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Effect of Dietary Tallow Level on Broiler Breeder Performance and Hatching Egg Characteristics

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Abstract: The effect of diets with different levels of tallow on broiler breeder performance was evaluated in the study. About 3 different levels of fats (0.5, 1 and 1.5%) were added into a corn-soybean meal-based broiler breeder diet. The control diet included no supplementary fat. All diets were isocaloric and isonitrogenous. Feeding of experimental diets was initiated when broiler breeders (Ross 308) were 22 week old. Body weight of females was not affected by dietary treatments during the experimental period. Adding different levels of tallow to broiler breeder diet affected egg yolk weight (%), albumen weight (%) and yolk: albumen ratio (%) compared with controls ($p<0.05$). However, double-yolked egg, liveability, fertility (%), hatchability of fertile eggs (%), hatchability of total eggs set (%) and chick weight (g) were not affected by dietary treatments. Tallow supplementation to breeder diet significantly reduced hen-day egg production and egg weight ($p<0.01$) in comparison with controls. Female body weights were not affected by dietary fat addition through the entire experimental period. These data suggest that inclusion of different levels of tallow up to a level of 1.5% to the corn-soybean meal diet may affect egg production performance, fertility, egg weight, chick weight, hatching of eggs set and specific gravity without any adverse effect on body weight and settable egg characteristics.

Key words: Broiler breeder, hatchability, tallow, settable egg, chick weight, Iran

INTRODUCTION

Broiler breeder diets influence subsequent egg production performance (Bozkurt *et al*., 2008; Peebles *et al*., 2000a, b) and also embryogenesis and hatchability of broiler eggs (Peebles *et al*., 1999, 2000a, b). Owing to their energy and fatty acid characteristics, fats and vegetable oils affect the egg production (Ozdogan and Sari, 2001). Addition of fat in broiler breeder diets had no effect on egg production (Sohail *et al*., 2003; Bryant *et al*., 2005; Shahriar *et al*., 2008). O'Sullivan *et al*. (1991) reported that yolk and albumen weights and yolk: albumen ratios grew as hen age increased. Furthermore, the use of added poultry fat in broiler breeder diets caused increased egg weight (Brake, 1990) and decreased eggshell percentage (Brake, 1990). The quantity of chicks produced per hen was maximized with addition of 4% poultry fat to broiler breed diets (Brake, 1990). Incorporation of 5% poultry fat to broiler breed diets without increasing ME intake has been reported to raise egg weight and egg production (Brake, 1990). Moreover, Bozkurt who appraised supplementation of different fat sources (sunflower oil, fish oil and tallow) into a corn-soybean meal-based broiler breeder diet, reported that body weights of female and male breeders were not affected by dietary treatments during the experimental period and tallow addition to breeder diet significantly diminished hen-day egg production and cumulative settable egg yield (Bozkurt *et al*., 2008). There are data in the literature that also report the effects of changes in dietary Fatty Acid (FA) on proportional changes in yolk FA (Ding and Lilburn, 1996; Cherian and Sim, 1993) which confirms the potential of influencing embryonic FA metabolism and overall embryonic growth (Peebles *et al*., 1998). Effects on laying hens have been well documented since the 1960s (Menge *et al*., 1965; Sell *et al*., 1987; Keshevarz, 1995). A number of reports have also detected no effect of up to 5% supplementary fat on egg weight of breeders (Peebles *et al*., 1999; Brake, 1990) fed on corn wheat-based diets.

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Tallow, lard and fish oil processing by-products have become more available to the poultry industry in some states as a low-cost dietary fat source. It was hypothesized that the type as well as the level of fat added to breeder diets may exert effects on broiler performance that may be modified by the age of the breeder. There is a lack of information on the effects of different levels of dietary fat through the laying period on the performance of broiler breeders. Also there has not been any investigation with regard to the actual linoleic acid content in the diet of broilers.

In this study, inclusion of three levels of tallow in standard broiler breeder diets up to 1.5% and the effect of actual linoleic acid content of diets on egg production and reproductive performance were examined.

