qualifications of existing regulations, and five are proposed regulations published for comment by the public.

The final regulations pertain to so-called "imitation" foods; foods for special dietary use; labeling of spices, flavorings, colorings, and chemical preservatives; foods packaged for use in main dishes or "dinners;" and further details on usage of various vitamin and mineral preparations.

The proposals include labeling of chemical preservatives in food, establishment of U. S. Recommended Daily Allowances (RDAs) for infants under 12 months of age, use of common or usual names for restructured foods, technical changes establishing International Units as the accepted measurements for vitamins A and D, and a request for alternate names for "filled milk".

NUTRIENT LABELING REGULATIONS SUMMARIZED

Approximately 123 *Federal Register* pages of food labeling proposals, regulations and "preamble" commentary have been published since the original nutrition labeling proposal saw the light of day on March 30, 1972. The original proposal was 5 pages in length. The subsequent implementing proposals and regulations together with their commentary and accompanying detail occupied the major portion of the 118 remaining pages. The major features of this massive matrix of interdependent regulations may be summarized as follows.

Declarable nutrients

In the absence of any nutrient oriented claims on the label or in advertising, nutrition labeling is "voluntary." In practice, most food processors assume that competitive pressures will require them to place nutrition labeling on a substantial portion of their products.

Food energy is declared in terms of calories and protein, carbohydrate, and fat content in terms of grams per serving. A list of 19 vitamins and minerals regarded as essential in human nutrition was established. Seven of these must appear on any label bearing nutrition information, the inclusion of the remainder is optional.

Sodium content can be included. In the interest of encouraging sodium declarations, the regulations provide that a sodium declaration can be made without triggering full nutrition labeling.

Without taking sides in the argument over the significance of cholesterol in heart disease, the FDA elected to permit cholesterol declarations in food containing 10% or more fat on a dry weight basis. Fatty acid composition may be stated, and the term "polyunsaturated" is defined.

In addition to the specifically enumerated items, it remains true that any truthful statement can be made on the label that would not tend to mislead the consumer. Fiber content for example is not included in the enumeration of food components and it has been carried on some food labels. Those who wish to include a fiber declaration may continue to do so providing that it does not disrupt the order in which the nutrients are to appear.

Units, increments, and nutritional significance

The old familiar Minimum Daily Requirements have been replaced by the new U. S. Recommended Daily Allowance (U.S. RDA). U.S. RDA's have been established for infants under 12 months, children up to 4 years, adults and children over 4, and pregnant or lactating women. Except for foods intended for special dietary use, protein, vitamin, and mineral declarations will be in terms of the percent of the adult U.S. RDA furnished in a serving. These may be stated in increments of 2 up to 10%, 5 up to the 50% level and in 10% increments thereafter. Nutrients present in quantities less than 2% of the U.S. RDA are declared zero or are footnoted with an asterisk and characterized in the footnote as present in quantities less than 2%.

TABLE 1. U.S. RECOMMENDED DAILY ALLOWANCES (U.S. RDA) ESTABLISHED BY THE REGULATIONS

Item	Amount
Vitamin A	5,000 I.U.
Vitamin C	60 mg
Thiamine	1.5 mg
Riboflavin	1.7 mg
Niacin	20 mg
Calcium	1.0 g
Iron	18 mg
Vitamin D	400 I.U.
Vitamin E	30 I.U.
Vitamin B_6	2.0 mg
Folic Acid	0.4 mg
Vitamin B_{12}	6 mcg
Phosphorus	1.0 g
Iodine	150 mcg
Magnesium	400 mg
Zinc	15 mg
Copper	2 mg
Biotin	0.3 mg
Pantothenic acid	10 mg

The food energy or "caloric content" is declared in two calorie increments up to 20, five calorie increments up to 50, and in ten calorie increments thereafter.

Protein *quality* is to be defined in terms of the still controversial "Protein Efficiency Ratio." The U.S. RDA of the protein in a product is 45 g if the PER is equal to or greater than that of casein and 65 g if the PER is less than that of casein. Comparable levels for 1 to 4 year old infants are established at 20 and 28 g. If the total protein has a PER less than 20% of the PER of casein, the protein content may not be stated on the label in terms of the percent U.S. RDA, and the statement of protein content in grams per serving must be modified with the statement "not a significant source of protein" immediately adjacent to the declaration, regardless of the quantity present.

For those who wish to make comparisons or boast of superior nutritional significance, the regulations established a minimum difference of 10% of the U.S. RDA per serving.

Format

The location, type size, and order of appearance of all the mandatory and nutrition labeling data are specified. An information panel immediately con-

tiguous and to the right of the principal display panel is mandatory (with certain specified exceptions). The minimum type size is specified as 1/16 of an inch.

Nutrients are to be listed in the order prescribed in the regulations. The serving size is to be stated in terms of a convenient unit of measure easily identified and readily understood by purchasers such as a cup, a number of slices, ounces, or fluid ounces. The number of servings per container must be declared.

Portion and serving size

Although the common household units of measure such as teaspoon, tablespoon, and cup are defined by the regulation, there is no attempt to specify serving sizes. To regulate a vast list of serving sizes for all of the conceivable food products is virtually an impossible task and one that the FDA has wisely avoided. A serving is defined in terms of a quantity of food suitable for or practicable of consumption as part of a meal by an adult male engaged in light physical activity.

It was the highly subjective nature of the term "serving" that prompted us to urge the use of the word "portion" in its place rather than become embroiled in the highly individual and potentially controversial process of deciding upon an "average or usual serving." We submit that there are no valid data indicating the "average or usual serving" of food products in American homes. The menu, food preferences, occupation, and environment each affect the quantity of food considered a serving. Virtually every homemaker has her own conception of serving size for products she uses, depending upon eating habits of her own family.

There is usually a different "serving" in the mind of the homemaker for each member of the family—consider the pre-schooler being introduced to new foods; the rapidly growing, physically active elementary age child; the weight and figure conscious teenage girl; the teenage boy whom most mothers consider a "bottomless pit;" and possibly the dieting mother or father.

The Commissioner has agreed in principle that serving sizes should be uniform and has stated that it is incumbent upon industry and consumers t work together to devise uniform serving and portion sizes. If confusion results, he says, a procedure for regulating serving sizes may be imposed.

The American Home Economics Association has been asked to develop recommendations for serving sizes, since it represents an unbiased, outside source of professionally trained persons with a lively interest in the problem. Its 11-member Serving Size Standards Committee includes representatives from FDA, USDA, and nutritionists, quantity food service specialists, food journalists, and a grocery store home economist. No food manufacturer is represented on the committee. Ths group also recognizes that servings are highly subjective, and they are having difficulty developing practical and realistic recommendations. There were indications at a recent meeting that the term "serving" might well be too confusing or misleading for many consumers. A standard unit of measure or *portion* would permit comparisons of nutritional quality without implying that this was the quantity of food recommended or necessary for each family member.

In the initial industry efforts to agree upon uniform serving sizes, we continue to meet the suggestion that much confuson could be avoided by the simple use of "portion" rather than serving. While industry and professional home economist groups continue to study the question, initial nutrition labeling statements for the majority of canned fruits and vegetables will probably be based on one-cup serving or portion sizes to facilitate easy comparisons among these foods in terms readily understood by all homemakers.

Compliance testing

For compliance purposes, nutrients are divided into two classes. Class I nutrients in fabricated or fortified foods must be present in quantities equal to or exceeding the label declaration. The Class II nutrients in food commodities packaged essentially as they are harvested, that is without fortification and therefore beyond the control of the food processor, must be present in amounts equal to or exceeding 80% of the values declared on the label. Declarations of calories, carbohydrates, and fat are, in effect, maximum declarations and to avoid misbranding actions must not be exceeded by more than 20%. Reasonable excesses of a vitamin, mineral, or protein over label amounts are acceptable within Good Manufacturing Practices.

Fortification levels

Fortification triggers mandatory nutrition labeling and the quantities of added nutrient are subject to certain limitations. If the added nutrient equals or exceeds 50% of the U.S. RDA the product must be marketed as a special dietary supplement, and if it exceeds 150% of the U.S. RDA it is classed as a drug. Exceptions are provided for natural foods containing nutrients in excess of these quantities, or in any instances in which a standard of identity or a nutritional quality guideline provides for such fortification.

The regulations published August 2, define the

term "imitation" in terms of nutritional significance. Fabricated foods resembling a natural product formerly had to be labeled "imitation" even though the fabricated product might be nutritionally superior to the imitated product. The new regulations provide that such products need no longer be labeled "imitation" if they are nutritionally equivalent to the imitated or substituted natual product. Nutritional equivalence however, requires that the fabricated product contain equivalent amounts of *all* of the measureable essential nutrients with the exception of calorie or fat content.

Prohibited claims

A number of claims sometimes associated with "health foods," and food products utilized by those of eccentric dietary convictions are specifically prohibited. Among these are claims or implications that a balanced diet of ordinary foods cannot supply adequate amounts of nutrients. Bizarre health claims associated with rutin, bioflavinoids, and other food constituents that are unsupportable by sound experimental evidence are actionable under the new regulations.

PROGRESS WITH THE IMPLEMENTATION OF NUTRITION LABELING

Since the Commissioner has indicated that data from recognized compilations such as U.S.D.A. Handbook No. 8 will be unsatisfactory as a basis for nutrition labeling, extensive data collection programs are required. These are in progress throughout the industry. Many food processors are cooperating in the collection of information on products in which they have a common interest. Such cooperative programs are most advantageous to the smaller companies who would find the analytical costs too burdensome to permit them to operate a private program for their own company's products. The NCA Research Foundation is coordinating a number of these efforts and others are going forward under the guidance of commercial laboratories working through state or local trade associations.

What about the Quality Control programs that must be instituted to insure that nutrients are not lost unnecessarily during food processing? This is properly the subject of a separate discussion beyond the scope of this paper. The principles involved in optimum retention of nutrients during canning are well recognized and have been collected in a booklet, *Retention of Nutrients During Canning*, available from our organization.

When will the labels bearing nutrition statements begin to appear in the market place? There are a few nutritive content labels already in distribution, however label changes take considerably more time than some consumers may appreciate. The effective date for the bulk of the label changes incorporated in the new regulations is December 31, 1973, for labels ordered, and December 31, 1974, for products shipped in interstate commerce. Some additional time will also be required for newly labeled products to displace those already in the distribution chain.

More significantly, the physical task of assembling and interpreting the necessary data and designing and ordering the labels is simply too great to permit most packers to convert an entire product line in a single season. Most food processors expecting to use nutrition labeling will introduce it first in a limited number of their products, gradually expanding the list in accordance with the indications from the market place.

Even though the job is well underway, it is still too early to assess all the difficulties that may be encountered in implementing nutrition labeling, or to obtain any real indication of how it may be accepted by consumers. Some very preliminary indications suggest some confusion on the part of the few homemakers who have been questioned.

Several data collection programs now nearing completion were focused on samples from the 1972 season. Of necessity, the data from "last year's pack" will be utilized in the design of labels for some of the current production. Additional programs are planned or are in progress for production from the 1973 season. In any event, the nature of the nutrition labeling regulations will make it necessary for producers of most food commodities to utilize data from earlier seasons in the design of labels intended for products still unharvested, or perhaps not even planted. The potential difficulties that may be associated with such a situation are all too obvious.

As the 1973 season's products begin to enter the market place, an increased sprinkling of nutrition labels will be encountered. The effort will have occupied a very significant portion of the available resources in the industry. We certainly hope that the results will amply repay this significant expenditure of energy and money.

COMMUNITY HEALTH ASPECTS OF WATER POLLUTION PROBLEMS

BAILUS WALKER AND THEODORE J. GORDON

Environmental Health Administration
Department of Environmental Services
Government of the District of Columbia, Washington, D.C. 20002

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ABSTRACT

Expanding industrial, agricultural, and recreational activities have accentuated a built-in paradox where more and more water is needed but less becomes available at the required quality. It is not only quality that has to be preserved and ameliorated but quantity. Because a certain level of quality can be assured in a technologically advanced era and because proper quantities for the same community activities are reckoned with does not mean that the total water needs of an area have been satisfied. We must also be concerned about equality and this cannot be achieved until water in the proper quality and quantity is available to meet every segment of community need, industrial, domestic, and recreational.

While many of the waterborne diseases have been laid to rest, physicians and other enlightened professional and lay groups have become increasingly concerned about viruses and the wide spectrum of chemicals now reaching the water contact cycle. At the present level of exposure, water pollutants do not seem to have a significant acute effect on community health with the exception of nitrates, which can cause methemoglobinemia and death in infants. Less well-defined, however, is the potential for chronic effects caused by long-term, low-level exposure. Nevertheless, the call is loud and clear for a revision of drinking water standards whose requirement can be translated more directly into measurements of water quality which will be more refined as to specific contaminants. Equally as loud is the plea for bacterial standards for bathing beaches, based on sound epidemiologic data. How soon these pleas will be heard and responded to is, today, a matter of conjecture.

Dire predictions of health dangers from environmental contamination are routine in news media and are common topics of daily conversation. Some allegations are sound, others are patented alarmist and exaggerated; for many important data are lacking. In the last decade it has become clear that problems of environmental health are too urgent to be blithely brushed aside.

With the growth of technology, problems of environmental contamination have become increasingly apparent. Electric power generating capacity has increased over 20-fold from 1920 to 1970. Rapid urban development in the past 20 years imposed increasing demands on the available water supply. Many communities have fully developed all local sources of water and are dependent on development of distant water supplies to meet future requirements.

In the District of Columbia the Potomac River is the only viable source of water for the Washington Metropolitan area and will be for some time in the future. At the present time, the maximum daily demands on the River are about 400 million gallons per day (MGD). When the River is at low ebb, the flow was 388 MGD. Maximum daily demands in the mid 1970's to 1984 is anticipated to be 955 MGD, a period which for supply purposes is already here.

It is well-known that the District has only a 2.5-days' reserve supply of water, compared to a 1-year supply for Baltimore and a 3-year supply for New York City. This fact has been aired publicly for many years, but no action has yet been taken to correct this situation.

Although studies for developing water resources on the Potomac have been made over the past 10 to 15 years, hearings held, investigations made, conferences convened, nevertheless, significant construction to meet the ever mounting demands is limited to the Bloomington, Maryland Reservoir, now in early stages of construction, and an emergency intake structure on the upper estuary for the District, also in the early stages of construction. These will only begin to meet the water supply problem.

The Bloomington Reservoir will only increase the low flow by 142 MGD. The proposed Verona and Sixes Bridges Reservoirs would increase the low flow by an additional 219 MGD. Therefore the combined low flow with construction of the three dams plus the Potomac River low flow of record would only result in a total dependable low flow of 749 MGD, still far short of the anticipated 1984 requirement of 995 MGD.

Only two reservoirs—Verona (near Staunton, Virginia) and Sixes Bridge, on the Monocacy River in Maryland—out of a possible six or seven dams, have been recommended to the Congress for authorization by the Secretary of the Army.

A continuous shortage of water in the Washington Metropolitan Area could lead to rationing of water for all but essential uses, and to a building moratorium. The latter would mean less employment in the building trades, one of the major sources of income in the area. In the meantime, the population of the area

(covering the District and populous area of Maryland and Virginia) continues to grow, with each person using more and more water.

In view of this continuing water resources problem and related issues of environmental health, it is significantly appropriate to review relevant information on water quality and community health and provide selected references for an informed judgement on this subject.

Health Considerations

While accomplishments in the Western World have lowered the morbidity and morality rates of waterborne diseases, approximately two-third's of the globe's population is still under serious threats to health via unsafe and inadequate water supplies. In this century, cholera has appeared in India, Ceylon, Iran, Vietnam, and China. As late as July 1971, the hardy El Tor strain of cholera made a new advance across Asia, Europe, and Africa from the beginning of its most recent pandemic in the Celebes Islands. At the height of the tourist season, the Spanish Government confirmed several cases of cholera in the northeastern province of Zaragoza while thousands of Spaniards in that city waited in line to be inoculated against the disease. This disease remains unconquered and a symbol of a way of life where safe water is still an unattainable luxury.

American communities are concerned over waterborne viral disease. This concern exists despite the fact that of the enteric-viral diseases, only infectious hepatitis has been shown to be water borne, but proving a waterborne character for infectious hepatitis has been difficult because of its prolonged incubation period and the inability to isolate and identify the causative virus. In fact, the first isolation of viruses from drinking water in the U.S. was accomplished last year by Mack at Michigan State University, from a 100 foot well in Monroe County Michigan *(11)*. The virus isolated was serologically identified as poliovirus type 2 and probably was excreted Sabin vaccine.

The literature of the past suggested that poliomyelitis may be transmitted through sewage-contaminated water, especially in the course of swimming; and these theories have been revived from time to time with the demonstration of the poliomyelitis virus in sewage and other waste waters. While this possibility cannot be denied, it is extremely difficult to accept this as an important mode of spread. The theory would certainly not explain the general occurence of the disease in the past, especially the large number and wide distribution of abortive cases, nor would it explain the wave-like character of spread. The spread of poliomyelitis in urban areas has not followed the water distribution system; on the contrary, with one exception *(7)*, there is no epidemic on record in which the pattern of spread was consistent with the hypothesis of transmission through sewage-polluted water.

The pollution of bathing beaches is a constant source of anxiety for community health specialists, and it is customary for these recreational areas to be kept under constant surveillance. Nevertheless, convincing evidence to incriminate bathing in polluted water as a cause for outbreaks of intestinal disease is extremely hard to find. A few outbreaks of typhoid fever between 1920 and 1932 seem ascribable to this mode of infection, but in extensive retrospective studies, only a few sporadic para-typhoid infections were attributable to bathing in natural bathing beaches *(3)*.

Only three epidemiologic studies have been reported in this country which were designed to relate bacterial quality of natural bathing waters to human health *(21)*. None of the three was conclusive or even highly suggestive as to suitable water quality standards for recreational waters. Eye, ear, nose, and throat ailments were the dominant illnesses reported. Gastrointestinal disturbances, the type that would be caused by fecal bacteria, accounted for 20% or less of the complaints. Swimmers showed distinctly higher rates of illness than non-swimmers, regardless of the bacterial quality of the water, a point which has been noted in other studies of illness experiences of swimmers.

A "new" disease has been reported as being acquired from swimming in fresh or brackish water. Amoebic meingoencephalitis, caused by a small free-living ameba, *Naegleria gruberi*, has epidemiologic features which suggest a waterborne origin. In fact, Butt *(5)* reported three fatal cases of primary amebic meingoencephalitis in which the evidence indicated that the disease was acquired during warm weather by swimming and diving in fresh water lakes or streams. Apley et al. *(2)* reported a case of menigitis in a child that may have been acquired by playing in a mud puddle. Callicott *(6)* and Duma *(8)* in separate papers have reported similar cases.

Retrospective studies of this infection and studies of environmental factors that influence the biology of ameba are underway, and results of these investigations should indicate the true scope of this disease and suggest methods of prevention and control. As Neva *(1)* asked in a recent editorial in the *New England Journal of Medicine*: "Is this another example of a new disease pattern that man has created by fouling his environment?"

