REARING PHOTOPERIOD AND EGG COMPOSITION: DIFFERENTIAL EFFECTS OF LD 12:12 AND LONG PHOTOPERIOD (LD 18:6) IN RIR HENS

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ABSTRACT

One day old pullets of Indian RIR breed were reared under LD 12:12 (NLD) throughout, or under a step down photic schedule of LD 18:6 (long photoperiod; LP; from day 1 to day 90) followed by LD 12:12. The effect of these photoperiodic schedules on physical features and biochemical composition of eggs has been assessed. The LP hens laid marginally heavier eggs compared to the NLD hens. The eggs of LP hens showed higher weights of yolk and albumen and a lower yolk:albumen ratio. On a temporal scale, the percentage water content of yolk and solid content of albumen showed a reverse trend between the NLD and LP eggs. The total protein and total cholesterol contents were significantly increased in both yolk and albumen of LP eggs while the carbohydrate and total lipid contents decreased in yolk and albumen respectively. A comparison of calorific value shows significantly greater energy content (13.4%) in LP eggs. Overall, the present evaluations provide hitherto unreported evidence of a step down photoperiodic schedule on the structure and composition of eggs and their nutritional status.

INTRODUCTION

The practice of using different photic schedules as part of poultry management, has necessitated an evaluation of the impact of such photoperiodic manipulations, on egg composition though, some studies have focused on the egg size alone (Hutchinson and Taylor, 1957; Dunn et al., 1990; Eitan and Soller, 1991; Sandoval and Gernat, 1996; Etches, 1996). The previous study in our laboratory had showed subtle, yet definite effect of a short photoperiod on the egg composition of domestic fowl. This has prompted the present study on the effect of a step-down photoperiodic manipulation on the physical features and chemical composition of the eggs in the Indian RIR breed.

MATERIAL AND METHODS

24 one day old pullets of the domestic fowl of Rhode Island Red (RIR) breed were procured from Model Poultry Farm, Baroda, Gujarat, India. From day 1 to day 90, the chicks were housed in cages (4x2.5x2 ft) and placed in light proof enclosures, and thereafter shifted to layer's cages. The chicks were fed with water ad libitum and a rations diet as follow:

<table>
<thead>
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<th>days/initiation of egg laying (IL)</th>
<th>termination of egg laying</th>
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<tbody>
<tr>
<td>Chick mash</td>
<td>days 1-56</td>
<td>30 gm/bird/day</td>
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<tr>
<td>Grower mash</td>
<td>day 57 to IL</td>
<td>90 gm/bird/day</td>
</tr>
<tr>
<td>Layer mash</td>
<td>from IL to termination of IL</td>
<td>110 gm/bird/day</td>
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The lighting of the cages was done by four fluorescent tubes fitted atop the cages. The light intensity was maintained at 250 lux and checked with a lux meter.

The chicks were divided into two groups having 12 chicks each. The chicks of Group I were reared under a photoperiod of L:D 12:12 throughout referred to as NLD and Group II were reared under a long photoperiod of LD 18:6 from day 1 to day 90 post hatch and thereafter shifted to L:D 12:12 referred to as LP.

The lights were switched on for both the groups at 0700 hrs for both the groups.

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and switched off at 1900 hrs for group I and at 0200 hrs for group II by an automatic timer. Random selection of 12 eggs was done and the analysis of eggs was carried out during the initial (35-40 days after IL), mid phase (5-6 months after IL) and late phase (10-12 months after IL). The physical parameters of eggs like the egg weight, height, width, volume, shell weight, shell thickness and yolk and albumen weights were recorded. Known amounts of fresh yolk or albumen were taken and their protein content was estimated by the method of Lowry et al. (1951). The carbohydrate content was estimated by the method of Seifer et al. (1950), whereas the total lipid and total cholesterol contents were estimated by the methods of Folch et al. (1957) and Crawford (1950) respectively. The data was examined for statistical significance by Student’s 't' test. Nonlipid dry matter was calculated by subtracting the sum of total protein and carbohydrate from total lipids (Ricklefs, 1977). The calorific value was calculated utilising energy equivalents of 9 Kal/gm for lipid and 4 Kal/gm for protein and carbohydrates (Winton, 1993). The relative component of egg was expressed in terms of water index (ratio by weight of water to non-lipid dry matter) and lipid index (ratio by lipid to non-lipid dry matter).