MATERIALS AND METHODS

Male and female Ross-308 broiler breeder chicks (Ross Breeders Management Guide, 1998) were placed in an open house with natural ventilation and reared in conventional litter floor pens with standard management practices. Birds were exposed to natural day length through the growing period (1-21 weeks). Amount of feed was adjusted weekly during the growing period to maintain BW gain as recommended by Ross Broiler Breeders. The experimental analysis was initiated when the birds were 2 weeks of age. Briefly, 10 females and 1 male were assigned to each of 10 breeder pens (4 treatments entailed 5 replicates per treatment) in a curtain sided breeder house. Each pen was equipped with 1 automatic waterer, 3 hanging feeders and one 6 hole nest box. The floor of breeder pens was covered with pine shaving as litter material. With the exception of hand feeding, the housing was comparable with commercial standards. Occasion of breeder housing was in early summer (beginning of June) when the mean environmental temperature was 26°C and natural day length provided a 14 L: 10 D cycle. Hens were subjected to natural environmental conditions at the subtropics climatic zone from July to February through the laying period.

Upon movement to the breeder house at 22 weeks of age using a combination of natural and incandescent lights, day length was increased by 1 h weekly increments from 14-16 h at start of lay (26 weeks). Diets were adjusted weekly to maintain recommended body weights during the pre lay period (22-25 weeks). Weekly incremental augmenting in feed began before lay so that feed rations were adjusted from 125 g/bird/days at housing to 165 g/bird/days at initiation of lay.

After egg lay commenced (26 weeks) daily feed allotment was sustained continuously at 165 g/hen/days and energy intake was 443 kcal/hen/days through the

Table 1: Composition of the experimental diets

Ingredients	Control	TW1	TW2	TW3
Maize	54.00	52.60	51.04	49.00
Soybean meal	16.40	16.30	16.30	16.10
Wheat bran	2.03	1.60	2.70	3.50
Wheat	16.10	16.24	16.40	17.40
Alfalfa	2.71	4.00	3.80	3.74
Tallow	0.00	0.50	1.00	1.50
Calcium carbonate	7.00	7.00	7.00	7.00
Calcium m phosphate	0.95	0.95	0.95	0.95
Salt	0.25	0.25	0.25	0.25
L-Lysine	0.02	0.02	0.02	0.02
DL-Methionine	0.04	0.04	0.04	0.04
Premix[1]	0.50	0.50	0.50	0.50
Composition, analyzed				
ME (kcal kg^{-1})	2703.89	2702.54	2702.78	2701.78
Crude protein (%)	14.50	14.49	14.51	14.48
Linoleic acid (%)	1.20	1.20	1.20	1.20
Lysine (calculated) (%)	0.66	0.66	0.66	0.66
Methionine (%) (calculated)	0.26	0.26	0.26	0.26
Met+Cys (%)	0.50	0.50	0.50	0.50
Calcium (%)	2.85	2.85	2.85	2.85
Phosphorus (total) (%)	0.58	0.57	0.56	0.57
P. available (%)	0.37	0.37	0.37	0.37