Unquestionably, recreational or occupational exposure to surface water increases the range of disease that can be acquired because of the accessibility of multiple portals of entry for microorganisms, but gas-

tro-intestinal infections seem to play a small role, if data thus far in the literature can serve as a reliable basis for this conclusion. However, infections of the nasopharynx, mucus membranes, and skin abrasions would appear to be fairly common among persons frequently exposed to natural recreational waters.

There is, in fact, no significant epidemiologic basis for the total coliform standards used to assess the quality of bathing water. Commenting on the problem, E. R. Krumbiegel, Commissioner of Health for the City of Milwaukee, said, "The Milwaukee Health Department has applied standards for bathing water quality which are more tolerant of coliform organism concentrations than any standard I know of. Are the Milwaukee standards too lenient or are they more restrictive than is necessary?" The same fundamental question can be raised about standards for recreational water in the Potomac River Basin and other areas.

The simple answer is: we do not know. There is no evidence that human disease has been caused among persons swimming in water with a coliform in excess of 220, 500, or 10,000/ml. However, it has been noted that there is a sharp increase in the frequency of *Salmonella* when fecal coliform densities were above 200/100 ml. In this connection, Geldreich *(9)* concludes that the inability to detect *Salmonella* in some instances of fecal pollution does not imply poor correlation of the fecal coliform test, but indicates the highly variable occurrence of *Salmonella* outbreaks.

Chemical Pollutants

Any review of water hygiene and community health must consider the major "new" water pollution problem which has emerged with the growth of the synthetic chemical industry. Wastes from this industry are reaching water courses in increasing frequency and amount each year, both from the use of the manufactured products and from wastes produced during their manufacture. These chemicals reach the stream by way of municipal and industrial sewers, land drainage, or direct application of chemicals to the stream, lake, or impoundment.

Waste and products originating with the synthetic chemical industry are extremely complex in their composition and behavior. Many do not respond to modern water treatment procedures and they may therefore persist in streams for long periods. We do not have readily available technics to detect most of these compounds in water, nor can they be removed from waste effluents. In fact, we know very little of the possible effects on community health at environmental levels. The urgency to evaluate these hazards is high on the list of community health priorities, but the difficulties are well-known and have been described in a comprehensive review by Stokinger and Woodward *(18)*.

Further light is focused on this problem by Neel *(19)*. He indicates that there seems to be very little danger of massive genetic damage from trace chemicals in water supplies, but it is highly possible that trace chemicals have increased human mutation rates. He further suggest that our ignorance of chemical mutagenesis in man or other mammals is such that it is impossible to find data to sustain even a brief argument.

Likewise, the role of carcinogenic substances and irritants is far from clear. The presence of such substances in a community water supply adds imponderably to the difficulty of setting a satisfactory water standard for such materials. Permitting no measureable quantity of carcinogenic agents in water would appear to be the only present means of dealing with such material, but it is scarcely a practical one.

Russell has recently detailed the possible health effects of a sodium imbalance as an environmental pollutant in drinking water *(15)*. Studying Santa Ana River, which serves as a principal water supply for Orange County, California, he found that 39.7% of the residents within that water district were supplied with water containing 110 mg or more of sodium per liter.

The county morbidity data for 1968 revealed that 54% of deaths were caused by nine disease groups associated with high sodium retention. Data presented in that report, although incomplete, suggest the need for a more comprehensive study on the engineering, medical, and community health aspects of the sodium content of domestic water supplies.

Water mineralization and its influence on the course of coronary heart disease (CHD) and cardiovascular disease (CVD) has also been investigated by several workers during the past decade.

Morris et al. *(12)* described a highly negative correlation between water hardness and cardiovascular mortality in England and Wales. Linderman and Assenzo *(10)* explored the cardiovascular disease and soft-water correlation in Oklahoma and reported a positive but statistically insignificant correlation. Mulcahy *(13)* was able to show no correlation in similar studies conducted in the Republic of Ireland. From the Netherlands, Biersteker *(4)* reported a statistically negative correlation between water hardness and CVD in women but not in men. With the current trend toward artifically softened water, the work of Robertson *(14)* is of interest. He found that mortality from CVD significantly increased in the English town of Scunthorpe several years after the town started softening its municipal water supply.

Schroeder, *(16, 17)* a long-time student of this problem, suggested that cadmium is perhaps the real factor, and he reasons that corrosive soft water leaches cadimium from galvanized pipes and that this could readily enter a community's water supply. It has also been shown that cadmium in the kidneys can contribute to hypertension in some of the lower vertebrates and that a deficiency in chromium (trivalent state) favors arteriosclerotic disease. But here again is a large area in which the data are insufficient to clearly reject or accept the suggestion that there is a water quality factor influencing to any degree the development of certain cardiovascular disease.

As Wolman *(20)* recently concluded: "Although the disease evidence is elusive, some have been unable to resist the temptation to alarm the public by less than convincing data."

WATER QUALITY STANDARDS

The origin of current drinking water standards can be traced back to some 51 years ago when Congress passed a law which required the U.S. Surgeon General to establish interstate quarantine regulations. The first standards developed in 1914 included bacteriologic quality consistent with federal responsibility for communicable disease control. Since 1914, revisions (1925, 1942, and 1946) have covered inorganic chemicals, radioactivity, and in 1962, organic chemicals. It has been said that as testing procedures become more and more delicate, more ingredients will be added to the prohibited list; and several community health specialists have questioned whether this move toward zero risk is being considered realistically against resulting health benefits—or at what price.

It should be acknowledged that the present water quality standards are basically performance specifications; instead of providing the means by which standards can be met, they merely delineate goals. Since these standards are applicable to interstate carriers and disease control between states, only about 600 places in the United States are subject to federal inspections and regulations. Actually the revision of drinking water standards is now being considered within the federal establishment and will probably be brought to fruition as the new U.S. Environment Protection Agency begins to devote more manpower and financial resources to this aspect of the water environment.

The American Water Works Association has already indicated its intention to work toward standards whose requirements can be translated more directly into measurements of water quality and which will be more refined as to specific contaminants.

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FLAVOR DEVELOPMENT AND MICROBIOLOGY OF SWISS CHEESE–A REVIEW

IV. DEFECTS[1, 2]

T. Langsrud and G. W. Reinbold
Department of Food Technology
Iowa State University, Ames, Iowa 50010

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Abstract

The fourth and last paper of this series deals mainly with bacteriological defects in Swiss cheese. These include: lack of eye formation, crystal formation, split defect, early and late fermentation, bitterness, and other flavor and color defects. Ways to counteract development of these defects are discussed.

Swiss cheese is vulnerable to defects resulting from incorrect manufacturing processes, deviations in gas production, and growth of deleterious microorganisms that may produce off-flavors and faulty eyes. Reinbold *(345)* discusses causes and cures of defects related to manufacturing and handling. This review considers primarily those defects of a bacteriological nature.

Inadequate eye formation

Swiss cheese sometimes may not develop eyes in a normal way. This, of course, results from failure of the propionibacteria to grow and produce CO_2 in sufficient amounts. Whey contains a factor that may temporarily inhibit growth of propionibacteria *(442);* residual antibiotics in milk also may be responsible *(233).* Higher cooking temperature and an increase in copper content in milk through storage in the kettle may be implicated *(233).* Faulty lactic-acid production in both the milk and the curd because of bacteriophages active against the lactic-acid starters also may cause deficient eye formation. Desirable acid and pH ranges are presented elsewhere *(345).* Attempts in this laboratory to isolate bacteriophages for propionibacteria have not been successful.

Crystal formation

Flückiger and Schilt *(113)* found that well-ripened Swiss cheese, prepared from heated milk, contained tyrosine crystals, which occurred most frequently in the surface layer of the cheese. These crystals were not found in Swiss cheese made from raw milk. The stage at which these crystals appear, as well as the influence of milk composition, curd properties, packaging, and storage conditions on the crystal formation, is unknown.

Split defect

This defect also is known by such names as "checks," which describe small fissures and cracks, and "glass" and "slit eyes," which describe larger cracks in the body of the cheese. This defect has traditionally been thought to develop because of brittleness or lack of elasticity by the curd. This explanation, however, may not always be correct. When eyes are formed, curd must be firm enough to hold its shape, which is accomplished by reducing the temperature of the cheese after eye formation and by having developed the proper type of body during the make procedure. Addition of 8 to 15% water to the whey during vat production, preferably before or during cooking, prevented this defect *(130, 131).* Uotila *(439)* maintained that part of the reason for the split defect was quantitative variation in dry matter and sodium chloride between different layers of cheese. In their earlier studies of this defect Hammond and Reinbold *(142)* found no correlation between the split defect and dissolved carbon dioxide, eye volume, volatile fatty acids, and proteolysis. A correlation was found between splitting and oxygen penetration into cheese towards the end of ripening *(346).* A strain of *Propionibacterium shermanii* that grew well at 7.2 C (45 F) was compared with a strain of *P. arabinosum* that grew poorly at this temperature for cheesemaking. The cheese made with the *P. shermanii* strain showed a much greater tendency toward splitting, possibly because of gas formation in the cold room *(318).* Significant differences in carbon dioxide evolution between these two strains has been found *(161). Propionibacterium shermanii* produced larger quantities of carbon dioxide, and utilized lactate and sugars much faster, than *P. arabinosum.* Certain strains of *P. shermanii* even grew at 3.8 C (38.8 F) in sodium lactate broth,

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[2]This review has appeared in four parts: I. Milk Quality and Treatments; II. Starters, Manufacturing Processes and Procedures; III. Ripening and Flavor Production; and IV. Defects. Literature citations follow this part of the review.

which suggests that these organisms could produce gas in cheese during cold storage *(160)*. This indicates that the microorganisms able to produce splits in cheese must possess metabolic capabilities different from strains that lack this ability. For background information concerning these reactions, refer to a review paper by Hettinga and Reinbold *(157)*. Cell-free extracts of low-temperature-growing propionibacteria had higher specific activities for lactate and malate dehydrogenase at 3 C (37.4 F) in comparison with strains lacking ability to grow at low temperatures *(159)*.

Cheese with a rind more easily permeable to carbon dioxide was less susceptible to swelling and splitting than densily rinded cheese with poor carbon-dioxide permeability *(205)*.

Therefore, many instances of splitting in rindless block Swiss cheese may be explained by the combination of use of gas impermeable wrappers and low-temperature growth of gas-producing microorganisms.

Early fermentation

Early fermentation denotes gas formation while the cheese is still in the press or before it is transferred to the hot room for ripening *(116)*. This defect may be caused by bacteria or yeast. From his experiments with cheeses with excessive eye formation Sahli *(369)* concluded that a defective fermentation in the early stages of ripening can only be identified by chemical analyses of cheese and starters. Determination of metabolic products by isolated bacteria also would be required. Cheeses graded as defective by visual inspection and organoleptic tests may not show any bacteriological or chemical anomalies. The most common organisms causing early blowing are bacteria of the coli-aerogenes group *(232, 351)*. Coliforms may be inhibitory, stimulatory, or inert to strains of *L. helveticus, L. lactis,* and *S. thermophilus*. If inhibitory, the lactic-acid fermentation may be depressed, and early blowing may be the result *(351)*; but the coliforms must be present in large numbers. Bacteriophages against the lactic-acid bacteria also will depress the lactic-acid fermentation. Tjepkema et al. *(433)* isolated *Bacillus polymyxa* from Swiss cheese with early gas defect. A defect characterized by formation of many small eyes during the first hours of pressing has been studied *(232)*. *Lactobacillus fermentii* was isolated and found to cause this defect together with the coli-aerogenes group. A strain of *Clostridium perfringens* has been isolated from a Swiss cheese with an abnormal gassy fermentation *(2)*. Experimental cheeses inoculated with this organism showed both the nissler type of fermentation, a uniform distribution of very small eyes, and the pressler type, in which the gassy condition occurs in the press. Weiser *(458)* detected *C. perfringens* in extremely gassy cheese, often in combination with *Torula cremoris*, whereas when cheese was mildly defective only *C. perfringens* was isolated.

Besides bacteria, yeast may induce early blowing. Weiser *(458)* isolated *Torula cremoris* from cheese in significant numbers. Three strains of nonsporulating yeasts that had been isolated from starter cultures were studied by Sahli *(367)*. These organisms were fairly heat vulnerable at 56 C (132.8 F), but even after 10 min at this temperature, 2 to 3% survived. Inoculation with 1,400 to 24,000/ml of milk did not influence Swiss cheese quality. Inoculations of these yeasts set up to 100,000/ml or more caused defective eye-formation and off-flavors, and cheeses made from milk with the highest inoculation were blown after 5 hr in the press. Results of this sort, however, are of little practical importance because heat-treated milk is now used generally for Swiss cheese production. Contamination could, of course, occur in the milk in the lines or vats following the milk heat treatment but for the contamination to reach dangerous levels would imply gross mismanagement.

Late fermentation

Late fermentation occurs during ripening of Swiss cheese. The gas may form pinholes, called the nissler defect, or resulting eyes may appear in clusters. This defect is usually caused by lactate-fermenting bacteria belonging to the genus *Clostridium (116)*. Strains of butyric-acid bacteria, the name usually used by Swiss-cheese makers for those organisms isolated from blown cheese, were examined by Stüssi et al. *(419)*, who found that their strains could be differentiated on the basis of lactate and lactose fermentation at pH 5.7. Lactate-utilizing clostridia only utilized lactate in sugar media in the presence of acetate *(360)*. The lactate-fermenting clostridia are designated as *Clostridium tyrobutyricum* and the lactose fermenters as *Clostridium butyricum*. Stüssi *(418)* used strains of *C. butyricum* isolated from blown cheese and found some strains able to reproduce the defect. Usually, *C. tyrobutyricum* is associated with late fermentation. This bacterium ferments fewer carbon compounds than *C. butyricum*, and *C. tyrobutyricum* can grow better at lower pH values than *C. butyricum (237, 339)*. *Clostridium tyrobutyricum* also is more salt tolerant *(339)*. Using *C. tyrobutyricum, C. butyricum,* and *Clostridium sporogenes*, Kutzner *(238)* found that only *C. tyrobutyricum* produced blown cheeses. The same effects in Swiss cheeses that were inoculated with *C. tyrobutyricum* or *C. bu-*

tyricum were observed by Kiermeier et al. *(196)*. More n-butyric acid was produced in cheese with *C. tyrobutyricum*, but the amount in cheese with *C. butyricum* was about equal to that in the control cheese. Sahli *(368)* subjected cavity gases to gas chromatography to determine if a butyric-acid fermentation had occurred. If so, greater concentrations of hydrogen than with normal propionic-acid fermentation would be present.

Propionibacteria also may be symbiotic to growth of *C. tyrobutyricum*. By simultaneous inoculation of cheese milk with propionibacteria and butyric-acid bacteria, the butyric-acid fermentation occurred much earlier than when proponibacteria were not added *(202)*. But it also seems likely that the butyric-acid fermentation, by increasing pH, could accelerate the propionic-acid fermentation. Other bacteria that encourage formation of butyric-acid by butyric-acid bacteria are coliforms, strains of streptococci, leuconostocs, lactobacilli, and *Bacillus subtilis (422)*. The growth-promoting substance(s) was dialysable and heat stable and was so effective that butyric-acid bacteria were able to grow under conditions that were not strictly anaerobic. In producing Grana cheese inoculated with butyric-acid bacteria, Annibaldi *(7)* found that use of *S. thermophilus* as starter resulted in a more rapid and more marked blowing of the cheese.

Generally, most strains of *S. thermophilus*, *L. helveticus*, and *P. shermanii* promoted growth of *C. tyrobutyricum (228)*. However, nine strains of *L. helveticus* from Scandinavian milk products, three from Africa calabash and one from kefir, and strains of *S. thermophilus* from unusual sources (e.g., moss) inhibited growth of *C. butyricum*. These strains yielded eight new starters, one of which has been used for 10 years. Only one strain of *P. shermanii* was not stimulatory to *C. tyrobutyricum*, and this strain produced good eye development in Swiss cheese.

This is one of the most serious defects in Swiss cheese production, and, in Europe, oxidizing salts are used to control this problem. This is not permissible for cheese manufacture in the United States *(345)*. Potassium nitrate and potassium nitrite prevented the butyric-acid fermentation in milk exposed to lower heat treatments, while only nitrite was effective when cheese was produced from milk heat-treated at high temperatures *(129)*. Ystgaard *(468)* observed that sodium nitrate in an amount of 30 g/100 liters cheese milk effectively controlled butyric-acid fermentation and had no influence on lactic-acid fermentation and propionic-acid fermentation. The amount of sodium nitrate decreased rapidly in cheese during ripening *(468)*. In examining Tilsit cheese made from milk to which sodium nitrate had been added, Ritter et al. *(359)* found little nitrate; evidently, most of the nitrate had been retained in the whey. Propionibacteria were inhibited by 20 g potassium nitrate/100 liters of medium, and Ritter and coworkers *(359)* also found, contrary to other workers, that adding nitrate to cheese milk did not inhibit growth of lactate-fermenting butyric-acid bacteria. Gábor et al. *(126)* found that 5 g potassium nitrate/100 kg milk usually was enough to prevent blowing of the cheese and that higher concentrations inhibited not only butyric-acid bacteria, but also propionibacteria and caused a red discoloration and bitter taste of the cheese.

Experiments to determine if blowing of Tilsit cheese could be prevented with salt instead of nitrate were conducted by Schulz et al. *(384)*. Their results showed that blowing could be prevented by salting curd sufficiently so the interior salt concentrations in fresh cheese was brought up to 0.9 to 1.0% before the usual brine salting.

Nisin, use of which is forbidden in the United States *(345)*, has been used to prevent blowing of Swiss cheese. Adding 44 Reading units of nisin to cheese milk inhibited the lactic-acid fermentation, but failed to affect clostridia *(465)*. Most of the nisin appeared in the curd but had disappeared from a 14-day-old cheese and was, therefore, ineffective against late blowing. Lipinska *(261)* used antibiotic-producing lactic streptococci in cheese milk in the vat, and the streptococci inhibited butyric-acid fermentation in Edam cheese. Doležálek and Dočekalová *(90)* found that *Microbacterium flavum* could be used satisfactorily in cheesemaking to prevent blowing caused by coliforms and clostridia.

Bitter cheese

This defect is common in cheese and occurs more frequently in Cheddar than in Swiss cheese. Swiss cheeses with an extremely bitter taste and a soft body were investigated by Mair-Waldburg and Sturm *(263)*. *Streptococcus faecalis* var. *liquefaciens* formed the major part of the ripening flora and was directly responsible for the bitterness. Mair-Waldburg and Sturm believed that this organism, which is penicillin-resistant, becomes dominant if cheese milk contains penicillin. The same results were obtained with a bitter Gruyére cheese *(49)*; in this instance it also was believed that the bitterness was related to activity of the proteolytic enzymes of *S. faecalis* var. *liquefaciens*.

