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Supplementation of broiler breeders with fat sources and vitamin e: carry over effect on performance, carcass yield, and meat quality offspring

[*Suplementação de matrizes de frangos de corte com fontes de gordura e vitamina E: transferência dos efeitos sobre a* performance*, o rendimento da carcaça e a qualidade da carne da progênie*]

J.I.M. *Fernandes*[1], H.L.F. *Bordignon*[2], K. *Prokoski*[3], R.C. *Kosmann*[3], E. *Vanroo*[2], A.E. *Murakami*[4]

[1] Universidade Federal do Paraná – Setor Palotina – UFPR – Palotina, PR.
[2] Aluna de graduação – Universidade Federal do Paraná – Setor Palotina – UFPR– Palotina, PR
[3] Aluna de pós-graduação – Universidade Federal do Paraná – Setor Palotina – UFPR – Palotina, PR
[4]Universidade Estadual de Maringá – UEM – Maringá, PR

ABSTRACT

The aim of this study was to evaluate two sources of oil (soybean and fish) and four additional levels of vitamin E (0, 150, 250 and 350mg/kg diet) in breeder diets between the 42nd and 56th week of age and its effect on performance and meat quality of offspring. The supplementation of fish oil in the maternal diet increased the deposition of DHA and CLA in egg yolk. From 1 to 35 days of age, intermediate levels of vitamin E resulted in lower weight gain and feed intake. To feed conversion, the best result was obtained supplementing the maternal diet with soybean oil, regardless of vitamin inclusion. In addition, the evaluation of meat quality, the fish oil-supplemented-diet resulted in lower moisture loss of the breast fillets. For maternal diet supplemented with fish oil, the inclusion of vitamin E resulted in a linear increase of the pH value of the meat. Greater levels of vitamin E in the maternal diet influenced the functional properties of meat according to the type of oil that was added to the diet. The deposition of different fatty acids in the embryonic egg yolk can directly influence the meat quality of offspring.

Keywords: antioxidant, breeders, fatty acid profile, moisture loss, PUFA

RESUMO

O objetivo deste estudo foi avaliar duas fontes de óleo (soja e peixe) e quatro níveis adicionais de vitamina E (0, 150, 250 e 350mg/kg dieta), em dietas de matrizes entre a 42º e a 56º semana de idade, sobre o desempenho e a qualidade de carne da progênie. A suplementação de óleo de peixe na dieta das matrizes aumentou a deposição de DHA e CLA na gema dos ovos. Entre um e 35 dias de idade, níveis intermediários de vitamina E resultaram em menor ganho de peso e consumo de ração. Para a conversão alimentar, o melhor resultado foi obtido suplementando a dieta materna com óleo de soja, independentemente da inclusão vitamínica. Dietas suplementadas com óleo de peixe resultaram em menor perda de umidade nos filés de peito. Para a dieta materna suplementada com óleo de peixe, a inclusão de vitamina E resultou em um aumento linear do valor de pH da carne. Níveis mais altos de vitamina E na dieta materna influenciaram as propriedades funcionais da carne de acordo com o tipo de óleo adicionado à dieta. A deposição de diferentes ácidos graxos na gema de ovos embrionados pode influenciar diretamente a qualidade da carne da progênie.

Palavras-chave: antioxidante, matrizes, perda de umidade, perfil de ácidos graxos, PUFA

INTRODUCTION

The supplementation of fatty acids in the diets of heavy breeders can have benefits regarding the fatty acid composition of egg yolks and subsequent offspring performance. In egg yolk, greater amounts of unsaturated fatty acids are found with approximately 67% versus 33% of saturated fatty acids. This fatty acid composition can be influenced by the lipid composition of the diets of breeders (Ribeiro *et al*., 2007).

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E-mail: jimfernandes@ufpr.br

During the 21 days of incubation, around 80% of yolk lipids are absorbed by the developing embryo. In addition to supplying energy to the embryo, fatty acids from the yolk contribute to the formation of embryonic structural phospholipids through the deposition of long chain polyunsaturated fatty acids (PUFA) (Surai, 2000; Pappas *et al*., 2005).

