CHAPTER 6

Transient mild hyper/hypocorticalism in pullets and egg composition in the domestic fowl (RIR breed).

Introduction

The avian egg is a closed system and its structure and composition are designed to withstand the stresses and strains of the terrestrial environment and support external development. Though the general organisation and chemical make-up are quite similar in the eggs of birds in general, some differences in terms of chemical composition occur in relation to altricial or precocial mode of development (Ricklefs, 1977; Roca *et al.*, 1982, 1984). Apart from its interest from the development point of view, the study of chemical composition of the eggs of domestic fowl has received greater attention due to its economic interest and relevance to human diet. The physical features and chemical composition of eggs are a consequence of metabolic status of the bird and more relevantly dependent on the metabolic capacities of liver, ovary and oviduct. In this respect, both external and internal factors having influence on metabolic functions are potentially capable of affecting the composition of eggs. The influence of some external factors like season, age and diet as well as internal factors, essentially genetic make-up have been studied in relation to the chemical composition of eggs of the domestic fowl (Cruickshank,

1941; Everson and Sounders, 1957; Cunningham *et al.,* 1960; Edwards, 1964). Since hormones exert significant moculatory effects on metabolic functions, they qualify as important factors of internal origin capable of influencing the composition of eggs. However, the influence of hormones in general, and that of adrenal corticosterc ds or thyroid hormones, in particular, (important metabolic hormones) on composition of avian eggs has not been studied, though their influence on body growth and general metabolism of domestic fowl have been stuc ed to some extent (Blivaiss, 1947; Winchester and Davis, 1952; Raheja and Snedecor, 1970; Marks, 1971; Howarth and Marks, 1973; King and King, 1973). Previous studies had documented a definite influence of hypercorticalism (HPR) or hypocorticalism (HPO) in growing pullets in relation to normal or experimental photoperiodic schedules, on sexual maturity and laying performance in the Indian RIR breed (Dandekar, 1998; Chapter 1). As a follow up, the present study on the structure and composition of eggs (at different ages of lay) laid by hens subjected to HPR or HPO during their immature pullet stage has been undertaken to decipher the role of corticosteroids on egg composition.

Results

Physical features :

The overall mean egg weight of HPR and HPO hens was significantly less, the lowest being that of the latter. There was no significant difference in any of the other physical measurements except for a tendency for slightly reduced egg volume in the case of HPR eggs and a slightly reduced shell thickness in the case of HPO eggs. All the physical measurements showed a gradual increment from the initial to late phase

of lay except, shell weight, which showed a decrement. This trend was showed by eggs of all the three groups of birds. The mean yolk weight was the same in all the three groups, approximately 32% of the egg weight. The albumen weight was however significantly less in both HPR and HPO birds and this difference in the albumen weight was mainly due to the significant reduction in the initial phase in HPR eggs and in the mid phase in HPO eggs (table 1).

Chemical composition :

There was no difference in the percentage water and solid contents in yolk and albumen of HPR eggs, while, in the HPO eggs, there was significant increment in the water content of yolk with concomitant decrement in the solid content. This difference was mainly due to changes in the initial and late phases of lay. With reference to metabolite content, the protein content of albumen was significantly increased in both the experimental groups, more pronouncedly in the HPR eggs. In the HPO eggs, the protein content of yolk was significantly decreased. In general, the glycogen content did not show much change except for an increment in the albumen of HPR eggs. The total lipid content of yolk was significantly more in both the experimental groups, more pronouncedly in the HPR. The lipid content of albumen however showed a decrement in the HPR eggs. The cholesterol content of yolk was significantly higher in the HPR eggs while that of albumen was significantly lower in both the groups (table 2)(fig. 1).

The yolk protein content which was lesser by 8% in HPO eggs in the initial phase, decreased further by 5.4% in the late phase, as compared to the control eggs, which showed a maximal increment by 15.11% in the mid

phase. In general, the protein content of albumen increased in the mid phase and decreased in the late phase. The increment was minimal (7.2%) and the decrement maximal (19.7%) in the control eggs and, vice-versa by (17.32% and 2%) in the HPR eggs. These changes were intermediate in the albumen of HPO eggs. In general, the carbohydrate content of both yolk and albumen tended to decrease during the course of lay. Though there were phase specific differences in the yolk carbohydrate content between the three groups, they however tended to nullify each other resulting in no net change in the yolk carbohydrate content. Same was the case with respect to the albumen carbohydrate content in the control and HPO hens. However, the albumen carbohydrate content of HPR eggs which was 40% higher in the initial phase decreased by only 73% in the late phase as against 87% in the control eggs thereby resulting in a net higher albumen carbohydrate content (fig. 2a). The total lipid content of yolk showed a general trend of decrease from the initial to late phases of lay. The decrease was more pronounced in the HPR eggs (57.4%) as against the control and HPO eggs (19.8% and 25.4% respectively). However, the yolk lipid content of HPR and HPO eggs was higher by 75.5% and 20% respectively in the initial phase and by 87.5% and 41.8% respectively in the mid phase. This has resulted in a significantly higher overall yolk lipid content in the HPR and HPO eggs. The overall albumen lipid content was higher in HPR eggs compared to control eggs mainly, due to a lesser decrease in the late phase (by 29.2%) as against (72.6%) and, an increased lipid content as against a decreased content in the mid phase, though the initial albumen lipid content was 55.6% lesser in the HPR eggs. The yolk cholesterol content was significantly higher in the HPR eggs due to a very high content in the initial phase (75%) despite the fact that the maximal decrement was higher in the HPR eggs compared to the control eggs (57.6% Vs 32%). The net

Table 1. Overall physical features of eggs of birds subjected to HPR and HPO birds under **NLD**.