Generally, bitter cheese is not caused by a detrimental flora but by some starter strains that may not contain enough peptidases to degrade peptides produced by proteolysis *(67, 107, 376)*. This may result from the higher proteolytic activity of rennet at lower pH, which leads to accumulation of polypeptides in-

cluding the bitter-tasting ones *(66)*. Cheese manufactured using temperatures higher than normal had a greater incidence of bitterness than cheeses made by orthodox methods *(71)*. Cheddar cheese was extracted with a chloroform-methanol mixture to isolate a peptide fraction which was bitter *(154)*. This fraction, then, was extracted with water followed by removal of the methanol. The remaining water-phase was extremely bitter and astringent. One of three fractions isolated by Sephadex gel filtration was extremely bitter. This fraction contained all of the amino acids of casein but in different proportions. Proline, in particular, was present in a particularly large amount. It was later found that this bitter fraction could be extracted in higher concentrations from bitter than from non-bitter cheese and that the bitter fraction contained three basic peptides *(153)*. Bitter peptides have been isolated from a tryptic hydrolysate of casein *(269)*. Three bitter peptides of the following formulation were found: Gly-Pro-Phe-Pro-Val-Ileu; Phe-Phe-Val-Ala-Pro-Phe-Pro-Glu-Val-Phe-Gly-Lys; and Phe-Ala-Leu-Pro-Try-Leu-Lys. The L-phenylalanine and L-tyrosine residues increased the bitterness. Aqueous solutions of phenylalanine and tyrosine and their acetyl and ethoxy derivates at a 0.1% concentration, arranged in order of bitterness, were as follows: Phe=Ac-Phe < Phe-OEt < Ac-Phe-OEt and Tyr=Ac-Tyr < Tyr-OEt < Ac-Tyr-OEt. Thus, the bitterness of these amino acids may be reduced by free amino or carboxyl groups and intensified in small peptides.

Formation of pyrrolidone-carboxylic acid at the N-terminal end of a hydrophobic peptide derived from casein may cause bitterness *(420)*. Presence of a pyrrolidone carboxylyl peptidase in non-bitter starters may explain the absence of bitterness in cheese made with these organisms. Other workers *(108)*, however, have observed that the activity of pyrrolidone carboxylyl peptidase was higher in bitter than in non-bitter strains of starter organisms.

Flavor defects

Such different undesirable flavors and odors as putrid, unclean, fermented, yeasty, rancid, and fruity may develop in Swiss cheese. Putrid flavor is probably caused by an objectionable protein decomposition, and the odor frequently resembles hydrogen sulfide with other equally offensive aromas. Large numbers of clostridia have been found in such spoiled cheese but very few in unaffected cheese *(141)*. *Clostridium lentoputrescens* was associated with a putrid flavor and with development of a white, crumbly condition and large irregular eyes *(141)*. Bolliger and Zand *(42)* found a *Micrococcus* species that produced a putrid flavor and an odor reminiscent of cow dung in commercial Swiss cheese. Otherwise, the cheese had normal eyes. Kurmann *(235)* isolated gas-forming streptococci, closely related to *S. faecalis*, from Bergkäse, a small variant of Swiss cheese *(345)*, that had a foul odor.

Ribes flavor, a flavor related to the odor of feline urine has been observed in Swiss-type cheese *(409)*. Cheeses with this defect had greater proteolysis, a low sodium-chloride concentration, abnormal ultraviolet absorption curves, and greater amounts of acetaldehyde, methanol, acetone, ethanol, isopropanol, pentanone, butanol, amylalcohol, and isoamylalcohol. The flavor could not be associated with any of these compounds, so Steinsholt et al. *(409)* suggested that the flavor was related to unstable compounds. They suggested the flavor may have been produced from a microaerophilic yeast isolated from the cheese. A C_6 mono-unsaturated ketone was isolated by McGugan and Emmons *(270)* from portions of a Cheddar cheese with catty flavor. This compound was not found in the unaffacted portions; however, it did not have a feline odor. Badings *(20)* isolated mesitylene oxide, which is a C_6 mono-unsaturated ketone, from Gouda cheese. By adding hydrogen sulfide to mesityl oxide, the ribes flavor compound, 2-mercapto-2-methyle-pentan-4-one, was formed.

Rancid flavor also is found in Swiss cheese, usually because of higher concentrations of butyric acid produced by *C. butyricum* or *C. tyrobutyricum (137)*. Oxidative rancidity resulting from lipid oxidation also may occur *(95)*. Besides this, use of lipolysed milk also may yield rancid cheese *(336)*.

In addition to these flavor defects, other defects such as "green" flavor and fruity flavor, should be mentioned, even though no reports concerning these defects in Swiss cheese have been found. Lindsay et al. *(259)* found that a diacetyl:acetaldehyde ratio of 4:1 produced a desirable flavor in butter cultures. If the ratio was < 3:1, a disagreeable green flavor appeared in the product. Ethyl butyrate and ethyl hexanoate caused the fruity flavor in Cheddar cheese as shown by Bills et al. *(37)*. These compounds have been found in Swiss cheese *(241)* but do not seem to be of consequence.

Color defects

Colored spots may be formed by growth of pigmented propionibacteria in Swiss cheese. Tomka *(436)* observed round, brown spots on the cut surface or eyes of cheese. The brown spots occurred in cheese with low numbers of propionibacteria and could be overcome by adding starter propionibacteria. This defect was most pronounced when cows were not on pasture, and when milk contained fewer propionibacteria *(455)*. *Propionibacterium rubrum* and

P. thoenii are brightly colored and may cause these spots *(345)*. Other pigmented microorganisms also may cause dark spots in the body of the cheese.

Lactobacillus helveticus, when grown anaerobically, may produce a brownish-pink color from tyrosine in whey *(448)*. In cheese, colored spots were located around checked surfaces where air could enter. One strain each of *L. helveticus* and *L. bulgaricus* produced pink discoloration in Italian cheese *(389, 390, 391)*. By using a combination of *S. thermophilus* with the defect-producing *Lactobacillus*, development of the discoloration could be delayed. Cheese made with this starter always had a higher redox potential than the control. This defect is rarely seen in young Swiss cheese but may appear in 4-month-old or older cheese *(345)*. Park et al. *(318)* showed that this was because of use of certain strains of propionibacteria that contained oxidative mechanisms.

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A QUALITY CONTROL PROGRAM FOR THE FOOD INDUSTRY[1]

R. M. Darrah

Dairy Division, Safeway Stores, Inc.
2538 Telegraph Avenue, Oakland, California 94612

(Received for publication August 15, 1973)

Abstract

This paper states the method used by Safeway's Dairy Division to arrive at a quality control program and includes a quality control policy statement and condensed outline of the program. Company views on the role of the Quality Control Supervisor and the author's views on aseptic sampling, environmental air control, and current trends in quality control are offered.

No modern, progressive food business today can long survive without a vigorous quality program, supported with equal enthusiasm by top management and line supervision. All of the quality claims dreamed up by all the ad men cannot convince Mrs. American housewife that product X is the best *unless* it truly satisfies her. Unless that product stays flavorful and fresh, crisp and crunchy, creamy and sweet, or whatever it's supposed to do, it will ultimately fail.

Now we all recognize that no one person can be entirely responsible for the quality of the product. Oh, yes, it can be said that the owner-manager of a company is responsible in that "the Buck stops here." Or, that the quality control supervisor, as our firm calls him, or the quality assurance manager, as many other such persons are titled, is the responsible man, because, "that's his job." Well, is it now? Is the foreman responsible for quality? He is after all, the man who translates a production order into finished products by directing those people working on his shift to do specific jobs. And while we're at it, how about those people on the job—that individual person or group that actually does the processing of the product? Are not these people actually responsible for quality? I believe the answer is yes.

A Policy Statement

The opening statement of Safeway's Milk Department Quality Program says it this way: "Any quality program must begin with policies and attitudes fostered at the Division level, which are perpetuated and supported at the individual plant management level. These policies and attitudes *must* be passed on to the plant supervisory and quality control level and firmly implanted in the performance of the personnel on the job. The following program is designed to be basic enough to be applicable to plants regardless of size, and to help plant management accomplish our goal to establish—'QUALITY AS AN ATTITUDE'."

Unless the "man on the job" is motivated to be quality minded to the point that he will not feel right letting anything go by him that is below company standards, and unless his foreman makes him feel that only a top quality product will be tolerated, the quality battle becomes tough. A Quality Control Supervisor on the floor helping to check line quality, taking samples, testing, and reporting results with thoughtful interpretation, can go a long way toward improving quality. But, if what he finds and reports is not understood by the employee, backed by the foreman, believed and backed by the manager, most of his effort is wasted.

I'm going to discuss the rest of the policy portion of our quality program so that readers can get an idea how it's structured and recognize that while we established this for dairy operations, it is applicable to most food processing plants. You will notice also that we attempt to involve directly all those people who we depend on to motivate others and the people on the line doing the job. The balance of the policy statement is in 9 paragraphs.

I. "The prime emphasis of the program is two-fold: (1) Kindle in the people doing the cleanup and production job a pride in workmanship, surroundings, and most importantly, in "Quality Products." (2) Make each Q.C. Supervisor an effective part of the plant management staff.
   A. Quality Control Supervisors should spend the necessary portion of their total time on the plant floor in observation and investigative time.
   B. Quality Control Supervisors should be involved in training new clean-up personnel in proper techniques—and must be consulted when changes in the processing and/or C.I.P. Systems are being considered.

II. The Plant Manager will, by direction, example and actions, demonstrate the determination that his plant shall be the leading plant in the Company in quality and housekeeping. The Quality Control Supervisor will be responsible for coordinating the efforts of the

[1]Presented at the Rocky Mountain Food Safety Conference, Ft. Collins, Colorado, April 19, 1973.

management team (Superintendent(s) and Foremen) to accomplish this goal.

III. Superintendent and Foremen will make specific area assignments for each employee. Each man will be responsible for the cleanliness and housekeeping in the area of the plant to which he is assigned. He will be held accountable for the appearance of that area any time during his shift. The aim is to build pride, first in an area, then in the plant.

IV. Daily examination of the test reports and samples will be made by the Manager and/or Superintendent and all possible shift foremen . The man directly responsible for a product (such as pasteurizer and cheese maker) should also examine the samples.

V. The Quality Control Supervisor will inspect the plant weekly in turns with the following persons: Plant Manager, Superintendent, the Foremen—or any of the trainees with at least 6 months' plant experience. It is suggested that more than one person make the inspection tour, working as a team; many more observations are possible this way. Daily walk-through tours are expected of all of the above people as a normal part of their routine.

VI. Weekly inspection tours may be conducted in the manner which the individual plant desires; their own inspection forms, the Company forms, or a note pad may be used to record observations. Repeat items should always be marked with the number of times repeated so that the manager will be aware that follow-through action is required. The plant manager will have the responsibility to follow through and see that corrective action is taken.

VII. Record results of all quality control tests on the appropriate control sheets to provide a permanent record of each product produced from raw material to finished and shipped product. Deviations in quality should be highlighted by using a red pencil or pen. Almost anything you or your Manager choose, may be recorded on these sheets to become a part of your Laboratory record.

VIII. It is the responsibility of the Shift Foreman to see that all necessary and designated samples are collected for laboratory analysis. The ultimate assignment for this function will, of course, fall on the operator closest to the operation, and on his shift foreman to follow through.

IX. Weekly meetings between the Manager, Superintendent, Deli Superintendent, Foreman, and Q. C. Supervisor and any other personnel at the discretion of the Manager are an important tool for opening lines of communication and solidifying quality progress, and are an expected part of this program."

Needs For A Successful Quality Program

What goes into a qualty program that works? I would not presume to claim that this formula we used will work for every situation. It does work for us and we believe it works well. Here is how it went together.

First. A middle management conference established goals for a program. Several of us at the Home Office with considerable plant background sat down and asked ourselves what did we want from a quality program. We decided what the scope of the program would be, where it begins, and where it goes. Note I did not say where it ends, because where does a quality program really end?

Second. Middle management writes a draft of the proposed program and submits it to top management for conditional approval. With considerable help from Robert Winslow, and from the other people in our department I wrote a draft and we submitted it to the Milk Department Manager and the Division Manager.

Third. The draft program is sent to the plant (or plants) as a tentative program with Management support. The draft program is given a trial period, during which questions are raised and hopefully answered, and we learn if we can live with and by this program. For us this period was approximately 1 year.

Fourth. After the trial period a line management-middle management conference is called to make additions and corrections and to give the involved people a chance to air their views. When our meeting was over, it was no longer a management program, it was the Quality Control Supervisors' program and enthusiasm ran high. The "line management" people asked to attend the meeting, were the Quality Control Supervisor from each plant or the man designated to handle those duties.

Fifth. The final draft is made, including changes from the fourth step, submitted for final management approval, and it becomes company policy.

You've written yourself a quality program—now what? Nothing—unless you make it happen. Follow-through like in any successful management procedure is the answer to a working program. When your quality control man comes to you and says, "Boss, they've started bottling buttermilk and the acidity is only 0.80% and it's green as grass." Do you say—"Oh it'll be O.K. in a day or two, anyway, I can't stop the line for an hour while we wait on it." Or do you go to the foreman and say "Charlie, shut her down until that buttermilk is up to 0.86% where we agreed to let it go. Have the fellows work on that warehouse marking for OSHA while we wait."

Of course, I've made that up and it's easier to say, than to take what seems to be a loss at that point. But if that product reaches the shelf, sub-standard, and Mrs. Housewife gets a bottle she doesn't like, you've probably lost her and you deserve to lose her. If you wait those few minutes, chances are the higher quality product will go out and win a few more sales. That's at least one way in which management can demonstrate to the employee that quality really is a goal of the company.

One essential to building a quality control program that I've not touched on yet is the quality control

supervisor himself. What sort of individual is it that imposes his iron will on the production staff? Convinces the Boss that pulling the cork on that batch of product was the best thing he ever did? Produces documentary evidence to back his decisions with the guile of a lawyer? Well, he's a figment of my imagination. But we can find a man who can do this big job, whether in our own plant or from the ranks of the experienced unemployed or fresh out of one of our many fine universities, not necessarily in that order.

Selecting and training a man to cover a job like this must necessarily vary with size of the operation and the complexity of the program. In small plants a supervisor should be chosen to operate the program. He will take the proper samples either for his own analysis, if a laboratory is available or for analysis by an outside laboratory. He will conduct the housekeeping surveys, most likely on a more or less continuous basis and do a portion of your line supervision at the same time.

In the field of fluid dairy products, in plants of 10,000 gal a day and upward, a full time Quality Control Supervisor with sufficient processing background to line supervise in relief and emergency situations only, will more than pay his way in butterfat control, volume control, and control of return products and lost sales through Qauilty Control techniques. Even larger plants may employ a Quality Control Supervisor and one or more part or full-time technicians. The Q. C. Supervisor should be free to spend much of his time on the line looking at the processes and procedures, temperatures and times, handling techniques, weights and fills, taking samples, making inspections in a continuous effort to keep a control on Quality.

Keeping complete and accurate laboratory records, maintaining supply inventories, supervising assistants, cooperating and communicating with the rest of the supervisory staff, take up another large share of the Q. C. Supervisor's time.

The last item I mentioned—communicating with the rest of the supervisory staff, is perhaps the key to training a Q. C. man. I believe we can assume some aptitude for laboratory work is a prerequisite for consideration of an applicant for the job. The aptitude is, of course, necessary, but the ability to communicate what the Quality Control Supervisor needs to correct in the plant to his fellow supervisors, is indispensable. If, in selecting and training a qualified man, you can also impart to him the importance of getting his ideas across in a manner that gets their cooperation, his job is half done. Show your Q. C. Supervisor where and how to look for problems his test results tell him are there. Be sure he knows what clean means when he looks at equipment. What temperature and time relationships are important? How do they affect the finished product?

As for tests he'll do, that will depend on the kind of program that is designed and its goals, as well as how extensively the laboratory is equipped. The following is a summary of the program we use in our plants. It is minimal by design and each plant is encouraged to add tests they feel will give them needed information or to increase frequencies of the tests as they feel the need. The nine-point policy statement given above constitutes Section I of our Minimum Quality Program. A greatly condensed version of Sections II and III is outlined below.

SECTION II.—GENERAL LABORATORY PROCEDURE

Tests on producer samples, raw tanker samples, and finished products should be done as directed in the outline or more frequently as requested or approved by the plant manager, with the approval of the district manager. The Quality Control Supervisor is directly responsible for this portion of the program.

I. *Producer tests.* Minimum frequency and procedural recommendations are presented for producer sample tests including butterfat, bacteria, solids-not-fat, flavor and odor, sediment, antibiotics, abnormal milk, and ropy milk.

II. *Raw Milk in tankers.* On tanker loads where entire supply is from outside groups where we have no individual producer control, this section will have added significance. Sufficent samples from regular and outside suppliers must be taken and examined for excessive bacteria count, flavor, odor, to insure the quality of our milk supply. The tests considered under this heading include those for flavor and odor, acidity, temperature, butterfat, solids-not-fat, bacteria, antibiotics, and ropy milk.

III. *Daily production (raw side).* Checks made on samples of each tank of raw milk and any tank held over include flavor and odor, acidity, temperature, butterfat, and bacteria.

IV. *Daily production in process.* Pre-packaging tests include organoleptic checks on each batch of each product and butterfat, solids-not-fat, or Brix as needed for verification of standardization of any product.

V. *Daily production (packaged products).* Sampling-Our minimum sampling program for finished products includes sampling of the very first two bottles or packages of each product offered for sale off each filling machine at the beginning of each operating day and after each changeover plus additional packages taken in duplicate at random intervals during each run.

VI. *Packaged product sample analyses.* Of the two "first off" samples, one is immediately checked for fill weight, fat test, organoleptic evaluation, carton quality, and open date. The other "first off" sample is incubated in the original carton overnight at room temperature for plating the next day using Violet Red Bile or DCT agar to give an indication of post-pasteurization contamination. Of the random sample pairs, one of each pair is incubated overnight at room temperatre for plating using Violet Red Bile or DCT agar the following day. The other sample of each pair is

incubated in its original carton at 45 F until 5 to 7 days past pull date when it is examined organoleptically and may also be plated for shelf-life evaluation. *Follow-through procedure with collected samples.* A paragraph emphasizes that laboratory work is only as meaningful as the corrective action that it generates in actual plant processing and operation.

VII. *Outside ingredients.* Avoid being caught with only a poor ingredient on hand by setting up a procedure to check all incoming shipments of new ingredients. On carefully taken samples of all outside ingredients, do those specified tests which logically apply. Recordkeeping on all the listed items is very important. A number of observations, inspections, and analyses are then specified for use as applicable; e.g., here the necessity of inspection for shipping damage and rodent or insect infestation is emphasized along with routine organoleptic, bacteriological, and compositional evaluations.

Section III - Additional Duties

Additional duties we expect of all our Quality Control Supervisors include such things as checks at specified frequencies of items such as thermometers, scales, package weights and appearance, processing and packaging temperatures, C.I.P. solution strengths and temperatures, chlorine solutions, and many other similar details. While this list might well vary according to specific products processed in a given operation, one responsibility quite standard regardless of product line is that of accompanying regulatory officials on their rounds of the plant.

While I have touched rather lightly on the details of this Additional Duties section, I might suggest that we found this to be an excellent place to develop a rather complete job description for our Quality Control Supervisor. It's important in larger operations not to tie down the Quality Control Supervisor to routine testing. Let a technician handle this. The Q. C. man can and will make money for the company if he has some freedom.

