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Potential of alfalfa as an alternative molt induction diet for laying hens: egg quality and consumer acceptability

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Abstract

Dietary molt induction to initiate additional egg laying cycles in commercial laying hen flocks is a wide spread practice in the United States. Feed deprivation is the most commonly used method but this practice has generated several concerns which has lead to research for viable alternative approaches. From a management standpoint a single ingredient molting diet consisting of high fiber-low energy represents an easily adaptable diet for large laying hen production units. Alfalfa meal is readily available in most commercial locations and possesses many of the desirable properties of an ideal laying hen molt diet. In the current study hens at a commercial laying facility were molted by both alfalfa and feed deprivation. After the hens had reentered post-molt commercial egg production, eggs were examined for egg quality performance. Egg shell strength, albumen height, yolk height, weight, length, and yolk color were all tested using various mechanical techniques. The eggs were also sampled for testing by consumer sensory panels that assessed the desirability of the eggs' color and flavor/texture. Eggs laid by hens molted by alfalfa had a significantly lower ($p < 0.05$) "a^*" level of colorimetry. Eggs laid by hens molted with alfalfa also exhibited significantly higher ($p < 0.05$) egg weights and length. In the consumer sensory test, there was no significant difference ($p > 0.05$) in color or flavor/texture scores in eggs from either feed deprived or alfalfa molted hens. The consumer sensory and mechanical quality attributes indicates that alfalfa shows promise as an alternative molt induction diet by providing a single diet option for extending egg production into a second egg laying cycle.

Keywords: Egg quality; Consumer sensory; Alfalfa molting; Feed deprivation; Mechanical evaluation

1. Introduction

Induced molting to initiate additional egg laying cycles in commercial laying hen flocks is a practice that has been extensively documented, with studies beginning in the early 1900s (Bell, 2003). During the past several decades, commercial laying facilities have been using feed deprivation for a period of several days as a means of inducing molt to extend the productivity of a flock of laying hens (Brake, 1992). Consequently, the eggs laid by feed deprived molted hens have been used for human consumption for several years. However, due to increasing animal welfare concerns regarding the use of feed deprivation, other approaches that use some sort of dietary manipulation for inducing a molt have become attractive alternatives to the egg production industry (Berry, 2003; Park et al., 2004b). In addition, hens undergoing fasting appear to be more susceptible to *Salmonella enterica* serovar Enteritidis (*S. enteritidis*)

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colonization of the gastrointestinal tract and infections (Holt, 2003; Ricke, 2003).

From a management standpoint a single ingredient molting diet consisting of high fiber-low energy represents an easily adaptable diet for large laying hen production units. It has previously been demonstrated that birds in controlled experiments given ad libitum access to fiber sources such as wheat middlings will cease egg production within a similar time frame as feed withdrawal and limit *S. enteritidis* colonization during the molt induction period (Seo et al., 2001). However an important issue for selecting viable alternative molting diet candidates is the availability of the fiber source and the influence on post-molt egg quality. Alfalfa meal is readily available in most commercial locations and possesses many of the desirable properties of an ideal laying hen molt diet (Landers et al., in press). Previous research on alfalfa has also been conducted to ascertain its merits as a feed supplement for the purpose of yolk coloration (Fletcher et al., 1985; Ganeshan and Kumar, 1989; Guenthner et al., 1973; Johns, 1986). This is an issue since it is conceivable that commercial producer would most likely prefer eggs of a uniform color. Additionally, differences in components of layer diets, such as menhaden oil, have been known to alter egg flavor (Van Elswyk et al., 1992). In order to substantiate alfalfa as a viable alternative to feed deprivation for the induction of molt, it is important to verify that the diet does not impart any differences in aesthetics or organoleptic qualities. This requires measurement of interior and exterior egg quality in the early second cycle of production of both feed deprived and alfalfa molted hens. In previous studies we have confirmed that using alfalfa as the single dietary source during the molt period would stop egg production and limit *S. enteritidis* colonization (Landers et al., in press; Woodward et al., submitted for publication). However the measurements on egg parameters for the post-molt eggs were limited due to the small number of experimental laying hens used in the study. The objective of the current study was to determine if untrained consumers could detect a difference in taste/texture and yolk color of eggs laid by a large number of laying hens in a commercial production facilities molted by alfalfa or feed deprivation.

