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# Purified glycerin diets for broilers from 8 to 42 days old[1]

# Glicerina purificada em dietas para frangos de corte dos 8 aos 42 dias de idade

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## Abstract

Here we evaluate the technical viability of including purified glycerin in balanced diets for broilers from 8 to 42 days old. For this, we used 160 8-day-old broiler chickens from the Cobb 500® lineage, distributed in a completely randomized design (CRD) with four treatments (0, 2, 4, and 6% of purified glycerin inclusion) and four replicates of ten birds. We evaluated feed intake, weight gain, feed conversion, final weight, organs biometry (heart, liver, gizzard and small intestine), carcass yield, special cuts yields (thigh, drumstick, and breast), meat color, and protein and fat deposition in the breast muscle. The purified glycerin inclusion levels in diets influenced ($p < 0.05$) weight gain, feed conversion, and broiler weight at 42 days, with no effect ($p > 0.05$) on feed intake (FI). Similarly, there was no effect ($p > 0.05$) on carcass and special cuts yields. The purified glycerin inclusion levels did not influence ($p > 0.05$) the relative gizzard weight, nor the relative small intestine weight and length. However, the purified glycerin inclusion levels did affect the relative heart and liver weights ($p < 0.05$). The purified glycerine inclusion levels in diets did not affect ($p > 0.05$) lightness (L*), redness (a*), yellowness (b*) values, pH, or protein deposition, but did increases ($p < 0.05$) fat deposition in breast muscle. Based on our findings, we propose that the inclusion of 6% purified glycerin in diets is technically feasible for broilers of 8 to 42 days old.
**Key words**: Biodiesel co-products. Fat deposition. Meat quality**.** Protein deposition. Productive performance.

## Resumo

Objetivou-se neste trabalho avaliar a viabilidade técnica da inclusão de glicerina purificada em dietas balanceadas para frangos de corte, dos 8 aos 42 dias de idade. Foram utilizados 160 pintos de corte, com 8 dias, da linhagem Cobb 500®, distribuídos em delineamento experimental inteiramente casualizado

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(DIC), com quatro tratamentos (0, 2, 4 e 6% de inclusão de glicerina purificada) e quatro repetições de dez aves. Foram avaliados o consumo de ração, ganho de peso, conversão alimentar, peso final, biometria dos órgãos (coração, fígado, moela e intestino delgado), rendimento de carcaça, rendimentos de cortes nobres (coxa, sobrecoxa e peito), coloração e a deposição de proteína e deposição de gordura da carne do peito. Os níveis de inclusão de glicerina purificada nas dietas influenciaram ($p < 0,05$) o ganho de peso, a conversão alimentar e o peso das aves aos 42 dias, não havendo efeito ($p > 0,05$) sobre o consumo de ração. Da mesma forma, não houve efeito ($p > 0,05$) sobre os rendimentos de carcaça e cortes nobres. Os níveis de inclusão de glicerina purificada não influenciaram ($p > 0,05$) os pesos relativos da moela, nem o peso relativo e/ou comprimento do intestino delgado. Entretanto, observou-se efeito ($p < 0,05$) sobre o peso relativo do coração e fígado. Os níveis de inclusão de glicerina purificada nas dietas não afetaram ($p > 0,05$) os valores de luminosidade (L*), vermelho (a*), amarelo (b*), pH e a deposição de proteína, mas, aumentou de maneira linear ($p < 0,05$) a deposição de gordura da carne de peito. A inclusão de até 6% de glicerina purificada nas dietas mostrou-se tecnicamente viável para frangos de corte dos 8 aos 42 dias de idade.
**Palavras-chave**: Coprodutos do biodiesel. Deposição de gordura. Desempenho produtivo. Deposição de proteína. Qualidade de carne.

## Introduction

The high costs of feeding broiler chickens has aroused interest in new alternative sources of food, which can partially replace energy and protein foods in the diet, aiming at minimizing the costs of nutrition and, consequently, production (FREITAS et al., 2017; HENZ et al., 2013;2014; SILVA et al., 2017).

Foods derived from agro-industrial processing have gained prominence in animal nutrition, including glycerine, a production co-product of biodiesel. Biological tests carried out to verify the energy content of glycerines have demonstrated their efficiency as an energy source for birds (ABD-ELSAMEE et al., 2010; DOZIER et al., 2008; 2011; JUNG; BATAL, 2011; OLIVEIRA et al., 2013).