PUFA, which make up the n-6 family, are derived from linoleic acid and are found in the majority of seeds and vegetables such as corn, sunflower, saffron, and soybean. Meanwhile, those from the n-3 family, which are derived from α-linolenic acid, can be found in canola, linseed, nut, dark green colored plant, and fish oils, mainly those from the polar regions (Ahn *et al*., 1995).

The intake of greater concentrations of oils rich in PUFA n-6 increases the incorporation of arachidonic acid (20:4n6) in cell membranes. However, sources of PUFA n-3 incorporate fatty acids of this series, such as eicosapentaenoic acid – EPA (20:5-n3) and docosahexaenoic acid - DHA (22:6n-3) in the cell membrane 72 hours after intake through the diet (James *et al*., 2000; Calder, 2010; Koppenol *et al*., 2014).

Currently, the formulation for breeders and broilers presents a high ratio of essential fatty acids PUFA omega-6: PUFA omega n-3. Despite the known benefits of diets with better profiles of PUFA omega 3, the supplementation of broiler diets with these sources cannot be viable due to the high cost, lack of availability, and the sensorial and organoleptic effects associated with lipid oxidation (Lopez-Ferrer *et al*., 2001).

However, the inclusion of a source of polyunsaturated fat in the diets of breeders can predispose them to lipid peroxidation; thereby, compromising the antioxidant status of breeders and their offspring (Surai, 2000). The lipid oxidation of yolk from fertile eggs can result in a reduction of the energy that is available for embryonic development or the formation of compounds that can compromise embryonic feasibility (Moran, 2007).

In membranes, alpha-tocopherol or vitamin E is the main free-radical scavenger that avoids the lipid peroxidation reaction chain. The diet of breeders has an important function in the formation of the antioxidant system during embryonic development (Karadas *et al*, 2011).

Vitamin E is effectively transferred from the ration that is provided to breeders to the egg yolk (Lin *et al*., 2005; Vieira, 2007), indicating that supplementation in the rations of breeders increases the concentration of vitamin E in egg yolks and consequently in the tissues of chicks, which can reduce their susceptibility to lipid peroxidation. However, tissues could represent a limitation in the capacity of vitamin E storage, and the excess could be excreted (Kayden and Traber, 1993). Moreover, vitamin E guarantees membrane stability to reduce lipid oxidation in the muscle, which gives better meat quality to broilers.

For several years, the nutrition of breeders has been pointed towards the performance associated with lower production costs. Recently, several studies have attempted to evaluate the effects of this nutritional strategy on carcass quality. Thus, the focus is to stimulate the growth of birds to produce eggs with greater concentrations of available nutrients during the incubation period. The maternal dietary manipulation can have a direct effect on gene transcription, thereby influencing specific key points in the metabolic processes during the pre and post-hatching periods and consequently altering the performance, immune system response, and carcass yield of the offspring (Peebles *et al*., 2002; Leandro *et al*., 2011).

Based on this information, the aim of this study was to verify the effect of the addition of soybean oil, fish oil, and vitamin E in maternal diets on performance, carcass yield, and meat quality of broilers.

MATERIAL AND METHODS

The research was conducted in experimental avian Federal University of Paraná - Sector Palotina. All procedures of animal husbandry and biological material collection were approved by the Ethics Committee on Animal Use in Experimentation (protocol number 29-2012).

Four hundred and sixteen breeding broilers (384 females and 32 males) from the Ross lineage were utilized. The experimental design was completely randomized in a 2x4 factorial scheme with two sources of oil (soybean and fish) and four supplementary levels of vitamin E (0, 150, 250, and 350mg/kg of feed), totaling eight treatments and four replicates with twelve females and one male/ experimental unit. The experimental period started during the birds' 42nd week of age and was finalized during the 56th week of age.