22-58 weeks of experimental period. Males fed together with females in the same feeders; separate-sex feeding was not applied. Dietary treatments initiated at week 22 and all diets were formulated to meet or exceed (Ross Breeders Management Guide, 1998) specifications. Four diets were formulated to meet or exceed (Ross Breeders Management Guide, 1998) specifications (Table 1). The experimental diets included different levels of added tallow. The levels of ethoxyquin added to diets exceeded the total antioxidant potential currently recommended by manufacturers for the fats utilized. All diets were isocaloric and isonitrogenous (Table 1). Diet 1 was a common corn-soybean mash diet and contained no added fat (CT); diets 2, 3 and 4 (so-called TW1, TW2 and TW3) contained 0.5, 1 and 1.5% tallow, respectively. All of the birds were weighed individually at 22, 34, 46 and 58 weeks. Egg production and percent settable eggs per hen were recorded daily. Egg production was calculated in terms of hen-day egg production (%) of total laid eggs per each replicate. A percent settable egg per hen was defined as ratio of total settable eggs to total laid eggs per each treatment. Mortality was recorded daily and feed allowance adjusted accordingly. Eggs were collected 4 times a day and recorded as nest- or floor-laid, cracked, broken or soft-shelled eggs. Only nest eggs that were not dirty, misshapen, broken, cracked, excessively small or double-yolked were classified as settable eggs and stored in a cooler until set. Random samples of eggs from each treatment (10) for 2 consecutive days every week were weighed individually to determine average egg weight. Additionally, 40 newly hatched chicks (21.5 days incubation) per treatment (20 chicks per replicate pen) were weighed individually at the hatchery on a weekly basis. About 60 settable eggs per replicate pen were set for incubation weekly between 28 and 58 weeks of age. Eggs were incubated in Jamesway model 252B incubators. Incubator was set at 37.6°C dry bulb and 28.6°C wet bulb temperatures. Eggs were candled at 10 days of incubation for determination of infertile eggs. All infertile eggs were opened and examined macroscopically for evidence of embryonic mortality. Fertility was expressed as rate of fertile eggs to total eggs set. At 19 days, eggs were transferred to the hatching cabinet of the same incubator for hatching. Hatching incubator was set at 37.5°C dry bulb and 29.2°C wet bulb temperatures. Number of eggs that hatched was recorded at 21.5 days of incubation. Hatchability of fertile eggs was expressed as rate of hatching chicks to fertile eggs and percentage cumulative hatchability was expressed as percentage of hatching chicks to the total eggs set. Settable egg quality was measured at 28, 34, 40, 46, 52 and 58 weeks of broiler breeder hen age. Settable egg quality parameters included Egg Specific Gravity (ESG), Egg Yolk Weight (EYW) and Albumen Weight (EAW). They were expressed as percentages of total egg weight. Randomly collected settable eggs (6 per pen) were used for evaluation of settable egg quality parameters. Therefore, 40 settable eggs were examined for each trial period (a total of 240 setting eggs). The method for measurement of ES was according to Hamilton (1982). The standard techniques for the proximate analysis were used to determine the nutrient concentrations in the diets (noman). Metabolizable energy content of the diets was calculated based on chemical composition (Naumann and Bassler, 1993). The data were analyzed using the GLM procedure of SAS (1990). Significant differences between treatment means were separated using Duncan's multiple range test at a probability of 5% ($p<0.05$).

RESULTS AND DISCUSSION

Body weights of females determined at 22, 34, 46 and 58 weeks of age are shown in Table 2. Female body weights were not affected by dietary fat addition through the entire experimental period.

It was demonstrated in an early report (Brake, 1990) that added animal or vegetable fat at the 5% level did produce slightly but consistently higher female body weights after peak egg production. The results of the current study are similar to those in an earlier study of broiler breeder hens (Peebles *et al*., 2000a, b) fed corn oil, poultry oil and lard supplemented diets at the levels of 1.5-3% and (Bozkurt *et al*., 2008) fed sunflower oil, fish oil and beef tallow supplemented diets at the level of 1.5%. Production and reproductive performance characteristics of breeder hens are shown in Table 3. Except for egg production and egg weight, the inclusions of different levels of tallow to the diet had no adverse effects on egg production of broiler breeders. Tallow supplementation significantly depressed egg production and egg weight ($p<0.05$). However, in some previous reports inclusion of dietary fats such as tallow or lard rich in saturated fatty acids had no deleterious effect on egg production of broiler breeders and layers (Peebles *et al*., 2000a, b; Baucells *et al*., 2000) while in other cases an increase in egg production was reported (Brake, 1990; Bozkurt *et al*., 2008). On the other hand, this finding is consistent with the report of Peebles *et al*. (2000a, b) who proposed that increased saturation level of dietary fat may have adverse effects on egg production. More saturated fatty acid content of tallow diet might be responsible for slower follicle formation when compared with control diet. Settable egg rate of hens fed with different levels of tallow displayed no significant changes compared to control treatments. Hens fed the supplemental tallow in diets produced smaller eggs (60.92, 61.50 and 61.78 g for 1.5, 1 and 0.5%, respectively) than those fed the control diet (61.82 g). The inclusions of fats to diets of commerce layers (Sell *et al*., 1987; Whitehead *et al*., 1991) and broiler breeders (Bozkurt *et al*., 2008) have been proved to increase egg weight. However, in some recent studies (Peebles *et al*., 2000a, b), it was demonstrated that poultry fat and lard supplementation to broiler breeder diets up to the level of 3% did not significantly affect egg weight. Similarly, a significant reduction in egg weight was observed for high n-3 as compared to low n-3 eggs. Van Elswyk *et al*. (1994) suggested that increasing dietary n-3 fatty acid content might cause a decline in circulating triglycerides of birds thus limiting availability of lipids for yolk formation. As can be shown in Table 3, dietary added fats had no significant effect on the rate of double-yolked eggs and hen liveability in this study. Consistent with results of previous broiler breeder studies (Peebles *et al*., 2000a, b) the moderate energy (2,800 kcal kg^{-1}) and fat addition level (1.5%) applied in this study had no sdetrimental effect on hatchability of fertile eggs. Brake (1990) established that hens that consumed 5% added poultry fat diets had significantly lower fertility (90.6 vs. 93.5%) and hatchability (90.6 vs. 91.8%) than those fed a non-fat-added, corn-soybean-based control diet. Peebles *et al*. (2000a, b) indicated that increased saturation of dietary fat increased ESG and eggshell

