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Effects of Carton Material and Storage Temperature on the Flavor of UHT-Sterilized Milk[1]

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ABSTRACT

Ultra-high-temperature sterilized milk packaged in aluminum foil-lined or plain polyethylene-lined cartons was stored 1.5 months at 4 C in the dark or 22 C under fluorescent light. Five trained judges found milk at 4 C was not as stale and thus had a more acceptable flavor than milk at 22 C. Flavor of milk in aluminum foil-lined cartons was not as good as freshly pasteurized milk, but superior to milk in polyethylene-lined cartons. Increases in off-flavor intensity paralleled increases in concentrations of n-pentanal and an unidentified neutral volatile compound. A 24-member, untrained consumer taste-panel preferred the flavor of freshly pasteurized milk to 3-month-old commercial or 6-month-old experimental ultra-high-temperature sterilized milks in aluminum foil-lined cartons, which in turn were preferred over 6-month-old experimental ultra-high-temperature sterilized milk in polyethylene-lined cartons.

Ultra-high-temperature (UHT) sterilized milk has made strong inroads into European fluid milk markets (*7*), and it is gaining popularity in Canada (*1*). In Italy and Germany, an estimated 50% of the fluid milk consumed in 1976 was UHT (*7*). The reluctance of American dairymen to follow the Europeans and Canadians stems from concern that U.S. consumers will not accept the flavor of UHT milk. The problem likely to limit acceptance of UHT milk in the U.S. is the off-flavor it develops when stored for prolonged periods. Packaging the UHT milk in aluminum foil-lined cartons (AC) rather than polyethylene-lined cartons (PC) (*3,6*) and storing at refrigeration temperatures (*2,4,5,8*) helped control the rate that off-flavor developed. However, effects of combining different storage temperatures and different types of carton materials (with and without aluminum foil-lining) on the flavor of UHT milk have not been determined.

This research was to establish effects of carton material and simulated commercial storage conditions on the flavor of UHT milk and to relate changes in neutral volatile compounds in stored milk to the changes.

MATERIALS AND METHODS

The cheapest and most practical method of storing and displaying UHT milk in grocery stores would be in PC at room temperature under fluorescent light (approximately 2000 1 ×). However, "ideal" storage conditions most likely involve refrigerating AC milk in the dark. We compared properties of UHT milk stored under "ideal" conditions with the same milk under simulated grocery-storage conditions.

Three batches of raw milk were UHT-sterilized (140 C for 3.5 sec) and each was packaged aseptically in Pure Pak AC or PC as described previously (*6*). Half the cartons were stored at 22 ± 2 C and exposed to 2150 1 × (200 ft candles) of cool-white fluorescent light; the other half, at 4 ± 2 C in the dark; both light exposure and storage temperature are known to affect chemical and flavor changes in stored milk. Reference milk (R) was freshly pasteurized at 77 C for 15 sec either on the day of testing or the day before. Limitations in capacity to handle samples necessitated testing the 1½-month-old milks at different times (42 days at 22 C and 50 days at 4 C). Since different reference milks were required for the 42-day (22 C) and 50-day (4 C) samples, there are two entries for R-milk in Table 1. In Fig. 1, those bars designated "Untreated a" depict results for freshly pasteurized milks tasted and compared to UHT milks stored at 22 C. Those designated as "Untreated b" represent freshly pasteurized milks compared to UHT milks stored at 4 C.

Microbial, organoleptic and gas chromatographic (GLC) analyses were conducted as described by Mehta and Bassette (*6*). Five trained judges used a modification of the National Collegiate Student Judging Contest procedure to assign flavor scores to the milks; stale and cooked flavor intensities were scored on a scale of 0 = none to 9 = pronounced (*6*). GLC was used to quantitify neutral volatile compounds (*6*). The model used for variance analysis of the randomized complete block design was:

$$Y_{tb} = \mu + a_t + \beta_b + E_{tb}$$

Y_{tb} = response (e.g., stale flavor intensity, concentration of hexanal, etc.)