2. Methods

2.1. Molting procedure and egg storage

Single comb white leghorn hens greater than 60 weeks of age were molted at a commercial laying facility by either feed deprivation or ad libitum access to alfalfa. The details of the molting procedure cannot be provided here due to the proprietary nature of the information of the commercial company that provided the eggs. After the hens had reentered commercial production (second egg laying cycle), eggs were placed in a cooler at 4 °C, 97% relative humidity for a period of one week prior to the evaluations due to scheduling constraints for the consumer panels. Eggs were also obtained prior to the molt (first egg laying cycle), transported, and stored in the same way. One trial was conducted before the molt and one trial was conducted after the molt.

2.2. Egg quality

Five parameters were used to assess exterior and interior quality of eggs, both before and after the molt. Yolk and albumen height were measured with a micrometer and expressed in mm. Yolk color was measured by Minolta Colorimetry (Chroma Meter Model CR-200, Minolta Corp., Ramsey, NJ) and Hunter color values as L^* (lightness), a^* (green to red), and b^* (blue to yellow) values were recorded (Hunter and Harold, 1987). Since the eggs were stored, Haugh unit calculations were not performed due to an increase in variability attributed to the calculation (Silversides and Villeneuve, 1994). Albumen heights were used solely because of their high correlation to Haugh unit measurements (Silversides et al., 1993). Egg length was measured using a caliper and was recorded in cm. Egg weight was measured using a balance and was recorded in grams to the nearest hundredth of a gram. Shell strength was assessed using an instron machine (Model 1011, Instron Universal Texting Machine, Instron Corp., Canton, MA) and was recorded in kg force required to crack the shell surface. The egg was stood in its large end and placed on a level surface with a round indentation in the center measuring 1 cm at its narrowest point and 2.5 cm at its widest point. Force was applied using an anvil measuring 2.5 cm in width and 0.2 cm in thickness with a 50 kg load cell at a cross head speed of 50 mm/min to the narrow end of the egg (Hammerle, 1969).

2.3. Consumer sensory panels

Egg sensory panels were held using untrained volunteer human panelists for a 3-day period during the afternoon for testing both pre- and post-molt eggs. The panelists were asked to rate the color of 3 randomly selected raw yolk samples. In addition, the panelists were also subjected to a triangle test where they were randomly given 3 samples of scrambled egg (Roessler et al., 1948). Scrambled eggs were used since no fat was added and flavor differences between scrambled and hard cooked would be minimal (Van Elswyk et al., 1992). During these evaluations, the panelists were asked to select the two samples that were the most similar. This was conducted to ascertain whether or not panelists could detect which samples were from birds molted by the same treatment. In addition, the panelists rated each sample from 1 to 8, where each integer represented a degree of opinion ranging from extremely undesirable to extremely desirable, by marking an "X" on a 15-cm line. This line represented the evaluator's opinion of the egg sample based on both flavor and texture.

Triangle test data was analyzed by assigning a numerical value to a panelist's response. If they correctly chose the sample that was not in the majority group, the value was 1. An incorrect response was scored with a 0 value.

2.4. Statistical analysis

Statistical analysis was performed using SAS version 8.0 (2000). Data was analyzed using molting treatment as the independent variable for each sensory and mechanical attribute tested. All sampling days were pooled due to a lack of significant difference between sampling days. For quality analysis, $n = 30$ for each parameter. For sensory panels, $n = 66$ (where $n = 38$ and 28, for alfalfa and feed deprived eggs as the majority sample, respectively) for flavor and $n = 46$ (where $n = 25$ and 21 for alfalfa and feed deprived eggs as the majority sample, respectively) for color for the pre-molt trial. In the post-molt trial $n = 49$ (where $n = 24$ and 25 for alfalfa and feed deprived eggs as the majority sample, respectively) for flavor and $n = 53$ (where $n = 27$ and 26 for alfalfa and feed deprived eggs as the majority sample, respectively) for color. Analysis of variance using the general linear model was used to analyze all egg quality and sensory data. Mean separation was performed using the Tukey test. Significance was indicated by $p < 0.05$.

3. Results

3.1. Egg quality

Pre-molt albumen height, yolk height, shell strength, and colorimetric b^* (blue to yellow) and L^* (lightness) values were not significantly different when alfalfa and feed deprived molting treatments were compared (Table 1). Post-molt albumen height values were 5.99 mm for eggs laid by alfalfa molted hens and 5.94 mm for hens molted by feed deprivation. Colorimetric values for alfalfa hens were a b^* value of 45.07 and an L^* value of 54.67 while feed deprived hens had a b^* value of 43.54 and an L^* value of 53.66. It appears that egg yolks from alfalfa molted hens were comparable in colorimetric pattern to yolks from feed deprived hens in terms of lightness and degree of yellow coloration (Table 2).

