agriculture

Article

Rearing Performance and Carcass Composition of Broiler Chickens Fed Rations Containing Guar Meal at Graded Levels

Anna Milczarek *, Magdalena Pachnik, Maria Osek and Renata Świnarska

Faculty of Agrobioengineering and Animal Husbandry, Institute of Animal Science and Fisheries, Siedlce University of Natural Sciences and Humanities, Bolesława Prusa 14, 08-110 Siedlce, Poland
* Correspondence: anna.milczarek@uph.edu.pl; Tel.: +48-256-431-377

Abstract: This study aimed to evaluate how different percentages of guar meal in feed rations for broiler chickens affect their rearing performance and carcass composition. The experiment was conducted in a group of one hundred sixty Ross 308 broilers randomly allocated to four equinumerous groups (K, G4, G8 and G12). The birds were reared over 42 days with the application of three feeding periods: starter (days 1–21), grower (days 22–35) and finisher (days 36–42). All the feed rations were prepared using maize meal, soybean meal, oil and mineral and vitamin additives. An experimental factor was the share of guar meal in feed rations: group K—0%, G4—4%, G8—8% and G12—12%. It was demonstrated that a higher percentage (8% or 12%) of guar meal in the feed rations had a negative effect on the chickens' weight gain and feed intake. The birds receiving feed rations supplemented with guar meal featured higher feed conversion levels than those fed rations in which soybean meal was the only protein-rich component ($p \leq 0.05$). Birds fed rations with the highest percentage (12%) of guar meal showed a significant decrease in chilled carcass weight and dressing percentage compared with other chickens. A higher percentage (8% or 12%) of guar meal in feed rations had an adverse effect on the birds' muscularity. In addition, it was demonstrated that their meat was DFD (dark, firm and dry; $pH_1 > 6.4$), but from a dietary point of view, it contained the smallest amount of intramuscular fat. To sum up, 4% of guar meal should be recommended in broiler chicken feeding to ensure their satisfactory rearing performance and carcass composition, including the physico-chemical properties of their muscles.

Keywords: guar meal; broiler chickens; performance results; carcass composition; physico-chemical properties of meat

check for updates

Citation: Milczarek, A.; Pachnik, M.; Osek, M.; Świnarska, R. Rearing Performance and Carcass Composition of Broiler Chickens Fed Rations Containing Guar Meal at Graded Levels. *Agriculture* **2022**, *12*, 1385. https://doi.org/10.3390/agriculture12091385

Academic Editor: Lin Zhang

Received: 1 August 2022
Accepted: 30 August 2022
Published: 3 September 2022

1. Introduction

Intensive poultry production, utilising the genetic potential of broiler chickens to the maximum, combined with state-of-the-art feeding technologies, requires that large amounts of protein-rich components of feed rations are available on the market. The main source of protein in poultry feed, and the best one in terms of digestibility and amino acid composition, is genetically modified soybean meal. However, the growing requirement for this raw material makes researchers look for alternative protein-rich plant components that are not genetically modified [1–5].

Guar meal—a by-product of extracting guar gum from guar beans—seems to be an interesting choice [3,6,7]. Guar (*Cyamopsis tetragonoloba)* is a genetically non-modified (non-GMO) annual legume. Due to the high content of a valuable polysaccharide—β-galactomannan, commonly known as guar gum—it is grown on a commercial scale [8,9]. Guar gum extracted from *Cyamopsis tetragonoloba* is used, for instance, as a thickener and stabiliser in ice cream, yoghurt and sauces. It also has other applications, including in oil, pharmaceutical, paper-making and cosmetic industries and in the mining sector [8,10–12].

About 95% of the global production of guar is derived from India, mainly from the Rajasthan province, and from Pakistan [13–16]. The annual global production of guar seeds ranges from 1.0 to 1.6 million tonnes and depends, among other factors, on the weather in India [17,18]. Nidhina and Muthukumar [12] and Bhatt et al. [19] reported that *Cyamopsis tetragonoloba* beans consist of three fractions: the endosperm (35–42%), the seed (43–47%) and the shell (14–17%). Depending on the predominant fraction in guar meal, protein content ranges from 35% to 60%. On average, the seed fraction contains about 60% protein, while the shell contains 35% [20–22]. Guar meal makes an excellent source of essential amino acids, mainly: arginine, lysine, tryptophan, isoleucine, valine and phenylalanine [18,23,24]. In view of a higher content of crude protein, methionine and phosphorus in relation to soybean meal, adding guar meal to poultry feed may be an efficient strategy for cutting down on the feeding cost with no adverse effect on production [25]. However, the use of a high percentage of this source of plant protein in poultry feed is limited due to the observed undesirable effects, including diarrhoea, reduced growth rate, deteriorated productivity and increased mortality rate [26–28]. The usage of guar meal in broiler diets limits the level of anti-nutrients such as guar gum (β-mannan), saponins and trypsin inhibitors. β-mannan is considered a major anti-nutritional factor in guar meal. One of the methods to ameliorate the negative effects of β-mannan in guar meal is to supplement the diet with the β-mannanase enzyme [3,12,23,27].

Many researchers have attempted to determine the optimum content of guar meal in feed rations that will not adversely affect the production performance, the features of the carcass or the economic performance of broiler chickens. Reference literature implies that 2.5% and 5% of guar meal in broiler chicken feed had no adverse effect on the results of the supravital assessment. In contrast, higher doses (7.5%, 10%, 12% and 18%) had a negative effect on the birds' growth rate and health [26,29–31]. Mishra et al. [32], having partially replaced soybean meal with guar meal in broiler feed, found that a gradual increase in the share of guar meal (2% at the first and 5% at the second and third rearing phase) had no adverse effect on the birds' weight gain, feed conversion rate and carcass quality. Gheisarai et al. [33] and Rao et al. [31], having replaced soybean meal with 3 to 18% of guar meal, at three phases of the chickens' rearing, noted an improvement in productivity ratios and carcass parameters for the lowest (3–9%) percentage and deterioration of those parameters for levels from 12% to 18%. In addition, reference literature provides no information on the impact of guar meal in broiler chickens' diet on their carcass composition, including on the physico-chemical properties of meat.

Therefore, an experiment was undertaken to evaluate how different percentages of guar meal in feed rations for broiler chickens affect their rearing performance and carcass composition.

2. Materials and Methods

2.1. Chemical Analysis of Guar Meal

The guar meal was purchased on the feed market as a coarse meal (Guar 60PF). The content of dry mass, crude protein, crude fat, crude fibre and crude ash in guar meal was determined according to the methodology of AOAC International [34]. The number of nitrogen-free extracts (NFE) was calculated from the formula:

$$\text{NFE} = \text{dry matter} - (\text{crude protein} + \text{total ash} + \text{crude fat} + \text{crude fibre})$$

The content of amino acids (except tryptophan) was determined through UPLC-UV ultraperformance liquid chromatography with spectrophotometric detection (PB 59 KLP, 2014). Tryptophan was, by contrast, determined by HPLC-FLD high-performance liquid chromatography with fluorescence detection [35]. Fatty acids were separated using the Folch method [36]. The fatty acid profile of the lipid fraction was determined by gas chromatography of methyl esters in a Varian 450-GC gas chromatograph with a flame ionisation detector (air–hydrogen). A Select ™ Biodiesel for FAME capillary column (30 m, 0.32 mm, 0.45 μm) with a Select Biodiesel for FAME Fused Silica filling was used. The injector temperature was 250 °C, detector temperature was 300 °C and column temperatures were 100 °C (initial) and 235 °C (final). Helium was used as a carrier gas, with a flow of

1.5 mL per minute. Fibre fractions were analysed using Van Soest and Wine's detergent method [37] with alpha-amylase in an Ancom Fiber Analyser. The gross energy value of guar meal was determined using an Oxygen Bomb Calorimeter [38].

In addition, the content of tannins was assayed in guar meal [39] by extracting tannins using a mixture of ethyl alcohol, glycerine and water, creating a coloured complex with phosphomolybdenum–phosphowolfram reagent and measuring the absorption of the coloured solution at 700 nm wavelength. Furthermore, anti-trypsin activity was determined in guar meal using a method designed by Smith et al. [40], that is, a spectrophotometric assay of absorption of the products of casein breakdown by trypsin in the presence of an inhibitor.

