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Effect of Pasteurization Tempertaure on Susceptibility of Milk to Light-Induced Flavor

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ABSTRACT

Milk pasteurized at 73, 80 and 90°C for 16.2 s and homogenized than exposed to 50-foot-candle intensity of fluorescent light in clear glass bottles was compared for flavor and concentrations of acetaldehyde, propanal, n-pentanal and n-hexanal with similarly treated milk in foil-covered glass bottles. Flavor (hedonic scaling by five judges) was influenced by pasteurization temperatures, storage time and exposure to light. Milk pasteurized at 73°C and held in foil-covered bottles through 10 d at 2°C had the most acceptable flavor. However, when milk was pasteurized at this temperature but exposed to light, it had the least desirable flavor during 10 d. At 14 d, flavor score of the 73°C, unexposed milk declined, and that of the irradiated milk increased so that both were almost identical. At pasteurization temperatures of 80 and 90°C, the adverse effect of irradiation was either reduced or eliminated and the incidence of oxidized flavor lessened. Poorer flavor at these pasteurization temperatures from unexposed milks reflected greater intensities of cooked flavor. Concentrations of acetaldehyde, propanal, n-pentanal and n-hexanal increased much more in the light-treated samples than those kept in the dark. However, high-heat treatment (90°C) lessened those increases in propanal and n-hexanal but enhanced increases in acetaldehyde and n-pentanal.

A survey of the quality of six different brands of fresh and 1-wk-old milk from retail outlets in the Manhattan, KS area over a 5-wk period yielded unexpected results. Although flavors of these milk samples (five in plastic gallon jugs and one in a half-gallon Pure-Pak carton) tended to deteriorate when held 1 wk in store display cases under fluorescent light, one of the milk samples in a plastic jug actually improved in flavor in 3 of the 5 wk. Although the milk in the carton did not improve in flavor, it did not deteriorate appreciably as did four of the milk samples in plastic jugs (*4*).

A peculiarity in the brand of milk that consistently improved in flavor was a pronounced cooked flavor in the fresh sample. A GLC study of some of the volatile materials showed that the milk that improved had, in general, a reduction in the concentration of the volatile carbonyl compounds, n-pentanal and n-hexanal. These particular carbonyl compounds reflect light-activated and oxidized flavor development in milk. Except for the milk in the carton, the concentration of n-pentanal and n-hexanal in the other milk samples tended to increase during 1 wk under fluorescent light. This observation prompted us to study the effect of higher-than-normal pasteurization temperature on the susceptibility of milk to light-induced off-flavors.

It is readily apparent that some conflicting results of early research reported in reviews on light-induced changes in milk by Greenbank (*6*) and Stull (*9*) occurred because there are two principal mechanisms involved and two distinct types of flavors that result. One mechanism involves the serum portion of milk being acted upon to produce the so-called ''light-activated'' flavor and the other involves the lipids and is responsible for the ''oxidized flavor''. Each of these has been described with unique terms, such as ''burnt feather'', ''burnt protein'' and ''scorched'' for the light-activated flavor and ''tallowy'' for the oxidized flavor (*9*). It would appear that the differences in these flavors would enable analysts to distinguish them. However, commercial milk processing conditions influence these two mechanisms in different ways. Consequently researchers who alter these processing conditions may enhance or inhibit light-induced changes. The resulting flavor is a blend of the activated and oxidized flavor.

Dahle (*5*) reported that the oxidized flavor, when compared with raw milk, was intensified by pasteurization at 63°C (145°F) for 30 min, but eliminated at 76 °C (170°F) for 30 min. Greenbank (*6*) concluded that the thermal inhibition of oxidized flavor occurred by lowering the oxidation-reduction potential. Stamberg and Theophilus (*8*) found raw milk to be more susceptible to light-activated flavor development than either pasteurized or homogenized milk. Weinstein and Trout (*10*) found that heating milk to 79.5°C (175°F) for 5 min did not retard the development of light-induced flavors. On the other hand, Smith and MacLeod (*7*) reported that the loss of ascorbic acid and degree of oxidized flavor development of milk exposed to 20 ft-c of incandescent light decreased with increasing pasteurization temperature.

