Wafer-type biscuit waste in meat-quail diets

Resíduo de biscoito tipo wafer na alimentação de codornas de corte

Lucas Silva Gonzaga[1] , Sandra Roseli Valerio Lana[1*] , Geraldo Roberto Quintão Lana[1] , Romilton Ferreira Barros Junior[1] , Ana Patricia Alves Leão[1] , Daniel Silva Santos[1]

[1]Universidade Federal de Alagoas, Maceió, Alagoas, Brazil.
*Correspondent- sandraroselilana@gmail.com

Abstract

Two experiments were carried out to evaluate the nutritional composition and effect of different levels of inclusion of wafer-type biscuit waste (WW) in the diet of European quail on production performance, carcass yield and economic viability. In the metabolizability trial, WW showed 87.45% DM, 4,128.53 kcal/kg GE, 3,833.14 kcal/kg AME, 3,818.92 kcal/kg AMEn, 9.37% CP and 17% EE. The metabolizability coefficients of DM, GE, EE and CP were 93.20, 92.85, 93.01 and 47.16%, respectively. In the performance trial, feed intake decreased linearly (P<0.05) from 22 to 42 and from one to 42 days of age. Weight gain and feed conversion were not influenced (P>0.05) by WW inclusion. The WW inclusion levels did not influence (P>0.05) carcass yield. The diet with 20% inclusion of WW provided the best financial return. Wafer-type biscuit waste can be included up to the level of 20% in quail diets without compromising production performance, carcass yield or the economic viability of the activity.

Keywords: agro-industrial by-product; metabolism; nutrition; quail farming

Resumo

Foram realizados dois experimentos com o objetivo de avaliar a composição nutricional e a utilização de diferentes níveis de inclusão de resíduo de biscoito tipo wafer (RB), na alimentação de codornas europeias, sobre o desempenho produtivo, rendimento de carcaça e viabilidade econômica. No ensaio de metabolizabilidade, o RB apresentou 87,45% de MS, EB de 4.128,53 kcal/kg, EMA de 3.833,14 kcal/kg, EMAn de 3.818,92 kcal/kg, com 9,37% de PB e 17% de EE. Os valores do coeficiente de metabolizabilidade (CM) para MS, EB, EE e PB foram: 93,20; 92,85; 93,01 e 47,16%, respectivamente. No ensaio de desempenho, houve redução linear (P<0,05) do consumo de ração das aves nos períodos de 22 a 42 dias e de um a 42 dias de idade. O ganho de peso e a conversão alimentar das aves não foram influenciados (P>0,05) pela inclusão do RB. Não houve efeito (P>0,05) dos níveis de inclusão do RB sobre o rendimento de carcaça. A ração com 20% demonstra ser mais rentável. Recomenda-se a inclusão do RB até o nível de 20% nas dietas para codornas, sem comprometer o desempenho produtivo, o rendimento de

carcaça e a viabilidade econômica.
Palavras-chave: coturnicultura; metabolismo; nutrição; subproduto da agroindústria.

Introduction

Poultry farming is considered a segment of great importance in the production of high-protein foods, where producers are always seeking to adapt to the new techniques to improve animal production efficiency[1,2]. In this scenario, quail production has stood out in the Brazilian poultry sector due to the low investment required for the activity and the rapid growth, early development, high productivity and sexual maturity of the species. However, feeding is highlighted as one of the factors of greatest relevance, as it accounts for around 70% of total quail production costs[3,4]. Therefore, new feedstuffs should be sought to replace those traditionally used such as maize and soybean meal, which are the main responsible for the high costs of poultry production systems. Cost reduction should thus be prioritized considering the regional availability and quality of the product as well as its environmental pollution potential[1,5].

Some of the alternative feedstuffs are those derived from the food industry. This industry has generated a considerable amount of waste, raising great concern for regulatory agencies in terms of the final destination of this waste, which is commonly discarded in the environment, causing the most diverse environmental problems[6,7]. The biscuit industry is no different, generating large amounts of waste due to inadequacy in the processes of production and distribution to the final consumer that usually stems from losses due to breaking or excess or insufficient cooking during processing. This waste can, however, be considered a sustainable alternative when used in animal feeding. It may also include unmarketed products or products past the expiration date, characterized as not approved by the quality control sector of factories[8-12].