2.2. Experiment Design, Birds and Diets

The experiment involved one hundred sixty Ross 308 chickens assigned to four equinumerous groups (K, G4, G8 and G12). One-day-old, sexed chicks were weighed and randomly put into 20 metal cages—eight birds per cage (4 males and 4 females)—which resulted in five replications in each feeding group. All the cages were placed in one room, in an identical environment, and the chicks had unlimited access to feed and water. Throughout the rearing period, 24 h electric lighting was used. In the first week of the experiment, the ambient temperature was 32 °C. Afterwards, it was reduced every seven days by 1–2 °C until it reached about 2 °C in the final week of rearing. The 42-day chicken period was divided into three feeding phases: starter (days 1–21), grower (days 22–35) and finisher (days 36–42). The feed rations were all in mash form. The all-mash feed formulas were designed according to recommendations for broiler chickens [41], making them isoenergetic and isoprotein diets. The nutritional value of feed was calculated based on the chemical composition of the feed components and metabolizable energy, using equations [42]. The rations were prepared by own means from maize meal, soybean meal, oil and mineral and vitamin additives. An experimental factor was the share of guar meal in all-mash feed: control group (K)—0%, G4—4%, G8—8% and G12—12% (Tables 1–3).

Table 1. Composition and nutritive value of starter rations containing graded levels of guar meal.

Item	Groups			
	K (Control)	**G4**	**G8**	**G12**
Raw materials (%) and feed additives (%)				
Maize meal	50.02	50.62	51.40	52.20
Soybean meal	42.00	37.50	33.00	28.50
Guar meal	-	4.00	8.00	12.00
Rapeseed oil	4.70	4.60	4.30	4.00
DL-methionine 99%	0.22	0.21	0.21	0.20
Limestone	0.64	0.65	0.71	0.72
2-Ca phosphate	1.80	1.80	1.75	1.75
NaCl	0.12	0.12	0.13	0.13
Premix *	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00
Calculated nutrients per 1 kg of rations:				
ME (MJ)	12.84	12.88	12.87	12.87
Crude protein (g)	225.1	225.4	225.9	226.3
Crude fibre (g)	26.2	27.85	29.53	31.22
Lysine (g)	13.05	13.20	13.36	13.51
Methionine (g)	5.82	5.80	5.89	5.88
Methionine + cysteine (g)	9.80	9.68	9.66	9.54
Threonine (g)	9.29	9.05	8.83	8.60
Tryptophan (g)	2.95	2.96	2.97	2.97

Table 1. *Cont.*

Item	Groups			
	K (Control)	**G4**	**G8**	**G12**
Ca (g)	9.71	9.70	9.72	9.72
P (g)	11.38	11.42	11.24	11.28
P available (g)	4.45	4.45	4.43	4.42
Na (g)	1.69	1.68	1.69	1.68

* One kilogram of starter premix contained: vitamin A—2,400,000 IU; D_3—900,000 IU; E—9000 IU; K—700 mg; B_1—500 mg; B_2—1200 mg; B_6—800 mg; B_{12}—6000 µg; PP—8000 mg; pantotenian calcium—2600 mg; B_9—300 mg; H—50,000 µg; B_4—70,000 mg; microelements: Cu—3500 mg; Fe—15,000 mg; J—350 mg; Mn—20,000 mg; Zn—20,000 mg; Se—55 mg; antioxidant.

Table 2. Composition and nutritive value of grower rations containing graded levels of guar meal.

Item	Groups			
	K (Control)	**G4**	**G8**	**G12**
Raw materials (%) and feed additives (%)				
Maize meal	55.77	56.58	57.58	58.67
Soybean meal	36.00	31.50	26.80	22.10
Guar meal	-	4.00	8.00	12.00
Rapeseed oil	5.00	4.70	4.40	4.00
Lysine 98.5%	0.03	0.01	-	-
DL-methionine 99%	0.20	0.20	0.19	0.18
Limestone	0.74	0.76	0.78	0.79
2-Ca phosphate	1.61	1.60	1.60	1.60
NaCl	0.15	0.15	0.15	0.16
Premix *	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00
Calculated nutrients per 1 kg of rations:				
ME (MJ)	13.14	13.15	13.15	13.14
Crude protein (g)	203.5	204.0	203.7	203.5
Crude fibre (g)	25.43	27.12	28.78	30.47
Lysine (g)	11.76	11.76	11.77	11.88
Methionine (g)	5.34	5.33	5.36	5.34
Methionine + cysteine (g)	9.02	8.90	8.82	8.68
Threonine (g)	8.37	8.15	7.89	7.64
Tryptophan (g)	2.62	2.63	2.62	2.63
Ca (g)	9.31	9.31	9.32	9.32
P (g)	10.40	10.38	10.42	10.45
P available (g)	4.08	4.05	4.04	4.02
Na (g)	1.70	1.70	1.69	1.70

* One kiloggram of grower premix contained: vitamin A—2,000,000 IU; D3—800,000 IU; E—7000 IU; K—600 mg; B1—360 mg; B2—1000 mg; B6—700 mg; B12—2600 µg; PP—6000 mg; pantotenian calcium—2600 mg; B9—200 mg; H—40,000 µg; B4—70,000 mg; microelements: Cu—3000 mg; Fe—12,000 mg; J—300 mg; Mn—18,000 mg; Zn—20,000 mg; Se—90 mg; antioxidant.

Table 3. Composition and nutritive value of finisher rations containing graded levels of guar meal.

Item	Groups			
	K (Control)	**G4**	**G8**	**G12**
Raw materials (%) and feed additives (%)				
Maize meal	57.46	58.35	59.14	60.24
Soybean meal	33.80	29.20	24.70	20.00
Guar meal	-	4.00	8.00	12.00
Rapeseed oil	5.70	5.40	5.10	4.70
DL-methionine 99%	0.12	0.11	0.10	0.09
Limestone	0.74	0.76	0.77	0.77
2-Ca phosphate	1.52	1.52	1.52	1.53
NaCl	0.16	0.16	0.17	0.17
Premix *	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00
Calculated nutrients per 1 kg of rations:				
ME (MJ)	13.41	13.41	13.41	13.40
Crude protein (g)	195.2	195.3	195.8	195.6
Crude fibre (g)	22.05	26.72	28.41	30.10
Lysine (g)	10.93	11.06	11.22	11.33
Methionine (g)	4.44	4.43	4.41	4.40
Methionine + cysteine (g)	7.99	7.87	7.75	7.62
Threonine (g)	8.02	7.78	7.56	7.30
Tryptophan (g)	2.50	2.50	2.51	2.50
Ca (g)	7.99	7.67	7.35	7.02
P (g)	8.02	8.17	8.33	8.47
P available (g)	2.50	2.58	2.67	2.74
Na (g)	8.94	8.97	8.96	8.93

* One kilogram of finisher premix contained: vitamin A—2,000,000 IU; D_3—800,000 IU; E—7000 IU; K—600 mg; B_1—360 mg; B_2—1000 mg; B_6—700 mg; B_{12}—2600 µg; PP—6000 mg; pantotenian calcium—2400 mg; B_9—200 mg; H—40,000 µg; B_4—70,000 mg; microelements: Cu—3000 mg; Fe—12,000 mg; J—300 mg; Mn—18,000 mg; Zn—20,000 mg; Se—50 mg; antioxidant.

During the experiment, the chickens were weighed on rearing days 1, 21, 35 and 42, and the amount of feed intake was measured. The collected data were used for calculating the feed conversion rate (FCR).

2.3. Assessment of Carcass Quality

On the 42nd day of the birds' life, eight birds (4 males and 4 females)—with a body weight representative of a specific group and sex—were selected from each group and slaughtered. Fifteen minutes after the slaughter, the reaction (pH_1) was measured in their breast muscles (*m. pectoralis major*) and thigh muscles (*m. iliotibialis*). Next, the carcasses were chilled over 24 h at a temperature of 4 °C, after which, the reaction (pH_{24}) of the muscles was measured again. In order to calculate the dressing percentage, the chilled carcass weight was determined, and simplified dissection analysis was carried out following a procedure described by Ziołecki and Doruchowski [43]. During dissection, breast and leg muscle samples were taken to evaluate their physico-chemical characteristics.

The proximate composition and fatty acid profile in the breast and thigh muscle was determined in line with the adopted guar meal evaluation methods.