Table 2: The effect of different levels of tallow on body weights of broiler breeder females and males

Sex	Age (weeks)	Control	0.5 tallow	1 tallow	1.5 tallow	SEM	p-value
Female	22	2081.80	2087.30	2092.64	2101.12	16.36	NS
	34	3399.47	3420.22	3422.60	3421.09	25.22	NS
	46	3447.39	3495.26	3482.80	3494.57	27.25	NS
	58	3573.68	3590.50	3585.60	3596.71	30.52	NS

Table 3:Effect of dietary fat type on egg production and reproductive performance of broiler breeders

Items	Control	0.5 tallow	1 tallow	1.5 tallow	SEM	p-value
Egg production (%), hen-day	64.16^{a}	63.75^{b}	63.48^{bc}	62.82^{c}	0.51	0.01
Egg weight (g), n = 8193 eggs	61.82^{a}	61.78^{ab}	61.50^{b}	60.92^{c}	0.48	0.05
Settable egg (%)	85.23	84.75	84.89	84.39	1.12	NS
Total settable egg (per hen)	121.29	120.20	119.30	119.08	1.78	NS
Double-yolked egg (%)	0.89	0.91	0.91	0.97	0.08	NS
Liveability (%)	94.78	94.85	92.22	91.12	1.25	NS
Fertility (%)	89.23	90.23	90.23	89.16	0.88	NS
Hatchability of fertile eggs (%)	88.80	88.56	88.26	88.30	0.91	NS
Hatchability of total eggs set (%)	79.20	79.10	79.00	79.10	0.83	NS
Chick weight (g)	39.10	38.80	39.20	39.50	0.49	NS

$^{a-c}$Means with different superscripts in row differ at p<0.05

Table 4: Percentages of eggshell, yolk weights, shell weight, yolk: albumen ratio and egg specific gravity (g cm $^{-3}$) of eggs from breeder hens at 26, 31, 35, 41, and 47 weeks of age fed diets 1 through 6

	Settable egg																			
	Egg albumen weight (%)				Egg yolk weight (%)				Egg shell weight (%)				Yolk: albumen ratio (%)				Egg specific gravity (g cm $^{-3}$)			
Characteristics	22	34	48	58	22	34	48	58	22	34	48	58	22	34	48	58	22	34	48	58
Control	65.50	64.40^{a}	64.10^{a}	64.20^{a}	25.60^{a}	26.80^{a}	27.00^{a}	26.80^{a}	8.90	8.80	8.90	9.00	0.390	0.430	0.420	0.420	1.065	1.066	1.065	0.067
0.5 tallow	65.50	64.20^{ab}	64.00^{ab}	64.00^{ab}	25.70^{a}	26.90^{a}	27.20^{a}	27.10^{ab}	8.80	8.90	8.80	8.90	0.390	0.430	0.430	0.420	1.068	1.070	1.071	1.070
1 tallow	65.40	63.90^{b}	63.90^{ab}	63.80^{ab}	25.90^{ab}	27.30^{b}	27.40^{ab}	27.20^{ab}	8.70	8.80	8.70	9.00	0.390	0.430	0.430	0.420	1.069	1.070	1.072	1.070
1.5 tallow	65.20	63.90^{c}	63.40^{c}	63.60^{c}	25.90^{b}	27.20^{b}	27.80^{b}	27.50^{b}	8.90	8.90	8.80	8.90	0.400	0.450	0.440	0.430	1.072	1.072	1.072	1.075
SEM	1.07	1.08	1.06	1.11	0.85	0.81	0.89	0.91	0.11	0.15	0.18	0.16	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001
p-value	NS	0.05	0.05	0.05	0.05	0.05	0.05	0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

