The effect of red yeast rice supplements on egg production, feed intake and egg cholesterol levels of laying hens

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Keywords: red yeast rice; feed intake; egg production; Hyline brown layer; egg cholesterol

Summary

The effects of red yeast rice (RYR) supplements on feed intake, egg production and egg cholesterol content over 6 weeks is reported. Hyline brown layers (aged 28 weeks) were fed the following: Treatment 1, typical corn-soya control diet; and for Treatments 2 and 3 the control diet were supplemented with 2 and 4 % RYR respectively. The addition of RYR in the ration resulted in maroon coloured faeces from the first day of feeding and the intensity of the colour directly corresponded to RYR inclusion levels. The feeding trial showed that there were no significant differences (p>0.05) for daily bird feed intake, weekly feed intake, FCR and egg production between the control and the treatments. However, mean egg weight was significantly lower (p <0.05) in the control compared to treatment 3. Egg cholesterol levels was significantly lower (p<0.05) in treatment 2 compared to the control and treatment 3. The concentration of cholesterol in the yolk was also significantly lower (p <0.05) in treatment 2 compared to the control and treatment 3. The feeding trial showed that RYR supplement can be used as a feed additive in layer diets with no deleterious effects on layer egg production and feed conversion.

Introduction

As a whole food, eggs are an inexpensive and low calorie source of nutrients such as folate, riboflavin, selenium, choline and vitamins A, B12, D and K. Furthermore, eggs are a source of high quality protein, and the lipid matrix of the yolk serves to enhance the bioavailability of nutrients such as lutein and zeaxanthin, two important carotenoids which have recently received attention for their potential role in delaying age-related macular degeneration (Sommerburg, 1998), and which also act as antioxidants to protect the retina from photo-toxic damage. Eggs are high in cholesterol because of its role in sustaining the developing embryo. Cholesterol has many varied uses including its role as a structural component of cell membranes, and as a precursor for sex and adrenal hormone, vitamin D and bile acids.

The perception of cholesterol-rich eggs as a “forbidden food” developed in response to the highly publicized 1970s recommendation by the American Heart Association (AHA) to restrict egg consumption and limit dietary cholesterol intake to no more than 300 mg per day (or 4 eggs per week). An extensive Harvard study (cited by Herron and Fernandez, 2004) found no relationship between egg consumption and cardiovascular disease in a population of 117,000 over a period of 8-14 years showing that it is possible to eat an egg a day without increasing coronary heart disease (CHD) risk in healthy men and women. A comparison of per capita egg consumption patterns and rates of cardiovascular disease (CVD) mortality for males and females aged 35-74 years from the 22 developed Organization for Economic Co-operation and Development (OECD) countries in Europe, N. America, Japan, Australia and New Zealand show negative relationships. Three of the highest eggs consuming countries also have the lowest rates of CVD (Wong and Tan, 2003). The most recent AHA report (Krauss et al, 2000) states that the intake of one yolk a day would be acceptable, if other cholesterol contributing foods were limited in the diet.

There have been very limited successes in significantly reducing egg cholesterol and the reasons behind the lack of success to lower egg cholesterol content have been reviewed by Griffin (1992). It suggest that meaningful reduction in egg cholesterol content will likely accrue only through the genetic
Manipulation of processes involved in lipoprotein synthesis and transport to the developing follicle. However recently, several authors have reported that egg cholesterol can be reduced by cupric sulphate (Pesti and Bakalli, 1998) and copper and chromium (Lien et al. 2004), but there have not been many other scientific studies to support these findings and commercial exploitations of these findings have yet to appear.

Red yeast rice is the fermented product of rice on which red yeast (Monascus purpureus) has been grown and its use in China was first documented in the Tang Dynasty in 800 AD. It has been used to make rice wine, as a food preservative for maintaining the colour and taste of fish and meat, and for its medicinal properties (cited by Heber et al, 1991). In China, consumption of red yeast rice has been studied in animals and humans and found to reduce cholesterol concentrations by 11–32% and triacylglycerol concentrations by 12–19% (cited by Heber et al. 1999). Endo (1979) first reported that a strain of Monascus yeast naturally produced a substance that inhibits cholesterol synthesis, which he named monacolin K (also known as mevinolin and lovastatin), as well as a family of 8 monacolin-related substances with the ability to inhibit 3-hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase. The use of RYR supplement to reduce blood cholesterol in humans has also been reported by Heber et al. (1999).

The current study was conducted to examine the efficacy of different levels of red yeast rice supplement in typical corn-soy diets on lowering egg cholesterol levels, egg laying performance, feed intake and feed efficiency in Hyline brown layers.

