Effect of Dietary Frying Fat, Vegetable Oil and Calcium Soaps Of Palm Oil on the Productive Behavior and Carcass Yield of Broiler Chickens

ABSTRACT

Vegetable oils (VO) and animal fats are conventional lipid sources used in feed formulations. Frying fats (FF) and calcium soaps of palm oil (CaSPO) are low-cost lipid sources. This study evaluated the productive performance of broiler chickens fed diets with CaSPO in substitution for VO or FF. Two hundred, 1-day old male broiler chickens were allocated in a randomized design with factorial arrangement (22). Diets included 2 lipid sources (FF and VO) and 2 CaSPO levels (0 and 50%). The study had two phases (starter and finisher) of 21 days each. For the starter phase there was no effect (p>0.05) of dietary treatments on the chickens' productive performance. For the finisher phase birds fed diets with FF had higher feed intake and feed conversion ratio (main effect; p<0.01) than those fed diets with VO. Over the 42-day feeding period animals fed FF had higher feed conversion ratio (main effect; p=0.02) and tended (p=0.08) to show higher feed intake than those fed diets with VO. The CaSPO substitution for VO or FF had no effect (p>0.05) on the productive performance of broiler chickens. There was no influence of treatment on carcass yield. The drumsticks plus thighs were higher (main effect; p<0.01) in birds receiving VO than in those receiving FF. The interaction (fat source*CaSPO) was not significant (p>0.05). These results may indicate that VO is superior to FF and CaSPO may substitute for VO or FF without affecting productive performance of broiler chickens. Lipid source showed small influence on carcass characteristics.

INTRODUCTION

In 2018, the poultry industry in Mexico represented 63.3% of all animal production; within poultry, 34.9% were broiler chickens. Chicken meat is a significant food source for Mexican consumers; protein intake from chicken was 39% compared to 16% from beef and 8% from pork. In Mexico, per capita consumption in 2018 was 23 kg of broiler chicken meat (UNA, 2018).

Broiler chicken productive performance is improved with different energy-rich ingredients in the diet. Carbohydrates in cereal grains supply the majority of energy required by broiler chickens; however, per se, cereal grains do not cover broiler chickens' energy requirement (Infante-Rodriguez et al., 2016). Lipids with high energy density are included in the diet to cover the requirements needed by highly productive broiler chickens. Animal fats, vegetable oils and a blend of both are the most common sources of lipids used in poultry diets. Vegetable oils with higher concentration of linoleic and linolenic essential fatty acids have improved growth in broiler chickens (Itzá-Ortiz et al., 2008). The main animal fat used in animal feed is beef tallow, which is obtained during meat processing for human consumption; it has a high melting...
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MATERIALS AND METHODS

Study area

The study was carried out at the poultry farm of the College of Veterinary Medicine and Animal Science of the Autonomous University of Tamaulipas, in Ciudad Victoria, Tamaulipas (dry subtropical area in northeastern Mexico). The area is located at 23°44'06"N and 97°09'50"W, at an altitude of 323 m. The mean annual rainfall is 926 mm, and the average temperature is 24°C (INEGI, 2017). These climatic characteristics are typical for the dry subtropics (ACw).

Management and diets

All procedures involving animal care and management were approved by the Bioethics Committee of the College of Veterinary Medicine and Animal Science of the Autonomous University of Tamaulipas.

Two hundred, 1-day-old male Ross broiler chickens weighing 41.3±1.34 g on average were obtained from a commercial hatchery. Each treatment (diet) included 50 birds randomly assigned with five replicates of ten animals each. During the entire experiment, birds were housed in 20 floor pens with ground grass straw as litter. Twenty-four hours of light per day were provided during the entire trial. Each pen had an automatic drinker and a manually-filled feeder. Space allocation was at ten birds per square meter. Water and feed were offered ad libitum. Birds were vaccinated on day 7 of the trial against fowl pox (wing puncture) and against Newcastle (ocular) using the La Sota strain.

The chickens were raised following standard commercial practice. Two feeding phases were used: 1–21 and 22–42 days of age, for starter and finisher phases, respectively. There were four treatments (T) for starter and finisher diets. The only difference between experimental diet composition was the lipid source: Frying fat (FF), vegetable oil (VO), calcium soap of palm oil (CaSPO), and a mixture of frying fat and vegetable oil (FF + 50% VO). Diets were prepared according to recommendations and are shown in Tables 1 and 2.