	Egg weight (gms)	Height (cm)	Width (cm)	Volume (cc)	Shell weight (gms)	Shell thickness (mm)	Yolk weight (gms)	albumen weight (gms)
C	50.78 ±.45	5.36 ±.004	4.30 ±.06	40.95 ±.18	5.54 ±.11 (10.9%)	0.327 ±.004	16.31 ±.23 (32.1%)	28.1±.21 (55.4%)
HPR	48.50 ±.348***	5.23 ±.036	4.15 ±.060	39.98 ±.407	5.40 ±.013 (11.13%)	0.326 ±.007	16.14 ±.083 (33.27%)	26.77 ±.289 (55.13%)
HPO	47.71 ±.24***	5.26 ±.063	4.10 ±.026	41.22 ±.302	5.43 ±.077 (11.38%)	0.291*** ±.002	15.66 ±.158 (32.82%)	26.6±.16*** (55.75%)

Values : Mean ± SE, n=12 ,* P<.05, **P<.005, ***P<.0005.

Table 2. Physical features of eggs of birds subjected to HPR or HPO under **NLD**, during initial peak and late phases of lay .

	Initial Phase			Peak Phase		
	Control	**HPR**	**HPO**	**Control**	**HPR**	**HPO**
Egg weight	48.76 ±.41	46.81 ±.77*	46.74 ±.86*	50.6 ±1.87	49.20 ±.37	47.6 ±.50
Height (cm)	5.14 ±.18	5.07 ±.40	4.96 ±.31	5.44 ±.05	5.26 ±.06	5.64 ±.04
Width (cm)	3.97 ±.30	3.88 ±.32	4.06 ±.16	4.52 ±.02	4.18 ±.02	4.02 ±.03*
Egg volume (cc)	40.07 ±.69	38.06 ±.82	39.77 ±.72	41.60 ±1.69	41.4 ±.40	42.2 ±.58
Shell weight (gms)	6.11 ±.46 (12.5%)	5.47 ±.39 (11.68%)	5.81 ±.48 (12.43%)	5.31 ±.26 (10.49%)	5.36 ±.27 (10.89%)	5.20 ±.22 (10.92%)
Shell thickness (mm)	0.317 ±.037	0.361 .001	0.297 ±.032	0.348 ±.005	0.316 ±.006	0.280 ±.004***
Yolk weight (gms)	15.08 ±.88 (31.13%)	15.76 ±.80 (33.66%)	14.91 ±.60 (31.89%)	16.6 ±.70 (32.8%)	16.2 ±.40 (32.9%)	16.5 ±.20 (34%)
Albumen weight (gms)	27.18 ±.47 (55.74%)	25.36 ±.86 (54.1%)	26.02 ±.73 (55.6%)	29.0 ±.95 (57.3%)	27.4 ±.50 (55.65%)	26.4 ±.40 (55.4%)
yolk : albumen	0.55	0.59	0.57	0.57	0.59	0.62

Values : Mean ± SE, n=12 ,* P<.05, **P<.005, ***P<.0005.

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	Late Phase		
	Control	**HPR**	**HPO**
Egg weight	51.00 ±.93	49.5 ±.73	48.8 ±.77
Height (cm)	5.50 ±.48	5.38 ±.32	5.41 ±.37
Width (cm)	4.43 ±.29	4.39 ±.34	4.23 ±.42
Egg volume (cc)	41.20 ±.93	40.5 ±.73	41.7 ±.55
Shell weight (gms)	5.20 ±.39 (10.09%)	5.38 ±.05 (10.8%)	5.30 ±.138 (10.9%)
Shell thickness (mm)	0.317 ±.007	0.301 ±.005	0.298 ±.011
Yolk weight (gms)	17.15 ±.58 (33.62%)	16.46 ±.86 (33.2%)	15.89 ±.77 (32.5%)
Albumen weight (gms)	28.30 ±.54 (55.49%)	27.5 ±.63 (55.67%)	27.4 ±.73 (56.49%)
yolk : albumen	0.60	0.59	0.57

Values : Mean ± SE, n=12 ,* P<.05, **P<.005, ***P<.0005.

Table 3. Overall chemical composition of eggs of birds subjected to HPR and HPO groups under **NLD**.

	% Water content		% Solids		Total Protein		Carbohydrates		Total Lipids		Total cholesteol	
	yolk	albumen	yolk	albumen	yolk	albumen	yolk	albumen	yolk	albumen	yolk	albumen
C	48.10 ±.41	86.33 ±.26	52.10 ±.47	13.67 ±.26	17.74 ±.29	13.83 ±.54	0.086 ±.019	.0153 ±.0003	20.14 ±.54	0.290 ±.044	1.47 ±.67	0.0309 ±.0009
HPR	48.39 ±.067	86.85 ±.25	51.67 ±.036	13.02 ±.29	18.17 ±.63	17.02*** ±.321	0.073 ±.011	.0231* ±.0039	31.13** ±2.91	0.220 ±.104	2.22 ±.212	0.0136** * ±.0023
HPO	50.54** ±.42	86.84 ±.216	49.37*** ±.37	13.38 ±.29	15.05*** ±.146	15.66** ±.193	0.091 ±.020	.0174*** ±.0015	25.10** ±.964	0.292 ±.030	1.85 ±.098	0.0169** * ±.0019

Values : Mean ± SE, n=12 ,* P<.05, **P<.005, ***P<.0005.