According to Oliveira et al. (2013), glycerin has a good gross energy content (relative to maize) that is highly metabolizable and, thus, can be considered for use in poultry feed. Topal and Ozdogan (2013) evaluated the effects of different amounts of glycerol (0, 4, and 8%) on the variables of performance, organ weight, and chemical composition of broiler muscles from 1 to 42 days of age and concluded that glycerin can be used as a source of energy up to 8%, especially in the 1 to 21 days phase, without compromising bird performance. Likewise, Mclea et al. (2011) tested different glycerin inclusion levels (3.3, 6.7, and 10.0%) in broiler diets and found that inclusion of up to 6.7% did not cause negative effects on broiler diets, productive performance, and digestibility of nutrients.

However, there is yet no clear consensus on the ideal level of food inclusion in the diets, due to the different raw materials and catalysts used to produce biodiesel, which cause excesses of some minerals that may affect its composition and limit its use in the feeding of birds (FREITAS et al., 2017; ROMANO et al., 2014).

In addition, excessive levels of glycerin in diets can decrease glycerol metabolism capacity in the body, and consequently increase excretion by birds, favoring greater bed humidity (GIANFELICI et al., 2011).

Here, we aimed to evaluate the technical viability of the inclusion of purified glycerin in balanced diets for broilers from 8 to 42 days of age.

## Material and Methods

The trial was conducted at the Poultry Research Centre of the School of Veterinary Medicine and Animal Science, Federal University of Tocantins, Araguaína – TO, from September 29th to November 10th 2015. The study was conducted in accordance with the statements of the Ethics in Animal Use Committee, Federal University of Tocantins (CEUA-UFT) under the protocol number 23101.000830/2014-16.

A total of 160 male Cobb 500® broiler chicks, raised up to the 7th day of life, were used according to the lineage recommendations. The birds were fed at will with diets formulated with corn and soybean meal according to the nutritional requirements recommended by Rostagno et al. (2011) for broiler chickens of medium performance males, from 1 to 7 days of age. On the 8th day, birds with a mean weight of 208 ± 16.78 g were homogenized, and the treatments were distributed in a completely randomized experimental design (DIC), with four treatments (0, 2, 4, and 6% inclusion of purified glycerin), with four replicates of ten birds per experimental unit.

Broilers were housed in an experimental shed with 16 boxes of 2 m², supplied with tubular feeders and pendulum drinkers. Replenishing of feeders and cleaning of drinkers were performed twice a day to ensure free access to water and feed throughout the experimental period.

Until the 14$^{th}$ day old, broilers were heated artificially, using incandescent lamps (60 W) located inside the boxes. Environmental conditions inside the facility during the experimental period were monitored and recorded daily every 5 min using HOBO Data Loggers OnSet® ware Version 3.4.1. The devices were placed at the half height in the boxes to obtain data of temperature and relative humidity. The average air maximum and minimum temperatures inside the facility during the experimental period were 25.6, 32.8, and 20.8 °C respectively, and the relative humidity was 85%.

The experimental diets were calculated considering the purified glycerin chemical composition (Table 1) and the nutritional requirements for medium performance male broilers following the Rostagno et al. (2011) recommendations from 8 to 21 (Table 2) and from 22 to 42 days of age (Table 3).

**Table 1.** Composition of purified glycerin used in the formulation of experimental diets.

| Nutrients and energy | Purified glycerin[1] |
|---|---|
| Crude protein (%)[2] | 0.23 |
| Metabolizable energy (kcal/kg)[3] | 3560 |
| Dry matter (%)[4] | 89.98 |
| Ether extract (%)[4] | 1.19 |
| Mineral matter (%)[4] | 7.86 |
| Methanol (g/kg)[4] | Less than 0.1 |
| Glycerol (%)[4] | 80.4 |
| NaCl (%)[4] | 7.47 |
| Na (%)[4] | 2.96 |

[1]Glycerin from the processing of soybeans, sold in southern Brazil.
[2]Rostagno et al. (2011).
[3]Analysis conducted at the Animal Nutrition Laboratory from the School of Veterinary Medicine and Animal Science, Federal University of Tocantins.
[4]Approximate values supplied by the manufacturer.

