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Effects of 16L : 8D photoperiod on growth performance, carcass characteristics, meat composition, and blood parameters of Pekin ducks

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Abstract: The aim of this study was to determine the effects of a 16L : 8D photoperiod on growth performance, carcass characteristics, relative organ weight, meat composition, and blood parameters in Pekin ducks. A total of 120 (60 male and 60 female) ducklings were used in the research. Each sex group was randomly allocated into 2 photoperiod groups, 24L : 0D and 16L : 8D. Ducks reared under the 24L : 0D photoperiod had higher body weight gain ($P < 0.001$); feed intake ($P < 0.001$); percentage of breast, wings, and skin with subcutaneous fat percentage ($P < 0.001$); and abdominal fat ($P < 0.05$). Sex of ducks affected body weight gain ($P < 0.05$; $P < 0.001$) and feed intake ($P < 0.05$) at days 1–42, as well as ash of thigh meat ($P < 0.001$) and creatine kinase level ($P < 0.05$). The present study concluded that the body weight gain and carcass development of ducks reared under the 24L : 0D photoperiod was superior to those reared under the 16L : 8D photoperiod. A 24L : 0D photoperiod is recommended for growth and carcass development in intensive Pekin duck-rearing systems.

Key words: Photoperiod, growth performance, carcass characteristics, meat composition, Pekin duck

1. Introduction

Photoperiod has the potential to modulate performance and welfare through behavioral and physiological mechanisms. Several types of lighting programs, such as restricted, intermittent, and continuous or near continuous photoperiods, exist in poultry production. Light allows the bird to establish rhythmicity and synchronize many essential functions, including body temperature and various metabolic steps that facilitate feeding and digestion. Continuous lighting programs are important for a high rate of feed intake and growth. Although there are a number of studies on the effects of different photoperiods on growth performance, carcass, and meat characteristics of broilers, there are no reports that focus on the influence of photoperiods on duck production. Ducks have a different growth curve than broilers due to their nature as waterfowls. Therefore, the results of photoperiods for broilers should not be adapted for ducks. The changes in plasma total cholesterol, triglyceride, and creatine kinase activity that occur in response to acute or chronic stress have been reported by researchers for some poultry species (1–5). However, most research on lighting periods is focused on broiler management and rearing systems. Photoperiod may influence Pekin duck growth performance, carcass characteristics, meat composition, and some blood parameters. Therefore, the objective of the present study was to evaluate the effects of a 16L : 8D photoperiod on growth performance, carcass characteristics, some blood parameters, relative organ weight, and meat composition of male and female Pekin ducks.

2. Materials and methods

2.1. Birds and housing

This study was approved by the Ankara University Animal Care and Use Committee (2011/112/425). A total of 120 (60 male and 60 female) ducklings (Star 53 H.Y., Grimaud Freres) were obtained from a commercial hatchery (Köy-Tav, Ankara, Turkey). The poultry house was separated with a black plastic divider into 2 rooms for 2 photoperiods. In one room a 24L : 0D photoperiod (control group) was applied, while a 16L : 8D photoperiod was applied per day to the ducks in the other room. Each group was subdivided into 10 replicates (consisting of 5 male and 5 female replicates) of 6 ducklings each, located in floor pens with dimensions of 170 × 94 × 90 cm (width

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× length × height). Male and female ducklings were held in separate pens in each room, and each pen was littered with wood shavings. During the first week, each pen was equipped with a bell drinker and a chick feeder; in the following weeks, they were equipped with a bell drinker and a hanging suspended feeder. Ducklings were fed with a starter diet from day 1 to day 21 of age (2830 kcal/kg metabolizable energy and 18.2% crude protein), and a grower diet from day 22 to day 42 (2720 kcal/kg metabolizable energy and 17.3% crude protein). Food and water were provided ad libitum during the experiment. Ducklings in both treatment systems were reared under similar environmental conditions (temperature was 32–34 °C in the first week and then was decreased to 20–22 °C) in a naturally ventilated house. Fattening duration was 42 days.

2.2. Growth performance

Ducklings were weighed at the beginning of the experimental period and then weekly to determine body weight and body weight gain for each replicate. Feed intake was recorded weekly and expressed as grams per duck per week, and feed-to-gain ratio was calculated as grams of feed per gram body weight gain. The calculations described above were performed separately for each replicate (consisting of 5 male and 5 female replicates for each photoperiod group).