Table 4. Composition of eggs of birds subjected to HPR and HPO under NLD, during initial, peak and late phases of lay.

	Initial Phase						Peak Phase					
	Control		HPR		HPO		Control		HPR		HPO	
	yolk	albumen	yolk	albumen	yolk	albumen	yolk	abumen	yolk	albumen	yolk	albumen
% Water content	46.10 ±.71	87.11 ±.23	48.07 ±1.41	87.9 ±1.36	51.23** ±1.67	87.80 ±.52	48.74 ±1.29	86.88 ±.15	48.61 ±.96	87.9 ±.64	48.5 ±.69	86.75 ±.46
% Solids	54.36 ±.58	12.89 ±.35	51.81* ±1.39	13.09 ±1.39	48.97** ±1.67	12.20 ±.52	51.77 ±2.49	13.14 ±.12	51.73 ±.92	11.73* ±.71	51.18 ±.69	13.23 ±.40
Total Protein	16.54 ±.46	14.61 ±.45	18.76** ±.39	15.71 ±.31	15.19 ±.057	14.76 ±.396	19.04 ±.81	15.67 ±.41	20.53 ±.64	18.43* ±.37	15.59 ±.75	16.35* ±.43
Carbohydrate	0.182 ±.004	0.03 ±.09	.125*** ±.008	0.042 ±.003	0.211 ±.026	0.038 ±.001	0.036 ±.007	0.010 ±.001	0.068*** ±.008	0.015*** ±.001	0.029 ±.002	0.007 ±.002
Total Lipids	22.74 ±2.27	0.501 ±.06	39.92*** ±1.41	.222*** ±.036	27.32* ±.91	0.392* ±.019	19.46 ±2.45	0.233 ±.036	36.49** ±4.60	0.280 ±.040	27.6* ±1.68	0.335** ±.046
Total Cholesterol	1.78 ±.07	0.078 ±.09	3.12*** ±.32	0.027*** ±.003	2.03 ±.008	0.043** ±.004	1.21 ±.11	0.010 ±.002	2.24*** ±.143	0.008 ±.001	2.15*** ±.141	0.003* ±.0005

Values : Mean ± se, n=12 ,* P<.05, **P<.005, ***P<.0005.

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	Late Phase					
	Control		HPR		HPO	
	yolk	albumen	yolk	albumen	yolk	albumen
% Water content	49.50 ±1.12	85.02 ±.38	48.5 ±.64	58.76 ±.45	51.99* ±.55	85.97 ±.31
% Solids	50.50 ±.50	14.98 ±.02	51.5 ±.60	14.24 ±.078	48.17** ±.40	14.73 ±.071
Total Protein	17.6 ±.21	11.73 ±.36	15.24** ±.38	16.03* ±.23	14.37* ±.245	15.87* ±.354
Carbohydrate	0.039 ±.005	0.004 ±.0006	.026** ±.00003	.0114** ±.0003	.0341 ±.0004	.007* ±.0004
Total Lipids	18.23 ±.88	0.137 ±.009	16.98* ±.56	0.157 ±.007	20.38* ±.587	0.148 ±.005
Total Cholesterol	1.44 ±.11	0.004 ±.0008	1.32 ±.17	0.005 ±.0004	1.37 ±.29	.0038 ±.0003

Values : Mean ± se, n=12 ,* P<.05, **P<.005, ***P<.0005.

Table 5. Composition of eggs of birds subjected to HPR and HPO under **NLD**, during initial, peak and late phases of lay (values expressed in terms of gms in yolk/albumen in whole egg).

	Initial Phase						Mid Phase					
	Control		HPR		HPO		Control		HPR		HPO	
	yolk	albumen	yolk	albumen	yolk	albumen	yolk	albumen	yolk	albumen	yolk	albumen
Total Protein	2.51	3.97	2.95	3.98	2.26	3.84	3.16	4.54	3.32	5.04	2.52	4.31
Carbohydrate	0.025	0.008	0.019	0.010	0.031	0.009	0.006	0.003	0.011	0.004	0.004	0.001
Total Lipids	3.45	0.136	6.29	0.056	4.07	0.101	3.23	0.067	5.91	0.076	4.47	0.088
Total Cholesterol	0.270	0.021	0.492	0.006	0.303	0.011	0.201	0.002	0.363	0.002	0.348	0.0008

	Late Phase					
	Control		HPR		HPO	
	yolk	albumen	yolk	albumen	yolk	albumen
Total Protein	3.01	3.31	2.50	4.41	2.28	4.34
Carbohydrate	0.006	0.011	0.004	0.003	0.005	0.002
Total Lipids	3.12	0.038	2.74	0.043	3.23	0.04
Total Cholesterol	0.24	0.001	0.217	0.0013	0.218	0.0010

Values : Mean

Table 6. Overall metabolite content in eggs HPR and HPO birds under **NLD** during initial, peak and late phases of lay.

