Influence of Feeding Full-Fat Flax and Sunflower Seeds on Internal and Sensory Qualities of Eggs

Z. JIANG, D. U. AHN, L. LADNER,1 and J. S. SIM2

Department of Animal Science, University of Alberta, Edmonton, Alberta, T6G 2P5, Canada

(Received for publication July 15, 1991)

ABSTRACT The present study was carried out to examine the influence of feeding full-fat oil seeds on the sensory quality of fresh eggs and the internal quality of eggs during a 6-wk storage period. White Leghorn laying hens, 16 mo of age, were fed diets containing either 15% flax seed (FLAX), 18% high oleic acid sunflower seed (HOAS), 21% regular, high linoleic acid sunflower seed (HLAS), or 3% animal tallow (control). Feeding oil seeds had no adverse effects on the Haugh units of eggs at any point of storage. Yolks from the FLAX regimen had the highest color index and those from HOAS the lowest when measured by comparison to the Roach yolk color fan. The Haugh units decreased whereas the yolk color index increased during 6 wk storage. The sensory quality of fresh eggs (stored for less than 2 wk at 4 C) was evaluated in two independent studies using hard-cooked eggs. Feeding two types of sunflower seeds had no effect on the sensory traits of the egg. Both studies revealed that eggs from the FLAX regimen had lower preference (hedonic) scores (P<.01) than those from other dietary treatments. About 36% of the sensory evaluations in both studies reported a fishy or fish-related flavor for eggs from hens fed FLAX. The causes of the off-flavor of eggs and measures to prevent it must be studied prior to producing and marketing the fatty acid-modified eggs.

(Key words: flax seed, sunflower seed, sensory quality, Haugh units, yolk color)

1992 Poultry Science 71:378-382

INTRODUCTION

Attempts to reduce cholesterol content of eggs by dietary manipulations were not successful (Naber, 1983). It is known, however, that the fatty acid composition of yolk lipids can be readily altered by modifying the quantity and type of fat in laying hen diets (Cruickshank, 1934; Noble, 1987). There is a growing consensus among nutritionists that dietary n-3 polyunsaturated fatty acids (n-3 PUFA), such as α-linolenic acid (LNA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA), play important roles in human health (Kinsella et al., 1990).

The cholesterol-lowering and ameliorative effects against atherosclerosis of dietary n-3 PUFA are of particular interest to egg producers, consumers, and researchers. These much needed n-3 PUFA could be readily incorporated into yolk lipids by feeding laying hens diets containing full-fat flax or canola seed (Nwokolo et al., 1988; Caston and Leeson, 1990; Sim, 1990) or fish oils (Yu and Sim, 1987; Hargis et al., 1991). Recent studies from the authors' laboratory demonstrated that longer chain n-3 PUFA (EPA, DHA, and docosapentaenoic acid) were preferentially deposited into yolk phosphatidylethanolamine fraction after feeding flax seeds (Jiang et al., 1991). Feeding n-3 PUFA-enriched eggs to

1Marketing Services Division, Food Processing Development Centre, Leduc, AB, T9E 6M2, Canada.
2To whom correspondence should be addressed.
rats reduced plasma and liver cholesterol contents, indicating that the cholesterogenic property of chicken eggs was markedly modified by incorporating n-3 PUFA into yolk lipids (Jiang and Sim, 1991). The n-3 PUFA-enriched eggs might thus be more appealing to health-conscious consumers.

Consumer acceptance of eggs, however, also depends on egg quality parameters such as Haugh units, yolk color, storage stability, and in particular the sensory traits. There is little information on the effects of dietary full-fat oil seeds or fish oils on these quality parameters. The objective of the current study was to examine the dietary effects of n-3 or n-6 PUFA-rich oil seeds on the sensory quality of hard-cooked eggs and the internal quality of eggs during storage.

