CHAPTER 5

Rearing photoperiod and egg composition : Differential effects of normal (LD 12:12) and long photoperiod (LD 18:6) in RIR hens.

Introduction :

The shelled egg of birds, is a large female gamete, with an inherent genetic programme for development post-fertilization, forming a closed container for withstanding the rigours of the terrestrial conditions and, with a store house of micro and macronutrients in the yolk and albumen, for support of development (Freeman and Vince, 1974). Due to its status as an important component of human diet, the egg of galliform birds has drawn more attention (Everson and Sounders, 1957; Sevensson, 1964; Parkinson, 1966; Lahiri and Balinga, 1970; Froning, 1971; Cotteril *et al.,* 1977; Sibbald, 1979). The composition of both yolk and albumen of the domestic fowl, has been studied in some detail in terms of their lipid and protein contents (Riemenschneider *et al.,* 1938; Cruickshank, 1941; Shorland, 1951; Rhodes and Lea, 1956; Evans and Bandermer, 1961; Parkinson, 1966; Christie and Moore,1970, 1972; Edwards, 1974, Cunningham and Lee, 1978). The size and composition of eggs, are known to be influenced by their nutritional status, age and body weight, genetic make up and, even conditions of maintenance (Cruickshank, 1941; Gutteridge and O'Neil, 1942; Everson and Sounders, 1957; Patton and Palmer, 1958; Cunningham *et al.,* 1960; Edwards, 1964; Chung and Staddman 1965; Marion *et al.,*1965; Sibald, 1979; Washburn, 1979; Sainz *et al.,*1983; Winton, 1993; Panda, 1995; Etches, 1996). Of these, the genetic make up, the age at sexual maturity, the protein content of the diet and even photoperiodic conditions, are suggested to have greater bearing on the size and weight of eggs (see Etches, 1996). As, the micronutrients and the major bulk of organic nutrients, are needed to support embryonic development, their content in the eggs has been shown to remain constant under different dietary status of the hen. Most of the studies on the composition of eggs of domestic fowl, have remained restricted to temperate breeds (Ricklefs, 1977; Roca *et al.,* 1984). Except for an isolated study in a restricted sense on the eggs of some breeds from Egypt (Amer, 1972), no studies have been conducted in tropical breeds. Moreover, 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 of the egg size alone (Hutichnson and Taylor, 1957; Dunn *et al.*, 1990; Eitan and Soller, 1991; Sandoval and Gernat, 1996; Etches, 1996). 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 as, the impact of such a photic schedule on egg productivity and various facets of laying performance was previously reported (see Chapter 2).

Results :

Physical features :

The overall egg weight of both NLD and LP hens was similar, though marginally higher in the latter. The egg weight increased gradually from initial to late phase of lay, in both groups, with the egg weight of LP hens being significantly greater. With similar weight in the initial phase, the maximal increase was 4.6% in the NLD eggs and 11% in the LP eggs. There was no difference in the overall height of egg and shell weight, but the egg width and shell thickness were significantly less and, egg volume significantly more in the LP eggs (Table1).

The height, width, egg volume and shell weight showed increment from initial to late phase in both the NLD and LP eggs. Except for the egg width, which showed maximum increment in the NLD eggs (13.3% Vs 8.6%), all other features showed maximum increment in the LP eggs (height 7% Vs 14.1%; Volume, 3.8% Vs 8.9%; Shell thickness, 3.1% Vs 20.4%). The shell weight showed a temporal decrement in both the groups, with maximal decrement by 14.8% in the NLD eggs and 22.8% in the LP eggs, in the late phase. The overall weights of yolk and albumen were nearly identical and, on percentage basis, the yolk content was slightly lesser and, the albumen content was slightly more in the LP eggs. The weight of both yolk and albumen, tended to increase during lay with maximum increment being shown by the LP eggs (12.9% Vs 16.5% for yolk and 6.6% Vs 15.6% for albumen). In general, the yolk : albumen ratio, was lesser in the LP eggs. The percentage content of water and solids did not show any difference in the albumen, while the percentage water content of yolk was significantly decreased in the LP eggs. On a temporal scale, the percentage water and solid contents in the yolk and albumen, showed a reverse trend between the NLD and LP eggs, with the percentage water content of yolk and the solid content of albumen increasing in the NLD eggs and, percentage solid content of yolk and the percentage water content of albumen increasing in the LP eggs (Table 2).

