Animal performance, yield and characteristics of the meat of quail fed diets containing vegetable and mixed glycerin

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Abstract – The objective of this work was to evaluate the effect of the inclusion of vegetable and mixed glycerin in the diet of broiler quail (*Coturnix coturnix coturnix*) on animal performance, yield of carcass and organs, and physical and sensory characteristics of the meat. A total of 432 quails aged 1–42 days were used in a completely randomized design with a 4×2+1 factorial arrangement (5, 10, 15, and 20% inclusion of vegetable or mixed glycerin, besides one treatment without glycerin) with 4 replicates of 12 birds each. Feed intake, weight gain, feed conversion, yield (carcass, breast, thigh+drumstick, heart, liver, gizzard, and abdominal fat), and physical and sensory characteristics of the meat. The diet containing mixed glycerin resulted in higher feed intake and feed conversion. The yield of carcass, meat cuts, and organs, as well as the sensory characteristics of the meat, did not vary between the treatments. Abdominal fat content and shear strength were higher in birds fed diets containing vegetable glycerin. The tested glycerin and levels do not interfere with weight gain, yield, and sensory quality of the meat. However, weight gain and feed conversion are lower when mixed glycerin is used, although meat tenderness is higher when 15% vegetable glycerin is used.

Index terms: *Coturnix coturnix coturnix*, carcass yield, meat quality, weight gain.

Desempenho, rendimento e características da carne de codornas que receberam rações contendo glicerina vegetal e mista

Resumo – O objetivo deste trabalho foi avaliar o efeito da inclusão de glicerinas vegetal e mista na dieta de codorna de corte (*Coturnix coturnix coturnix*) sobre o desempenho, o rendimento de carcaça e de órgãos, e as características físicas e sensoriais da carne. Utilizaram-se 432 codornas com 1 a 42 dias de idade, em delineamento inteiramente casualizado, no arranjo fatorial 4×2+1 (5, 10, 15 e 20% de inclusão de glicerina vegetal ou mista, mais um tratamento sem glicerina), com 4 repetições e 12 aves cada uma. Avaliaram-se o consumo de ração, ganho de peso, conversão alimentar, rendimento (de carcaça, peito, coxa+sobrecoxa, coração, fígado, moela e gordura abdominal) e características físicas e sensoriais da carne. A dieta com glicerina mista proporcionou maior consumo de ração e conversão alimentar. O rendimento de carcaça, cortes, órgãos, bem como as características sensoriais da carne, não variaram entre os tratamentos. Já a gordura abdominal e a força de cisalhamento foram maiores nas aves que consumiram ração contendo glicerina vegetal. Os níveis e as glicerinas testados não interferem no ganho de peso, nem nos rendimentos e na qualidade sensorial da carne. No entanto, há prejuízo no ganho de peso e na conversão alimentar quando se utiliza glicerina mista, embora a maciez da carne seja maior quando se utilizam 15% de glicerina vegetal.

Termos para indexação: *Coturnix coturnix coturnix*, rendimento de carcaça, qualidade da carne, ganho de peso.

Introduction

The high cost of feed for animal production demands the search for alternative feeds. In this respect, glycerin is a byproduct of the agro-industry and has been searched as a substitute for corn and soybean meal. Glycerin is derived from biodiesel produced from renewable sources, such as animal fats and vegetable oils (Pasquetti et al., 2014). Swiatkiewicz & Koreleski (2009) reported that 1,000 kg biodiesel yielded approximately 100 kg glycerin.

Glycerin is considered as a mixed compound with a variable chemical composition, and its use as a feed may result in poultry performance variation (Zavarize et al., 2014). Furthermore, the inclusion of high levels of glycerol in diets may exceed the capacity of the liver enzyme glycerol kinase, resulting in saturation of glycerol and limiting its absorption (Min et al., 2010). However, Cerrate et al. (2006) found that glycerin did not limit the performance of poultry and can thus be used as an alternative energy source.

The use of quail meat, although still limited, is increasing because of the introduction of a European variety that meets the requirements of meat production. In Brazil, the production of quail meat has considerably increased (Winter et al., 2006) because of its sensory characteristics that favor consumer acceptance (Oliveira et al., 2005).

The objective of this work was to evaluate the effect of the inclusion of vegetable and mixed glycerin in the diet of broiler quail on animal performance, yield of carcass, cut and organs, and physical and sensory characteristics of the meat.