The lighting program was constantly kept with 17 hours of light per day. The supply of the feed was limited and controlled daily for both males and females according to recommendations of the lineage manual (Manual.., 2008). Water was provided *ad libitum*. The nutrient requirements that were utilized for the formulation of the diets of breeding hens were based on recommendations contained in the lineage manual. Two basal diets were formulated according to the source of oil, and in order to obtain the levels of vitamin E, Dl-α-tocopherol was added on top. The oil, independent of the source that was utilized, was added to all of the experimental feed in amounts of 1.5%. The roosters of each experimental unit received the diet corresponding to the treatment that was received by the breeders.

During the 51st week, a sample of 3 incubated eggs/replicate was removed, after which they were cracked open and the yolk was separated. The 3 yolks of each replication were homogenized, thereby producing a collective pool for the determination of the total fatty acids and the lipid profile of the egg yolk. The analyses referring to the lipid profile of the egg yolk were performed in the Chemical Laboratory at the State University of Maringa, Parana, Brazil. The extraction of fatty acids from the yolk was performed according to methodologies described by Bligh and Dyer (1959). The methyl esters of fatty acids were analyzed in a gas chromatograph with a fused silica capillary column. The area of the peak was analyzed through a software program and it was compared to the standard retention time of a methyl ester acid of fatty acids (Sigma, EUA). Data were expressed as % of fatty acids in relation to the amount of total lipids in the samples.

During the 52nd week, egg collections were performed in all experimental replications to total 200 eggs per treatment. The eggs were previously weighed, incubated in a multiple-stage industrial incubator (Jamesway Company Inc.), and maintained within the parameters of the incubation process.

After hatching, the chicks were housed according to the treatments received by breeders in a completely randomized experimental design in a 2x4 factorial scheme with two sources of oil and four supplementary levels of vitamin E, totaling eight treatments and four replicates with 30 birds each replicate.

Water and feed (commercial formulation) were provided ad libitum in a feeding program divided into two phases (starter and growth/finisher).

During the experimental period, animal performance was categorized from 1 to 28 days of age and at 35 days, 3 chicks were slaughtered per experimental unit (12 chicks/treatment) for the evaluation of carcass yield and meat quality of chick breasts.

For determination of the carcass yield, chicks were identified, submitted to fasting for six hours, and slaughtered via electrical stunning and subsequent exsanguination. In order to calculate the carcass yield, the hot eviscerated carcass weight was considered without the feet, head, and abdominal fat pad in relation to the body weight that was individually obtained before slaughtering the chicks. The yield of the prime cuts, the yield of the entire breast with skin and bone, as well as the yield of the legs (thigh and drumstick with skin and bone) were calculated in relation to the eviscerated carcass weight. The determination of the pH was directly performed in the breast fillet of the chicks that were utilized for carcass yield by using a potentiometer Sentron 1001 at 6 and 24 hours post mortem. The point of the electrode incision was in the ventral-cranial part of the breast fillet.

The measurements of color were performed in the ventral part of the breast fillet at 24 hours post mortem by measuring three different points per sample for each system of color in the same samples that were used for the determination of the pH; this was accomplished by using a colorimeter Minolta CR10. The analysis of color was performed by the Hunter L* (lightness), a* (redness) b* (yellowness) system.

The measurements of water loss were performed according to the method described by Barbut (1996). In this procedure, at 24 hours post mortem, 5g of duplicate samples were homogenized with 8.0mL of 0.6M NaCl solution. The homogenate was then transferred to polycarbonate centrifuge tubes and kept in a melting ice bath for 30 minutes, after which they were centrifuged at 7000g for 5 minutes at 20°C. Afterwards, the supernatant was then discarded, and the tubes were weighed on an analytical scale. The results were expressed as the weight of retained saline solution.