Water losses, expressed as water-holding capacity (WHC), were established using Grau and Hamm's method [44], as modified by Pohja and Ninivaara [45], based on the percentage of water loss from a meat sample placed on blotting paper (Whatman No. 4) and pressed continually (with a 2 kg weight) in between two glass plates. Following a planimetric assessment of the surface area of infiltration (in cm^2), the forced drip loss was determined on the assumption that 1 cm^2 of the infiltration surface corresponds to 10 mg of muscle drip absorbed by the blotting paper. The measurement was carried out twice, and the mean value was calculated.

The instrumental evaluation of breast muscle colour was performed by means of the photocolorimeter in the system CIE L*a*b*, where L* represented lightness as a spatial vector, whereas a* and b* were trichromatic coordinates (positive values of a* corresponded to the red colour, negative to green colour, positive b* values were for yellow, and negative b* for blue) [46]. The chroma index (C*) and the colour hue (H) were calculated based on colour parameters a* and b* according to the following formulas [47]:

$$C^* = [(a^*)^2 + (b^*)^2]^{0.5};\ H = \log(b^*/a^*)$$

2.4. Statistical Analysis

The results were statistically analysed with Statistica software ver. 13.3 [48]. The elements of the calculation were measures of location (arithmetic mean) and absolute measures (SEM), and one-way analysis of variance (ANOVA) was applied. The significance of differences between the mean values was evaluated using the post hoc Duncan's Multiple Range test.

3. Results

3.1. Chemical Composition of Guar Meal

The nutritional value of guar meal used in the growing experiment involving broiler chickens is presented in Table 4.

Table 4. Chemical composition of guar meal.

Item	Contents
Basal nutrients ($g \cdot kg^{-1}$)	
Dry matter	904.3
Crude ash	48.9
Crude protein	483.9
Crude fat	38.3
Crude fibre	77.8
N-free extracts	255.4
Amino acids ($g \cdot kg^{-1}$)	
Lysine	20.9
Methionine	5.93
Cysteine	4.52
Tryptophan	7.00
Asparagine	48.1
Threonine	13.9
Serine	21.7
Glutamine	97.9
Proline	17.1
Glycine	24.3
Alanine	18.9
Valine	18.8
Isoleucine	15.0
Leucine	27.1
Tyrosine	16.1
Phenylalanine	18.9
Histidine	13.2
Arginine	62.7
Fatty acids profile (% of total fatty acids)	
C14:0	0.15
C15:0	0.11
C16:0	15.26

Table 4. *Cont.*

Item	Contents
C16:1	0.19
C17:0	0.13
C17:1	0.08
C18:0	6.60
C18:1	26.09
C18:2 n-6	43.16
C18:3 n-3	3.32
C20:0	1.30
C20:1	0.39
C22:0	0.94
C22:1	0.10
C23:0	0.30
C24:0	1.76
Others	0.12
SFA—saturated fatty acids	26.55
UFA—unsaturated fatty acids	73.33
MUFA—monosaturated fatty acids	26.85
PUFA—polysaturated fatty acids	46.48
Fibre fraction (%)	
Neutral detergent fibre—NDF	26.56
Acid detergent fibre—ADF	8.50
Lignine—ADL	0.90
Cellulose—CEL	7.60
Hemicellulose—HCEL	18.06
Gross energy (kcal·kg^{-1})	4460
Anti-nutritional factors (g·kg^{-1})	
Trypsin inhibitors	1.2
Tannins	11.8

The analysed guar meal contained 48.39% crude protein consisting of lysine, arginine, leucine, phenylalanine, valine and tyrosine and 7.78% crude fibre. The determined content of anti-nutrients, such as tannins and trypsin inhibitors, was 1.18% and 0.12%, respectively.

3.2. Performance and Carcass Composition of Broiler Chickens

All-mash feed containing graded levels of guar meal significantly varied the body weight of broiler chickens as early as day 21 of rearing (Table 5).

Along with increasing the share of guar meal in the diet to 4%, 8% and 12%, the birds' body weight decreased linearly by 26 g, 53 g and 145 g, respectively, compared with the group of birds receiving feed rations with soybean meal as the only protein-rich component (group K). After the grower phase, chickens from the K and G4 groups had a similar body weight and were significantly ($p \leq 0.05$) heavier than chickens from the other two groups (G8 and G12). Moreover, on the last day of the experiment, chickens from the K and G4 groups had a similar body weight that was approx. 8% and 20% higher compared with birds from the G8 and G12 groups ($p \leq 0.05$). Chicken body weight was largely determined by feed intake since chicks that weighed significantly more at respective phases also consumed more feed. Over 42 rearing days, birds from the K and G4 groups consumed more ($p \leq 0.05$) feed than chicks fed rations containing a higher percentage (8% and 12%) of guar meal. The increasing share (4%, 8% and 12%) of guar meal in starter and grower diets linearly increased the feed conversion ratio compared with the K group ($p \leq 0.05$). At the last rearing phase (finisher), the mean feed conversion was from 1.97 kg in G8 to 2.33 kg in G4. Compared with chicks from the K group, featuring the lowest (1.63 kg) feed conversion per weight gain unit throughout the rearing period, birds fed diets with lower levels (4% or 8%) of guar meal consumed 0.08 kg more but much less (0.30 kg) than chicks in G12 ($p \leq 0.05$).

Table 5. The rearing performance of broiler chickens fed graded levels of guar meal.

Item	Group				SEM	*p*-Value
	K	G4	G8	G12		
			Body weight (g)			
1 day	47	47	47	47	0.074	0.125
21 days	695 ^{a}	669 ^{b}	642 ^{c}	550 ^{d}	12.772	0.001
35 days	1884 ^{a}	1834 ^{a}	1652 ^{b}	1388 ^{c}	45.006	0.001
42 days	2397 ^{a}	2324 ^{ab}	2210 ^{c}	1920 ^{d}	41.927	0.001
			Feed intake (g)			
1–21 days	41	43	42	39	0.733	0.267
22–35 days	133 ^{a}	133 ^{a}	122 ^{b}	123 ^{b}	0.583	0.032
36–42 days	160	163	157	154	1.119	0.846
1–42 days	91.5 ^{a}	93.0 ^{a}	87.8 ^{b}	85.9 ^{b}	0.831	0.011
			Feed conversion ratio ($kg \cdot kg^{-1}$)			
1–21 days	1.33 ^{b}	1.45 ^{c}	1.48 ^{c}	1.63 ^{a}	0.058	0.009
22–35 days	1.57 ^{c}	1.60 ^{c}	1.69 ^{b}	2.05 ^{a}	0.049	0.001
36–42 days	2.18 ^{ab}	2.33 ^{a}	1.97 ^{c}	2.03 ^{bc}	0.045	0.003
1–42 days	1.63 ^{c}	1.71 ^{b}	1.71 ^{b}	1.93 ^{a}	0.029	0.001

K—0%, G4—4%, G8—8% and G12—12% guar meal in rations for broiler chickens. SEM—standard error of mean. abc—means with different superscripts within a row are significantly different at $p \leq 0.05$.

The body weight of chicks selected for slaughter varied ($p \leq 0.05$) between K and G4 and G8 and G12, which was associated with a mean body weight of birds from respective groups on day 42 of rearing (Table 6).

The pre-slaughter body weight of chickens had an influence on chilled carcass weight. Carcass weight higher by about 12% and 23% was noted in the K and G4 groups compared with the G8 group ($p \leq 0.05$). By contrast, chilled carcass weight and dressing percentage were lower ($p \leq 0.05$) compared with other groups in the case of birds fed rations containing 12% of guar meal. Analysis of carcass muscularity showed that the carcasses of chicks fed rations containing a higher percentage (8% or 12%) of guar meal had a lower total share of muscles compared with birds from the G4 group ($p \leq 0.05$). The highest percentage (28.83%) of breast muscles was found in the carcasses of chicks from the G4 group, lower (by one percentage point) in birds from the K group, and the lowest ($p \leq 0.05$) was in those fed rations containing 8% or 12% of guar meal. On the contrary, the share of thigh muscles in the carcasses of birds from the G4 group was the lowest and differed significantly from that in chicks from other groups ($p \leq 0.05$). No differences between the groups were found in the percentage of skin with subcutaneous fat and abdominal fat. Guar meal replacing soybean meal in feed rations increased the share of giblets as the percentage of guar meal in the feed increased ($p \leq 0.05$). Chicks from the G12 group featured the highest share of gizzard, whereas birds from the control group had the lowest ($p \leq 0.05$). Despite no differences found ($p > 0.05$) in the share of heart and liver, the results imply that their share was slightly higher in chickens fed rations with higher levels (8% or 12%) of guar meal.

