PERFORMANCE RESPONSE OF BROILER CHICKENS TO THE REPLACEMENT OF SOYBEAN OIL AND ACIDULATED FATTY ACIDS BY LECITHIN IN THE DIET†

[RESPUESTA PRODUCTIVA DEL POLLO DE ENGORDA AL REEMPLAZAR ACEITE DE SOYA Y ACIDOS GRASOS ACIDULADOS POR LECITINA EN LA DIETA]

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SUMMARY

Lecithin is the main phospholipid of soybean oil. It participates in the membrane formation of all body cells and provides energy. The aim of this research was to study the partial or total substitution of soybean oil (SB) and acidulated soybean fatty acids (AFA) by soybean lecithin (L) on the productive response, amount of liver ether extract, and the coloration of liver and skin from chickens fed with corn-soybean diets. Mixed-Cobb 500 broiler chickens from 1 to 42 days of age were used in a completely randomized design composed by 7 treatments of 8 repetitions with 50 birds each. The treatments consisted in the partial or total replacement (25% and 50%) of SB by L and AFA. No significant differences (P>0.05) were found in the productive variables, liver yellowness, carcass skin and the percentage of liver ethereal extract between treatments. In conclusion, the L is an alternative source for SB or AFA in corn-soybean diets for broiler chickens as a total or partial replacement, without affecting the productive response, liver ether extract, and yellowness coloration of liver and skin.
Keywords: Broiler chickens; soybean oil; acidulated oil; soybean lecithin.

RESUMEN

La lecitina representa el principal fosfolípido del aceite de soya, participa en la formación de membranas de todas las células del organismo y aporta energía. El objetivo del presente trabajo fue estudiar la sustitución parcial o total del aceite de soya (SB) y ácidos grasos acidulados de soya (AFA) por lecitina de soya (L) en pollos alimentados con dietas maíz-soya sobre la respuesta productiva, cantidad de extracto etéreo hepático, así como el color del hígado y la piel. Se emplearon pollos de engorda mixtos Cobb 500 de 1 a 42 días de edad, en un diseño completamente al azar con 7 tratamientos de 8 repeticiones con 50 aves cada una. Los tratamientos consistieron en el reemplazo parcial o total del SB por L y AFA (25 y 50%). No se encontraron diferencias significativas (P>0.05) para variables las productivas, amarillamiento del hígado, piel de la canal y el porcentaje de extracto etéreo hepático entre los tratamientos. En conclusión, la L es una fuente alternativa al SB o AFA en dietas maíz-soya para pollos de engorda como reemplazo total o parcial, sin afectar la respuesta productiva, extracto etéreo hepático, color del hígado y de la piel.
Palabras clave: Pollos de engorda; aceite de soya; aceite acidulado; lecitina de soya.

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INTRODUCTION

The inclusion of fats and oils in broiler chicken diets is a common practice because they provide essential fatty acids, improved the absorption of soluble nutrients in oil and increased the content of metabolizable energy (ME) in the diets (Hossain and Das, 2014). Feeding programs are established based on EM needs, so nutritional strategies are sought to optimize productivity considering economic and environmental aspects during the production cycle (Andreoti *et al.,* 2004; Dozier *et al.,* 2007). The ME level in the diet of broilers is one of the main factors related to the regulation of voluntary feed consumption, growth and feed conversion. In chickens fed *at libitum*, feed consumption increases or decreases either to low or high ME levels in diets (Cortes-Cuevas *et al.,* 2018).

Soybean crude oil (SB) is used as a concentrated source of energy in balanced feeds for birds; however due to its cost, which has increased in the recent years because of biodiesel production (Cortes-Cuevas *et al.,* 2018), profitable alternatives are being sought, such as acidulated oils of lower cost and acceptable nutritional quality (Barbour *et al.* 2006; Cuca *et al.,* 2009; Cortes-Cuevas *et al.,* 2018). Soybean acidulated oils (AFA) are by-products of the refining process of soybean oil for human consumption (Pardío *et al.,* 2001).

