J. Milk Food Technol. Vol. 39, No. 11, Pages 759-762 (November, 1976)

Total Plate Count and Sensory Evaluation as Measures of Luncheon Meat Shelf Life

W. M. HILL, J. REAUME, AND J. C. WILCOX

Armour Food Company, Research Division
Scottsdale, Arizona 85260

(Received for publication January 19, 1976)

ABSTRACT

The relationship between sensory attributes and total numbers of bacteria was investigated in a study involving 600 samples of spiced luncheon meat, cooked salami, bologna, and chopped ham. The vacuum packaged products were purchased from 60 markets throughout the United States. Samples were subjected to microbiological and sensory evaluation within a few days after purchase and once a week during a 3-week refrigerated storage period. Based upon an off-flavor intensity scale of 1 = none to 7 = extremely strong, the samples having total plate counts (TPC) of $< 10^4$, 10^4, 10^5, 10^6, 10^7, and 10^8 per gram had mean taste panel scores (TPS) of 2.00, 2.25, 1.92, 2.06, 1.93, and 3.17, respectively over the 3-week storage period. A microbiological standard of 10^6 TPC would terminate shelf life of these products at 24-28 days after manufacture. Establishment of a total bacterial population of 10^8 per gram with a corresponding decrease in sensory quality did not occur until 46-60 days after manufacture.

Shelf life may be defined as the period a product can be stored under specified conditions without significant deterioration in quality. The consumer employs various sensory attributes to judge the quality of foods. To the consumer, then, the shelf life of a perishable food such as ready-to-eat luncheon meats has ended when the appearance, odor, or taste becomes unacceptable.

Total plate count microbiological standards have been placed upon meat products by several state regulatory agencies (*6*). It is argued that these standards improve the quality of meats available to the consumer at the retail level (*3*). Thus, to some regulatory agencies, the shelf life of perishable meats has ended when the product contains a total number of bacteria in excess of that allowed by the microbiological standard.

To be of value, a microbiological standard must provide some benefit to the consumer. Therefore, the relationship between the consumer's sensory measurement of quality and shelf life and a regulatory agency's microbiological measurement of quality and shelf life is worthy of investigation.

There have been several studies conducted on the growth of microorganisms in vacuum packaged sliced luncheon meats during refrigerated storage. Brooks and Henrickson (*2*) examined 350 retail samples representing seven varieties of luncheon meat. The number of aerobic bacteria per gram ranged from a low of about 300 to a high of over 300,000,000 with mean values ranging from 700,000 to over 18,000,000. At the time of plating, 343 of the samples were judged organoleptically acceptable. The authors concluded that total plate counts did not provide a clear-cut differentiation between organoleptically acceptable and unacceptable samples. Allen and Foster (*1*) found that signs of spoilage in sliced luncheon meats, if they appeared at all, were not detectable until after the bacterial population exceeded 10,000,000 per gram. Similar results were reported by Kempton and Bobier (*7*) who observed that bologna and cooked ham were stable in odor and appearance throughout a 15-week storage study even though a maximum of 100,000,000 bacteria per gram was attained in 3 to 4 weeks.

The studies which provided valuable information in the growth patterns and types of organisms occuring in luncheon meats under controlled conditions (*1, 7*) may not accurately reflect the condition of these products as they are available to the consumer from supermarket shelves due to variable transportation and retail stocking practices. Other studies (*2*), while measuring product quality as perceived by the consumer, often lack information on the age of the product at the time of analyses.

The objective of our study was to further evaluate the relationship between total plate counts, organoleptic attributes, and age of luncheon meats obtained at retail and held under refrigeration for up to 3 weeks.

MATERIALS AND METHODS

Collection of samples

The Armour products were removed from the display cases of as many pre-selected stores as necessary to obtain a sufficient number of samples representing three product code dates per city surveyed. The products were purchased by personnel of an independent research service organization, packed in insulated shipping containers, and sent air freight to the Armour Food Research Laboratory. Product temperatures in the shipping container of less than 10 C were considered acceptable.

Storage of samples

The samples were held in a 3-4 C cooler until one week before analysis when selected packages were placed in a lighted display case, simulating retail conditions. Case temperature was adjusted to 4-7 C.