Waste from the biscuit industry can have variable compositions, which depend on the formula and ingredients used. Biscuit waste is considered a high-energy source, given its starch, sugar, fat, protein and lysine contents that are similar to those of maize, but higher sodium levels[11]. A study led by Nunes et al.[13] revealed metabolizable energy values of 4,480 and 4,105 kcal/kg in biscuit and pasta wastes, respectively, when fed to broiler chicks. According to Rostagno et al.[14], the protein and energy contents of biscuit waste are 8.69% and 4,010 kcal/kg, respectively, with metabolizable energy values higher than those found in maize. The nutritional value of biscuit waste described in the literature is thus inferred to provide a great energy uptake, similarly to high-energy grains, which has aroused interest in this ingredient as a partial substitute for maize in the diet of non-ruminants[11,15].

Shittu et al.[16] tested different levels of biscuit waste inclusion in the diet of broiler chickens and found that it can replace up to 15% of maize during the starter and finisher phases of rearing without compromising performance, nutrient digestibility or carcass characteristics.

On the basis of the foregoing, the present study proposes to determine the chemical

and energy composition and the metabolizability of wafer-type biscuit waste as well as examine the effect of its inclusion in meat-quail diets on production performance, carcass characteristics and economic viability in the period of one to 42 days of age.

Materials and methods

The experiment was carried out in the Quail Farming unit of CECA/UFAL, located in Rio Largo - AL, Brazil. All procedures were approved by the Ethics Committee on Animal Use of the Federal University of Alagoas (approval no. 27/2017).

Experiment I – Metabolizability trial

The wafer-type biscuit waste (WW) was acquired from the Pandurata Alimentos company, located in the municipality of Rio Largo - AL, Brazil. The waste originated from discard at the production line of the company, in the form of pressed sheets without filling, which were ground through 6-mm sieves to obtain the biscuit waste meal that was used to compose the diets. The chemical composition of WW was determined by analyzing the dry matter (DM), crude protein (CP), ether extract (EE), mineral matter (MM) and gross energy contents (GE), following the methodology proposed by Silva & Queiroz[17].

One hundred 21-day-old European quail were used for the WW metabolizability trial. The birds were allocated to two treatments (control diet - 0% biscuit waste; and test diet - 20% biscuit waste) in a completely randomized design with five replicates and 10 birds per experimental unit. The experimental diets (Table 1) were formulated following the nutritional recommendations of Rostagno et al.[18].

The experimental period was 10 days, consisting of five days of adaptation to the diet and management and five days of excreta collection. The total excreta collection method was adopted, with start and end determined based on the appearance of marked excreta (1.0% Fe_2O_3 added to the diets), as described by Sibbald & Slinger[19]. The apparent metabolizability coefficients of DM and GE and the apparent metabolizable energy (AME) and nitrogen-corrected AME (AMEn) values of the diets were calculated using formulae proposed by Matterson et al.[20].

For the excreta collection, trays lined with plastic, from the very cage, were placed under each compartment so as to individualize the material and prevent contaminations and losses. The collected excreta were weighed, packed in labeled plastic bags and frozen at -18 °C. At the end of the experimental period, they were homogenized and dried in a forced-air oven (55 °C for 72 h) and ground for later analyses. The amounts of feed consumed and the total excreta produced per experimental unit were determined. Chemical analyses of diets and excreta were performed at the Laboratory of Animal Nutrition of UFPB according to methodologies described by Silva & Queiroz[17].

The metabolizability coefficients of DM, GE, CP and EE were calculated using formulae proposed by Matterson et al.[11]. The AME and AMEn values of the diets and waste were calculated using the results of the laboratory analysis of feed and excreta. Data were subjected to analysis of variance ($P < 0.05$) using R Core Team software[21].

