

A Survey of Milk Flavor and Quality¹

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ABSTRACT

Six brands of milk sold at Manhattan, Kansas, retail outlets were evaluated for quality on the day the milk was delivered, and again after being held in display cases for a week. Five of the six were in one gallon plastic jugs; the other one was in a 1/2 gallon carton. Only freshly delivered milks were analyzed for chemical composition. Both freshly delivered and stored samples were examined for bacteria, temperature, flavor and some volatile materials. The study continued five weeks, with fresh samples collected weekly.

Only 3 (all from one processor) of the 30 samples were below the 3.25% legal fat limit for Kansas (considering a 0.1% allowance for Babcock testing); they were 2.4, 3.1, and 3.15%. Temperatures of milks held in the display cabinets were generally lower than milk as delivered; only 2 of the 30 samples exceeded 4.5 C (40 F). Fourteen of the milks as delivered exceeded 4.5 C (40 F), but only one 8.5 C (47 F) exceeded the 7 C (45 F) legal limit.

Most bacterial counts (SPC) of freshly delivered milks were within legal limits, but three of the brands of week-old milks had consistently high counts, and most often were >300,000/ml. Psychrotroph counts of milk from the same 3 brands were consistently >300,000/ml after a week in the display case. Only two SPC and four psychrotroph counts from the other three brands exceeded 20,000/ml after one week in the display case.

All milks showed less than one coliform per ml. Flavors tended to deteriorate after one week storage except in two brands that remained good. One of the two was cartoned milk. Gas liquid chromatographic (GLC) analysis of milks showed increases in acetaldehyde, n-pentanal and n-hexanal, which paralleled increases in off-flavors, in milk held in the display cases. There was no apparent relationship between methyl sulfide concentration and tendency of milk to deteriorate in flavor during one week display-storage.

The shelf-life of fluid milk influences its acceptability. If market milk does not remain fresh 5 to 7 days in home refrigerators, a 20% loss in sales can be expected. If a poor-flavored milk is purchased by consumers three or more consecutive times, a loss of up to 50% in sales can be expected (8). In evaluating flavor and quality of fresh

and stored (sell-by-date) market milk, several investigators (2,4,15) reported that more than 50% of stored samples had objectionable off-flavors.

The effect of light on milk flavor is well-known. Dimick (9), who packaged pasteurized-homogenized milk in different types of containers and held them in a sliding door display case with 100 ft-c fluorescent light exposure, found that fiberboard containers protected from light-activated flavor up to 48 h compared with only 12 h by plastic and glass containers. Barnard (3) reported that 12.7% of the retail milk samples in paperboard had oxidized off-flavor and 86.1% of those in blow-molded plastic containers were oxidized. Exposure of milk to light of wavelengths below 500 nm causes two distinct off-flavors to develop rapidly, usually in a few hours: a typical oxidized flavor and one due to sulphur compounds (10). Hoskin and Dimick (11) found that blocking the transmission of the 380-480 nm wavelength region of light spectrum protected against the light-induced off-flavor.

Bacterial growth in milk also induces off-flavors. Ledford et al. (13) found that as bacterial population increased in milk, flavor scores decreased with log SPC vs. flavor score giving correlations of -0.80 for a trained panel and -0.73 for a consumer panel. Low temperature retards bacterial growth and should increase shelf-life of milk. Ikurior (12) reported that pasteurized milk refrigerated at 4 C for 12 days retained acceptable nutritive quality.

Gallon milk containers are popular, accounting for 53% of the fluid milk sold in 1979 (14). To understand the quality and flavor of typical milk marketed in Manhattan, KS, we evaluated six brands (five of them in gallon-plastic jugs, one in a 1/2 gallon carton) by bacteria counts, temperatures, flavor and some volatile materials in milk as delivered to the retailer, and on "companion" samples (from same delivery cases) held in display cases one week. Chemical compositions were determined only on freshly delivered milks. Test results of milk from a particular milk source (retailer) were sent to the manager of that source with a non-technical interpretation.