Chemical composition :

The protein, lipid and cholesterol contents of yolk, were significantly increased in the LP eggs while, the carbohydrate content was decreased. The protein, carbohydrate and cholesterol contents of albumen were also increased in the LP eggs, though the total lipid content showed a decrement (Table 3, fig. 1).

In terms of protein, glycogen, lipid and cholesterol contents of yolk and albumen in the initial phase, the eggs of LP hens showed a significantly decreased yolk carbohydrate (37.3%), albumen lipid (65%) and albumen cholesterol (79.4%) contents and, an increased albumen protein content (8.8%). Temporally, the protein content of yolk was higher than in the initial phase in both NLD and LP eggs with, a maximal increase of 15.1% in the mid phase, in the former and of 19.1% in the late phase in the latter. The protein content of albumen was maximal in the mid phase, by 7.2% in the NLD eggs and by 26% in the LP eggs and, minimal in the late phase, by 25% in the NLD eggs and by 9.6% in the LP eggs. The yolk carbohydrate content decreased during lay, in both NLD and LP eggs, with maximal decrement in the mid phase by 80.2% in the former and by 58.7% in the latter. The albumen carbohydrate content of NLD eggs showed a very significant depletion by 86.6% in the late phase, while that of LP eggs showed a decrease only in the mid phase by 28% (fig. 2a). The yolk lipid content decreased by19.8% in the late phase in NLD eggs, while the same increased by 15% in the LP eggs. The albumen lipid content also showed a similar trend in the NLD eggs with a maximum decrease of 72.6%. However, the albumen lipid content in the LP eggs increased by 47.4% in the mid phase and, decreased by 44% in the late phase. The cholesterol content in yolk and albumen of NLD eggs, decreased during lay, with a maximal decrease of 28.6% in the mid phase in yolk, and of 94.8% in the

Table 1: Physical features of eggs of birds under NLD and LP

	Egg weight (in gms)	Height of egg (mm)	Width (mm)	Volume (cc)	Shell weight (gms)	Shell thicknes s (mm)	Yolk weight (gm)	Albume n weight (gm)
NLD	50.78 ± .45	5.36 ± .045	4.30 ± .067	40.95 ± .187	5.54 ± .117 (10.9%)	0.327 ± .004	16.31 ±0.231 (32.19%)	28.16 ± .216 (55.4%)
LP	51.98 ± .760	5.37 ± .099	3.92*** ± .046	45.82*** ± .535	5.88 ± .178 (11.31%)	0.290** ± .011	16.20 ± .347 (31.11%)	29.90* ± .599 (57.5%)

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.

	Initial Phase		Peak Phase		Late Phase	
	NLD	LP	NLD	LP	NLD	LP
Egg weight (gms)	48.76 ± .41	48.25 ± .69	50.60 ± 1.87	54.19* ± .52	51.00 ± .93	53.51* ± .86
Height (cm)	5.14 ± .18	4.90 ± .07	5.44 ± .05	5.50** ± .07	5.50 ± .48	5.71 ± .57
Width (cm)	3.97 ± .30	3.70 ± .01	4.52 ± .02	4.03 ± .06	4.43 ± .29	4.05 ± .04
Egg volume (cc)	40.07 ± .69	43.25** ± .51	41.60 ± 1.69	46.66* ± .84	41.20 ± .93	47.5*** ± 1.15
Shell weight (gms)	6.11 ± .46 (12.53%)	6.57 ± .53 (13.61%)	5.31 ± .26 (10.49%)	6.01 ± .54 (11.09%)	5.20 ± .39 (10.09%)	5.07 ± .52 (9.47%)
Shell thickness (mm)	0.317 ± .037	0.276 ± .007	0.348 ±.005	0.347 ± .008	0.317 ± .007	0.249 ± .031
Yolk weight (gms)	15.18 ± .88 (31.13%)	14.73 ± .33 (30.52%)	16.60 ± .70 (32.8%)	17.66 ± .23 (32.58%)	17.15 ± .55 (32.62%)	16.50 ± .288 (30.8%)
albumen weight (gms)	27.18 ± .47 (55.74%)	27.25 ± .902 (56.37%)	29.0 ± 3.30 (57.3%)	30.33 ± .23 (55.96%)	28.30 ± .54 (55.49%)	32.3 ± 1.02 (60.36%)
yolk : albumen ratio	0.55	0.54	0.57	0.58	0.60	0.51