MATERIALS AND METHODS

A total of 528 Single Comb White Leghorn laying hens, 16 mo of age, were housed in double-deck cage batteries with two birds in each cage (.31 × .36 m). The birds were allotted to one of the four dietary treatments with each treatment replicated three times randomly among the three batteries. Four isonitrogenous, isocaloric laying hen diets were prepared to contain either 15% full-fat flax (FLAX), 18% high oleic acid sunflower seed (HOAS), 21% regular, high linoleic acid sunflower seed (HLAS), or 3% animal tallow (control) (Jiang et al., 1991). These diets provided 15.0% CP, 3.6% calcium, and 2,728 kcal ME/kg. Eggs were collected during the 4th wk of the feeding trial and stored at 4°C. On Day 0, 14, 28, and 42 of storage, eight eggs were selected randomly from each replicate making a total of 24 eggs per treatment. Haugh units were determined according to Haugh (1937) and yolk color index was obtained by comparison to the Roche yolk color fan (Vuilleumier, 1969). Two yolk samples from each replicate were subjected to fatty acid analyses by gas chromatography as described previously (Jiang et al., 1991).

On Day 7 of storage, 24 eggs from each treatment were sampled for sensory evaluation. Two separate studies were conducted, one at the University and the other at the Food Processing Development Centre of Alberta Agriculture, Leduc, AB, Canada. In the University study, 28 untrained students and staff members from the Departments of Food Science and Animal Science participated. The study by the Food Centre was conducted using 12 trained panelists (5 males and 7 females, 31 to 45 yr of age) with three repetitions for a total of 36 observations. In both studies, eggs were cooked by bringing tap water to a boil and then kept simmering for 20 min. After being cooled in tap water for 15 min, eggs were shelled and cut into four pieces along the major axis. Four samples were coded using three-digit random numbers and presented randomly to panelists. Cold tap water was provided for panelists to rinse their mouths between samples. The evaluations were carried out in sensory evaluation rooms with a dim red light to eliminate any possible effects of sample color on the preference test. Nine-centimeter hedonic lines were used for panelists to quantitatively record their preference scores. Each line was labeled with descriptors “Dislike extremely”, “Neither like nor dislike”, and “Like extremely” at the left end, middle, and the right end of the line, respectively. The preference score was measured by the distance from the left end to where it was checked. Thus a score of 0 represented “dislike extremely”, and a 9 “like extremely”. The panelists in the University study were asked to describe any off-flavors detected in the egg samples. Characteristic descriptors for fresh egg flavors such as “sweet”, “acid”, “sulfury”, “salty”, “earthy”, “bitter”, “fatty”, “hydrolyzed protein” (Koehler and Jacobson, 1966), and “fishy” were provided for the panelists in the Food Centre study.

Two-way ANOVA was used to analyze the effects of diet and storage on Haugh units and yolk color index using eggs within diet by storage as the error term. Means of main effects (diet and storage) were separated by the Student-Newman-Keuls (SNK) test. Means of interaction (diet by storage) were compared using the PDIFF function of the SAS® program (SAS Institute, 1985). Sensory evaluations were analyzed by one-way ANOVA with die-
<table>
<thead>
<tr>
<th>Storage (wk)</th>
<th>FLAX</th>
<th>HOAS</th>
<th>HLAS</th>
<th>Control</th>
<th>(x)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>78.2(^{a,x})</td>
<td>83.3(^{a,x})</td>
<td>79.2(^{a,x})</td>
<td>78.7(^{a,x})</td>
<td>79.8(^{x})</td>
</tr>
<tr>
<td>2</td>
<td>66.9(^{a,y})</td>
<td>66.3(^{a,y})</td>
<td>67.8(^{a,y})</td>
<td>71.6(^{a,y})</td>
<td>68.2(^{y})</td>
</tr>
<tr>
<td>4</td>
<td>64.9(^{a,y})</td>
<td>65.2(^{a,y})</td>
<td>59.0(^{b,z})</td>
<td>59.0(^{b,z})</td>
<td>62.3(^{z})</td>
</tr>
<tr>
<td>6</td>
<td>65.6(^{a,y})</td>
<td>64.8(^{a,y})</td>
<td>58.6(^{b,z})</td>
<td>60.4(^{ab,z})</td>
<td>62.0(^{z})</td>
</tr>
<tr>
<td>(\bar{x})</td>
<td>68.9(^{a})</td>
<td>69.9(^{a})</td>
<td>66.2(^{b})</td>
<td>67.4(^{ab})</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>3.4(^{a,z})</td>
<td>2.0(^{c,z})</td>
<td>2.5(^{b,y})</td>
<td>3.2(^{a,y})</td>
<td>2.8(^{z})</td>
</tr>
<tr>
<td>2</td>
<td>3.5(^{a,z})</td>
<td>2.2(^{d,z})</td>
<td>2.8(^{c,y})</td>
<td>3.2(^{b,y})</td>
<td>2.9(^{z})</td>
</tr>
<tr>
<td>4</td>
<td>3.7(^{a,y})</td>
<td>3.2(^{b,y})</td>
<td>3.1(^{b,x})</td>
<td>3.5(^{a,x})</td>
<td>3.4(^{z})</td>
</tr>
<tr>
<td>6</td>
<td>4.1(^{a,x})</td>
<td>3.6(^{bc,x})</td>
<td>3.3(^{c,x})</td>
<td>3.6(^{b,x})</td>
<td>3.7(^{x})</td>
</tr>
<tr>
<td>(\bar{x})</td>
<td>3.7(^{a})</td>
<td>2.7(^{d})</td>
<td>2.9(^{c})</td>
<td>3.4(^{b})</td>
<td></td>
</tr>
</tbody>
</table>

