

MICROBIAL GROWTH AND MEAT QUALITY
*MICROBIAL ANTAGONISM IN CONTROLLING GROWTH**

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I. Introduction

A. Microbiological characteristics of perishable foods

Most mildly preserved, moist foods contain initially saprophytic organisms in numbers that exceed the number of food poisoning organisms which may be present. The saprophytes will in general also outnumber the hazardous microorganisms in stored foods unless the storage conditions or the composition of the food is highly selective for food poisoning species. As examples can be mentioned the rapid and often selective growth of C. perfringens in cooked food that is kept at a temperature in the upper range of the growth interval for this organism. Staph. aureus may grow partially selectively when foods with moderate concentrations of salt and low in acid are kept at room temperature or warmer. However, it will generally be found that one or several groups of saprophytic organisms present will grow as fast or faster than the food poisoning species and this can have one of several consequences.

1. The saprophytes have no or little effect on the multiplication of food poisoning strains--but may produce signs of spoilage and thus warn the consumer. This seems to be a common situation with many moist, un-preserved foods (raw meat, fish) and some mildly preserved moist foods.
2. The saprophytes may enhance the growth of food poisoning organisms. A few examples are known and they will be discussed briefly below.
3. The saprophytes inhibit or slow down the growth of food poisoning organisms. This generally require a certain composition of the food (presence of fermentable carbohydrates, small amounts of NaCl as a preservative), the presence of certain groups of actively competing saprophytes and storage of the food within certain temperature ranges. These conditions prevail in the preservation of foods (sauerkraut, fermented sausages, etc.) by fermentation. However, the safety of many foods--including perishable processed meats--which are not intentionally fermented rests on exactly the same principles. This will be discussed in some detail after a review of the literature dealing with microbial competition and synergism.

B. Microbial competition in foods - Literature

Effect of saprophytic organisms on various food poisoning bacteria.

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1. C. botulinum

A synergistic effect of lactic acid bacteria has been observed (Benjamin et al. 1956) and may be due to a reduction of the oxidation-reduction potential or production of growth factors. A similar effect has been observed with strains such as C. sporosphaeroides and B. polymyxa which facilitated C. botulinum type C toxin production in laboratory media (Bulatova et al. 1967). It is also known that the natural flora, e.g. Pseudomonas species (Valenzuela et al. 1967), enables C. botulinum type E to grow on the surface of fish (exposed to atmospheric oxygen). Fungi (yeast, mold) have been found to induce growth of C. botulinum in fruit juices apparently by oxidizing organic acids with a resulting decrease in acidity to around pH 5 (Meyer and Gunnison, 1929, Tanner et al. 1940).

Examples of growth inhibition of C. botulinum are more numerous. Saprophytes in raw, frozen vegetables can increase the acidity during defrosting to pH 5 or less. A similar situation is found in some pre-cooked frozen foods such as chicken a la king. Addition of lactic acid bacteria resulted in an increase in acidity to pH levels of 3.5-4.4 during defrosting and no botulinum toxin was formed in inoculated packs (Saleh and Ordal, 1955a and b).

C. botulinum grow slowly at pH 5.0 and not at all at pH 4.5 and it seems that a decrease in pH is the main factor in "natural" inhibition. Bacteria which spoil cream-style corn without a decrease in pH did not prevent toxin production by type A or B (Malin and Greenberg, 1964) and we have similar experiences with formation of type A and E toxin in spoiling meat. However, it has been reported that Streptococcus lactis and Lactobacillus viridescans inhibit or delay toxin production by type E in raw fish where only very limited fermentation can be expected (Valenzuela et al. 1967). The inhibition may be due to antibiotics since it is known that certain strains of Strept. lactis produce nisin. Brevibacterium linens which grow in certain types of cheese can produce antibiotic active against C. botulinum (Greez, et al. 1959a,b; 1961, Greez, 1964).

Some C. botulinum strains produce antibacterial agents, bacteriocins, active against other C. botulinum strains. Bacteriocins are also produced by C. sporogenes and there are cross reactions between this species and C. botulinum with regard to bacteriocin sensitivity (Beerens and Tahon, 1967).

A bacteriocin which is very active against C. botulinum E is produced by some non-toxic botulinum E like organisms (Kautter, 1964). The importance of bacteriocins in food is unknown but it has been found that isolation of C. botulinum from natural sources can be difficult when bacteriocin producing organisms are present; the difficulty can be overcome by trypsin addition (Harmon and Kautter, 1967).