	Yolk			albumen			Whole egg		
	Control	**HPR**	**HPO**	**Control**	**HPR**	**HPO**	**Control**	**HPR**	**HPO**
Total Lipids	3.28	5.02	3.93	0.081	0.058	0.077	3.36	5.07	4
Total non-lipid dry	5.21	3.31	3.82	3.76	3.47	3.43	8.95	6.78	7.25
Water Index	2.07	2.35	2.07	6.46	6.69	6.73	3.58	4.57	4.27
Lipid Index	1.02	1.51	1.02	0.021	0.016	0.022	0.375	0.747	0.551

	control	**HPR**	**HPO**
Calorific value (edible egg)	57.43	75.70	62.18
Calorific value (per 100gm egg)	129.14	176.41	147.13

Values : Mean

Fig. 1. Overall contents of protein, carbohydrates, lipids and cholesterol of HPR and HPO eggs under NLD.

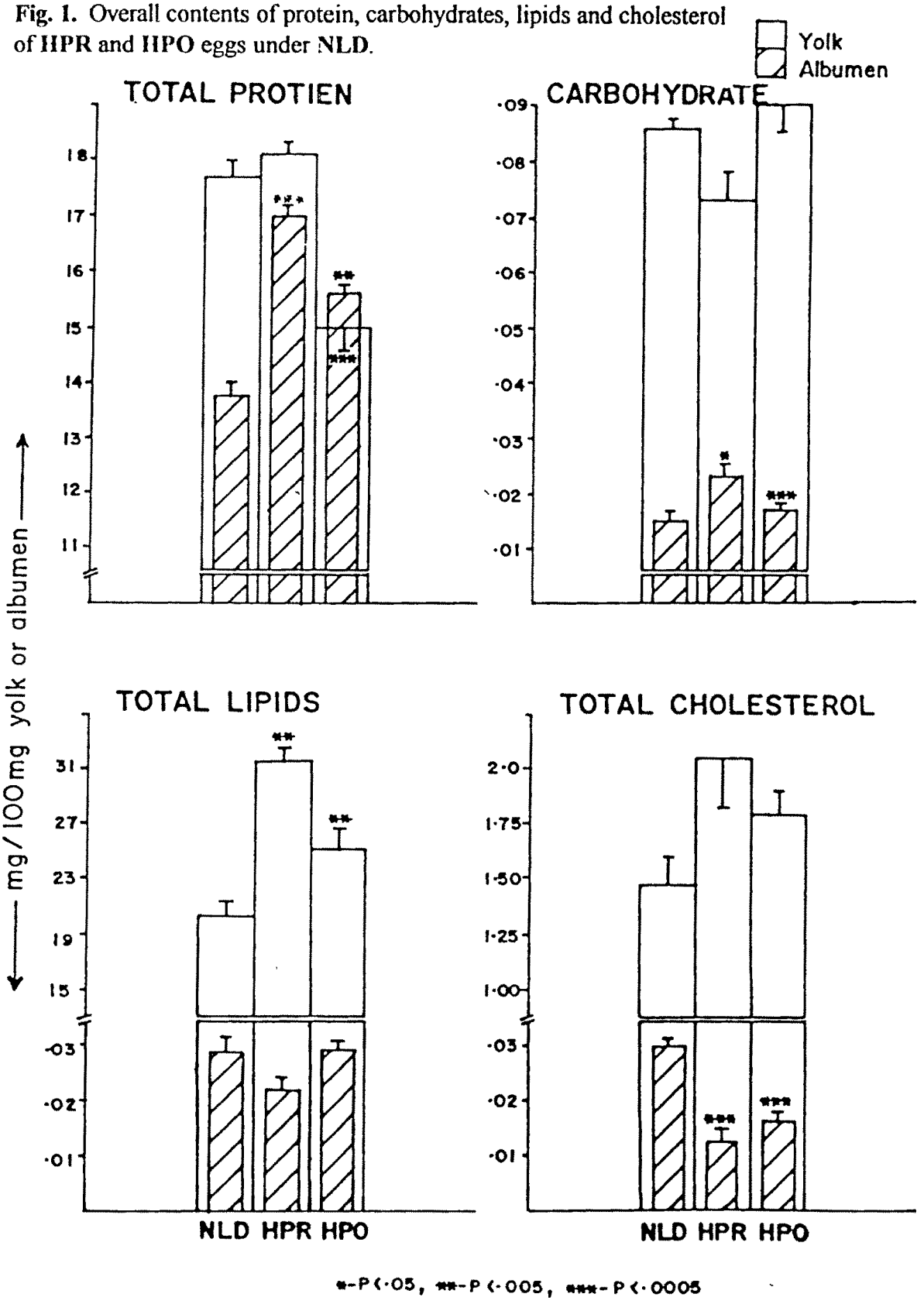


Fig. 2a. Contents of total protein and carbohydrates of HPR and HPO eggs under NLD.