Sampling

Two packages of product from each city/code date group were analyzed within 2 days after receipt and again each week thereafter for 3 weeks. The packages were removed from the display case and sampled for microbiological analyses. The remainder of the product was then taken to the Home Economics Section for immediate sensory evaluation.

Microbiological analyses

Packages were opened aseptically and a wedge cut through the slices of product to obtain a 33-g sample. The sample was blended with 300 ± 2 ml of water in a Waring Blendor jar for 2 min. Plates were poured with Difco Plate Count Agar and incubated at 30 C for 48 h.

Sensory evaluation

Ten taste panel judges for each product (12 for bologna) were selected from laboratory personnel. The judges were trained to detect flavor changes in their assigned products. Since these studies were conducted over a 4-year period, most panelists evaluated all four of the products. The product slices were cut in half, rolled and secured with a plastic toothpick. Two sets of samples were served to the judges at each test session. Each set included three code dated samples purchased in one city. Samples were placed on aluminum foil trays, under code, in predesigned randomized order. Judges scored the samples on a 7-point off-flavor intensity scale with 1 equal to no off-flavor, 4 equal to moderate off-flavor, and 7 equal to extremely strong off-flavor.

To approximate consumer acceptance of the samples, the off-flavor intensity scale was arbitrarily divided into two ranges. A score < 3.5 was considered acceptable while a score ⩾ 3.5 was deemed unacceptable. The criteria of product failure have been discussed by Gacula (*4*) and Gacula and Kubala (*5*).

RESULTS AND DISCUSSION

The results of the microbiological and sensory evaluations of bologna, spiced luncheon meat, cooked salami and chopped ham are shown in Tables 1-5.

As would be expected, the total plate counts (TPC) and off-flavor taste panel scores (TPS) increased with storage time (Table 5). Initially, 69% of the samples analyzed contained less than 10^6 TPC and the means TPS for the initial samples was 1.72. After 3 weeks of storage, 71% of the samples exceeded 10^6 TPC and the mean TPS for the 3-week samples was 2.47. Also, the number of samples having TPS ⩾ 3.5 increased from 3.3% initially to 16.7% after 3 weeks of storage. While storage time is related to both total counts and sensory characteristics of vacuum packaged luncheon meats, we did not observe a cause and effect relationship between total counts and off-flavor development. Indeed, there often was a decrease in the off-flavor scores at the four sampling periods with increasing bacterial numbers up to 10^8 per gram. This trend is shown in Fig. 1 which is a three-way plot of storage time, taste panel scores, and total numbers of bacteria. Initially, there was little difference in taste panel scores of samples containing up to 10^8 TPC. However, after 3 weeks of storage, samples con-

TABLE 1. *Taste panel scores (TPS) and total plate counts (TPC) for bologna stored at 4-7 C.*

	Storage time (Weeks)														
	Initial			One			Two			Three			Total		
Range TPC/g	No. of samples	Mean TPS	%TPS ⩾ 3.5	No. of samples	Mean TPS	% TPS ⩾ 3.5	No. of samples	Mean TPS	% TPS ⩾ 3.5	No. of samples	Mean TPS	% TPS ⩾ 3.5	No. of samples	Mean TPS	% TPS ⩾ 3.5
LT 10^4	28	1.73	10.7	8	2.54	37.5	7	2.38	28.6	4	2.34	50.0	47	2.04	21.3
10^4-10^5	5	1.73	0	3	1.56	0	2	1.67	0	4	2.67	50.0	14	1.95	14.3
10^5-10^6	5	1.13	0	5	1.60	0	6	1.56	0	4	2.00	0	20	1.55	0
10^6-10^7	13	1.56	7.7	11	2.24	9.1	7	2.05	0	10	1.70	0	41	1.87	4.9
10^7-10^8	9	1.56	0	24	1.74	0	25	2.07	4.0	27	1.78	0	85	1.83	1.2
10^8-10^9	0	—	—	9	2.70	33.3	13	3.15	38.5	11	3.49	54.5	33	3.14	45.5
TOTAL	60	1.61	6.7	60	2.06	11.7	60	2.24	13.3	60	2.19	16.7	240	2.03	12.1