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

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	Late Phase	
	NLD	LP
Egg weight (gms)	51.00 ±.93	53.51* ±.86
Height (cm)	5.50 ±.48	5.71 ±.057
Width (cm)	4.43 ±.29	4.05* ±.04
Egg volume (cc)	41.20 ±.93	47.5** ±1.15
Shell weight (gms)	5.20 ±.39 (10.09%)	5.07 ±.52 (9.47%)
Shell thickness (mm)	0.317 ±.007	0.249 ±.031
Yolk weight (gms)	17.15 ±.55 (33.62%)	16.5 ±.288 (30.80%)
albumen weight (gms)	28.30 ±.54 (55.49%)	32.3** ±1.02 (60.36%)
yolk : albumen ratio	0.60	0.51

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

Table 3: Composition of eggs of birds under NLD and LP

	% Water content		% Solids		Total Protein		Carbohydrate		Total Lipids		Total Cholesterol	
	yolk	albumen	yolk	albumen	yolk	albumen	yolk	albumen	yolk	albumen	yolk	albumen
NLD	48.10 ± .418	86.33 ± .269	52.10 ± .474	13.67 ± .269	17.74 ± .295	13.83 ± .546	0.0864 ±.0019	0.0153 ±.0003	20.14 ± .549	0.290 ± .044	1.47 ± .067	0.0309 ± .0009
LP	46.46* ± .345	86.79 ± .721	53.52 ± .519	13.17 ± .495	19.18* ± .531	16.78** ± .692	0.0483*** ± .0004	0.0303*** ± .0032	24.23*** ± .607	0.179* ± .023	2.15*** ± .124	0.0197*** ± .0009

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

Table 4: Composition of eggs of birds under NLD and LP during initial, peak and late phases of lay (expressed as mg/100mg yolk or albumen).

	Initial phase				Peak phase			
	NLD		LP		NLD		LP	
	yolk	albumen	yolk	albumen	yolk	albumen	yolk	albumen
% Water content	46.10 ± .71	87.10 ± .83	46.71 ± 1.63	85.23 ± .31	48.74 ± 1.29	86.88 ± .15	44.19* ± .97	86.04 ± .22
% Solids	54.36 ± .58	12.89 ± .35	53.29 ± 1.63	14.77* ± .31	51.45 ± .93	13.14 ± .12	55.09** ± .89	12.96 ± .22
Total Protein	16.54 ± .46	13.61 ± .45	16.58 ± .88	15.91*** ± .77	19.04 ± .81	15.67 ± .41	20.47 ± 1.31	20.06*** ± .55
Carbohydrates	0.182 ± .004	0.030 ± .001	0.044*** ± .018	0.032 ± .005	0.036 ± .007	0.010 ± .001	0.047 ± .010	0.023*** ± .002
Total Lipids	22.74 ± 2.27	0.501 ± .062	22.58 ± .72	0.175*** ± .033	19.46 ± 2.45	0.233 ± .036	23.52 ± .61	0.258 ± .051
Total Cholesterol	1.78 ± .07	0.078 ± .001	1.72 ± .18	0.016*** ± .004	1.21 ± .11	0.010 ± .002	2.55 ± .468	0.022** ± 003