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MATERIALS AND METHODS

Milk sample collection

Six brands of milk, each from a different processor, marketed in Manhattan, KS, in April and May, 1980, were collected weekly over a 5-week period and coded A, B, C, D, E and F. Five of the samples in gallon jugs and one (sample D) in a 1/2 gallon carton were collected on the day delivered to the retail outlets. When the fresh sample was taken, a "companion" sample adjacent to it was tagged *not for sale* and left in the display case one week. Except for chemical analyses, all samples were tested fresh and after one-week storage. Chemical analyses were performed only on freshly delivered samples.

Gross composition

Chemical composition of the milks was determined as follows: fat by the Babcock method, protein by dye binding (16) and total solids gravimetrically as weight remaining after 4 h in an oven at 100 C.

Bacteriological analyses

Mesophiles (SPC), psychrotrophs and coliforms were determined by standard methods (1).

Temperature measurement

Temperatures of the milk samples were measured as close to the delivery time as possible (always within 2 h) and on "companion" milks after being held in the display cases for one week. A -10 to 110 C laboratory thermometer with 1-C division was used for temperature measurements.

Flavor test

Six judges evaluated the milks each week on the afternoon of the day after the samples were collected and scored them on a seven-point hedonic scale, with 1 denoting "like very much", 4 "neither like nor dislike" and 7 "dislike very much." Specific criticisms were reported by judges so inclined.

Volatile materials in milk

Milk was steam distilled in micro-Kjeldahl equipment, and the headspace vapors of the distillate were analyzed by gas liquid chromatography (GLC). Sampling procedures, GLC operating conditions and measurement of volatile materials, acetaldehyde, methyl sulfide, pentanal and hexanal were described by Bassette and Ward (6). GLC peaks were identified by using a combination of subtractive techniques (5) and peak retention times.

RESULTS AND DISCUSSION

Table 1 shows the compositions of fat, protein, and total solids of all the brands of milk. Except for sample C on weeks 3, 4 and 5, the milks were within legal limits for fat. Compositions of proteins and total solids were normal.

Bacterial counts, expressed as log₁₀ CFU/ml (Figs. 1 and 2) of the week-old samples, for both mesophiles

TABLE 1. *Composition of six milks collected from four Manhattan, Kansas retail outlets at weekly intervals.*

Assay	Week				
	1	2	3	4	5
Brand A					
Fat (%)	3.2	3.25	3.3	3.35	3.35
Protein (%)	3.19	3.17	3.14	3.10	3.11
Total solids (%)	11.72	11.96	11.84	11.93	11.82
Brand B					
Fat (%)	3.3	3.2	3.45	3.35	3.4
Protein (%)	3.15	3.18	3.25	3.04	3.15
Total solids (%)	11.68	11.84	11.86	11.54	11.78
Brand C					
Fat (%)	3.28	3.27	3.10	3.15	2.4
Protein (%)	3.18	3.11	3.14	3.02	3.03
Total solids (%)	11.64	11.68	11.42	11.33	10.72
Brand D					
Fat (%)	3.4	3.25	3.35	3.25	3.35
Protein (%)	3.25	3.23	3.26	3.18	3.28
Total solids (%)	11.96	11.98	12.08	11.82	11.84
Brand E					
Fat (%)	3.2	3.45	3.6	3.55	3.45
Protein (%)	3.18	3.25	3.24	3.13	3.18
Total solids (%)	12.08	12.04	12.15	11.86	11.86
Brand F					
Fat (%)	3.2	3.2	3.25	3.2	3.2
Protein (%)	3.21	3.18	3.14	3.08	3.51
Total solids (%)	11.67	11.98	11.76	11.73	11.68

(SPC) and psychrotrophs increased considerably. The asterisks above the bar on the figure mean the count exceeded 300,000/ml (TNTC). Most counts of freshly delivered milks were within legal limits of 20,000/ml SPC. But most counts of week-old milks from brands A,