Various bacterial proteases can reduce or destroy the toxicity of botulinum toxin.

2. C. perfringens

This species seem to be as sensitive to low pH as is C. botulinum. It has, however, the advantage of being able to multiply very rapidly at a high temperature (46°C) and may therefore under conditions that would inhibit C. botulinum be able to outgrow acid producing organisms. Also, C. perfringens produce bacteriocins (Welchicins) some of which are active against a broad spectrum of spore formers (Sasarman and Antohi, 1967).

3. Staphylococcus aureus and Salmonella

Staph. aureus and Salmonella are strongly repressed in foods that ferment easily such as chicken, turkey and beef pies. Complete repression was found even when the pathogens initially outnumbered the saprophytes hundredfold (Dack and Lippitz, 1962). In another food, macaroni-and-cheese dinner, no repression was observed (Petersen, et al. 1962a.) However Staph. aureus was outgrown by saprophytes in raw crab meat (Stabyj et al. 1965) and many different organisms compete successfully with Staph. aureus although moderate amounts of salt tend to favor the latter (Peterson et al. 1962b, 1964; Graves and Frazier, 1963). The mechanism of inhibition--when drop in pH is not involved--is unknown.

Staph. aureus is often strongly repressed by lactic acid bacteria in mildly cured meats such as bacon and bologna sausage (Eddy and Ingram, 1962; Ingram, 1960, 1962; Tonge et al. 1964; Christiansen and Foster, 1965). When enterotoxin is produced in meat the production seems mainly confined to the surface (Casman et al. 1963).

II. Experimental Studies

A. Inhibition of C. botulinum by curing factors alone.

The brine concentration and pH required for inhibition of C. botulinum in mildly processed meats are well known. The results we have obtained with inoculated packs containing very few saprophytes are stated in Table 1 and they agree fairly well with the results published by others.

B. Inhibition of C. botulinum in products with subinhibitory levels of salt.

It is known that a large proportion of the mildly processed meat products which are on the market today do not contain levels of brine concentration and pH sufficient for a complete inhibition of C. botulinum (Riemann, 1968). One could therefore expect that toxin production would occur frequently when perishable cured market meats are inoculated with botulinum spores and incubated at elevated temperatures. This, however, is not the case. Out of 121 freshly vacuum packed samples of meat products picked up in supermarkets and inoculated with botulinum spores only 11 became toxic.

Table 1. Levels of curing factors required to prevent formation of botulinum toxin in meat containing low numbers of saprophytes.

<u>Type</u>	<u>Temperature</u>	<u>Brine concentration</u>	<u>pH</u>
E	10° - 30° C	3.3	6.5
A	25° - 30° C	6.7	6.5
-	---	5.5	6.2
-	---	<4.5	5.4

Table 2. Composition of perishable meat products which became toxic after inoculation with C. botulinum type A spores and incubation at 20-30°C for 2-4 days.

<u>Type of products</u>	<u>Brine concentration</u>	<u>pH after incubation</u>
Vacuum packed sliced ham	3.2 - 4.8%	Higher than 5.6
Sliced vacuum packed smoked chicken and turkey		

(Table 2) and these 11 were characteristic in having pH values above 5.6 after incubation for several days at 20-30°C. All the non-toxic products had lower pH values. Typical examples are shown in Table 3. The study showed that many perishable meat products undergo acid fermentation when exposed to an elevated storage temperature. The fermentation must be due to added carbohydrate since meat itself does not contain enough carbohydrate to permit fermentation to proceed to such low pH values. The effect of added carbohydrates was confirmed in experiments where glucose was added to different meat products and pH measured before and after incubation (Table 4). The drop in pH can be quite rapid (Table 5). However, addition of glucose did not invariably cause pH drop (Table 4). A number of meat products were sampled at the time they arrived at supermarkets (24-48 hours after packaging) and analyzed for composition including content of glucose (measured by Tes tape) and the results are presented in Table 6. The results suggest that addition of glucose is determined not only by type of product but also a characteristic of the manufacturer. Some manufacturers apparently add glucose up to 2% or more to most of their products and this gives their products an additional built-in safety factor.