Body weight and feed intake were measured weekly and feed conversion ratio (FCR; feed intake, g/weight gain, g) was calculated. At the end of the trial, two
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Table 1 – Contents (%) of broiler experimental diets for the starter phase (1-21 days of age).

| Ingredients                  | Vegetable oil | Frying fat |
|------------------------------|---------------|------------|
|                              | 0% CaSPO¹    | 50% CaSPO  | 0% CaSPO  | 50% CaSPO  |
| Sorghum grain                | 58.9          | 58.9       | 58.9      | 58.9       |
| Soybean meal                 | 33.7          | 33.7       | 33.7      | 33.7       |
| Vegetable oil (VO)           | 3.4           | 1.7        | 0         | 0          |
| Frying fat (FF)              | 0             | 0          | 3.4       | 1.7        |
| Ca soap of palm oil (CaSPO)  | 0             | 1.7        | 0         | 1.7        |
| Premix*                      | 4             | 4          | 4         | 4          |
| Total                        | 100           | 100        | 100       | 100        |

Nutrient composition

Crude protein, % | 21.4 | 21.4 | 21.4 | 21.4 |
ME, kcal/kg     | 3040 | 3040 | 3040 | 3040 |

¹Calcium soaps of palm oil (CaSPO)
*Premix: monocalcium phosphate, calcium carbonate, common salt, growth promoter (BDM and 3-nitro), sodium monensin, mineral oil, ethoxyquin, retinol (vitamin A-acetate), cholecalciferol-D3 (vitamin D3), α-tocopheryl acetate (vitamin E), vitamin K3, riboflavin (vitamin B2), cobalamin (vitamin B12), niacin (vitamin B3), calcium D-pantothenate (vitamin B5), choline chloride (vitamin B4), butylated hydroxytoluene (BHT). Calculated to contain: 21.40% Ca; 8.10% total P; 3.40% Na; 0.80% L-lysine chlorhydrate; and 4.15% DL-methionine.

Table 2 – Contents (%) of broiler experimental diets for the finisher phase (22-42 days of age).

| Ingredients                  | Vegetable oil | Frying fat |
|------------------------------|---------------|------------|
|                              | 0% CaSPO¹    | 50% CaSPO  | 0% CaSPO  | 50% CaSPO  |
| Sorghum grain                | 65.6          | 65.6       | 65.6      | 65.6       |
| Soybean meal                 | 26.4          | 26.4       | 26.4      | 26.4       |
| Vegetable oil (VO)           | 3.7           | 1.85       | 0         | 0          |
| Frying fat (FF)              | 0             | 0          | 3.7       | 1.85       |
| Ca soap of palm oil (CaSPO)  | 0             | 1.85       | 0         | 1.85       |
| Premix*                      | 4             | 4          | 4         | 4          |
| Pigment                      | 0.33          | 0.33       | 0.33      | 0.33       |
| Total                        | 100           | 100        | 100       | 100        |

Nutrient composition

CP, % | 18.7 | 18.7 | 18.7 | 18.7 |
ME, kcal | 3120 | 3120 | 3120 | 3120 |

¹Calcium soaps of palm oil (CaSPO)
*Premix: monocalcium phosphate, calcium carbonate, common salt, growth promoter (BDM and 3-nitro), sodium monensin, mineral oil, ethoxyquin, retinol (vitamin A-acetate), cholecalciferol-D3 (vitamin D3), α-tocopheryl acetate (vitamin E), vitamin K3, riboflavin (vitamin B2), cobalamin (vitamin B12), niacin (vitamin B3), calcium D-pantothenate (vitamin B5), choline chloride (vitamin B4), butylated hydroxyltoluene (BHT). Pre-mix calculated to contain: 19.80% Ca; 3.70% total P; 3.70% Na; 4.33% L-lysine chlorhydrate; and 5.15% DL-methionine.

birds per cage, selected at random, were sacrificed by cervical dislocation (Mexican official law NOM-033-SAG/ZOO-2014) for carcass determinations. Carcass weight without viscera was used to estimate hot carcass yield. Then the carcass was dissected for main cuts: breast, thighs plus drumsticks, wings, and back.