On the other hand, lecithin is the main phospholipid of crude soybean oil, which is an alternative in the formulation of rations as a source of energy, phosphorus and choline (Menten *et al.,* 1997). Due to the aforementioned, the aim of the present study was to evaluate the partial or total substitution of soybean oil (SB) and acidulated soybean fatty acids (AFA) by soybean lecithin (L) on the productive response amount of liver ether extract, and the liver and skin coloration from chickens feed with corn-soybean diets.

MATERIALS AND METHODS

Birds husbandry

The study was carried out in an experimental poultry farm located in the municipality of Charo, from the Michoacan State, México at 1940 meters above sea level, with an average annual temperature of 18ºC and an average rainfall of 700 mm. A total of 2800 broiler chickens of the Cobb 500 strain, without sexing and from 1 to 42 days of age, were used (50 birds for each lot with a density of 10 birds x m^2). The birds were kept in 56 cement floors that had wooden litters. Water and feed consumption were *ad libitum*.

This experiment was conducted in compliance with poultry management guidelines of the Institutional Committee for care and use of experimental animals (CICUAE-FMVZ-UNAM) based of the Official Mexican Norm (NOM-033-SAG/ZOO-2014). All birds were orally vaccinated against the Newcastle disease (La Sota strain) at 8 and 24 days of age.

During the first week of life, the chickens had 18 hours of light; then they were maintained with a natural light photoperiod during the day and at night with artificial light (9 to10 PM, 1 to 2 AM and 5 to 6 AM).

Experimental design

A completely randomized design was used. It consisted in 7 treatments of 8 repetitions with 50 birds each. The treatments consisted of partial (25% and 50%) or total replacement of SB by L and AFA (Table 1).

Table 1. Experimental design of treatments

Treatment	Diet description
SB	100% soybean oil
AFA	100% acidulated fatty acids
L	100% lecithin (positive control)
SB75 + L25	75% soybean oil and 25% lecithin
AFA75 + L25	75% acidulated fatty acids and 25% lecithin
SB50 + L50	50% soybean oil and 50% lecithin
AFA50 + L50	50% acidulated fatty acids and 50% lecithin

L = Lecithin. SB = Soybean oil, AFA = Acidulous fatty acids

The diets used were in the form of mash. For each treatment, three feeding phases were employed (Starting 0-21, growth 22-35, finishing 36-42 days of age). In Table 2, only corn-soybean diets with 100% SB are shown per feeding phase and their calculated analyzes that covered the nutritional profiles indicated in the Manual Cobb (Cobb, 2015).

Table 3 shows the inclusion percentages of each energy source used in the diets, which were isocaloric and isoproteic. The ME values used for diet calculations in kcal/kg were 8850, 8000 and 6700 for SB, AFA and L, respectively (FEDNA, 2013).

Table 2**.** Composition of the corn-soybean meal diets for the three feeding phases with soybean oil (100%).

Ingredients (Kg/Ton)	Starting 0-21 days	Growth 22-35 days	Finishing 36-42 days
White corn	578.55	606.75	654.85
Soybean meal	342	295	251
Soybean oil	19	40	38
Meat flour	25	30	30
Calcium orthophosphate	6.1	2.3	0.6
Calcium carbonate	12.4	9.6	9
Refined salt	2.8	2.4	2.2
DL-Methionine	4.4	3.4	3.1
L-lysine HCl	3.3	2.3	2.9
Sodium bicarbonate	2	1.8	2
Choline chloride 60%	1	1	0.7
Premix of minerals and vitamins *	1.1	1.1	1.1
Bacitracin BMD	0.5	0.5	0.5
Nicarbazine Coccidiostat	0.5	0	0
L-Threonine	1.1	0.6	0.8
Ronozyme Hiphos (phytase)	0.1	0.1	0.1
Antioxidant	0.15	0.15	0.15
Yellow pigment (30 g/kg)	0	2.2	2.2
Red carophil 1%	0	0.25	0.25
Salinomycin Coccidiostat	0	0.55	0.55
Total	1000	1000	1000
Nutrients (%)		Calculated analysis	
Crude protein	22	20	18.5
Lysine	1.45	1.25	1.18
Methionine + cystine	1.12	0.97	0.9
Threonine	0.93	0.81	0.76
Metabolizable energy (kcal/Kg)	3025	3190	3225
Calcium	1.09	0.95	0.88
Available phosphorus	0.5	0.44	0.4
Sodium	0.205	0.182	0.18