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

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	Late Phase			
	NLD		LP	
	yolk	albumen	yolk	albumen
% Water content	49.50 ± 1.12	85.02 ± .38	47.82 ± 2.04	89.10** ± 0.11
% Solids	50.50 ± .50	14.98 ± .02	52.18 ± 2.04	10.97** ± 0.29
Total Protein	17.60 ± .21	11.73 ± .36	20.51*** ± .55	14.38*** ± .37
Carbohydrates	0.039 ± .005	0.004 ± .0006	0.053 ±.003	0.0362*** ± .001
Total lipids	18.23 ± .88	0.137 ± .0009	26.61*** ± .92	0.098*** ± .008
Total Cholesterol	1.44 ± .11	0.004 ± .0008	2.35 ± .188	0.0211*** ± .0018

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

Table 5 : Compostion of eggs of NLD and LP birds expressed in terms of gms. in yolk/albumen.

		% Water content	% Solids	Water Index	Lipid Index	Total Lipids (gms.)	Non-lipid dry (gms.)	Carbohydrate (gms.)	Protein (gms.)
Yolk	NLD	7.84	8.49	1.5	0.631	3.28	5.21	0.014	2.89
	LP	7.52	8.67	1.55	0.8	3.86	4.82	0.0078	3.1
Albumen	NLD	24.31	3.84	6.46	0.021	0.081	3.76	0.004	3.89
	LP	25.95	3.93	6.65	0.011	0.043	3.9	0.006	5.01

Values : Mean

Table 6. Composition of eggs of NLD and LP birds expressed as gms. in whole egg, along with water index, lipid index and calorific value.

	Water content (gms)	Lipid content (gms)	Non-lipid dry (gms)	Water index	Lipid index	Carbohydrate (gms)	Total Protein (gms)	Calorific value	
								Edible egg	Per 100 gm edible egg
NLD	32.15	3.36	8.95	3.58	0.374	0.0182	6.78	57.43	129.14
LP	33.47	3.90	8.72	3.83	0.448	0.0138	8.11	67.61	146.67

Values : Mean

Fig. 1. Overall contents of protein, carbohydrates, lipids and cholesterol of NLD and LP eggs.