The evaluated parameters were growth curve (g), growth rate (days), feed intake (FI), weight gain (WG), feed conversion ratio (FC), final weight (FW), organ biometry (heart, liver, gizzard), weight and/or length of the small intestine, carcass yield (CY), special cuts yield (thigh, drumstick and breast), color of breast muscle (L*= lightness, a*= redness, b*= yellowness), pH, protein deposition and fat deposition.

The birds were weighed at the beginning and at the end of the experimental period for GP determination. The CR was calculated considering the amount of feed supplied and the leftovers in the feeders. The AC was obtained by the ratio between the consumption of ingested ration and the weight gain of the birds during the experimental period.

At 42 days of age, two broilers per repetition with body weights within ± 5% of the average were fasted for 12 h and then slaughtered by cervical dislocation. Subsequently, they were subjected to bleeding, scalding, plucking, and evisceration procedures. Relative weights of whole carcasses (with legs, neck, and head) and special cuts (thigh, drumstick, and breast) were determined.

**Table 2.** Composition of experimental diets containing increasing levels of purified glycerin for broilers from 8 to 21 days of age.

| Ingredients | Levels of purified glycerin (%) | | | |
|---|---|---|---|---|
| | 0 | 2 | 4 | 6 |
| Corn | 59.119 | 56.977 | 54.835 | 52.692 |
| Soybean meal (45%) | 34.741 | 35.116 | 35.493 | 35.868 |
| Purified glycerin | 0.000 | 2.000 | 4.000 | 6.000 |
| Dicalcium phosphate | 1.508 | 1.511 | 1.513 | 1.516 |
| Soybean oil | 2.157 | 2.077 | 1.997 | 1.917 |
| Limestone | 0.924 | 0.923 | 0.919 | 0.917 |
| Salt | 0.482 | 0.333 | 0.185 | 0.037 |
| DL-Methionine | 0.287 | 0.289 | 0.292 | 0.294 |
| L-Lysine HCl | 0.218 | 0.211 | 0.203 | 0.196 |
| L-Threonine | 0.064 | 0.063 | 0.063 | 0.063 |
| Mineral and vitamin supplement[1] | 0.500 | 0.500 | 0.500 | 0.500 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 |
| Calculated nutritional composition | | | | |
| Metabolizable energy (kcal/kg) | 3000 | 3000 | 3000 | 3000 |
| Crude protein (%) | 20.80 | 20.80 | 20.80 | 20.80 |
| Calcium (%) | 0.819 | 0.819 | 0.819 | 0.819 |
| Available Phosphorus (%) | 0.391 | 0.391 | 0.391 | 0.391 |
| Digestible Lysine (%) | 1.174 | 1.174 | 1.174 | 1.174 |
| Digestible Methionine + Cysteine (%) | 0.846 | 0.846 | 0.846 | 0.846 |
| Digestible Methionine (%) | 0.562 | 0.562 | 0.563 | 0.564 |
| Digestible Threonine (%) | 0.763 | 0.763 | 0.763 | 0.763 |
| Sodium (%) | 0.210 | 0.210 | 0.210 | 0.210 |
| Potassium (%) | 0.808 | 0.808 | 0.809 | 0.809 |

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| | | | | |
|---|---|---|---|---|
| Chlorine (%) | 0340 | 0.251 | 0.161 | 0.072 |
| Electrolyte balance (mEq/kg)[2] | 202.1 | 227.2 | 252.9 | 277.9 |

[1]Composition/ton: Folic Acid: 150.00 mg; Cobalt: 178.00 mg; Copper: 2,675.00 mg; Choline: 120.00 g; Colistin: 2,000.00 mg; Iron: 11.00 g; Iodine: 535.00 mg; Manganese: 31.00 g; Mineral matter: 350.00 g; Niacin: 7,200.00 mg; Nicarbazin: 24.00 g; Calcium Pantothenate: 2,400.00 mg; Selenium: 60.00 mg; Vitamin A: 1,920,000.00 IU; Vitamin B1: 300.00 mg; Vitamin B12: 3,600.00 mg; Vitamin B2: 1,200.00 mg; Vitamin B6: 450.00 mg; Vitamin D3: 360,000.00 IU; Vitamin E: 3,600.00 IU; Vitamin H: 18.00 mg; Vitamin K: 480.00 mg; Zinc: 22.00 g.
[2]Calculated according to Mongin (1981): Electrolyte Balance = (mg/kg of dietary $Na^+$/22.990) + (mg/kg of dietary $K^+$/39.102) - (mg/kg of dietary $Cl^-$/35.453).