The data were tabulated and analyzed by using variance analysis (ANOVA) from the procedure Generalized Linear Model (GLM) while utilizing the statistical program SAS (2002). The data were submitted to regression analysis by polynomial decomposition of the degrees of freedom in relation to the levels of vit E, using the statistical model:

$$Y_{ij} = b_0 + b_1 vitE_i + b_2 vitE_i + b_3 vitE_i + e_{ij}$$

where:

Y_{ij}: observation of the dependent variable in the experimental unit j submitted to level *i* of vit E, *i*: 1, 2, 3, 4 (1= 0, 2= 150mg, 3= 250mg, 4= 350mg).
b_0: constant;
b_1, b_2, *and* b_3: linear, quadratic, and cubic regression coefficients of the dependent variable as a function of the levels of vit E;
e_{ij}: random error associated with each Y_{ij} observation.

The determination coefficients were calculated as percentages of the sum of the squares of the model in relation to the total sum of squares.

RESULTS AND DISCUSSION

The supplementation of maternal diets with oil and vitamin E altered the fatty acid profile deposited in the embryonic egg yolk. There was no interaction (P>0.05) between source of oil and supplementation of vitamin E for the deposition of fatty acids. There was greater (P<0.05) deposition of myristic (C14:0), palmitoleic (C16:1 n-7), heptadecenoic (C17:1 n-9), and oleic acids (C18:1 n-9) when maternal diets were supplemented with fish oil (Table 1). On the other hand, when the supplementation was soybean oil, there was an increase (P<0.05) in the deposition of stearic acid (18:0). The supplementation with vitamin E did not alter (P>0.05) the fatty acid deposition.

In Table 2, data referring to the lipid profile from the omega-3 and omega-6 series are shown. Similarly, there was no interaction (P>0.05) between sources of oil and supplementation of vitamin E. For fish oil, there was greater (P<0.05) deposition of docosahexaenoic acid (22:6n-3) and CLA, while the supplementation of diets with soybean oil resulted in greater (P<0.05) deposition of linoleic acid (C18:2 n-6), α-linolenic acid (C18:3 n-3), di-homo-(α-linolenic) acid (C20:3 n-3), arachidonic acid (C20:4 n-6), and timnodonic acid (C22:4 n-6).

Table 1. Fatty acid profile of embryonated egg yolk from breeders fed supplemented diets with different oil sources and vitamin E

Oil	14:00	15:00	16:00	16:1n-7	16:1n-9	17:00	17:1n-9	18:00	18:1n-9	18:1n-7	22:00
Soybean	0.25[b]	0.07	26.50	1.84[b]	0.46	0.19	0.11[b]	8.78[a]	37.62[b]	0.09	0.16
Fish	0.30[a]	0.10	26.39	2.38[a]	0.49	0.22	0.19[a]	7.81[b]	39.99[a]	0.10	0.13
0	0.271	0.086	26.76	1.89	0.471	0.186	0.129	8.76	38.03	0.100	0.171
150	0.271	0.086	26.44	2.39	0.529	0.229	0.143	7.74	39.71	0.100	0.116
250	0.288	0.088	26.75	2.20	0.525	0.200	0.150	8.26	38.57	0.088	0.138
350	0.267	0.083	25.67	1.92	0.333	0.200	0.167	8.43	38.97	0.100	0.150
Oil	*	ns	ns	**	ns	ns	**	*	*	ns	ns
Vitamin E	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Different letters in the same line differ (P<0.05*, P<0.01**); ns: not significant
14:00: Myristoylation; 15:00: Pentadecanoic acid; 16:00: Palmitic acid; 16:1n-7: Palmitoleic acid; 16:1n-9: 9-hexadecenoic acid; 17:00: Margaric acid; 17:1n-9: 9-heptadecanoic acid; 18:00: Stearic acid; 18:1n-9: Oleic acid; 18:1n-7: Vaccenic acid; 22:00: Benzoic acid.