Table 1. Control diet

Ingredient	Control diet
Maize	57.213
Soybean meal (45%)	38.186
Wafer waste	0.000
Soybean oil	1.051
Dicalcium phosphate	1.387
Limestone	1.164
Common salt	0.395
L-lysine	0.140
DL-methionine	0.127
L-threonine	0.037
Vitamin supplement[1]	0.100
Mineral supplement[2]	0.050
Zinc bacitracin	0.050
Cygro (virginiamycin)	0.050
Antioxidant[3]	0.050
Total	100.00
Calculated composition	
Metabolizable energy (kcal/kg)	2,900
Crude protein (%)	22.00
Total calcium (%)	0.900
Available phosphorus (%)	0.375
Sodium (%)	0.176
Digestible methionine (%)	0.420
Digestible lysine (%)	1.200
Digestible threonine (%)	0.790

[1]Vitamin supplement/kg: vit. A 13,440.000 IU; vit. D 3,200.000 IU; vit. E 28,000 mg/kg; vit. K 2,880 mg/kg; thiamin 3,500 mg/kg; riboflavin 9,600 mg/kg; pyridoxine 5,000 mg/kg; cyanocobalamin 19,200 mcg/kg; folic acid 1,600 mg/kg; pantothenic acid 25,000 mg/kg; niacin 67,200 mg/kg; biotin 80,000 mcg/kg; selenium 600 ppm.

[2]Mineral supplement/kg: Mg 150,000 ppm; Zn 140,000 ppm; Fe 100,000 ppm; Cu 16,000 ppm; I 1,500 ppm.

[3]Butylated hydroxytoluene.

Experiment II - Performance, carcass yield and economic viability

A total of 250 one-day-old mixed European quail with an average initial weight of 9.14 ± 0.27 g were allocated to five treatments (control diet and diets with 0, 5, 10, 15 and 20% inclusion of biscuit waste) in a completely randomized design with five replicates and 10 birds per plot, totaling 25 experimental units. The birds were housed in galvanized-wire battery cages (50 × 60 × 30 cm) in an air-conditioned room. The cages were equipped with trough feeders, syphon drinkers and an excreta-collection tray.

The climatic conditions in the room were measured daily, at 08h00 and 16h00, using a maximum-minimum thermometer, a black-globe thermometer and a thermohygrometer. The black-globe humidity index (BGHI) was calculated by the formula proposed by Buffington et al.[22]. The following mean maximum and minimum temperatures, air relative humidity and BGHI values were recorded during the experimental period: 26.94 ± 2.63 °C, 25.65 ± 2.50 °C, 88.51 ± 3.91% and 76.92%,

respectively.

Water and feed were available *ad libitum* from one to 42 days of age. The diets (Table 2) were maize- and soybean meal-based and formulated according to the nutritional requirements recommended by Rostagno et al.[18], containing equal levels of protein, energy and amino acids. The chemical composition values of the biscuit waste obtained in the metabolizability trial were used for its inclusion in the formulated diets.

Table 2. Centesimal and calculated composition of the experimental diets

Ingredient (%)	Biscuit waste inclusion level (%)				
	0	5	10	15	20
Maize	57.213	52.734	48.255	43.777	39.298
Soybean meal (45%)	38.186	37.622	37.059	36.495	35.932
Wafer waste	0.000	5.000	10.000	15.000	20.000
Soybean oil	1.051	1.016	0.980	0.945	0.909
Dicalcium phosphate	1.387	1.409	1.430	1.451	1.472
Limestone	1.164	1.158	1.151	1.144	1.138
Common salt	0.395	0.398	0.400	0.403	0.405
L-lysine	0.140	0.170	0.199	0.228	0.258
DL-methionine	0.127	0.137	0.147	0.157	0.167
L-threonine	0.037	0.058	0.079	0.100	0.122
Vitamin supplement[1]	0.100	0.100	0.100	0.100	0.100
Mineral supplement[2]	0.050	0.050	0.050	0.050	0.050
Zinc bacitracin	0.050	0.050	0.050	0.050	0.050
Cygro (virginiamycin)	0.050	0.050	0.050	0.050	0.050
Antioxidant[3]	0.050	0.050	0.050	0.050	0.050
Total	100.00	100.00	100.00	100.00	100.00
Calculated composition					
Metabolizable energy (kcal/kg)	2,900	2,900	2,900	2,900	2,900
Crude protein (%)	22.00	22.00	22.00	22.00	22.00
Total calcium (%)	0.900	0.900	0.900	0.900	0.900
Available phosphorus (%)	0.375	0.375	0.375	0.375	0.375
Sodium (%)	0.176	0.176	0.176	0.176	0.176
Digestible methionine (%)	0.420	0.420	0.420	0.420	0.420
Digestible lysine (%)	1.200	1.200	1.200	1.200	1.200
Digestible threonine (%)	0.790	0.790	0.790	0.790	0.790