Materials and Methods

The study was approved by the animal research ethics committee of Universidade Federal do Ceará (UFC), in state of Ceará, Brazil, under Protocol No. 20/2013, and complied with the ethical principles for animal experimentation adopted by the Brazilian College of Animal Experimentation.

The experiments were conducted in the poultry farming sector of the federal university Universidade Federal do Ceará (UFC), in municipality of Fortaleza, state of Ceará, and included 432 European quails aged 1–42 days in mixed batches, distributed in a completely randomized design with a 4×2+1 factorial arrangement, and undergoing a total of nine treatments with four replicates of 12 birds per pen.

The evaluated factors were four levels of inclusion of glycerin to the diet (5, 10, 15, and 20%), two types of glycerin (vegetable and mixed), and a control diet of corn and soybean meal without the inclusion of glycerin. The feeds were formulated according to the nutritional recommendations of NRC (1994), and the feed composition was based on that used in the study by Rostagno (2011) (Table 1).

Energy values of glycerin at the time of feed formulation were determined by a previous metabolic assay using quails in the period from 14 to 21 days of age, housed in metabolic cages and distributed in a completely randomized design with a 2×2+1 factorial arrangement, including two levels of replacement of the reference feed with glycerin (10 and 20%), two types of glycerin (vegetable and mixed), and a reference diet, totaling five treatments with six replicates of six birds each. The obtained energy values were 5,195 and 3,884 kcal EMAn kg^{-1} of dry matter for vegetable and mixed glycerin, respectively.

The tested glycerin formulations included plant-derived crude glycerin obtained from cottonseed oil (provided by the Usina de Biodiesel of the Centro de Tecnologias Estratégicas do Nordeste – the biodiesel unit of the strategic technology center of the Northeast region, located in municipality of Caetés, state of Pernambuco, Brazil), and a semi-purified mixed glycerin composed of 60% tallow and 40% soybean oil (provided by the biodiesel plant of the Petrobras unit located in the municipality of Quixadá, state of Ceará, Brazil).

The temperature and humidity in the shed were measured using a digital thermo-hygrometer, and data were collected daily at 8 a.m. and 4 p.m., with a maximum and minimum temperature of 33.45 and 28.62°C, respectively, and relative air humidity of 53%.

The broiler quails aged 1 day were weighed (9 g), selected based on live weight to be distributed in the experimental units according to body weight, as described by Sakomura & Rostagno (2007). After that, the animals were housed in 36 pens with dimensions of 60 × 60 cm, containing bedding of wood shavings, a pendular drinking system, and a tubular feeder, and they remained there until the age of 42 days. Animal performance was assessed by determination of feed intake (g per bird), weight gain (g per bird), and feed conversion (g g^{-1}) during the study period.

At the age of 42 days, two birds with an average weight similar to that of the pen were selected from each pen. The animals fasted for 6 hours and then were slaughtered, plucked, and eviscerated. After weighing the quail carcasses without the head, feet, and edible offal, meat cuts were made. The yield of carcass and relative weight of the liver, gizzard, and heart (%) were calculated relative to the live weight of the birds, and the yield of the breast, thigh + drumstick, and abdominal fat (%) was calculated relative to the weight of the eviscerated carcass.

Meat physical and sensory characteristics were analyzed using the breast muscle of slaughtered animals. The tissues were deboned, packaged, labeled, and frozen until the beginning of the analyses;

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these analyses were conducted in the laboratory for agricultural products technology, in the Universidade Estadual Vale do Acaraú, in municipality of Sobral, state of Ceará, Brazil. The evaluated physical characteristics were weight loss after cooking, water retention capacity, and shear strength.

Weight loss after cooking was determined according to the method used by Duckett et al. (1998a). The samples were composed of three slices with a thickness of approximately 1.5 cm, length of 3.0 cm, and width of 2.5 cm. They were weighed, transferred to containers covered with aluminum foil, and then baked in a preheated oven at 170°C until the temperature of the geometrical center reached 71°C. The temperature was assessed using a copper/constantan thermocouple equipped with a digital reader, model HD9218 (Delta OHM, Caselle di Selvazzano PD, Italy). Then, the samples were cooled to room temperature and reweighed. Weight loss during cooking was calculated by the difference in sample weight before and after the samples were subjected to heat treatment. Weights were expressed as grams per 100 g of meat (g 100 g^{-1}).