μ = mean

a_t = treatment effects (AC 4C = AC stored at 4 C; AC 22C = AC stored at 22 C; PC 4C = PC stored at 4 C; PC 22C = PC stored at 22 C; R 4C = reference milk examined with UHT milk at 4 C; and R 22C = reference milk examined with UHT milk at 22 C)

β_b = block effects (blocks 1-3)

E_{tb} = random experimental error, as a deviation from the mean for the t^{th} treatment of the b^{th} block. $E \sim N(0, \sigma^2)$ where σ^2 is estimated by error mean square.

In the second phase of the study, a taste-panel of untrained consumers compared the flavors of the last batch of our AC- and PC-milks to those of a Canadian commercial UHT milk and a freshly-pasteurized reference milk. The Canadian milk contained 2% milkfat, was sterilized by an indirect process and aseptically packaged in Tetra Brik AC carton. When presented to the panel, it had been stored at room temperature 90 days. Our UHT experimental milks were stored for 170 days at room temperature. The 24-member consumer taste panel consisted of almost equal numbers of men and women (students and faculty at Kansas State University). Panel members were asked to grade each coded sample of cold milk (4 C) as: like extremely, like moderately, like slightly, neither like nor dislike, dislike slightly, dislike moderately, or dislike extremely. Milks judged by the consumer panel were tasted cold, whereas the previous samples were analyzed at room temperature. The responses were rated on a scale of 1 = like extremely to 7 = dislike extremely and analyzed for variance with the same model as in the first phase of the study. Block

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effects were represented by panelists, and treatments were R = reference milk, AC = 170-day-old experimental AC milk, PC = 170-day-old experimental PC milk and Commercial = 90-day-old commercial Canadian UHT milk.

RESULTS AND DISCUSSION

Microbiological results confirmed that all UHT milks were sterile. Organoleptic and GLC results of the first phase are presented in Table 1 and Fig. 1. Staleness appeared to be a major contributor to flavor of stored UHT milks. As expected, freshly pasteurized, untreated reference milks were superior in flavor to the UHT milks. Flavor scores and stale intensities indicated that among UHT milks, those stored at 22 C in PC had the least desirable flavor; it was beneficial to refrigerate the PC milks. The two AC-milks (4 and 22 C) and the PC-milk stored at 4 C had the same intensity of stale off-flavor; however, overall flavor scores of the AC-milks stored at 4 C were better than those of the refrigerated PC-milk. The absence of a statistical difference (P = .05) among cooked flavor intensities in milk stored 1½ months may be misleading because significant differences were observed in cooked flavor intensities at the 10% probability level. Average mean differences among cooked flavors in Table 1 are similar to those among stale intensity scores.

Statistical differences in the GLC data were observed only for concentrations on n-pentanal and an unidentified compound with a retention time of 28 min. These increases parallelled deterioration in flavor and the increase in intensity of a stale off-flavor. In a companion study on sterile milk (*6*), we observed statistically higher concentrations of propanal, n-pentanal, a 13.8-min peak, and n-hexanal in milk stored at room temperature in plastic-wrapped polyethylene-lined pint cartons. In the current study, propanal, n-pentanal, the 13.8-min peak, n-hexanal and the 28-min peak were all higher in PC

