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THE EFFECT OF MATERNAL DIETARY OMEGA (ω)-3 FATTY ACIDS ON HATCHABILITY AND GROWTH OF BROILER CHICKENS

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Summary

The effects of different maternal dietary $_{\omega}$-3 fatty acids on hatchability and post-hatch development of the broiler chickens were investigated. Incubated eggs were Low ($L_{\omega}3$), Medium ($M_{\omega}3$) or High ($H_{\omega}3$) in $_{\omega}$-3 fatty acids. The eggs were produced by feeding broiler breeder hens with a wheat-soybean meal diet containing (g/kg) 50 g of sunflower oil ($L_{\omega}3$); 25 g sunflower oil + 25 g fish oil ($M_{\omega}3$); or 50 g fish oil ($H_{\omega}3$). Hens fed the $M_{\omega}3$ diet had highest ($P<0.05$) fertility and hatchability values 78.26 and 65.35% compared to 69.01 and 47.18% for the $H_{\omega}3$ fed group. However, hens fed the $L_{\omega}3$ diets produced eggs that were significantly ($P<0.01$) larger than eggs from the $M_{\omega}3$ and $H_{\omega}3$ fed group. Consequently, the day-old chick live-weight were significantly different ($P<0.01$) with chicks hatched from the $L_{\omega}3 > M_{\omega}3 > H_{\omega}3$ fed groups. Best performance was obtained from the $M_{\omega}3$ fed group, which might indicate an optimum level of $_{\omega}$-3 for hatchability and growth.

I. INTRODUCTION

The physiological, biological and neurological importance of $_{\omega}$-3 fatty acids in human and livestock nutrition is well documented in the literature (Sim, pers. comm.). Consequently poultry products are enriched with nutritionally desirable $_{\omega}$-3 fatty acids by the manipulation of dietary fatty acids composition. In recent years the "hen-egg-embryo-chick" avian model has been used extensively to study nutrient accretion, in-particular $_{\omega}$-3 fatty acids metabolism during embryogenesis (Cherian *et al.,* 1997) and post hatch fatty acid composition of heart, brain and spleen (Ajuyah *et al.,* 2002).

Operators of commercial hatcheries are seeking to improve fertility, hatchability and reduce embryonic mortality while broiler producers expect minimal culls, improved feed conversion and weight gain of broiler chickens. Some studies have shown that the alteration of yolk fatty acid composition can have undesirable effects on fertility, hatchability embryonic survival and post hatch growth (Donaldson and Fites, 1970; Aydin *et al.,* 2001). Recently Halle (1999), reported that when broiler breeder hens were fed diets containing high levels of oleic acid (C18:1) or linoleic acid (C18:2), fertility was significantly affected, however embryonic mortality, hatchability and weight of the day old chicks were not significantly affected by the fatty acid composition.

This study was designed to examine the effects of different maternal dietary $_{\omega}$-3 fatty acids on egg weight, fertility, hatchability, early and late embryonic mortality, and post hatch traits such as live weight, weight gain, feed intake and feed conversion ratio of broiler chickens from hatch to slaughter. These traits are of economic importance to the Canadian broiler industry.

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II. MATERIALS AND METHODS

Eggs with low ($L_\omega3$), medium ($M_\omega3$) and high ($H_\omega3$) $_\omega3$ fatty acids were produced by feeding broiler breeder hens with the following diets: - a wheat-soybean meal based diet containing (g/kg) 50 g of sunflower oil ($L_\omega3$); 25 g sunflower oil + 25 g fish oil ($M_\omega3$); or 50 g fish oil ($H_\omega3$). The diets were calculated to contain the same amounts of protein (CP, 160 g/kg) and energy (11.8 ME MJ /kg). Vitamin E (27-mg/kg diet) was added to the $M_\omega3$ and $H_\omega3$ diets to protect the highly unsaturated fish oil fatty acids from undergoing auto-oxidation.