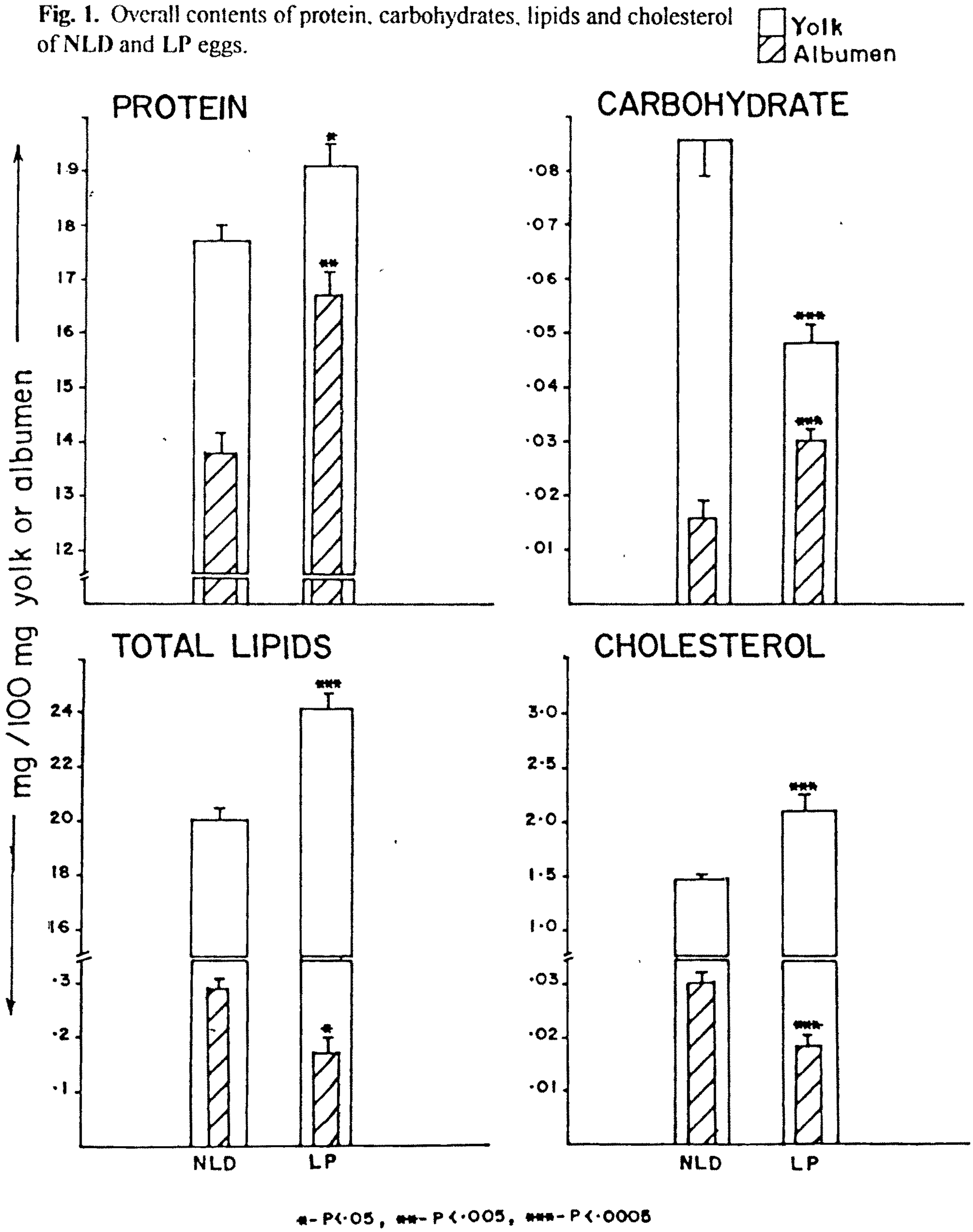


Fig. 2a. Contents of total protein and carbohydrates of NLD and LP eggs.