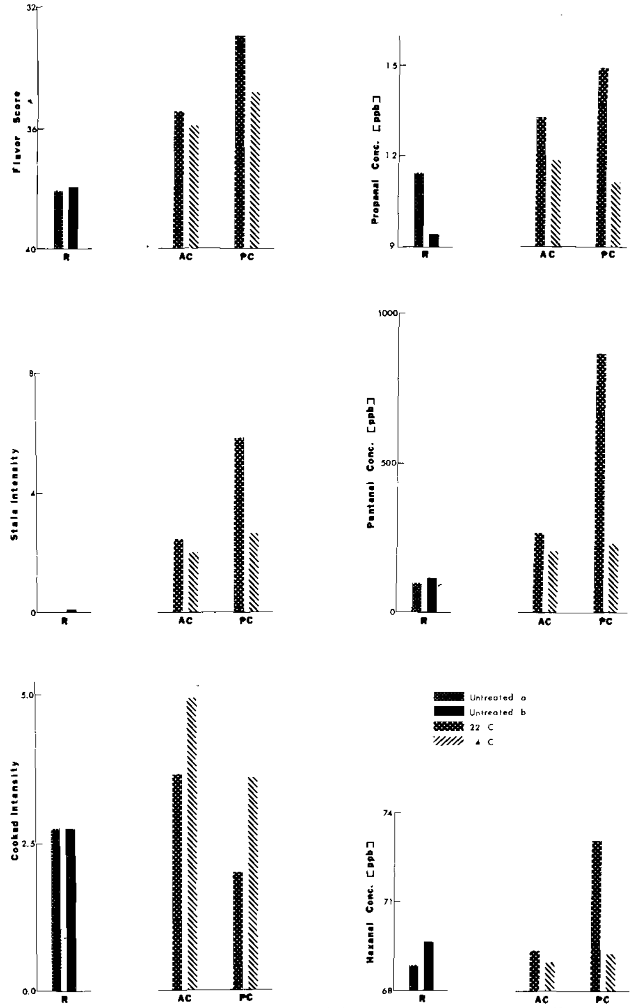

Figure 1. *Changes in reference (R) milks and UHT milks from cartons (AC = Aluminum foil-lined and PC = polyethylene-lined) half exposed to fluorescent light at 22 C for 42 days and half stored in the dark at 4 C for 50 days. Untreated R milks (a) were freshly pasteurized and evaluated with 22 C milk samples and R milks (b) with 4 C samples.*

TABLE 1. *Comparison of UHT milks stored at 4 and 22 C for one and one half months.*

Item	Organoleptic analyses: Flavor score	Stale flavor	Cooked flavor	Component and/or its retention time on the chromatogram: 3.1[1] min methyl sulfide	3.6[1] min propanal	9.5[1] min n-pentanal	13.8[2] min	16.6[1] min n-hexanal	28.0[2] min
				Probabilities					
Treatments[3]	.0000	.0001	.0684	.1675	.5744	.0053	.7475	.3641	.0110
Blocks[3]	.1652	.7802	.6015	.1902	.2928	.4406	.4106	.0953	.3242
Treatments[4]				*Means*[5]					
AC 4C	35.92a	2.00a	4.92a (x)	24.43a	11.9a	207a	23a	68.95a	74ab
AC 22C	35.50ab	2.43a	3.63a (y)	25.46a	13.3a	268a	34a	69.37a	124a
PC 4C	34.84b	2.63a	3.58a (y)	23.76a	11.2a	229a	53a	69.26a	47b
PC 22C	33.02	5.81	1.98a (z)	24.29a	14.9a	869	82a	73.06a	125a
R 4C	37.96c	0.04b	2.75a (yz)	25.14a	9.4a	114a	20a	69.63a	0b
R 22C	38.22c	0.00b	2.76a (yz)	26.31a	11.5a	96a	38a	68.82a	0b

[1]Concentrations in ppb calculated from the regression equation of the standard curve.

[2]Peak heights relative to the peak of 1 ppm acetone = 1000 units (% full-scale deflection peak height × attenuation).

[3]Degrees of freedom for treatments = 5, for blocks = 2.

[4]AC 4C = aluminum foil-lined carton at 4 C, AC 22C = aluminum foil-lined carton at 22 C, PC 4C = polyethylene-lined carton at 4 C, PC 22 = polyethylene-lined carton at 22 C, R 4C = reference milk examined with UHT milk at 4 C, and R 22 C = reference milk examined with UHT milk at 22 C.