Water retention capacity was evaluated according to the methodology described by Miller & Groninger (1976). The results were expressed in mL of absorbed water per 100 g of meat (mL 100 g^{-1}).

Shear strength was evaluated according to the methodology described by Duckett et al. (1998b). The

Table 1. Composition and nutritional and energy levels of the feed administered to broiler quails.

Ingredients	Control diet	Semi-purified mixed glycerin (%)				Crude vegetable glycerin (%)			
		5	10	15	20	5	10	15	20
Corn	51.40	45.73	39.96	33.72	27.47	46.72	41.18	33.15	25.12
Crude vegetable glycerin	0.00	0.00	0.00	0.00	0.00	5.00	10.00	15.00	20.00
Semi-purified mixed glycerin	0.00	5.00	10.00	15.00	20.00	0.00	0.00	0.00	0.00
Soybean meal (45%)	43.47	44.45	45.45	46.54	47.62	44.28	45.24	46.64	48.03
Soybean oil	1.99	1.94	1.94	2.09	2.25	0.85	0.00	0.00	0.00
Calcitic limestone	1.17	1.16	1.16	1.15	1.14	1.16	1.16	1.15	1.14
Monodicalcium phosphate	0.96	0.97	0.98	0.99	0.99	0.97	0.98	0.99	1.00
Supplementation with minerals and vitamins(1)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Salt	0.51	0.23	0.00	0.00	0.00	0.51	0.51	0.51	0.52
DL-methionine	0.16	0.16	0.16	0.17	0.17	0.16	0.16	0.17	0.17
Zinc bacitracin	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Coxistac	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Inert(2)	0.00	0.00	0.00	0.00	0.00	0.00	0.42	2.05	3.67
Choline chloride	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated nutritional level									
Metabolizable energy (kcal kg^{-1})	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900
Crude protein (%)	23.80	23.80	23.80	23.80	23.80	23.80	23.80	23.80	23.80
Dry matter (%)	88.57	88.64	88.73	88.86	89.00	88.64	88.80	89.20	89.60
Ether extract (%)	4.59	4.35	4.16	4.10	4.04	3.30	2.27	2.00	1.73
Crude fiber (%)	3.19	3.15	3.10	3.05	3.00	3.15	3.11	3.04	2.98
Acid detergent fiber (%)	5.24	5.13	5.02	4.89	4.77	5.15	5.04	4.88	4.72
Neutral detergent fiber (%)	12.13	11.59	11.03	10.44	9.84	11.68	11.15	10.38	9.62
Calcium (%)	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Available phosphorus (%)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Sodium (%)	0.22	0.22	0.24	0.35	0.46	0.22	0.22	0.22	0.22
Total lysine (%)	1.33	1.34	1.36	1.37	1.39	1.34	1.36	1.38	1.40
Total methionine + cystine (%)	0.88	0.88	0.88	0.88	0.87	0.88	0.88	0.87	0.87
Total methionine (%)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Total threonine (%)	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Total tryptophan (%)	0.30	0.31	0.31	0.31	0.32	0.31	0.31	0.31	0.32

(1)Safety levels per kg of product: 5,500,000 IU vitamin A; 500 mg vitamin B1; 7,500 mcg vitamin B12; 2,502 mg vitamin B2; 750 mg vitamin B6; 1,000,000 IU vitamin D3, 6,500 IU vitamin E; 1, 250 mg vitamin K3; 25 mg biotin; 17.5 g niacin; 251 mg folic acid; 6,030 mg pantothenic acid; 50 mg cobalt; 3.000 mg copper; 25 g iron; 500 mg iodine; 32.5 g manganese; 100.05 mg selenium; and 22.49 g zinc. (2)Washed sand.

evaluated samples were those used for the calculation of weight loss after cooking. After cooking and weighing, two cylinders were excised from each meat slice in the direction of the fiber using a puncher with a diameter of 1.6 cm. The cylinders were transversely cut using a TA-XT2 texturometer (Extralab, Surrey, England) equipped with a Warner Bratzler blade, operating at a rate of 20 cm min^{-1}. The peak shearing strength was recorded, and the result was expressed in kgf cm^{-2}.