In recent years some new techniques have come along that, when properly pursued, can be of considerable value to a Quality Control program. One of these techniques is aseptic sampling, and while not a cure-all, it can help to solve some of those mysterious count problems that plague us all from time to time. What is aseptic sampling? It simply means "obtaining a sample under controlled conditions such that outside contamination is excluded." Let's look at the *how and where* of aseptic sampling techniques. The system we currently ask our plants to use consists of a 1/4 inch hole drilled in the line and a rubber grommet (actually the molded foot pad from an adding machine) which is forced into the hole. This grommet can be sanitized before each use, a syringe needle inserted, sample withdrawn, syringe sanitized, and you have an aseptic sample. These grommets are shaped in a manner that prevents blow out and they seem to clean in place very well. They usually can be punctured up to 50 times before they need replacement. Modifications of this technique can be used for continuous line sampling for bacteriological purposes.

Other types of samplers that I'm aware of are: *(a)* the grommet, such as I've mentioned, plus a perforated pipe band to hold it in place under pressure extremes; *(b)* the cap from an injectable vial held in place by a perforated pipe band over a suitably sized hole in the line; and *(c)* nylon or teflon or metal plug caps for sanitary lines can be drilled and counter-sunk, and a drilled stainless or teflon male plug threaded into the counter-sunk portion will hold a soft rubber disk in place; this requires a tee fitting and much more work and expense than the other two methods I mentioned. There are probably many more kinds that I've not heard of. I've used these three systems and I recommend the rubber grommet without a band for most applications.

When you've decided on a sampler, where do you put it? Isolation is the key word here. We start with a sampler just over the bottle machine surge bowl. If samples from this point are consistently clear and we have counts in bottled products, we have pretty sound proof that the bottle machine, rather than the system is the source of contamination. If we find consistent counts at the machine sampler, we then begin to concentrate on the processing system. If an end-to-end search of all the components of the system does not turn up the problem area, the next step is to install samplers in places that segment the system into easily identifiable sections. Sample sizes up to 10 ml and sample frequencies as often as 30 min may be necessary initially to pinpoint the source of the problem. At the same time, any night during clean-up, one of the workers may do some one thing he'd forgotten to do for weeks and clear up the whole problem with no one realizing why it happened. Such occurrences are the frustrations of the business we're in. An aseptic sampling network in the plant can help head off long, expensive searches for the answer.

We have an aseptic sample, we have a lab, a good technician—what's the next step to the improvement of our product? I call it insurance. Other names for this step are, "clean room technique" and "clean environment techniques." In the pure state, a "clean room" is a sealed room with air lock type doors supplied with 99.999% particulate-free air under slight pressure. The people who work in these rooms wear special sterile clothing, including face masks and all materials in and out go through air locks and/or autoclaves. Remember I said this is a clean room in

its pure state. Food processing does not strictly lend itself to this type of room, but many aseptic product processors have made modifications of this type of room. As an example, one of the "sterile" dairy product processors, processes his product and bottles it in a room which was constructed to be completely and easily cleanable. It has an air supply that is 99.99% + particulate-free. Cartons are fed by the case into the room through a vacuum gas chamber which sterilizes each carton in a dry manner. Only one man works in the room at a time, the equipment being of moderate volume and highly automated so that he has time to operate both the processing unit and the bottle machine. The dressing room and rest room open through an air lock door into the pressurized processing area so that the man only needs to come out for lunch. This is a good system, justifiable expensewise because of the premium priced sterlized product yielding long shelf life.

In building new plants and remodeling existing plants, the clean environment technique should be kept in mind. Room construction making clean-up easy, a high quality air supply introduced in surplus to what a *low level* exhaust system removes, providing slight positive pressure in the room, a good floor surface well drained, are all features which tend toward good environmental control. Good housekeeping and good insect, rodent control practices round out a well planned plant.

Another application of clean room techniques, well worth considering, is the clean bench for laboratory use. The most carefully taken and prepared sample may well be jeopardized by plating in an atmosphere with a high contamination level. A clean bench provides a zone of highly filtered air in which to do critical work of this nature. Culture transfers may also be carried on in this type unit with greatly reduced risk of contamination.

Trends in Quality Control

A few words about what appears to us to be trends in the Quality Control field. First of all, obviously, there is a much more critical look at our product. Consumers are better informed and more critical than ever before. Competition between food producers is rapidly closing the quality gap. Careful and rigid control of our products is the only answer.

Automation is blossoming in the Quality field as it has in the rest of the food business. Automated fat and solids testing equipment, automated colony counters for reading bacterial plates, expanded scale, solid state, pH and conductivity equipment, improved and less expensive microscopes, a host of disposable equipment of all kinds; all of these are aids to, and indicative of the postive movement of Quality Control.

All the consumer pressure, the automation, the move toward clean room techniques, increased regulatory action, spells more action in the Quality Control field, and an increased need for dedicated and capable people. We see a trend toward more audio-visual training aids as an adjunct to all I've mentioned above. Training will be aimed at all levels of plant activity from clean-up crews to plant managers. Training toward a Quality attitude is a never ending process.

CHARACTERISTICS OF CHEDDAR CHEESE COOLED AT DIFFERENT RATES DURING EARLY CURING STAGES

A. H. MIAH[2], G. W. REINBOLD, J. C. HARTLEY[3],
E. R. VEDAMUTHU[4], AND E. G. HAMMOND
Department of Food Technology
Iowa State University, Ames, Iowa 50010

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ABSTRACT

Sixteen lots of Cheddar cheese were made from manufacturing-grade and grade-A milk by using commercial starters and cultures reported to give fruity and bitter-flavored cheese. Curd blocks were pressed for 4 and 20 h, then cooled to 7.5 C in brine or in air. There were no statistically significant differences in total, enterococcus, and Violet red bile agar counts, or proteolysis and judging scores among different pressing or cooling treatments. Significantly greater amounts of lactose, glucose, and galactose were present in brine-cooled cheese. Lactose persisted beyond 3 months. Air-cooled cheese had a significantly higher lactic-acid content, more free fatty acids, and more color variation. Air-cooled cheese was more severely criticized for flavor defects. Brine cooling produced uniform flavor, body, and color, and six of the seven judges preferred brine-cooled cheese.

Even though the effects of different curing temperatures on cheese characteristics have been carefully documented, there is virtually no literature on the influence of temperature *during the early part of curing* on subsequent Cheddar-cheese maturation. Conochie and Sutherland *(5)* have cited a particular instance in which differences between blocks from the same vat could be attributed to the block stacking of warm cheese on pallets and block stacking of pallets. Reinbold *(25)*, in more general terms, noted that cheese graders sometimes encounter flavor differences between blocks from the same vat. Wilson and Reinbold *(34)* stated that the openness in texture in Cheddar cheese cured at high temperatures has been related to the fermentation of residual carbohydrate, suggesting prompt and efficient cooling before curing.

Before the early 1900's, Cheddar cheese was cured at room temperature *(30)*. It was found later that cheese ripened below 7.2 C has more uniform flavor, body, and texture *(1, 24)*. A sizeable amount of commercial Cheddar cheese is still criticized, however, for lack of flavor, high acidity, defective body and texture, and off-flavors.

Temperature of cheese blocks when taken out of the press may range between 21 and 35 C and the length of press may range between 2.5 and 17 h *(33)*. In large commercial operations making thousands of pounds of cheese daily, blocks are sometimes stacked close together in the curing room, with no effort made to hasten cooling.

Our study explored the effect of temperatures used during *the early stages* of Cheddar-cheese curing on the physical, chemical, and bacteriological changes during ripening and on the finished cheese.

EXPERIMENTAL METHODS

Manufacture and treatment of cheese

The experimental treatments used represent curd-handling procedures currently employed in 20 commercial plants surveyed in Iowa, Wisconsin, New York, and South Dakota *(33)*. Details of the manufacturing treatments are presented in Table 1. Make procedures were essentially those recommended by Wilson and Reinbold *(34)*; starter cultures, milk source, and other factors, however, were selected and adjusted to produce the kinds of cheese listed in Table 1. Pressing time and early-curing temperature variations were then introduced. After 4-h pressing, two sets of blocks were wrapped in foil-cello-foil wrappers (Marathon, Division of American Can Company, Neenah, Wisc.) and sealed with a Flexpress (Model R.L. 100. D. L. Manufacturing Company, W. De Pere, Wisc.). One set was immersed in a 4 C brine tank for rapid cooling to 7.5 C, and the other was stacked on a pallet in the curing room at 7.5 C for conventional air cooling. After 20 h, two more sets of blocks were removed from the press and were treated in the same way.

Sampling, tests, and cheese analysis

Table 2 lists the tests and testing schedule used for analysis. All cheeses, except lot A, were judged organoleptically after 3 and 6 months of curing by a panel of seven experienced judges using the American Dairy Science Association Intercollegiate Scorecard. Lot A was abnormally acid and bitter at 3 months; flavor scores were, therefore, rejected. Because it had somehow improved by 6 months, results were then included with data from the other lots. In addition, paired comparisons *(15)* were made among the four treatments (4- or 20-h press, followed by brine or air cooling) after 3 months of curing. Samples representing the four treatments were combined into the six possible pairs. These pairs were

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[2]Present address: Department of Dairy Science, Bangladesh Agricultural University, Mymensingh, Bangladesh.
[3]Present address: 203 Dairy Products Bldg., University of Kentucky, Lexington, Kentucky 40506.
[4]Present address: Microlife Technics, 1833 - 57th St., Sarasota, Florida 33578.

TABLE 1. CHEESE MANUFACTURING DATA AND TESTING PROCEDURES

Lot	Milk grade	Heat treatment	Culture	Milling acidity (% titratable acidity)	General description	Tests[a]
A	Mfg.[b]	62.8 C/17 sec	CL[c]	0.60	Slightly high acid	All
B	Mfg.	62.8 C/17 sec	CL	0.68	High acid	All
C	Mfg.	62.8 C/17 sec	CL	0.70	High acid	All
D	Mfg.	62.8 C/17 sec	CL	0.56	Nomal	All
E	Mfg.	Raw	CL	0.60	Raw milk	All
F	Mfg.	62.8 C/17 sec	CL	0.50	Normal	All
G	A	62.8 C/17 sec	Fruity[d]	0.55	Fruity	All
H	A	62.8 C/17 sec	Fruity	0.54	Fruity	All
I	A	62.8 C/17 sec	Fruity	0.56	Fruity	All
J	A	62.8 C/17 sec	CL	0.53	Good	Organo.
K	A	62.8 C/17 sec	CL	0.58	Good	Organo.
L	A	62.8 C/17 sec	CL	0.59	Good	Organo.
M	A	62.8 C/17 sec	Bitter[e]	0.51	Bitter	Organo.
N	A	62.8 C/17 sec	Bitter	0.54	Bitter	Organo.
O	A	62.8 C/17 sec	Bitter	0.64	Bitter	Organo.
P	A	71.7 C/17 sec	1% CL 0.5% Coliform	0.58	Gassy	Organo.

[a]The bacteriological, chemical, and color measurements listed in Table 2, unless otherwise noted, were made during the first 3 months of curing. Organoleptic determinations were made after 3 and 6 months of curing.
[b]Iowa grading law for milk manufacturing purposes, Chapter 194, Iowa Department of Agriculture.
[c]The symbol CL indicates the use of 1% commercial lactic starter.
[d]See reference 31 and 32.
[e]Provided by Dr. D. B. Emmons, Canadian Department of Agriculture, Ottawa.

presented to the judges in randomized order. The judges were asked to determine if there were differences in flavor, body and texture, and color within each pair and to indicate their preferences within each pair. A sample received 1 point each time it was preferred over the other in the pair. If no preference was indicated within a pair, it was allotted 0.5 point. The number of points for each sample in the six pairs was added and multiplied by 2 to remove half points. This provided a means to determine each judge's paired-comparison score on each treatment for that cheese lot. Statistical analyses were made only on the basis of preference with each pair.

Statistical analysis

Results from samples collected from lots A through I after 12 days and after 1, 2, and 3 months of curing were used for statistical analyses. Statistical significance was determined by comparing F values with critical values given by Steel and Torrie *(28)*.

RESULTS AND DISCUSSION

Statistical significance of the effects of pressing times and cooling rates on the bacteriological, chemical, physical, and organoleptic tests are in Table 3. Specific results are given for the cheese of lot D because it is similar to typical commercial Cheddar cheese.

To simplify the presentation, results are furnished only for samples collected after milling, 4-h pressing, 12 days, and after 1, 2, and 3 months of curing. Detailed results for all the lots are presented elsewhere *(19)*.

Bacterial counts of the manufacturing-grade milk and the curd for lot D cheese are presented in Table 4. Counts are presented for curd pressed 4 h and then brine-cooled. Although air-cooled curd required considerably more time than did brine-cooled curd to reach 8 C or below *(20)*, no corresponding significant differences were observed in the total enterococcus, or Violet red bile count. Nor did pressing times have a significant effect on the counts.

With reference to other cheese lots, enterococci were present in large numbers only in cheese made from manufacturing-grade milk. For example, the enterococcus count of lot E was 18×10^6/g at milling; it reached a high of 52×10^6/g at 1 month of curing; at 3 months, the count was 52×10^4/g. Lot H, made from grade-A milk, contained 10×10^1 enterococci/g at milling, 30×10^1/g at 1 month of curing, and 40×10^1/g at 3 months. Both these cheeses were made from curd pressed 4 h and brine-cooled. The greater number of enterococci in manufacturing-grade milk cheese curd was not unexpected because Clark and Reinbold *(4)* have reported frequent occurrence of enterococci in young commercial Cheddar cheese.

Lactic-acid content of cheese from lot D is presented in Fig. 1. Statistical analysis showed that the lactic-acid concentration in air-cooled cheese was significantly higher than in brine-cooled cheese and in 20-h- over 4-h-pressed cheese ($P < 0.01$). The higher acidity in the air-cooled and longer-pressed cheese probably resulted from more rapid growth and metabolism of starter organisms during cooling of the curd to curing-room temperature. Since the

TABLE 2. TESTS AND TESTING SCHEDULE

Product and test period	Tests: Bacteriological[a]	Chemical[b]	Organoleptic and color[c]
Milk			
Raw	+		
After heating	+		
Cheese			
4-h press	+	+	
20-h press	+	+	
4 days	+	+[d]	
8 days	+	+[d]	
12 days	+	+[d]	
21 days	+	+[d]	
1 month	+	+	
3 months	+	+	+
6 months	+		+

[a]Bacteriological tests included: Total counts—Eugonagar *(2)*, 21, 21 C for 7 days; Enterococcus counts—Citrate azide agar *(26)*, 37 C for 72 h; Violet red bile counts—Violet red bile agar, 32 C for 18-20 h. Samples were collected and analyzed immediately.
[b]Chemical tests included: Lactic acid *(13, 19)*; Proteolysis *(12)*; Total free fatty acids *(14)*; Reducing sugars *(19)*. Samples were analyzed immediately whenever possible, otherwise, they were stored at −10 C until tested.
[c]All cheeses were subjected to organoleptic tests after 3 and 6 months of curing. Color measurements were made at 3 months by using a Beckman DK-2A ratio recording spectrophotometer for reflectance measurements at 400-700 nm. The reflectance data taken at the absorption maxima of 465 nm were statistically analyzed.
[d]Proteolysis and total free fatty acids tests not done.

TABLE 3. STATISTICAL SIGNIFICANCE[a] OF EFFECTS OF PRESSING TIMES AND COOLING RATES OF CHEESE CURD ON BACTERIOLOGICAL, CHEMICAL, PHYSICAL, AND ORGANOLEPTIC TESTS ON COMMERCIAL CHEDDAR CHEESE (LOT D)

Significant	Not significant
Pressing time[b]	
Lactose	Total count
Galactose	Enterococcus count
Lactic acid	Violet red bile count
Free fatty acids	Glucose
	Proteolysis
	Reflectance
	Judging score
	Flavor
Cooling rate[c]	
Lactose	Total count
Glucose	Enterococcus count
Galactose	Violet red bile count
Lactic acid	Proteolysis
Free fatty acids	Judging score
Reflectance	Flavor

[a]$P < 0.05$.
[b]Curd was pressed for 4 and 20 h.
[c]Curd was cooled in 4.4-7.2 C brine and in 7.2 C air to 7.5 C.

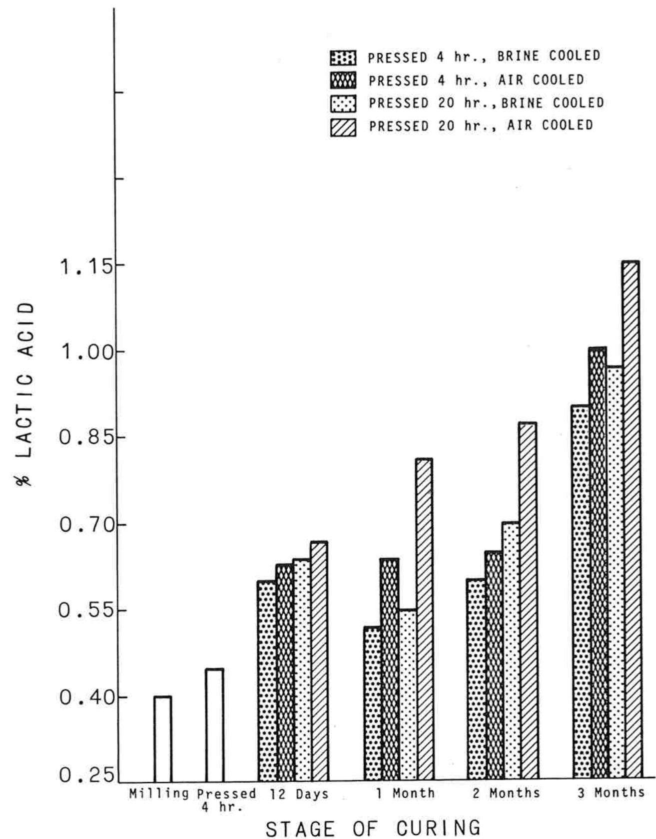

Figure 1. Lactic acid content of Cheddar cheese from lot D (manufacturing-grade milk) during curing.

treatments did not produce a significant difference in bacterial counts at the test intervals, it is possible that the temperature affected the metabolic rate, but did not change the bacterial population. Changes in total number between 4 and 20 h of pressing were not determined. It is possible, although not likely, that other groups of microorganisms not enumerated in this experiment could have converted the available sugar to lactic acid.

A substantial amount of lactose was still present after 3 months of curing (Fig. 2). This contradicts earlier belief that, in hard cheeses, lactose is completely utilized within the first 2 weeks of curing *(21, 23, 27)*. Many other research workers *(9, 11, 18, 29, 30)* have reported that lactose is utilized early in the ripening of Cheddar cheese. Methods used by earlier investigators for detecting lactose were less sensitive. In 1956, Mabbitt and Zielinska *(17)* detected lactose in Cheddar cheese after 4 months of ripening. In our study, cheese pressed 20 h and then air-cooled contained 0.34% lactose after 3 months of curing. Pressing intervals and cooling rates showed a significant difference ($P < 0.01$) in the amount of lactose present during curing. The shorter pressing time and faster cooling rate resulted in greater amounts of residual lactose in the cheese.

