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Effects of Genetic, Physiological, and Other Variations on Yolk Cholesterol Level

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난황 콜레스테롤 수준에 미치는 유전적, 생리적 및 기타 변이 요인들의 효과

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ABSTRACT

Four experiments were conducted to investigate the association of yolk cholesterol level with egg traits, serum cholesterol level, body weight(BW) and breed differences and other variations. Athens Canadian Randombred (ACRB), a commercial layer breed (CL) and two commercial broiler breeds (BR1 and BR2) were used for this studies.

Egg weight of CL was heavier by 8.7g per egg than that of ACRB, but the yolk percentage and yolk cholesterol were lower by 7.8% per egg and 5.5mg per g yolk than those of ACRB, respectively. Yolk cholesterol content had no significant relation with the average egg weight or yolk weight in ACRB, but was significantly related with yolk fat level. However, yolk cholesterol level in CL showed inverse relationship with other egg traits compared to that of ACRB. In the CL female group, the association of yolk cholesterol level with BW was significant($P \leq 0.05$) at 25 weeks of age, but was not significant different at 26 wks of age. The relationship of yolk cholesterol with serum was not significantly different at 25 weeks of age, whereas it showed significant negative(−) correlation coefficient($P \leq 0.01$) at 26 wks of age. The association of yolk cholesterol level with egg age in CL population was not high comared to that of other treatments.

The serum cholesterol content of CL was not significantly different with BR1 and BR2 populations at 25 weeks of age, but was significantly($P \leq 0.05$) higher than that of BR1 or BR2 at 26 weeks old.

(Key words: yolk cholesterol, serum cholesterol, egg weight, layer, broiler)

INTRODUCTION

A standard egg size(56.7g /egg) contains approximately 200mg cholesterol (Beyer and Jensen, 1989a). The cholesterol originated from the egg yolk was relatively high compared to other foods. Hypercholesterol or other related

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materials(saturated fatty acids) in egg cause the development of cardiovascular diseases, such as heart attacks, high blood pressure, and atherosclerosis(Shih et al., 1983). As a result, egg consumption per person has declined in other countries for the last few decades.

Many studies have reported that the yolk cholesterol content was different due to genetic or physiological differences(Edwards et al., 1960; Marks and Washburn, 1977; Somes et al., 1977; Bair and Marion, 1978; Ansah et al., 1985; Washburn and Marks, 1985; Mahapatra et al., 1987; Hargis, 1988). The yolk cholesterol content of lower body weight(BW) groups tended to be lower compared to higher BW groups of Leghorn population(Washburn and Marks, 1977). The correlation coefficient between BW and yolk cholesterol was also 0.44(Edwards et. al, 1960). Although yolk cholesterol is derived from plasma cholesterol, Washburn and Nix (1974_b) indicated that the correlations between yolk cholesterol and blood cholesterol level were not closely related. There were sex differences ($P \leq 0.01 \sim P \leq 0.03$) in plasma cholesterol. The plasma cholesterol content of male showed 17% higher than that of females in the high plasma cholesterol line. It was 19% greater in female groups than male groups in the low plasma cholesterol line of Japanese quail(Marks and Washburn, 1991). Therefore, the current study was designed to investigate the association of yolk cholesterol level with egg traits, serum cholesterol level, BW and breed differences.

MATERIALS AND METHODS

Four experiments were conducted to evaluate the relation of yolk cholesterol level with egg traits, body weight, breed differences, egg age, and serum cholesterol levels. In experiment 1 and 2, 31 and 34 wks of age Athens Canadian Random Breed(ACRB) and Commercial Layer (CL) were used at the Southeast Poultry Research Laboratory of USDA, located in Athens, GA, USA. Two other experiments using CL, Boiler Breed 1(BR1) and Broiler Breed 2(BR2) were conducted at the Poultry Laboratory of Korean Sahmyook University.

1. Stocks

150 Commercial Layer(CL) and ACRB hens, developed from broiler randombred population in America as described by Hess (1962) were raised in experiment 1 and 2. 34 hens and 10 cockerels CL and 6 females and 3 males in each of two broiler breeds were fed in our country.

2. Measured Parameters

1) Egg traits, yolk cholesterol and fat content were measured from three and eight consecutively laid eggs of ACRB and CL populations, respectively.

2) Body weights of CL and two broiler breeder populations were measured at a day old, 6 wks, 25 wks, and 26 wks of age.

3) The serum cholesterol concentration values were obtained from CL, BR1, and BR2 populations at 25 wks and 26 wks of age.

