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Effects of Environmental Temperature on Egg Production, Food Intake and Water Consumption in Laying White Leghorns

II. In the Case of Corn Oil Supplemented Feeding

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(Fig. 1; Tables 1–6)

As a function of mechanisms regulating the food intake, environmental temperature is important to animal production. The change of quality of diet, therefore, may have also different effects under various temperatures.

It has been said that an increase of productive energy in diet for laying hens increases the rate of egg production, the rate of food efficiency for egg production, the rate of body weight, the rate of egg weight and induces the spearing action for protein. RAYNE (1967)[1] suggested that an increase of energy content of the diet might have an affect on the increase of ME ingested, especially under a high temperature, and that the decrease of egg weight under a high temperature might be attributed to the deficient caloric intake.

In this experiment, in succession with the previous paper[2], effects of environmental temperature on egg production, food intake and water consumption were investigated in the case of corn oil supplemented feeding for laying White Leghorns.

MATERIALS AND METHODS

Materials and methods were approximately the same as reported in the previous paper. This investigation was carried out on 24 mature laying White Leghorn hens. These had been selected from the flocks hatched at Fukuyama Poultry Center on the 8th of May 1969, and reared in this laboratory.

Under natural environment and using the commercial standard diet for the last 60 days they were laying at a rate above 75%. The hens were divided into three groups (A), (B) and (C) randomly including each 8 menbers. The mean egg production rates of each group selected during the last 60 days were 86%, 86% and 87% in (A), (B) and (C) respectively. The mean body weights and their S. D. in kg were 1.74 ± 0.14 for (A), 1.74 ± 0.20 for (B) and 1.76 ± 0.07 for (C).

(A) was fed with the standard commercial chicken food, (B) with the standard chicken feed supplemented with 7% of corn oil, and (C) with the standard chicken food supplemented with 14% of corn oil.

Supplying of food and water, weighing of eggs and measurements of food intakes and water consumptions were done at 13: 00 every day.

Daily food intake was calculated from the difference between supplied food weight and remaining food weight.

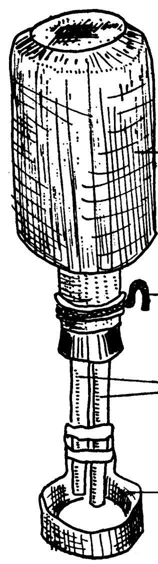

Fig. 1. The water supplying apparatus.

The water supplying apparatus is shown in Figure 1. The drink water was always supplied automatically dropping stocked water into a polyethylene cup. The difference between supplied water and remaining water was calculated and expressed as consumed water per day per hen. The evaporation from the surface of the polyethylene cup was measured every day and the water consumption was corrected with this figure.

The check of shell condition, the control and measurement of room temperatures were performed with the same methods as in the previous experiment.

It was artificially lighted by 2 electric bulbs of 60 W operated by a time switch, from 7 o'clock in the morning till 7 o'clock in the evening.

Every 10 or 15 days checking was conducted, from December 11, 1969 to February 15, 1970, under room temperatures of 25°C, 30°C, 32.5°C and 35°C. The set temperature, mean measured temperature and relative humidity are given in Table 1.

Table 1. The temperature, mean measured temperature and relative humidity.

Set temperature °C	Date from to	Mean measured temp.		Relative humidity %
		Dry bulb °C	Wet bulb °C	
25	20 December 30 December	25.3	17.1	39
30	6 January 16 January	29.9	19.6	33
32.5	17 January 27 January	32.4	21.2	31
35	28 January 6 February	34.6	22.1	28

Body weight was measured at the first and last day of the period of each temperature regime.