Materials and methods

A total of 105 Hyline Brown layers (aged 28 weeks, 7 pullets /replicate and 5 replicates / treatment) under open housing were kept in individual cages (450 X 260 mm). The minimal nutrients in the typical corn-soybean meal diets were ME 11.08 MJ/kg, CP 16.8%, Lysine 0.93%, Methionine 0.46%, Methionine+Cystine 0.76%, Calcium 4%, Sodium 0.17%, available Phosphorus 0.38%, Chloride 0.2%, Choline 1500 mg/kg and 0.3% mineral-vitamin premix. The birds were allocated the following three dietary treatments: Treatment 1 (Control) = a typical corn-soybean meal based diet, treatment 2 = control diet supplemented with 2% RYR and treatment 3 = control diet supplemented with 4% RYR. The RYR supplement was a Monascus purpureus species grown on rice under solid state incubation at 30 °C for 10 days. The dried substrate called RYR was used as a supplement to the basic diet. Diets were formulated to be isonitrogenous and isocaloric. Feed intake data for each replicate were collected weekly to give weekly means over the 6 weeks experimental period (28-33 weeks). Weekly feed intake data was then pooled to give mean daily and total feed intake for each bird for the period. Eggs were collected and counted daily. All eggs produced on day 3, 5 and 7 of each week were weighed and then pooled to give the mean weekly and total egg weight for each bird. Six eggs from each replicate from day 42 and 43 were sampled for cholesterol analysis. According to the USDA (Gebhardt and Thomas, 2002), egg cholesterol content is directly correlated to egg size and thus eggs of almost the same size (Table 2) were chosen for cholesterol analysis to give a fairer comparison of cholesterol content. The HPLC method of Beyer and Jensen (1989) for cholesterol analysis was used to measure egg cholesterol. Data were subjected to analysis of variances using SAS (1985).

Results

There were no significant differences (p >0.05) in daily feed intake and egg production between the supplemented groups and control (Table 1). However, mean egg weight was significantly lower (p <0.05) in the control compared to treatment 3.
Table 1  Comparison among treatments of feed intake, egg production and feed conversion ratio of layers fed RYR supplements.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Treatment 1</th>
<th>Treatment 2</th>
<th>Treatment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean feed intake (g/bird/day)</td>
<td>105.85 a</td>
<td>104.72 a</td>
<td>105.65 a</td>
</tr>
<tr>
<td>Total feed intake (kg per bird)</td>
<td>4.446 a</td>
<td>4.398 a</td>
<td>4.437 a</td>
</tr>
<tr>
<td>Mean egg production (%)</td>
<td>86.82 a</td>
<td>89.16 a</td>
<td>88.46 a</td>
</tr>
<tr>
<td>Total egg produced per bird</td>
<td>36.46 a</td>
<td>37.45 a</td>
<td>37.16 a</td>
</tr>
<tr>
<td>Mean egg weight (g)</td>
<td>59.27 a</td>
<td>59.49 ab</td>
<td>61.61 b</td>
</tr>
<tr>
<td>Total egg weight (kg per bird)</td>
<td>2.1185 a</td>
<td>2.1856 a</td>
<td>2.2454 a</td>
</tr>
<tr>
<td>Feed conversion ratio (FCR)</td>
<td>2.098 a</td>
<td>2.012 a</td>
<td>1.976 a</td>
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</table>

Values within a row bearing the same letter are not significantly different according to LSD test (p >0.05)

Generally over the whole period of the trial, egg weight increased with age and treatment C clearly has a strong positive effect on egg weight compared to the control while treatment B did not seem to have an effect (Figure 1). Egg production due to treatment B was higher at the earlier part of the trial (first 2 weeks); this difference disappeared by the end of the trial (Figure 2). Treatment C showed a slightly elevated egg production from 3-5 weeks compared to treatment A and B. Clearly there was an interaction effect between treatment x time.

Over the 6 weeks feeding trial, total feed intake, total egg produced, total egg weight and feed conversion ratio were not significantly different (p >0.05) between the treatments (Table 1). Addition of RYR in the diet resulted in maroon coloured faeces from the first day of feeding and the intensity of the colour directly corresponded to RYR inclusion levels. However, the RYR colour was not transferred to the yolk as no significant differences in yolk colour were observed between treatments and control.

At the 6th week, eggs selected for cholesterol analysis are shown in Table 2. Mean yolk weight was significantly higher (p <0.05) in treatment 2 compared to the control but not significantly different (p >0.05) to treatment 3.
Mean cholesterol per egg was significantly lower (p < 0.05) by 13.1% in treatment 2 compared to the control and treatment 3 (Table 2). The concentration of cholesterol per gram yolk was also significantly lower (p < 0.05) in treatment 2 compared to the control and treatment 3. The values for mean cholesterol per gram egg was also significantly lower (p < 0.05) in treatment 2 compared to the control but not significantly different from treatment 3.

Table 2  Cholesterol composition of eggs from layers fed RYR supplements.