Table 2. Profile of omega-6 and omega-3 fatty acids of embryonated egg yolk from breeders fed supplemented diets with different oil sources and vitamin E

Oil	18:2n-6	18:3n-6	18:3n-3	20:3n-3	20:4n-6	20:5n-3	22:4n-6	22:5n-3	22:6n-3	CLA
Soybean	17.51[a]	0.09	0.44[a]	0.18[a]	2.09[a]	0.19	0.61[a]	0.46	1.10[b]	0.12[b]
Fish	14.49[b]	0.11	0.34[b]	0.11[b]	1.19[b]	0.28	0.23[b]	0.59	2.82[a]	0.20[a]
Vitamin E (mg/kg)										
0	16.03	0.086	0.400	0.171	1.71	0.200	0.386	0.643	2.30	0.186
150	16.10	0.086	0.386	0.129	1.40	0.214	0.286	0.586	1.79	0.163
250	15.96	0.125	0.375	0.150	1.67	0.350	0.300	0.575	2.04	0.175
350	15.92	0.100	0.400	0.133	1.80	0.150	0.767	0.250	1.67	0.117
Oil	**	ns	**	**	**	ns	*	ns	**	**
Vitamin E	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Different letters in the same line differ (P<0.05*, P<0.01**); ns: not significant,
18: 2n-6: Linoleic acid; 18: 3n-6: γ-linolenic acid; 18: 3n-3: α-linolenic acid; 20: 3n-3: Dihomo-α-linolenic acid; 20: 4n6: Arachidonic acid; 20: 5 n3-: Eicosapentaenoic acid; 22: 4n-6: Timnodonic acid; 22: 5n-3: Docosapentaenoic acid; 22: 6n-3: Docosahexaenoic acid; CLA (Conjugated Linoleic Acid).

The docosahexaenoic acid (DHA) is the most important PUFA of the omega-3 family in the lipid structure of the meninges, and it is essential for brain development and mental functions. There were greater nutrient requirements of DHA in the pre- and postnatal period as there was a rapid cell proliferation rate and membrane synthesis (Ghebremeskel *et al*., 2000). However, the residual effect of maternal DHA in the egg yolk on chick growth is unknown (Ajuyah *et al*., 2003).

In Table 3, results referring to the animal performance of offspring whose breeders received diets supplemented with soybean or fish oils and vitamin E were shown. In the initial period from 1 to 10 days of age, there was a linear negative effect of the inclusion of levels of vitamin E (P<0.05) in the maternal diet on the weight gain of offspring, independent of the source of oil (ŷ= 285,039-0,138766x; R^2: 0,73). Regarding feed intake, there was a significant interaction (P<0.05) between oil source x vitamin E; and in the deployment, we observed that there was a linear reduction in feed intake when the maternal diet was supplemented with soybean oil (ŷ= 379.673-0.193754x; R^2: 0.52).

Table 3. Effect of vitamin E and lipid sources in breeder’s diet on weight gain, feed intake and feed conversion ratio from 1 to 10 days of age

Vitamin E	Weight gain, g			Feed intake, g			Feed conversion ratio		
	Oil			Oil			Oil		
(mg/kg)	Soybean	Fish	Mean[1]	Soybean[2]	Fish[3]	Mean	Soybean	Fish	Mean
0	298.52	290.44	294.48	394.40	384.47	389.44	1.324	1.323	1.324
150	280.79	252.29	266.54	370.69	338.88	354.79	1.319	1.341	1.330
250	283.09	255.32	269.20	359.38	337.91	348.65	1.275	1.323	1.299
350	292.00	238.03	265.02	361.73	312.12	351.92	1.341	1.312	1.327
Mean	288.60	259.02		371.55	348.34		1.315[b]	1.325[a]	
Interaction		ns			*			ns	
CV, %		7.28			6.99			1.98	

Different letters in the same line differ (P<0.05*); ns: not significant, [1]Vitamin E: ŷ= 285,039-0,138766x; R^2: 0,73, [2]Vitamin E + soybean oil: ŷ= 379.673-0.193754x; R^2: 0.52, [3]Vitamin E + fish oil: ŷ= 395.00-0.35395x+0.000954587x^2; R^2: 0.94.