TABLE 2. *Taste panel scores (TPS) and total plate counts (TPC) for spiced luncheon meat stored at 4-7 C*

	Storage time (Weeks)														
	Initial			One			Two			Three			Total		
Range TPC/g	No. of samples	Mean TPS	% TPS ⩾ 3.5	No. of samples	Mean TPS	% TPS ⩾ 3.5	No. of samples	Mean TPS	% TPS ⩾ 3.5	No. of samples	Mean TPS	%TPS ⩾ 3.5	No. of samples	Mean TPS	% TPS ⩾ 3.5
LT 10^4	10	2.38	0	0	—	—	0	—	—	0	—	—	10	2.38	0
10^4-10^5	2	2.10	0	8	2.65	25.0	4	3.00	50.0	5	2.84	40.0	19	2.72	31.6
10^5-10^6	11	1.85	0	1	1.80	0	4	2.50	0	3	2.33	0	19	2.06	0
10^6-10^7	7	2.11	14.3	14	2.24	21.4	9	2.51	33.3	13	2.26	0	43	2.28	16.3
10^7-10^8	2	2.30	0	8	2.10	12.5	11	2.02	9.1	9	2.49	11.1	30	2.20	10.0
10^8-10^9	0	—	—	1	3.80	100.0	4	3.20	50.0	2	3.30	50.0	7	3.31	57.1
TOTAL	32	2.12	3.1	32	2.34	21.9	32	2.39	25.0	32	2.49	12.5	128	2.34	15.6

TABLE 3. *Taste panel scores (TPS) and total counts (TPC) for cooked salami stored at 4-7 C*

	Storage time (Weeks)														
	Initial			One			Two			Three			Total		
Range TPC/g	No. of samples	Mean TPS	% TPS ⩾ 3.5	No. of samples	Mean TPS	% TPS ⩾ 3.5	No. of samples	Mean TPS	% TPS ⩾ 3.5	No. of samples	Mean TPS	%TPS ⩾ 3.5	No. of samples	Mean TPS	% TPS ⩾ 3.5
Lt 10^4	14	1.67	0	0	—	—	0	—	—	0	—	—	14	1.67	0
10^4-10^5	9	1.18	0	4	1.65	0	5	2.84	20.0	4	2.65	25.0	22	1.91	4.5
10^5-10^6	2	1.20	0	14	1.51	0	7	2.71	0	8	2.78	12.5	31	2.09	3.2
10^6-10^7	5	1.40	0	5	1.56	0	7	2.51	14.3	11	2.31	0	28	2.06	7.1
10^7-10^8	4	1.30	0	5	1.60	0	6	2.47	16.7	0	—	—	15	1.87	6.7
10^8-10^9	0	—	—	6	2.17	0	9	3.11	33.3	11	3.40	45.5	26	3.02	30.8
TOTAL	34	1.43	0	34	1.66	0	34	2.75	17.7	34	2.81	20.6	136	2.16	9.6

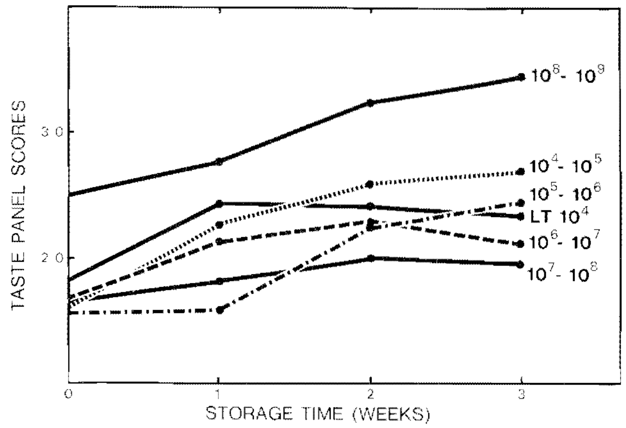

Figure 1. *Mean taste panel scores for bologna, spiced luncheon meat, cooked salami, and chopped ham.*

