

Relationships of Microbial Quality of Retail Meat Samples and Sanitary Conditions¹

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ABSTRACT

A sanitation profile scoring form for evaluating sanitation in retail food stores was designed. The profile was tested in 10 Oregon retail markets to evaluate its ability to reflect sanitary conditions. At the time of inspection, samples of meat processed in-store were purchased for microbiological analysis to explore the feasibility of bacterial quality as a measurement of sanitary conditions. Microbiological tests performed included total aerobic plate count (APC), coliform, *Escherichia coli*, *Staphylococcus aureus*, *Clostridium perfringens*, and *Salmonella*. Certain deficiencies were noted in the profile designed; however, it provides a means for objective, uniform measurement of sanitary conditions. Data show no correlation exists between microbiological quality of products processed in the store and total store profile sanitary conditions. Fifty percent of the products sampled exceeded bacterial load guidelines currently enforced in Oregon. These "high" counts appear to be directly related to poor temperature control.

Food shoppers are concerned about cleanliness and food quality in selecting a food store. A recent food shopping survey (6) showed that food quality and store cleanliness were important considerations to shoppers in selecting a store. Terms used to describe these considerations by the shopper included "good food", "dependable quality", "clean store appearance", "neat and cleanliness", and "an orderly store that smells clean". Shoppers also indicated they felt the stores they patronized were doing a good job in keeping their stores clean and neat.

Practicing good sanitation and safe food handling procedures are ways the food market can reduce spoilage and loss. A good sanitation program prevents food contamination, protects quality and increases consumer acceptability. Customers are impressed with the aesthetic considerations and the more obvious aspects of a sanitation program - that is, a clean store and personnel in the store giving an impression of neatness and cleanliness as well as improved food safety and product quality.

Many government regulatory agencies are concerned about enforcing sanitation regulations. A Federal ordinance proposed by the U.S. Food and Drug Administration establishes a model sanitation program for retail stores to be adopted uniformly across the country (4). A sanitation program may include identification and recording of the source and condition

of foods received, the temperature at which potentially hazardous foods are held, facilities for hand washing, insect and rodent control, specifications for floor and wall materials and personal hygiene.

It is generally agreed that clean and sanitary implies a piece of equipment or room is free from dirt, soil and harmful microorganisms. However, individual judgments on cleanliness and sanitation do vary and uniformity is not always achieved. In some instances, regulatory agencies attempt to perform objective measurements rather than subjective. Analyses of food products for microbial quality are used in an attempt to establish a quantitative measurement of the sanitary conditions. Regulatory personnel are unable to inspect retail markets at intervals sufficiently frequent to provide them with evidence that good sanitation practices are being followed. Therefore, these personnel are inclined to look to microbial quality analyses as a substitute (9).

The question arises-do these microbiological analyses provide information on the sanitary conditions of the store? Counts above certain limits have been used by regulatory agencies as "a means of identifying poor sanitation practices" (9). Many questions have been raised in regard to such assumptions, but certain ideas are lacking in this area. What microbial quality of product should we expect under good manufacturing practices coupled with suitable retail case storage? How can the inspector communicate his findings to management? What aspects of sanitation inspection reflect sanitary conditions and what relationship do these factors have to product quality? What is important to public health?

The objectives of this research were: (a) to develop a model scoring system or profile that could be used by regulatory personnel and store employees alike to give a uniform reflection of the sanitary conditions in the retail store, and (b) to determine if a correlation exists between sanitary conditions and the bacterial quality of meat products.