Table 6. Carcass composition of broiler chickens fed graded levels of guar meal.

Item	Group				SEM	*p*-Value
	K	G4	G8	G12		
Body weight before slaughter (g)	2413 ^{a}	2380 ^{a}	2166 ^{b}	1929 ^{c}	52.775	0.001
Chilled carcass weight (g)	1891 ^{a}	1868 ^{a}	1650 ^{b}	1447 ^{c}	44.634	0.001
Dressing percentage (%)	78.4 ^{a}	78.5 ^{a}	76.2 ^{a}	75.0 ^{b}	0.409	0.001
Share in chilled carcass (%)						
Muscles total	47.04 ^{ab}	47.86 a	45.10 ^{b}	44.61 ^{b}	0.435	0.023
			including:			
Breast	27.83 ^{a}	28.83 ^{a}	25.49 ^{b}	25.12 ^{b}	0.422	0.001
Thigh	11.29	11.67	11.66	11.31	0.221	0.889
Drumstick	7.90 ^{a}	7.36 ^{b}	7.93 ^{a}	8.17 ^{a}	0.118	0.049
Abdominal fat	10.31	10.31	10.53	10.35	0.181	0.973
Skin with subcutaneous fat	0.99	1.00	1.13	0.95	0.044	0.515
Share in body weight (%)						
Giblets total share in body weightbefore slaughter (%)	3.56 ^{b}	3.61 ^{b}	3.67 ^{ab}	4.03 ^{a}	0.102	0.044
			including:			
Heart	0.45	0.46	0.48	0.49	0.012	0.108
Gizzard	1.22 ^{b}	1.35 ^{ab}	1.32 ^{ab}	1.49 ^{a}	0.042	0.030
Liver	1.90	1.80	1.87	2.05	0.094	0.384

K—0%, G4—4%, G8—8% and G12—12% guar meal in rations for broiler chickens. SEM—standard error of mean. abc—means with different superscripts within a row are significantly different at $p \leq 0.05$.

3.3. Physico-Chemical Properties of Muscles

Analysis of the content of essential nutrients in breast muscles did not reveal that the diet had any significant effect on the content of dry matter, including crude protein, crude fat and crude ash (Table 7).

Leg muscles showed no difference in protein content ($p > 0.05$). The muscles of chickens from the K group and those fed rations with the lowest (4%) share of guar meal contained more ($p \leq 0.05$) dry matter, consisting of more fat and less ash than in the two other groups ($p \leq 0.05$).

Tables 8 and 9 present the fatty acids profile of intramuscular fat in breast and leg muscles.

The examined breast muscles showed no significant differences from group to group, both in terms of total saturated fatty acids (SFA) and unsaturated fatty acids (UFA). Unsaturated fatty acids were predominantly monounsaturated fatty acids (MUFA) that were present in amounts two times higher than polyunsaturated fatty acids (PUFA). Significantly ($p \leq 0.05$) higher levels of linolenic acid (C18:3 n-3) were measured in the muscles of chickens from the K group and those receiving feed rations with the lowest percentage (4%) of guar meal compared with the G12 group. A higher ($p \leq 0.05$) share of arachidonic acid was identified in the muscles of birds fed rations containing more (8% or 12%) guar meal than in the muscles of chickens from the K and G4 group ($p \leq 0.05$). Similarly, the lipid profile of leg muscles in all chickens showed a similar content of SFA, UFA and PUFA, but the level of monounsaturated fatty acids (MUFA) varied. The share of MUFA was significantly higher ($p \leq 0.05$) in the muscles of chickens from the K and G4 groups compared with G12, which should be associated with a higher ($p \leq 0.05$) share of an essential MUFA—oleic acid (C18:1). The leg muscles of chickens fed rations with 12% of guar meal contained significantly more stearic acid (C18:0) than those of chickens from other groups ($p \leq 0.05$).

Table 7. Proximate composition (g·100 g^{-1}) in muscles of broiler chickens fed graded levels of guar meal.

Item	Groups				SEM	*p*-Value
	K	G4	G8	G12		
			Breast			
Dry matter	25.93	25.94	25.74	25.38	0.141	0.437
Crude ash	1.16	1.19	1.19	1.19	0.005	0.053
Crude protein	23.12	22.74	22.73	20.40	0.623	0.423
Crude fat	1.28	1.38	1.17	0.89	0.072	0.085
			Leg			
Dry matter	27.26 ^{a}	25.56 ^{ab}	26.12 ^{bc}	25.89 ^{c}	0.208	0.003
Crude ash	1.04 ^{b}	1.03 ^{b}	1.06 a	1.07 ^{a}	0.004	0.002
Crude protein	19.54	19.20	19.58	19.31	0.108	0.567
Crude fat	5.49 ^{ab}	5.89 ^{a}	4.56 ^{b}	4.53 ^{b}	0.168	0.003

K—0%, G4—4%, G8—8% and G12—12% guar meal in rations for broiler chickens. SEM—standard error of mean. abc—means with different superscripts within a row are significantly different at $p \leq 0.05$.

Table 8. Fatty acids profile (% of total fatty acids) in breast muscles of broiler chickens fed graded levels of guar meal.

Fatty Acids	Groups				SEM	*p*-Value
	K	G4	G8	G12		
C14:0	0.10	0.10	0.10	0.10	0.003	0.812
C14:1	0.01	0.01	0.01	0.02	0.001	0.203
C16:0	14.90	14.80	15.20	14.70	0.193	0.794
C16:1	1.30	1.46	1.42	1.38	0.005	0.681
C17:0	0.12	0.11	0.12	0.14	0.004	0.262
C17:1	0.05	0.05	0.06	0.07	0.067	0.463
C18:0	4.00	3.64	3.90	4.07	0.610	0.118
C18:1	52.90	53.00	52.10	51.80	0.191	0.064
C18:2 n-6	22.60	22.80	23.30	24.10	0.274	0.224
C18:3 n-3	3.03 ^{a}	3.10 ^{a}	2.77 ^{ab}	2.55 ^{b}	0.073	0.029
C20:0	0.01 ^{b}	0.01 ^{b}	0.04 ^{a}	0.07 ^{a}	0.006	0.001
C20:1	0.15	0.14	0.16	0.15	0.005	0.863
C20:2	0.05	0.06	0.07	0.07	0.006	0.401
C20:3 n-3	0.07	0.06	0.06	0.05	0.006	0.477
C20:4 n-6	0.55	0.50	0.55	0.57	0.024	0.844
C22:0	0.02	0.02	0.01	0.02	0.001	0.926
SFA	19.15	18.68	19.37	19.10	0.235	0.808
UFA	80.71	81.18	80.50	80.76	0.236	0.809
MUFA	54.41	54.66	53.75	53.42	0.192	0.078
PUFA	26.30	26.52	26.75	27.34	0.305	0.686
n-6:n-3	7.52	7.43	8.51	9.58	0.215	0.051

K—0%, G4—4%, G8—8% and G12—12% guar meal in rations for broiler chickens. SFA—saturated fatty acids, UFA—unsaturated fatty acids, MUFA—monounsaturated fatty acids, PUFA—polyunsaturated fatty acids, SEM—standard error of mean. ab—means with different superscripts within a row are significantly different at $p \leq 0.05$.

Table 9. Fatty acids profile (% of total fatty acids) in leg muscles of broiler chickens fed graded levels of guar meal.

