Light Activated Flavor in Milk

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ABSTRACT
An expert panel was used to determine the frequency and severity of light activated flavors in milk packaged in plastic jugs. Samples were evaluated weekly (different day each week) with a total of 90 samples being examined. Fifty-three samples (59%) of the total were rated as having a moderate to strong light-activated flavor. After establishing the existence of a severe problem, large consumer panels were run at two shopping centers. The triangle test was used to determine whether panelists could distinguish between milk and light activated flavor and milk with no noticeable off-flavor. In addition, preference was obtained from those respondents correctly identifying the odd sample. Consumers could distinguish between samples. The age group 25 yr and younger was the most successful in correctly detecting differences; therefore, a survey also was conducted at a local college with 69 of 132 respondents correct. Preference testing over all portions of the study indicated that 63% preferred the milk with no off-flavor, 27% preferred the light activated flavor, and 10% had no stated preference. Results from one of the malls (identified as a "blue collar" mall) brought the average down for those preferring milk with no light activated flavor.

INTRODUCTION
There exists great concern over the reported-ly high incidence of oxidized or light activated flavor (LAF) in milk packaged in plastic jugs (1, 2, 3, 6). For example, Hankin and Dillman (6) reported that 33% of milk packaged in polyethylene containers developed a light-induced oxidized flavor. Even more alarming are reports by Barnard (1, 2) which indicated that in surveys of market milk in 1970 and again in 1973, 86.1% and 84.2% of milk packaged in blow-molded plastic containers were oxidized. Though the sampling size was small, the results indicate a major flavor problem.

Hansen et al. (7) reported that homogenized milk packaged in polyethylene containers exposed to fluorescent lights showed both flavor and vitamin deterioration. The noted off-flavor development began within 2 to 4 h after exposure to a lighting system simulating commercial display cases. These workers reported that the detection of light-induced flavor was slight, medium, and strong after 4, 7, and 24 h of exposure. Bradley (3), in an excellent review on the effect of light on milk, also emphasized that the type of container used to hold milk between processing and consumption was extremely critical in minimizing flavor and nutrient alteration. He further stated that paperboard, of all single-service packaging materials, best protects milk's flavor and nutritional qualities.

Estimates (8) indicate a shift of fluid milk sold in plastic containers from 13% of total as late as 1970 to well over 50% in 1980. The convenience and lower price (to the customer) makes its choice an attractive one. However, one cannot help but wonder whether or not this spiraling shift from one package type to another without adequate protection from light, especially in the ultraviolet range, has not caused an erosion in total consumption of milk.

Processors often indicate that even though there might be a considerable amount of milk with a LAF on the market, customers cannot tell a difference; and even if a few could, these few have been "programmed" to prefer this flavor. This hypothesis was deemed worthy of testing if incidence of LAF milk were high in

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1 Dean Foods Company, Rockford, IL 61101.
TABLE 1. Overview of study involving light activated flavor (LAF) in milk packaged in plastic.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Methodology</th>
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<tbody>
<tr>
<td>Supermarket screening — expert panel</td>
<td>Whole milk and 2% low fat milk were evaluated by three judges trained in recognition of off-flavors in milk and milk products. Samples were purchased at grocery stores over 5 weeks. The milk was purchased on a different day each week in an attempt to eliminate the possibility of unknowingly purchasing the milk under the best or under the worst conditions each week. There was an average of 18 samples evaluated during each session for a total of 90 samples. Samples were identified either as having a &quot;clean&quot; flavor (no criticism) or as having a light activated flavor (LAF). If this LAF were present, the relative severity was indicated as: 1) moderate to strong, 2) slight, 3) very slight, or 4) no criticism.</td>
</tr>
<tr>
<td>Two shopping malls — consumer panels</td>
<td>The triangle test was used to determine whether consumers (panelists) could detect a difference in the samples. In addition, panelists were asked to indicate the degree of difference</td>
</tr>
<tr>
<td>difference — preference (three sample)</td>
<td></td>
</tr>
<tr>
<td>Testing at junior college — consumer panel</td>
<td></td>
</tr>
<tr>
<td>difference — preference (three sample)</td>
<td></td>
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<tr>
<td>Small preference panel (two sample)</td>
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</table>

the marketplace. Therefore, primary objectives of this study were to determine whether a problem existed; if affirmative, to determine whether the consuming public could distinguish between LAF and non-LAF milk; and if a distinction could be made, to determine the preference of those accurately indicating differences. Moreover, demographical information obtained should prove useful in subsequent educational advertising campaigns sponsored by marketing departments of dairy food companies.