The moderately crushed oyster shells were given *ad libitum.*

RESULTS

As shown in Table 2, the mean amount of daily food intake per kg of body weight, decreased with the increase of environmental temperature. As based on the mean at 25°C, each figure of food intake at 30°C, 32.5°C, 35°C was 85%, 70%, 54% respectively for (A), 77%, 57%, 46% for (B) and 78%, 52%, 40% for (C). Remarkable decrease of food intake was observed at 35°C for (A), above 32.5°C for (B) and (C). As based on the mean of (A) at each temperature, the decrease of food intake was greater in the case of corn oil supplementation in the higher temperature range. In (B), 4% of de-

Table 2. Dairy food intake, daily water consumption, water food ratio and productivity for eggs.

Temperature (°C)	25	30	32.5	35
Food intake (g/Kg)	72.2 69.5 67.2	61.3 53.4 52.3	50.6 39.5 34.7	39.2 31.6 26.9
Water consumption (g/kg)	152 140 126	169 153 155	157 138 146	159 148 136
Egg weight (g)	56.7 57.4 57.2	56.2 56.7 58.7	57.2 56.5 57.7	56.7 53.3 55.2
Egg weight (g/kg)	31.5 30.7 30.3	31.0 30.2 30.1	31.8 30.5 29.9	33.2 30.1 30.3
Egg production rate (%)	91.3 88.8 82.5	85.0 76.5 (73.0) 85.0	83.8 73.8 78.8	77.5 38.8 47.5 (46.3)
Egg production (g/kg)	28.8 27.3 25.0	26.4 23.0 (22.7) 25.6	26.6 22.5 23.6	25.7 11.8 14.4 (14.0)
Efficiency for egg production (%)	39.9 39.3 37.2	43.1 43.1 (42.5) 48.9	52.6 57.0 68.0	65.6 37.3 53.5 (52.0)
Water/food intake ratio	2.11 2.01 1.88	2.78 2.87 2.96	3.10 3.49 4.21	4.06 4.68 5.06
Body weight (kg)	1.80 1.87 1.89	1.81 1.88 1.95	1.80 1.85 1.93	1.71 1.77 1.82

Note: In each column, each figure shows from upper to lower (A), (B) and (C).
Parensis: Exclude abnormal eggs.

crease at 25°C, 13% at 30°C, 22% at 32.5°C and 19% at 35°C were observed. On the other hand in (C) 7%, 15%, 31% and 32% of decrease were observed respectively in each temperature regime.

In each group, water consumption was highest in the 30°C regime, but as the temperature rose an obvious tendency of increase in water consumption, as described in the previous paper, was not observed. In (B) and (C), about 10% decrease of water consumption was observed compared with (A) in each temperature regime.

In each group the egg weight was almost constant being 57g below 32.5°C, but at 35°C both (B) and (C) decreased as much as 5% excluding (A). Egg weight per kg of body weight in each temperature regime, was almost constant. Each figure of mean$\pm$standard deviation was 31.9 ± 0.8g, 30.4 ± 0.2g and 30.2 ± 0.2g, respectively, in (A), (B), (C). In the same temperature regime, as based on (A), both (B) and (C) were 3% lover at 25°C and 30°C, 5% at 32.5°C and 10% at 35°C.

As based on a 25°C regime, daily egg production per kg of body weight decreased 10% in (A) above 30°C, 16% at 30°C, 18% at 32.5°C and 57% at 35°C in (B), and 6% at 32.5°C, 42% at 35°C in (C).

Abnormal eggs seldom appeared, but at 30°C in (B) one egg per 61, and at 35°C in (C) one egg per 38 were out of the normal.

In regard to the egg production rate, based on 25°C regime in each group, a great decrease was observed at 35°C in feeding corn oil, as low as 44% and 58% of the figure at 25°C, respectively, on the other hand 15% in (A). In the same temperature at 35°C, corn oil feeding groups had a lower egg production rate, as low as 50% and 61% of the (A), on the other hand below 32.5°C the decrease was within 12%.

In each temperature regime, the percentage of mean body weights based on 25°C was 101, 100, 95%, respectively in (A), 101, 99, 95% in (B) and 103, 102, 96% in (C).