RESULTS AND DISCUSSION

The influence of photoperiod, an environmental factor identified to be of great relevance in poultry maintenance and productivity, on the structure and composition of eggs, has not been investigated comprehensively though, some studies have shown realisation of larger egg size with an improved shell quality under ahermal photic schedules (Etches, 1996). The present study in this respect brings out some of the favourable effects of a step-down photoperiod on the egg quality of Indian RIR hens. On an overall basis, taking into consideration the entire lay, the only physical measurements which showed significant change under LP were, decreased egg width (-8.8%) and shell thickness (-15%) and increased egg volume (+12%) (Table 1). Though there was no difference in egg weight on an overall basis, the average egg weight during the mid and late phases of lay, were significantly greater in LP hens (50.8 gm in NLD Vs 53.8 gm in LP). This suggests that 65-70% of the eggs laid by LP hens are heavier than those laid by NLD hens. Further, the temporal increase in physical measurements of eggs from initial to late phase, is also greater in LP eggs on a percentage basis, except for egg width. The mean overall yolk and albumen contents were similar in NLD and LP eggs though, there was slight higher albumen content, and the values are within the range reported for poultry eggs (Panda, 1995: Etches, 1996). The temporal increment in yolk and albumen contents was more in the LP eggs and, in terms of maximal increase, was more prominent in that of albumen (6.6% in NLD Vs 15.6% in LP). The increase in the albumen content is more remarkable in the late phase, reflected in the much lesser yolk: albumen ratio of LP eggs (5.1), as compared to that of the NLD eggs (6.0) (Table 2).

<table>
<thead>
<tr>
<th>Table 1. Physical features of eggs of birds under NLD and LP</th>
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<tbody>
<tr>
<td>Egg weight (in gms)</td>
</tr>
<tr>
<td>NLD 50.78 ± .45</td>
</tr>
<tr>
<td>LP 51.98 ± .760</td>
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</table>

Values: Mean ±SE, *P< .05, **P< .005, P< .0005.
Table 2. Physical features of eggs of birds under NLD and LP during initial, peak and late phases of lay.

<table>
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<tr>
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<th>Initial Phase</th>
<th>Mid Phase</th>
<th>Late Phase</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>NLD</td>
<td>LP</td>
<td>NLD</td>
</tr>
<tr>
<td>Egg weight (gms)</td>
<td>48.76 ± .41</td>
<td>48.25 ± .69</td>
<td>50.60 ± 1.87</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>5.14 ± .18</td>
<td>4.90 ± .07</td>
<td>5.44 ± .05</td>
</tr>
<tr>
<td>Width (cm)</td>
<td>3.97 ± .30</td>
<td>3.70 ± .01</td>
<td>4.52 ± .02</td>
</tr>
<tr>
<td>Egg Volume (cc)</td>
<td>40.07 ± .69</td>
<td>43.25** ± .51</td>
<td>41.60 ± .26</td>
</tr>
<tr>
<td>Shell weight (gms)</td>
<td>6.11 ± .46</td>
<td>6.57 ± .53</td>
<td>5.31 ± .26</td>
</tr>
<tr>
<td></td>
<td>(12.53%)</td>
<td>(13.61%)</td>
<td>(10.49%)</td>
</tr>
<tr>
<td>Shell thickness (mm)</td>
<td>0.317 ± .037</td>
<td>0.276 ± .007</td>
<td>0.348 ± .005</td>
</tr>
<tr>
<td>Yolk weight (gms)</td>
<td>15.18 ± .88</td>
<td>14.73 ± .33</td>
<td>16.60 ± .70</td>
</tr>
<tr>
<td></td>
<td>(31.13%)</td>
<td>(30.52%)</td>
<td>(32.8%)</td>
</tr>
<tr>
<td>Albumen weight (gms)</td>
<td>27.18 ± .47</td>
<td>27.25 ± .902</td>
<td>29.0 ± 3.30</td>
</tr>
<tr>
<td></td>
<td>(55.74%)</td>
<td>(56.37%)</td>
<td>(57.3%)</td>
</tr>
<tr>
<td>Yolk : albumen ratio</td>
<td>0.55</td>
<td>0.54</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Values: Mean ±SE, * P< .05, ** P< .005, *** P< .0005.

