WHAT TESTS USEFULLY PREDICT KEEPING QUALITY OF PERISHABLE FOODS?

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ABSTRACT

The keeping quality of milk and salad samples is shown to be generally unrelated to standard microbiological and chemical tests. Relatively little of the observed variation in flavor score, assigned to milk samples upon receipt from retail outlets, could be accounted for by microbiological and chemical tests made at the same time. The flavor score given to milks immediately after pasteurization seems to be most useful to predict keeping quality, i.e., the number of days required to attain an unsatisfactory flavor score.

To the consumer the term "food quality" may bring forth visions of quality control through laboratory testing. Indeed, the food industry uses many analytical procedures, both microbiological and chemical, to monitor the sanitary quality of its products. Such testing is most rigorous with perishable food products as for example, dairy foods. Regulatory agencies concerned with public health also monitor these products.

However, what the consumer desires is not only a sanitary product, but also one with a good flavor and acceptable keeping quality. That is, if it is not destined for immediate consumption, how long can it be refrigerated before it becomes unpalatable and must be discarded?

Do the tests presently used answer this question for both consumers and processors? In this report we show that the results of standard laboratory tests reflecting the sanitary condition of food products are generally unrelated to their flavor rating and do not necessarily predict their keeping quality.

METHODS

The microbiological and chemical tests performed on milk and salad samples included Standard Plate Count, coliform count, acid degree value *(2)*, oxidase count *(3)*, pH determination, and yeast and mold count *(1)*. An organoleptic analysis was made on each sample upon receipt. Specific tests performed are detailed under each experiment described below.

The flavor score assigned to each sample (either raw or pasteurized) was determined by at least two persons according to procedures recommended by the American Dairy Science Association and modified for use in the Connecticut Milk Flavor Improvement Program *(6)*. Scores ranged from 40 to 30; the higher score indicating a sample with no off-flavor. In Experiments 1 through 4 unacceptable samples were those which had a flavor score of 35 or less. In Experiments 5-6 unacceptable samples were those which had attained a flavor score of 36 or less. Thus, in Experiments 5-6, keeping quality is defined as the number of days from pasteurization until a score of 36 was reached.

In Experiments 1 and 2 the relation of microbiological, chemical, and physical tests to the flavor score of pasteurized milk samples, all made at the time of collection, was examined. The collection, handling, and testing of these samples of whole milk obtained at retail outlets during 1969-70 has been described *(6)*. Experiment 1 had 1006 samples. Only a portion of these, 560, were also tested for acid degree value and represent Experiment 2.

Experiments 3 and 4 had the same objective as Experiments 1 and 2. An additional 1177 samples of whole milk from retail outlets collected during 1970-71 were treated and tested as in Experiments 1 and 2. Only 825 of these samples were tested for acid degree value and they comprise Experiment 4.

Experiment 5 was designed to determine if tests made on raw milk and on the same milk after pasteurization are related to the keeping quality of the pasteurized milk. The 38 samples of raw milk, each representing 12 to 20 producers, were collected from bulk tank trucks on four occasions during the months of June and July. Microbiological and organoleptic analyses were made as described above, both before and after pasteurization. All samples were laboratory pasteurized at 145 F for 30 min. The pasteurized samples were refrigerated (34-38 F) and the flavor tested on successive days until judged unacceptable (until a flavor score of 36 was reached). Flavor testing was discontinued after 42 days.

Experiment 6 had the same objective as Experiment 5 except that each sample represented an individual producer. The 77 samples of raw milk were obtained in the month of November at the processing plant and were treated as in Experiment 5 except that flavor testing was discontinued after 18 days.

Experiments 7 and 8 were made to test the relation of microbiological and chemical tests to the keeping quality of other perishable foods. The 30 samples of potato salad and 11 of coleslaw, all of various types, were collected as previously described *(5)*. After initial organoleptic, chemical, and microbiological tests were made, each sample was refrigerated (34-38 F) and subsequently tasted at least three times per week by a panel of two or more persons. Flavor was termed unacceptable if, in the opinion of the panel, it would be judged unacceptable by the consumer. Flavor testing was discontinued after 21 days.

All data were statistically analyzed using a regression program which screened the independent variables, singly or in combination, for their contribution to the observed variation in the dependent variables, flavor score or keeping quality in days. Professor G. M. Furnival, Yale University School of Forestry, kindly provided the computer program.

TABLE 1. RELATION OF LABORATORY ANALYSES AND MONTH OF SAMPLING TO FLAVOR SCORE OF PASTEURIZED MILK FROM RETAIL OUTLETS

Variables	R^2 Exp. 1 1969-70	Exp. 2 1969-70	Exp. 3 1970-71	Exp. 4 1970-71
Standard plate count	0.156**	0.152**	0.088**	0.094**
Oxidase count	0.124**	0.137**	0.082**	0.083**
Coliform count	0.034**	0.048**	0.048**	0.050**
Month of sampling	0.023**	0.037**	0.005	0.028**
Milk temperature	0.003	0.005	0.001	0.000
Acid degree value	—	0.032**	—	0.052**
All variables combined	0.163	0.188	0.097	0.153
Number of samples	1006	560[1]	1177	825[2]

**significant at 0.01% level
[1]Only samples with acid degree values in Experiment 1 used.
[2]Only samples with acid degree values in Experiment 3 used.