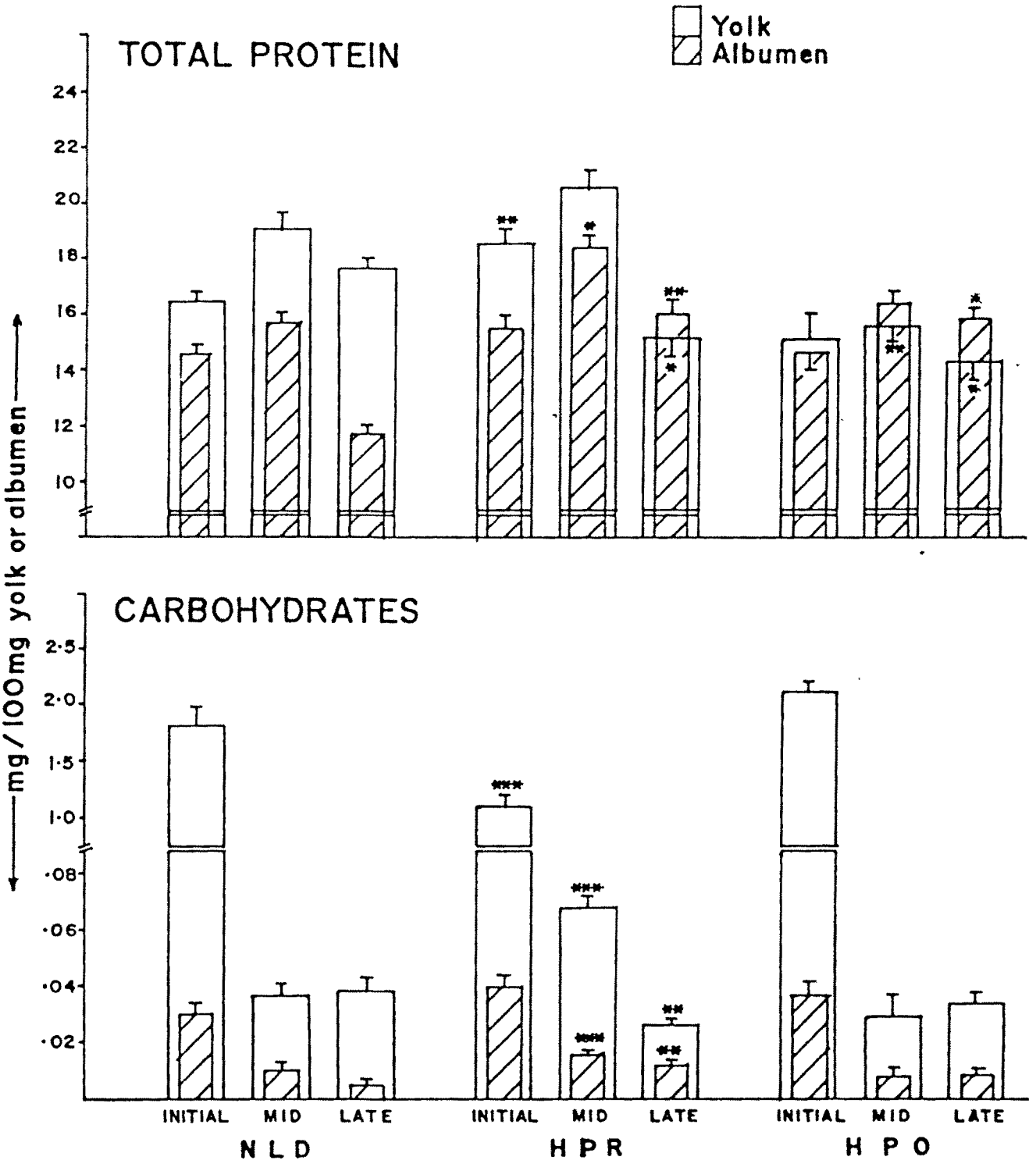


Fig. 2b. Contents of total lipids and cholesterol of HPR and HPO eggs under NLD.