The overall mean protein content of both yolk and albumen was significantly greater in the LP eggs compared to NLD eggs. On a temporal scale, the protein content of both yolk and albumen increased in the mid phase and then decreased during the late phase in the case of NLD eggs. On the other hand, in the case of LP eggs, though the protein content of albumen showed a similar change, the protein content of yolk remained high from mid to late phase. On a comparative basis, the maximal increase in the protein content was significantly greater in the LP eggs with reference to both yolk (15.1% NLD Vs 19.1% LP) and albumen (7.2% NLD Vs 26% LP). Moreover, the protein content of yolk and albumen in the late phase was significantly greater by 16.5% and 22.5% respectively. It is conceivable from these that, a long photoperiod during the rearing period of pullets, amounting to a step-down photoperiodic schedule, has a favourable positive influence on the protein content of eggs. This is of a further additive nature as, the protein content recorded in the present study for the eggs of Indian RIR breed under NLD is slightly higher than the range documented for other breeds (see Panda, 1995; Etches, 1996), though similar yolk protein content has been recorded by Sainz et al. (1983) and Roca et al. (1984) in the RIR hens (Figs. 1 and 2a).

The carbohydrate content, essentially representing the free glucid fraction (estimated in the present study), is 82% more in yolk than in albumen of NLD eggs. The eggs of LP birds showed a 44% reduction in the yolk glucid content with a reciprocal 46.4% increment in the albumen glucid content. In the initial phase of laying, whereas the free glucid content of albumen was similar in both NLD and LP eggs, the glucid content of Yolk was 37% lesser in the LP eggs. There was a temporal decrease in the yolk glucid content of both NLD and LP.
Fig. 1. Changes in composition of eggs of birds reared under NLD or LP

**PROTEIN**

**CARBOHYDRATE**

**TOTAL LIPIDS**

**CHOLESTEROL**

* * P < .05, ** * P < .005, *** * P < .0005
Fig. 2a. Changes in total protein and carbohydrate contents in eggs of birds reared under NLD or LP during the initial, mid and late phases of lay.

**TOTAL PROTEIN**

![Graph showing changes in total protein](image)

**CARBOHYDRATES**

![Graph showing changes in carbohydrates](image)

* - P < .05, ** - P < .005, *** - P < .0005
eggs which was relatively more pronounced in the NLD eggs compared to LP eggs (80.7% Vs 58.7% respectively). There was a similar decrement in the glucid content of albumen as well, in the eggs of NLD hens by 86.6% while, the glucid content in the LP eggs tended to remain constant, except for a 28% decrease in the mid phase. Overall, a step-down photos-periodic schedule has an influence on the egg glucid content in the form of an increased load in the albumen and decreased load in the yolk (Fig. 1 and 2a).

The mean total lipid content, estimated in the eggs of Indian RIR hens maintained under NLD, is slightly different from the total lipid content reported by other workers (Broody, 1945; Romanoff and Romanoff, 1949; Roca et al., 1984; Hall and Mckay, 1993; Panda, 1995; Etches 1996) as, the yolk lipid content was slightly lower and the albumen lipid content slightly higher in the present study. The lipid content of LP eggs showed a differential change, with 18.5% increase in the yolk and 15.5% decrease in the albumen. Apparently, LP has influence on the lipid load of yolk and albumen, suggesting alterations in the metabolism of liver and oviduct. Temporal alterations in the lipid content, during the course of lay, reveals an increase in the yolk lipid content (15.14%) in the LP eggs and a decrease in the same (19%) in the NLD eggs. The albumen lipid content, which also showed a continuous decrement by 72.6% in the NLD eggs, did not reveal a similar pattern in the LP eggs as there was an increase by 47.6% in the mid phase, which was then followed by decrement by 44% in the late phase (Figs. 1 and 2b).