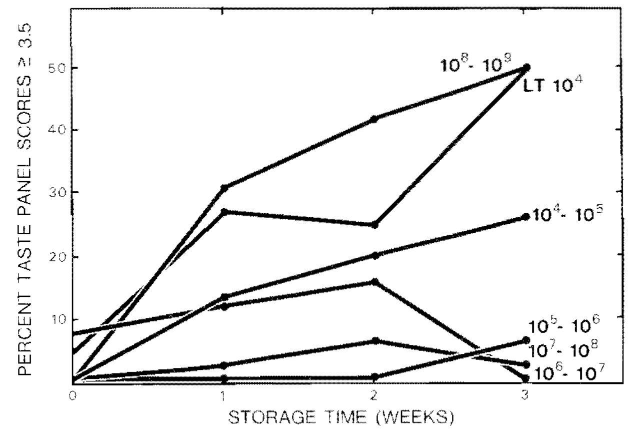

Figure 2. *Percent taste panel scores ⩾ 3.5 for bologna, spiced lucheon meat, cooked salami, and chopped ham.*

taining less than 10^6 TPC had higher off-flavor scores than those samples having total counts of 10^6-10^8 per gram. Off-flavor development was consistently greater in those samples having 10^8-10^9 TPC.

The percent of samples having off-flavor scores ⩾ 3.5 is plotted with storage time and total counts in Fig. 2. At each of the weekly testing periods there was less "consumer rejection" of the luncheon meat samples with 10^5-10^6, 10^6-10^7 and 10^7-10^8 TPC than those samples containing less than 10^4, 10^4-10^5 and 10^8-10^9 TPC.

The apparently greater "consumer acceptance" of luncheon meats containing progressively higher numbers of total bacteria (up to 10^8 TPC) may be the result of lactic acid fermentation processes. Lactic acid producing bacteria, which are the dominant microflora of vacuum packaged luncheon meats (*1, 7*), may act as oxygen scavengers and thus inhibit oxidative reactions which form off-flavors. Or, the lactic acid may simply mask the off-flavors yielding a more acceptable product up to the point where the acid itself becomes objectionable. Lactic cultures are commonly employed to create specialized products by the dairy and dry sausage industries. Reddy and Chen (*6*) have shown that the sensory shelf life of raw ground beef is improved by the addition of lactic cultures. There seems little reason to believe that the growth of lactic bacteria in luncheon meats would not create flavor changes desired, and perhaps even expected, by the consumer.

The relationship between shelf life as defined by microbiological standards and shelf life as perceived by the consumer can be estimated from the data presented in Fig. 3. Linear regression analyses of total plate counts and product age from the date of pack yield best fit growth rates of the bacteria in the four luncheon meat products. While chopped ham has a relatively stable microbial population, the off-flavor scores for this product still increased at a rate (Table 4) comparable to that of the other products. The regression lines shown for bologna, cooked salami, and spiced luncheon meat are similar. Assuming a microbiological standard of 10^6

TABLE 4. *Taste panel scores (TPS) and total plate counts (TPC) for chopped ham stored at 4-7 C*

	Storage time (Weeks)														
	Initial			One			Two			Three			Total		
Range TPC/g	No. of samples	Mean TPS	% TPS ⩾3.5	No. of samples	Mean TPS	% TPS ⩾3.5	No. of samples	Mean TPS	% TPS ⩾3.5	No. of samples	Mean TPS	% TPS ⩾3.5	No. of samples	Mean TPS	% TPS ⩾3.5
LT 10^4	9	1.73	0	3	2.13	0	1	2.60	0	0	—	—	13	1.89	0
10^4-10^5	7	1.91	0	7	2.54	14.3	9	2.49	11.1	10	2.66	10.0	33	2.43	9.1
10^5-10^6	2	1.60	0	3	1.67	0	1	2.60	0	1	1.80	0	7	2.10	0
10^6-10^7	0	—	—	3	2.33	0	2	1.20	0	2	2.10	0	7	1.94	0
10^7-10^8	4	1.89	0	2	2.30	0	6	2.00	0	5	1.96	0	17	1.99	0
10^8-10^9	2	2.50	0	6	3.27	50.0	5	3.72	60.0	6	3.50	50.0	19	2.56	47.4
TOTAL	24	1.88	0	24	2.52	16.7	24	2.53	16.7	24	2.64	16.7	96	2.39	12.5