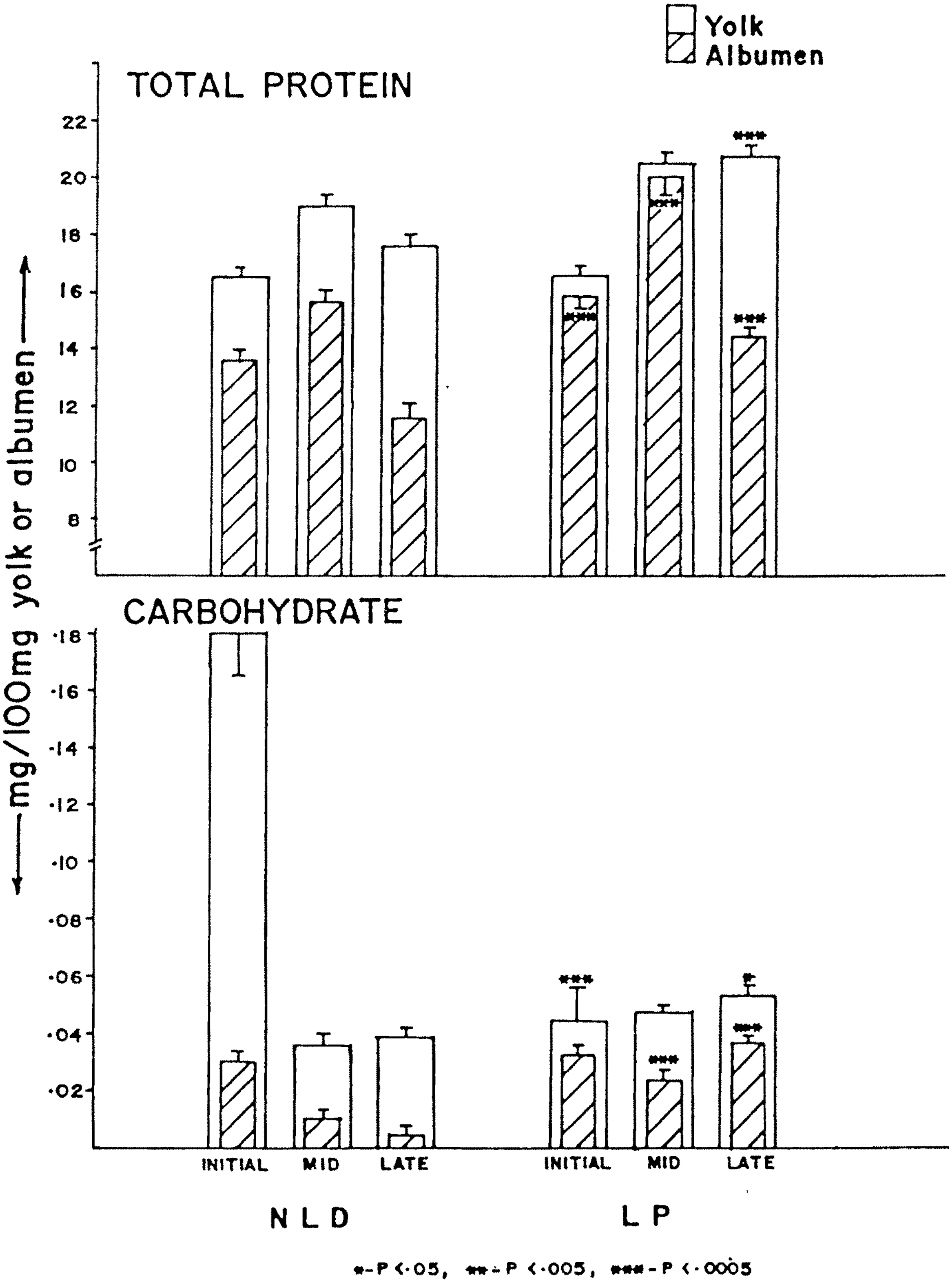


Fig. 2b. Contents of total lipids and cholesterol of **NLD** and **LP** eggs.