The mean efficiency of egg production was calculated as follows on each temperature, as based on 25°C; 108, 132, 164% in (A); 108, 145, 95% in (B) and 131, 183, 140% in (C). In (A) the higher the temperature gave a better efficiency. In corn oil supplemented groups, the highest feeding efficiency was obtained at 32.5°C. Compared to (A) in the same temperature regime, (B) and (C) showed a higher feeding efficiency at 32.5°C, and a lover at 35°C and 25°C.

The ratio of water consumption per one g of food intake increased slowly with the temperature rising till 32.5°C in (A) and (B), and till 30°C in (C), but rapidly once over the mentioned temperature. As based on (A) in higher temperature range, the ratio was highest for (C). At 30°C, 103 and 106%, at 32.5°C 113 and 136%, and at 35°C 115 and 125% of the figure of (A), were indicated in (B) and (C) respectively.

DISCUSSION

The decrease of food intake, one of the appetite control factors, is considered as a function of the regulation of caloric intake as reported by many researchers. Experiments suggest that the control of energy intake is the dominant factor in the regulation of food intake by poultry. For laying hens it has been shown that an increase of the dietary energy level induces a reduction in quantity of food eaten (PAYNE, 1967).[1] Food intake and environmental temperature are closely related. Addition of corn oil especially accelerates a decrease of food intake. At 32.5 and 35°C regimes, about 20% of decrease in (B) and about 30% in (C) were observed respectively, and the greater addition of corn oil showed an inverse proportion to food intake.

Comparing the energy intake under a low temperature regime (18°C; 60–70% R. H.) to that under high temperature conditions (30°C; 50% R. H.), PAYNE (1967)[1)] noted that the energy intake under a low temperature regime was higher than the one under a high temperature regime, the energy content of the diet having been equivalent or not. Under a low temperature regime, the same caloric intake was observed regardless of the energy content, but under a high temperature regime, an increase of enregy content in diet increased the rate of energy intake.

Body weight change and ME intake in the present research under each temperature regime compared with PAYNE's figures were given in Table 3. A tendency to greater ME intake under lower temperature regimes was observed. At 25 and 30°C, the gradual increase of energy content in diets induced gradually higher ME intake. On the other hand under the regimes above 32.5°C, ME intake kept nearly constant regardless of the ME content, especially at 35°C. It was interesting to note that in this high temperature (35°C) and relatively low temperature (18°C) reported by PAYNE (1967)[1)], every energy intake seemed so well controlled although each level was different. The ratio of ME intake in this experiment to that shown by PYANE was proportional to the body weight change and the more it exceeded the 100%, the more it gained in weight, and *vice versa*.

Table 3. Body weight change, ME intake and Caloric efficiency.

Set temperature °C	Group	Body weight Intial g	Body weight Final g	Mean kg	Balance g	ME intake Cal	Calorie into Egg Cal	Caloric efficiency %
25	A	1741±140	1830±116	1.80	+89	375 (110)	85	23
	B	1738±200	1925±252	1.87	+187	422 (124)	84	20
	C	1755± 68	1940±136	1.89	+185	479 (141)	79	16
30	A	1790±120	1804±116	1.81	+14	320 (97)	79	25
	B	1864±252	1900±310	1.88	+36	328 (99)	71	22
	C	1899±125	1990±108	1.95	+91	385 (117)	82	21
32.5	A	1804±116	1768±138	1.80	−36	262 (81)	79	30
	B	1900±310	1807±310	1.85	−93	237 (73)	69	29
	C	1990±108	1870±127	1.93	−120	253 (78)	75	30
35	A	1768±138	1642±158	1.71	−126	196 (61)	72	37
	B	1807±312	1739±290	1.77	−68	182 (57)	34	19
	C	1870±127	1770±124	1.82	−100	185 (58)	44	24

Parentheses: Percentage to PAYNE's figure.