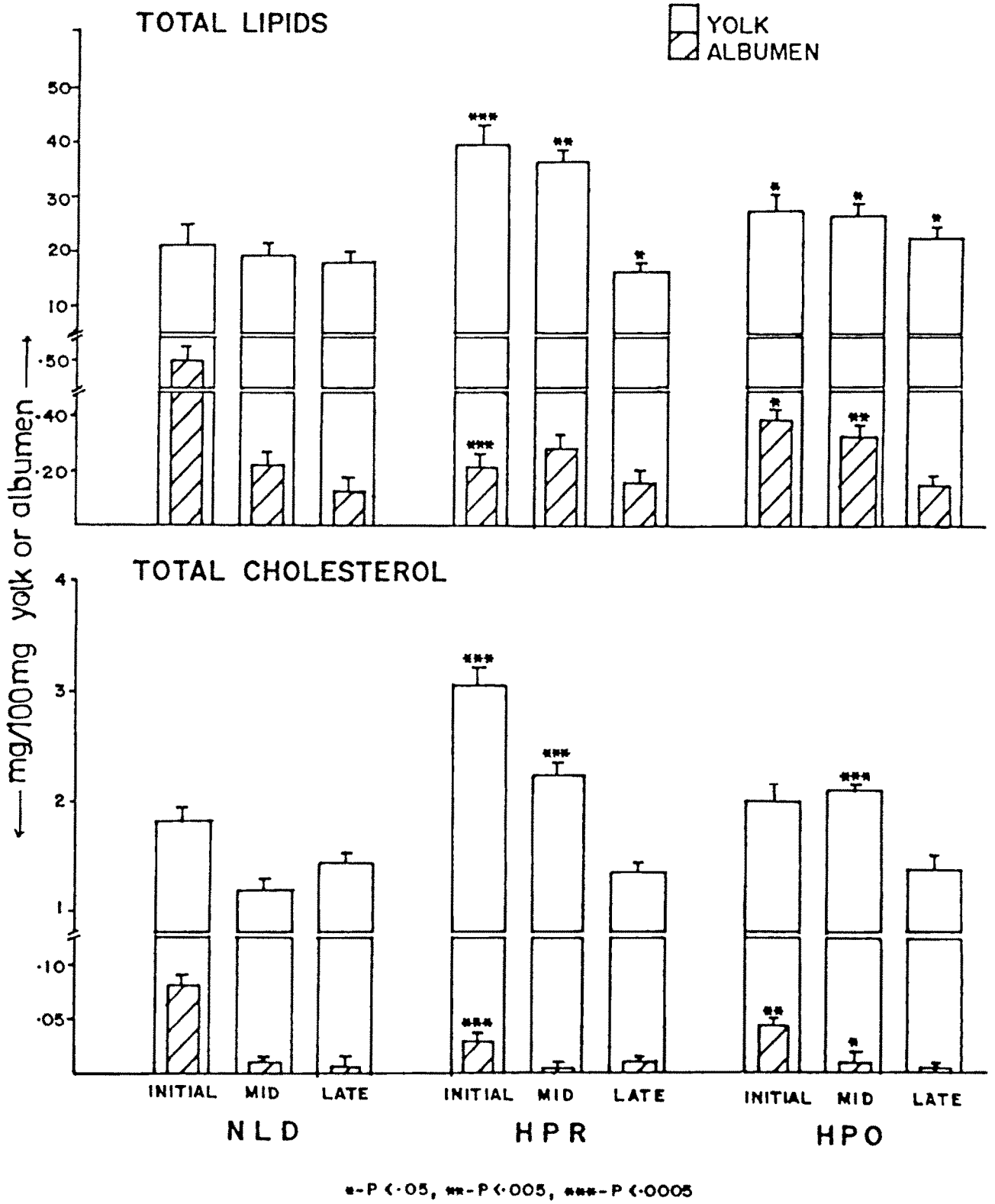
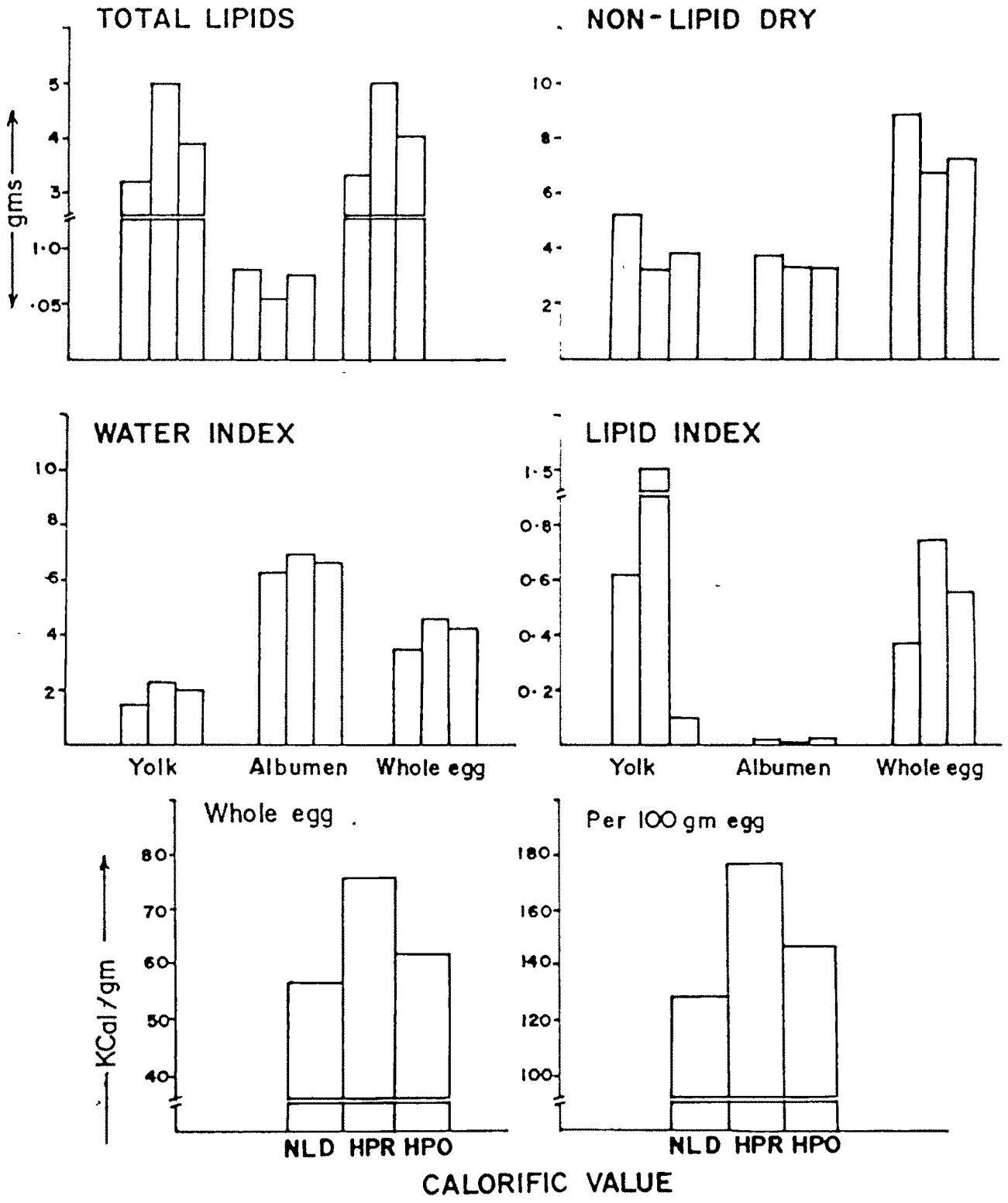


Fig. 3. Contents of lipid, non-lipid dry matter, water & lipid indices and calorific value of **HPR** and **HPO** eggs under **NLD**



albumen cholesterol content was significantly decreased in both HPR and HPO eggs due to a persistently lower content from the initial to the late phase of lay and, the decrease during the course of lay was more or less identical (21.7% in the HPR and 93% in the HPO Vs 94.8% in the control) (table3)(fig. 2b).