For supplementation with fish oil, we observed quadratic effect (P<0.05). As from the level of 185mg/kg of vitamin E in the maternal diet, the intake of feed by the offspring decreased ($\hat{y}$= 395.00-0.35395x+0.000954587x^2; R^2: 0.94). The type of oil that was supplemented in the maternal diet only influenced feed conversion. The inclusion of soybean oil in maternal diet resulted in a better (P<0.05) feed conversion in comparison to the supplementation with fish oil.

From 1 to 28 days of age (Table 4), there was a significant interaction (P<0.05) between sources of oil and vitamin E that were added to the diets of breeders for weight gain and feed intake of broilers. In the deployment of interaction, we observed a quadratic effect (P<0.05) of the levels of vitamin E when supplemented in diets with soybean oil. According regression equations ($\hat{y}$= 1734.89-1.29085X+0.003155x^2; R^2: 0.32 and $\hat{y}$= 2970.69-2.59077X+0.00628728 x^2, R^2: 0.54) levels of 204 and 205mg/kg of vitamin E, respectively, resulted in greater weight gain and feed intake.

Table 4. Effect of vitamin E and lipid sources in breeder's diet on weight gain, feed intake and feed conversion ratio from 1 to 28 days of age

Vitamin E	Weight gain, g			Feed intake, g			Feed conversion		
	Oil			Oil			Oil		
(mg/kg)	Soybean[1]	Fish	Mean	Soybean[2]	Fish	Mean	Soybean	Fish	Mean
0	1787.92	1754.27	1771.10	3028.42	2999.58	3014.00	1.695	1.710	1.703
150	1722.48	1527.42	1624.94	2922.92	2597.14	2760.03	1.697	1.700	1.699
250	1741.48	1711.16	1746.32	2967.84	2867.63	2917.74	1.672	1.677	1.675
350	1740.79	1633.22	1687.00	2949.41	2779.94	2864.68	1.694	1.703	1.699
Mean	1748.17	1656.52		2967.15	2811.07		1.690	1.698	
Interaction		*			*			ns	
CV, %		3.81			3.06			1.66	

Different letters in the same line differ by Tukey test (P<0.05*), [1]Vitamin E + soybean oil: $\hat{y}$= 1734.89-1.29085X+0.003155x^2; R^2: 0.32, [2]Vitamina E + soybean oil: $\hat{y}$= 2970.69-2.59077X+0.00628728 x^2, R^2: 0.54, ns= not significant.

We observed that the inclusion of vitamin E in levels above 200mg/kg in the maternal diet negatively interfered the performance of the offspring. Adebiyi *et al*. (2014) considered that the level of 125mg/kg of vitamin E in diets of breeders contributed positively to embryo survival. It seems likely that an increased vitamin E supplementation of breeders (>100ppm) in commercial conditions is not always associated with improved their performance and egg quality.

It is known that breeder nutrition is one of the most important factors affecting quality of chick offspring, and may influence offspring growth (An *et al*., 2010). The nutrients required for chicken embryo development are derived from the nutrients stored in the egg, whose nutrient profile changes with the maternal diet and thereby creates differences in nutritional status of offspring (Calini and Sirri, 2007). Peebles *et al*. (2002) showed that the type of fat that is included in the maternal diet affects the body composition of offspring at the age of slaughter. The inclusion of 1.5 and 3% corn oil in comparison to animal fat improved the carcass yield (breast, wings, and back) at 43 days of age. These findings showed that the reduction of the saturated:unsaturated ratio in the diets of breeders has a positive effect on the carcass yield of broilers.

Dietary fatty acids can be incorporated into the yolk of breeder eggs and therefore be available to the offspring early in their development (Koppenol *et al*., 2014). In this experiment, despite the greater deposition of DHA in egg yolks of breeders supplemented with fish oil, there was no positive effect on the performance of offspring.

The supplementation of breeders with soybean or fish oils and with vitamin E did not alter (P>0.05) the carcass yield of offspring at 35 days of age (Table 5).