Bray et al. (4) conducted surveys at three county fairs in Vermont (2,000 consumers) in which each survey participant was presented with two samples, one good and one with a light-induced flavor. When asked for preference, 73.2% indicated the good sample as their choice, and 20.3% preferred the sample with a light induced flavor. While this question, "Can you tell a difference between the two samples?" was asked, actual difference testing technique was not employed, probably because of the large number of consumers involved. At any rate, the study emphasizes that, in a direct comparison, consumers prefer good milk. This supports objectives of the current study.

Coleman et al. (5) had a consumer taste panel (781 people) rate three samples of milk, two of which had been exposed to fluorescent light (one exposure period of 1076 lx at 7°C for 12 h and another for 24 h). A 5-point hedonic ranking scale had the control (nonlight exposed) rated best, then the milks exposed 12 and 24 h, respectively.

In addition to the stated objectives, the primary supposition or underlying fear of the authors was that while people might drink this milk with a less than "totally" desirable taste and not recognize a "bad enough" flavor note to complain to the store or processor, their action would probably be to avoid drinking a second glass of milk or buying a third or fourth jug of milk during subsequent trips to the grocery store. While this might be a subconscious factor, the authors are convinced that this "hidden" or "inherent" flavor has cut down on the overall consumption of fluid milk products. Quite naturally, this supposition is almost impossible to prove, especially to marketing departments when coloring (darkening) of plastic containers coupled with strong educational advertising is suggested. Hence, further information is required for more definitive data.

MATERIALS AND METHODS

An overview of the current study is in Table 1. Detailed description of the study will be as shown in the overview.

Supermarket Screening — Expert Panel

Whole milk and 2% low fat milk were evaluated by three judges trained in recognition of off-flavors in milk and milk products. Samples were purchased at grocery stores over 5 weeks. The milk was purchased on a different day each week in an attempt to eliminate the possibility of unknowingly purchasing the milk under the best or under the worst conditions each week. There was an average of 18 samples evaluated during each session for a total of 90 samples. Samples were identified either as having a "clean" flavor (no criticism) or as having a light activated flavor (LAF). If this LAF were present, the relative severity was indicated as: 1) moderate to strong, 2) slight, 3) very slight, or 4) no criticism.

Consumer Panel — Two Shopping Malls

Public opinion booths were manned at each of two malls. The same manager operated both malls, and he indicated that mall 1 was frequented more by "white collar" families while mall 2 was frequented more by "blue collar" families. This meaning is intended in future uses for these terms.

The triangle test was used to determine whether consumers (panelists) could detect a difference in the samples. In addition, panelists were asked to indicate the degree of difference
between selected odd and paired samples. Finally, panelists were asked for their preference for either the odd or paired set of samples. While there is some question as to the statistical validity of combining a preference test with a difference test, it was done to facilitate collection of data and conservation of funds. One other controversial method was the use of the triangle test for a consumer panel. This was done to try to obtain the most accurate reflection possible as to whether consumers (untrained) actually could tell a difference in the samples. A total of 190 panelists participated in the first session (mall 1) and 250 in the second (mall 2) for a grand total of 440 consumer panelists.

Consumer responses were categorized by age group and sex. Age groups were: Less than 18 yr, 18 to 25, 26 to 35, 36 to 45, 46 to 55, and more than 55.

The LAF milk was prepared by exposing jugs (number as required for specific study) of milk to direct sunlight for 20 min. The milk was tasted by the expert panel and rated as having a moderate LAF. The peroxide value was run on both LAF milk and control milk (no light exposure).

**Consumer Panel — Local Junior College**

Because the age group 25 and under was most successful in detecting differences among milk samples, a similar study was conducted on a college campus. Also, this target age group represents a large milk-drinking segment of the total population. A total of 132 responses was obtained. Because of the time of year (summer session) a larger portion of older (than 25) people participated in the study than would have been represented in a regular semester.