Efficiency of egg production, being calculated from the egg production divided by food intake, was highest at 35°C in (A) and at 32.5°C in (B) and (C) as indicated in Table 2. Caloric efficiency for egg production in each temperature was shown in Table 3. Caloric efficiency was also highest in (A) at 35°C, in (B) and (C) at 32.5°C.

In this experiment, the calorie protein ratio, expressed as productive energy in one lb. of the food per protein content, was calculated as follows; 56: 1 in (A), 66: 1 in (B) and 79: 1 in (C). Since the optima ratio is said to be 60: 1, (B) and (C) had a rather wide ratio. The crude protein intake at each temperature is visualised in Table 4. PAYNE (1967)[1], MOWBRAY and SYKES (1971)[3] have pointed out that the least protein quantity require for maximum egg production was 14 g per day. As absolute protein intake was lowest at 35°C in (C) being 7.5 g, the egg production rate was about half of that in (C) at 30°C.

Table 4. Daily protein intake.

Protein level	Set temperature C°			
	25	30	32.5	35
A 17.7%	23.0	19.7	16.1	11.9
B 16.5%	21.4	16.7	12.1	9.2
C 15.2%	19.3	15.5	10.2	7.5

Table 5 and Table 6 show the relationships between environmental temperature and food intake, and temperature and water consupmtion per body weight in (A) compared with the data in the previous experiment (1970)[2] respectively. Food intake and water consumption have differently respond to environmental temperature putting a boundary between 30°C and 32.5°C. Water consumption was higher under lower wet bulb temperatures below 30°C, but it was also higher under higher wet bulb tem-

Table 5. Food intake in various environmental temperatures (g/day/kg).

		Dry bulb temperature °C			
		25	30	32.5	35
Wet bulb temperature °C	17	72*			
	20	64**	61*		
	21			51*	
	22		55**		39*
	25			51**	
	26				39**

* This experiment
** Previous experiment

Table 6. Water consumption in various environmental temperatures (g/day/kg).

		Dry bulb temperature °C			
		25	30	32.5	35
Wet bulb temperature °C	17	152*			
	20	116**	169*		
	21			157*	
	22		147**		159*
	25			191**	
	26				205**

* This experiment
** Previous experiment

peratures above 32.5°C. On the other hand, food intake was lower under higher wet bulb temperatures below 30°C, but above 32.5°C it was almost constant.

Calculated from Table 5 and 6, water consumptions seemed to keep the following proportions below 30°C; one g of food intake accompanies 1.2g of water, and the increase of 1°C of wet bulb temperature decreases 6% of water consumption. And an increase of 1°C of dry bulb temperature increased 10% of water consumption. Above 32.5°C food intake does not change regardless of the change of wet bulb temperatures. An increase of 1°C of wet bulb temperature increases 5.4% and 7.2% of water consumption at 32.5 and 35°C, respectively. These interesting relationships might be attributed to the following reasons. Below 30°C of dry bulb temperature, the higher water consumption under lower wet bulb temperatures may be attributed to thirst in low humidity, but above 32.5°C the heat stress may increase and under higher wet bulb temperature, water consumption may be increased but not food intake. Below 30°C, thirst may have an larger effect than direct heat stress of environmental temperature. Under low wet bulb temperature the food intake increased and consequently called for more water consumption, but it may be relavent to consider that the increase of water consumption may be due to thirst. Above 32.5°C an increase of water consumption accompanied with the same level of food intake along the increase of wet bulb temperatures seemed to come from an increase of direct heat stress fo environmental temperature. At the same wet bulb temperature decreased the more food intake by 1.4% from 25 to 30°C, 2.9% from 30 to 32.5°C, 9.4% from 32.5°C to 35, respectively. The differences within 30–32.5°C and 32.5–35°C were very drastic jumping to the double or even 7 times of the one within 25–30°C, respectively.