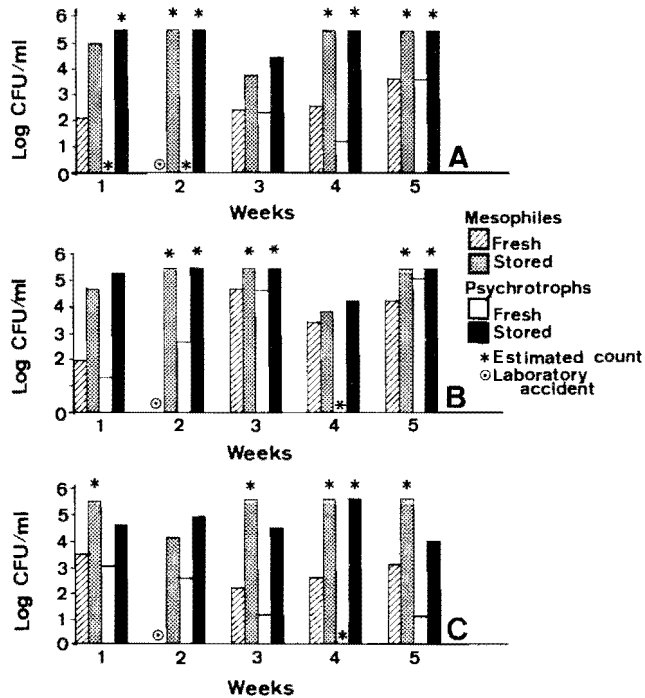


Figure 1. Histograms representing mesophile (SPC) and psychrotroph counts of three fresh and week-old milks, brands A, B and C, collected from Manhattan, KS retail outlets for a five week period.

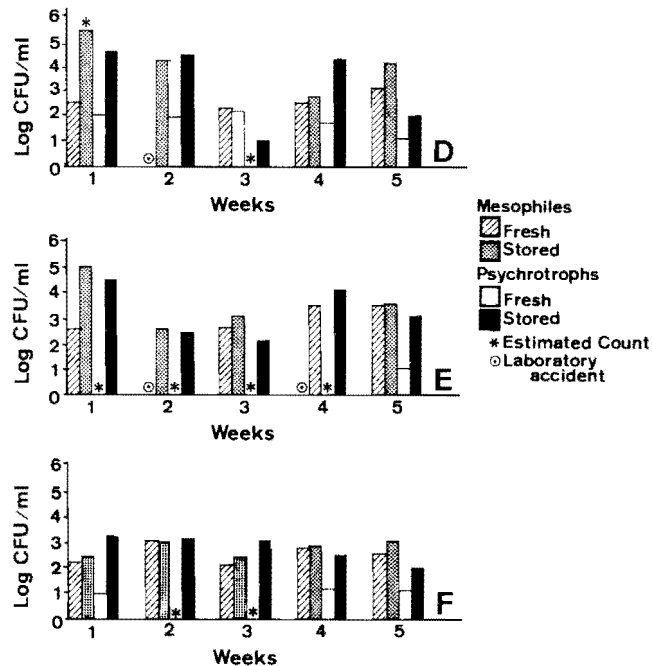


Figure 2. Histograms representing mesophile (SPC) and psychrotroph counts of three fresh and week-old milks, brands D, E and F, collected from Manhattan, KS retail outlets for a five week period.

B and C (Fig. 1) exceeded legal limits (most >300,000 SPC/ml and many of the psychrotroph counts also >300,000/ml). Brands D, E and F (Fig. 2) were considerably better with only a few SPC exceeding the legal limits of 20,000/ml after one week's storage. All milk samples showed <1 coliform/ml. Psychrotroph counts were similar to SPC's and in some instances exceeded SPC's. Due to a laboratory accident, no results were reported for one series of SPC for the 2nd week of freshly delivered samples.

Temperatures of milk as delivered and in the display cases varied from 2-8.5 C (36-47 F). Most were less than 4.5 C (40 F). However, temperatures in the display cabinets were generally lower than delivery temperatures. Only 2 week-old milk samples exceeded 4.5 C (40 F) being 5.5 C and 6 C (42 F and 43 F), but 14 freshly delivered milks exceeded 4.5 C (40 F) with one of the 14 being over the legal limit of 7 C (45 F). During April and May outside temperatures were moderate.

Figure 3 represents the results of the flavor analyses; shorter bars indicate better flavor than longer bars. Flavors of milk tended to deteriorate after one week storage except for sample C, which improved during storage in 3 of the 5 weeks and did not differ on the 5th week. The flavor of milk D, which was in a carton rather than a plastic jug, remained good after one week's storage.