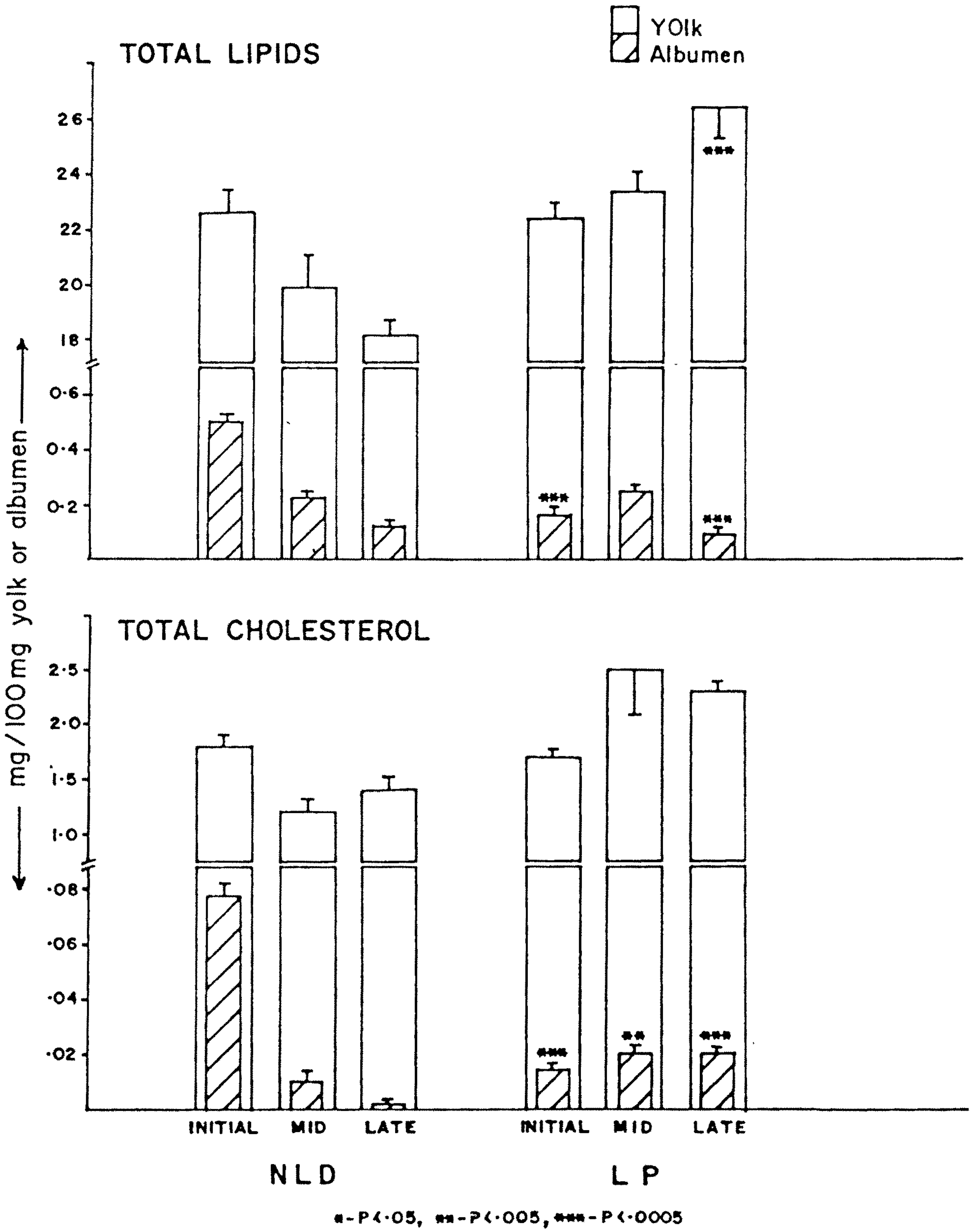
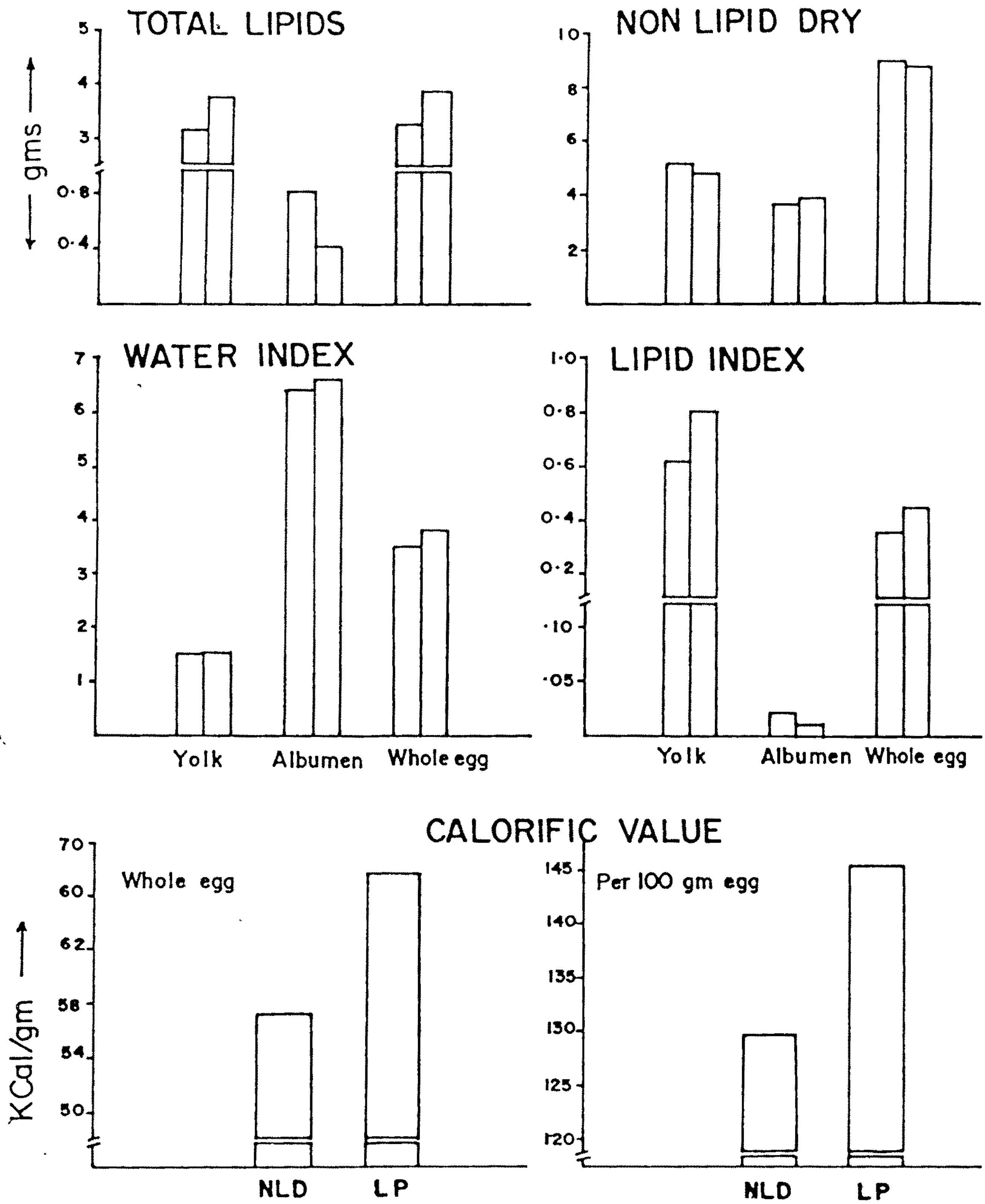