Statistical analyses

The experiment consisted of four dietary treatments with five replicates each, using a completely randomized design with factorial arrangement (2²) of treatments. The analysis of variance considered as main effects two lipid sources (FF and VO) and two CaSPO levels (0 and 50%) as well as the interaction of these effects. For the productive performance (weight gain, feed intake, and feed conversion ratio) the replicate was the average of all broiler chickens in each pen. For carcass evaluation the replicate was the average of two birds (selected at random) per pen. The percentage of dressed carcass yield was determined as carcass weight (g)/live weight (g). Significance was declared at *p*≤0.05; a tendency was considered at *p*>0.05 and *p*≤0.10. For statistical analyses the GLM procedures of SAS (2007) were used.

RESULTS

Growth performance

Results of productive performance of broiler chickens are shown in Table 3. In the study, the interaction (Fat source*CaSPO level) was not significant (*p*>0.05). During the starter phase (1-21 days), there was no effect (*p*>0.05) of dietary treatments on weight gain, feed intake or feed conversion ratio.

For the finisher phase (21-42 days), there was no effect (*p*>0.05) of dietary treatment on weight gain.
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However, broiler chickens fed diets with FF had higher feed intake and feed conversion ratio (main effect; \( p<0.01 \)) than those fed diets with VO.

Over the 42-day feeding period, there was no treatment effect (\( p>0.05 \)) on weight gain. Nevertheless, broiler chickens fed diets with FF had a higher feed conversion ratio (main effect; \( p=0.02 \)) and tended (\( p=0.08 \)) to show higher feed intake than those fed diets with VO. The substitution of CaSPO for VO or FF had no effect (\( p>0.05 \)) on the productive performance of broiler chickens.

### Carcass characteristics

Carcass characteristics of broiler chickens in the study are shown in Table 4. The interaction (Fat source*CaSPO level) was not significant (\( p>0.05 \)). There was no influence of treatment on carcass weight, carcass yield or wing yield. The drumstick plus thigh yield was higher (main effect; \( p<0.01 \)) in animals receiving VO than in birds fed FF. Broiler chickens fed dietary CaSPO tended to exhibit higher breast yield (main effect; \( p=0.06 \)) and lower back yield (main effect; \( p=0.07 \)) than chickens not fed CaSPO.

### DISCUSSION

#### Growth performance

Broiler chickens fed diets with VO had better productive performance than birds fed diets with FF. Ali et al. (2020) also found reduced productive performance of broiler chickens fed diets with thermally oxidized palm oil when compared with broiler chickens receiving fresh palm oil in the diet. In contrast, Dorra et al. (2014) and Orduña-Hernández et al. (2016) observed similar productive performance in broiler chickens fed diets with FF or VO, attributing this response to the low levels of free fatty acids in the FF that they used. Wu et al. (2011) observed similar productive performance in broiler chickens fed diets with soybean oil or FF with low levels of free fatty acids (3%); however, when FF had high free fatty acids levels (12%), the broilers’ productive performance was reduced. Frying fats do not have constant nutritive values because they are a blend of fats and oils obtained from different restaurants or other commercial food companies where fats and oils were subjected to varying processes during cooking. The increase in free fatty acids in fats reduces their absorption (Sklan, 2013).