The sensory characteristics of the meat samples were analyzed considering the nine types of meat obtained using the factorial scheme described above, and the attributes that best describe the quality of the cooked meat were used: aroma, color, flavor, and overall assessment. A panel of six trained tasters was used, including three men and three women aged 21–25 years, for three sessions totaling 18 repetitions.

A nine-point hedonic scale was used with the following scores: 1, extremely disliked; 2, disliked considerably; 3, disliked moderately; 4, disliked slightly; 5, neither liked nor disliked; 6, liked slightly; 7, liked moderately; 8, liked considerably; and 9, liked extremely (Araújo et al., 2012).

The samples were fractionated into cubes with edges of approximately 2.0 cm, baked in an electric grill preheated to 170°C for 16 minutes (8 minutes each side), packed in aluminum foil, and kept in a water bath at 55°C until serving. The samples were labeled using three-digit random numbers and served with cracker-type biscuits and mineral water to allow the tasters to clean their palate between each sampling. The tests were conducted in individual booths with controlled temperature and lighting.

For the assessment of animal performance, yield (carcass, noble cuts, and organs), and physical characteristics of the meat, data were subjected to analysis of variance using the software SAS (SAS Institute, Inc., Cary, NC, USA) and a completely randomized design with a 4×2+1 factorial arrangement in which the degrees of freedom related to the levels of inclusion of glycerin (5, 10, 15, and 20%), excluding the zero level of inclusion (control diet), were broken down into polynomials to determine the equation that best described the behavior of data.

For assessment based on the type of glycerin (vegetable and mixed), the means were compared by the F-test, at 5% probability, and Dunnett's test, also at 5% probability, was used to compare results obtained separately for each level of inclusion of glycerin and those obtained with zero level of inclusion of glycerin (control diet). For obtaining the sensory characteristics of the meat, data were subjected to analysis of variance, and the means were compared by Duncan's test, at 5% probability.

Results and Discussion

The inclusion of glycerin in the diet affected feed intake in the period from 1 to 42 days of age for quails. Regardless of the glycerin used in the diet, for each 1% glycerin added, the consumption of feed by quails increased by 4.1475 g ($y = 996.9614 + 4.1475x$; $R^2 = 0.77$) (Table 2). With regard to the type of glycerin, feed intake and feed conversion were higher when semi-purified mixed glycerin was added to the feed.

Similarly, Guerra et al. (2011) included increasing levels of crude mixed glycerin to the feed of broiler chickens aged 1–42 days and observed a linear increase in feed intake without changes in weight gain, resulting in lower feed conversion.

There was no difference in the yield of carcass, breast, thigh + drumstick, liver, heart, and gizzard of birds between treatments (Table 3). This result indicates that the addition of glycerin caused no changes in the

Table 2. Performance of quails aged 1–42 days fed diets containing different types of glycerin.

Levels (%)	Variables		
	Feed intake	Weight gain	Feed conversion
0	1,030.85	269.96	3.82
5	1,031.56	270.29	3.83
10	1,019.63	279.03	3.67
15	1,055.21	279.64	3.79
20	1,088.82	279.45	3.92
Glycerin(1)			
SMG	1,077.46a	274.69	3.93a
CVG	1,020.15b	279.52	3.67b
CV (%)(2)	4.71	8.78	7.37
Anova		p-value	
Levels (L)	0.0166	0.8333	0.3879
Glycerin (G)	0.0008	0.5734	0.0176
L × G	0.5602	0.9420	0.6676
Regression		p-value	
Linear	0.0050(3)	0.4660	0.3710
Quadratic	0.1410	0.6030	0.1770

(1)SMG, semi-purified mixed glycerin; CVG, crude vegetable glycerin. (2)Coefficient of variation. (3)Linear equation of feed intake at ages of 1–42 days: $y = 996.9614 + 4.1475x$ ($R^2 = 0.77$).

meat cuts and marketable organs of quails. A similar result was observed by Freitas (2012), who used broiler chickens slaughtered at the age of 49 days, which were fed a diet containing 5–10% of glycerin, wherein no significant difference was observed in the yield of the carcass, breast, wing, thigh + drumstick, back, and abdominal fat.