Although homogenization was found to inhibit oxidized flavors in milk (*9*), Dahle (*5*) reported that it affords no protection to milk that is later exposed to light. Many others have found that homogenization actually enhances development of the light-activated flavor (*9*). Bassette (*2*) showed that changes in concentrations of n-pentanal and n-hexanal in milk were greatest in pasteurized-homogenized milk, followed by laboratory pasteurized milk (not homogenized) and least in raw milk.

The purpose of this research was to test the hypothesis that higher than normal pasteurization temperature will render milk more resistant to light-induced off-flavor development.

MATERIALS AND METHODS

Preparation of milk samples

Fresh raw milk from the Kansas State University dairy herd was pasteurized in the University dairy plant at 73, 80 and 90°C, each for 16.2 s. Samples at each temperature were collected manually from a three-way valve at the outlet tube of the high-temperature short-time (HTST) press. One set of samples at each temperature was collected in sterile clear pint glass milk bottles. A second set was collected in aluminum foil-covered, sterile pint glass milk bottles that were completely opaque to light. All of these milks, capped with aluminum foil, were placed in the milk cooler at 2°C. Bottles were positioned under a 40 W Delux Cool White fluorescent light so the intensity of light at the surface of milk in the clear glass bottles was 50 ft-c. Milk samples were maintained under those conditions until examined. The testing periods were 3, 7, 10 and 14 d. One of the clear glass bottles (light-exposed) and one of the foil-covered sample bottles were removed from the cooler at each test period and examined for bacteria counts, flavor, and for some volatile compounds that are known to be associated with oxidized or light-activated flavors.

Bacteriological analyses

Samples of milk at each experimental condition were analyzed for standard plate and psychrotroph counts at each testing period according to *Standard Methods for the Examination of Dairy Products* (*1*). Milk from these bottles was then used for organoleptic and volatile materials analyses.

Sensory evaluation

Flavors of the milk samples were determined by five experienced judges and flavor scores registered on a 10-point hedonic scale, with 10 representing superior flavor. In addition, judges were asked to report any defects they could recognize. Tempered milk samples were transferred to Erlenmeyer flasks that were randomly coded and evaluated for flavor by panelists.

Changes in concentration of volatile materials

At each testing period, milk samples of each treatment were analyzed in duplicate for volatile materials commonly associated with light-activated and oxidized flavor. Head space gas sampling and GLC analysis of the steam distillates were done by the method of Bassette and Ward (*3*). Changes in the concentrations of acetaldehyde, propanal, n-pentanal and n-hexanal were followed in terms of changing peak heights. The identity of these peaks had been established from previous research (*2*).

RESULTS AND DISCUSSION

Standard plate and psychrotroph counts for the raw milk were 2.5×10^3 and 1.2×10^2 colony-forming units (CFU)/ml, respectively. Standard plate counts of the pasteurized milk samples from 0 through 14 d were extremely low. All milk samples had <30 CFU/ml except for the 0-d, 73°C pasteurized milk sample which had 33 CFU/ml. The psychrotroph counts of the pasteurized milks remained non-detectable throughout the 14-d sampling period for all treatments.