The edible viscera (gizzard, heart, and liver) and the small intestine were collected during evisceration. Subsequently, they were cleaned, dried on paper towels, and weighed separately on a precision scale. From the gizzard, all the adhered fat, its contents, and the koilin membrane were removed. In addition to weight, the length of the small intestine, from the beginning of the duodenum to the ileocecal junction, was measured. The relative weight of plucked and eviscerated carcass was calculated in relation to fasting weight. The relative weights of the cuts, edible viscera, and small intestine were obtained in relation to plucked and eviscerated carcass.

In the raw breast meat (boneless, skinless, without ligaments and fat) the pH and color of the meat were evaluated by the CIELAB system (L*= lightness, a*= redness, b*= yellowness) with a colorimeter (Chroma meter®). The readings were performed at three different points of the musculature and pH determination was performed by means of penetration electrode, inserted directly into the meat.

**Table 3.** Composition of experimental diets containing increasing levels of purified glycerin for broilers from 22 to 42 days of age.

| Ingredients | Levels of purified glycerin (%) | | | |
|---|---|---|---|---|
| | 0 | 2 | 4 | 6 |
| Corn | 64.039 | 61.843 | 59.647 | 57.451 |
| Soybean meal (45%) | 29.434 | 29.821 | 30.206 | 30.592 |
| Purified glycerin | 0.000 | 2.000 | 4.000 | 6.000 |
| Dicalcium phosphate | 1.172 | 1.174 | 1.177 | 1.179 |
| Soybean oil | 3.078 | 3.040 | 3.005 | 2.968 |
| Limestone | 0.817 | 0.815 | 0.812 | 0.810 |
| Salt | 0.450 | 0.302 | 0.154 | 0.006 |
| DL-Methionine | 0.248 | 0.250 | 0.253 | 0.255 |
| L-Lysine HCl | 0.214 | 0.207 | 0.199 | 0.192 |
| L-Threonine | 0.048 | 0.048 | 0.047 | 0.047 |
| Mineral and vitamin supplement[1] | 0.500 | 0.500 | 0.500 | 0.500 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 |

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| Calculated nutritional composition | | | | |
|---|---|---|---|---|
| Metabolizable energy (kcal/kg) | 3125 | 3125 | 3125 | 3125 |
| Crude protein (%) | 18.75 | 18.75 | 18.75 | 18.75 |
| Calcium (%) | 0.685 | 0.685 | 0.685 | 0.685 |
| Available Phosphorus (%) | 0.320 | 0.320 | 0.320 | 0.320 |
| Digestible Lysine (%) | 1.044 | 1.04 | 1.044 | 1.044 |
| Digestible Methionine + Cysteine (%) | 0.762 | 0.762 | 0.762 | 0.762 |
| Digestible Methionine (%) | 0.501 | 0.502 | 0.503 | 0.504 |
| Digestible Threonine (%) | 0.678 | 0.678 | 0.678 | 0.678 |
| Sodium (%) | 0.197 | 0.197 | 0.197 | 0.197 |
| Potassium (%) | 0.725 | 0.725 | 0.726 | 0.727 |
| Chlorine (%) | 0.322 | 0.232 | 0.143 | 0.053 |
| Electrolyte balance (mEq/kg)[2] | 180.3 | 205.7 | 231.0 | 256.7 |

[1]Composition/ton: Folic Acid: 120.00 mg; Cobalt: 179.00 mg; Copper: 2,688.00 mg; Choline: 108.00 g; Iron: 11.00 g; Iodine: 537.00 mg; Lincomycin 800.00 mg; Manganese: 31.00 g; Mineral matter: 350.00 g; Niacin: 6,000.00 mg; Calcium Pantothenate: 1,920.00 mg; Salinomycin: 12.00 g; Selenium: 54.00 mg; Moisture 80.00 g; Vitamin A: 1,500,000.00 IU; Vitamin B1: 300.00 mg; Vitamin B12: 2,800.00 mg; Vitamin B2: 960.00 mg; Vitamin B6: 450.00 mg; Vitamin D3: 300,000.00 IU; Vitamin E: 3,000.00 IU; Vitamin H: 20.00 mg; Vitamin K: 480.00 mg; Zinc: 22.00 g.
[2]Calculated according to Mongin (1981): Electrolyte Balance = (mg/kg of dietary $Na^+$/22.990) + (mg/kg of dietary $K^+$/39.102) - (mg/kg of dietary $Cl^-$/35.453).