MATERIALS AND METHODS

Profile development

A model sanitation profile was designed taking into consideration the state sanitation requirements (8), score sheets used in FDA inspections in food service establishments (11) and requirements included in the proposed FDA model ordinance for food store sanitation (4). The factors delineated in the profile were; cleanliness of

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facility inside and out, water source, plumbing, lighting, restrooms, sewage, ventilation, evidence of rodents/insects, condition of foods, temperature controls and sanitation procedures. All departments of the store (meat, bakery, produce, delicatessen, dairy and general grocery) were scored individually. For each department, the above factors were evaluated for the display, preparation and storage areas, temperatures, load lines, code dates, cleanliness of equipment, food contact surfaces, proper separation of food, food protection, personal hygiene, hand washing facilities and garbage disposal. A scoring system was devised. A maximum score of 100 was possible and the factors considered most significant from a public health point of view were weighted with a range of 1 to 3. The "sanitation index" is the actual score obtained out of 100 maximum points possible.

Selection of stores

Ten stores were selected to represent a cross-section of the major supermarket chains and independents in the state. The stores selected for inspection were located within 1-h driving time from the laboratory to facilitate prompt delivery of samples. Temperatures of the products were measured and recorded at the time of purchase and at time of receipt in the laboratory.

The store manager was always contacted before proceeding with the survey. The purpose and intent of the activity were carefully explained and discussed with store personnel. In most instances, the store manager accompanied the survey team during the inspection. A copy of the recorded data, observations and sample analyses was sent to the store.

Temperature

Temperatures of product storage room and display cases were taken with a YSI model 42SF Telethermometer. The use of a flat surface probe readily permits temperature measurement of the outer surface of the container without product destruction as well as measurement of room or air stream temperatures. The temperature was observed on the direct reading dial of the electronic thermometer in approximately 20 sec. The temperature was then recorded on the sanitation profile form.

Collection of samples

At least two samples, as offered for sale, were obtained directly from the retail case at the completion of an inspection tour. One of these was ground meat and the other chopped cubed steak or pork sausage depending upon which product was prepared and available in the store. The samples were transported to the laboratory in insulated chests containing ice packs. Samples were prepared for microbial analyses immediately upon receipt in the laboratory.

Microbiological methods

A 50-g sample of each test product was weighed into a sterile blender jar containing 450 ml of sterile 0.1% peptone water. A second 50-g portion of the product was weighed into a blender jar containing 450 ml of lactose broth. The product was blended at high speed for 2 min. Subsequent 10-fold dilutions were prepared with 0.1% peptone water.

The procedures for total aerobic plate count (APC), coliforms, *Escherichia coli* and *Staphylococcus aureus* were according to those published in the Food and Drug Administration *Bacteriological Analytical Manual* (3).

Salmonellae

A 3-ml volume of 1 N NaOH was added to the original 10⁻¹ dilution of product in lactose broth. After incubation for 24 h at 35 C, a 1-ml portion was transferred to tubes containing 10 ml of selenite cystine broth and 10 ml of tetrathionate (TT) broth. These tubes were incubated 24 h at 35 C after which time loopfuls of culture were streaked onto brilliant green agar and XLD agar. Selective differential agar plates were incubated 24 h at 35 C; colonies typical of salmonellae (10) were subjected to confirmatory testing using the Analytab Products API 20 E system (1).

Clostridium perfringens

Ten ml of the 10⁻¹ peptone water dilution were divided among 3 plates which were poured with tryptose-sulfite-cycloserine (TSC) agar. The plates were incubated at 35 C for 24 h in a BBL anaerobic Gas Pak system. Typical colonies were counted and transferred to tubes of fluid thioglycollate broth which were incubated 4-6 h in a 45.5-C water bath. Portions of the growth from gassing tubes were streaked onto plates of trypticase-sucrose-egg-yolk-agar (TSEY). These were incubated anaerobically at 35 C overnight. A second purification was effected by transferring typical *C. perfringens* colonies to tubes of fluid thioglycollate medium for incubation at 45.5 C for 4-6 h. A loopful of inoculum from the gassing tubes was transferred to lactose-gelatin medium, sucrose broth, motility-nitrate medium and Bactotryptone broth for confirmation of *C. perfringens* (10).

Data analyses

The data were subjected to statistical analysis. Pearson coefficients were calculated comparing each profile score to total microbiological quality and absence or presence of pathogens (7).