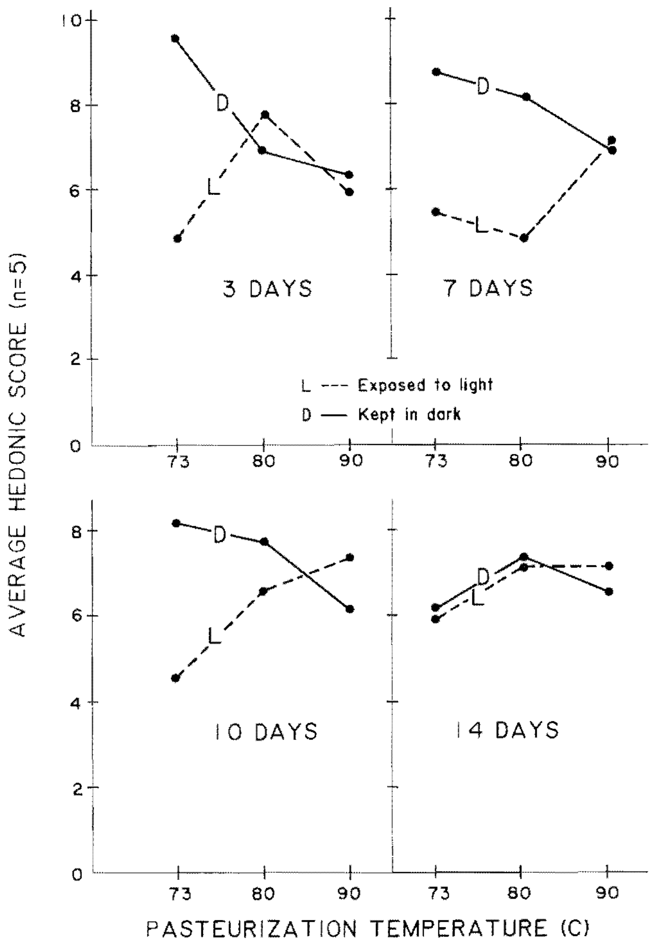

Figure 1. *Average hedonic responses to flavor of milk pasteurized at 73, 80 and 90°C, stored at 2°C under fluorescent light for 14 d.*

Changes in flavor scores of the milks exposed to light, as well as those in opaque bottles, at each of the three pasteurization temperatures are shown in Fig. 1. The greatest difference in flavor scores of the "light" and "dark" milk was from milk pasteurized at 73°C and stored 3 d. Milk in the foil-covered bottle at that time scored close to a superior rating, whereas the score of the light-exposed sample fell into the undesirable range. As pasteurization temperatures were increased, the differences at 3-d storage became small. At 7-d storage, the improvement in flavor of light-treated samples of the 80°C milk was lost, and there was a decrease in the flavor score. However, the sample kept in the dark improved, probably as the cooked flavor dissipated.

Both "light" and "dark" milk samples pasteurized at 90°C had almost identical scores throughout the 14-d storage period. These flavor changes at each storage period in relation to the three pasteurization temperatures are shown in Fig. 1.

Considering the treatments employed, panelists recorded observations regarding cooked and oxidized flavors. These are presented in Table 1. Results are expressed in terms of predominant criticisms. The predominant criticism for milk samples held in the dark throughout the 14-d period was cooked. Predominance of "oxidized"flavor criticism for

TABLE 1. *Percentage of the predominant flavor criticism of the experimental milk samples.*

Temperature (°C)	Treatment	Percentage of predominant criticism[a,b]			
		3 d	7 d	10 d	14 d
73	Light	80% ox.	100% ox.	80% ox.	60% ox.
	Dark	60% no crit.	40% no crit.	60% cook.	40% cook.
80	Light	60% cook.	80% ox.	80% ox.	80% ox.
	Dark	80% cook.	80% cook.	100% cook.	80% cook.
90	Light	80% cook.	100% cook.	80% cook.	60% ox.
	Dark	100% cook.	100% cook.	100% cook.	80% cook.

[a] ox. = oxidized; no crit. = no criticism; cook. = cooked.
[b] n = 5.