Discussion

Though corticosterone has been used either by parenteral administration or through diet for growth and fattening in chicks (Nagra and Meyer, 1963; Bartov, 1982; Saddaun *et al.,* 1987; Siegel *et al.,* 1980; Akiba and Horiguchi, 1992; Hayashi *et al.,* 1994), this is the first study which shows the influence of induced HPR or HPO during the rearing period on structure and composition of the eggs laid by these hens in the adult condition. Since there are definite differential alterations on various parameters evaluated, the discussion on the influence of HPR or HPO has been taken up separately for the sake of convenience and clarity.

HPR :

A previous study on HPR with similar experimental protocol had shown increased egg yield by way of altered ovarian functions resulting in better egg yield (Chapter 3). The present study further shows some alterations in structure and composition of the eggs on an overall basis, taking the entire lay into consideration, only two physical measurements which showed significant differences were egg weight and volume which were less in the HPR eggs. This decrease is essentially due to the significantly reduced egg weight and volume of the eggs laid during the initial phase as there was no significant difference in eggs laid during the

mid and late phases. The absolute content of albumen was significantly less in the HPR eggs and, this was clearly evident in the initial and mid phases of laying. The reduction in the albumen content was evident even in terms of percentage content of total egg. However there was no significant difference in yolk content in absolute terms, though there was a slightly increased percentage content of yolk in HPR eggs. The yolk : albumen ratio is also higher in the HPR eggs during the initial phase. These alterations suggest some persistent effects of HPR on the isthmus of the oviduct in terms of its albumen secreting ability in the initial phases of egg laying.

Hypercorticalism did not have any influence on percentage solid and water contents of the edible egg. However, on a chronological basis, there was a qualitative difference in the yolk and albumen contents of water and solid of HPR eggs. Whereas the percentage water content gradually increased in yolk, with reciprocal decrease in solid contents of NLD eggs, the water and solid content of yolk of HPR eggs remained steady. The water content of albumen tended to decrease gradually in control eggs from initial to late phase while, in the HPR eggs, water content remained steady till mid phase and then reduced during the late phase. There was significant reduction in the solid content in the albumen of HPR eggs during the mid phase.

The protein content of yolk was significantly high in the initial phase and lower in the late phase in the HPR eggs resulting, in no apparent overall effect on yolk protein content. However, the protein content of albumen was significantly high in HPR eggs throughout, with the difference increasing from 7.5% in the initial phase to 36.6% in the late phase compared to the control eggs. Moreover, the increase from the initial to

mid phase was more pronounced (7.2% Vs 17.3%) and the decrease from the mid phase to late phase was very much attenuated (19.7% Vs 2%). It is inferable from this, that HPR has a favourable influence on the protein loading capacity of the oviduct

Whereas there was no effect on the free glucid content of yolk, (though there was a tendency for a marginal decrement), the glucid content of albumen was significantly increased in the HPR eggs. This difference was not only due to a higher albumen glucid content in the initial phase (40%) but also due to a reduced decrement during the lay (86.6% Vs 72.8%) adding upto 185% higher albumen glucid content in the late phase. The total lipid content of the edible egg also showed significant alterations with increased content in the yolk and decreased content in the albumen of HPR eggs. The increased yolk lipid content was essentially a reflection of the very high contents in the initial and mid phases, by 75.5% and 87.5% respectively. Another qualitative difference was, the pronounced decrease from the mid phase to late phase (19.8% in the control as against 57.4% in the HPR). Overall, the yolk lipid content was higher in the HPR eggs by 54.5%. The reduced albumen lipid content in the HPR eggs is mainly due to a significantly lower content in the initial phase (55.6%). Though the general decreasing trend in the albumen lipid content during the course of lay was evident in both control and HPR eggs, the decrease was of a lesser degree in the latter (72.6% Vs 29.2%). The total cholesterol content also showed a similar change of increased content in the yolk and decreased content in the albumen. This higher overall yolk cholesterol content of HPR eggs was essentially due to the content in the initial and mid phases, which was 75-85%more than in the control eggs. However, the yolk cholesterol content in the late phase was comparable to that of control eggs due to a significant reduction (57.6%), as against a small

reduction in the control eggs (19.6%). Like in the case of yolk, the difference in the albumen cholesterol content was also restricted to the initial and mid phases when the contents were 64% and 20% less in HPR eggs. The significant reduction in the cholesterol content of albumen during initial and mid phase, in both HPR and control eggs and was more or less identical. These changes in the lipid and cholesterol contents of yolk and albumen indicate some alterations in the metabolic features of liver and oviduct due to HPR; the effect of which wanes with increasing age of the animal. Since the increase in the cholesterol content of yolk is parallel to the increase in total lipid content and, as the proportion of cholesterol : lipid remains the same, it is clear that the observed contents represent a quantitative change and not a qualitative change. Apparently, there is a higher lipoprotein synthesis in the liver of HPR hens. However, the changes seen in albumen represent a qualitative change with a significantly reduced proportion of cholesterol to non-cholesterol lipid fraction. Evidently, HPR in the rearing stage induces quantitative and qualitative alterations in lipoprotein metabolism of liver and oviduct respectively (table 5).