Compared with quails fed without the addition of glycerin (control), quails fed with glycerin, considering all levels of inclusion of crude vegetable glycerin to the diet, had increased abdominal fat (Table 3). Similarly to the results obtained in this research, Batista et al. (2013) evaluated quails aged 15–35 days fed with levels of inclusion of 4, 8, 12, and 16% of crude vegetable glycerin and semi-purified vegetable glycerin, and observed no significant differences in the yield of carcass, breast, and thigh + drumstick; however, there was a significant difference in the yield of abdominal fat. In contrast, Peña Martínez (2012) evaluated broiler chickens fed a diet containing 2% (age of 1–21 days) and 4% (22–40 days) soy glycerin and found a significant difference in carcass yield but no significant difference in the yield of commercial meat cuts (breast and leg), nor abdominal fat. Silva et al. (2012) evaluated broiler chickens that received four distinct levels of glycerin and observed no differences in the yield of carcass, breast, thigh + drumstick, and wings.

There was no significant correlation between the levels of glycerin and abdominal fat of quail. The types of glycerin tested (vegetable and mixed) affected abdominal fat, and quails fed a diet containing crude vegetable glycerin had higher abdominal fat than those fed a diet containing semi-purified mixed glycerin. Hurwitz et al. (1988) found a strong correlation between the lipid content of the feed and fat deposition in the carcass of poultry. Similarly, Crespo & Esteve-Garcia (2001) reported that the lipid composition of crude vegetable glycerin added to the diet might affect the amount of total abdominal fat and body fat, which may have occurred because of the lipid composition of crude vegetable glycerin. Ooi et al. (2004) and Retore et al. (2012) indicated that the higher amount of fatty acids in crude glycerin than in semi-purified glycerin might explain the higher deposition of abdominal fat.

The addition of glycerin to the diet did not have an effect on the yield of liver, heart, and gizzard. Topal & Ozdogan (2013) evaluated the effect of mixed vegetable glycerol (sunflower, corn, and soybean oil) on broiler chickens and found no significant differences in the size of the internal organs, with the exception of enlargement of the heart in males.

There was no difference in the quality of meat between the treatments when considering water retention capacity and weight loss after cooking (Table 4). It is of note that meat products that are

Table 3. Yield of carcass, noble meat cuts, organs, and abdominal fat of quails fed a diet containing glycerin.

Levels (%)	Variables (%)(1)						
	CY	BY	TDY	LY	HY	GY	AF
0	70.70	36.54	18.61	2.84	1.03	2.59	0.70
5	71.26	36.01	18.85	2.62	1.14	2.53	1.24*
10	71.79	34.58	17.81	2.49	1.07	2.44	1.27*
15	72.10	34.31	17.27	2.54	1.05	2.26	1.26*
20	71.74	34.81	17.29	2.42	1.10	2.55	1.42*
Glycerin(2)							
SMG	71.85	35.14	17.57	2.55	1.12	2.45	1.15b
CVG	71.60	34.72	18.03	2.49	1.06	2.44	1.44a
Coefficient of variation (%)	4.88	5.99	7.81	17.34	8.67	10.27	24.04
Anova	p-value						
Levels (L)	0.9724	0.2597	0.0944	0.7984	0.2652	0.1209	0.3985
Glycerin (G)	0.8399	0.5079	0.3512	0.7114	0.0813	0.9792	0.0372
L × G	0.9114	0.8594	0.4017	0.8687	0.5782	0.6247	0.1095
Regression	p-value						
Linear	0.7610	0.1800	0.0230	0.3970	0.2950	0.7880	0.1860
Quadratic	0.7240	0.1380	0.2800	0.9660	0.0930	0.0470	0.2870

(1)CY, carcass yield; BY, breast yield; TDY, thigh and drumstick yield; LY, liver yield; HY, heart yield; GY, gizzard yield; AF, abdominal fat. (2)SMG, semi-purified mixed glycerin; CVG, crude vegetable glycerin. *Statistical difference by the Dunnett's test, at 5% probability.

attractive to the palate cannot lose significant amounts of water during preparation to remain easy to chew and juicy. In contrast, Bernardino et al. (2014) provided crude vegetable glycerin, crude mixed glycerin, and semi-purified mixed glycerin to broiler chickens and observed a 0.0457% linear reduction in water loss after cooking for every 1 g of glycerin added per kg of feed.

There was a correlation between the type of glycerin and the level of inclusion of glycerin for shear strength (Table 5). Shear strength decreased only in the meat of quails that consumed diet containing crude vegetable glycerin at a level of inclusion of 15% compared with those that consumed diets containing the same level of semi-purified mixed glycerin. At all other levels of inclusion tested, shear strength of the meat was not affected by the type of glycerin.