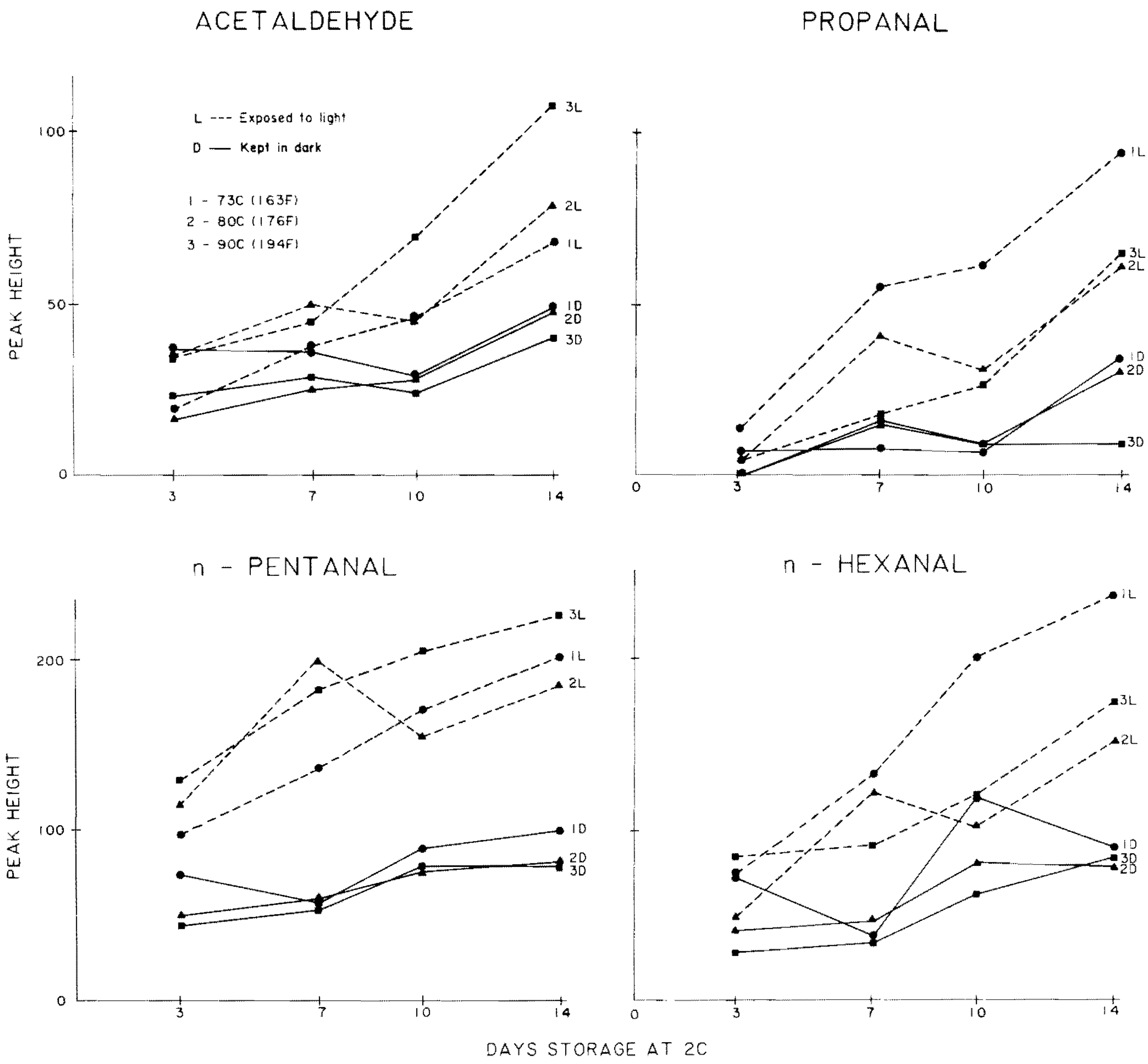

Figure 2. *Effect of fluorescent light and storage on production of acetaldehyde, propanal, n-pentanal and n-hexanal in experimental milk samples.*

milk samples exposed to light decreased as the pasteurization temperature was increased from 73 to 90°C. This criticism was the predominant one in milk pasteurized at 90°C after only 14 d under the fluorescent light. These data indicate that cooked flavor either inhibits or masks oxidized flavor.

By observing changes in peak heights of C-2, 3, 5 and 6 saturated aliphatic straight chain aldehydes, it is obvious that these carbonyl compounds increase as a function of the time of light exposure. With regard to pasteurization temperatures, acetaldehyde and n-pentanal concentrations were greater in milk pasteurized at 90°C throughout most of the light exposure times (Fig. 2). On the other hand, propanal and n-hexanal concentrations were greater in milk pasteurized at the lowest temperature (73°C) throughout 14 d under fluorescent light. Previous research with light-exposed skim milk resulted in relatively greater increases in acetaldehyde and n-pentanal than in propanal and n-hexanal (*2*). This would implicate the role of nonfat milk components (most likely protein) in increases in acetaldehyde and n-pentanal. Higher pasteurization temperatures may have accommodated some of those changes. However, relatively lower concentrations of propanal and n-hexanal in light-exposed milk at higher pasteurization temperatures may occur as a result of reducing substances generated by higher temperature that inhibit lipid oxidation.

There appears to be an advantage to using higher pasteurization temperatures in minimizing light-activated flavors. However, more work is needed to establish if there is an optimum combination of temperatures and times that will limit the light-activated flavor while controlling the heated flavor.

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