The breasts were cut in half and frozen in plastic bags. One of the separated halves was ground in an industrial meat grinder. The ground cuts were weighed, homogenized, and pre-dried in an oven at 55 °C for 72 h. Subsequently, they were ground in a knife-type mill and transported to the laboratory for analysis (crude protein and ether extract) according to Silva and Queiroz (2002).

Protein and fat deposition rates in breast meat (g/day) were calculated based on the slaughtering of an additional group of six one-day-old chicks, compared to those birds slaughtered at 42 days of age, according to the formulas described by Scherer et al. (2011).

To determine the weight loss during cooking, breast fillets were weighed and baked in an electric oven at 170ºC until reaching the internal temperature of 40 ºC. Subsequently, they were turned once to reach the internal temperature of 70ºC. The samples were placed on absorbent paper for cooling to a temperature of 20 to 25°C and then weighed again to determine the weight loss during cooking. Finally, the samples were kept under refrigeration at 4°C for 24 h, according to the methodology adapted from Froning and Uijttenboogarte (1988).

To determine the shear force, cylindrical samples (1.27 cm in diameter) were taken and placed with the fibers oriented perpendicular to the direction of plunger travel, using a Warner-Bratzler instrument.

The data were submitted to Normality tests (*Cramer Von Mises*) and homoscedasticity (*Levene*). The variables were subjected to regression analysis using polynomial models of first or second order, considering the inclusion level of purified glycerin as an independent variable. To check the adjustment of the equation, it was considered the significance of “F” test for models, the significance of “t” test for the parameters ($\beta0$, $\beta1$ and $\beta2$) of the models, and the coefficient of determination ($R^2$ = SS regression/ SS total), considering the significance level equal to or less than 5%. Statistical analyses were performed with the aid of SISVAR statistical program.

## Results and Discussion

It was observed that the inclusion levels of purified glycerin in the diets influenced (p <0.05) the weight gain (GP), the feed conversion (CA), and the weight of the birds at 42 days (P42d), with no effect (p>0.05) on feed intake (CR) (Table 4).

**Table 4.** Average feed intake (FI), weight gain (WG), feed conversion (FC) and weight at 42 days (W7d) in broilers from 8 to 42 days old according to the inclusion level of purified glycerin.

| Variables | Purified glycerin inclusion level (%) | | | | Mean | P | | | CV[1] (%) |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 2 | 4 | 6 | | LE | QE | LD | |
| FI[2] (g) | 435.50 | 4427.00 | 4329.75 | 4481.25 | 4398.36 | 0.191 | 0.393 | 0.061 | 2.05 |
| WG (g) | 2629.75 | 2712.50 | 2701.50 | 2756.00 | 2699.94 | 0.028 | 0.676 | 0.302 | 2.44 |
| FC (g/g) | 1.658 | 1.631 | 1.600 | 1.628 | 1.628 | 0.040 | 0.058 | 0.230 | 1.46 |
| P42d (g) | 2835.00 | 2918.25 | 2907.75 | 2962.25 | 2905.81 | 0.027 | 0.670 | 0.302 | 2.26 |

[1]Coefficient of variation (%).
[2]$\hat{Y}$ = NS.
LE = linear effect; QE = quadratic effect; LD = linearity deviation; P = probability of type I error at 5% using F test. Equation: WG (g) = 2644.78 + 18.39 IL (P=0.028; $r^2$ = 0.81); FC (g) = 144.25 + 1.875 IL (P=0.001; $r^2$ = 0.79); FC (g/g) = 1.09 – 0.0075 IL (P=0L002; $r^2$ = 0L79); P42d (g) = 2850L13 + 18.55 IL (P=0.027; $r^2$ = 0.82); in which IL = purified glycerin inclusion level (%).

The lack of effect on the CR of the birds may be related to the fact that the experimentais diets were formulated to be isoenergetic and isunutritive meeting the requirements of metabolizable energy (kcal/kg), regardless of the level of inclusion of purified glycerin. Thus, the voluntary consumption of feed by the birds is directly related to the energy level of the diets, which provided the balanced intake of metabolizable energy and crude protein by birds.