[1]Vitamin supplement/kg: vit. A 13,440.000 IU; vit. D 3,200.000 IU; vit. E 28,000 mg/kg; vit. K 2,880 mg/kg; thiamin 3,500 mg/kg; riboflavin 9,600 mg/kg; pyridoxine 5,000 mg/kg; cyanocobalamin 19,200 mcg/kg; folic acid 1,600 mg/kg; pantothenic acid 25,000 mg/kg; niacin 67,200 mg/kg; biotin 80,000 mcg/kg; selenium 600 ppm.
[2]Mineral supplement/kg: Mg 150,000 ppm; Zn 140,000 ppm; Fe 100,000 ppm; Cu 16,000 ppm; I 1,500 ppm.
[3]Butylated hydroxytoluene.

Birds, supplied feed and orts were weighed weekly for the calculation of the following performance indices: feed intake, weight gain and feed conversion. At 42 days of age, two birds (one male and one female) representing the average weight of the experimental

plot were selected per unit. After a six-hour feed-deprivation period, the birds were slaughtered, plucked and subsequently eviscerated for the cuts to be removed and carcass yield determined.

The following parameters were evaluated: absolute (grams) and relative (%) weights of carcass, prime cuts (breast and legs) and edible offal (heart, liver and gizzard). After the carcasses were weighed, the relative weight (%) was calculated in relation to the post-fasting live weight, using the following formula: Carcass yield (%) = (carcass weight/live weight × 100). The percentage yield of cuts and edible offal was determined as a function of the eviscerated carcass with feet, by the following formula: Cut or offal yield (%) = (cut or offal weight/carcass weight × 100).

Economic viability was determined as a function of changes in live weight, feed intake and diet costs, which depended on the waste inclusion levels, in accordance with the methodology described by Lana[4]. The sale price of the live quail and the prices of the raw materials used in the calculation of diet costs corresponded to those charged during the development of the experiment. Each one-day-old quail was purchased at BRL 1.40, and its sale (kilogram of slaughtered quail) was estimated at BRL 16.00. The ingredients used in the diet formulation were purchased at the following prices (per kg): maize - BRL 1.25; soybean meal - BRL 1.45; wafer waste - BRL 0.30; soybean oil - BRL 3.95; dicalcium phosphate - BRL 6.00; limestone - BRL 0.27; common salt - BRL 0.85; lysine - BRL 9.00; methionine - BRL 25.00; threonine - BRL 11.00; vitamin supplement - BRL 20.00; mineral supplement - BRL 10.00; zinc bacitracin - BRL 15.00; Cygro - BRL 46.00; BHT - BRL 37.00.

Statistical analyses of the variables were performed using R Core Team software[21]. Results were subjected to analysis of variance at the 5% probability levels and means showing significant differences ($P<0.05$) were subjected to regression analysis.

Results and discussion

Experiment I

Table 3 shows the chemical and energy composition values and the metabolizability coefficients of WW.

The DM content of the waste was 87.45%, which is close to the 92.24% found by Volpato et al.[7], who evaluated sweet-biscuit waste; the 92.40% determined in biscuit waste by Tardocchi et al.[23]; and the 91.07% found in biscuit waste meal by Corassa et al.[11].

The WW had a gross energy content of 4,128.53 kcal/kg. This value is higher than the minimum and maximum GE contents of 3,200 and 4,485 kcal/kg reported by Corassa et al.[11], respectively. By contrast, Volpato et al.[7] described a GE content of 4,494 kcal/kg in sweet-biscuit waste.