2.3. Blood parameters

On day 41, one duck from each sex and photoperiod group pen (5 males and 5 females for each photoperiod group) were randomly selected and bled from the brachial vein. Blood samples were taken for estimating cholesterol, triglyceride, and creatine kinase levels. These levels were determined using a Vitros 350 autoanalyzer (New York, NY, USA; product code 680-2153) and its accompanying commercial kits.

2.4. Slaughter weight, carcass characteristics, and relative organ weights

On day 42, prior to slaughtering, the ducks were weighed and deprived of feed for 6 h. All Pekin ducks (30 males and 30 females for each photoperiod group) were slaughtered in a commercial slaughterhouse. After the defeathering process, all internal organs were carefully removed. Relative organ weights, including the heart, liver, and gizzard, were measured and expressed as a percentage of slaughter weight (SW%). Carcass weight was recorded and expressed as percentage of slaughter weight as hot carcass yield (SW%). The carcasses were stored at 4 °C for 24 h by hanging. Cold carcass weight was recorded and expressed as percentage of slaughter weight as cold carcass yield (CC%). After this process, a total of 20 duck carcasses (5 males and 5 females for each photoperiod group) were randomly selected from each subgroup and dissected individually. Each carcass was cut into parts including wings with skin, neck, legs (thighs + drumsticks), and breast without skin, and subcutaneous fat with skin and abdominal fat. These parts were weighed separately and expressed as a percentage of cold carcass weight (CC%).

2.5. Meat composition and pH

The pH values of the breast muscle (*M. pectoralis superficialis*) and thigh muscle (*M. biceps femoris*) were measured with a pH-meter 24 h after slaughtering. Breast and thigh meats were used for analyses of moisture, protein, fat, and ash in 10 duck carcasses of each photoperiod group (5 males and 5 females for each group) (6). Results were expressed as percentage over fresh matter basis. The pH values and meat samples were taken from the same carcasses as described in the previous section and were dissected individually.

2.6. Statistical analysis

Data were tested for normality of distribution using the Kolmogorov–Smirnov test and for homogeneity of variance using Levene's test. Two-way ANOVA was used to identify the differences and interactions between photoperiod and sex groups. When a significant difference was found among groups for post hoc multiple comparisons, Tukey's test was used. Statistical analyses were performed using SPSS for Windows. A value of $P < 0.05$ was considered statistically significant.

3. Results

3.1. Growth performance

Duckling weight at hatching, body weight gain (days 1–42), and feed-to-gain ratio (days 1–42) in Pekin ducks are summarized in Table 1 according to photoperiod and sex. Hatching body weight was not different between the photoperiod groups. Body weight gains of ducks (day 1 to day 42) were 3069.16 and 2482.37 g/bird ($P < 0.001$) and feed intakes of ducks (day 1 to 42) were 6658.32 and 5202.42 g/bird ($P < 0.001$) for birds reared under the 24L : 0D and 16L : 8D photoperiods, respectively.

3.2. Blood parameters

The means of total cholesterol, triglyceride, and creatine kinase levels are shown in Table 2. The means of total cholesterol, triglyceride, and creatine kinase levels for 24L : 0D and 16L : 8D photoperiod groups were 92.80 and 92.00 mg/dL, 79.90 and 95.50 mg/dL, and 678.70 and 655.20 IU/L, respectively. Creatine kinase levels were only influenced by sex ($P < 0.05$). The other examined blood parameters were not influenced by sex or photoperiod. The means of creatine kinase levels for male and female ducklings were 606.00 and 727.70 IU/L, respectively.

Table 1. Effects of photoperiod and sex on growth performance of Pekin ducks.