[5]Means not significantly different at 0.05 are indicated with a common letter of the alphabet (a,b,c). For cooked flavor, means not significantly different at 0.10 are indicated with a common letter of the alphabet in brackets (x,y,z).

milk at 22 C (see Table 1) but only n-pentanal and the 28-min peak-component were statistically different. The concentration of methyl sulfide in this milk was not affected by carton material (see Table 1). Refrigerating both AC and PC milks resulted in lowered concentrations of all the observed compounds.

Results of the 24-member consumer taste panel (Table 2) and of our 5-member experienced panel (organoleptic analysis, Table 1) agree. The flavor acceptability of the two AC (our experimental and the Canadian) milks was equal; however, both had better flavors than the milk in PC. Freshly pasteurized milk had the best flavor. It is significant that when the average scores were rounded to the nearest whole number, average comment of the consumer panel was "like moderately" for the freshly pasteurized milk, "neither like or dislike" AC milks and "dislike slightly" the PC milk, which indicates that American consumers may accept the flavor of UHT milk. But a more comprehensive study needs to be conducted to confirm that.

TABLE 2. *Probabilities and separation of means for consumer taste-panel scores*

Item	Scores
	Probabilities
Treatments	.0000
Panelists	.0011
Treatments[2]	*Means*[1]
R	2.000
AC	4.250a
Commercial (Canadian)	4.333a
PC	5.458

[1]Means not significantly different at 0.05 are indicated with a common letter of the alphabet. Scores are on a 7-point scale with 1 = like extremely, 2 = like moderately, 3 = like slightly, 4 = neither like nor dislike, 5 = dislike slightly, 6 = dislike moderately, and 7 = dislike extremely.

[2]R = reference milk, AC = Al foil lined cartons, and PC = plain polyethlene-lined cartons.

CONCLUSION

Refrigerating either AC or PC milk and storing it in the dark helped limit off-flavor development during 1½ months of storage; according to a 5-member trained panel, AC milk was superior to PC milk in maintaining acceptable flavor. Increases in off-flavor were accompanied by increases of several compounds, but the increases of only n-pentanal and an unidentified component (28-min peak) were statistically significant.

A consumer panel found that AC milks (3-month-old commercial and 6-month-old experimental) were superior in flavor to 6-month-old experimental PC milk. Freshly pasteurized milk was preferred over all the UHT milks.

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REFERENCES

1. Anon. 1979. UHT milk successful in Canada. Amer. Dairy Rev. 41:22-25.
2. Ashton, T. R. 1965. Practical experiences: The processing and aseptic packaging of sterile milk in the United Kingdom. J. Soc. Dairy Technol. 18:65-83.
3. Flückiger, E. 1972. Packaging of Uperised milk: a comparison between polyethylene-coated cartons with and without aluminum foil. Milk Ind. 70:(4);17-20.
4. Hansen, A. P., L. G. Turner, and V. A. Jones. 1974. Effect of ultra-high-temperature steam injection on flavor acceptability of whole and fortified skim milks. J. Dairy Sci. 57:280-284.
5. Kirk, J. R., T. I. Hedrick, and C. M. Stine. 1967. Gas chromatographic study of the flavor deterioration in high-temperature short-time fluid sterile milk. J. Dairy Sci. 50:951.
6. Mehta, R. S., and R. Bassette. 1978. Organoleptic, chemical and microbiological changes in ultra-high-temperature sterilized milk stored at room temperature for 6 weeks. J. Food Prot. 41:806-810.
7. Regez, W. 1977. The future of UHT milk and milk products in Europe. J. Soc. Dairy Technol. 30:164-168.
8. Zadow, J. G., and R. Birtwistle. 1973. The effect of dissolved oxygen on the changes occurring in the flavor of ultra-high-temperature milk during storage. J. Dairy Res. 40:169-177.