^{a,b}Means within variables for different week with no common superscript differ significantly (p<0.05)

weight per unit of surface area. In the present study (Table 4), ESG of eggs from hens fed different tallow-supplemented diets which have increased saturation level were significantly smaller than those from hens fed the control diet (5). Furthermore, it was suggested that increased saturation level of fat may have an injurious impact on egg production and eggshell quality (Peebles *et al.*, 2000a, b). Similarly, adding poultry fat to a broiler breeder diet decreased eggshell percentage weight in an earlier research (Brake, 1990). Diets with different levels of additional tallow had significant effects on EYW and EAW in the current study. These data confirm earlier research (Peebles *et al.*, 2000a, b) that reported dietary poultry fat and corn oil addition in broiler breeder diet had no significant effect on EYW, EAW and ESW. Another previous research (Sell *et al.*, 1987) reported a linear increase in yolk weight with increment of additional dietary fat. As the eggshell cuticle is partially composed of lipid, the fat content of the hen diet may also modify the cuticle's impact on egg water loss and embryogenesis (Peebles *et al.*, 2000a, b). Moreover, fatty acid oxidation is the primary source of energy and metabolic water for developing embryos 1991. Besides, embryos appear to preferentially absorb certain fatty acids rich in long-chain Polyunsaturated Fatty Acids (PUFA) 1994. However, differing in fatty acid profile, three different dietary fat supplementations in this experiment (three different levels of tallow used in this study) had no significant effect on egg weight and hatchability of fertile eggs.

It was shown by Vilchez *et al.* (1990) that supplementation of diets for Japanese quail hens with palmitic or oleic acids declined embryonic mortality as compared with linoleic or linolenic acid supplements. On the other hand, Halle (1999) did not find detrimental effects on reproductive performance of broiler breeder hens due to dietary fat supplements of up to 50 g kg^{-1} of palm oil or safflower oil. Whereas tallow supplementation to breeder diets with equal amount of dietary linoleic acid decreased egg weight, the detrimental effect on fertility was unexplained in the current study. Increased linoleic acid content in breeder diets reduced eggshell weights without significantly affecting egg weight (Peebles *et al.*, 2000a, b). Blesbois *et al.* (1997) proposed that the lipid composition of the diet might modify the fatty acid composition of the semen and its fertilizing ability.

CONCLUSION

In this study, on top of that broiler breeders fed on FO (salmon) diet gave significantly higher fertility rates (96%) than those fed a corn oil diet (91.6%). Although, the fatty acid composition of spermatozoa showed notable amounts of 20:4n-6 and 22:4n-6, elongated PUFA and these essential fatty acids were synthesized from dietary 18:2n-6 (linoleic acid), it could not explain the lower fertility results of SO treatment. It is obvious that there are limited data about influence of fat and FA component of breeder diets on fertility metabolism although detailed reports were available focused on embryonic growth and hatchability.

REFERENCES

Baucells, M.D., N. Crespo, A.C. Barroeta, S. Lopez-Ferrer and M.A. Grashorn, 2000. Incorporation of different polyunsaturated fatty acids into eggs. Poult. Sci., 79: 51-59.

Blesbois, E., M. Lessire, I. Grasseau, J.M. Hallouis and D. Hermier, 1997. Effect of dietary fat on the fatty acid composition and fertilizing ability of fowl semen. Biol. Reprod., 56: 1216-1220.

Bozkurt, M., M. Cabuk and A. Alcicek, 2008. Effect of dietary fat type on broiler breeder performance and hatching egg characteristics. J. Appl. Poult. Res., 17: 47-53.

Brake, J., 1990. Effect of four levels of added fat on broiler breeder performance. Poult. Sci., 69: 1659-1663.

Bryant, M., G. Wu and D.A. Roland, 2005. Optimizing dietary energy for profits and performance of two strains of white leghorns. In: International Poultry Scientific Forum Abstracts, Atlanta, GA, USA., pp: 23.