TABLE 4. BACTERIAL COUNTS OF MANUFACTURING-GRADE MILK (PER ML) AND CURD (PER GRAM) FOR LOT D CHEESE[a]

Sample	Total count $\times 10^6$	Enterococcus count $\times 10^3$	Violet red bile count $\times 10^1$
Milk			
Raw	61	180	290,000
Heat treated	15	64	36
Curd			
Milling	1,500	2,900	9,100
4-h pressing	920	2,700	7,800
12 days	68	24,000	1,500
1 month	600	32,000	5,900
2 months	110	6,600	1,600
3 months	42	530	<10

[a]Curd was pressed 4 h and brine-cooled.

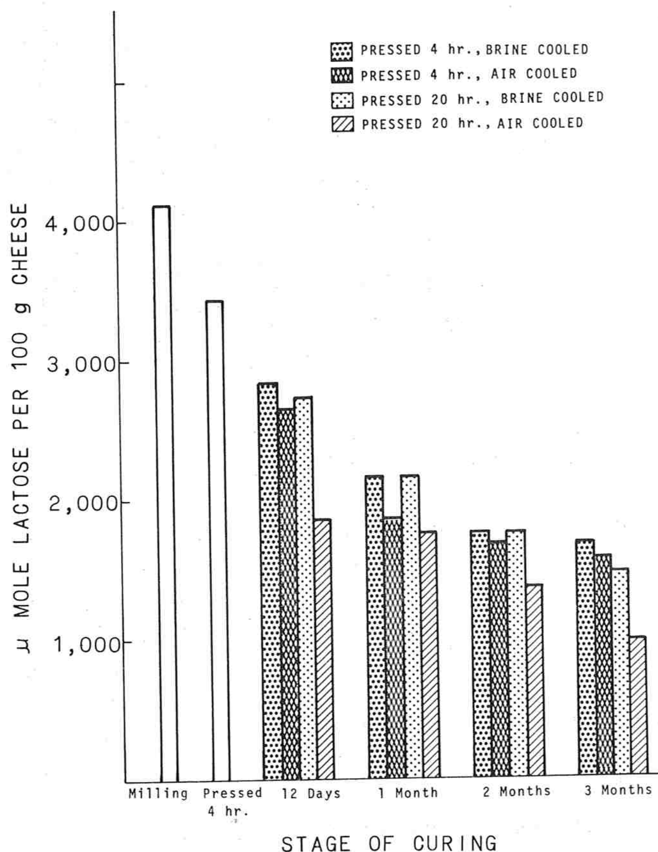

Figure 2. Lactose content of Cheddar cheese from lot D (manufacturing-grade milk) during curing.

The amount of glucose present in the brine-cooled cheese was significantly higher ($P < 0.05$) than in the air-cooled cheese. Pressing time, however, did not have a significant effect on the glucose level. These statements are based on average glucose content of all cheeses but are not apparent in the data given in Fig. 3.

Disappearance of galactose followed a pattern similar to that of glucose. Brine-cooled cheese contained significantly higher amounts of galactose than did the air-cooled cheese ($P < 0.01$). Even though there was more lactose hydrolysis in air-cooled cheese, the glucose level was considerably lower than that of galactose during the first 12 days of curing. This probably was due to preferential utilization. Figure 4 gives the pattern of galactose disappearance in lot D cheese. Unfortunately, the same anomalous results as with glucose disappearance in Fig. 3 are apparent in this figure, however, as indicated previously, for purposes of continuity, all specific data shown pertain to lot D cheese.

The free fatty acid content of cheese from lot D is presented in Fig. 5. Air-cooled cheese contained significantly larger amounts of free fatty acids than did brine-cooled cheese. Greater amounts of fatty acids in air-cooled cheese probably resulted from the increased activity of bacterial flora during the early stage of ripening. Pressing also had a highly significant effect on the amount of fatty acids, 20-h pressed cheese containing more than did 4-h pressed cheese. Cheese sampled at 3 months from lot B (high-acid cheese) pressed 4 h and then brine-cooled required only 6.91 ml of 0.01 N alcoholic KOH, compared with 10.47 ml for cheese from lot D. Higher amounts of free fatty acids found in normal cheese relative to high-acid cheese suggest that lipoly-

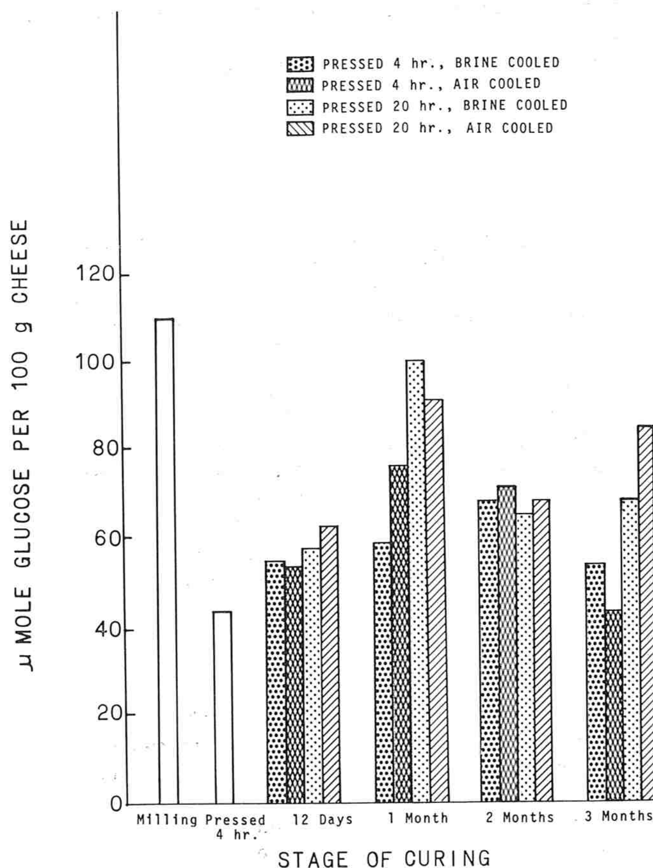

Figure 3. Glucose content of Cheddar from lot D (manufacturing-grade milk) during curing.

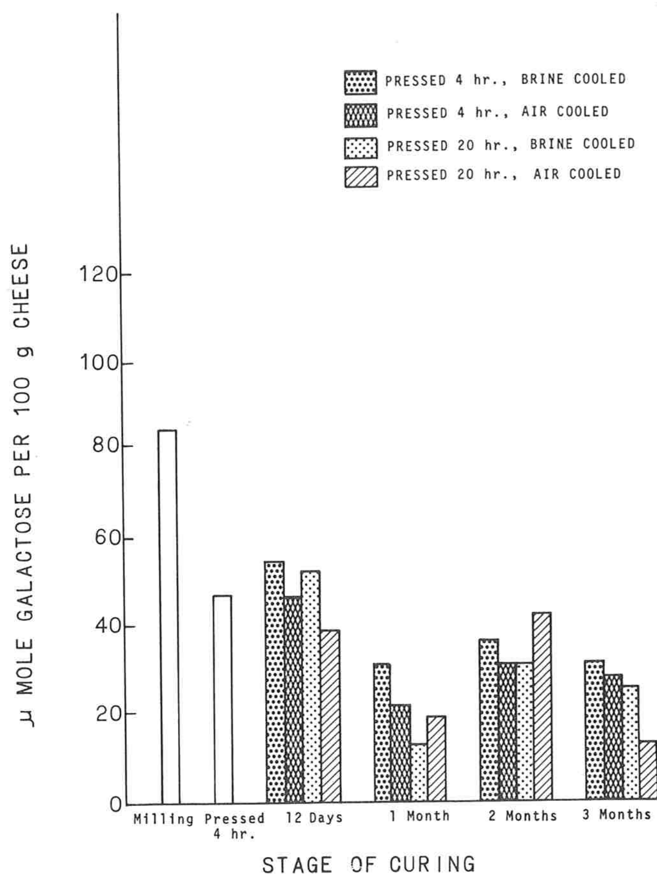

Figure 4. Galactose content of Cheddar cheese from lot D (manufacturing-grade milk) during curing.

tic activity is diminished at low pH. Irrespective of press and cooling treatment, the high-acid cheeses required an average of 6.66 ml of 0.01 N alcoholic KOH per 5 g cheese. Cheeses made at normal acid levels required 10.63 ml for neutralization of the fatty acids per 5 g cheese.

Vedamuthu et al. *(31, 32)* reported that fruity-flavor defects could be caused by high amounts of aldehydes and other carbonyl compounds produced by certain starter organisms. One of these cultures was used for the fruity cheese lots. Fatty acids in these cheeses were significantly less than in the other cheese lots. One of the reasons for the flavor defects could be the formation of esters from alcohol and fatty acids. Mabbitt *(16)* suggested that residual sugar fermentation by heterofermentative bacteria produced acetic acid, ethanol, glycerol, and mannitol. If these are produced in excessive quantities, their reaction with fatty acids would produce detectable levels of esters. Bills et al. *(3)* found that excess fatty esters caused fruity flavor in Cheddar cheese. In this experiment, only one lot of the cheeses made with a fruity-flavor culture developed a characteristic fruity taste. The defect did occur casually in a few other lots of cheese, usually where slow cooling had been used. But, there were not enough instances for proper evaluation; therefore, the effect of press time and cooling rate cannot be reported. With this experience, however, it seems reasonable to expect that slowly cooled cheese would more readily develop this defect. This conjecture should be thoroughly tested.

There was no statistically significant difference in the amount of proteolysis due to the pressing period or cooling rate. Naturally, the amount of proteolysis increased during curing. As an example of this increase, cheese from lot D had proteolysis indexes of 13.0, 21.9, and 26.9% at 1, 3, and 6 months, respectively.

Use of rapid cooling did not improve the flavor of cheese made with the bitter culture. Development of bitter flavor in cheese has been attributed to insufficient breakdown of proteins and polypeptides to amino acids *(6, 8)*. Raadsveld *(22)* isolated substances with a polypeptide structure from bitter cheese, but similar products also were obtained from nonbitter cheese. He concluded that bitter taste resulted with certain combinations of odoriferous compounds. Emmons et al. *(7)* found that the development of bitter flavor in Cheddar cheese was more dependent on the starter strains used than on the manufacturing procedure.

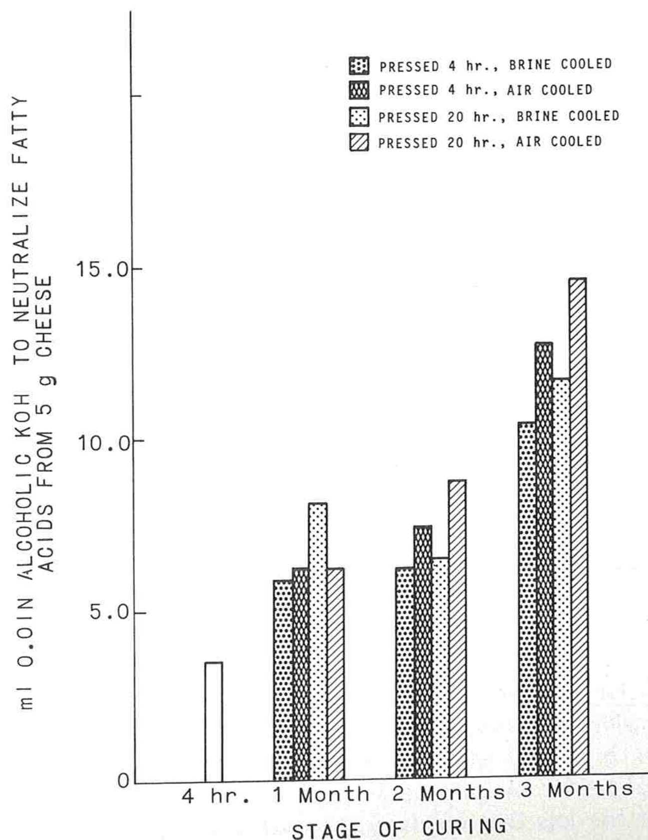

Figure 5. Free fatty acid content of Cheddar cheese from lot D (manufacturing-grade milk) during curing.

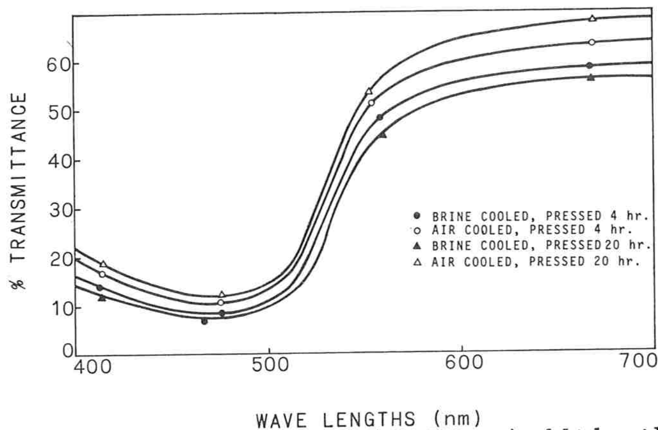

Figure 6. Reflectance spectra (400-700 nm) of high acid Cheddar cheese from lot B (manufacturing-grade milk) after 3-months curing.

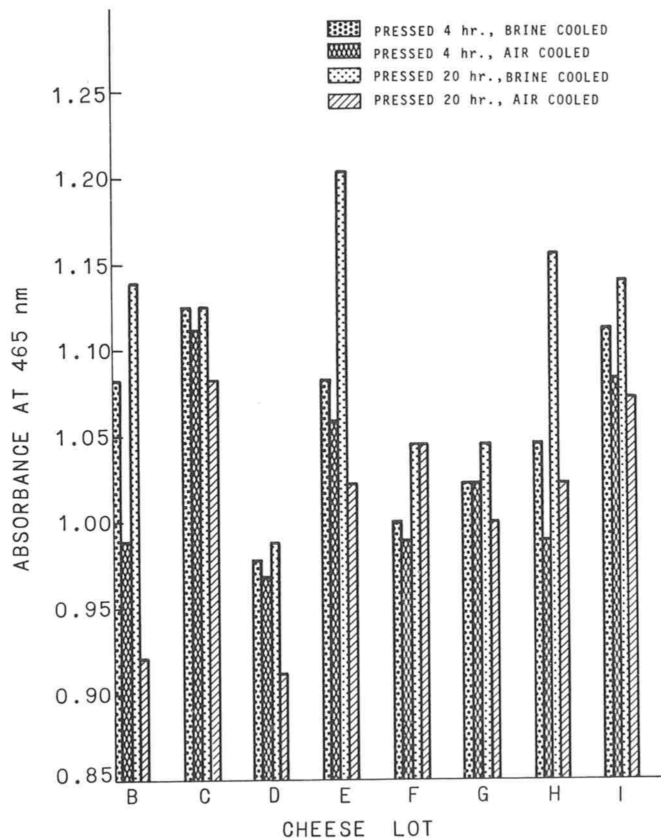

Figure 7. Intensity of Cheddar cheese color measured by reflectance at 465 nm after 3-months curing.

A reflectance spectra of cheese from lot B, performed after 3 months of curing, is shown in Fig. 6. Color differences between cheeses subjected to the various pressing and cooling treatments were greater in high-acid cheese. Figure 7 shows absorbance values for samples of 3-month-old cheese from eight of the lots that received the four treatments. Brine-cooled cheese showed more intense color than did air-cooled cheese. These differences were highly significant ($P < 0.01$). Color differences are explainable in light of sugar breakdown and acidity. There were, however, no significant differences in color because of differences in pressing time.

Judging results were consistent with results of the chemical tests. Brine-cooled cheese, which contained higher concentrations of sugar, less lactic acid, and less fatty acids, received higher flavor scores. Thus, differences in the cooling rate of cheese blocks can attribute serious problems in cheese flavor as suggested by Conochie and Sutherland *(5)*. With poor-quality milk containing millions of adventitious bacteria, the organisms, if the temperature is suitable, could produce unbalanced fermentations leading to serious defects. Bacterial flora in cheese made from poor-quality milk can be controlled to some extent if cooled rapidly to curing-room temperature (7.5 C) after pressing.

There was great variation among judges in the scoring of cheeses subjected to the different treatments. No statistically significant difference was observed between the different treatments. There was

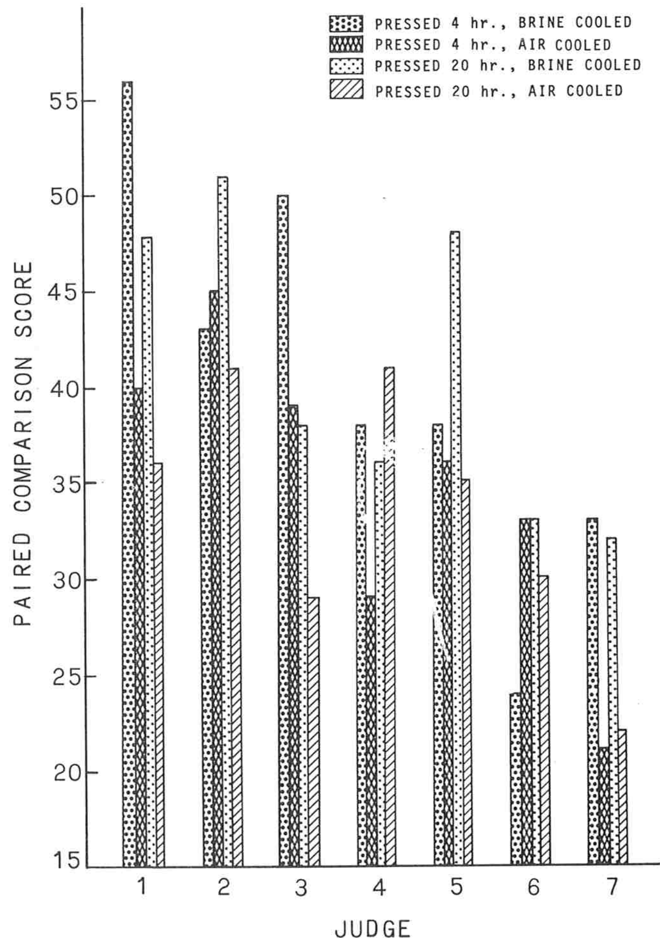

Figure 8. Paired comparison scores for each judge on 15 lots of Cheddar cheese which received four pressing and cooling treatments.

a significant difference ($P < 0.01$) in body and texture scores among normal-acid cheese (D, E, F), fruity cheese, (G, H, I), the three lots manufactured with recommended procedures, and the three lots manufactured with a culture that produced bitter flavor. Cheese made under "ideal conditions" and cheese made with the bitter culture had a firmer and smoother body than the normal-acid and fruity cheese. Each type of cheese had a significantly higher flavor and body score at 6 months than at 3 months of curing.

Figure 8 shows the paired comparison scores of each judge on individual treatments over 15 lots of cheese. Brine-cooled cheese had higher total scores in most instances. The preference of only one judge was statistically significant ($P < 0.01$); he preferred 4-h pressed, brine-cooled cheese. Six of the seven judges preferred the 4-h pressed cheese, and three judges preferred the 20-h pressed cheese. Although one judge preferred 20-h pressed, air-cooled cheese, four judges did not prefer the cheese receiving this treatment. Most judges noted a slight-to-moderate difference in flavor and body within a pair composed of air- and brine-cooled cheeses. Differences between 4- and 20-h pressing were insignificant.

On the basis of the criticisms marked on the scorecards, an attempt was made to categorize the defects of the cheese. Five of six judges criticized the air-cooled, high-acid cheese (A, B, C), for high acid and bitter flavor. The brine-cooled cheeses were not criticized for such defects by three judges; three others described the acid or bitter flavor in these cheeses as being slight when compared with the air-cooled cheese.