The AME and AMEn values found in the current study were similar to the 3,959 and 3,480 kcal/kg, respectively, found by Oliveira et al.[24], in cracker and biscuit waste in a metabolism trial with 16-day-old broiler chickens, using the waste at a replacement level of 30% in control diet.

Table 3. Chemical and energy composition and metabolizability coefficient of nutrients in wafer waste

Component	Determined value
Dry matter (%)	87.45
Gross energy (kcal/kg)	4,128.53
Apparent metabolizable energy (kcal/kg)	3,833.14
Nitrogen-corrected apparent metabolizable energy (kcal/kg)	3,818.92
Crude protein (%)	9.37
Ether extract (%)	17.00
Mineral matter (%)	1.12
Organic matter (%)	86.33
Metabolizability coefficient	
Dry matter (%)	93.20
Gross energy (%)	92.85
Ether extract (%)	93.01
Crude protein (%)	47.16

Source: Author, 2018.

Rostagno et al.[14] reported similar AME values (4,010 kcal/kg) for cracker and biscuit waste in a metabolism trial with broiler chickens from 16 to 24 days of age. However, an experiment led by Nunes et al.[13] involving 40% biscuit waste replacing control diet for broiler chickens revealed higher AME and AMEn values: 4,480 and 4,339 kcal/kg, respectively.

The CP contents found in WW was 9.37%, which is considerably lower than the 19.25% found by Shittu et al.[16] in biscuit waste. However, the current result is close to the 9.07 and 8.38% CP obtained by Corassa et al.[11] and Nunes et al.[13], respectively, in biscuit waste.

The EE content of 17% found in the waste is higher than the values around 12% described by Tardocchi et al.[23] in biscuit waste and by Volpato et al.[7] in sweet biscuit.

There is a great variability in the chemical composition of biscuit meal in the literature, which is due to the fact that the product is formed by waste that is often inconstant, thus altering the material composition. Additionally, few studies describe the type of biscuit used.

The organic and mineral matter contents of WW were 86.33 and 1.12%, respectively, which are similar values to those found by Corassa et al.[11] in biscuit waste.

The metabolizability coefficients of DM, GE, CP and EE found in the waste were 93.20, 92.85, 47.16 and 93.01%, respectively.

Table 4 shows the AME and AMEn values and the metabolizability coefficients of control diet and the test diet containing 20% WW.

There was no significant effect (P>0.05) for AME, AMEn or the metabolizability coefficients of DM, GE, EE and CP. These results demonstrate the similarity between the treatments with 0% and 20% inclusion of the waste.

Table 4. Metabolizability coefficients of control diet and diet with 20% inclusion of wafer waste

Variable	wafer waste inclusion level[NS]		P-value	CV (%)
	0%	20%		
AME	2,812.83	2,805.16	0.94	6.09
AMEn	2,754.23	2,795.89	0.70	5.93
DMMC	54.32	56.10	0.34	5.01
GEMC	63.78	63.61	0.94	6.09
EEMC	59.71	54.21	0.27	12.81
CPMC	53.36	51.13	0.30	6.05

[NS] – not significant; CV (%) – coefficient of variation.

The mean AME values were 2,812.83 and 2,805.16 kcal/kg and the mean AMEn values were 2,754.23 and 2,795.89 kcal/kg for the WW inclusion levels of 0% and 20%, respectively. According to Nunes et al.[13], differences in metabolizable energy values can be used to evaluate feedstuffs with high energy contents when the AME value is above 2,500 kcal/kg, which was found in the present experiment.

The DM metabolizability coefficients found in the biscuit waste were 54.32 and 56.10% for the respective dietary inclusion levels of 0 and 20%.

High GE metabolizability coefficients were found in the waste: 63.78 and 63.61% for the inclusion levels of 0 and 20%, respectively. The mean EE metabolizability coefficients were 59.71 and 54.21% for the same inclusion levels. Considering the obtained results for the metabolizability coefficients of these two components, it can be stated that the meat quail efficiently utilized the energy present in this waste. Wafer waste can thus be considered a high-energy feedstuff, given the EE contents present in the ingredients used in its manufacture besides the high metabolizability values found.