It is of interest to know what kind of organisms are responsible for the acid formation in glucose containing perishable meat products. The following studies were carried out to obtain information on this point.

Table 3. Composition and change in pH in some perishable meat products during storage at 20-30°C for 2-4 days. Samples which became toxic after addition of botulinum spores are marked *.

Product	Percent brine	pH	
		Before storage	After storage
*Ham	4.5 - 4.8	6.0	6.2 - 6.6
*Sliced dark turkey	2.6 - 4.1	6.2 - 6.5	5.2 - 6.7
Spicy beef	4.6 - 6.5	5.9 - 6.0	4.8 - 5.0
*Smoked sliced chicken	2.9 - 3.4	6.3	5.7
Spiced luncheon loaf	3.2 - 3.6	6.2	4.5 - 5.0
Salami	4.5	4.9	4.6 - 4.7
Pepper loaf	3.6 - 4.5	5.4	4.4 - 4.8
Bologna	3.6 - 5.3	5.2 - 6.3	4.4 - 4.7
Sliced Beef	5.2	5.9	5.1 - 5.4

Table 4. Change of pH in meat products after addition of 1% glucose and storage 4 days at 20-30°C.

<u>Product</u>	<u>Initial pH</u>	<u>Final pH</u>	
		<u>No glucose added</u>	<u>Glucose added</u>
Ham	6.0	6.3 - 6.6	5.3 - 6.6
Smoked sliced dark turkey	6.4	5.6 - 6.1	4.7 - 5.3
Spicy beef	5.9 - 6.0	4.7 - 5.0	4.6 - 5.0
Smoked sliced chicken	6.3	5.5 - 5.7	4.5 - 5.0
Luncheon loaf	6.2 - 6.4	4.9 - 5.1	4.5

Table 5. Rate of pH decrease at 20° C in smoked sliced chicken with and without 1% added glucose.

<u>Storage time</u>	<u>pH</u>	
	<u>Glucose</u>	<u>No glucose</u>
0 days	6.2	6.2
2 days	5.0	5.5
4 days	4.7	5.4
9 days	4.5	5.4

Table 6. Concentration of glucose in freshly packed (24-48 hours under refrigeration) perishable meat products. 2+ means higher than 2%

<u>Manufacturer</u>	<u>Product</u>	<u>Percent glucose</u>
A	Hot dog	2+
B	Pork sausage	0.1 - 0.25
	Pork sausage with sage	2+
C	All beef bologna	0.1
	Pepper loaf	0
	Cooked ham	0 - 0.1
D	Smoked turkey	0.1
	Smoked ham	0.1
	Smoked chicken	0.1
E	Chopped pork	2+
	Beef salami	0.25 - 2
	Bologna	2+
	Spiced luncheon loaf	0 - 2
	Liver loaf	0.1 - 0.25
	Smoked beef	0
	Cooked ham	0 - 0.1
	Beef loaf	0.25 - 0.5
	Chopped ham	0
	Franks	2+
All beef franks	2+	
F	Cooked ham	0.1 - 0.25
	Ham loaf	0.1 - 0.25
	Picnic ham	0.1
G	Summer sausage	0.5 - 2.0
	Pressed pork	0 - 0.1
H	Corned Beef	0 - 0.1
	Smoked turkey	0 - 0.1
	Smoked dark turkey	0 - 0.1
	Smoked chicken	0 - 0.5
	Pastrami	0.1 - 0.25
	Sliced beef	0.1 - 0.25
	Sliced ham	0.1
	All beef salami	0.25

Table 6 - continued

<u>Manufacturer</u>	<u>Product</u>	<u>Percent glucose</u>
I	Spiced lunch loaf	0.25 - 0.5
	Cooked ham	0 - 0.1
	Boneless ham	0
	Chopped ham	2+
	Gellied cooked beef	0
	Beef loaf	0.1
	Beef bologna	2+
	Smoked beef loaf	0.1
	Liver sausage	2+
J	Sliced chicken	0
K	Liver sausage	2+
	Pork sausages	0.5
	Cotto salami	2+
	Bologna	2+
	Chopped ham	2+
	Old fashion loaf	2+
	Ham salad spread	2+
Fresh sausage	2+	
L	Spiced loaf	0.25
	Bologna	2+
	Cooked ham	2+
	Braunschweiger	2+
M	Turkey slices	0 - 2.0
	Beef slices	0.1 - 0.25
	Corned beef slices	0.1
	Smoked ham	0.1
	Cooked ham	0 - 2.0
	Chopped ham	0 - 2.0
	Liver sausage	2+
	Sliced ham	0.1
	Ham slices	0 - 0.1

c. Effect of saprophytes and glucose on toxigenesis by C. botulinum.