Eggs laid by alfalfa molted hens (64.07 g) were significantly heavier ($p < 0.05$) than eggs laid by feed deprived hens (59.30 g) (Table 2). Eggs laid by alfalfa molted hens (5.83 cm) were also significantly longer ($p < 0.05$) than eggs laid by feed deprived hens (5.66 cm) (Table 2). Post-molt eggs from alfalfa molted hens are more likely to fall into the "extra large" category, when using sizing guidelines described by the USDA (USDA, 1995) while eggs from hens molted by feed deprivation were most likely to have weights in the "large" range (Table 2). Eggs from alfalfa molted hens also exhibited a significantly lower a^* value (−2.18; $p < 0.05$) than eggs from feed deprived hens (−1.62) which is indicative of an increase in green color. While these values were significantly different, both values were numerically lower when compared to the values of the pre-molt data of both treatments.

3.2. Sensory response

From both the pre-molt and post-molt consumer sensory panels, there were no significant differences found between molting treatment for taste/texture and color evaluations ($p > 0.05$) when using unseasoned scrambled eggs as the test sample for taste/texture evaluations and raw yolk for the color evaluation (Tables 3 and 4). During post-molt evaluation, eggs from alfalfa molted hens exhibited a taste/texture value of 5.22 and a color evaluation of 5.45. This can be compared to eggs from feed deprived hens which yielded 4.91 for taste/texture and 5.20 for color. Based on these responses it appears that

Table 1
Interior and exterior quality characteristics of pre-molt eggs[a]

Parameter	Pre-molt alfalfa	Pre-molt feed deprivation
Albumen height (mm)	5.92 ± 0.21	5.87 ± 0.17
Yolk height (mm)	17.85 ± 0.17	17.41 ± 0.16
Shell strength (kg force)	2.70 ± 0.14	2.78 ± 0.11
Minolta b^*	43.60 ± 0.45	43.39 ± 0.58
Minolta L^*	54.86 ± 0.36	54.94 ± 0.33
Minolta a^*	−3.62 ± 0.11	−3.38 ± 0.09
Egg length (cm)	5.72 ± 0.03	5.71 ± 0.14
Egg weight (g)	62.10 ± 0.83	61.19 ± 0.77

[a] Means within a row do not differ significantly ($p > 0.05$).

Table 2
Interior and exterior quality characteristics of post-molt eggs

Parameter	Post-molt alfalfa	Post-molt feed deprivation
Albumen height (mm)	5.99 ± 0.27	5.94 ± 0.21
Yolk height (mm)	19.60 ± 0.20	19.18 ± 0.17
Shell strength (kg force)	3.36 ± 0.14	3.08 ± 0.17
Minolta b^*	45.07 ± 0.55	43.54 ± 0.77
Minolta L^*	54.67 ± 0.54	53.66 ± 0.38
Minolta a^*	−2.18 ± 0.14[a]	−1.62 ± 0.11[b]
Egg length (cm)	5.83 ± 0.03[a]	5.66 ± 0.04[b]
Egg weight (g)	64.07 ± 0.62[a]	59.30 ± 0.70[b]

Means within a row with no common superscript differ significantly ($p < 0.05$).

Table 3
Consumer sensory evaluations of pre-molt eggs from hens molted by alfalfa and feed deprivation[a]

Parameter	Pre-molt alfalfa	Pre-molt feed deprivation
Taste/texture rating (0–8)	5.89 ± 0.13	5.41 ± 0.16
Color rating (0–8)	5.25 ± 0.22	5.40 ± 0.19
Taste/texture triangle test success rate (%)	23.68 ± 6.99	42.86 ± 9.52
Color triangle test success rate (%)	48.00 ± 10.20	23.81 ± 9.52

[a] Means within a row do not differ significantly ($p > 0.05$).

Table 4
Consumer sensory evaluations of post-molt eggs from hens molted by alfalfa and feed deprivation[a]

Parameter	Post-molt alfalfa	Post-molt feed deprivation
Taste/texture rating (0–8)	5.22 ± 0.17	4.91 ± 0.17
Color rating (0–8)	5.45 ± 0.18	5.20 ± 0.15
Taste/texture triangle test success rate (%)	45.83 ± 10.39	32.00 ± 9.52
Color triangle test success rate (%)	40.74 ± 9.64	19.23 ± 7.88

[a] Means within a row do not differ significantly ($p > 0.05$).

consumers displayed no preference towards post-molt eggs from either alfalfa or feed deprived molted hens.