Table 5. Effect of vitamin E and lipid sources in breeder's diet on carcass yield of broilers at 28 days of age

Vitamin E	Carcass, %			Breast, %			Thighs, %		
	Oil			Oil			Oil		
mg/kg	Soybean	Fish	Mean	Soybean	Fish	Mean	Soybean	Fish	Mean
0	70.78	69.59	70.18	36.22	36.71	36.46	30.70	30.09	30.39
150	69.04	70.34	69.69	36.91	35.64	36.27	30.48	30.57	30.52
250	69.86	70.71	70.29	36.20	35.67	35.94	30.60	30.99	30.80
350	70.65	68.84	69.74	36.03	35.57	35.80	30.22	30.84	30.53
Média	70.08	69.87		36.34	35.90		30.50	30.62	
Interaction		ns			ns			ns	
CV, %		1.93			3.16			2.35	

ns= not significant.

In Table 6 and 7, results referring to the evaluation of the functional properties of breast meat from broilers are shown. There was an interaction ($P<0.05$) for color L of the breast meat, and in the deployment of the interaction, we observed a decreasing linear effect of the inclusion of vitamin E associated only with soybean oil ($\hat{y}$= 50. 0445-0.00848084x; R^2: 0.73) For water loss, the deployment of interaction showed that the level of 187mg/kg of vitamin E in the diet supplemented with fish oil resulted in a lower level of water loss in the breast fillet from broilers ($\hat{y}$= 14.7452-0.02131477X+0.0000570658x^2; R^2: 0.64).

For the evaluation of pH, the interaction between supplementation of sources of oil and vitamin E was also significant ($P<0.05$). For maternal diets that were supplemented with fish oil, the addition of levels of vitamin E resulted in an increasing linear effect on the pH values of meat ($\hat{y}$= 6.1036+0.000349; R^2: 0.80).

Table 6. Effect of vitamin E and lipid sources in breeder's diet on color of broilers' breast meat at 28 days of age

Vitamin E	Color L			Color a			Color b		
	Oil			Oil			Oil		
(mg/kg)	Soybean[1]	Fish	Mean	Soybean	Fish	Mean	Soybean	Fish	Mean
0	49.76	50.19	49.98	4.77	4.92	4.85	0.91	1.22	1.06
150	48.64	48.44	48.54	4.94	5.54	5.05	1.43	0.91	1.17
250	49.19	49.27	49.23	4.65	4.74	4.70	1.10	0.97	1.03
350	46.23	49.18	47.70	5.22	4.57	4.90	1.26	1.14	1.20
Mean	48.45	49.27		4.90	4.85		1.17	1.06	
Interaction		*			ns			ns	
CV, %		2.90			15.21			40.42	

ns= not significant, [1]Vitamin E + soybean oil: $\hat{y}$= 50. 0445-0.00848084x; R^2: 0.73.

Table 7. Effect of vitamin E and lipid sources in breeder's diet on moisture loss and the measurement of pH 24 hours post mortem in broiler breast at 35 days of age

Vitamin E	Moisture loss,%			pH, 6 hr			pH, 24 hr		
	Oil			Oil			Oil		
(mg/kg)	Soybean[1]	Fish	Mean	Soybean	Fish	Mean	Soybean	Fish	Mean
0	13.92	14.94	14.43	6.12	6.11	6.12	Soybean	Fish[2]	Mean
150	13.47	11.96	12.72	6.12	6.15	6.14	6.14	6.12	6.13
250	14.00	14.02	14.01	6.06	6.12	6.09	6.20	6.15	6.17
350	14.54	13.90	14.22	6.16	6.04	6.10	6.17	6.16	6.16
Mean	13.99	13.71		6.11	6.11		6.16	6.25	6.21
Interaction		*			ns			*	
CV, %		7.95			1.83			1.44	

[1]Vitamin E + fish oil: $\hat{y}$= 14.7452-0.02131477X+0.0000570658x^2; R^2: 0.64, [2]Vitamin E + fish oil: $\hat{y}$= 6.1036+0.000349; R^2: 0.80.