The breeder hens were 26 weeks old at the start of the experiment and each treatment had 40 females in individual cages with free access to feed and water. To facilitate the collection of fertile $L_\omega3$, $M_\omega3$ and $H_\omega3$ eggs, the hens were artificially inseminated weekly, two weeks after the introduction of the experimental diets. Eggs were collected and stored in a cold room (13-15 °C) for 6 weeks prior to incubation in a forced-draft 5000 egg capacity incubator, with automatic hourly turning (model PT-100, serial number H-A0019) and temperature set at 37.5°C (dry bulb) and 29.4°C (wet bulb). At 18 d of incubation the eggs were transferred to a 5000 egg unit hatcher (model PT-100, serial number H-A0014) with temperature set at 37.2°C (dry bulb) and 29.4°C (wet bulb). At the end of incubation (21 d) all the un-hatched eggs were cracked open to determine the number of clear eggs and the incidence of early and late embryonic mortality.

Post-hatch chicks were raised on deep-litter floor (pen size = 6.89 m^2) at a stocking density of 0.07 m^2 per bird. All the birds were fed the same commercial broiler starter (1-3 weeks) and finisher (3-6 weeks) diets, and water was provided *ad-libitum.* The design of the growth trial was completely randomized and the lighting regime employed throughout the experimental period was a light:dark (L:D) cycle of 23L:1D. Subsequently chicks hatched from $L_\omega3$, $M_\omega3$ and $H_\omega3$ diets were re-designated as groups 1, 2 and 3 respectively (n=100 birds per replicate and 5 replicates per group). The following data was collected: - number of total eggs incubated, post incubation clear eggs, early dead in shell (EDIS) and late dead in shell (LDIS) embryos, for determining percent fertility, hatchability and early and late embryonic mortality. In addition post-hatch traits such as live weight, weight gain, feed intake and feed conversion ratio of the broiler chickens from hatch to slaughter were also determined.

The chemical analysis of the fatty acid composition of the diet and eggs were determined using the method of Wang *et al.* (2000), and all the data were then subjected to analysis of variance (Genstat, 1997). The differences between means were determined by Least Significance Difference (LSD).

III. RESULTS

Table 1 shows the selected fatty acid composition of maternal diets and corresponding egg yolk (mg/g). Fertility was expressed as percent of total eggs less total clear eggs (F), while hatchability values were expressed for both total eggs (HTE) and fertile eggs (HFE). Hens fed the $M_\omega3$ diet had highest F, HTE and HFE (Figure 1). The early (EDIS) and late (LDIS) embryonic mortality were expressed as a percentage of total fertile eggs. EDIS was highest (26.3%) in the $H_\omega3$ group which, however, had the lowest LDIS (0.41%, data not shown). Percent culls for all groups were less than 5% ranging from 4.9% in the $H_\omega3$ group 3.6% in the $M_\omega3$ group (data not shown).

Hens fed the $L_\omega3$ diets (table 2) produced larger ($P<0.01$) eggs than $M_\omega3$ and $H_\omega3$ – fed hens, which were not significantly different. Consequently the day-old chick live-weight

for the $L_{\omega}3$, $M_{\omega}3$ and $H_{\omega}3$ groups were significantly different ($P<0.01$). The effect of maternal diet on live-weight and weight gain persisted for 3 weeks. However at 6 weeks of age there were no significant differences between all the groups for live weight, weight gain and feed conversion ratio. The correlation coefficient between egg weight and day-old chick weight was 0.987, and between day-old chick weight and 3 and 6 weeks live-weight were 0.955 and 0.928 respectively. The correlation coefficient between 3 and 6 week live weight was 0.776.

Table 1. Selected fatty composition of maternal diets and corresponding egg yolk (mg/g)

	$L_{\omega}3$	$M_{\omega}3$	$H_{\omega}3$
Diet			
C18:0	2.17	1.64	1.40
C18:1	10.03	7.82	7.01
SAFA	8.80	11.57	15.04
MUFA	10.31	10.48	12.47
ω-3	1.04	5.00	9.43
Egg-yolk			
C18:0	28.14	25.23	25.03
C18:1	103.78	112.00	114.41
SAFA	111.51	110.17	118.29
MUFA	113.50	125.46	133.23
ω-3	2.59	17.56	25.68

Lω3 = Low, Mω3 = Medium; Hω3 = High;
SAFA = Saturated fatty acids; MUFA = Monounsaturated fatty acids.