Fatty Acids	Groups				SEM	p-Value
	K	G4	G8	G12		
C14:0	0.08	0.08	0.09	0.10	0.002	0.063
C14:1	0.01	0.01	0.01	0.01	0.001	0.750
C16:0	14.00	14.20	13.90	13.90	0.197	0.972
C16:1	1.51	1.74	1.74	1.73	0.049	0.289
C17:0	0.12 ^{b}	0.13 ^{b}	0.14 ^{b}	0.16 ^{a}	0.004	0.001
C17:1	0.05 ^{b}	0.06 ^{ab}	0.06 ^{ab}	0.07 ^{a}	0.014	0.033
C18:0	2.71 ^{b}	2.61 ^{b}	2.68 ^{b}	3.16 ^{a}	0.067	0.007
C18:1	53.60 ^{a}	53.40 ^{a}	52.80 ^{ab}	52.30 ^{b}	0.155	0.007
C18:2 n-6	23.90	23.80	24.0	24.60	0.264	0.475
C18:3 n-3	3.50	3.31	3.13	3.30	0.058	0.156
C20:0	0.01 ^{b}	0.08 ^{a}	0.01 ^{b}	0.02 ^{b}	0.005	0.001
C20:1	0.12	0.15	0.12	0.14	0.004	0.090
C20:2	0.03	0.03	0.03	0.04	0.003	0.364
C20:3 n-3	0.02	0.03	0.03	0.03	0.001	0.078
C20:4 n-6	0.20 ^{b}	0.20 ^{b}	0.23 ^{b}	0.30 ^{a}	0.011	0.001
C22:0	0.01	0.01	0.01	0.01	0.001	0.283
SFA	16.93	17.11	16.83	17.35	0.224	0.855
UFA	82.94	82.73	82.15	82.52	0.224	0.856
MUFA	55.29 ^{a}	55.36 ^{a}	54.74 ^{ab}	54.25 ^{b}	0.166	0.047
PUFA	27.65	27.37	27.42	28.27	0.311	0.730
n-6:n-3	6.90	7.30	8.03	7.58	0.739	0.091

K—0%, G4—4%, G8—8% and G12—12% guar meal in rations for broiler chickens. SFA—saturated fatty acids, UFA—unsaturated fatty acids, MUFA—monounsaturated fatty acids, PUFA—polyunsaturated fatty acids, SEM—standard error of mean. ab—means with different superscripts within a row are significantly different at $p \leq 0.05$.

The pH reaction of breast and thigh muscles varied, both 15 min after slaughter and after 24 h of carcass chilling (Table 10).

The lowest pH_1 and pH_{24} were observed in the muscles of birds from the K group, and the highest was observed in those receiving feed rations containing 12% of guar meal. After 24 h of chilling, the pH reaction of breast muscles ranged from 5.97 in chickens from the K group to 6.16 in chickens fed rations with a 12% share of guar meal. The fastest glycolysis (pH decreased by 0.44) was noted in the breast muscles of chickens from the G8 group, while the slowest was recorded in the muscles of birds from the G4 group (pH decreased by 0.27). Analysis of thigh muscles showed that 45 min after slaughter, their pH was lower (except in G8) than that of breast muscles. After 24 h of carcass chilling, these muscles were not acidified since their pH did not decrease (except in the control group), but it rather increased linearly along with the increasing share of guar meal in the diet. No significant effect of the feed rations on the water-holding capacity (WHC) of breast muscles was observed, but a downward trend in WHC was recorded for an increasing share of guar meal in the feed. The thigh muscles of birds that were fed rations with a higher share of guar meal (8% and 12%) showed a significantly ($p \leq 0.05$) lower drip compared to other birds. Analysis of the L*a*b*C*H parameters of muscle colour led to a conclusion that both breast and thigh muscles varied significantly between the groups in terms of colour lightness (L*) only. The lightest colour was observed in the muscles of control chickens, and the colour lightness of both muscles decreased with an increasing share of guar meal in the feed. The difference (4.43) between the colour lightness of muscles of chickens from the K group and those from the G12 group was confirmed to be significant ($p \leq 0.05$).

Table 10. Physical properties of muscles of broiler chickens fed graded levels of guar meal.

Item	Groups				SEM	*p*-Value
	K	G4	G8	G12		
			Breast			
pH_1	6.35 ^{b}	6.38 ^{ab}	6.44 ^{ab}	6.54 ^{a}	0.029	0.008
pH_{24}	5.97 ^{b}	6.11 ^{ab}	6.00 ^{ab}	6.16 ^{a}	0.035	0.003
WHC (%)	15.18	14.41	13.58	12.29	0.707	0.088
L*	52.30 ^{a}	50.24 ^{ab}	49.08 ^{b}	47.87 ^{b}	0.584	0.023
a*	2.79	2.74	2.75	3.04	0.114	0.772
b*	2.31	2.96	3.75	3.92	0.290	0.176
$C^* = [(a^*)^2 + (b^*)^2]^{0.5}$	3.88	4.24	4.73	5.07	0.214	0.209
H = log (b*/a*)	0.64	0.78	0.84	0.92	0.054	0.314
			Thigh			
pH_1	6.21 ^{b}	6.29 ^{b}	6.48 ^{a}	6.36 ^{ab}	0.028	0.006
pH_{24}	6.20 ^{d}	6.47 ^{c}	6.64 ^{b}	6.78 ^{a}	0.045	0.001
WHC (%)	13.41 ^{a}	11.50 ^{ab}	8.25 ^{b}	8.27 ^{b}	0.726	0.018
L*	49.11 ^{a}	47.50 ^{ab}	45.78 ^{b}	47.25 ^{ab}	0.539	0.043
a*	6.34	6.66	6.19	7.66	0.492	0.735
b*	4.29	5.64	4.57	5.99	0.338	0.224
$C^* = [(a^*)^2 + (b^*)^2]^{0.5}$	7.83	7.85	8.98	10.12	0.466	0.254
H = log (b*/a*)	0.59	0.64	0.70	0.71	0.049	0.711

K—0%, G4—4%, G8—8% and G12—12% guar meal in rations for broiler chickens. L*—lightness, a*—redness, b*—yellowness, C*—chroma, H—hue, WHC—water-holding capacity, SEM—standard error of mean. abcd—means with different superscripts within a row are significantly different at $p \leq 0.05$.

4. Discussion

The content of protein in guar meal depends on the plant cultivar and the type of fraction (seed, shell) being predominant in the raw material [20–22]. If the seed is dominant, the protein level can reach up to 60%, while for the shell, it is only about 35%. The analysed guar meal contained an average (48.39%) amount of this ingredient, similar to that determined by Peng et al. [49] and Haribhau et al. [3]. The evaluated guar meal was rich in essential amino acids, which is consistent with studies by Lee et al. [23], Saeed et al. [18], Biel and Jaroszewska [24] and Peng et al. [49]. Lee et al. [21] and Song et al. [50] claimed that about 88% of the crude protein in guar meal true protein, compared to soybean meal (SBM), is rich in arginine but deficient in lysine, methionine, threonine, isoleucine and leucine. The share of specific fractions in guar meal is also associated with the content of crude fibre, which is little desired by poultry. The examined guar meal contained nearly twice more (7.78%) fibre than guar beans, in which a low content of fibre (4.1% and 5.13%) was determined by Pathak et al. [51] and Rao et al. [28]. In contrast, its level was lower (9.3%) than in beans analysed by Ahmed et al. [52]. The determined gross energy value of the evaluated raw material was slightly lower than reported by Peng et al. [49]. Unfortunately, most animal feeds, next to nutrients, also contain anti-nutrients. According to Rao et al. [31], the main nutrients present in guar meal are trypsin inhibitors and highly viscous galactomannan polysaccharides. The level of trypsin inhibitors determined during the analysis was similar to that measured in soybean meal. Thus, the results of Conner [20], Lee et al. [21,26] and Nasrala et al. [53], who found that guar meal contained fewer trypsin inhibitors than soybean meal, were not corroborated.

The rearing performance measured for birds fed rations containing 4%, 8% or 12% of guar meal coincides with other authors' findings [20,26,29–33,54]. The above-mentioned researchers used slightly different proportions of guar meal in feed rations, and its content varied in respective diets (starter, grower, finisher), but the final outcome was similar.