3. Yolk Cholesterol, Fat and Serum Cholesterol Analyses

Yolk cholesterol and yolk fat were extracted by the procedure of Folch et al.(1956) as modified by Washburn and Nix.(1974a). Yolk cholesterol levels were determined by the Zlatkis method(Zlatkis et al., 1953) and the yolk fat contents were determined by the method described by Washburn(1989). To determine the serum cholesterol concentration values, three

blood samples in each chicken at 25 wks and 26 wks of age were taken from the brachial wing veins into heparin-treated capillary tubes. The blood samples were centrifuged for 10 minutes with 3,000 rpm and then stored at 4℃ until further analysis.

4. Statistical Analysis

Data was analyzed by using the General Linear Models (GLM) procedure of the SAS institute (1994). Significant mean value differences were tested by the method of Fisher's Least Significant Difference-test (LSD-test, 1949).

RESULTS AND DISCUSSION

1. Breed Differences between Yolk Cholesterol Level and Other Egg Traits

Egg weight, yolk weight, yolk percent, fat and yolk cholesterol content in ACRB and CL populations are presented in Table 1. From the data of the trials combined, the egg weight of CL was significantly($P \leq 0.05$) heavier than that of ACRB. However, the yolk weight, yolk percent per egg and yolk cholesterol content of CL were significantly ($P \leq 0.05$) lower than those of ACRB. Yolk cholesterol content of CL showed to be significantly lower by 5.5mg/g yolk compared to that of ACRB, but yolk fat content had no difference between these two populations. Previously, Washburn and Nix (1974_b) reported that the mean yolk cholesterol

Table 1. Differences on egg traits between the Athens Canadian Randombred (ACRB) and commercial layers (CL)

Trait	Trial	ACRB	CL
		$\bar{X}$ ± SE	$\bar{X}$ ± SE
Egg wt.	T1	42.4 ± .28	50.1 ± .56
(g)	T2	43.4 ± .30	52.9 ± .57
	Combined	42.9 ± .28[a]	51.6 ± .43[b]
Yolk wt.	T1	12.7 ± .10	10.9 ± .18
(g)	T2	12.8 ± .10	11.5 ± .15
	Combined	12.8 ± .09[a]	11.3 ± .12[b]
% Yolk	T1	29.9 ± .16	21.9 ± .36
(%)	T2	29.4 ± .15	21.8 ± .26
	Combined	29.7 ± .15[a]	21.9 ± .21[b]
Yolk fat	T1	248 ± 1.46	270 ± 9.38
(mgs/g yolk)	T2	241 ± 1.13	236 ± 6.32
	Combined	245 ± .99	241 ± 4.66
Yolk cholesterol	T1	20.5 ± .18	14.6 ± .25
(mgs/g yolk)	T2	20.2 ± .27	15.2 ± 1.16
	Combined	20.4 ± .16[a]	14.9 ± .88[b]

T1=Trial 1, T2=Trial 2, Combined=Combination of T1 and T2. The different superscripts (a, b) indicate significant differences ($P \leq 0.05$) between chicken populations in each trait.

content for the ACRB population was 22.8mg/g yolk. The results of this experiments showed that the yolk cholesterol content of ACRB was 20.4mg/g per yolk. It was slightly lower than the result of Washburn and Nix(1974). Yolk cholesterol of broiler breed indicated higher concentration relative to that of laying hen (Washburn and Marks, 1977). Those reports might explain that yolk cholesterol could be different as the breed differences. The indication by Washburn and Marks for breed differences in yolk cholesterol level showed the same tendency with the result of this study. The result of lower yolk cholesterol level of CL compared to that of ACRB, originally developed from broiler randombred population, suggests that there were significant difference for this trait between layers and broilers.

2. Association of Yolk Cholesterol Level with Other Egg Traits

The correlations between egg traits in the ACRB and CL populations are shown in Table 2. In previous studies, egg weight had significantly positive correlations($P \leq 0.001 \sim P \leq 0.01$) with yolk weight(Rodda et al., 1977; Beyer and Jensen, 1989b; Belorechkov and Sredkova, 1990). These conclusions were further confirmed by the result of this study. Yolk weight also showed positive correlations with yolk percent per egg in both ACRB and CL populations. In contrast, the egg weight negatively affected the % yolk per egg in the two groups. Yolk fat show the negative correlation with egg weight, but was not significantly different between them. The lack of relationship between yolk fat and egg weight is similar to the reports of Washburn and Marks(1985).