Two lots of the normal-acid cheese (D, E, F) were criticized by four judges for high acid and by three judges for fruity-flavor defects at 6 months of curing. Air-cooled cheese was severely criticized by all judges for high-acid and fruity-flavor defects, but brine-cooled cheese did not receive these criticisms. Of the three lots of cheese made with recommended procdures, the air-cooled cheese was criticized for high-acid flavor.

None of the cheeses (G, H, I) made with the fruity culture was criticized for fruity flavor at 3 months of curing. At 6 months, only lot I had developed an appreciable amount of fruity flavor. Because of this, the effect of press time and cooling time and cooling rate could not be properly measured. The brine-cooled cheese, however, did not receive criticism for high-acid flavor.

When the bitter culture was used, both brine- and air-cooled cheese was criticized for bitter flavor. The lot of cheese made with added coliform organisms received low scores for all treatments and had a gassy, weak, and pasty body. Five of six judges, however, considered the brine-cooled cheeses of this lot flat rather than high-acid flavored. On the other hand, four of six judges criticized the air-cooled cheese for having a high-acid taste, and two of them detected fruity flavor.

From the foregoing, it is evident that high-quality milk, desirable starters, and rapid curd cooling are necessary for the manufacture of uniformly high-quality Cheddar cheese.

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AMENDMENT TO
3-A SANITARY STANDARDS AND ACCEPTED PRACTICES

This amendment adds (1) "3-A" and a serial number to two 3-A Sanitary Standards, (2) adds serial numbers to two 3-A Sanitary Standards, one Supplement to a 3-A Sanitary Standard, four 3-A Accepted Practices and two Amendments to 3-A Accepted Practices and (3) changes the serial numbers of twenty-one 3-A Sanitary Standards, twenty-three Amendments to 3-A Sanitary Standards, four Supplements to 3-A Sanitary Standards, three 3-A Accepted Practices and one Amendment to a 3-A Accepted Practices.

The following 3-A Sanitary Standards are amended in title by the addition of 3-A and the addition of a serial number:

3-A Sanitary Standards for Weigh Cans and Receiving Tanks for Raw Milk, Serial #03-00.

3-A Sanitary Standards for Seamless and Welded Tin-Coated Can-Type Milk Strainers, Serial #07-00.

The title of the following 3-A Sanitary Standards, Supplements and 3-A Accepted Practices are amended by the addition of the serial number given:

Supplement No. 1 to 3-A Sanitary Standards for Instrument Fittings and Connections Used on Milk and Milk Products Equipment, Serial #09-01

3-A Sanitary Standards for Milk and Milk Products Filters Using Disposable Filter Media, Serial #10-00

3-A Sanitary Standards for Inlet and Outlet Leak Protector Plug Valves for Batch Pasteurizers, Serial #14-00

3-A Accepted Practices for the Sanitary Construction, Installation, Testing and Operation of High-Temperature Short-Time Pasteurizers, Revised, Serial #603-01

Amendment to 3-A Accepted Practices for the Sanitary Construction, Installation, Testing and Operation of High-Temperature Short-Time Pasteurizers, Revised, (Effective January 22, 1967), Serial #603-02

3-A Accepted Practices for the Sanitary Construction, Installation, Testing and Operation of High-Temperature Short-Time Pasteurizers, Revised, (Incorporating Amendment Effective June 7, 1969), Serial #603-03

3-A Accepted Practices for Permanently Installed Sanitary Product-Pipelines and Cleaning Systems, Serial #605-00

Amendment to 3-A Accepted Practices for Permanently Installed Sanitary Product-Pipelines and Cleaning Systems, Serial #605-01

3-A Accepted Practices for the Design, Fabrication and Installation of Milking and Milk Handling Equipment, Serial #606-00

The following serial numbers of 3-A Sanitary Standards, Amendments and Supplements to 3-A Sanitary Standards and 3-A Accepted Practices and an Amendment to a 3-A Accepted Practices are hereby changed as indicated:

Present Serial Number	New Serial Number	Present Serial Number	New Serial Number	Present Serial Number	New Serial Number
0203	02-03	1103	11-03	2001	20-01
0204	02-04	1204	12-04	2002	20-02
0205	02-05	1301	13-01	2003	20-03
0403	04-03	1302	13-02	2004	20-04
0511	05-11	1303	13-03	2005	20-05
0809	08-09	1304	13-04	2300	23-00
0810	08-10	1305	13-05	2400	24-00
0811	08-11	1401	14-01	2500	25-00
0812	08-12	1604	16-04	2600	26-00
0813	08-13	1700	17-00	2700	27-00
0900	09-00	1701	17-01	2800	28-00
0902	09-02	1702	17-02	2900	29-00
0903	09-03	1703	17-03	3000	30-00
0904	09-04	1800	18-00	60304	603-04
0905	09-05	1900	19-00	60403	604-03
0906	09-06	1901	19-01	60700	607-00
1001	10-01	2000	20-00	60800	608-00
1002	10-02				

This amendment is effective March 26, 1974.

3-A SANITARY STANDARDS FOR STORAGE TANKS FOR MILK AND MILK PRODUCTS

Serial #01-06

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

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

A.
SCOPE

A.1
These standards cover the sanitary aspects of storage tanks for milk and milk products.

A.2
In order to conform with these 3-A Sanitary Standards, storage tanks shall comply with the following design, material, fabrication, and cleaning criteria.

B.
DEFINITIONS

B.1
Product: Shall mean the milk or milk product stored in the tank.

B.2
Storage Tank: Shall mean a cylindrical, rectangular, oval or other equally satisfactory shape tank except a vertical tank whose inside height is in excess of 10 feet[1] and the tank is used for the storage or storage and cooling of a product.

B.3
SURFACES

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

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

B.4
Mechanical Cleaning or Mechanically Cleaning: Shall denote cleaning, solely by circulation and/or flowing chemical detergent solutions and water rinses onto and over the surfaces to be cleaned, by mechanical means.

C.
MATERIALS

C.1
All product contact surfaces shall be of stainless steel of the AISI 300 series[2] or corresponding ACI[3] types (See Appendix, Section E.), or stainless steel which under conditions of intended use is at least as corrosion resistant as stainless steel of the foregoing types and is non-toxic and non-absorbent except that:

C.1.1
Rubber and rubber-like materials may be used for umbrellas for vertical agitator assemblies, gaskets, seals and parts used in similar applications. These materials shall comply with the applicable provisions of the "3-A Sanitary Standards for Multiple-Use Rubber and Rubber-Like Materials Used as Product Contact Surfaces in Dairy Equipment, Serial #18-00."

C.1.2
Plastic Materials may be used in sight and/or light openings and for umbrellas for vertical agitator assemblies, bearings, gaskets, seals, direct reading gauge tubes (see D.17), and parts used in similar applications. These materials shall comply with the applicable provisions of the "3-A Sanitary Standards for Multiple-Use Plastic Materials Used as Product Contact Surfaces for Dairy Equipment, Serial #20-00" as amended.

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[1]Vertical tanks in excess of 10 feet inside height are defined as silo-type tanks. Sanitary criteria for silo-type tanks are covered in "3-A Sanitary Standards for Silo-Type Storage Tanks for Milk and Milk Products, Serial #22-03."

[2]The data for this series are contained in the following reference: AISI Steel Products Manual, Stainless & Heat Resisting Steels, April 1963, Table 2-1, pp. 16-17. Available from American Iron and Steel Institute, 150 East 42nd Street, New York, N. Y. 10017.

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

C.1.3
Where functional properties are required for specific applications, such as agitator bearing surfaces and rotary seals, where dissimilar materials are necessary, carbon and/or ceramics may be used. Ceramic materials shall be inert, non-porous, non-toxic, non-absorbent, insoluble, resistant to scratching, scoring, and distortion by the temperature, chemicals, and methods to which they are normally subjected in operation or cleaning and bactericidal treatment.

C.1.4
Glass may be used in sight and/or light openings and for direct reading gauge tubes (see D.17) and when used shall be of a clear heat resistant type.

C.2
The materials used for the lining shall not be less than No. 14 U. S. standard gauge.

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

D.
FABRICATION

D.1
All product contact surfaces shall be at least as smooth as a No. 4 finish on stainless steel sheets. (See Appendix, Section F.)

D.2
All permanent joints in product contact surfaces shall be welded. All welded areas of product contact surfaces shall be at least as smooth as the adjoining surfaces.

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

D.4
All product contact surfaces shall be self-draining except for normal clingage. The bottom pitch of a vertical tank designed for mechanical cleaning shall be at least 3/4 inch per foot toward the outlet.

Horizontal rectangular tanks designed for mechanical cleaning which have a built-in bottom pitch, shall have a pitch of at least 1/4 inch per foot toward the outlet.

Horizontal tanks shall be so constructed that they will not sag, buckle, or prevent complete drainage of water when the tank has a pitch of not more than 1 inch in 100 inches.

D.5
If it is necessary to enter the tank to clean any or all of the product contact surfaces, the tank shall have the following minimum dimensions:

(1) 36 inches in height by 48 inches in diameter, or 48 inches square.

(2) 36 inches in height, 36 inches in width, by 48 inches in length, if oval or rectangular.

D.6
Gaskets shall be removable. Any gasket groove or gasket retaining groove shall not exceed 1/4 inch in depth or be less than 1/4 inch wide. The minimum radius of any internal angle in a gasket groove or gasket retaining groove shall be not less than 1/8 inch.

D.7
The inside radii of all welded or permanent attachments shall be not less than 1/4 inch. Where the head(s) joins the lining of the tank the radius shall not be less than 3/4 inch.

D.8
There shall be no threads on product contact surfaces.

D.9
Sanitary pipe and fittings shall conform with "3-A Sanitary Standards for Fittings Used on Milk and Milk Products Equipment and Used on Sanitary Lines Conducting Milk and Milk Products, Serial #08-09" as amended.

D.10
One or more fittings to accommodate indicating and/or recording thermometer temperature sensing devices shall be provided.

D.10.1
They shall conform to one of the following types:

D.10.1.1
Fittings conforming to thermometer well supplements to "3-A Sanitary Standards for Instrument Fittings and Connections Used on Milk and Milk Products Equipment, Serial #09-00," as amended and supplements thereto.

D.10.1.2
Fittings for temperature sensing devices which do not pierce the tank lining, either temperature sensing element receptacles securely attached to the exterior of the lining or means to attach temperature sensing elements securely to the exterior of the lining.

D.10.2

The fittings for temperature sensing devices shall be located to permit the registering of the temperature of the product when the tank contains no more than 20 percent of its capacity.

D.11

Agitation: Unless otherwise specified, means for mechanical and/or air agitation of product shall be provided that when operated intermittently or continuously shall be sufficient to maintain the butterfat content of whole milk throughout the tank within a variation of plus or minus 0.1 percent as determined by an official AOAC Milk Fat Test.[4] The agitator, if not designed for mechanical cleaning, shall be located in such a manner that it shall be readily accessible and removable for manual cleaning. Mechanical agitators may be of a vertical or horizontal type. They shall comply with the applicable provisions of D.11.1 and D.11.2.

D.11.1

Vertical mechanical agitators. The opening for a vertical agitator shall have a minimum diameter of 1 inch on tanks which require removal of the agitator shaft for cleaning or be of a diameter that will provide a 1 inch minimum annular space between the agitator shaft and the inside surface of the opening on tanks which do not require removal of the agitator for cleaning. An umbrella or drip shield of sanitary design that can be raised or dismantled, to permit cleaning of all of its surfaces, shall be provided to protect against the entrance of dust, oil, insects and other contaminants into the tank through the annular space around the agitator shaft. The agitator shaft, if removable, shall be provided with an easily accessible, readily demountable coupling of either a sanitary type located within the lining or a coupling located outside the lining provided that it is above the umbrella provided to protect the annular space around the shaft. A bottom support or guide, if used, shall be welded to the lining and shall not interfere with drainage of the tank and the inside angles shall have minimum radii of 1/8 inch. When the agitator shaft has a bearing cavity, the diameter of the cavity shall be greater than the depth.

D.11.2

A seal for the agitator shaft, if provided, shall be of a packless type, sanitary in design and durable. A seal shall be provided for (1) a horizontal agitator, (2) a vertical agitator when it is specified that the tank is to be located so that the portion of the shaft outside the tank is not in a processing area and (3) an agitator in a tank having means for mechanically cleaning the tank.

D.12

Air Under Pressure: Means for applying air under pressure shall conform to the applicable provisions of the "3-A Accepted Practices For Supplying Air Under Pressure in Contact With Milk, Milk Products and Product Contact Surfaces, Serial #604-03," except that clamp-type fittings shall not be used in the product zone.

Tubing and related fittings within the tank shall be readily and easily removable for cleaning outside the tank or be designed for mechanical cleaning. If designed for mechanical cleaning, the tubing and all related fittings shall be self-draining. Permanently mounted air tubing shall be constructed and installed so that it will not sag, buckle, vibrate or prevent complete drainage of the tank or tubing and shall be located so that the distance from the outside of the tubing to the lining shall be at least two inches, except at point of entrance.

D.13

A sample cock shall be provided. It shall be of a type that has its sealing surface relatively flush with the product contact surface of the tank and have an inside diameter no less than that of one inch 3-A Sanitary tubing.

D.14

Sight and light openings, when provided, shall be of such design and construction that the inner surfaces drain inwardly; and if the tank is designed for mechanical cleaning, the inner surface of the glass (or plastic) shall be relatively flush with the inner surface of the lining. The inside diameter of the opening shall be at least 3 3/4 inches. The external flare of the opening shall be pitched so that liquid cannot accumulate.

D.15

An opening for a pressure transmitter, if provided, shall be in a portion of the tank that is in the processing area; and if the tank is designed for mechanical cleaning, the transmitter shall be relatively flush with the inner surface of the lining.

D.16

An opening for a gauge down pipe, if provided, shall be in the portion of the tank in the processing area. The inside diameter of the opening shall be not less than 1.75 inches.

D.17

A direct reading gauge of the sight glass (or plastic tube) type, if provided, shall be sanitary in

[4]The method of making these tests will be found in the following reference: Official Methods of Analysis: Available from the Association of Official Analytical Chemists, P. O. Box 540, Benjamin Franklin Station, Washington, D. C. 20044.

design and construction and shall be readily accessible for cleaning or shall be designed for mechanical cleaning. If designed for mechanical cleaning, the inside diameter of the gauge parts shall be sufficiently uniform that all product contact surfaces will be cleaned.

It shall be designed and constructed so that all product in the gauge may be discarded. Means to accomplish this shall be provided at the lowest point and in such a manner that product in the gauge will not enter the tank outlet line nor reenter the tank.

The valve shall be closed coupled. The distance, measured along the passage for the product in the tank to the gauge valve, from the nearest point on the shell to the ferrule or flange for the valve shall not be more than the smaller of (1) twice the nominal diameter of the passage or (2) five inches.

D.18

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

D.19

The outlet shall be located where readily accessible and in a position to provide complete drainage of the tank. The top of the terminal end of the outlet passage shall be lower than the low point of the bottom of the lining at the outlet. The outside diameter of the outlet opening shall be at least as large as that of 1 1/2 inch 3-A Sanitary Tubing.

D.20

Inlet and Outlet connections in the tank shall be provided with welding stub ends, bolted or clamp-type flanges or 3-A sanitary threaded connections. The face of a bolted or clamp-type flange or a 3-A sanitary threaded connection below the maximum normal product level shall be as close as practical to the outer shell of the tank. (See Appendix, Section G and Section H.)

D.21

The manhole shall be located at the outlet end or side of the tank or the top of the tank. The inside dimensions of the manhole opening shall not be less than 15 inches by 20 inches oval, or 18 inches diameter.

A top manhole opening shall be not less than 3/8 inch higher than the surrounding area and if the exterior flange is incorporated in it, it shall slope and drain away from the opening. The sleeve or collar of a manhole opening for an inside swing-type manhole cover shall be pitched so that liquids cannot accumulate.

D.22

The cover for a manhole in the end or side wall shall be either of the inside or outside swing type. If the cover swings inside, it shall also swing outside, away from the opening. Threads or ball joints employed to attach the manhole cover(s) shall not be located within the lining. The cover for a manhole in the top shall be of the outside swing type.

D.23

Equipment for producing and introducing air under pressure into the product and which is supplied as an integral part of the tank shall comply with the "3-A Accepted Practices for Supplying Air Under Pressure in Contact with Milk, Milk Products and Product Contact Surfaces, Serial #604-03."

D.24

Insulation

D.24.1

The tank shall be insulated with insulating material of a nature and amount sufficient to prevent, in 18 hours, an average temperature change of greater than 2°F in the tank full of water when the average difference between the temperature of the atmosphere surrounding the tank is 30°F above or below that of the water in the tank. The insulating value of the insulation over non-refrigerated areas of the tank shall be not less than:

D.24.1.1

Two inches of cork on

(a) tank designed to be installed wholly within a building.

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

D.24.1.2

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

D.24.2

Insulation material shall be installed in such a manner as to prevent shifting or settling.

D.25

Means of supporting tanks.

D.25.1

The means of supporting tanks designed to be installed wholly within a processing area shall be one of the following:

D.25.1.1

With Legs. Adjustable legs shall be provided of sufficient number and strength and so spaced that the filled tank will be adequately supported. Legs shall have sealed bases. Exterior of legs and leg sockets shall be readily cleanable. Legs shall be such that the product outlet is sufficiently high to allow for adequate cleaning and will provide an 8-inch minimum clearance between the floor and the tank outlet valve or bracing whichever is lower. The legs of cylindrical horizontal tanks shall be installed so that the leg will be vertical when the tank lining is pitched 1/4 inch per foot toward the outlet.

D.25.1.2

Mounted on a slab or island. The base of the tank shall be such that it may be sealed to the mounting surface. (See Appendix, Section L.)

D.26

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

D.27

The outer shell shall be smooth and effectively sealed except for a vent or weep hole in the outer shell of the tank. The vent or weep hole shall be located in a position that will provide drainage from the outer shell and shall be vermin proof. Outside welds need not be ground.

D.28

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

D.29

Storage tanks shall have an information plate in juxtaposition to the name plate giving one of the statements in D.29.1 (See D.24.1.1(a) and D.24.1.2) and if the tank has a vertical agitator, one of the statements in D.29.2 (See D.11.2) or the statement(s) shall appear on the name plate. The wording of the statement(s) can be changed but not the intent.

D.29.1

The insulation of this tank complies with the requirements for a tank to be installed * -- a building.

*Insert one of the following:

(a) wholly within

(b) partially outside of

D.29.2

The agitator of this tank is designed so that the portion of agitator shaft outside of the tank ** -- in a processing area.

**Insert one of the following:

(a) does not have to be

(b) must be

APPENDIX

E.

STAINLESS STEEL MATERIALS

Stainless steel conforming to the applicable composition ranges established by AISI for wrought products, or by ACI for cast products, should be considered in compliance with the requirements of Section C.1 herein. Where welding is involved the carbon content of the stainless steel should not exceed 0.08 percent. The first reference cited in C.1 sets forth the chemical ranges and limits of acceptable stainless steels of the 300 series.