#### Table 3 – Effect of fat source on the productive performance of broiler chickens.

| Variables and Feeding Stage | Vegetable Oil | Frying fat | SEM | Fat | CaSPO | Fat*CaSPO | p value main effect |
|-----------------------------|---------------|------------|-----|-----|-------|-----------|-------------------|
|                              |              |            |     |     |       |           |                   |
|                              | 0% CaSPO     | 50% CaSPO  | SEM |     |       |           |                   |
|                              |              |            |     |     |       |           |                   |
| Weight gain, g               | 902          | 948        | 24  | 0.27| 0.55  | 0.21      |                   |
| Feed intake, g               | 1474         | 1589       | 68  | 0.55| 0.49  | 0.34      |                   |
| FCR (p<0.01)                 | 1.63         | 1.68       | 0.07| 0.97| 0.64  | 0.88      |                   |
|                              |              |            |     |     |       |           |                   |
| Finishing phase (22-42 days) |              |            |     |     |       |           |                   |
| Weight gain, g               | 2223         | 2291       | 36  | 0.65| 0.47  | 0.90      |                   |
| Feed intake, g               | 4052         | 3954       | 92  | <0.01| 0.61  | 0.59      |                   |
| FCR (p<0.01)                 | 1.74         | 1.73       | 0.05| <0.01| 0.99  | 0.70      |                   |
|                              |              |            |     |     |       |           |                   |
| Entire study (1-42 days)     |              |            |     |     |       |           |                   |
| Weight gain, g               | 3224         | 3239       | 53  | 0.41| 0.82  | 0.61      |                   |
| Feed intake, g               | 5526         | 5544       | 140 | 0.08| 0.99  | 0.91      |                   |
| FCR (p<0.01)                 | 1.71         | 1.71       | 0.84| 0.84|       |           |                   |

1Calcium soaps of palm oil (CaSPO)
2FCR=Feed conversion ratio = feed intake, g/weight gain, g.

#### Table 4 – Broiler chicken carcass characteristics.

| Carcass evaluation | Vegetable oil | Frying fat | SEM | Fat | CaSPO | Fat*CaSPO | p value main effect |
|--------------------|---------------|------------|-----|-----|-------|-----------|-------------------|
|                    | 0% CaSPO      | 50% CaSPO  |     |     |       |           |                   |
|                    |              |            |     |     |       |           |                   |
| Hot carcass weight, g | 2434         | 2566       | 86  | 0.21| 0.53  | 0.40      |                   |
| Carcass yield, % 2   | 74.7          | 73.0       | 1.13| 0.31| 0.20  | 0.84      |                   |
| Breast yield, %      | 37.7          | 39.4       | 0.70| 0.53| 0.06  | 0.75      |                   |
| Thigh + drumstick yield, % | 31.0      | 31.3       | 0.37| <0.01| 0.49  | 0.99      |                   |
| Wing yield, %        | 10.7          | 10.3       | 0.40| 0.80| 0.74  | 0.47      |                   |
| Back yield, %        | 19.4          | 18.4       | 0.34| 0.13| 0.07  | 0.40      |                   |

1Calcium soaps of palm oil (CaSPO)
2Percentage of dressed carcass yield = (carcass weight, g/live weight, g)*100
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Conversely, the productive performance of broilers was not improved by substituting CaSPO for FF. The fatty acids of triglycerides in palm oil, during the saponification process bind to calcium, thus CaSPO has lower energy concentration than palm oil. The information declared by the manufacturer of CaSPO used in this study shows a content of 8 to 9.6% calcium and 14% ash. Despite this high content of non-fat compounds in CaSPO that do not provide energy, it was not revealed in the production of the broiler chickens. Further research to elucidate these substitutions of fats is warranted. There is limited information on the dietary use of calcium soaps of palm oil in broiler chickens. For applied broiler chicken production, CaSPO is an alternative as a partial substitution for VO or FF in cases where the cost of CaSPO is competitive with the other fat sources.

Carcass characteristics

Carcass weight, carcase yield or wings yield showed no influence of dietary treatment. The greater drumsticks plus thighs in animals receiving VO than in birds receiving dietary FF is consistent with improved productive performance of broiler chickens fed VO. Dorra et al. (2014) reported no effect of dietary frying fat substituting for fresh oil on carcass traits in broiler chickens. Nobakht et al. (2011) found no influence of different dietary vegetable oils on yield of carcase, breast and thigh, whereas feed efficiency was influenced by dietary oil. Similarly, Anjum et al. (2004) did not observe differences in carcase dressing percentage and organ weights in broiler chickens fed diets with fresh soybean oil or oxidized soybean oil.

In the present study, the positive effects on carcase characteristics obtained with dietary calcium soaps of palm oil are of importance in broiler chicken production. Further research on the effect of CaSPO on carcase and meat quality is warranted. Malá et al. (2004) found that the replacing vegetable oils with calcium salts of fatty acids of rape and soybean seeds produced no negative effects on carcase characteristics in broiler chickens. In other studies, calcium salts of soybean oil have not affected carcase abdominal fat in broiler chickens (Tabeidian & Sadeghi, 2006; Mosavat et al., 2011). Information on this theme is currently limited.