In agreement with this result, Peña Martínez (2012) observed that the physical and sensory characteristics of the meat of broiler chickens did not change with the addition of mixed glycerin to the feed. In contrast, Bernardino et al. (2014) found a linear increase in shear strength of the meat of broiler chickens with the inclusion of crude vegetable and mixed glycerin.

Table 4. Physical characteristics of the meat of European quail fed diets containing different types and levels of inclusion of glycerin.

Levels (%)	Variables(1)		
	WRC (mL $100g^{-1}$)	CWL (g $100g^{-1}$)	SS (kgf cm^{-2})
0	43.87	28.87	2.35
5	47.39	32.39	3.71*
10	44.97	31.30	2.94*
15	48.93	33.67	2.83*
20	46.82	36.52	3.67*
Glycerin(2)			
SMG	46.02	31.59	3.30
CVG	48.04	35.35	3.28
CV (%)(3)	10.78	12.84	14.86
Anova		p-value	
Levels (L)	0.4457	0.2496	0.0000
Glycerin (G)	0.2488	0.0564	0.9216
L × G	0.0530	0.0966	0.0056
Regression		p-value	
Linear	0.7700	0.0900	0.7200
Quadratic	0.9280	0.2980	0.0000(4)

(1)WRC, water retention capacity; CWL, cooking weight loss; and SS, shear strength. (2)SMG, semi-purified mixed glycerin; and CVG, crude vegetable glycerin. (3)Coefficient of variation. (4)Quadratic equation for SS: $y = 5.3680 - 0.4082x + 0.0161x^2$ ($R^2 = 0.99$). *Statistically different from the control treatment by Dunnett's test at 5% probability.

With respect to the sensory characteristics, the nine types of meat obtained with the factorial scheme used in this study were evaluated. Our results indicated that the levels of inclusion of glycerin and the type of glycerin did not affect the aroma, color, flavor, and overall assessment of quail meat at the end of the 42-day production period.

The mean scores of flavor and color of the meat samples were 7.43 and 7.44, respectively. These scores indicate a median acceptance by the tasters because according to the 9-point hedonic scale, this score is located between "liked moderately" and "liked considerably," regardless of the type of glycerin used, which indicated a similar acceptance of the meat of quails fed diets containing glycerin and those fed a control diet of corn and soybean meal.

Faria et al. (2013) found no significant difference in the color of the meat of broiler chickens by increasing the level of glycerin in the feed to 120 g of glycerin per kg of feed, a similar result to the one found in this research.

The average scores of flavor and overall assessment of the meat samples were 7.04 and 7.05, respectively, which corresponded to a score of "liked moderately", which demonstrated that glycerin did not affect the flavor and acceptance of such meat by the consumers, so glycerin may be used in the feed of quail without affecting their marketing or the satisfaction of the end consumers.

Table 5. Interaction between factors on the shear strength (kgf cm^{-2}) of quails fed diets containing different types and levels of inclusion of glycerin.

Levels (%)	Glycerin(1)		Average	p-value
	SMG	CVG		
5	3.68	3.75	3.71	0.8158
10	2.71	3.18	2.94	0.1036
15	3.29a	2.37b	2.83	0.0024
20	3.51	3.84	3.67	0.2627
Average	3.29	3.28	3.29	
Anova	p-value			
Levels	0.0000(2)	0.0084(2)		
CV (%)(3)	14.96			

(1)SMG, semi-purified mixed glycerin; and CVG, crude vegetable glycerin. (3)Quadratic equation for SMG: $y = 4.7748 - 0.2975x + 0.0119x^2$ ($R^2 = 0.66$) and for CVG: $y = 5.9613 - 0.5189x + 0.0203x^2$ ($R^2 = 0.77$). (3)Coefficient of variation.

Conclusions

1. The levels of inclusion of mixed or vegetable glycerin do not interfere with weight gain; yield of carcass, meat cuts, and organs; and sensory characteristics of quail meat.

2. The use of mixed semi-purified glycerin in the feed reduced feed intake and feed conversion of quails.

3. The use of feed containing crude vegetable glycerin increased the levels of abdominal fat in quails.

4. The tenderness of the meat is higher with the addition of 15% of crude vegetable glycerin to the feed.

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