Panelists could not discern which samples were different in both taste/texture and color evaluations, regardless of which treatment was the majority group (Tables 3 and 4). When two out of three samples were from alfalfa molted hens, the post-molt eggs (Table 4) from feed deprived hens were correctly isolated 45.83% of the time for taste/texture and 40.74% of the time for color evaluations, compared to 23.68% ($p = 0.0711$) and 48.00% ($p = 0.6069$), respectively, for pre-molt evaluation (Table 3). However, when two out of three post-molt egg samples (Table 4) were from feed deprived hens, alfalfa eggs were only isolated 32.00% of the time for taste/texture and 19.23% for color, compared to 42.86% ($p = 0.4254$) and 23.81% ($p = 0.7104$) in the pre-molt evaluation (Table 3). This coupled with the lack of significant difference between consumer preferences for the eggs from the different molting treatments implies that consumer detection of differences between the two treatments is minor.

4. Discussion

Implementation of an induced molt provides the egg producer an opportunity to rejuvenate the egg laying flock with higher egg production, renewal of feathering and improvements in egg production (Bell, 2003). Induced molting of hens has been shown to lead to improved egg albumen quality, candled grade, shell thickness, specific gravity, and shell texture (Bell, 2003). Feed deprivation is considered the most widely practiced by the US poultry industry (Bell, 2003). Consequently, evaluation of post-molt egg quality of alternative molt induction approaches should include post-molt eggs from feed deprivation molted birds as a comparative control. In this study post-molt eggs from alfalfa molted hens yielded interior egg quality characteristics (albumen and yolk height) that were comparable to egg produced from hens that had been molted by feed deprivation. These comparative responses are similar to those observed for experimental hens but yolk heights in general were higher in the current study than those reported previously by Landers et al. (in press). Shell strength was similar for the two molting methods but egg length and weight were greater for alfalfa molted birds. Landers et al. (in press) saw no difference in post-molt egg lengths and weights for alfalfa and feed deprived molted experimental hens. Egg size is a key factor in US retail markets with eggs classified as "large" being the predominant shell egg product on display (Koelkebeck et al., 2001).

The technological advances in egg production and processing have provided the egg production industry with the capability of rapidly delivering high quality fresh eggs to retail markets (Bell et al., 2001). Consequently, consumer perception of a high quality egg product both for direct consumption as well as a food ingredient is becoming more essential. Therefore as the egg laying industry examines options for alternative molt diets for extending egg production into a second and even possibly a third egg laying cycle egg quality must be considered as part of the evaluation. Consumer-based egg quality attributes consist of not only taste but color perception as well. Consequently, human testing panels are an important evaluation tool for predicting whether consumer preferences will be influenced by the molt induction method that second egg laying cycle eggs are produced from laying hens after molt induction. Except for colorimetric a^* measurements, non-statistical differences were generally observed for the various color and taste parameters used to compare post-molt eggs from alfalfa and feed-deprived molted birds. Similar estimates of colorimetric values were reported for post-molt eggs from feed deprived hens in a previous study (Park et al., 2004a). However, it should also be noted that considerable variation occurred in the data for consumer taste, texture, and color triangle test responses to post-molt eggs but similar variations were prevalent in responses to pre-molt eggs as well. The consumer sensory data in this study based on the taste, texture and color evaluations of the cooked product appears to support the concept that hens molted by this method do not lay post-molt eggs that should be considered markedly less acceptable by purchasers than those produced from hens molted by feed deprivation. Therefore, second laying cycle eggs derived from alfalfa molted hens should not alter marketability compared to eggs produced from feed withdrawal hens. However, more consumer research will be needed using actual market purchasing patterns as an indicator of eggs produced from these sources. Furthermore egg production will need to be monitored over a period of several years to assess whether seasonal factors need to be considered.

5. Conclusion

Due to increasing public pressure regarding animal welfare issues with feed withdrawal molt induction as well as problems with *S. enteritidis* infestation, identifying a viable, economically advantageous alternative to feed deprivation for the induction of molt is becoming much more important to the commercial egg laying industry. The current study on consumer sensory and mechanical quality attributes indicates that alfalfa shows promise as an alternative molt induction diet that retains similar post-molt egg qualities when compared to eggs from feed deprivation molted hens and provides a single dietary option for extending egg production into a second egg laying cycle.

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