\(^{a-d}\)Means in a row with no common superscripts differ significantly (\(P<0.05\)).

\(^{x}\)Means in a column with no common superscripts differ significantly (\(P<0.05\)).

1Data (\(n = 24\)) were analyzed by two-way ANOVA followed by Student-Newman-Keuls test to separate means of main effects (diet and storage). Means of experimental units (diet by storage) were analyzed using the PDIF function of the SAS program (SAS Institute, 1985).

2The laying hen diets contained either 15% flax seed (FLAX), 18% high oleic acid sunflower seed (HOAS), 21% regular high linoleic acid sunflower seed (HLAS), or 3% animal tallow (control).

Results and Discussion

The effects of feeding oil seeds on the quality of egg albumen were examined by means of measuring Haugh units of eggs during the 6-wk storage period (Table 1). A rapid decline of Haugh units was found for eggs from all dietary treatments during the first 2 wk of storage (\(P<0.05\)). Haugh units of eggs from HOAS and FLAX diets did not change significantly over the next 4 wk of storage, but those of eggs from the HLAS and control diets continued to decrease from Week 2 to 4.

Feeding HOAS to laying hens resulted in higher (\(P<0.05\)) Haugh units than feeding HLAS. Overall, feeding oil seeds did not adversely affect egg Haugh units during storage.

Yolk color is an important quality trait in influencing consumer acceptability (Huntton, 1987). In the present study, both diet and storage significantly (\(P<0.05\)) affected yolk color as measured by comparison to the Roche yolk color fan (Table 1). For all dietary treatments, yolk color index increased steadily over the storage period. The exact cause for such an increase of yolk color is not known. Feeding FLAX to laying hens resulted in darker yolks than other dietary regimes (\(P<0.05\)). Although having no influence on the nutritive value of eggs, darker yolks might be more appealing to consumers of certain ethnic groups. Storage up to 6 wk at 4 C did not significantly change yolk fatty acid profiles (data not shown).

One of the most important quality parameters in determining consumer acceptance of any food item is the sensory characteristic. As indicated in Figure 1, studies at both the University and the Food Centre generated similar preference patterns. Eggs from hens fed the FLAX diet scored significantly lower in preference evaluation than others but those from the sunflower seed diets were not affected when compared with the control. Thirty-six percent of the evaluations in both studies detected a fishy or fish-product-related flavor, such as "cod liver oil" or "tuna flavor", for eggs from the FLAX diet (Table 2).
FIGURE 1. Effects of dietary full-fat oil seeds on the hedonic scores of eggs (X ± SEM, n = 36 and 28 for Food Centre study and University study, respectively). A hedonic score of 0 represents “dislike extremely”, and a 9 represents “like extremely”. Bars in the same study with no common letters differ significantly (P<.05). The laying hen diets contained either 15% flax seed (FLAX), 18% high oleic acid sunflower seed (HOAS), 21% regular high linoleic acid sunflower seed (HLAS), or 3% animal tallow (control).