Photoperiod	Sex	Duckling weight at hatch (g)	Body weight gain (g/bird)			Feed intake (g/bird)			Feed to gain ratio (g/g)		
			Day 1–21	Day 22–42	Day 1–42	Day 1–21	Day 22–42	Days 1–42	Day 1–21	Day 22–42	Day 1–42
24L : 0D (control)	Male	49.64	1321.36	1880.17	3201.53	1885.63	49162.00	6801.63	1.43	2.62	2.13
	Female	45.05	1178.45	1758.33	2936.79	1833.00	4682.00	6515.00	1.56	2.66	2.22
16L : 8D	Male	50.15	1016.01	1605.17	2621.18	1171.17	4186.17	5357.33	1.15	2.61	2.05
	Female	45.28	919.72	1423.84	2343.55	1110.33	3937.17	5047.50	1.23	2.77	2.16
24L : 0D (control)		47.34	1249.91	1819.25	3069.16	1859.32	4799.00	6658.32	1.49	2.64	2.17
16L : 8D		47.72	967.87	1514.50	2482.37	1140.75	4061.67	5202.42	1.19	2.69	2.10
	Male	49.90	1168.69	1742.67	2911.36	1528.40	4551.08	6079.48	1.29	2.62	2.09
	Female	45.17	1049.08	1591.08	2640.17	1471.67	4309.58	5781.25	1.39	2.72	2.19
Pool SEM		0.761	21.283	17.043	17.682	24.933	50.900	58.685	0.031	0.041	0.028
Photoperiod		NS	***	***	***	***	***	***	***	NS	NS
Sex		**	*	***	***	NS	*	*	NS	NS	NS
Photoperiod × sex		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

n = 5, NS: nonsignificant; ***: $P < 0.001$; **: $P < 0.01$; *: $P < 0.05$.

Table 2. Effects of photoperiod and sex on some blood parameters of Pekin ducks.

Photoperiod	Sex	Total cholesterol (mg/dL)	Triglyceride (mg/dL)	Creatine kinase (IU/L)
24L : 0D (control)	Male	82.80	81.80	645.00
	Female	102.80	78.00	712.40
16L : 8D	Male	93.40	83.80	567.00
	Female	90.60	107.20	743.40
24L : 0D (control)		92.80	79.90	678.70
16L : 8D		92.00	95.50	655.20
	Male	88.10	82.80	606.00
	Female	96.70	92.60	727.90
Pool SEM		2.237	4.505	27.325
Photoperiod		NS	NS	NS
Sex		NS	NS	*
Photoperiod × sex		*	NS	NS

n = 5, NS: nonsignificant ; *: $P < 0.05$.

3.3. Slaughter weight, carcass characteristics, and relative organ weight

Slaughter weight of ducks reared in the 24L : 0D photoperiod (control group) was found to be 2913.78 g, whereas it was 2615.70 g for those reared in the 16L : 8D photoperiod. Photoperiod and sex significantly affected slaughter weight ($P < 0.001$). Slaughter weight of male ducks (2857.23 g) was significantly ($P < 0.001$) higher than that of female ducks (2672.25 g). The values for hot carcass yield were 71.03% and 71.74% in ducks reared under the 24L : 0D and 16L : 8D photoperiod groups, respectively. Hot carcass yield was 71.90% and 70.86% in male and female Pekin ducks, respectively. Percentages of breast, wings, and skin with subcutaneous fat and abdominal fat of ducks reared under the 24L : 0D and 16L : 8D photoperiods were 28.67% and 27.14% ($P < 0.001$), 12.60% and 11.07% ($P < 0.001$), and 21.31% and 19.64% ($P < 0.05$), respectively (Table 3). Relative weights of liver, heart, and gizzard were not affected by photoperiod. The means of relative weights of liver, heart, and gizzard were 1.66% and 1.70%, 0.68% and 0.63%, and 2.96% and 2.95% for the 24L : 0D and 16L : 8D photoperiod groups, respectively (Table 3).

3.4. Meat composition and pH

The mean values of ash, fat, and crude protein in thigh meat for the 24L : 0D and 16L : 8D photoperiod groups were 1.11% and 1.11%, 0.97% and 0.78%, and 22.01% and 22.25%, respectively. These values for breast meat were 1.197% and 1.198%, 0.46% and 0.39%, and 21.81% and 21.81%, respectively. In the present study, average pH_{24} of thigh meat for the 24L : 0D and 16L : 8D photoperiod groups was 6.70 and 6.45, respectively. Although photoperiod affected the fat ($P < 0.01$) and pH ($P < 0.05$) of thigh meat, sex only affected the ash of thigh meat ($P < 0.001$) (Table 4).