RESULTS

Inspections

The profile was tested in 10 retail markets for its ability to measure objectively sanitary conditions in retail food markets. Table 1 shows the findings of the profile for the stores inspected. Not all stores inspected had all the various departments provided for in the profile. If the store did not have certain sections, it was considered not applicable (N/A) and was disregarded in determining the over all score possible. Each inspection required an average of 2 h. The total scores ranged from a low of 74.8 to a high of 92.9 out of a possible 100. No attempt was made to determine what should be an acceptable or unacceptable score. Further work and refinement of the profile form will be needed before such a judgement can be made.

No particular problem was noted in the areas of construction, water source, plumbing or sewage water disposal among the stores inspected. Failure to have proper shields on lighting fixtures was noted occasion-

TABLE 1. Sanitation indices¹ of ten retail food markets in Oregon.

Store number	Total score	General	Meat	Bakery	Produce	Dairy	Grocery
1	74.8	80.0	76.5	N/A ²	87.0	57.9	62.5
2	85.6	88.6	89.7	N/A	87.0	80.0	75.0
3	75.8	84.8	79.4	N/A	69.0	73.7	64.7
4	89.9	91.4	100.0	64.5	98.2	94.7	94.1
5	92.2	94.3	95.6	93.5	100.0	89.5	72.5
6	84.4	88.6	95.6	N/A	82.4	76.3	67.5
7	85.5	87.1	98.5	N/A	75.9	86.8	72.5
8	85.5	90.3	92.6	N/A	87.0	78.9	70.0
9	85.3	90.0	91.2	80.6	96.4	76.3	67.3
10	77.2	80.0	86.8	67.7	91.1	68.4	60.0

¹Sanitation index = actual score obtained out of 100 possible.

²N/A - not applicable.

ally. In the various sections, particularly warehouses, rodent and insect infestations were observed. Proper measures were not taken to prevent the infestation.

Most of the stores surveyed employ exterminators who use bait stations, particularly in warehouse sections. However, it is felt more could be done to prevent the entrance of rodents into the retail store, instead of simply trying to take care of the problem once they have it.

Lack of proper temperature control was mainly responsible for low sanitation index scores. In most instances, thermometers were present and visible in retail display cases and storage rooms, as required by regulations, but were often inaccurate. In scoring, points were allotted if thermometers were present and visible as required by law; however, the emphasis was on product temperatures and accurate and reliable thermometers.

Results of each inspection were made available to store management. The form was useful as a means of communicating results of an inspection. One of the criticisms of the present regulatory inspections in Oregon is the lack of uniformity among inspectors and quantitative measurements. A scoring sheet achieves uniformity and helps management know exactly how their operational procedures are evaluated.

Table 2 shows the relationship of temperature control and sanitation indices. "A" reflects "average" where conditions of foods held under refrigeration met minimum requirements of Oregon law, that is, products and storage conditions in the range of 45 and 0 F. "S" was assigned to a store if its temperature control was regarded as being "superior", in that all observed temperatures were 35 F or below and -10 F or below. "U" was assigned to the store if its temperature control program was "unsatisfactory" or if product or areas were above 45 or 0 F. It was an all or none assignment. For instance, many stores had good conditions for unfrozen, refrigerated foods but the frozen foods would be above 0 F. The temperatures checked were for potentially hazardous foods only (i.e., frozen foods, meat, dairy

products and delicatessen items). The ability of a store to achieve a good temperature control program is reflected in the total "sanitation index". For example, stores having an "unsatisfactory" temperature control program, had a "sanitation index" of 81.3. Similarly, in the meat area the stores rated as superior had an average sanitation index of 95.6.

Microbiological analyses

Table 3 shows the results of the microbiological examination of the meat samples. Oregon guidelines for fresh raw meat products consider a total aerobic plate count in excess of 5×10^6 organisms/g to be a violation. Five of 10 samples of ground beef failed to meet these guidelines. Two of 6 pork sausage samples failed and 2 of 5 chopped beef samples.