The yolk proportion tended to small in larger egg compared to small egg(Marion et al., 1964; Sainz et al., 1983). In the ACRB population, neither mg of yolk fat nor mg of yolk cholesterol per gram of yolk were correlated with egg weight. Those parameters were not affected by egg size or egg weight. However, in the CL population the mgs of yolk cholesterol per gram of yolk was correlated with egg weight although the mg of yolk fat per gram of yolk was not affected by egg weight. From these results, the relationship of egg size or egg weight with the yolk cholesterol content had different tendencies between ACRB and CL populations. The correlation of yolk cholesterol mg per gram yolk with yolk weight in ACRB population had negative low values, but was not statistically significant. However, the correlation between these two traits in CL population was positive and statistically significant($P \leq 0.05$). The relationship of yolk cholesterol content with egg weight in ACRB population was very low($r=0.002$) and not significant. In contrast, the relationship between these two traits in CL population showed highly significant positive value($r=0.50$). It was different from the result of Atalla et al.(1983). The association of yolk cholesterol content with yolk fat content in ACRB population was of low magnitude($r=0.16$), but exhibited positive and significant difference. These results agreed with previous investigations that the phenotypic correlations between yolk cholesterol and yolk fat content might be significantly different in low magnitude of ACRB and ARB(Washburn and Marks, 1985). The association of yolk cholesterol level and yolk fat content in CL population was statistically significant($P \leq 0.05$), but had a negative value($r=-0.34$). As a result, the relationships of yolk cholesterol level with other egg traits showed different tendencies between ACRB and CL populations.

Table 2. Phenotypic correlation (r) among egg traits in the Athens Canadian Randombred (ACRB) and commercial layer (CL) population

Trait	Trial	Egg wt.	Yolk wt.	% Yolk	Yolk fat	Yolk cholesterol
T1	----	.36*	−.29	−.02	.10	
Egg wt.	T2	----	.51***	−.35*	−.004	.45**
(g)	Combined	----	.50***	−.29*	−.14	.50***
	T1	.73***	----	.79***	.15	.28
Yolk wt.	T2	.76***	----	.63***	.04	.05
(g)	Combined	.74***	----	.33**	.04	.25*
	T1	−.17**	.54***	----	.17	.22
% Yolk	T2	−.24***	.45***	----	.04	−.35*
(%)	Combined	−.22***	.48***	----	.15	−.14
	T1	.08	.20***	.20***	----	.17
Yolk fat	T2	−.03	.03	.09	----	−.32*
(mg/g yolk)	Combined	−.01	.10*	.17***	----	−.34*
	T1	−.06	−.04	.02	.21***	----
Yolk chol.	T2	.04	−.06	−.15**	.13*	----
(mg/g yolk)	Combined	.002	−.05	−.08*	.16***	----

*P≤0.05, **P≤0.01, ***P≤0.001.

T1=Trial 1, T2=Trial 2, Combined=Combination of T1 and T2.

The correlation coefficients (r) of CL population are above and those of ACRB population are below the diagonal.

3. Associations of Yolk Cholesterol Level with BW and Serum Cholesterol Level

The relationships of yolk cholesterol level with BW and serum cholesterol levels in both sexes of CL population are shown in Table 3. The birth weight in female groups negatively affected yolk cholesterol level at 25 and 26 wks. However, it showed a significant relationship ($P \leq 0.05$) at 26 wks of age only. BW of female groups showed a significant relationship ($P \leq 0.05$) with yolk cholesterol level at 25 weeks, but did not show correlation at 26 weeks. Edwards et al.(1960) reported that the correlation coefficient(r) of yolk cholesterol with BW was 0.44 in some females at 36 weeks, but Collins et al. (1968) pointed out that the correlations between yolk cholesterol and weight gains were inconsistent and insignificant. Marks and Washburn (1977) reported that the 32-wk BW in the high and low yolk cholesterol lines of the Leghorn populations was not significant different over generations and showed a trend toward lower body weights in the low line. When we compared the results of this study with those of previous studies, it indicate that the association of yolk cholesterol level with BW was different according to the hen's age. The association of yolk cholesterol level with serum cholesterol level in female group of CL was of low magnitude(r=0.08). It was not also significant at 25

Table 3. Association of yolk cholesterol level (YC) with body weights (BW and serum cholesterol (SC) level in commercial layer population

	BW				YC		SC	
Traits	Day old	6 wk	25 wk	26 wk	25 wk	26 wk	25 wk	26 wk
BW (day old)	----	−.24	−.33**	−.16	−.13	−.30*	−.02	−.03
BW (6 wk)	.31	----	.15	.13	.25	−.02	.61***	.08
BW (25 wk)	.01	−.01	----	.80***	.38*	.03	−.01	.17
BW (26 wk)	−.18	−.01	.93***	----	.51***	.17	−.07	−.14
YC (25 wk)	----	----	----	----	----	.38*	.08	−.10
YC (26 wk)	----	----	----	----	----	----	−.24	−.46**
SC (25 wk)	.10	−.15	.28	.23	----	----	----	.08
SC (26 wk)	.06	−.50	.31	.33	----	----	−.41	----