Mishra et al. [32], supplementing the diets with guar meal at the amount of 20 g/kg (pre-starter) or 50 g/kg (starter and grower) as a partial substitute for soybean meal, did not observe any significant impact on the chickens' body weight and feed intake. After 14 days, birds fed pre-starter rations containing guar meal weighed 539.9 g, while the control birds weighed 526.9 g. After two more weeks, the difference in body weight was 8.6 g to the advantage of the group fed a guar meal diet. On the final day of the experiment (day 35), the chickens had nearly an identical weight (1866.5 g—feed rations without guar meal; 1863.1 g—with guar meal). In turn, Kamran et al. [25], using higher (5%, 10% and 15%) proportions of guar meal in chicken feed, noted a clear decrease in body weight gain at increased levels of guar meal in the diets. After the first three weeks of rearing, the difference in weight gain between chickens fed rations containing 5% and 15% of guar meal amounted to 214 g (14%). At the end of rearing, this difference increased to 27%. The highest (15%) percentage of guar meal in the birds' diet also significantly reduced feed intake and conversion compared with broiler chickens fed rations in which soybean meal was the only protein-rich component. The highest feed intake was noted for chickens that were fed diets with 5% guar meal, but it did not differ significantly from the intake recorded in the control group and for birds fed rations containing 10% of guar meal. The use of 5% of guar meal in the birds' diet increased their feed conversion by 0.15 kg compared with chickens fed rations that did not contain guar meal at all ($p > 0.05$). Moreover, Conner [20], Hassan [54] and Lee et al. [29] demonstrated that up to 5% of guar meal in feed rations for broiler chickens was a level having no adverse impact on the birds' rearing performance. By contrast, Gharaei et al. [55], having added 3%, 6% and 9% of guar meal to feed rations for broiler chickens, proved that irrespective of whether the feed contained 3% or 6% of guar meal, the final body weight of chickens (on day 42 of rearing) was similar (2530 g and 2503 g) and did not differ from the weight of birds fed rations without guar meal (2545 g). Chickens receiving feed rations with 9% of guar meal weighed (by ca. 200 g) less ($p \leq 0.05$), while their feed conversion rate was higher (from 3% to 7%) compared with other birds. Rajasekhar et al. [4], having introduced lower levels (4% and 6%) of guar meal into the birds' diets, observed a linear decrease in body weight and an increase in feed conversion at respective phases of broiler chicken rearing. By contrast, Gheisarai et al. [33] demonstrated that from 3% to 9% of guar meal increased the birds' body weight, while higher (12–18%) levels of guar meal in the chickens' diets deteriorated their rearing performance. Mohayayee and Karimi [56], by using guar meal in starter, grower and finisher feed rations at graded levels of low (2%, 4% and 6%), medium (4%, 6% and 8%) and high (6%, 9% and 12%), proved that over 42 days of rearing the highest feed intake was recorded for chickens fed rations without guar meal. In contrast, a significant decrease in feed intake was noted for birds fed diets with the highest percentage of guar meal ($p \leq 0.05$). Moreover, Ahmed and Abou-Elkhair [1], having used 7.5% and 10% of guar meal in chicken feed, found that the intake of feed decreased linearly ($p \leq 0.05$) as the share of guar meal in the feed increased. The decreasing feed intake for birds fed rations with increasing levels of guar meal should most likely be attributed to an increased concentration of anti-nutrients making the feed taste bitter, discouraging the birds. As a consequence, lower feed intake contributes to the reduced intake of nutrients, resulting in smaller weight gain, particularly in the youngest broiler chickens, the most sensitive to diet quality.

The decrease in dressing percentage at higher levels of guar meal in feed rations for broiler chickens is consistent with the findings of Ahmed and Abou-Elkhair [1]. The use of 7.5% or 10% of guar meal in chicken feed linearly decreased the share of breast muscles compared with birds receiving diets in which the only source of protein was soybean meal ($p \leq 0.05$). The deteriorated carcass composition of broiler chickens should be associated with worse rearing performance ratios (BW, FI). Ahmed and Abou-Elkhair [1] did not find any influence of guar meal in feed rations on the percentage of abdominal fat in the carcass and the heart weight. However, compared to the control birds, chickens fed rations with 10% of guar meal were observed to have bigger livers ($p \leq 0.05$), while bigger gizzards were characteristic of those receiving feed containing less guar meal (7.5%). Rao et al. [28] did not note any significant influence of 6%, 12% and 18% of guar meal added to feed rations for broiler chickens on the dressing percentage, breast yield, giblet weight, abdominal fat and the weight of heart and liver.

The proximate composition of breasts and legs should be deemed typical of respective muscles [2,5,57,58]. It is difficult to refer these results to other studies that have analysed guar meal's impact on the chemical composition of muscles since no such data are available in reference literature. This is similar to the case of the composition and share of fatty acids in the lipid fraction of breast and leg muscles. It is a known fact that the percentage of fatty acids in intramuscular fat depends on the composition of the birds' diet [2,5,57,59]. Differences noted in the share of fatty acids in both muscles stem from the selected chicken-feeding pattern. Studies by Konieczka et al. [60] and Milczarek et al. [61] clearly illustrate the effect of the composition and share of fatty acids in oils used in broiler chicken feed rations on the lipid profile of muscles. An increased share of n-3 acids in the chickens' diet increases their concentration in intramuscular fat, improving health. However, high levels of PUFA from the n-3 family accelerate fat oxidation.

According to the classification of meat quality based on acidity, as proposed by Trojan and Niewiarowicz [62] and by Gardzielewska et al. [63], meat can be considered free of defects if its pH_1 ranges from 5.8 or 5.9 to 6.2 or 6.3. Studies showed that the reaction (pH_1) of breast muscles of all chickens exceeded the upper limit (6.3). In the breast muscles of birds fed rations containing a higher percentage (8% and 12%) of guar meal, pH_1 was high (above 6.4). Due to such a high pH, the meat is classified as DFD (dark, firm and dry), whereas the muscles of control chickens can be still regarded as normal meat since the 6.3 limit was only exceeded minimally. After 24 h of chilling, their pH reaction was lower and ranged from 5.97 in the muscles of chickens from the K group to 6.16 in the muscles of chickens fed rations with a 12% share of guar meal ($p \leq 0.05$). Analysis of the reaction of thigh muscles showed that pH_1 was even lower (except in G8) than that of breast muscles. The values measured in the K and G4 groups imply that the meat was free of defects. A value slightly (by 0.06) above the recommended upper limit of the pH range was noted in the G12 group, whereas pH_1 of the thigh muscles of chickens from the G8 group, amounting to 6.48, was significantly higher compared with the muscles of other birds. The aforementioned value testifies that the meat showed signs of DFD. Surprising results were recorded in the measurement of the pH reaction of thigh muscles after 24 h of chilling since the muscles were not acidified, and their pH even increased (except for the control group). Moreover, it was revealed that the pH_{24} of the muscles of chickens fed rations containing guar meal was higher at higher levels of guar meal in chicken feed; the G12 group reached a level of 6.78, which was significantly higher than in other groups.

No significant effect of the feed rations on breast muscles' water-holding capacity was confirmed. However, it was noted that as the pH_1 increased, the percentage of free water in the muscles decreased. A significantly smaller drip was observed in the thigh muscles of chickens from groups G8 and G12 compared with K and G4. The measured WHC ratio of breast and leg muscles can be associated with their pH reaction and colour lightness (L*) and leads to a conclusion that as the muscles' pH_1 increases, the free water drip loss decreases, and the colour lightness is reduced. Irrespective of the chicken feed rations, the colour of both muscles did not differ in terms of red saturation (a*) and yellow saturation (b*), as well as chroma (C*) and hue (H).

It is impossible to discuss the results relating to the physical properties of the muscles since the reference literature does not offer results from similar studies.

5. Conclusions

To sum up, the results provide a basis for recommending 4% of guar meal in chicken feed as a partial substitute for soybean meal. Higher levels (8% and 12%) of guar meal in broiler chicken feed resulted in a significantly decreased feed intake and, as a consequence, a clear reduction in the birds' body weight and a higher feed conversion ratio compared with broiler chickens fed rations without guar meal and rations containing 4% of guar meal. Chickens fed rations containing a higher percentage of guar meal (in particular 12%) performed significantly worse in terms of carcass composition, that is, dressing percentage and carcass muscularity. In addition, it was demonstrated that their meat was DFD (pH_1 > 6.4) but contained the smallest amount of intramuscular fat from a dietary perspective.

Author Contributions: Conceptualization, M.P. and M.O.; methodology, M.O., A.M. and M.P.; software, M.P. and R.Ś.; validation, M.O., M.P. and A.M.; formal analysis, A.M.; investigation, M.P., R.Ś. and A.M.; resources, M.O., M.P., R.Ś. and A.M.; data curation, M.O., M.P., A.M. and. R.Ś.; writing—original draft preparation, M.P. and M.O.; writing—review and editing, A.M. and M.O.; visualization, M.O., M.P., A.M. and. R.Ś.; supervision, M.O. and A.M.; project administration, M.O.; funding acquisition, M.O., M.P. and A.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Ministry of Science and Higher Education of Poland (projects no. 152/15/MN and 212/04/S).