**Preference Test — Two Sample**

A preference test was conducted on a small number of office personnel. This effort was intended to see if consumers presented with only two samples, rather than the three in the triangle preference testing, would yield clearer results. Only 14 panelists participated because we merely wanted an approximation of the preference, which, if decidedly one-sided, legitimately could be extrapolated to larger numbers.

**RESULTS AND DISCUSSION**

**Expert Panel**

The expert panel evaluated 90 samples with results in Table 2. Based on results of the expert panel, there appeared to be significant problems with LAF milk sold in plastic jugs, at least those sold in this marketing area. This is evidenced by the fact that of the 90 total samples purchased and evaluated, 53 (58.9%) samples had a moderate to strong LAF which was recognized easily. Seventeen additional samples had either a slight or very slight LAF. All samples were manufactured by local dairies and were within expiration date. It is alarming
that over 75% of all samples had some degree of
this flavor. The average age of the milk (from
date of processing) was 4.4 for low fat and 5.2
days for whole milk.

All Consumer Panels

The data in Table 2 led into the large con-
sumer panel testing to determine whether the
public actually could tell a difference, and, if
they could, then to determine whether these
consumers preferred the "clean" milk or the
LAF milk. The mean peroxide value over all
test samples was .31 meq peroxide/kg milk
whereas control milk averaged .17 meq perox-
ide/kg milk. Results of all consumer panels
are in Table 3.

Overall consumer studies, panelists could
distinguish between the LAF and non-LAF
milk by picking out the odd sample in the
triangle difference test (Table 3) (P<.001).
The survey at mall 1 and at the college yielded
approximately the same results (53.2% correct
respondents at mall 1 and 52.3% at the junior
college). These panelists were more accurate in
correctly identifying the odd samples than
those at mall 2 (43.2% correct respondents —
108 of 250). As mentioned, the manager of
both malls (same person) indicated that mall 1
was frequented more by "white collar" families
whereas mall 2 was frequented more by "blue
collar" families.

Thus, after ascertaining that consumers
could tell a difference between LAF and non-
LAF milks, preference testing was used to
determine which of the two milk types was pre-
ferred. The data at the bottom of Table 3 repre-
sent only preferences of those respondents who
correctly noted a difference in the samples. In
every phase of the overall study the non-LAF
milk was preferred by those respondents cor-
rectly noting a difference. For example, at mall
1 74 of 101 (73%) respondents preferred the
"clean" sample. Overall, 63% preferred the

### Table 3. Consumer difference and preference panels for comparison of LAF milk and non-LAF milk.

<table>
<thead>
<tr>
<th></th>
<th>Mall 1</th>
<th>Mall 2</th>
<th>Junior college</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference testing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panelists</td>
<td>190</td>
<td>250</td>
<td>132</td>
<td>572</td>
</tr>
<tr>
<td>Correct respondents</td>
<td>101b</td>
<td>108a</td>
<td>69b</td>
<td>278b</td>
</tr>
<tr>
<td>(%)</td>
<td>(53.2)</td>
<td>(43.2)</td>
<td>(52.3)</td>
<td>(48.6)</td>
</tr>
<tr>
<td>Preference of those</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>correct (difference testing) respondents</td>
<td>101</td>
<td>108</td>
<td>69</td>
<td>278</td>
</tr>
<tr>
<td>Non-LAF (%)</td>
<td>74 (73)</td>
<td>54 (50)</td>
<td>47 (68)</td>
<td>175 (63)</td>
</tr>
<tr>
<td>LAF (%)</td>
<td>19 (19)</td>
<td>38 (35)</td>
<td>18 (26)</td>
<td>75 (27)</td>
</tr>
<tr>
<td>No preference (%)</td>
<td>8 (8)</td>
<td>16 (15)</td>
<td>4 (6)</td>
<td>28 (10)</td>
</tr>
</tbody>
</table>

*aSignificant at .01.

bSignificant at .001.