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

F.

PRODUCT CONTACT SURFACE FINISH

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

G.

INLET AND OUTLET CONNECTIONS

The distance between the nearest point on the outer shell of the tank to (1) the face of a bolted or clamp-type flange or (2) the face of a 3-A sanitary threaded connection on an inlet or outlet connection below the normal product level should not exceed the smaller of (a) twice the nominal diameter of the connection or (b) five inches.

H.

VALVES

Valves on inlet and outlet connections in the tank below the maximum normal product level should be of the close coupled plug-type or of the close coupled compression-type.

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

I.

MANUAL CLEANING

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

J.

MECHANICAL CLEANING

One cleaning method found to be satisfactory is to pump the cleaning solution to the dome of the tank or the upper portion of the tank surface, as the case may be, through stainless steel lines with C-I-P fittings or welded joints and distribute it in such a manner as to provide flooding over all interior surfaces. The tank should be installed with sufficient pitch to accomplish draining and to have a fast flushing action across the bottom. The pitch should be at least 1/4 inch per foot. Means should be provided for manual cleaning of all surfaces not cleaned satisfactorily by mechanical cleaning procedures. NOTE: Cleaning and/or sanitizing solutions should be made up in a separate tank—not the storage tank.

K.

AIR VENTING

To insure adequate venting of the tank which will protect it from internal pressure or vacuum damage during normal operation, the critical relationship between minimum vent-size and maximum filling or emptying rates should be observed. The size of the free vent opening of a tank should be at least as large as those shown in the table below:

Minimum Free Vent Opening Size (Inches, I.D.)	Maximum Filling or Emptying Rate (gallons per minute)
1-3/4	175
2-1/4	300
2-3/4	400

The above sizes are based on normal operation and are sized to accommodate air only and not liquid. A perforated vent cover, if used, should have a free opening area equal to at least 1 1/2 times the area of the vent opening in the tank. The venting system covered in the preceding paragraphs is intended to provide for venting during filling and emptying; *however, it is not adequate during cleaning.* During the cleaning cycle, tanks when cleaned mechanically should be vented adequately by opening the manhole door to prevent vacuum or pressure build up due to sudden changes in temperature of very large volumes of air.[6] Means should be provided to prevent excess loss of cleaning solution through the manhole opening. The use of tempered water of about 95°F for both pre-rinsing and post-rinsing is recommended to reduce the effect of flash heating and cooling. Provisions should be made to prevent overfilling with resultant vacuum or pressure damage to the tank.

L.

SLABS OR ISLANDS

When a tank is designed to be installed on a slab or an island, the dimensions of the slab or island should be such that the tank will extend beyond the slab or island at least one inch in all horizontal directions. The slab or island should be of sufficient height so that the bottom of the outlet connection is not less than 8 inches above the floor. The surface of the slab or island should be coated with a thick layer of waterproof mastic material, which will harden without cracking. The junction of the outer shell of the tank and the slab or island should be sealed.

These standards are effective January 5, 1974, at which time the "3-A Sanitary Standards for Storage Tanks for Milk and Milk Products, Serial #0104" and the amendment to it are rescinded and become null and void.

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[6]For example, when a 6,000-gallon tank (with 800 cu. ft. of 135°F hot air after cleaning) is suddenly flash cooled by 50°F water sprayed at 100 gpm the following takes place:
Within one second, the 800 cu. ft. of hot air shrinks approximately 51 cu. ft. in volume. This is the equivalent in occupied space of approximately 382 gallons of product. The shrinkage creates a vacuum sufficient to collapse the tank unless the vent, manhole, or other openings allow the air to enter the tank at approximately the same rate as it shrinks. It is obvious, therefore, that a very large air vent such as the manhole opening is required to accommodate this air flow.

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3-A SANITARY STANDARDS FOR SILO-TYPE STORAGE TANKS FOR MILK AND MILK PRODUCTS

Serial #22-03

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

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

A.
SCOPE

A.1
These standards cover the sanitary aspects of silo-type storage tanks for milk and milk products.

A.2
In order to conform with these 3-A Sanitary Standards, silo-type storage tanks shall comply with the following design, material, fabrication, and refrigeration criteria.

B.
DEFINITIONS

B.1
PRODUCT: Shall mean milk and milk products.

B.2
SILO-TYPE TANK: Any vertical tank in excess of 10 feet inside height for the storage or storage and cooling of milk or milk products.

B.3
CONTROL AREA(S): Shall mean the area(s) in which all appurtenances for the operation of the silo tank are located and vent lines terminate, except as provided in subsection D.11 and shall be a part of one or more of the following:

B.3.1
A processing area.

B.3.2
An area in the plant at least the equivalent of a processing area.

B.4
ALCOVE(S): Shall mean an extension of the control area(s) in which appurtenances and vent line openings are located.

B.5
Mechanical Cleaning or Mechanically Cleaning: Shall denote cleaning, solely by circulation and/or flowing chemical detergent solutions and water rinses onto and over the surfaces to be cleaned, by mechanical means.

B.6
SURFACES

B.6.1
Product Contact Surfaces: Shall mean all surfaces which are exposed to the product and surfaces from which liquids may drain, drop, or be drawn into the product.

B.6.2
Non-Product Contact Surfaces: Shall mean all other exposed surfaces.

C.
MATERIAL

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

C.1.1
Rubber and rubber-like materials may be used for gaskets, seals and parts used in similar applications. These materials shall comply with the applicable provisions of the "3-A Sanitary Standards for Multiple-Use Rubber and Rubber-Like Materials Used as Product Contact Surfaces in Dairy Equipment, Serial #18-00."

[1]The data for this series are contained in the following reference: AISI Steel Products Manual, Stainless & Heat Resisting Steels, April 1963, Table 2-1, pp. 16-17. Available from American Iron and Steel Institute, 150 East 42nd Street, New York, N. Y. 10017.

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

C.1.2

Plastic materials may be used for bearings, gaskets, seals, and parts used in similar applications. These materials shall comply with the applicable provisions of the "3-A Sanitary Standards for Multiple-Use Plastic Materials Used as Product Contact Surfaces for Dairy Equipment, Serial #20-00" as amended

C.1.3

Where functional properties are required for specific applications,such as bearing surfaces and rotary seals, where dissimilar materials are necessary, carbon, and/or ceramics may be used. Ceramic materials shall be inert, non-porous, non-toxic, non-absorbent, insoluble, resistant to scratching, scoring, and distortion by the temperature, chemicals, and methods to which they are normally subjected in operation, or cleaning and bactericidal treatment.

C.2

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

D.

FABRICATION

D.1

All product contact surfaces shall be at least as smooth as a No. 4 finish on stainless steel sheets (see Appendix, Section G.).

D.2

All permanent joints shall be welded. All welded areas of product contact surfaces shall be at least as smooth as the adjoining surfaces.

D.3

All product contact surfaces shall be easily accessible for cleaning, either when in an assembled position or when removed. Removable parts shall be readily demountable. Sight or light openings, when provided, shall be relatively flush and shall be located in a control area.

D.4

Means shall be provided for mechanically cleaning the product contact surfaces of the tank, piping and all non-removable appurtenances thereto.

D.5

All product contact surfaces shall be self-draining. The bottom of the lining, if flat, shall have a minimum slope of 3/4 inch per foot toward the outlet or if the bottom of the lining is of the reverse dish-type the portion of the bottom adjacent to the side wall shall have a minimum slope of 3/4 inch per foot toward the outlet.

D.6

Gaskets shall be removable. Any gasket groove or gasket retaining groove shall not exceed 1/4 inch in dept or be less than 1/4-inch wide. The minimum radius of any internal angle in a gasket groove or gasket retaining groove shall be not less than 1/8 inch.

D.7

The inside radii of all welded or permanent attachments shall be not less than 1/4 inch. Where the top head and the bottom join the vertical lining of the tank the radius shall not be less than 3/4 inch. The top head shall be dished or otherwise shaped so that it readily facilitates mechanical cleaning.

D.8

There shall be no threads on product contact surfaces.

D.9

Sanitary pipe and fittings shall conform with "3-A Sanitary Standards For Fittings Used On Milk And Milk Products Equipment And Used On Sanitary Lines Conducting Milk And Milk Products, Serial #08-09," as amended and supplements thereto, except that sanitary fittings made of optional metal alloy shall not be used.

D.10

Fittings to accommodate the temperature sensors of both an indicating thermometer and a recording thermometer shall be provided.

D.10.1

They shall conform to one of the following types:

D.10.1.1

Fittings conforming to "Supplement No. 1 to 3-A Sanitary Standards for Instrument Fittings and Connections Used on Milk and Milk Products Equipment, Serial #09-01."

D.10.1.2

Fittings for temperature sensors which do not pierce the tank lining, but which have temperature sensor receptacles securely attached to exterior of the lining.

D.10.2

The fittings for temperature sensors shall be located not more than 24 inches above the bottom of the lining and the indicating or recording thermometer shall be located so that it is easily readable.

D.11

All openings in the tank lining shall be within a

control area, except openings for mechanical agitators and openings for cleaning and/or vent line(s). Cleaning and/or vent line(s) shall terminate in a control area.

When the re-vent line method is used to prevent siphonage, the terminal ends of the cleaning and/or vent line(s) in the control area shall be arranged or means provided to prevent liquids or objects being drawn up in the re-vent line.

D.12

Unless otherwise specified, means for mechanical and/or air agitation of product shall be provided that when operated intermittently or continuously shall be sufficient to maintain the butterfat content of whole milk throughout the tank within a variation of plus or minus 0.1 percent as determined by an official AOAC Milk Fat Test[3]. The agitator, if not designed for mechanical cleaning, shall be readily accessible from a control area and shall be removable for manual cleaning. A mechanical agitator shall have a seal of a packless type, sanitary in design. A bottom support or guide, if provided for a vertical agitator, shall be welded to the tank and shall be readily accessible for inspection. It shall not interfere with the drainage of the tank. All internal angles shall have radii of at least 1/8 inch. When the agitator shaft has a cavity, the diameter of the cavity shall be greater than the depth.

D.13

A sanitary connection(s) of sufficient diameter to prevent back pressure during normal filling and to prevent vacuum during emptying shall be provided in or near the top of the tank as a vent connection. The vent line(s) from this connection(s) shall terminate in a control area and shall be provided with a perforated cover(s) having openings not greater than 1/16 inch diameter, or slots not more than 1/32 inch wide. This cover(s) shall be so designed that parts are readily accessible and easily removable for cleaning. Woven wire mesh shall not be used for this purpose. (See Appendix, Section I)

D.14

The outlet and inlet shall be located where they are readily accessible. The outlet shall be in a position that will provide complete drainage of the tank. The top of the terminal end of the outlet passage shall be lower than the low point of the bottom of the lining at the outlet. When tanks are located in the processing area or an area in the plant at least the equivalent of a processing area, inlets and outlets may be in the side or bottom of the tank. Means shall be provided for easy access to the valve(s) for cleaning and inspection purposes.

D.15

The control area and alcove, or if there is more than one, the lowest shall be at an elevation that will include the lowest vertical portion of the tank.

D.16

A manhole(s) shall be provided. If there is more than one control area, there shall be a manhole that is accessible from the lowest control area. The inside dimensions of the manhole opening shall be not less than 15 inches by 20 inches oval, or 18 inches diameter. A hand grip shall be mounted externally on the tank near the manhole in order to facilitate easy access to the tank interior.

The sleeve or collar of a manhole opening for an inside swing type of manhole cover shall be pitched so that liquids cannot accumulate.

D.17

The manhole cover shall be the inside or outside swing type. If the cover swings inside, it shall also swing outside away from the opening for disassembly and cleaning. No threads or ball joints shall be employed within the lining to attach the manhole cover and its appendages. The manhole cover and its appendages shall be removable without tools.

D.18

Equipment for producing and introducing air under pressure into the product and which is supplied as an integral part of the tank shall comply with the "3-A Accepted Practices For Supplying Air Under Pressure In Contact With Milk, Milk Products And Product Contact Surfaces, Serial #604-03."

D.19

The tank shall be insulated with insulating material of a nature and amount sufficient to prevent freezing, or in 18 hours, an average temperature change of greater than 3°F. in the tank full of water when the average differential between the temperature of the atmosphere surrounding the tank is 30°F. above or below that of the water in the tank, provided that the insulating material shall be the equivalent of not less than 2 inches of cork in insulating value. Tanks installed partially or wholly outside of a building shall be insulated with insulating material having the equivalent of not less than 3 inches cork in insulating value over

[3]The method of making these tests will be found in the following reference: Official Methods of Analysis: Available from the Association of Official Analytical Chemists, P. O. Box 540, Benjamin Franklin Station, Washington, D. C. 20044.

non-refrigerated areas. Insulation material shall be installed in such a manner as to prevent shifting or settling.

D.20

Tanks Supports (When the tank is installed in a processing or an area in the plant at least the equivalent of a processing area.)

D.20.1

Adjustable legs of round stock with sealed bases shall be provided of sufficient size and spacing to carry the tank when full and to raise the milk outlet sufficiently high to allow for adequate cleaning. The tank or bracing, whichever is lower, shall have a minimum clearance of 8 inches from the floor. Leg socket exterior shall be readily cleanable.

D.20.2

When tanks are mounted on a slab or island, that portion of the base within the processing area shall be effectively sealed.

D.21

The outer shell shall be smooth and effectively sealed. Outside welds need not be ground. A vent hole shall be provided in the outer shell of the tank and shall be located to provide drainage from the outer shell and shall be vermin proof.

D.22

Non-product contact surfaces to be coated shall be effectively prepared for coating.

E.

REFRIGERATION

E.1

Refrigerated tanks shall be capable of maintaining milk temperature of 40°F. or lower when the tank is full.

APPENDIX

F.

STAINLESS STEEL MATERIALS

Stainless steel conforming to the applicable composition ranges established by AISI[1] for wrought products, or by ACI[2] for cast products, should be considered in compliance with the requirements of Section C.1 herein. Where welding is involved the carbon content of the stainless steel should not exceed 0.08 percent. The first reference cited in C.1 sets forth the chemical ranges and limits of acceptable stainless steels of the 300 series. Cast grades of stainless steel corresponding to types 303, 304, and 316 are designated CF-16F, CF-8 and CF-8M, respectively. These cast grades are covered by ASTM[4] specifications A 296-68 and A 351-70.

[4]Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.

G.

PRODUCT CONTACT SURFACE FINISH

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

H.

SUGGESTED CLEANING PROCEDURES

One cleaning method found to be satisfactory is to pump the cleaning solution to the dome of the tank through stainless steel welded lines and distribute it in such a manner as to provide flooding over the entire inner dome, side walls and bottom. Means sould be provided for manual cleaning of all surfaces not cleaned satisfactorily by mechanical cleaning procedures.

I.

AIR VENTING

To insure adequate venting of the tank which will protect it from internal pressure or vacuum damage during normal operation, the critical relationship between minimum vent size and maximum filling or emptying rates should be observed. The size of the free vent opening of a tank should be at least as large as those shown in the table below:

Minimum Free Vent Opening Size (inches, I. D.)	Maximum Filling or Emptying Rate (gallons per minute)
1 3/4	175
2 1/4	300
2 3/4	400

The above sizes are based on normal operation and are sized to accommodate air only and not liquid. The diameter of the connecting vent pipe line between the vent opening in the tank and the control area should be no smaller than the inside diameter of the vent opening in the tank. The perforated vent cover should have a free opening area equal to at least 1 1/2 times the area of the vent opening in the tank. Means should be provided to prevent siphonage, such as a re-vent line, or anti-siphon device (see illustrative sketches in Appendix). The vent piping of a tank outside of a building should be protected against freezing. The venting system covered in the preceding paragraphs is intended to provide for venting during filling and emptying; *however, it is not adequate during cleaning.* During the cleaning cycle, tanks when cleaned mechanically should be vented adequately by opening the manhole door to prevent vacuum or pressure build up due to sudden changes in temperature of very large volumes of air[5].

Means should be provided to prevent excess loss of cleaning solution through the manhole opening. The use of tempered water of about 95°F. for both pre-rinsing and post-rinsing is recommended to reduce the effect of flash heating and cooling. Provisions should be made to prevent overfilling with resultant vacuum or pressure damage to the tank.

J.

TEMPERATURE RECORDER

A temperature recorder should be provided on all tanks to record temperatures during the filling, storage, emptying and cleaning periods. This temperature recorder should be accurate to plus or minus 1°F. within the temperature range for milk storage. The recorded elapsed time, as indicated by the chart, should be the true elapsed time over at least a seven-day period.

K.

PLACEMENT

If the tank is not in a processing area or an area in the plant at least the equivalent of a processing area or adjacent to the outside wall of one of these areas, a hallway should be constructed at least 7 feet high and 5 feet wide to provide easy access to the control area. Extension through the roof is permissible.

These standards are effective January 5, 1974, at which time the "3-A Sanitary Standards for Silo-Type Storage Tanks for Milk and Milk Products, Serial #2200" and the amendments thereto are rescinded and become null and void.

---

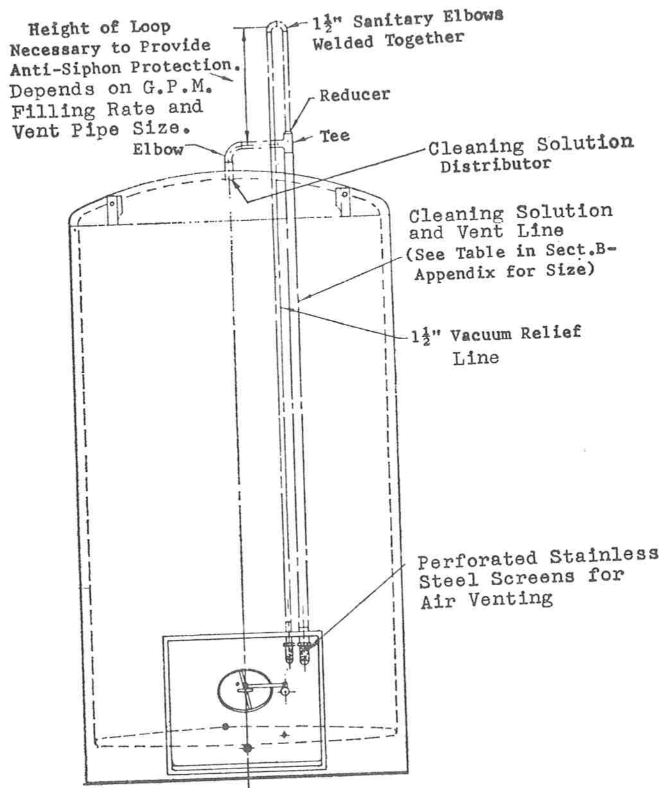
[5]For example, when a 12,000 gallon tank (with 1600 cu. ft. of 135°F. hot air after cleaning) is suddenly flash cooled by 50°F water sprayed at 100 gpm the following takes place:

Within one second, the 1600 cubic feet of hot air shrinks approximately 102 cubic feet in volume. This is the equivalent in occupied space of approximately 765 gallons of product. This shrinkage creates a vacuum sufficient to collapse the tank unless the vent, manhole, or other openings allow the air to enter the tank at approximately the same rate as it shrinks. It is obvious, therefore, that a very large air vent such as the manhole opening is required to accommodate this air flow.