Volatile carbonyl compounds, acetaldehyde, n-pentanal and n-hexanal, have been shown to be related to oxidized and fluorescent light-induced flavors in milk (7). From our GLC analyses, (Figs. 4, 5 and 6) changes in concentrations of these carbonyl compounds during storage were related to changes in flavor. The flavor of sample C improved in 4 of the 5 weeks (Fig. 3) and showed little or no concurrent increase in the carbonyl compounds (Fig. 4). On the other hand, sample E with relatively large increases in these carbonyl compounds,

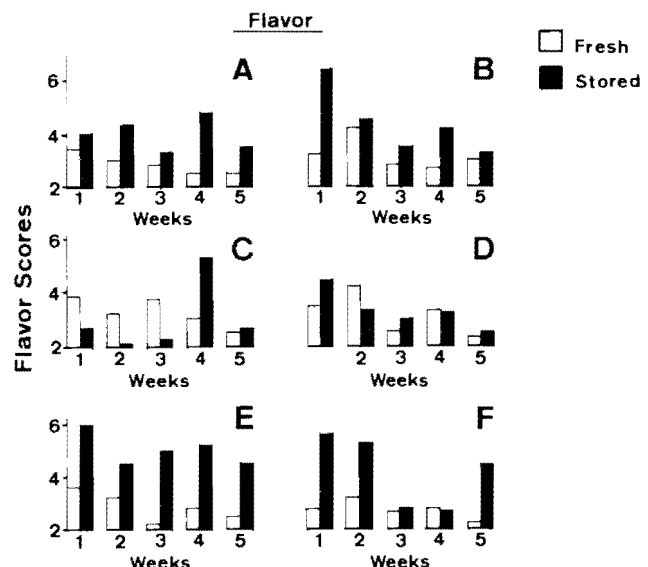


Figure 3. Histograms representing flavor scores of fresh and stored milk. Scale: 1 = like very much; 7 = dislike very much.

deteriorated considerably in flavor (Figs. 3 and 6). Changes in concentration of methyl sulfide did not appear to be related to flavor deterioration. There was no evidence that deterioration in flavor was related to bacteria. Samples from source C which had the best flavor after one week storage, had high bacterial counts.

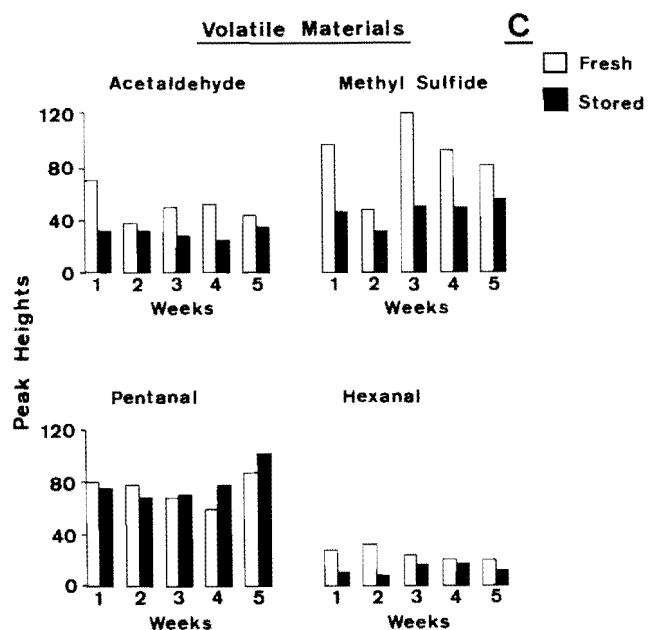


Figure 4. Histograms representing concentrations of four key chemical compounds in milk C that are possible contributors to flavor. Peak heights are % full scale recorder deflection \times attenuation factors.