From the results obtained, it can be inferred that the levels of inclusion of purified glycerin in the diets improved the performance of the broilers, and it is possible to affirm that the inclusion of up to 6% does not affect the performance variables. Similar results were found by Freitas et al. (2017), who developed an experiment, using levels of 0, 5 and 10% of glycerin in broilers fed from 1 to 42 days, and concluded that glycerin can be used in diets up to 5% without affecting the performance of the birds.

Similarly, Sehu et al. (2012) evaluated the 0, 5, and 10% levels of glycerin in broilers feeding and observed that the inclusion of up to 5% of the feed did not affect any of the performance characteristics during the total period of 1 to 42 days of growth.

It was observed that the levels of inclusion of purified glycerin in the diets did not affect (p> 0.05) the relative carcass, thigh, supercox, breast, and protein deposition weights. However, there was an increasing dose dependent effect (p<0.05) for the deposition of breast meat fat from chickens slaughtered at 42 days (Table 5).

**Table 5.** Average carcass (CY), thigh (TCY), drumstick (DSCY), and breast (BY), protein deposition (PD), and fat deposition (FD) in the breast meat of broilers at 42 days of age according to the level of inclusion of purified glycerin.

| Variables | Purified glycerin inclusion level (%) | | | | Mean | P | | | CV[1] (%) |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 2 | 4 | 6 | | LE | QE | LD | |
| CY[2] (%) | 85.28 | 85.08 | 84.36 | 84.70 | 84.85 | 0.452 | 0.706 | 0.627 | 1.68 |
| TCY[3] (%) | 12.14 | 11.88 | 11.84 | 12.11 | 11.98 | 0.904 | 0.199 | 0.935 | 3.27 |
| DSCY[4] (%) | 12.28 | 12.67 | 12.80 | 12.85 | 12.65 | 0.183 | 0.570 | 0.892 | 4.60 |
| BY[5] (%) | 35.93 | 37.15 | 36.31 | 36.14 | 36.38 | 0.949 | 0.379 | 0.439 | 4.17 |
| PD[6] (g/dia) | 5.18 | 5.16 | 5.14 | 5.36 | 5.20 | 0.311 | 0.312 | 0.619 | 4.54 |
| FD (g/dia) | 1.19 | 1.31 | 1.39 | 1.41 | 1.33 | 0.001 | 0.195 | 0.873 | 4.11 |

[1]Coefficient of variation (%).
[2,3,4,5,6]$\hat{Y}$ = NS.
LE = linear effect; QE = quadratic effect; LD = linearity deviation; P = probability of type I error at 5% using F test. Equation: FD (g/day) = 1.213 + 0.0382 IL (P=0.001; $r^2$ = 0.94); in which IL = purified glycerin inclusion level (%).

These results are in agreement with those found by Sehu et al. (2013) and Silva et al. (2012), who observed that the inclusion of up to 5% glycerin in broiler diets did not affect carcass yields and noble cuts.

The results of fat deposition in the breast meat are in agreement with the reports of Oliveira Neto et al. (2000), who verified a linear increase in the fat content of the carcass of broiler chickens as a result of the increase in the energy levels of the ration. Divergent results were found by Henz et al. (2014), who evaluated different levels (0, 3, 6, 9, 12, and 15%) of glycerin in broiler feed and did not observe effects on the levels of fat and protein deposition in broiler carcasses of 1 to 21 days of age.

Eyng et al. (2013) tested different levels of flours from the tilapia broiler industry in broiler feed and did not observe and effects of these levels on the deposition of protein and fat. According to these authors, the absence of effects on the values of fat and protein deposition for both thigh and overcook and for breast, may have occurred because the experimentais diets were isoenergetic and isonutritive, which providing the balanced daily intake of metabolizable energy and crude protein. Thus, it is probable that the absence of effect on the deposition of protein in the breast meat is associated with the fact that the experimentais diets were formulated to be isonutritive in all evaluated treatments.

The inclusion levels of purified glycerin did not influence (p> 0.05) the relative gizzard weights, nor the relative weight or length of the small intestine (Table 6). However, there was an effect (p<0.05) on the relative weight of heart and liver, which increased linearly according to the increase of glycerin purified in the diets.

The results for the relative weight of the heart are in agreement with those found by Topal and Ozdogan (2013), who observed that birds fed a diet containing 8% glycerin had higher relative weight of the heart. However, the authors found no effect on the relative weight of liver and gizzard of broilers fed 4 or 8% crude glycerin. Nevertheless, according to the authors, the relative weight of some internal organs, such as the heart and liver, might be related to the weight gain of the birds. This may justify the increase in the relative weight of this organ in the present work since the GP of the birds increased linearly with the inclusion levels of purified glycerin in the diets.