The water and lipid indices, representing the ratio of water and lipids to the non-lipid dry material, are inferred to show correspondence with the water and lipid indices of newly hatched chicks as, the non-lipid component is considered to be the most conservative fraction used primarily for synthesis and thereby assimilated by the embryo, while, the water and lipid contents of the eggs decrease during in ovo development due to evaporation and metabolism during respiration respectively (Ricklefs, 1977). Though there was no difference in the water index of NLD and LP eggs, the lipid index tended to be higher in the LP eggs due to both, a decrease in the non-lipid material, as well as increase in the lipid material. This increase in the lipid index of egg as a whole is mainly due to the increase in the yolk lipid index as a consequence of noticeable decrease in the non-lipid content and marginal increment in the lipid content. It can be inferred from the similar content of non-lipid dry material, that, the chicks hatching out of both the NLD and LP eggs would have similar weights, suggesting that LP has no effect in this respect (Fig. 3).

The cholesterol content of yolk is relatively more than that of albumen in both NLD and LP eggs as reported by other workers (Panda, 1993; Etches, 1996). The eggs of LP hens shows significant increment in the cholesterol content of both yolk and albumen by 46.2% and 172.5% respectively. During the course of lay, whereas the yolk cholesterol content showed a decrement in the eggs of NLD hens by 19% in the late phase and, a maximum decrement by 28.6% during the mid phase, that of LP eggs was significantly higher by 33.5% and 44.8% respectively. The albumen cholesterol content however showed differential change, with a decrease by 94.8% in the NLD eggs and increase by 37.5% in the LP eggs. The age dependent decrement in the yolk cholesterol content during lay recorded herein, as against the NLD eggs, is corroborated by a report of similar decrement during lay in the Hisex Brown breed (Hall and Mckay, 1993). However, they reported a concomitant reciprocal increment in the total lipid content of yolk though, in the present study, a
Fig. 2b. Changes in total lipids and total cholesterol contents in eggs of birds reared under NLD or LP during the initial, mid and late phases of lay.

**TOTAL LIPIDS**

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<th>INITIAL</th>
<th>MID</th>
<th>LATE</th>
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<tbody>
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<td>NLD</td>
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<td>LP</td>
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**TOTAL CHOLESTEROL**

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<td>LP</td>
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* - P < .05, ** - P < .005, *** - P < .0005
Fig. 3. Changes in composition of eggs of NLD and LP birds expressed in terms of gms in yolk/albumen.

- **TOTAL LIPIDS**
  - NLD
  - LP

- **NON LIPID DRY**
  - NLD
  - LP

- **WATER INDEX**
  - Yolk
  - Albumen
  - Whole egg

- **LIPID INDEX**
  - Yolk
  - Albumen
  - Whole egg

- **CALORIFIC VALUE**
  - Whole egg
  - NLD
  - LP
  - Per 100 gm egg
parallel decrement in the lipid content is noted, thereby suggesting a possible strain difference. But, the LP eggs in the present study, showed a parallel increase in both the cholesterol and the total lipid contents of yolk. Since the proportion of total cholesterol to total lipid remains more or less same, it is inferrable that, the increase in the cholesterol content is accompanied by proportionate increase in the non-cholesterol and non-lipid fractions in the lipoprotein moieties that are being synthesized. The differential changes noted with regard to the cholesterol content of albumen between the NLD and LP eggs, suggest an altered lipoprotein metabolism in the magnum part of the oviduct under the two photoperiodic schedules. A comparison of the caloric value of eggs of NLD and LP hens clearly projects significantly greater energy content, by 13.4%, in the latter in terms of 100 gm edible egg (Fig. 3).

In conclusion, the present evaluations provide hitherto unreported evidence of a step down photoperiodic schedule on the structure and composition of eggs and their nutritional status.

ACKNOWLEDGEMENT

Prof. A.V. Ramachandran acknowledges with thanks the Council of Scientific and Industrial Research, India, for the award of a Research Project no. 37(0820)/93/EMR-II, during the tenure of which part of this work was carried out.

REFERENCES