Table 4 shows the results of the items sampled for *E. coli* levels. The state's guidelines consider a product in violation if the number of *E. coli* is in excess of 50 MPN/g. Only 2 of the 10 samples of ground beef exceeded the guidelines, and all samples of pork sausage and chopped beef were in compliance with the guidelines.

Table 5 shows the results of the microbiological examinations of the products for the presence of pathogens. It is generally agreed that large numbers of *S.*

TABLE 3. *Microbial quality of retail meat samples.*

Store number	Ground beef (APC/g)	Pork sausage (APC/g)	Chopped beef (APC/g)
1	3.4×10^6	32.0×10^6 *	5.4×10^6 *
2	1.2×10^6	—	9.5×10^3
3	5.3×10^5	—	9.7×10^5
4	7.0×10^6 *	—	1.5×10^5
5	12.0×10^6 *	1.3×10^6	—
6	16.0×10^6 *	45.0×10^6 *	—
7	5.0×10^5	5.6×10^5	—
8	11.0×10^6 *	4.3×10^6	—
9	5.0×10^5	1.4×10^6	—
10	17.0×10^6 *	—	13.0×10^6 *
*Exceeded guidelines (8):	5/10	2/6	2/5

TABLE 2. *Relationship of sanitation index¹ and temperature control.*

Store number	Total store		Meat department		
	Sanitation index	Temperature rating ²	Store number	Sanitation index	Temperature rating ²
1	74.8	U	2	89.7	U
2	85.6	U	3	79.4	U
3	75.8	U	7	98.5	U
6	84.4	U	10	86.8	U
7	85.5	U	Av.	88.6	
8	85.5	U	1	76.5	A
10	77.2	U	8	92.6	A
Av.	81.3		Av.	84.6	
4	89.9	A	4	100.0	S
9	85.3	A	5	95.6	S
Av.	87.6		6	95.6	S
5	92.2	S	9	91.2	S
Av.	92.2		Av.	95.6	

¹See Table 1.

²U = unsatisfactory, above 45 F, above 0 F.

A = average, 45 F, 0 F.

S = superior all areas, 35 F or below, -10 F or below.

TABLE 4. Levels of *E. coli* in retail meat samples.

Store number	Ground beef (MPN/g)	Pork sausage (MPN/g)	Chopped beef (MPN/g)
1	21	43	15
2	21	—	15
3	7	—	< 3
4	4	—	< 3
5	93*	< 3	—
6	43	3	—
7	43	43	—
8	23	43	—
9	93*	< 3	—
10	4	—	4
*Exceeded guidelines (8):	2/10	0/6	0/6

aureus in foods signify a potential food hazard. According to Zaki et al. (12), foods containing numbers in excess of 100/g would be considered contaminated. We chose a level of 10 MPN/g for ranking samples since this is the minimum accuracy level of the method and MPN tables. Five of the 10 samples of ground beef contained numbers greater than 10. One of 6 pork sausage samples and none of the chopped beef samples contained counts of *S. aureus* greater than 10 MPN/g.

The presence of any pathogen in a food product is considered to be a potential health hazard (2). Therefore, salmonellae and *Clostridium perfringens* were reported as being present or absent in the samples. Only 2 of the pork sausage samples contained salmonellae (see Table 5); both of these samples were obtained from the same major food chain within a week. The meat market managers were immediately notified and the product resampled. It was determined that pork for both stores came from the same supplier. Several weeks later subsequent samples were found to be negative for salmonellae. *C. perfringens* was detected in 2 ground beef samples, 1 pork sausage sample and 1 chopped beef sample.

Table 6 shows the relationship of total aerobic plate count (APC) compliance and temperature ratings at the time of sampling for ground beef. The products were listed as to whether they exceeded the standard of

TABLE 6. Relationship of APC and temperature ratings of meat storage and display areas.