Appendix - Section I Continued

PIPING FOR AIR VENTING

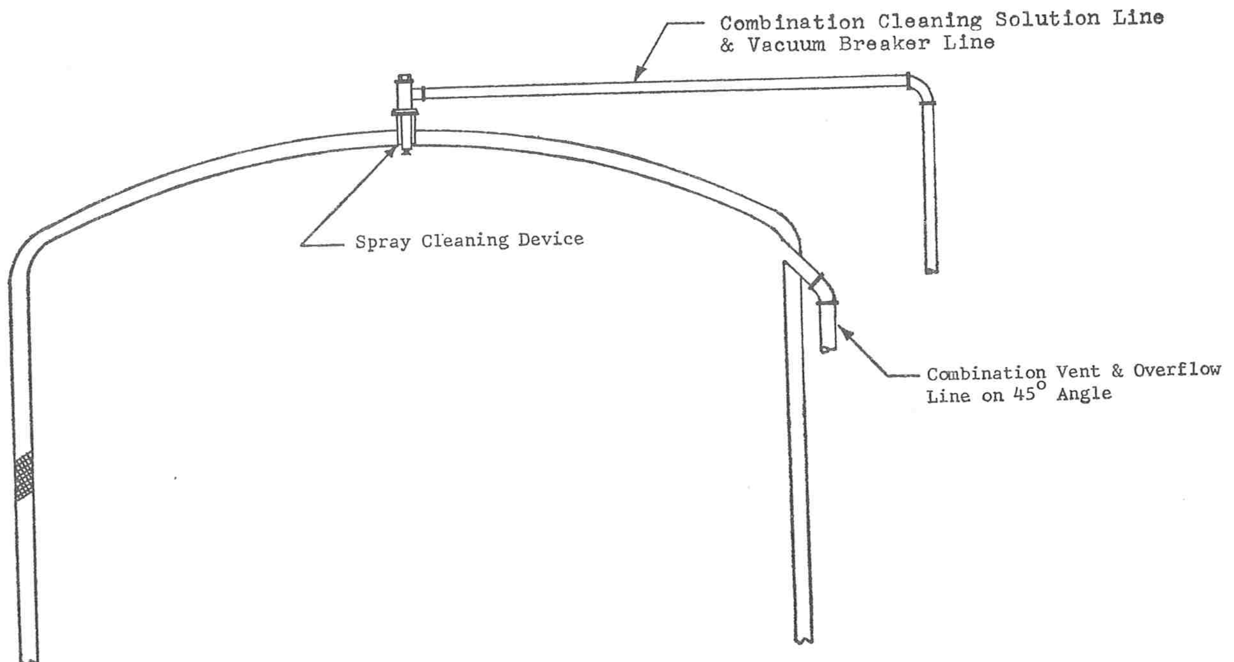
Example #1, a suggested method for venting



This design shows a loop-type syphon breaker. The loop is made so that its height above the vent line is sufficient to prevent milk rising in the vacuum relief line to the top of the loop when the tank is being filled at the maximum rate recommended by the manufacturer

Legend: In event of overfilling, milk enters the vent line through the opening in the top of the tank. The area of this opening is such that when the tank is being filled at the maximum rate recommended by the manufacturer, pressure in the tank will not exceed that for which the tank is designed. The vacuum relief line will prevent any siphoning action in the overflow line.

Example #2, a suggested method for venting.



Legend: The purpose of the opening at the juncture of the head and shell is to act as a vent during normal operation, and an overflow in case the tank is overfilled. In this event, the cleaning solution line acts as an auxiliary vent to break any siphoning action in the overflow line.

ASSOCIATION AFFAIRS

REPORT OF THE EDITOR, JOURNAL OF MILK AND FOOD TECHNOLOGY—1972-1973

REVIEW OF VOLUME 35

Volume 35 of the *Journal of Milk and Food Technology* was completed when the December 1972 issue was published. This volume broke all records established by any previous volume of the *Journal*. It was the largest ever published and contained more research papers and technical general interest articles than any previous volume. A total of 132 papers appeared on 832 pages of volume 35. When compared to volume 30 published in 1967, this represents more than a 100% increase in number of papers and a 62% increase in number of pages that were published. The number of research papers (78) published in 1972 was 160% greater than in 1967 and pages devoted to papers of this type increased by 130% over 1967. General interest papers of a technical nature increased by 220% over 1967 and these papers occupied 410% more space than was devoted to similar material in 1967. Seventeen percent fewer general interest papers of a nontechnical nature appeared in 1972 than in 1967 but these papers required 6% more pages than were devoted to such papers in volume 30. Complete details on the composition of volume 35 appear in Table 1, together with similar data for volumes 30-34.

As in previous volumes, many topics were discussed in papers that appeared in volume 35. Approximately 49% of the papers were concerned with dairy foods and 41% dealt with other foods. The remaining 10% considered environmental or other topics.

PRESENT STATUS OF VOLUME THIRTY-SIX

The first six issues of volume 36 consisted of 408 pages, including the covers. This compares to 440 pages in the first six issues of volume 35 and 264 pages for similar issues of volume 30. These six issues of volume 36 contained 36 research papers, 19 technical general interest papers, and 6 nontechnical general interest papers. This compares with 41, 19, and 7 papers in the same categories for the first six issues of volume 35.

On August 1, 1973 there was a backlog of 14 research papers, 9 technical general interest papers, and 3 nontechnical general interest papers. In addition, there were 10 research papers being reviewed or revised. This backlog is somewhat smaller than existed in the recent past and was accomplished by publication of substantially larger than usual issues of the *Journal* throughout most of 1972 and 1973. This reduced backlog insures prompt (less than 6 months after submission) publication of most research and other papers.

REVIEW PAPERS

A significant contribution of the *Journal* to its readers has

TABLE 1. SUMMARY OF CONTENTS OF THE *Journal of Milk and Food Technology*, 1967-1972

Item	Vol. 30 (1967)	Vol. 31 (1968)	Vol. 32 (1969)	Vol. 33 (1970)	Vol. 34 (1971)	(1972) Vol. 35
1. Total pages, incl. covers	512	540	624	688	728	832
2. Total papers published	64	62	87	104	102	132
3. Research papers						
a. Number	30	32	47	66	67	78
b. Pages	137	142	205	280	288	317
c. Percent of total pages	26.7	26.3	32.9	40.7	39.5	38.1
4. General interest papers—technical						
a. Number	11	16	14	18	24	35
b. Pages	47	74	87	99	150	242
c. Percent of total pages	9.2	13.7	12.2	14.3	20.6	29.1
5. Equipment standards						
a. 3-A, pages	9	22	12	44	40	23
b. E-3-A, pages	—	—	7[a]	16	30	15[b]
c. Percent of total pages, all standards	1.7	4.1	3.0	8.7	9.6	4.5
6. General interest papers—nontechnical						
a. Number	23	14	26	20	11	19
b. Pages	72	65	91	64	46	76
c. Percent of total pages	14.1	12.0	14.6	9.3	6.3	9.1
7. Association affairs						
a. Pages	64	68	62	49	45	47
b. Percent of total pages	12.5	12.6	9.9	7.2	6.3	5.6
8. News and events						
a. Pages	51	42	36	23	17	7
b. Percent of total pages	9.9	7.8	5.8	3.4	2.3	0.8
Percent of pages—Technical material including equipment standards	37.6	44.1	48.1	63.7	69.7	71.7
Percent of pages—Nontechnical material	36.5	32.4	30.3	19.9	14.9	15.5
Percent of pages—Covers, ads, index, etc.	25.9	23.5	21.6	16.4	15.4	12.8

[a]These were Baking Industry Equipment Standards
[b]Includes one page of Baking Industry Equipment Standards

been the publication, in recent years, of numerous timely review papers. Volumes 35 and 36 have contained reviews on such subjects as: sodium in foods, staphylococcal food poisoning, lead poisoning, ecology of milk packaging, trends in dairy foods, precooked frozen foods, automation in the dairy laboratory, the propionic acid bacteria, interactions between starter cultures and foodborne pathogens, diet and heart disease, microbiology of meats, the phosphate problem, emerging foodborne diseases, organic foods, lactic acid bacteria in food and health, public health problems of barbecued foods, nitrosamines, parahaemolyticus food poisoning, polychlorinated biphenyls in food, milk allergy, water relations of foodborne pathogens, and use of dairy ingredients in other foods.

Awaiting publication are a four-part review on the microbiology and flavor of Swiss cheese and a review of methods to remove glucose from eggs. A review of the process cheese industry will soon be available for publication. Subjects of other review papers which are or will soon be in preparation by various authors include: lactose intolerance, mercury in foods, abnormal milk and its processing, bacterial spores and food processing, frozen starter cultures, whey utilization, and foodborne parasites.

The Editor continues to believe that timely and well-written review papers are valuable contributions which are helpful to many persons. Evidence of this is the large number of requests for reprints that invariably are received by authors of review papers. Review papers are published promptly and authors are encouraged to prepare and submit such papers.

Letters to the Editor

A number of Letters to the Editor have appeared in each of the recent volumes of the *Journal*. The Editor believes that this form of publication could be used more extensively to: *(a)* present viewpoints on subjects of concern to the readership, *(b)* raise questions about papers which have appeared in the *Journal*, or *(c)* report observations or techniques which are not suitable for presentation in a conventional research paper or research note. The Letter to the Editor could serve as a valuable means by which useful information or ideas could be shared with the entire readership. Readers of the *Journal* are encouraged to prepare Letters to the Editor if this means of publication seems appropriate in a given instance.

Editorial Board

The Editorial Board is now composed of 42 scientists in industrial, governmental, or university laboratories. These persons voluntarily give of their time and ability to insure the high quality of papers that appear in the *Journal*. No further changes in the Editorial Board appear necessary at this time. In addition to the Editorial Board, the following persons have reviewed papers during the first six months of 1973: R. L. Bradley, Jr., J. H. von Elbe, J. Spinelli, F. Teeny, T. Richardson, R. C. Lindsay, D. B. Lund, A. A. Kraft, J. F. Uthe, L. W. Regier, N. N. Potter, J. Dassow, R. Nelson, R. G. Cassens, M. Eklund, R. W. Nelson, J. T. Peeler, M. Steinberg, and D. Miyauchi. Their help is acknowledged and appreciated

A new form for use by reviewers when they evaluate a manuscript was developed and introduced early in 1973. Use of this form together with printed instructions that go to the reviewer with a manuscript should serve to facilitate and improve the review process.

Respectfully submitted,
E. H. Marth
Editor
Journal of Milk and Food Technology

LETTER TO THE EDITOR

A modified Standard Plate Count?

Dear Sir:

I heartily agree with Prof. Blankenagel's contention (JMFT 36:358) that in doing bacteriological tests on raw milk our primary interest is the quality of raw milk production. But so far the only test which has shown a significant correlation with production conditions is the psychrotroph count, and most workers feel that 10 days is too long to wait for results.

As I see it, the main argument for changing the temperature and time of incubation in the Standard Plate Count is to reflect as much as possible the presence of psychrotrophs. These organisms are definitely a reflection of faulty production practices, as well as being the cause of spoilage in both raw and pasteurized milk. There is a good deal of evidence, mostly unpublished, showing that with a lower temperature and longer period of incubation we can improve the usefulness of the SPC in reflecting the presence of psychrotrophs. Until such time as industry and regulatory people are willing to wait for 10 days for the results, this looks to be our best bet. More studies such as those of Hartley at Ames are badly needed to establish the usefulness of a modified SPC; it is to be hoped that the desired information will be available in time for a change in the next edition of *Standard Methods for the Examination of Dairy Products.*

C. K. Johns
2184 Braeside Ave.
Ottawa, Ont. K1H 7J5

LETTER TO EXECUTIVE SECRETARY

Mr. H. L. Thomasson
Executive Secretary
Internat'l Ass'n of Milk, Food &
Environmental Sanitarians, Inc.
P. O. Box 437
Blue Ridge Road
Shelbyville, Indiana 46176

Dear Sir:

Your membership is probably operating under 2 false assumptions concerning the Federal Occupational Safety and Health Act of 1970.

First – That with only a few hundred safety inspectors in the field, it will be years, if ever, before they are inspected.

Second – Even if inspected, that they will receive minimal fines or penalties of $100 or so dollars.

You should take action to protect them from such false assumptions because there are 4 more important and potentially more costly aspects to the OSH Act that many associations and employers do not realize as yet.

First – The OSHA regulations established a new *National Standard of Safety and Health Conduct* which must be met in the workplace by all employers.

Second – Any worker injured as a result of a substandard work situation, as compared with the OSHA Regulations, may feel inclined to sue someone for damages, beyond Workmen's Compensation insurance.

Third – These legal liabilities and potential costs of defense exist, whether or not an OSHA inspection is ever made,

because of the new *Nation Standard of Conduct* expected of employers in providing a safe and healthful workplace.

Fourth — The new OSHA Safety and Health Regulations must be met in the workplace to protect the employer from such legal harassment as well as Federal or State inspection.

To provide an easy to follow *SELF INSPECTION SYSTEM for OSHA,* we have just published an INSPECTION SURVEY REPORT to guide employers in a VOLUNTARY safety and health program of compliance. The brochure describes the SYSTEM and HOW TO USE it.

The following features make the publications most meaningful to you and your membership and we recommend them for your consideration:

First — They provide an organized system for assisting non-safety professionals in finding, understanding and applying the OSHA regulations in a knowledgeable manner.

Second — They provide an instant DO-IT-YOURSELF inspection and training program.

Third — The Inspection Survey Report provides a series of key questions, keyed to the regulations, which constitutes a quick easy check list as to what is required.

Fourth — The looseleaf concept of Volume 3 presents a very viable technique for augmenting the Guide with your own inserts.

Fifth — You can buy in BULK AND CUSTOMIZE THE COVER and present them as your own set of rules.

After you have had time to examine the brochure, we feel confident that you will feel that these publications are just what your members need to initiate a safety and health program and head off the legal and other problems which exist potentially.

Thank you for taking the time to read and examine these materials. Should you desire additional information please call or write us, or contact the publisher directly.

Sincerely,

ROBERT D. GIDEL (S)
PATRICK F. CESTRONE
Authors

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The Editor expresses his appreciation to members of the Editorial Board and to the following invited reviewers for their help and guidance during 1973.

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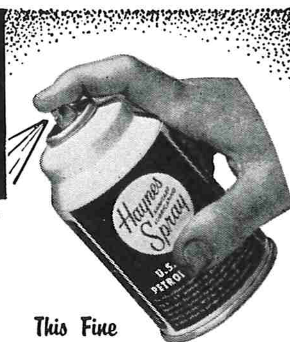

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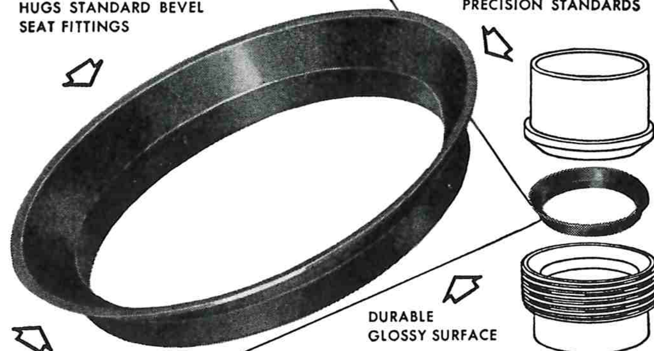

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Dairy authorities speak out on better cow milking

William L. Arledge
Director of Quality Control
Dairymen, Inc.

Quality milk makes consumers happy and helps dairymen prosper.

Dairy farmers are unique. In most cases their primary source of income is their milk check. A major influence on that milk check is quality, and it has been shown that, as the quality of milk in a given market improves, so does consumer demand, and so does income to the dairy farmer.

High quality milk starts with the cow but it must be continued each step of the way until the milk is purchased and consumed.

TASTE MAKES FRIENDS

The nutritional value of milk to the human diet is never disputed. The relative dollar value of these nutrients, particularly protein in relation to other food costs, is also not disputed. However, consumers could care less about protein and nutritional value if the milk does not taste good due to poor quality control practices somewhere between the cow and the consumer. People simply will not buy poor quality milk.

Over 90% of consumer complaints are the result of post-pasteurization contamination and improper temperature control of the bottled product after pasteurization. This is dramatized by the fact that seven Grade A dairy plants recently increased the shelf life of their total packaged products from an average of 6 days to more than 21 days by improving in-plant controls over post-pasteurization contamination. Little or no change was made in the quality of the raw milk coming into the plant. (This shows that significant improvements can be made in dairy plants as well as on farms.)

REVIEW YOUR EFFORTS

Your role of producing quality milk daily can be as simple as you desire to make it.

It has been proven many times that it is cheaper to spend whatever is necessary to thoroughly clean your bulk tank, pipeline, or bucket milkers (all milk contact surfaces) than it is to do an improper job.

Follow these recommendations:

1. Read the label of your chlorinated cleaner detergent and *measure* the correct amount of water to be added to the correct amount of cleaner.
2. Be sure when circulating cleaning systems to start your wash cycle with 160° F. water and *stop* circulating when the temperature drops to 110° F. (If you don't, you will redeposit soil and fat.)
3. In colder areas, the use of a heating element in the wash tank is recommended to help maintain wash temperatures above 110° F., preferably 130-140° F. (Six to ten minutes is usually enough*).
4. Many dairy barns do not have hot water heaters that will deliver water at 160-180° F. and even if they do—the recovery of temperature in the heater is too slow and you end up trying to wash in lukewarm to cool water.
5. To prevent loss of *hot* water for cleanup, many dairymen install a second hot water heater and set the regulator at around 110-120° F. for use in hand washing of cows' teats and udders prior to milking as well as other manual cleaning chores. This leaves your other hot water heater available for the important job of cleaning equipment.
6. If you have an electric hot water heater, install fast recovery heating elements to prevent cool down of your hot water. For safety make sure all heaters are equipped with an approved *pressure* and *temperature* relief valve.
7. After thorough washing of equipment, rinse in an acid rinse and then immediately prior to milking always *sanitize* all milk contact surfaces with an approved sanitizer.

CARELESSNESS IS A LUXURY

As surprising as it may seem, we still find some people rinsing equipment with plain water after sanitizing. This causes great problems affecting milk quality since all water supplies contain from a few to large numbers of the "cold loving" psychrothrophic bacteria that can and do cause some very undesirable off-flavors in milk. Granted these organisms are killed by pasteurization but, by carelessness, dairymen can alter the flavor of milk prior to its leaving the farm by 1) lack of sanitizing, or 2) rinsing equipment rather than washing, or by 3) only rinsing a bulk tank.

Too many times we see dairymen doing a good job in their milking management practices, but disregarding their water supply, temperature of cleaning solutions and sanitization, thus nullifying all other good practices.

Quality of your *only* product affects *your only* income; your milk check. You can do more concerning the quality of your milk! Follow the routine and procedures you know to be correct and with these few quality tips, you may prevent the shipment of a tank of less-than-superior-quality milk.

We must all relate to the consumer. Do a quality job in your personal operation and expect the same throughout the chain of events to the consumer. You will reap the benefits through personal pride "all the way to the bank".

*Refer to local Health Department regulations

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This is one of a series of topics developed by noted Dairy authorities. For a complete set write for a free booklet.