<table>
<thead>
<tr>
<th></th>
<th>Treatment 1</th>
<th>Treatment 2</th>
<th>Treatment 3</th>
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</thead>
<tbody>
<tr>
<td>Mean egg weight (g)</td>
<td>60.36 ab</td>
<td>59.82 a</td>
<td>61.77 b</td>
</tr>
<tr>
<td>Mean yolk weight (g)</td>
<td>13.44 a</td>
<td>14.11 b</td>
<td>13.92 ab</td>
</tr>
<tr>
<td>Mean cholesterol (mg/egg)</td>
<td>146.91 a</td>
<td>127.62 b</td>
<td>143.86 a</td>
</tr>
<tr>
<td>Mean cholesterol per gm yolk (mg/g)</td>
<td>10.93 a</td>
<td>9.04 b</td>
<td>10.33 a</td>
</tr>
<tr>
<td>Mean cholesterol per gm egg (mg/g)</td>
<td>2.43 a</td>
<td>2.13 b</td>
<td>2.33 ab</td>
</tr>
</tbody>
</table>

Values within a row bearing the same letter are not significantly different according to LSD test (p > 0.05)

Discussion

The use of RYR in layer diets has been reported previously by Wang and Pan (2003) who also observed no differences in egg production with addition of 2, 5 and 8% RYR. However, they reported significantly lower egg weight at 2% RYR compared to the control and no significant differences at higher supplementation, while our study showed no significant differences at 2% RYR. The higher egg weights seen at 4% RYR suggest that higher RYR supplementation can increase egg size. Although the 4% RYR supplementation group laid significantly bigger eggs and had higher egg production, the total egg weight for the experimental period was not significantly higher than the control. Wang and Pan (2003) reported significantly poorer FCR with RYR supplementation while no significant differences in FCR were observed in our study. This study showed that supplementation with RYR caused no adverse effects on layers. Red yeast rice is a dietary staple in many Asian countries, especially China and Japan, with typical consumption ranging from 14 to 55 g per person per day (cited by Heber et al, 1999). In addition, Zhu et al, (1998) have reported that rats treated with RYR doses of 5.0 g per kg bodyweight per day for 90 day showed no evidence of toxicity on histopathologic examination or in biochemical liver function tests and this dosage correspond to a dose roughly 50 times that used in humans.

Wang and Pan (2003) have reported a maximum of 13.9% reduction in egg cholesterol (167.17 mg cholesterol/egg, concentration 10.47 mg cholesterol/g yolk) with hens fed 2% RYR. By comparison, our study showed a maximum of 13.13% reduction in egg cholesterol (127.62 mg cholesterol/egg, concentration 9.016 mg cholesterol/g yolk) was achieved by feeding 2% RYR. It is noted that the egg
cholesterol for our control (146.9 mg) in this study is much lower than the RYR supplemented and control eggs (167.17 and 194.14 mg respectively) reported by Wang and Pan (2003). Some of the differences can be explained by the different breed (SCWL Hyline W36), age (48-54 weeks), egg size, feeding regime and environmental conditions. A major difference in cholesterol content reported between the studies may be the choice of analytical method as Wang and Pan used the colorimetric method which has been reported to overestimate cholesterol content by 26.3% (Beyer and Jensen, 1989) and 24.8% (Jiang et al., 1991) compared to the HPLC method used here.

Elkin et al. (1999) who conducted an extensive study on the use of pharmaceutical grade statins have reported reductions of 46%, 7% and 22% in egg cholesterol and -19%, +4% and -3% egg production in hens fed atorvastatin, lovastatin and simvastatin respectively. As the monacolins in RYR are similar to lovastatin, the bigger reduction in egg cholesterol (13.1%) achieved here compared to Elkin et al. (1999) study may be due to the fact that in addition to the statin inhibitors of HMGCoA reductase, red yeast rice also contain sterols (β-sitosterol, campesterol, stigmasterol, and sapogenin), isoflavones and isoflavone glycosides (Heber et al., 1999) which can reduce cholesterol.

Herron and Fernandez (2004) in their opinion paper have said that the current blanket recommendations regarding dietary cholesterol and egg intake are unwarranted for the majority of people and not supported by scientific data. It has been suggested that 70% of humans are hyperresponsive to excess dietary cholesterol consumption and evidence suggests that for healthy individuals, the nutritional benefits of egg consumption clearly outweigh the concern surrounding the 213 mg of dietary cholesterol provided by one large egg.

The egg cholesterol levels reported here is very much less (about 30 – 40% lower) than the 213 mg reported by the USDA (Gebhardt and Thomas, 2002) for a large egg (50 grams edible portion). As eggs are a common food item for most people and with the interest in good nutrition, there is a market niche for nutritionally enhanced (designer or functional food) eggs such as omega-3 and selenium enriched eggs, and eggs with less cholesterol (Wong and Tan, 2003). In countries like Singapore, eggs with 25% less cholesterol or below 160 mg can qualify as lower cholesterol eggs and fetch a higher premium price. The present study suggest that a 13% egg cholesterol reduction with RYR eggs with 25% less cholesterol or below 160 mg can qualify as lower cholesterol eggs and further studies perhaps with a combination of supplements (Lien et al., 2004) is required.

References


Effect of red yeast rice supplements on egg production and cholesterol: H.K. Wong et al.