### Table 4. Sex classification of consumer panels used to differentiate between LAF and non-LAF milk.

<table>
<thead>
<tr>
<th></th>
<th>Mall 1</th>
<th>Mall 2</th>
<th>Junior college</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct responses, by sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women (%)</td>
<td>79/138</td>
<td>81/183</td>
<td>38/69 (55)</td>
<td>198/390</td>
</tr>
<tr>
<td>Men (%)</td>
<td>22/52</td>
<td>27/67</td>
<td>31/63 (49)</td>
<td>80/182</td>
</tr>
</tbody>
</table>
TABLE 5. Age classification of consumer panels used to differentiate between LAF and non-LAF milk.

<table>
<thead>
<tr>
<th>Correct responses by age</th>
<th>Mall 1</th>
<th>Mall 2</th>
<th>Junior college</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;18</td>
<td>16/30 (53)</td>
<td>32/63 (51)</td>
<td>9/16 (56)</td>
<td>57/109 (52)</td>
</tr>
<tr>
<td>18–25</td>
<td>17/24 (71)</td>
<td>11/25 (44)</td>
<td>37/64 (58)</td>
<td>65/113 (58)</td>
</tr>
<tr>
<td>26–35</td>
<td>28/49 (57)</td>
<td>20/44 (45)</td>
<td>10/28 (36)</td>
<td>58/121 (48)</td>
</tr>
<tr>
<td>36–45</td>
<td>5/12 (42)</td>
<td>11/29 (38)</td>
<td>9/15 (60)</td>
<td>25/56 (45)</td>
</tr>
<tr>
<td>46–55</td>
<td>8/23 (35)</td>
<td>10/26 (38)</td>
<td>3/8 (38)</td>
<td>21/57 (37)</td>
</tr>
<tr>
<td>&gt;55</td>
<td>27/52 (52)</td>
<td>24/63 (38)</td>
<td>1/1 (100)</td>
<td>52/116 (45)</td>
</tr>
</tbody>
</table>

“clean” sample while 27% preferred the LAF sample, and 10% had no stated preference. The respondents at mall 2, “blue collar” shoppers, were responsible for the slightly elevated number that favored LAF milk.

In every testing situation (Table 4) women were more accurate in indicating differences between the samples (51% for women and 44% for men). This was particularly true for mall 1 where 57% of the women participating in the study were correct while only 43% of the men had correct responses.

With regard to age distinction, the 18 to 25 yr age group was the most accurate in detecting differences, e.g., 65 of 113 (58%) correct respondents. This group was followed closely by the under 18 and the 26 to 35 yr age groups (Table 5).

Small Preference Panel

A small preference test was with 14 untrained panelists. In this instance, each panelist was presented with only two samples. The panelist was asked simply to indicate the preference. All 14 panelists preferred the “clean” sample. We did not run a larger study as these results were so conclusive that we felt that the extra cost would not tell us anything that we did not already know.

There appears to be a serious problem with the flavor referred to as light-activated. As indicated earlier, we do not believe that the “average” consumer will complain bitterly, if at all, about this type of flavor; rather, we are afraid that the complaint will be a “silent” one with slightly depressed total milk sales being the only measuring stick.

While light guards, education of grocery store personnel, and use of special plant cooler lights all have been attempted with varying degrees of success, we believe that a change in containers will have far better effects. Whereas we certainly are not proposing a total change of containers, we are suggesting that those companies using blow-mold machines as a means of forming plastic containers look into the possibility of adding some color to the resins used in these machines. These colors could be a more opaque white or even other colors such as the dark amber color used years ago in glass containers. A valid concern would be whether a colored container would detract from the visual “eye appeal” of actually seeing the milk. This has been assumed in the past, but we question whether milk is really an “impulse” buying item at a grocery store. With relative ease marketing people can determine consumers’ opinions as to whether there would be objection to this colored plastic jug. Dark colored containers have not hurt the sale of beer or soft drinks. Of course, a strong educational advertising campaign would have to be implemented in each marketing area, but this should reap long-range benefits. Also, paper is a better protector of milk from light than is plastic, but in the minds of many people it does not give the convenience to the customer as does plastic.

Results of this study indicate a problem of serious enough consequence that the dairy industry should take a closer look at its solution.

REFERENCES