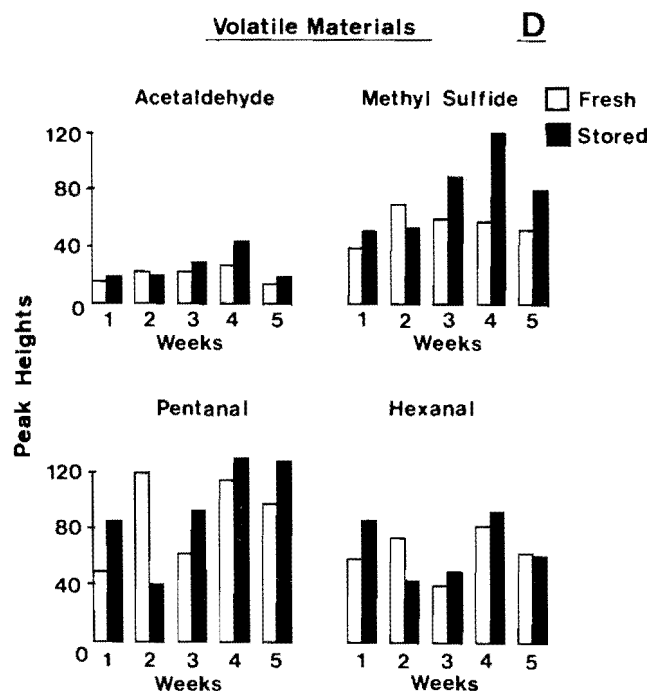


Figure 5. Histograms representing concentrations of four key chemical compounds in milk D that are possible contributors to flavor. Peak heights are % full scale recorder deflection \times attenuation factors.

Milk from source E, which consistently had the poorest flavor after storage, had quite low bacterial counts.

Evidence from changes in volatile materials during one week storage suggests that deterioration in flavor stems at least in part from light-induced flavors in display cases. These changes are similar to ones observed in controlled studies of the effects of fluorescent light and flavor (7,9). Although flavor scores were not extremely bad, they certainly could contribute to variation in milk sales. Comparing flavor scores and volatile materials in milk D (Figs. 3 and 5) with the other milks shows that milk cartons afford protection from light-induced off-flavors.

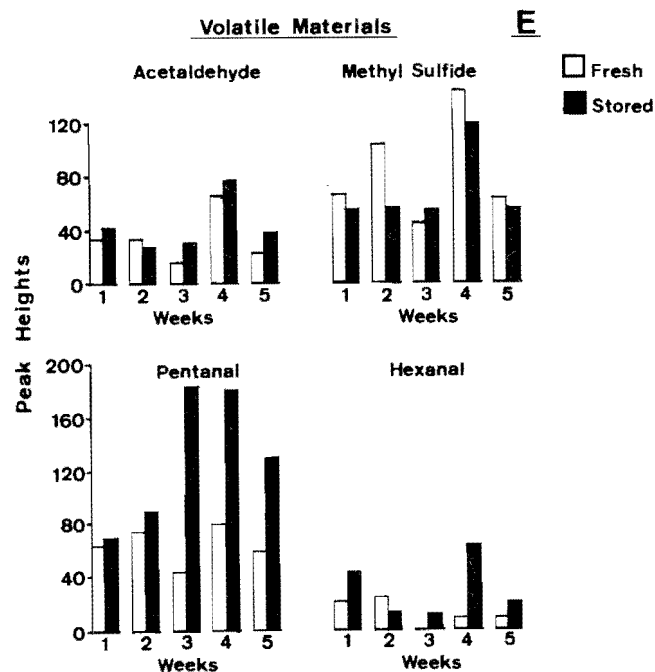


Figure 6. Histograms representing concentrations of four key chemical compounds in milk E that are possible contributors to flavor. Peak heights are % full scale recorder deflection \times attenuation factors.

CONCLUSIONS

Only three of 30 milk samples evaluated did not meet legal fat standards, and all three were from one processor. Temperatures of milks as delivered were generally higher than those in the display cases. But storage temperatures and bacterial counts were not closely related.

High bacterial counts of milk after storage were characteristic of certain processors' milk as were low-count milks. Increases of n-pentanal during storage tended to implicate light-induced defects that paralleled flavor deterioration. When flavor did not deteriorate in storage, the increase of volatile materials was slight or nonexistent. There was no apparent relationship between bacterial counts and flavor deterioration of this milk during one week of storage.

were obtained throughout the investigation. Advantages of this method over others are (a) ease and simplicity, (b) diameters of plaques situated at the periphery of a plate are easily measured, (c) even if the agar overlay is irregular, error is minimal, and (d) rapidity.

The procedure described in this paper could also be used successfully to measure the size of bacterial colonies.

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