Compared with the previous paper the ratio of water consumption per unit of food intake was lower in this experiment under the regimes of more than 32.5°C. This facts seem to indicate that heat stress derived from high wet bulb temperature was lower, causing lower water consumption within the same level of food intake and giving a lower water food intake ratio in this experiment.

Corn oil supplementation used in egg production was not effective for the egg weight, but affective on the egg production rate and the egg production per day above 32.5°C, especially at 35°C. These effects seem to be caused by deficiency of nutrients necessary for the egg production, such as protein. In this experiment, a commercial chicken food well designed showed the best results. As long as extra calories were supplemented only, egg production decreased. Especially protein supplements may be necessary in the case of an energy increase. Caloric intake was either well under control or a little too high, but by a caloric increase under higher temperatures the decrease of food intake may be caused by the different level of energy content in the food, and then it may induce an overall nutrient deficiency which means a decrease in the egg production.

Body weight decrease began under the temperature regimes from 32.5°C on and at this stage energy supplementation only had no satisfactory effect on body weight maintenance.

The effeciency of the egg production was highest at 32.5°C (31% R. H.) in the case of corn oil supplemented diet and at 35°C (28% R.H.) for commercial food. This result should be attributed mainly to the non-appearance of abnormal eggs. Therefore, it is important to note that calcium supplementation had an effect on prevention of broken eggs or no-shelled eggs in a higher environmental temperature.

SUMMARY

This research was performed in view of investigating the effects of environmental temperature on egg production, food intake and water consumption in the case of corn oil supplemented feeding in laying White Leghorns. Twenty-fore laying hens were divided into three groups (A), (B) and (C) of eight hens each. (A) was fed with the commercial chicken food, (B) with the commerical food supplemented with 7% of corn oil, and (C) was fed with the commercial food supplemented with 14% of corn oil. The hens were kept in a room temperature of 25°C, 30°C, 32.5°C and 35°C during 10–15 days. The results obtained were as follows.

1) The higher the environmental temperature becomes, the lesser food intake was observed. Supplementation with corn oil accelerated the decrease of food intake.

2) Effects of corn oil supplementation on egg production were not noticeable in the egg weight, but were affective on the egg production rate and the egg production per day above 32.5°C, especially at 35°C. This may be due to the deficiency of nutrients for egg production.

3) The highest efficiency for the egg production was observed at 32.5°C in the case of corn oil supplementation and at 35°C in the case of the commercial food. Compared with the previous paper the difference of the latter result may be attributed mainly to the non-appearance of abnormal eggs. Calcium supplementation proved to be efficient for provention for broken eggs or no-shelled eggs in higher environmental temperatures.

4) Effects of dry and wet bulb temperature on food intake and water consumption, were discussed.

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白レグの産卵，採食，飲水におよぼす環境温度の影響

II. コーンオイル添加飼料給与の場合

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白レグ産卵鶏24羽を各8羽ずつ3群にわけ，(A) には市販飼料を，(B) および (C) には，コーンオイルをそれぞれ7％および14％添加した市販飼料を与えた．前報にひきつづき，これらの飼料を給与した場合の産卵，採食，飲水におよぼす環境温度 (25°C; 39% R.H., 30°C; 33%, 32. 5°C; 31%, 35°C; 28%，各温度感作 10～15 日) の影響を環境調節室内で実験し，次の知見を得た．

1) 採食量は温度上昇と共に減少し，コーンオイル添加によりさらに減少した．

2) コーンオイル添加は卵重には変化なく，産卵率，産卵量の低下が 32.5°C 以上で，とくに 35°C でいちじるしかった．これらの低下は，栄養素の摂取不足にもとずくものと思われた．
3) (B), (C) 群は 32.5°C で，(A) 群は 35°C で最高の産卵効率となった．高温におけるカルシウムの添加は．軟卵の出現防止に効果があった．
4) 採食量，飲水量におよぼす乾，湿球温度について考察した．

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