In Experiments 1-4 the independent variables, the results of the laboratory tests, month of sampling and temperature at time of collection, were examined for their relation to the dependent variable, flavor score. In Experiments 5-6 the independent variables, the results of the microbiological tests and flavor score of the same milk sample, before and after pasteurization were tested for their contribution to prediction of keeping quality, i.e., the number of days required for the pasteurized sample to attain a flavor score of 36 or less. In Experiments 7-8 the independent variables, the results of the chemical and microbiological tests, were examined for their relation to the dependent variable keeping quality, i.e., the number of days required to attain an unacceptable flavor.

RESULTS AND DISCUSSION

The consumer, on a daily basis, uses taste and smell (and sometimes color change) to judge how long milk and other perishable foods, kept under refrigeration, maintain an acceptable flavor. This, in effect, is the consumers' own test of keeping quality. Generally, food processors also assess keeping quality in the same way. What factors do affect flavor and hence consumer acceptability? Flavor can tell us when a product is no longer acceptable but, are there any tests made when the product is first received which could be used to predict keeping quality? In this report we define keeping quality as the number of days required to attain an unsatisfactory flavor. To best answer these two questions, the experiments were divided into two parts. The first part (with milk) examines the relation of currently used laboratory tests to flavor score. All tests, including flavor score were made at the beginning of the storage period. The second part (on milk and salad) relates tests, laboratory and organoleptic, made at the beginning of the storage period to the prediction of keeping quality, i.e., the number of days required for the product to attain an unsatisfactory flavor score.

Whole milk samples collected at retail outlets over a two-year period allowed us to determine whether the laboratory tests were correlated with flavor score (Experiments 1-4, Table 1). Because the sample size was great, many of the observed parameters were significantly correlated with flavor score. However, all parameters, including the microbiological and chemical tests, accounted for relatively little of the observed variation in flavor score. Combining all of the parameters into a single multiple regression accounted for only 10 to 19% of the total variation in flavor score. It is obvious that these standard tests have little bearing on milk flavor.

To determine what factors actually contribute to the prediction of keeping quality of milk, both bulk

TABLE 2. RELATION OF LABORATORY ANALYSES AND FLAVOR SCORES TO KEEPING QUALITY OF PASTEURIZED WHOLE MILK

Variables	R^2 Exp. 5	Exp. 6
Standard plate count		
Raw	0.002	0.007
Pasteurized	0.002	0.029
Oxidase count		
Raw	0.007	0.005
Pasteurized	0.084	0.019
Flavor score		
Raw	0.193**	0.048
Pasteurized	0.333**	0.408**
All variables combined	0.443	0.429
Number of samples	38	77

**Significant at 0.01% level

TABLE 3. RELATION OF LABORATORY ANALYSES WITH KEEPING QUALITY OF POTATO SALAD AND COLESLAW FROM RETAIL OUTLETS

Variables	R^2 Exp. 7 Potato salad	Exp. 8 Coleslaw
pH	0.222**	0.273
Titratable acidity	0.022	—
Standard plate count	0.006	0.287
Oxidase count	0.069	0.364*
Coliform count	0.008	0.174
Yeast and mold count	0.063	0.001
Number of samples	30	11
All variables combined	0.444	0.666

*Significant at 0.05% level; **Significant at 0.01% level.

and individual producer samples were examined in Experiments 5-6 (Table 2). Both of the bacteriological tests on the raw or pasteurized milk samples were poor predictors of the keeping quality of pasteurized milk, defined as the number of days required to attain a flavor score of 36 or less. On the other hand, the flavor score of the pasteurized milk determined immediately after pasteurization accounted for considerably more of the observed variation in keeping quality; 33 and 41% in Experiments 5 and 6, respectively. That is, the higher the initial flavor score the better the keeping quality. The flavor score of pasteurized milk was a much better predictor of keeping quality than any other single value measured and no combination of two or more tests significantly improved the prediction. Therefore, although the bacteriological counts may attest to the sanitation of both production and processing of milk, they are ineffective indicators of keeping quality. Whatever factors control keeping quality, they appear unrelated to the mere presence or absence of bacteria.

Analyses of potato salad and coleslaw permitted us to examine the relation of standard tests to keeping quality of perishable foods other than milk (Experiments 7-8, Table 3). Keeping quality of potato salad, the number of days required to attain an unacceptable flavor, was poorly predicted by bacteriological or other laboratory tests. Although there was a significant negative correlation of pH with keeping quality, pH accounted for only 22% of the observed variation, a small amount indeed. With coleslaw only the oxidase count was significantly correlated with keeping quality. As the count increased, keeping quality decreased. The oxidase test has been shown to be useful in assessing quality of refrigerated foods *(5)*. However, in this instance the small number of samples suggests caution in interpretation. Nevertheless, we see again that the total bacterial count of salad, like milk, is not a good predictor of keeping quality.

From the data in this report, it is obvious that the really important parameters determining keeping quality of milk have simply not been measured in the standard tests presently used. Because the results of standard laboratory tests were poorly related to milk flavor (Experiments 1-4), it is not surprising that they fail to predict keeping quality based on flavor (Experiments 5-6) and these results are further confirmed with other perishable foods (Experiments 7-8). Although bacteriological tests provide assurance of sanitary processing, we have shown that they have little relation to the more practical problem of predicting keeping quality. The flavor rating of milk, although subjective, presently appears to be the most useful predictor. Hankin and Anderson *(4)* have shown that only certain off-flavors in milk are correlated with the oxidase count. Perhaps the key to predicting keeping quality is not the total bacterial count but rather measurement of the biochemical activity of particular types of organisms present in the sample.

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