Table 2. Effect of different maternal diets on egg weight, post hatch live weights and feed conversion efficiency of broiler chickens fed similar diets from hatch to slaughter

	$L_{\omega}3$	$M_{\omega}3$	$H_{\omega}3$	P
Egg wt. (g)	59.7^{a}	54.5^{b}	52.5^{b}	**
Live weight (g)				
0 day	45.60^{a}	43.60^{b}	42.01^{c}	**
3 weeks	677.4^{a}	662.8^{a}	631.2^{b}	*
6 weeks	2258	2192	2188	NS
FCR				
3 weeks	1.63	1.50	1.52	NS
6 weeks	1.95	1.95	1.94	NS
Weight gain (g)				
3 weeks	631.8^{a}	619.2^{ab}	589.2^{b}	*
6 weeks	1581.0	1529.0	1556.5	NS

* = $P< 0.05$; ** = $P < 0.01$; NS = not significant
[a-c] Means within rows with same superscript are not significantly different.
FCR = Feed conversion ratio.

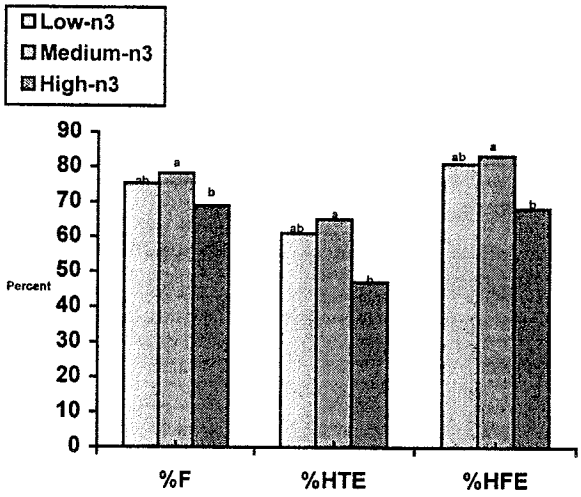

Figure 1. The effect of maternal diet on percent Fertility (F), Hatchability of Total Eggs (HTE) and Hatchability of Fertile Eggs (HFE).

IV. DISCUSSION

Studies have shown that alteration of yolk fatty acid composition can affect fertility, hatchability embryonic survival and post hatch growth of chicks. Aydin *et al.* (2001) attributed high embryonic chick mortality to decreases in yolk C18:1 and total monounsaturated fatty acids with associated increases in saturated fatty acids in the egg yolk. Donaldson and Fites (1970) observed that high levels of C18:0 and low levels of C18:1 induced embryonic mortality in quail. The current investigation suggests that high concentrations of maternal dietary $_{\omega}$-3 fatty acids may reduce egg size, fertility, hatchability, and early chick growth. Recently Halle (1999), reported that when broiler breeder hens were fed diets containing high levels of oleic acid (C18:1) or linoleic acid (C18:2), fertility was significantly affected, however embryonic mortality, hatchability and weight of the day old chicks were not significantly affected by fatty acid composition. Yolk fat as a source of energy and essential nutrients has been shown to play a crucial role in the avian embryonic development (Noble and Cocchi, 1990).

The maternal effects and high correlation between egg size, day-old chick and 3 week live-weight agree with the findings of numerous studies (e.g. Burke *et al.*, 1997) which show a reduced influence of egg weight on body weight as growth proceeds. Peebles *et al.* (2002) reported that age, maternal dietary energy levels and fat types influenced chick live weight to 43 days of age.

V. CONCLUSION

Our studies suggest that changes in maternal dietary $_{\omega}$-3 fatty acids had an impact on pre and post hatch development of the broiler chickens, indices that are of economic importance to the commercial broiler industry. We agree with the observation of Hill (1993), who concluded that egg composition can have important consequences on chick survival by influencing body size at hatch and suggested that the practice of using egg size alone as a

measure of egg "quality" needs to be broadened to also consider internal composition. The specific influences of egg nutrients, in-particular fatty acids, on pre and post embryonic growth and development require further study. In the current study, the causes of low fertility, poor hatchability and high embryonic mortality in the $H_{\omega}3$ group is unknown. However, the relatively high fertility and hatchability of the $M_{\omega}3$ group indicates an optimum dietary fatty acid balance for reproductive performance.

IV. ACKNOWLEDGMENTS

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