Cherian, G. and J.S. Sim, 1993. Omega-3 fatty acid and cholesterol content of newly hatched chick from alpha-linolenic acid enriched eggs. Lipids, 27: 706-710.

Ding, S.T. and M.S. Lilburn, 1996. Characterization of changes in yolk sac and liver lipids during embryonic and early post-hatch development of Turkey poults. Poult. Sci., 75: 478-483.

Halle, I., 1999. The effect of palm oil and safflower oil in the feed of parent fattening hens on fertility, hatchability and growth of progeny. Arch. Tierernahr., 52: 371-390.

Hamilton, R.M.G., 1982. Methods and factors that affect the measurement of egg shell quality. Poult. Sci., 61: 2022-2039.

Keshevarz, K., 1995. Further investigations on the effect of dietary manipulations of nutrients on early egg weight. Poult. Sci., 74: 62-74.

Menge, H., C.C. Calvert and C.A. Denton, 1965. Further studies of the effect of linoleic acid on reproduction in the hen. J. Nutr., 86: 115-119.

Naumann, C. and R. Bassler, 1993. Die Chemische Untersuchung Von Futtermitteln. VDLUFA-Verlag, Darmstadt, Germany..

Ozdogan, M. and M. Sari, 2001. Fat addition to broiler diets. J. Anim. Prod., 42: 28-34.

O'Sullivan, N.P., E.A. Dunnington and P.B. Siegel, 1991. Relationships among age of dam, egg components, embryo lipid transfer and hatchability of broiler breeder eggs. Poult. Sci., 70: 2180-2185.

Peebles, D., S. Doyle, S. Pansky, P. Gerard, M.A. Latour, C.R. Boyle and T.W. Smith, 1999. Effects of breeder age and dietary fat on subsequent broiler performance. 1. Growth, mortality and feed conversion. Poult. Sci., 78: 505-511.

Peebles, E.D., C.D. Zumwalt, S.M. Doyle, P.D. Gerard, M.A. Latour, C.R. Boyle and T.W. Smith, 2000a. Effects of breeder age and dietary fat sources and level on broiler hatching egg characteristics. Poult. Sci., 79: 698-704.

Peebles, E.D., C.D. Zumwalt, S.M. Doyle, P.D. Gerard, M.A. Latour, C.R. Boyle and T.W. Smith, 2000b. Effects of dietary fat type and level on broiler breeder performance. Poult. Sci., 79: 629-639.

Peebles, E.D., T. Pansky, S.M. Doyle, C.R. Boyle, T.M. Smith, M.A. Latour and P.D. Gerard, 1998. Effects of dietary fat and eggshell cuticle removal on egg water loss and embryo growth in broiler hatching eggs. Poult. Sci., 77: 1522-1530.

Ross Breeders Management Guide, 1998. Ross Breeders Limited. Newbridge Midlothian, Scotland, UK.

SAS, 1990. SAS/STAT User's Guide. SAS Institute Inc., Cary, NC.

Sell, J.L., C.R. Angel and F. Escribano, 1987. Influence of supplemental fat on weights of eggs and yolks during early egg production. Poult. Sci., 66: 1807-1812.

Shahriar, H.A., K.N. Adl, Y.E. Nezhad, R.S. Nobar and A. Ahmadzadeh, 2008. Effect of dietary fat type and different levels of vitamin e on broiler breeder performance and vitamin e levels of egg. Asian J. Anim. Vet. Adv., 3: 147-154.

Sohail, S.S., M.M. Bryant and D.A. Roland, 2003. Influence of dietary fat on economic returns of commercial Leghorns. J. Applied Poult. Res., 12: 356-361.

Van Elswyk, M.E., B. Hargis, J. Williams and P. Hargis, 1994. Dietary menhaden oil contributes to hepatic lipidosis in laying hens. Poult. Sci., 73: 653-662.

Vilchez, C., S.P. Toucburn, E.R. Chavez. and C.W. Chan, 1990. The influence of supplemental corn oil and free faty acids on the reproductive performance of japanese quail (*Coturnix coturnix* japonica). Poult. Sci., 69: 1533-1538.

Whitehead, C.C., A.S. Bowman and H.D. Griffin, 1991. The effects of dietary fat and bird age on the weights of eggs and egg components in the laying hen. Br. Poult. Sci., 32: 565-574.