Experiment II

Crude protein metabolizability coefficients of 53.36 and 51.13% were detected in the biscuit waste at the dietary inclusion levels of 0 and 20%, respectively.

It is important to consider that there is a great divergence in the literature regarding the nutritional value of this feedstuff, which may change depending on the technological process to which it was subjected[25,26]; the existing variations between the soils and climates where the wheat grain was cultivated; the species that will utilize it; environmental conditions; nutrient quantity and quality; and proportion relative to other nutrients, which may lead to alterations in its composition and digestibility, as well as other factors[27-29].

Results pertaining to the performance of meat quail fed diets with different WW inclusion levels are given in Table 5.

From one to 2 days of age, the WW inclusion levels had no effect (P>0.05) on feed intake, weight gain or feed conversion.

Table 5. Feed intake (FI), weight gain (WG) and feed conversion (FC) of meat quail fed diets with different wafer waste inclusion levels

Variable	Wafer waste inclusion level (%)					SEM
	0	**5**	**10**	**15**	**20**	**SEM**
	01 to 21 days of age					
FI	303.52	295.71	286.64	301.70	281.80	2.67
WG	145.32	144.27	139.91	146.42	140.03	1.30
FC	2.09	2.05	2.05	2.06	2.01	0.01
	22 to 42 days of age					
FI[L]	658.81	623.86	613.04	624.03	596.26	6.86
WG	124.35	115.07	117.69	119.09	113.32	1.96
FC	5.31	5.46	5.23	5.27	5.28	0.08
	01 to 42 days of age					
FI[L]	962.33	919.57	899.68	925.74	878.06	9.13
WG	269.67	259.34	257.60	265.51	253.34	2.59
FC	3.57	3.55	3.50	3.49	3.47	0.02

[L] - linear effect ($p<0.05$); SEM - standard error of the mean.

However, in the periods of 22 to 42 and one to 42 days of age, feed intake decreased linearly ($P<0.05$) by 0.8324 and 0.5414 g, respectively, with every percentage unit of the waste added to the diet, as shown by the following equations: $\hat{Y} = 216.06 - 0.8324x$ ($R^2=0.74$) and $\hat{Y} = 158.26 - 0.5414x$ ($R^2=0.67$). This decrease in feed intake may be related to a possible behavioral response, as the birds selected the larger particles. These findings corroborate those described by Adeyemo et al.[30], who worked with biscuit waste in the feeding of chickens and noted that feed intake decreased as the inclusion levels were increased, although feed conversion was not compromised. It should be stressed, however, that despite the drop in feed intake, weight gain and feed conversion were not influenced by the waste inclusion levels.

Results for the yields of carcass, cuts and edible offal of quail at 42 days of age are described in Table 6.

The absolute and relative weights of carcass, breast, heart, liver and gizzard were not influenced ($P>0.05$) by the WW inclusion levels. The different WW inclusion levels did not compromise the yields of carcass or edible offal from the quail. Similarly, Shahryar et al.[31] observed an increase in the blood glucose levels of broiler chickens fed diets with 24% WW but no negative impacts on carcass yield, which was attributed to the fact that the wafer biscuit efficiently contributed to the gluconeogenesis process. On the other hand, studies conducted by Ayanrinde et al.[32] described a reduction in gizzard size in broiler chickens fed increasing levels of bakery waste due to the reduced mechanical work of that organ.

Slaughter weight and the absolute weight of legs responded quadratically ($P<0.05$) to the WW inclusion levels, as can be seen by the following equations: $\hat{Y} = 269.61 - 3.2657x + 0.1543x^2$ ($R^2=0.72$) and $\hat{Y} = 43.187 - 0.5606x + 0.0362x^2$ ($R^2= 0.94$), respectively. The relative weight of the birds at 42 days of age rose linearly, by 0.0752%, at every 1% inclusion of the waste in the diet, according to the following equation:

$\hat{Y} = 22.132 + 0.0752x$ ($R^2 = 0.73$).