The nutrients that are required for the embryonic development of birds come from nutrients stocked in the egg and vitamin E, which can be incorporated by increased dietary levels. The increase in the vitamin E content in the yolk can improve the oxidative stability, which works biologically as a specific protective mechanism in the membrane against free radicals.

The significant effect of the inclusion of vitamin E in the maternal diet on the decrease in the meat´s luminosity is associated with a lower water loss and greater values of pH, which shows that there may be a deficiency in the antioxidant system, probably during the incubation period. The existence of tissue-specific antioxidant profiles has been reported in that an elevation of liver antioxidant system of the newly hatched chick from maternal diet antioxidant vitamin E supplementation together with selenium had increased antioxidant activities during embryonic development (Surai *et al*., 2000).

The supplementation of vitamin E in the diet in combination with fish oil may have contributed to additional antioxidant protection. Thus, the accumulation of omega-3 fatty acids, such as DHA and CLA (Table 2) in egg yolk from breeders supplemented with fish oil, can be a reserve to be saved from the oxidative pathway and deposited in membranes (Koppenol *et al*., 2014). Maintenance of the integrity of the cell membrane is fundamental to avoid water loss and to preserve meat color.

The capacity of water retention is among the most important functional properties of meat (Gaya and Ferraz, 2006), because it influences the aspect, palatability, and it is directly related to water losses before and during cooking (Allen *et al*., 1998). When consumers buy a poultry product, cook and serve it to their families, they expect it to look, taste, and feel good in their mouth. If these characteristics do not meet the consumer's expectation, the product is considered to be of lower quality.

According to Huff-Lonergan and Lonegan (2005), pH also influences the capacity of water retention of meat, because the decrease in pH post mortem alters the cell and extracellular composition of muscle fibers, thereby resulting in a reduction of the reactive groups that are available to retain water in proteins. On the other hand, the inclusion of soybean oil in the maternal diet was associated with the supplementation of vitamin E and the decreased luminosity of fillets from broilers.

When fish oil was supplemented in maternal diets, we observed a greater deposition of DHA and CLA in egg yolk. In addition, the supplementation of soybean oil increased, for example, the levels of linoleic and arachidonic acids. Could this greater deposition influence the functional characteristics of meat from offspring at 35 days of age? The concentrations and types of PUFA deposited in the yolk can interfere with the initial stages of the formation of the vascular network in the extra-embryonic membrane and therefore, as proposed by Harris *et al*. (2009) the metabolism of fatty acids n-3 and n-6 generate compounds with an angiogenic effect.

Color of cooked or raw poultry meat is important because consumers associate it with the product's freshness, and they decide whether to buy the product based on their opinion of its attractiveness. Poultry is unique because it is sold with and without its skin. In addition, it is the only known species to have muscles that are dramatic extremes in color (white and dark meat). Breast meat is expected to have a pale pink color when it is raw, while thigh and leg meat are expected to be dark red when raw. There are times when poultry meat does not have the expected color, and this has created some special problems for the poultry industry.

There is much interest at present in the role of dietary fatty acids in controlling gene expression or the biological programming of enzymes involved in lipid and PUFA metabolism (Peng *et al*., 2014). If the activity of enzymes involved in PUFA synthesis could be set by diet in early life, PUFA metabolism and eicosanoid-related functions, such as immune health of birds, could be manipulated in later life (Karadas *et al*, 2011). Further studies are required to elucidate the mechanism of dietary PUFA on these effects in later life.

CONCLUSION

The supplementation of fish oil in the maternal diet increased the deposition of DHA and CLA in egg yolk. These are important anti-inflammatories and components of cell membranes. The inclusion of vitamin E in the maternal diet above 180mg/kg negatively affected the performance of offspring regardless the type of oil, soybean or fish. Greater levels of vitamin E in the maternal diet influenced the functional properties of meat according to the type of oil that was added to the diet. The deposition of different fatty acids in the embryonic egg yolk can directly influence the meat quality of offspring.

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