*Provides: Vitamin A, 6 000 000 UI; Vitamin D_3, 1,500 000 UI; Vitamin E, 12 000 UI; Vitamin K_3, 2.0 g; Riboflavin, 8 g; B_{12}, 0.120 g; Pyridoxine, 6.0 g; Calcium pantothenate, 26.0 g; Niacin, 50 g; Biotin, 0.126 g; Choline chloride, 500 g; Selenium, 0.2 g; Cobalt, 0.1 g; Iodine, 0.3 g; Copper, 10 g; Zinc, 50 g; Iron, 100 g; Manganese, 100 g; Carrier to 2000 g.

Table 3. Inclusion (%) of soybean oil (SB), acidulated fatty acids (AFA) and lecithin (L) used in the treatments during the different feeding stages.

Treatment	Starting	Growth	Finishing
SB	19	40	38
AFA	23	48	45
L	32	67	64
SB75 + L25	16:6	33:12	32:11
AFA75 + L25	19:6	39:13	36:13
SB50 + L50	12:12	25:25	24:24
AFA50 + L50	13:14	28:28	28:27

Performance response and laboratory analyses

Weekly records of body weight, weight gain, feed intake, feed conversion and mortality percentage were recorded. At 42 days of age, two birds (male and female) were sacrificed per repetition (a total of 16 birds per treatment) in order to evaluate the percentage of liver fat (ether extract, AOAC, 2006). Liver yellowness coloration was measured with a CR-300 reflectance colorimeter using the CIELab scale. Sacrifice of the birds was by cervical dislocation according NOM-033-ZOO-1995. In addition, the sacrificed birds were kept in refrigeration for 24 hours a 4 ºC for evaluating skin yellowness pigmentation (in cold) on the right side of the pectoral muscle region (vein region of the fat) with a CR -300 reflectance colorimeter.

Statistical Analysis

The response variables were body weight (g), feed intake (g), feed conversion ratio (grams of feed/body weight), mortality (%), liver yellowness, skin yellowness and ether extract in liver (%) in function

of the different inclusion levels of soybean (SB), acidulated fatty acids (AFA) and lecithin (L). The mortality results were transformed to arcsine and then was analyzed same that other parameters, but in the table are presented in percent of total mortality. The results obtained from the evaluated variables were analyzed in order to verify the fulfillment of the normality and homogeneity of variances assumptions, setting a 5% significance level for both tests. After that, the variables under study were analyzed according to a completely random design. When significant differences ($P<0.05$) were found among treatments, these values were subjected to a comparison of means using a Tukey test (SPSS V 17.0).

RESULTS AND DISCUSSION

The average results from broiler chickens of 1 to 49 days of age, corresponding to body weight, feed intake, feed conversion and mortality percentage are showed in the Table 4. It is possible to observe that there was no effect ($P> 0.05$) to the total or partial inclusion of SB or AFA by L (25% and 50%).

Table 5 shows the average yellowness data in the liver, carcass skin and the percentage of liver ether extract. No differences were found between treatments ($P>0.05$), indicating that the partial or total substitution of SB and AFA by L did not affect the behavior of these variables.

Table 4. Average results of productive parameters in broiler chickens from 1 to 42 days of age.