Table 6. Yields of carcass, cuts and edible offal of quail at 42 days of age

Variable	Wafer waste inclusion level (%)					
	0.0	5.0	10.0	15.0	20.0	SEM
Absolute weight (g)						
Slaughter weight[Q]	268.00	262.50	246.00	258.50	265.50	2.16
Carcass	194.51	184.22	179.21	188.03	194.29	2.02
Breast	80.34	77.93	77.66	80.58	82.39	0.93
Legs[Q]	42.87	42.10	40.66	42.82	46.58	0.50
Heart	2.15	2.14	2.06	2.13	2.15	0.03
Liver	5.29	5.13	5.10	5.25	5.47	0.15
Gizzard	4.50	4.51	4.33	4.97	4.37	0.10
Relative weight (%)						
Carcass	72.55	70.19	72.84	72.74	73.20	0.52
Breast	41.29	42.30	43.30	42.89	42.40	0.28
Legs[L]	22.06	22.88	22.71	22.78	23.99	0.20
Heart	1.09	1.20	1.15	1.11	1.11	0.01
Liver	2.73	2.78	2.86	2.79	2.84	0.09
Gizzard	2.32	2.45	2.43	2.66	2.26	0.07

[L] - linear effect. [Q] - quadratic effect ($P < 0.05$); SEM - standard error of the mean.

This effect on slaughter weight may be related to the choice of the birds to be used in the experiment, which was based on the average weight of the plot.

Results for economic viability are presented in Table 7. Economic viability was inherent to the production and feeding components, considering that variations in production costs were dependent on differences in feed intake between the different levels to which the birds were subjected.

Table 7. Economic viability of wafer waste inclusion levels

Inclusion level (%)	ALW (kg/quail)	AFI (kg/quail)	FC (BRL/kg)	AGR (BRL/quail)	AFC (BRL/quail)	AGM (BRL/quail)	RGM (%)	AR (%)	RRR (%)
				Economic variable[1]					
0	0.268	0.962	1.52	4.29	1.46	1.43	100.00	97.51	100.00
5	0.263	0.920	1.48	4.21	1.36	1.45	101.45	106.23	108.95
10	0.246	0.900	1.44	3.94	1.30	1.24	86.97	95.68	98.13
15	0.259	0.926	1.40	4.14	1.30	1.45	101.53	111.66	114.52
20	0.266	0.878	1.36	4.26	1.19	1.66	116.56	139.18	142.74

[1]ALW - average live weight; AFI - average feed intake; FC - feed cost; AGR - average gross revenue; AFC - average feeding cost; AGM - average gross margin; RGM - relative gross margin; ARR - average return; RRR - relative rate of return.

The treatment with 20% inclusion of WW resulted in lower average live weight and feed intake values than those obtained without waste inclusion, demonstrating the existence of some proportionality between the acquired weight and the consumed

feed. The lowest feed cost was obtained with the diet with the WW inclusion level of 20%, with a BRL 0.04 reduction per kilogram of diet expected at each of the tested levels. Consequently, the lowest average feeding cost was also obtained with the diet with 20% inclusion of WW.

Average gross revenue was highest for the treatment with 0% inclusion of the waste. However, considering the average gross margin, it is clear that the lowest feed cost obtained using the treatment with the 20% inclusion level would provide the highest financial return after the initial costs are discounted, representing a relative gross margin of 16.56%.

The diet with 20% inclusion of WW showed to be the most profitable, providing a 42.74% higher financial return than control diet. Biscuit waste is characterized as a low-cost ingredient that allows a reduction in the use of corn and soybean oil, which are commonly included in poultry diets. Our findings corroborate the results published by Omoikhoje et al.[10], who concluded that greater economic return in chicken farming is achieved when using diets containing 50% biscuit waste, as compared with lower inclusion levels.

Conclusions

Wafer-type biscuit waste can be included up to the level of 20% in diets for meat quail without compromising production performance, carcass yield or the economic viability of the system.

Acknowledgments

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