Institutional Review Board Statement: Ethical review and approval were waived for this study, due to the slaughter of birds being carried out in accordance with the applicable rules on the handling of animals at the time of slaughter, including humane treatment. Additionally, the methods used in the meat quality tests were carried out in accordance with the current and commonly used methodology described in the Materials and Methods section. According to directive no. 2010/63/EU, the approval of the Ethics Committee was not required.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Ahmed, H.A.; Abou-Elkhair, R.M. Potential application of guar meal in broiler diet. *Asian J. Anim. Vet. Adv.* **2016**, *11*, 280–287. [CrossRef]
2. Milczarek, A.; Osek, M. Effectiveness Evaluation of Use of Various Protein Feeds for Broiler Chicken Feeding. *Ann. Anim. Sci.* **2019**, *19*, 1063–1081. [CrossRef]
3. Haribhau, G.A.; Lakshmi, K.V.; Alexander, G.; Gurram, S. Effect of supplementation of multiple enzymes to the diets containing variable protein sources on performance and nutrient utilization in commercial broilers. *Trop. Anim. Health Prod.* **2020**, *52*, 1739–1744. [CrossRef]
4. Rajasekhar, K.V.; Prakash, B.; Vijaya Lakshmi, K.; Rama Rao, S.V.; Raju, M.V.L.N. Effect of feeding diet with alternate protein sources and quality protein maize on performance and nutrient utilization in broiler chickens. *Trop. Anim. Health Prod.* **2020**, *52*, 2297–2302. [CrossRef]
5. Janocha, A.; Milczarek, A.; Pietrusiak, D.; Łaski, K.; Saleh, M. Efficiency of Soybean Products in Broiler Chicken Nutrition. *Animals* **2022**, *12*, 294. [CrossRef] [PubMed]
6. Hassan, S.M.; Hag, A.U.; Byrd, J.A.; Berhow, M.A.; Cartwright, A.L.; Bailey, C.A. Hemolytic and antimicrobial activities of saponin-rich extracts from guar meal. *Food Chem.* **2010**, *119*, 600–605. [CrossRef]
7. Reddy, E.T.; Reddy, V.R.; Preetham, V.C.; Rao, S.V.R.; Rao, D.S. Effect of dietary inclusion of graded levels of toasted guar meal on performance, nutrient digestibility, carcass traits, and serum parameters in commercial broiler chickens. *Trop. Anim. Health Prod.* **2017**, *49*, 1409–1414. [CrossRef]
8. Sabahelkheir, M.K.; Abdalla, A.H.; Nouri, S.H. Quality Assessment of Guar Gum (Endosperm) of Guar (Cyamopsis tetragonoloba). *ISCA J. Biol. Sci.* **2012**, *1*, 67–70.
9. Gendy, A.S.; Said-Al Ahl, H.A.; Mahmoud, A.A.; Mohamed, H.F. Effect of nitrogen sources, bio-fertilizers and their interaction on the growth, seed yield and chemical composition of guar plants. *Life Sci. J.* **2013**, *10*, 389–402.
10. Kadian, N.; Yadav, K.; Aggarwal, A. Significance of bioinoculants in promoting growth, nutrient uptake and yield of Cyamopsis tetragonoloba (L.) "Taub.". *Eur. J. Soil Biol.* **2013**, *58*, 66–72. [CrossRef]
11. Vishwakarma, R.K.; Shivhare, U.S.; Nanda, S.K. Physical properties of guar seeds. *Food Bioprocess Technol.* **2012**, *5*, 1364–1371. [CrossRef]
12. Nidhina, N.; Muthukumar, S.P. Antinutritional factors and functionality of protein-rich fractions of industrial guar meal as affected by heat processing. *Food Chem.* **2015**, *173*, 920–926. [CrossRef]
13. Sharma, P.; Gummagolmath, K.C. Reforming guar industry in India: Issues and strategies. *Agric. Econ. Res. Rev.* **2012**, *25*, 37–48. [CrossRef]
14. Tripathy, S.; Das, M.K. Guar gum: Present status and applications. *J. Pharm. Innov.* **2013**, *2*, 24–28. [CrossRef]

15. Akhtar, L.H.; Minhas, R.; Bukhari, M.S.; Shah, S.A.S. Genetic Analysis of Some Quantitative Traits in Cluster Bean (Cyamopsis tetragonoloba L.). *J. Environ. Agric. Sci.* **2015**, *4*, 48–51.
16. APEDA. Agricultural and Processed Food Products Exports Development Authority. 2021. Available online: https://apeda.gov.in/apedawebsite/SubHead_Products/Guargum.htm (accessed on 1 June 2022).
17. Rai, D.K. *Trends and Economic Dynamics of Guar in India*; Indian Council for Research on International Economic Relations (ICRIER): New Delhi, India, 2015; p. 48.
18. Saeed, M.; Hassan, F.U.; Shah, Q.A.; Arain, M.A.; El-Hack, M.E.A.; Alagawany, M.; Dhama, K. Practical application of guar (Cyamopsis tetragonoloba l. Taub) meal in poultry nutrition. *Adv. Anim. Vet. Sci.* **2017**, *5*, 491–499. [CrossRef]
19. Bhatt, R.K.; Jukanti, A.K.; Roy, M.M. Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.], an important industrial arid legume: A review. *Legume Res.* **2017**, *40*, 207–214. [CrossRef]
20. Conner, S.R. Characterization of Guar Meal for Use in Poultry Rations. Ph.D. Thesis, Texas A&M University, College Station, TX, USA, 2002.
21. Lee, J.T.; Connor, A.S.; Haq, A.U.; Cartwright, A.; Bailey, C. Quantitative measurement of negligible trypsin inhibitor activity and nutrient analysis of guar meal fractions. *J. Agric. Food Chem.* **2004**, *52*, 6492–6495. [CrossRef]
22. Salehpour, M.; Qazvinian, K. Effects of feeding different levels of Guar meal on performance and blood metabolites in Holstein lactating cows. *Sci. Pap. Anim. Sci.* **2012**, *55*, 73–77.
23. Lee, J.T.; Bailey, C.A.; Cartwright, A.L. beta-Mannanase ameliorates viscosity-associated depression of growth in broiler chickens fed guar meal and hull fractions. *Poult. Sci.* **2003**, *82*, 1925–1931. [CrossRef]
24. Biel, W.; Jaroszewska, A. Compositional and Nutritional Evaluation of Guar (Cyamopsis tetragonoloba L.) Meal. *Anim. Nutr. Technol.* **2019**, *19*, 385–393. [CrossRef]
25. Kamran, M.; Pasha, T.N.; Mahmud, A.; Ali, Z. Effect of commercial enzyme (Natugrain) supplementation on the nutritive value and inclusion rate of guar meal in broiler rations. *Int. J. Poult. Sci.* **2002**, *1*, 167–173.
26. Lee, J.T.; Bailey, C.A.; Cartwright, A.L. Guar meal germ and hull fractions differently affect growth performance and intestinal viscosity of broiler chickens. *Poult. Sci.* **2003**, *82*, 1589–1595. [CrossRef] [PubMed]
27. Hussain, M.; Rehman, A.; Khalid, M. Feeding value of guar meal and the application of enzymes in improving nutritive value for broilers. *Worlds Poult. Sci. J.* **2012**, *68*, 253–268. [CrossRef]
28. Rao, M.H.; Redd, V.R.; Rao, S.V.; Kumar, M.S.; Kumari, N.N.; Gurram, S.; Raghunandhan, T. Effect of commercial guar meal (CGM) on the performance and nutrient utilization in broilers. *Indian J. Anim. Sci.* **2019**, *89*, 556–561.
29. Lee, J.T.; Connor-Appleton, S.; Bailey, C.A.; Cartwright, A.L. Effects of guar meal by-product with and without beta-mannanase Hemicell on broiler performance. *Poult. Sci.* **2005**, *84*, 1261–1267. [CrossRef]
30. Şara, A.; Benţea, M.I. The Effects of Guar Meal on Production Performances in Broiler Chicken. *Bull. UASVM Anim. Sci. Biotechnol.* **2015**, *72*, 266–267.
31. Rao, M.H.; Redd, V.R.; Rao, S.V.; Kumar, M.S.; Kumari, N.N.; Gurram, S. Supplementation of raw and toasted guar meal on the performance and nutrient utilization in broilers. *Int. J. Poult. Sci.* **2019**, *54*, 225–231. [CrossRef]
32. Mishra, A.; Sarkar, S.K.; Ray, S.; Haldar, S. Effects of partial replacement of soybean meal with roasted guar korma and supplementation of mannanase on performance and carcass traits of commercial broiler chickens. *Vet. World* **2013**, *6*, 693–697. [CrossRef]
33. Gheisarai, A.A.; Zavareh, M.S.; Toghyani, M.; Bahadoran, R.; Toghyani, M. Application of incremental program, an effective way to optimize dietary inclusion rate of guar meal in broiler chicks. *Livest. Sci.* **2011**, *140*, 117–123. [CrossRef]
34. AOAC International. *Official Methods of Analysis of AOAC International*, 18th ed.; AOAC International: Gaithersburg, MD, USA, 2011.
35. Commission Regulation 2009. Commission Regulation (EC) No 152/2009 of 27 January 2009 Laying down the Methods of Sampling and Analysis for the Official Control of Feed (Text with EEA Relevance). Official Journal of the European Union. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02009R0152-20201116&from=en (accessed on 31 July 2022).
36. Folch, J.M.; Lees, M.; Stanley, G.H.S. A simple method for the isolation and purification of total lipides from animal tissues. *J. Biol. Chem.* **1957**, *226*, 497–509. [CrossRef]
37. Van Soest, P.J.; Wine, R.H. Use detergents in the analysis of fibrous feeds, Preparation of fibre residues of low nitrogen content, Determination of cell-wall constituents. *J. AOAC Int.* **1967**, *50*, 50–55. [CrossRef]
38. *ISO 9831*; Animal Feeding Stuffs, Animal Products, and Faeces or Urine—Determination of Gross Calorific Value—Bomb Calorimeter Method. International Organization for Standardization: Geneva, Switzerland, 2005.
39. *BN-90/79160-62*; Colorimetric Method. In Tannin Determination. Polski Komitet Normalizacyjny: Warsaw, Poland, 1990.
40. Smith, C.; van Megen, W.; Twaalfhoven, L.; Hitchcock, C. The determination of trypsin inhibitor levels in foodstuffs. *J. Sci. Food Agric.* **1980**, *31*, 341–350. [CrossRef] [PubMed]
41. Smulikowska, S.; Rutkowski, A. (Eds.) Standards and Recommendations of Poultry Nutrition. Recommended allowances and nutritive value of feedstuffs. In *Poultry Feeding Standards*, 4th ed.; The Kielanowski Institute of Animal Physiology and Nutrition PAS and Polish Branch of WPSA: Jabłonna, Poland, 2005.
42. WPSA. *European Tables of Energy Values for Poultry Feedstuffs*; Spelderholt Centre for Poultry Research: Beekbergen, The Netherlands, 1989.