*P≤0.05, **P≤0.01, ***P≤0.001.

wks of age, but was highly negative(r=-0.46) significance(P≤0.01) at 26 wks of age. In the male group of CL population, BW was not affect the serum cholesterol levels at both 25 and 26-wk of ages. Marks and Washburn(1991) reported that the mean BW of high plasma cholesterol line was significantly(P≤0.05) heavier than that of low plasma cholesterol line at early age stage(2 and 4wk), of Japanese quail, but was similar at later stage(8, 16, and 28wk) between two lines. The results of this experiment was different from those reports and inferred due to species differences.

The correlation coefficients (r) of combined data of female layers are above and those of the combined data of male layers are below the diagonal.

4. Effect of Egg Age on Yolk Cholesterol Level

In Trial 1, the mgs yolk fat per gram yolk of the two-day old egg had the lowest value and was significantly(P≤0.05) lower than that of other egg ages. However, it did not appear to have significant differences for yolk fat among egg ages in Trial 2(Table 4). The data of combined trials showed that the association of

Table 4. Effect of egg age on the levels (mg /g yolk) of yolk fat and yolk cholesterol

Egg age (Day)	Yolk fat			Yolk cholesterol		
	T1	T2	Combined	T1	T2	Combined
	$\bar{X}$ ±SE	$\bar{X}$ ±SE	$\bar{X}$ ±SE	$\bar{X}$ ±SE	$\bar{X}$ ±SE	$\bar{X}$ ±SE
0	267±23.33^{a}	226±26.88	244±18.73^{ab}	15.5±1.28	13.8±4.30^{ab}	14.7±2.89
1	300±0.00^{a}	239±11.89	244±12.00^{ab}	13.0±.00	14.8±2.24^{ab}	13.9±2.11
2	200±26.46^{b}	211±32.80	206±20.48^{b}	14.9±.67	20.8±3.96^{bc}	17.9±3.50
3	243±14.93^{a}	232±12.09	236±9.09^{ab}	13.7±.45	17.2±3.17^{ab}	15.5±2.83
4	233±21.86^{a}	255±7.36	246±10.14^{ab}	14.1±.32	13.0±3.40^{ab}	13.6±2.56
5	267±12.02^{a}	244±11.28	250±9.08^{a}	14.6±.62	11.7±2.18^{a}	13.2±1.86
6	258±15.48^{a}	250±0.00	256±12.08^{a}	14.9±.42	12.5±.00^{ab}	13.7±1.56
7	270±14.14^{a}	235±0.00	263±13.00^{a}	14.2±.12	23.8±.00^{bc}	19.0±4.04

$^{a, b, c}$Means within a column with no common superscripts are significantly different(P≤0.05).

Table 5. Effect of breed on body weight (g) and serum cholesterol levels (mg /100ml)

Traits	CL	BR1	BR2
	$\bar{X}$ ±SE	$\bar{X}$ ±SE	$\bar{X}$ ±SE
BW (day old)	39.4 ± 0.49[a]	41.3 ± 0.94[b]	40.9 ± 0.93[ab]
BW (6 wk)	426 ± 17.37[a]	1068 ± 59.23[b]	1021 ± 67.68[b]
BW (25 wk)	1593 ± 19.94[a]	2919 ± 75.73[b]	2852 ± 117.09[b]
BW (26 wk)	1706 ± 20.47[a]	3328 ± 107.53[b]	3223 ± 129.48[b]
Cholesterol (25 wk)	137.3 ± 9.71	130.3 ± 22.46	132.5 ± 14.25
Cholesterol (26 wk)	147.3 ± 17.31[a]	53.1 ± 14.04[b]	47.1 ± 9.14[b]

The different superscripts (a, b) indicate significant differences ($P \leq 0.05$) among chicken population in each trait.

yolk cholesterol value with egg ages was of low magnitude. As the result of the current study, the relationship of yolk cholesterol level with egg ages cannot directly compare with other studies because the studies on this area are few. Therefore, the results of this experiment indicated that the correlation between yolk cholesterol and egg age could explained that yolk cholesterol levels were not altered by the influence of egg age.