Treatments	Body weight (g)	Feed Intake (g)	Feed conversion	Mortality (%)
SB	2420	4072	1.71	3.5
AFA	2413	4087	1.72	4.8
L	2414	4036	1.70	6.5
SB75 + L25	2445	4091	1.70	3.5
AFA75 + L25	2426	4052	1.69	4.3
SB50 + L50	2453	4059	1.68	3.0
AFA50 + L50	2459	4056	1.68	2.8
Average	2433	4065	1.69	4.0
Probability	NS	NS	NS	NS
EEM	0.004	0.007	0.004	0.400

NS = Without significant differences ($P>0.05$), SEM = Standard error of the mean

Table 5. Ethereal extract and pigmentation of the birds slaughtered at 42 days of age.

Treatments	Liver Yellowness (b)	Skin Yellowness (b)	Ether extract % in Liver
SB	16.4	47.1	15.7
AFA	16.3	46.4	16.0
L	16.5	46.6	15.9
SB75 + L25	16.0	47.2	15.9
AFA75 + L25	16.3	46.4	16.0
SB50 + L50	16.2	46.5	16.3
AFA50 + L50	16.7	45.0	15.9
Average	16.3	46.5	15.9
Probability	P>0.05	P>0.05	P>0.05
EEM	0.102	0.240	0.098

SEM = Standard error of the mean.

The results of this study observed throughout the productive cycle, partially corroborate the findings of Baião (2005), Peña *et al.* (2014), Vieria *et al.* (2015) and Cortes-Cuevas *et al.* (2018), who showed that AFA is a substitute for SB, as a good source of energy and poly-unsaturated fatty acids. However, other authors (Sizemore and Siegel 1993; Cortes-Cuevas *et al.*, 2018) point out that this energy ingredient has a lower value of metabolizable energy on average (9.3% or 10%). In this study, liver yellowness and ether extract were similar, suggesting that the ME value in Kcal/kg used in the formulation of the experimental diets for SB 8850, AFA 8000 and L 6700 (representing 9.7% and 24.3% less with respect to SB) was adequate.

The ME value used for lecithin was similar to the one reported by Gaiotto *et al.* (2001) [6715 kcal/kg of ME], but it was different from the one found by Borsatti *et al.* (2018) [7051 kcal/kg of ME] and Peña *et al.* (2014) [7502 kcal/kg of ME] due to synergism of L with AFA and glycerol or to the variation between methods in the determination of metabolizable energy as indicated by Dourado *et al.* (2010). In our study, the partial substitution of AS or AFA by lecithin had no effect on the studied productive variables, indicating some synergism of lecithin with the other energy sources

evaluated. However, Huang *et al.* (2007), when using a 75:25 ratio mixture of soybean oil and soy lecithin in the diet, found greater weight gain and better feed efficiency in broilers at 42 days of age. On the other hand, Dubey *et al.* (2014) included different proportions of soybean oil and soybean lecithin in the diets of six-week-old broiler chickens; where they detected greater weight gains in chickens that consumed a 50:50 ratio, without observing significant differences in feed consumption and feed conversion.

Regarding skin pigmentation, which is considered an important factor for consumers in some countries and recognized as a critical attribute of quality during the marketing of broiler carcasses (Castañeda *et al.*, 2005; Liu *et al*., 2008), there were no differences when L was included as a partial or total replacement of SB and AFA. This information corroborates the findings of Cortes-Cuevas *et al.* (2018), who did not found differences in the yellowness of the skin with the use of AFA or SB.

CONCLUSION

From the data obtained under the experimental conditions used in this study, it is concluded that soy lecithin is an alternative energy source to soybean oil or acidulated fatty acids in diets as partial or total replacement (25%, 50% and 100%), without affecting the productive performance, liver ether extract, and the yellowness of liver and skin in broiler chickens of 42 days of age, fed with corn-soybean-based diets with nutritional profiles of commercial use.

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