4. Discussion

4.1. Growth performance

Hatching weight of ducklings was statistically different ($P < 0.01$) between sex groups. Male ducklings were heavier at hatching and gained more weight during the experiment than female ducklings ($P < 0.05$; $P < 0.001$) (Table 1). These results were in agreement with previous reports about body weight of male and female ducks (7–9). Male ducks had higher feed intake between days 22 and 42 and days 1 and 42 ($P < 0.05$) than female ducks; however, feed-to-gain ratio between days 1 and 42 was similar in both sex groups. The lower body weight gain ($P < 0.001$) during the experiment with increased darkness is likely related to reduced activity and feed intake. Therefore, they consumed less feed and gained less weight than ducks reared under the 24L : 0D photoperiod (control group) (Table 1). In previous studies with broilers, moderate day lengths resulted in acceptable performance levels, with similar final body weight compared with continuous lighting (1,3,10). However, we observed that by decreasing the lighting period, the body weight gain and feed intake of ducks were further affected, as waterfowls, than that of broilers. Feed-to-gain ratio was not affected by photoperiod between days 1 and 42. Previous reports on the influence of photoperiods of 18 h or less on feed-to-gain ratio have been inconsistent.

Table 3. Effects of photoperiod and sex on slaughter weight, carcass characteristics, and relative organ weight of Pekin ducks.

Photoperiod	Sex	Slaughter weight	Hot carcass yield	Neck[1]	Breast[1]	Legs[1]	Wings[2]	Skin with subcutaneous fat	Abdominal fat	Liver	Heart	Gizzard
		(g)	(SW %)	(CC %)[†]						(SW %)		
24L : 0D (control)	Male	3032.23	71.78	7.00	29.00	17.00	12.54	21.18	1.24	1.63	0.67	2.93
	Female	2795.33	70.27	6.58	28.33	18.56	12.67	21.44	1.33	1.68	0.68	2.99
16L : 8D	Male	2682.23	72.03	6.75	27.16	17.42	11.14	19.46	1.18	1.71	0.63	3.02
	Female	2549.17	71.45	6.87	27.12	17.39	11.00	19.82	1.22	1.69	0.64	2.87
24L : 0D (control)		2913.78	71.03	6.79	28.67	17.78	12.60	21.31	1.29	1.66	0.68	2.96
16L : 8D		2615.70	71.74	6.81	27.14	17.41	11.07	19.64	1.20	1.70	0.63	2.95
	Male	2857.23	71.90	6.87	28.08	17.21	11.84	20.32	1.21	1.67	0.65	2.98
	Female	2672.25	70.86	6.72	27.72	17.98	11.83	20.63	1.28	1.69	0.66	2.93
Pool SEM		27.001	0.266	0.055	0.198	0.196	0.110	0.163	0.019	0.031	0.011	0.055
Photoperiod		***	NS	NS	***	NS	***	***	*	NS	NS	NS
Sex		***	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Photoperiod × sex		NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS

Hot carcass yield and organs, n = 30.
Neck, breast, legs, wings, skin with subcutaneous fat and abdominal fat, n = 5.
[1]: Without skin and subcutaneous fat; [2]: with skin.
SW: Slaughter weight; CC: cold carcass; NS: nonsignificant; ***: $P < 0.001$; *: $P < 0.05$.
[†]: The remaining part of the carcass was a back portion not shown in this table.

Table 4. Effects of photoperiod and sex on meat composition of Pekin ducks.

Photoperiod	Sex	Thigh meat (% fresh matter)			Breast meat (% fresh matter)			pH_{24}	
		Ash	Fat	Crude protein	Ash	Fat	Crude protein	Breast meat	Thigh meat
24L : 0D (control)	Male	1.10	1.02	22.44	1.196	0.41	21.84	5.70	6.66
	Female	1.12	0.92	21.46	1.198	0.51	21.79	5.81	6.73
16L : 8D	Male	1.07	0.81	21.57	1.196	0.40	21.63	5.79	6.51
	Female	1.15	0.75	23.04	1.200	0.38	21.98	5.73	6.40
24L : 0D (control)		1.11	0.97	22.01	1.197	0.46	21.81	5.76	6.70
16L : 8D		1.11	0.78	22.25	1.198	0.39	21.81	5.76	6.45
	Male	1.08	0.91	21.95	1.196	0.41	21.73	5.75	6.59
	Female	1.14	0.84	22.31	1.199	0.44	21.89	5.77	6.57
Pool SEM		0.005	0.029	0.126	0.006	0.017	0.051	0.015	0.044
Photoperiod		NS	**	NS	NS	NS	NS	NS	*
Sex		***	NS	NS	NS	NS	NS	NS	NS
Photoperiod × sex		**	NS	***	NS	NS	NS	**	NS