Samples of vacuum packed bologna and sliced dark turkey were inoculated with 1000 spores of Clostridium botulinum type A. The incubation periods varied from 1 to 16 days at both 20°C and 30°C. After incubation, the meat samples were examined for the growth of organisms other than C. botulinum.

All meat samples where C. botulinum did not grow were streaked on All Purpose Medium (APT) plus 0.008% brom cresol green. Attempts were made to distinguish colonies which produced acid, but almost all of the colonies fell into this category. Therefore, several organisms were picked at random from each meat samples. Seventeen strains of acid-producing cocci were isolated, several of which were similar.

A special mixture of blood and most of the constituents of stock APT agar was then formulated. Difco APT agar contains Tween 80 and when mixed with blood this compound prevented the characteristic and distinctive hemolysis of C. botulinum. When the acid-producing cocci and C. botulinum were both grown on plain APT agar, there were no distinctive features to allow their separation, and several of the cocci strains were not able to grow on plain blood agar. Therefore, APT agar was mixed without Tween 80 and then 5% cow blood was added for assays of cocci-botulinum growth.

The cocci strains were divided into two groups on the basis of catalase activity. Seven strains of catalase positive and ten strains of catalase negative cocci were tested.

A factorial experiment was then conducted to determine the inhibitory effect, if any, which these cocci had on the growth of C. botulinum type A. The following factors were examined: 1% and 3% NaCl, pH 6 and 7, 0 and 100 ppm nitrite, 0.1% and 1.0% glucose, incubation temperatures of 25°C and 35°C, and two dilutions of cocci. APT agar plus 5% cow blood was mixed with varying amounts of salt, nitrite, and glucose, and pH was lowered to 6 by adding 0.75% glucono delta lactone. The plates were poured one day before they were to be used and then stored overnight at 10°C.

One million spores of C. botulinum type A were evenly spread on the APT-BA plates. S & S filter paper discs 6 mm in diameter were dipped in 10^{-1} and 10^{-3} dilutions of the various strains of cocci and placed on the plates which had been seeded with spores. The plates were immediately placed in anaerobic jars and duplicates were incubated at 25°C and 35°C for three days.

After incubation, the plates were examined and zones where C. botulinum was unable to grow were measured around the filter paper discs. The size of the zones of inhibition varied depending on the strain used and the factors involved. Low initial pH and high concentrations of NaCl, glucose and nitrite increased the inhibitory effects of the cocci. Certain strains of both catalase negative Streptococcus and catalase positive Staphylococcus were able to take advantage of these favorable high concentrations to inhibit the growth of C. botulinum. The temperature of incubation and the dilution of the inhibitory organisms had no significant

effects on botulinum growth. One strain of catalase negative cocci finally identified as Strep. faecium seemed to be slightly more inhibitory than the others. It was later used in inhibition studies in ground beef.

Fresh ground round was divided into ten gram portions. Half of the samples were "cooked" by autoclaving for 15 minutes before they were placed in small plastic petri dishes and the other half of the meat samples were used raw. 100, 10,000, and 1,000,000 spores of C. botulinum type A and 10^0 , 10^{-2} , 10^{-4} , and 10^{-6} dilutions of 16 hours ATP cultures of the most inhibitory strain of Strep. faecium were used to inoculate the meat.

The effects of the following factors have been explored: Glucose, NaCl, incubation temperature. The studies are being continued using complete factorial designs.

Table 7 illustrates the inhibitory effects of Strep. faecium on C. botulinum 62A. There is no effect of Strep. faecium when no glucose is added to the meat except for a minor inhibition in raw meat when 3% NaCl is added. In the presence of 1% glucose the inhibitory effect becomes manifest especially when 1 og 3% NaCl is also added. The inhibitory effect is more pronounced in raw than in cooked meat; the latter having a slightly higher pH value. The inhibitory effect seems also more pronounced at 20°C compared to 35°C.

D. Identification of inhibitory saprophytes.

Streptococci.