CONCLUSIONS

In the present study, broiler chickens fed dietary VO had better productive performance than broilers fed FF. The substitution of CaSPO for VO or FF had no effect
on the productive performance of broiler chickens. The fat source (VO or FF) or its substitution with CaSPO had no great influence on broiler carcass characteristics. In areas of the world where calcium soap of palm oils is less expensive than conventional vegetable oils, it represents a real alternative to formulate diets for broiler chickens. Further research considering digestive and meat parameters is warranted.

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DECLARATION OF INTEREST STATEMENT

No potential conflict of interest was reported by the authors.

REFERENCES

Ali SAF, Ismail AA, Abdel-Hafez SA, El-Genaidy HMA. Influence of thermally oxidized palm oil on growth performance and PPAR-α gene expression in broiler chickens. Egyptian Academic Journal of Biological Sciences. C, Physiology and Molecular Biology 2020; 12(1):23-37.

Anjum Mi, Mirza IH, Khan AG, Azim A. Effect of fresh versus oxidized soybean oil on growth performance, organs weights and meat quality of broiler chicks. Pakistan Veterinary Journal 2004; 24(4):173–178.

Baiao NC, Lara LC. Oil and fat in broiler nutrition. Brazilian Journal of Poultry Science 2005;7(3):129-141.

Chebet J, Kinyanjui T, Cheplogoi K P. Impact of frying on iodine value of vegetable oils before and after deep frying in different types of food in Kenya. Journal of Scientific and Innovative Research 2016;5(5):193-196.

Choe E, Min DB. Chemistry of deep-fat frying oils. Journal of Food Science 2007;72(5):77-86.

Dewi GAMK, Astawa PA, Sumadi JK. Effect of inclusion calcium-palm fatty acid (Ca-PFA) on growth performance and profile of body fatty acid of broiler. Journal of the Indonesian Tropical Animal Agriculture 2011;36(3):55-60.

Dorra TM, Hamady GAA, Abdel-Moneim MA. The use of recovered frying oil in broiler chicken diets:effect on performance, meat quality and blood parameters. Research Journal of Animal, Veterinary and Fishery Sciences 2014;2(3):11-15.

Garrett RL, Young RJ. Effect of micelle formation on the absorption of neutral and fatty acids by the chicken. Journal of Nutrition 1975;105(7):827-838.

INEGI - Instituto Nacional de Estadística, Geografía e Informática. Anuario Estadístico del Estado de Tamaulipas. 2017 [cited 2020 Jan 16]. Available from: http://www.datatur.sectur.gob.mx/itxef_docs/tams_anuario_pdf.pdf.
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UNA - Unión Nacional de Avicultores. Compendio de Indicadores Económicos del Sector Avícola 2018 [cited 2020 Jan 18]. Available from: https://www.una.org.mx/indicadores-economicos/.

Valencia ME, Watkins SE, Waldroup AL, Waldroup PW, Fletcher DL. Utilization of crude and refined palm and palm kernel oils in broiler diets. Poultry Science 1993;72(12):200-215.

Vázquez-Añón M, Jenkins T. Effects of feeding oxidized fat with or without dietary antioxidants on nutrient digestibility, microbial nitrogen, and fatty acid metabolism. Journal of Dairy Science 2007;90(9):4361-4867.

Vázquez-Añón M, Nocek J, Bowman G, Hampton T, Atwell C, Vázquez P, et al. Effects of feeding a dietary antioxidant in diets with oxidized fat on lactation performance and antioxidant status of the cow. Journal of Dairy Science 2008;91(8):3165-3172.

Wiseman J, Salvador F. The influence of free fatty acid content and degree of saturation on the apparent metabolizable energy value of fats fed to broilers. Poultry Science 1991;70(3), 573-582.

Waldroup PW, Watkins SE, Saleh EA. Comparison of two blended animal-vegetable fats having low or high free fatty acid content. Journal of Applied Poultry Research 1995;4(1):41-48.

Wu H, Gong LM, Guo L, Zhang L, Li JT. Effects of the free fatty acid content in yellow grease on performance, carcass characteristics, and serum lipids in broilers. Poultry Science 2011;90(9):1992-1998.