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 new 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 (Recklefs, 1977). Both the water and lipid indices of the edible egg were higher in the HPR eggs, essentially due to decrease in the non-lipid dry, material with reference to water index and, due to both decreased non-lipid dry matter

and increased water index, with reference to lipid index (table 6)(fig. 3). These differences in the edible egg are essentially a reflection of the changes in the yolk though, the lipid index of albumen was also less due to a lowered lipid content. The calorific value of HPR eggs (table6) is significantly greater than that of the control eggs and in terms of 100 gm edible egg it is higher by 26.8%.

HPO :

In a previous report, induction of HPO in rearing chicks with a similar experimental protocol had shown some influence on various aspects of laying performance during the adult condition (Chapter 2). In continuation, the present study reports some alterations in terms of structure and composition of eggs laid by HPO hens. Taking into consideration all the eggs laid during the first cycle, the only physical measurements which showed significant difference, were egg weight and shell thickness, which were decreased by 6% and 11%respectively with, the similar percentage increase in egg weight from initial to late phase. The HPO eggs tended to have persistent lower weight. This is unlike that of HPR eggs, where, the difference was essentially due to a significant decrease in egg weight during the initial phase of lay. Like the weight of eggs, shell thickness too was less throughout lay. The HPO eggs also showed reduced absolute albumen content by 5.5%, mainly due to differences during the initial and mid phases. However, as a proportion of egg weight, the albumen content was similar in both control and HPO eggs. Moreover, the yolk : albumen ratio was also identical. The percentage contents of water and solids in the yolk of HPR eggs were significantly increased and decreased respectively. Unlike the control eggs, where the water content gradually increased during lay with reciprocal decrease in solid content, the HPO eggs showed a constant higher water content with corresponding decreased solid

content. The yolk protein content increased from initial to mid phase and then decreased slightly in the late phase in the case of control eggs. The HPO eggs on the other hand did not show the increase from initial to mid phase but, showed the decrease from mid to late phase, thereby resulting in a decreased yolk protein content throughout. On the other hand, the albumen protein content which also shows a similar pattern of changes as that of control yolk protein, was significantly increased in the mid phase with a very marginal reduction in the late phase in the case of HPO eggs thereby depicting significantly higher protein content during mid and late phases. It is surmisable from these changes that, HPO has a favourable influence on the protein loading capacity of the oviduct while, it has a dampening effect on hepatic protein turnover during vitellogenesis. In terms of carbohydrate metabolism related to egg laying, HPO seems to have no effect as there was no change in the free glucid content of either yolk or albumen (fig. 2a).

The total lipid content in the yolk of HPO eggs was significantly more due to the steady higher contents in the initial and mid phases, which were 20-42% greater. Despite the significant decrease in the late phase (by 25.9%), the HPO eggs still had 11.8% higher yolk lipid content in the late phase. Obviously, there is a higher lipid turnover in the liver of HPO hens during the egg laying period. Though there was no difference in the overall albumen lipid content, temporally it was lower in the initial phase and higher in the mid phase in the HPO eggs. These differences in the initial and mid phases obviously nullified each other, contributing to no overall difference. The yolk cholesterol content was increased (25.8%) and, albumen cholesterol content decreased (45.3%) in the HPO eggs. This is mainly due to a steady high yolk cholesterol content in the initial and mid phases (14% and 78% respectively) and significantly reduced albumen cholesterol content in these phases (44.8% and 70% respectively), though

showing a decreasing pattern as in the control eggs. It is apparent that, in the early phases of egg laying, the metabolic alterations induced in liver and oviduct by HPO in the pullet stage, is persistent, as reflected by the composition of eggs. Since the increase in the yolk cholesterol content is paralleled by an increase in the total lipid content in HPO eggs and, as a proportion of cholesterol to lipids, remains the same as in the control eggs, it is conceivable that there is no qualitative change in the hepatic lipoprotein metabolism, though there is an increased turnover of cholesterol and non-cholesterol lipids in the initial and mid phases. In contrast, the changes in the albumen seem to be more of a qualitative nature with a significant reduction in the proportion of cholesterol: non-cholesterol lipid fraction.

The water and lipid indices of whole egg were higher in the HPO eggs as compared to the control eggs. Whereas the increase in water index is due to a decrease in the non-lipid dry matter, the increase in the lipid index is due to both, an increase in the lipid content as well as a decrease in the non-lipid dry matter. Essentially these changes in the whole egg are mainly a reflection of changes in yolk. The calorific value of HPO eggs in terms of 100 gm of edible egg is 14% more than that of the control eggs (tables 5,6) (fig. 3).

Overall, the present results suggest definite alterations in the metabolite contents and calorific value of the eggs under both HPR and HPO. In general, the alterations appear to be quite similar though, more pronounced in HPR condition and, essentially reflect some changes in the fine tuning of metabolic features of liver and oviduct. The similar changes in egg composition and energy content under both HPR and HPO are, however in contrast to the observed effects on sexual maturity, yield of eggs and laying performance, as reported earlier (Chapter 3). Moreover, these aspects cannot be discussed in detail as studies of this nature are

not reported in literature. However, our studies clearly show that functional alterations in the adrenocortical activity in the pullet stage can have long lasting influences related to lay and composition of eggs.