The catalase negative cocci isolated occurred mainly in pairs but were also found in small chains. They showed no pigmentation and, according to Bergey's Manual, they are more like Streptococcus faecalis than any other group.

Further tests of Sharpe and Fryer (1966) suggested that the organisms are variants of Streptococcus faecium. Growth at 50°C is a feature used to differentiate between S. faecium and the other enterococci. However, this characteristic may be lost on repeated subculturing (Sharpe and Fryer, 1966).

Strep. faecalis can reduce tetrazolium to the insoluble red formazan so that the colonies have dark red center. Strep. faecium is not able to reduce tetrazolium, (Barnes, 1956), and the strains isolated from bologna were white on the tetrazolium glucose agar.

Other characteristics, such as the ability to ferment melibiose and mannitol, differ from the proposed results. Suffice it to say that the cocci isolated are more like Strep. faecium than they are like Strep. faecalis. Their characteristics are shown in Table 8.

Table 7. Inhibitory effect of Str. faecium on C. botulinum A in meat.

Raw meat		No NaCl 35°C incubation				No NaCl, 1% glucose				1% glucose, 35°C				No glucose, 35°C incubation			
		no glucose		1% glucose		20°C		35°C		1% NaCl		3% NaCl		1% NaCl		3% NaCl	
Level of <u>C. botulinum</u> A spores	<u>Str. fae-</u> <u>cium K2</u> dilution	pH	toxin	pH	toxin	pH	toxin	pH	toxin	pH	toxin	pH	toxin	pH	toxin	pH	toxin
10 ⁶	0	6.82	+	4.88	+	4.50	-	4.56	-	4.74	-	4.56	-	6.95	+	6.92	+
	-2	6.80	+	5.08	-	4.60	-	4.60	+	4.62	-	4.63	-	7.02	+	6.99	+
10 ⁴	0	6.84	+	4.81	-	4.79	-	4.62	-	4.70	-	4.62	-	7.01	+	6.87	+
	-2	6.82	+	4.80	+	4.74	-	4.68	-	4.73	-	4.60	-	7.00	+	6.88	+
	-4	6.79	+	5.13	+	4.62	-	4.82	-	4.73	-	4.63	-	7.00	+	6.79	+
10 ²	-2	6.80	+	4.95	-	4.62	-	4.78	-	4.78	-	4.67	-	7.02	+	7.09	+
	-4	6.88	+	4.95	-	4.53	-	4.92	-	4.78	-	4.68	-	7.06	+	6.92	-
	-6	6.68	+	5.76	+	4.53	-	5.20	-	4.72	-	4.62	-	7.08	+	7.01	+
<u>Cooked Meat</u>																	
10 ⁶	0	6.35	+	5.13	-	5.18	-	5.08	+	5.19	-	5.09	-	6.72	+	6.35	+
	-2	6.12	+	5.40	+	5.02	-	5.00	+	5.26	-	5.10	-	6.68	+	6.31	+
10 ⁴	0	6.65	+	5.28	-	4.96	-	5.00	-	5.18	-	5.06	-	6.78	+	6.40	-
	-2	6.66	+	5.26	+	5.03	-	5.12	-	5.12	-	5.08	-	6.59	+	6.30	-
	-4	6.55	+	5.28	+	4.88	-	5.00	+	5.17	-	5.29	+	6.78	+	6.38	+
10 ²	-2	6.35	+	5.16	-	4.90	-	4.95	-	5.18	-	5.12	-	6.54	+	6.30	-
	-4	6.60	+	5.25	+	5.02	-	4.95	+	5.12	+	5.08	-	6.48	+	6.38	-
	-6	6.69	+	6.02	+	5.61	-	5.90	+	5.20	-	5.75	-	6.53	-	6.22	-

Table 8. Characteristics of streptococci isolated from meats.