**Table 6.** Relative weight of the heart (HY), gizzard (GY), liver (LY), small intestine (SIY) and small intestine length (LSY) of broilers slaughtered at 42 days of age.

| Variables | Purified glycerin inclusion level | | | | Mean | P | | | CV[1] (%) |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 2 | 4 | 6 | | LE | QE | LD | |
| HY (%) | 0.37 | 0.37 | 0.42 | 0.44 | 0.40 | 0.003 | 0.460 | 0.326 | 7.36 |
| GY[2] (%) | 1.30 | 1.33 | 1.30 | 1.31 | 1.31 | 0.983 | 0.833 | 0.777 | 11.48 |
| LY[3] (%) | 1.71 | 1.89 | 1.84 | 1.97 | 1.85 | 0.005 | 0.656 | 0.077 | 5.03 |
| SIY[4] (%) | 2.86 | 3.09 | 2.89 | 3.05 | 2.97 | 0.461 | 0.732 | 0.097 | 6.73 |
| LSY[5] (m) | 161 | 1.67 | 1.64 | 1.77 | 1.67 | 0.051 | 0.497 | 0.252 | 5.55 |

[1]Coefficient of variation (%).
[2,3,4,5]$\hat{Y}$ = NS.
LE = linear effect; QE = quadratic effect; LD = linearity deviation; P = probability of type I error at 5% using F test. Equation: HY = 0.3635 + 0.0124 IL (P=0.003; $r^2$ = 0.87) e LY = 1.743 + 0.00337 IL (P=0.005; $r^2$ = 0.75), in which IL = purified glycerin inclusion level (%).

Differing results were found by Sehu et al. (2012), who evaluated the levels of 0, 5, and 10% of glycerin in broiler feed and found that the relative weight of the liver, heart, and gizzard reduced with the inclusion level of 5% of the food in the diets.

It was observed that the levels of inclusion of purified glycerin in the diets did not affect the values of luminosity (L*), red (a*), yellow (b*), pH, shear force, or baking weight loss (PPCO) of broiler chicks slaughtered at 42 days of age (Table 7).

**Table 7.** Average lightness (L*), redness (a*), yellowness (b*) pH, temperature, shear force (FC) and weight loss per baking (PPCO) in the breast meat of broilers at 42 days of age according to the inclusion level of purified glycerin.

| Variables | Purified glycerin inclusion level (%) | | | | Mean | P | | | CV[1] (%) |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 2 | 4 | 6 | | LE | QE | LD | |
| L*[2] | 60.42 | 63.05 | 60.25 | 59.93 | 60.91 | 0.565 | 0.378 | 0.295 | 5.30 |
| a*[3] | 8.82 | 9.11 | 9.00 | 9.44 | 9.09 | 0.425 | 0.882 | 0.661 | 10.54 |
| b*[4] | 11.35 | 10.51 | 10.73 | 9.94 | 10.63 | 0.246 | 0.980 | 0.538 | 13.73 |
| pH[5] | 6,05 | 6.23 | 6.52 | 6.34 | 6.28 | 0.065 | 0.167 | 0.344 | 4.13 |
| FC | 1.38 | 1.42 | 1.32 | 1.34 | 1.35 | 0.505 | 0.947 | 0.460 | 10.75 |
| PPCO | 16.33 | 19.02 | 16.72 | 18.03 | 17.53 | 0.636 | 0.595 | 0.162 | 14.71 |

[1]Coefficient of variation (%).
[2,3,4,5]$\hat{Y}$ = NS.
LE = linear effect; QE = quadratic effect; LD = linearity deviation; P = probability of type I error at 5% using F test.

Differing results for meat staining were found by Faria et al. (2013), who evaluated increasing levels of glycerin in broilers feeding and observed that the raw meat of the breast presented an orange color in general and that the increase of the levels of glycerin in the diets promoted a greater trend towards color red. However, there was no effect of the levels of glycerin in the diets on the shear force and the weight loss by cooking the meat.

## Conclusion

The inclusion of 6% of purified glycerin in the diets was technically feasible for broilers from 8 to 42 days of age, provided that the diets are balanced to meet the nutritional requirements of the birds.

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