When the hedonic scores of panelists who did not detect the fishy flavor were compared, no dietary treatment effect was found, indicating that the fishy flavor was the major cause of lower preference scores of eggs from the FLAX diet. The exact percentages of fishy flavor being reported in the two separate studies might be coincidental, but it revealed that approximately one-third of the panelists were able to detect this off-flavor in eggs from the FLAX regime. Previously, Farrell and Gibson (1990) reported that eggs from hens fed diets containing fish oil, canola oil, or linseed (flax) oil were indistinguishable from those of the control. The discrepancy might be due to 1) dietary fat sources (whole seeds versus oils); and 2) methods of egg preparation. In the present study, eggs were hard-cooked and one piece of the egg representing each dietary treatment was presented to a panelist. In the study of Farrell and Gibson (1990), six eggs from each treatment were blended with 30 mL of water and cooked in a 700-watt microwave oven on “high” for 3 min. The samples were stirred and reheated for a further 1 min and let stand for 2 min before serving.

The cause or causes of fishy flavors in eggs from laying hens fed flax seed remain to be determined. It was speculated that the fishy flavor could be due to the presence of 1) trimethylamine (TMA); 2) lipid oxidation products; and 3) the flax flavor per se. Fishy flavor has been described in eggs from hens fed either fish meal (Wakeling, 1982) or rapeseed meal (Hobson-Frohock et al., 1975), and TMA was the suspected substance in these eggs (Hobson-Frohock et al., 1973). Choline, which was derived from sinapine in rapeseed meal, was the precursor molecule for TMA (Hobson-Frohock et al., 1977). This sinapine-choline-TMA scheme, however, might not be the case in the FLAX-fed laying hens in the current experiment. Firstly, it has been repeatedly demonstrated that sinapine-related fishy flavor was detected only in eggs from hen strains such as Rhode Island Reds but not from White Leghorns (Wakeling, 1982), which were used in the present study. Secondly, the sinapine or choline content of flax seeds is much lower than that of rapeseed.

The rancidity products of PUFA cause fishy flavor in some food products (Saxby, 1982). In the present study, eggs were stored at 4°C for 7 days before sensory evaluations were carried out. Therefore, there might be very little, if any, oxidation of PUFA occurred in yolks during the 1st wk postharvest. The oxidative rancidity was more likely to occur in the FLAX diet during the preparation and feeding of the diet. These oxidation products might find a way into the yolk when the diet was fed.

<table>
<thead>
<tr>
<th>Study</th>
<th>Laying hen diet¹</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FLAX</td>
<td>HOAS</td>
<td>HLAS</td>
<td>Control</td>
</tr>
<tr>
<td>Food Center,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n = 36)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>13</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Percentage</td>
<td>36</td>
<td>3</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>University</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n = 28)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Percentage</td>
<td>36</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

¹The laying hen diets contained either 15% flax seed (FLAX), 18% high oleic acid sunflower seed (HOAS), 21% regular high linoleic acid sunflower seed (HLAS), or 3% animal tallow (control).
to laying hens. As only a trace amount of lipid oxidation products are needed to cause fishy flavor in food products (Saxby, 1982), it might be possible that the fishy taint could be the result of rancidity of the FLAX diet.

The fishy flavor detected might also be the result of direct transfer of flavor compounds from flax seed into the yolk. One panelist from the University study who previously tasted fresh flax seed described flax flavor rather than fishy flavor in a yolk sample from the FLAX diet. Therefore, it is possible that the so-called fishy flavor described by other panelists was actually the characteristic flavor of flax seed.

In brief, feeding full-fat flax and sunflower seeds to laying hens did not affect egg internal quality in terms of specific gravity and Haugh units. Yolk color was darkened by the FLAX diet. Furthermore, feeding the FLAX diet in the present study resulted in a fishy flavor in some eggs. Questions on the extent of fishy eggs produced by hens fed the FLAX diet, the exact substance or substances that cause fishy flavors in these eggs, what components in FLAX diet are responsible for the off-flavors, and how to overcome these problems remain to be answered prior to any mass production and marketing of these fatty acid-modified eggs.

ACKNOWLEDGMENTS

Financial support from the Ontario Egg Producers’ Marketing Board, Alberta Agriculture, and the Flax Council of Canada was appreciated. The authors thank all panelists who participated in the sensory evaluation, the staff of the Poultry Research Centre of the University of Alberta for technical assistance, and R. T. Hardin for advice on statistical analyses.

REFERENCES