43. Ziołecki, J.; Doruchowski, W. *Slaughter Value Evaluation Methods*; COBRD Own Publishing Service: Poznań, Poland, 1989.
44. Grau, R.; Hamm, R. Eine einfache Methode zur Bestimmung der Wasserbindung im Muskel. *Naturwissenschaften* **1953**, *40*, 29. [CrossRef]
45. Pohja, M.S.; Niinivaara, F.P. Die Bestimmung der Wasserbindung des Fleisches mittels der Konstantdruckmethode. *Fleischwirtschaft* **1957**, *9*, 193–195.
46. CIE. *Draft Standard 014-4.3/E: Colorimetry—Part. 4: CIE 1976 L*a*b* Colour Space*; CIE Central Bureau: Vienna, Austria, 2007; p. 8.
47. *ISO 11037*; Sensory Analysis—Guidelines for Sensory Assessment of the Colour of Products. Standards Policy and Strategy Committee UK: Geneva, Switzerland, 2011; pp. 1–18.
48. StatSoft Inc. *Statistica (Data Analysis Software System)*, Version 13.3; StatSoft Inc.: Tulsa, OK, USA, 2022.
49. Peng, P.; Tang, X.; Deng, D.; Fang, R. The Nutritive Value of Guar Meal and its Effect on Growth Performance of Meat Ducks. *Pak. J. Zool.* **2020**, *52*, 1001–1006. [CrossRef]
50. Song, Y.S.; Frias, J.; Martinez-Villaluenga, C.; Vidal-Valdeverde, C.; Gonzalez de Mejia, E. Immunoreactivity reduction of soybean meal by fermentation, effect on amino acid composition and antigenicity of commercial soy products. *Food Chem.* **2008**, *108*, 571–581. [CrossRef]
51. Pathak, R.; Singh, M.; Henry, A. Genetic diversity and interrelationship among cluster bean (*Cyamopsis tetragonoloba*) genotypes for qualitative traits. *Indian J. Agric. Sci.* **2011**, *81*, 402–406.
52. Ahmed, M.B.; Hamed, R.A.; Ali, M.E.; Hassan, A.B.; Babiker, E.E. Proximate composition, antinutritional factors and protein fractions of guar gum seeds as influenced by processing treatments. *Pak. J. Nutr.* **2006**, *5*, 481–484.
53. Nasrala, M.M.; Waly, A.H.; Habib, H.H.; Abdel Magied, H.A.; Assaf, I.M.M.; Ouda, M.M. Effects of dietary inclusion of guar korma meal levels with or without enzyme supplementation on performance of local strain chicks (Anshas). *Egypt. J. Nutr. Feeds* **2015**, *18*, 323–331. [CrossRef]
54. Hassan, S.M. Effects of Guar meal, Guar gum and saponin rich Guar meal extract on productive performance of starter broiler chicks. *Acad. J.* **2013**, *8*, 2464–2469. [CrossRef]
55. Gharaei, M.A.; Dastar, B.; Nameghi, A.H.; Tabar, G.H.; Shams Shargh, M. Effects of Guar meal with and without β-mannanase enzymes on performance and immune response of broiler chicks. *Int. Res. J. Appl. Basic Sci.* **2012**, *3*, 2785–2793.
56. Mohayayee, M.; Karimi, K. The effect of guar meal (germ fraction) and β-mannanase enzyme on growth performance and plasma lipids in broiler chickens. *Afr. J. Biotechnol.* **2012**, *11*, 8767–8773. [CrossRef]
57. Laudadio, V.; Ceci, E.; Tufarelli, V. Productive traits and meat fatty acid profile of broiler chickens fed diets containing micronized fava beans (Vicia faba L. var. minor) as the main protein source. *J. Appl. Poult. Res.* **2011**, *20*, 12–20. [CrossRef]
58. Śliwa, J.; Brzóska, F. Effect of diets with non-gm soybean expeller on body weight, carcass quality and amino acid digestibility in broiler chickens. *Rocz. Nauk. Zoot.* **2018**, *45*, 59–87.
59. Dal Bosco, A.; Ruggeri, S.; Mattioli, S.; Mugnai, C.; Sirri, F.; Castellini, C. Effect of faba bean (Vicia faba var. minor) inclusion in starter and growing diet on performance, carcass and meat characteristics of organic slow-growing chickens. *Ital. J. Anim. Sci.* **2013**, *12*, e76. [CrossRef]
60. Konieczka, P.; Czauderna, M.; Smulikowska, S. The enrichment of chicken meat with omega-3 fatty acids by dietary fish oil or its mixture with rapeseed or flaxseed. Effect of feeding duration. Dietary fish oil, flaxseed, and rapeseed and n-3 enriched broiler meat. *Anim. Feed Sci. Technol.* **2017**, *223*, 42–52. [CrossRef]
61. Milczarek, A.; Osek, M.; Banaszkiewicz, T. The effect of oil type in diet in broiler chicken on pro-health and organoleptic properties meat. *Ann. Warsaw Univ. Life Sci.—SGGW Anim. Sci.* **2018**, *57*, 269–280. [CrossRef]
62. Trojan, M.; Niewiarowicz, A. Method of identifying of water broiler chicken meat and observations on the frequency of this anomaly. *Post. Drob.* **1971**, *13*, 47–50.
63. Gardzielewska, J.; Jakubowska, M.; Buryta, B.; Karamucki, T.; Natalczyk-Szymkowska, W. Relationship between pH_1 and the quality of broiler meat. *Med. Wet.* **2003**, *59*, 426–428.