TABLE 5. *Taste panel scores (TPS) and total plate counts (TPC) for bologna, spiced luncheon meat, cooked salami, and choppped ham stored at 4.7 C*

	Storage time (Weeks)														
	Initial			One			Two			Three			Total		
Range TPC/g	No. of samples	Mean TPS	% TPS ⩾ 3.5	No. of samples	Mean TPS	% TPS ⩾ 3.5	No. of samples	Mean TPS	% TPS ⩾ 3.5	No. of samples	Mean TPS	% TPS ⩾3.5	No. of samples	Mean TPS	% TPS ⩾ 3.5
LT 10^4	61	1.82	4.9	11	2.43	27.3	8	2.41	25.0	4	2.34	50.0	84	2.00	11.9
10^4-10^5	23	1.62	0	22	2.28	13.6	20	2.60	20.0	23	2.70	26.1	88	2.25	13.6
10^5-10^6	20	1.58	0	23	1.59	0	18	2.27	0	16	2.44	6.3	77	1.92	1.3
10^6-10^7	25	1.68	8.0	33	2.14	12.1	25	2.28	16.0	36	2.11	0	119	2.06	8.4
10^7-10^8	19	1.65	0	39	1.82	2.6	48	2.10	6.3	41	1.96	2.4	147	1.93	3.4
10^8-10^9	2	2.50	0	22	2.76	31.8	31	3.24	41.9	30	3.45	50.0	85	3.17	41.2
TOTAL	150	1.72	3.3	150	2.11	12.0	150	2.47	17.3	150	2.47	16.7	600	2.19	12.3

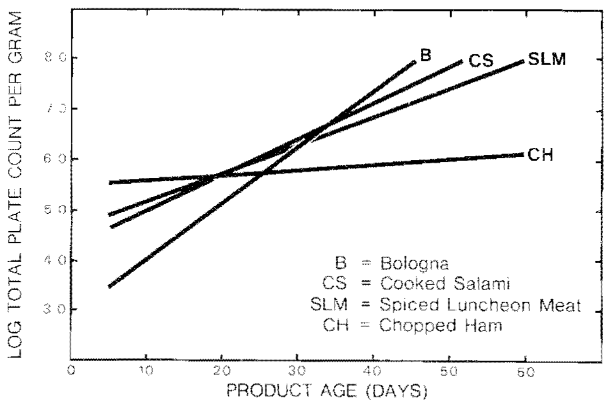

Figure 3. *Linear regression analysis of total plate counts and product age.*

TPC, the regulatory shelf life of bologna, cooked salami, and spiced luncheon meat would be 24-28 days beyond the date of pack. The consumer shelf life for these products, based upon sensory data, would be 46-60 days beyond the date of pack. Obviously, microbiological standards could cause the premature removal from the marketplace of a very large percentage of luncheon meat products which are no doubt wholesome and the consumer would find totally acceptable.

REFERENCES

1. Allen, J. R., and E. M. Foster. 1960. Spoilage of vacuum packed sliced processed meats during refrigerated storage. Food Res. 25: 19-25.
2. Brooks, R. F., and R. L. Henrickson. 1956. Microflora of pre-packaged lucheon meats. Univ. of Missouri Agr. Exp. Sta. Res. Bull. 611. Columbia, Missouri.
3. Carl, K. E. 1975. Oregon's experience with microbiological standards for meat. J. Milk Food Technol. 38:483-486.
4. Gacula, M. C., Jr. 1975. The design of experiments for shelf life study. J. Food Sci. 40:399-403.
5. Gacula, M. C., Jr., and J. J. Kubala. 1975. Statistical models for shelf life failures. J. Food Sci. 40:404-409.
6. Johnston, R.W. 1975. Microbiological criteria, and update, proceedings of the Meat Industry Research Conference. pp. 115-118.
7. Kempton, A. G., and S. R. Bobier. 1970. Bacterial growth in refrigerated vacuum packed luncheon meats. Can. J. Microbiol. 16: 287-297.
8. Reddy, S. G., and M. L. Chen. 1975. Influence of lactic cultures on the biochemical, bacterial and organoleptic changes in beef. J. Food Sci. 40:314-318.