	Strains		
	<u>K2</u>	<u>N1</u>	<u>H1</u>
Catalase	-	-	-
Hemolysis	none (gamma)	none	none
Aerobic acid production from:			
Arabinose	+	+	+
Glycerol	-	-	-
Glucose	+	+	+
Lactose	+	+	-
Mannitol	-	+	-
Melibiose	+	+	-
Raffinose	-	+	-
Salacin	+	+	+
Sucrose	+	+	-
Sorbitol	-	-	-
Trehalose	+	+	-
Glycerol, anaerobic acid production	-	-	-
Litmus milk	no change	no change	no change
Gelatin hydrolysis	-	-	-
Starch hydrolysis	-	-	-
Growth at 10° C	+	+	+
Growth at 45° C	+	+	+
Growth at 50° C	-	-	+
Growth at pH 9.6	+	+	+

Table 8 - continued

	Strains		
	<u>K2</u>	<u>N1</u>	<u>H1</u>
Growth in 0.1% methylene blue milk	+	+	+
Growth on 40% bile in blood agar	-	-	-
Growth in 12% NaCl	+	+	+
Growth in 15% NaCl	-	-	+
Tetrazolium reduction	-	-	-
Source	bologna, incubated 1 day at 30°C	bologna 1 day, 30°C	bologna, 4 day, 30°C

Staphylococci.

Using the classification of Baird-Parker (1963, 1966), the catalase positive cocci isolated belong to the *Staphylococcus* subgroups II and V which correspond to *Staph. epidermidis* in Bergey's Manual (Baird-Parker, 1962). These cocci are found mainly in pairs but also occur singly, in short chains or in groups.

The cocci are classified Staphylococci as opposed to Micrococci because of their ability to produce acid from glucose under anaerobic conditions (Baird-Parker, 1965). Their characteristics are shown in Table 9.

III. Discussion.

It seems clear that perishable meat products with their content of saprophytic microorganisms will have a built-in safety factor against *C. botulinum* and other food poisoning bacteria if glucose (1% or more) is added. Glucose is fermented to acid by several saprophytes and the resulting low pH inhibits toxin formation by *C. botulinum*. Small concentrations of NaCl, even 1% seem to support the inhibitory effect. These observations explain why a variety of market meats with subinhibitory levels of NaCl and pH are not botulinogenic. Fecal streptococci, especially *Str. fecium*, and staphylococci are of importance in inhibiting *C. botulinum* in glucose containing meats and most if not all of their inhibitory effect is due to acid formation.

Table 9. Characteristics of staphylococci isolated from meats.

	Strains		
	<u>J2</u>	<u>C1</u>	<u>N2</u>
Pigment	yellow	white	white
Coagulase production	-	-	-
Catalase production	+	+	+
Phosphatase production	+	-	-
VP test, acetoin production	+	+	+
Litmus milk	acid, coagulation	acid, coagulation, partial digestion	acid
Aerobic acid production from:			
Arabinose	-	-	-
Dextrin	+	+	+
Galactose	+	+	+
Glycerol	+	+	+
Glucose	+	+	+
Lactose	+	+	+
Maltose	+	+	+
Mannitol	-	-	-
Glucose, anaerobic acid production	+	+	+
Hippurate hydrolysis	+	+	+
Gelatin hydrolysis	-	-	-
Urea utilization	+	+	-
Nitrate reduction	+	+	+
Growth in 15% NaCl	+	+	-
Growth in 12% NaCl	+	+	+
Growth at 10°C	+	+	+
Growth at 45°C	+	+	+
Growth at pH 9.6	+	+	+
Growth in 0.1% methylene blue milk	+	+	+
Growth on 40% bile in blood agar	+	+	+
Baird-Parker classification	Subgroup II	Subgroup V	Subgroup V
Source	turkey, incubated 1 day at 30°C	turkey, 8 day, 30°C	bologna, 1 day, 30°C

It is obvious that these organisms must multiply to form large populations in order to produce acid enough to inhibit C. botulinum and although their presence is to be preferred to the presence of botulinum toxin many people will probably question the desirability of large populations of Str. fecium and Staphylococci in foods. It would therefore seem appropriate to search for other acid producing less objectionable microorganisms that could be added to perishable meat products and other perishable foods as a safeguard against C. botulinum and other food poisoning bacteria.

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BERNHOLDT: Thank you very much Dr. Riemann. Moving on to our next topic, our speaker will be Vincent DelGiudice, Manager, Sanitation, Microbiology and Chemical Department, Quality Assurance Division, Armour and Company, Chicago. Mr. DelGiudice has a M.S. from Northwestern University in Bacteriology and has been with Armour for some 27 years, spending most of his time in applied sanitation for at least the last 25 years. He will talk to us today about "Losses to the Meat Industry Due to Microbial Growth."

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