5. Effect of Breed on Serum Cholesterol Level

Serum cholesterol content(mg /100ml) at 25 wks of age, the breed differences between layer and broiler groups did not show significance. However, both broiler groups had significantly ($P \leq 0.05$) lower values in serum cholesterol contents at 26 weeks of age than the CL group, whereas serum cholesterol was not significantly different between the two broiler groups(Table 5). The result of breed differences on serum cholesterol level between CL and broiler groups at 26 wks of age was similar to the result of Marks and Washburn(1991) who found significant line differences on mean plasma cholesterol values(mg /100ml) between high and low plasma cholesterol lines.

6. Effect of Sex on Serum Cholesterol Level

Differences between sexes within breed in serum cholesterol contents are shown in Table 6. Although the serum cholesterol contents of male chickens from all populations had lower values(mg /100ml) than females, the statistically significant difference showed in CL population only. The mean serum cholesterol value of female chickens in CL population was especially 237% higher than that of males. In the study of Marks and Washburn(1991) using Japanese quail, the plasma cholesterol levels of control

Table 6. Effect of sex on serum cholesterol levels (mgs /100ml)

Breed	Trial	Male	Female
		$\bar{X}$ ± SE	$\bar{X}$ ± SE
CL	T1	93.0 ± 9.89[a]	145.7 ± 10.96[b]
	T2	38.1 ± 5.23[a]	162.9 ± 18.86[b]
	Combined	65.5 ± 8.92[a]	155.5 ± 11.74[b]
BR1	T1	70.9 ± 0.00	142.2 ± 23.34
	T2	93.6 ± 0.00	43.0 ± 12.57
	Combined	82.3 ± 11.36	98.1 ± 21.94
BR2	T1	103.7 ± 6.82	146.8 ± 18.81
	T2	68.7 ± 11.40	36.3 ± 10.20
	Combined	86.2 ± 9.83	91.5 ± 19.54

The different superscripts (a, b) indicate significant differences ($P \leq 0.05$) between sexes within chicken population in each trial.

group males and females were almost identical at 2 and 4 wks of age. However, the plasma cholesterol of male were higher at 8 and 16 wks of age than females. Therefore, they concluded that males of unselected Japanese quail, normally have higher plasma cholesterol values than females. The result of those experiements was quite different from the report of the CL population in the current study.

적 요

난황콜레스테롤 수준과 닭의 유전적, 생리적 및 이들 외적요인 간의 상호관계를 구명코자 미국에서 육용계 무작위교배 집단으로 부터 개발된 31주령 및 34주령의 Athens Canadian Randombred (ACRB)종과 국내 농가에서 사육되고 있는 갈색산란계 1종 (CL) 및 육용계 2종 (BR1 및 BR2)을 부화시켜 26주령 까지 사육하여 실험을 수행한 결과는 다음과 같다.

1. CL종은 평균난중이 ACRB에 비하여 8.7 g이 더 무거웠으나, 난황의 무게 및 난중에 대한 난황의 비율은 각각 1.5 g 및 7.8%가 유의적으로 ($P \leq 0.05$) 낮았다.
2. 실용산란계인 CL종의 난황콜레스테롤 수준은 ACRB종의 그것보다 난황 1 g당 5.5 mg이 적었다.
3. ACRB종에 있어서 난중과 난황의 무게는 난황콜레스테롤 수준에 유의적인 영향을 미치지 못하였으나, 난황지방의 함량은 난황콜레스테롤 수준과 상관관계 (+상관)가 높았다 ($P \leq 0.001$).
4. CL종의 난중 및 난황 무게는 난황콜레스테롤 수준에 정 (+)의 상관관계($P \leq 0.05$)를 나타냈으며, 난황지방의 함량과 난황콜레스테롤 수준간에는 ACRB종과 정반대의 경향으로 역 (−)의 상관관계($P \leq 0.05$)를 보였다.
5. CL종 암닭에 있어서 25주령과 26주령에 측정된 난황콜레스테롤 수준에 대한 체중의 효과는 25주령에서 유의적 ($P \leq 0.05$)으로 영향을 미쳤다.
6. CL종의 난황콜레스테롤 수준에 대한 계란의 일령 상호간에는 전체적으로 상호간에 차이가 없었다.
7. 26주령시 혈중콜레스테롤 수준은 CL종이 다른 두 육계종들 보다 유의적 ($P \leq 0.05$)으로 높았다.
8. 성별간 혈중콜레스테롤 수준의 차이는 CL종, BR1 및 BR2 중에서 CL종에서만 나타났으며, 수컷은 암컷보다 혈액 100 mL당 약 90 mg이 낮았다.

(색인: 난황콜레스테롤, 혈중콜레스테롤, 난중, 산란계, 육용계)

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