n = 5, NS: nonsignificant ; ***: $P < 0.001$; **: $P < 0.01$; *: $P < 0.05$.

Some researchers observed a decrease (11,12), whereas for others it was unaffected (1,3,10,13) or increased (14). The lack of effect on feed-to-gain ratio and the parallel effects on body weight and feed intake observed in the present study support the contention that lighting program effects on body weight are due to the influence on feed intake.

4.2. Blood parameters

Sex only affected the level of creatine kinase, which was higher ($P < 0.05$) in female ducks than in male ducks. Creatine kinase levels were not different between photoperiod groups of the same sex. Preslaughter environmental and management factors, including high temperature, catching, transportation, unloading, and hanging, are extremely stressful for the birds and can change the total plasma creatine kinase activity (15,16). Wyss and Kaddurah-Daouk (17) reported that an increase in creatine kinase concentration can be related to higher physical activity. This might be due to the female ducks having higher physical activity than male ducks due to their lower body weight. Photoperiod and sex interaction was found for cholesterol level. Female ducks reared in the 24L : 0D photoperiod (control group) had a higher cholesterol level than male ducks reared in the 24L : 0D photoperiod (control group) (Table 2).

4.3. Slaughter weight, carcass characteristics, and relative organ weights

The mean value of slaughter weight of ducks in the 24L : 0D photoperiod (control group) was higher than in the 16L : 8D photoperiod (Table 3). Due to continuous feed consumption in the 24L : 0D photoperiod (control group), constant lightening enhanced the slaughter weight of Pekin ducks. This finding was supported by body weight gain and feed consumption mean values and significances that were included for 1 to 42 days of age (Table 1). Slaughter weight of male ducks was significantly ($P < 0.001$) higher than that of female ducks (Table 3). This result was consistent with previous reports about the slaughter weight of male and female ducks (8,9). Sex did not affect the carcass characteristics and relative organ weight (Table 3). Compared with other research, hot carcass yields observed in this study were lower than those reported by Wawro et al. (18) for the A44 strain of Muscovy ducks, yet higher than those reported by Kokoszyński et al. (19) for the P44 and P45 strains of Pekin ducks. These differences may be due to genotype diversity. Hot carcass yield, percentage of neck and legs, and percentage of liver, heart, and gizzard were not affected by photoperiod. This result was consistent with a previous study that reported that photoperiod did not influence percentages of heart, gizzard, and liver in broilers (2). Percentages of breast and wings of male and female ducks in the present study were similar to those reported by Sarı et al. (20); however, percentages of neck were lower than in that previous study that reported carcass traits in Pekin ducks. Percentages of breast ($P < 0.001$), wings ($P < 0.001$), skin

with subcutaneous fat ($P < 0.001$), and abdominal fat ($P < 0.05$) of ducks reared under the 16L : 8D photoperiod were lower than those of ducks reared under the 24L : 0D photoperiod (control group). This might be due to the continuous lighting that provided more feed intake and movement for ducks. Hunton (21) reported that the development of body parts was affected by environmental conditions. After Pekin ducks hatch, the first growing part of the body is the legs, followed by the breast and wings. Leg muscles grow quickly until 2 weeks of age, and breast muscles until 7 weeks of age (22,23). Subcutaneous adipose tissue was the main place of fat accumulation in ducks. The percentage of skin with subcutaneous fat and abdominal fat was increased in ducks reared under the 24L : 0D photoperiod (control group). It was discovered that percentages of breast and wing were higher in the 24L : 0D photoperiod (control group) ($P < 0.05$) than the 16L : 8D photoperiod group. The interaction between sex and rearing method was not statically significant in all examined carcass characteristics.