Store Number	Ground beef	
	APC (exceeded guidelines) ¹	Temperature rating ²
1	NO	A
2	NO	U
4	YES	S
5	YES	S
6	YES	S
8	YES	A
10	YES	U
3	NO	U
7	NO	U
9	NO	S

¹Reference No. 8.

²S = Superior all areas, 35 F or below, -10 F or below.

A = Average, 45 F, 0 F.

U = Unsatisfactory, above 45 F, above 0 F.

5 million organisms/g or not, and if the temperature was rated as superior (S), average (A) or unsatisfactory (U) based upon previous established criteria.

The bacterial findings were studied in relation to various determinants, namely the storage or display temperatures and sanitary conditions at the time of sampling. The bacterial counts and the sanitation index were subjected to regression coefficient analyses. Attempts to correlate the sanitation index with total aerobic plate count, coliform, *E. coli*, and presence or absence of pathogens for all products (ground beef, pork sausage, and chopped beef) were conducted.

DISCUSSION

There is considerable interest in establishing microbiological standards for perishable foods. Regulatory agencies suggest high microbial levels in foods are associated with low-quality raw materials and/or flaws in processing, storage or distribution. The State of Oregon enforced bacterial standards and now has guidelines on maximum bacterial levels in raw and processed meat products. The results of these analyses and sampling program are considered to be "tools" for sanitation inspections (9).

TABLE 5. Presence of pathogens in retail meat samples.

Store number	Ground beef			Pork sausage			Chopped beef		
	<i>S. aureus</i> (MPN/g)	Salmonellae	<i>C. perfringens</i>	<i>S. aureus</i> (MPN/g)	Salmonellae	<i>C. perfringens</i>	<i>S. aureus</i> (MPN/g)	Salmonellae	<i>C. perfringens</i>
1	100*	—	—	< 10	—	—	< 10	—	—
2	< 10	—	—	< 10	—	—	< 10	—	—
3	< 10	—	—	< 10	—	—	< 10	—	—
4	10*	—	—	< 10	—	—	< 10	—	+
5	100*	—	+	< 10	—	—	< 10	—	—
6	< 10	—	—	< 10	—	—	< 10	—	—
7	10*	—	—	< 10	+	+	< 10	—	—
8	< 10	—	+	< 10	+	—	< 10	—	—
9	10*	—	—	10*	—	—	< 10	—	—
10	< 10	—	—	< 10	—	—	< 10	—	+
*Exceeded guidelines (8):	5/10	0/10	2/10	1/6	2/6	1/6	0/5	0/5	1/5

Results of this study indicate there is no correlation between microbial quality of retail meat products and the sanitary conditions of the store as reflected by a sanitation profile for a limited number of stores. All of the *r* values calculated were below the 5 and 1% levels of significance. Observations of the survey team indicate attitudes of personnel and careful attention to product temperatures appear to have a more significant influence on product quality. The model sanitation profile provides a means for objective measurements and adequately communicates the information, even though certain deficiencies were discovered in the model sanitation profile used in this study.

Sanitation deficiencies were noted in several bakery sections. Continued work is needed to relate the significance of these observations to public health.

No clear relationships between sanitary conditions and product quality were established. Many factors other than sanitary conditions of the store affect meat quality, such as conditions of slaughtering, processing, storage and distribution. The study was designed to model as closely as possible current inspection practices. Therefore, without complete knowledge of the whole chain of pre-retail conditions, it is difficult to determine the influences of retail level conditions on meat quality.

Refrigeration equipment in use today goes on "defrost" regularly and in some stores this occurs 3-4 times over a 24-h period. Recommendations have been put forth to hold frozen foods at -18 C (0 F) for maximum retention of their quality and nutrients (5). In some instances in this study, where refrigeration cases were set to meet minimum requirements of the law (i.e. 45 and 0 F), product temperature would rise quickly during the defrost cycle and be above required

temperatures. However, the total significance of this temperature fluctuation on safety, nutritive value and quality is not known.

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