Fig. 3. Contents of lipid, non-lipid dry matter, water & lipid indices and calorific value of NLD and LP eggs.



late phase in albumen. In contrast, the cholesterol content of LP eggs in the mid phase increased in both yolk and albumen by a maximum of 30.9% in the case of yolk and by 37.5% in the case of albumen (fig. 2b)(Table4).

Discussion :

Differences in structure and composition of eggs of birds have been reported, with bearing on the type of embryonic development and the status of the hatchling (Ricklefs,1977; Roca *et al.,* 1982, 1984; Dandekar, 1998). The egg of domestic fowl, *Gallus domestics*, has been studied in detail, due to its precocious status as well as its importance as a component of human diet. Some factors which affect the structure and composition of eggs of domestic hen are, the species, the genetic breed, the feed, the age of birds or oviposition interval (see Panda, 1995; Etches, 1996). 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 realization of larger egg size with an improved shell quality under ahemeral photic schedules (see 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%). 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 a slightlt higher albumen content, and the values are within the range reported for poultry eggs (see 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 (0.60).

The percentage contents of water and solids in the edible components of the egg, reveal decreased water content with increased solid content in the yolk and, no difference in the albumen of LP eggs. The pattern of change in water and solid contents of yolk and albumen on a temporal scale, has shown a noticable difference between the NLD and LP eggs. Whereas, the water content increased gradually with correlated decrement in the solid content in the yolk of NLD eggs, there was a significant decrement in the water content with concomitant increment in the solid content in he yolk of LP eggs, only during the mid phase. Similarly, the water content of albumen decreased with proportionate increase in solid content from initial to late phase in the NLD eggs while, in the LP eggs, there was a reciprocal pattern of change with increase in water content and decrease in solid content. Apparently, LP induces changes in the pattern of temporal alterations in the water and solid contents of yolk and albumen. The percentage water and solid contents in the yolk and albumen of Indian RIR eggs (recorded in the present study), when compared with the contents reported for other breeds (see Panda, 1995; Etches, 1996), suggest a slightly increased yolk solid content, with LP having a further magnifying influence.

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 Sains *et al.*(1983) and Roca *et al.* (1984) in the RIR hens.

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 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 photoperiodic 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. 2a)

The mean total lipid content, estimated in the eggs of Indian RIR hens maintained under normal photic schedule, 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 (fig. 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 an 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 (Table 5) (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 (see 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 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 calorific 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 (Table 5)(fig. 3).

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