4.4. Meat composition and pH

According to previous studies, the fat content of breast meat of different genotypes of ducks varied from 1.84% to 2.34% (24,25). This range was higher than the mean value we found in our study. Fat contents of thigh meat were also lower than those reported by Wołoszyn et al. (26). The protein content in the investigated breast muscles was slightly higher than that determined by Witak et al. (27) for the A44 genotype, and by Ali et al. (25) for the Cherry Berry genotype. In comparison to our results obtained for Pekin ducks, considerably lower thigh protein content was reported for the crossbred Pekin Type-SB (26). The ash content of breast meat in the present study was similar to that determined by Wawro et al. (18) for the A44 genotype and higher than that determined by Ali et al. (25) for the Cherry Berry genotype. Wołoszyn et al. (26) stated that the variations in meat composition concerning the basic chemicals traits of duck meat (e.g., fat and protein) depended on the genotype of the flock; therefore, the differences between our results and other studies were caused by the genotype of the ducks. Sex did not affect thigh meat composition, except for ash content of thigh meat. Ash of thigh meat in male ducks was lower ($P < 0.001$) than that in female ducks. Photoperiod only affected the fat and pH_{24} of thigh meat. Fat of thigh meat of ducks reared under the 24L : 0D photoperiod (control group) was higher ($P < 0.01$) than those reared under the 16L : 8D photoperiod. pH_{24} of thigh meat of ducks reared under the 24L : 0D photoperiod (control group) was significantly higher ($P < 0.05$) than that of ducks reared under the 16L : 8D photoperiod. Biochemical changes that occurred during the first 24 h postmortem are very important for the meat quality, including the decrease in pH_{24}, which shows that the glycolysis process is occurring in a normal way; thus, this factor is an important parameter for the preservation and stability of meat (15,28,29). Witak (27) stated that the average pH_{24} at 24 h postmortem was 5.75 and 5.77 in breast meat and 5.91 and 5.94 in thigh meat of male and female A44 ducks, respectively. Although in the present study the pH_{24} of breast meat was exactly the same in both sex groups, the pH_{24} of thigh meat was higher than in that previous study. We found that increasing lighting period enhanced the average pH_{24} value of thigh meat ($P < 0.05$), although sex had no effect on the pH_{24} of thigh meat. Perpetual movement throughout the growth period depends on continuous lighting (24L : 0D), which may have contributed to a decrease in the muscle glycogen and an increase in the pH_{24} of thigh muscle value during the slaughtering process. Previous results showed that muscle glycogen reserves at slaughter were significantly correlated with alterations of the pH_{24} of meat (30). Berri et al. (4) emphasized that high pH_{24} of muscle tissue was associated with a low glycogen concentration at slaughter. The difference between the mean values of breast meat fat contents was not statically significant for the photoperiod and sex groups. Both groups had equal ash and crude protein values of breast meat. Significant photoperiod and sex interaction was found for ash ($P < 0.01$), protein of thigh meat ($P < 0.001$), and breast meat pH_{24} ($P < 0.01$). Fat content of thigh meat was significantly higher ($P < 0.01$) in the 24L : 0D photoperiod (control group) than the 16L : 8D photoperiod group.

In conclusion, ducks reared under the 24L : 0D photoperiod (control group) showed markedly higher body weight gain than those reared under the 16L : 8D photoperiod. Blood parameters (total cholesterol, triglyceride, and creatine kinase) were not influenced by the photoperiod, and neither was the relative weight of the liver, heart, and gizzard. Percentages of breast and wing were higher in the 24L : 0D photoperiod (control group) than the 16L : 8D photoperiod group. However, the photoperiod affected the fat and pH values of thigh meat, whereas sex only affected the ash of thigh meat. The results of this study indicate that growth performance, carcass characteristics, and meat composition of ducks were affected by the photoperiod. Photoperiod plays an important role in the development of breast and wings in Pekin ducks. Sex affected body weight gain, feed intake, ash of thigh meat, and creatine kinase levels. It is concluded that body weight gain and carcass development of ducks (and especially breast and wing development) reared under the 24L : 0D photoperiod was superior to those of ducks reared under the 16L : 8D photoperiod. A 24L : 0D photoperiod (continuous lighting schedule)

is recommended for growth and carcass development in intensive Pekin duck rearing systems.

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