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RESEARCH ARTICLE

Dried Giant Snail Meal (*Archachatina achatina*) on the Performance in Broiler Diets

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ABSTRACT

Dried giant snail based meal (*Archachatina achatina*) was evaluated and used as a feedstuff for broiler diets. Four trials were carried out at different inclusion levels. Trial 1 was used as feed additive at 0, 0.05, 0.1 and 0.2% inclusion levels. In trial 2, DGSM was included in the growing and finishing diets for broilers at 0.0, 2.0, 4.0 and 6.0%. Moreover, DGSM was used in trial 3 as a calcium and phosphorus supplement at 1.5% of the diet to replace 24.5 and 33.3% of bone meal in the growing and finishing diets, respectively. In trial 4, 0.0, 2.0, 4.0 and 6.0% of the broiler grower diets was replaced by the same percentage of the DGSM. Performance of broilers in trial 1 was not affected significantly by DGSM when fed either at 0.05, 0.1, 0.15, or 0.2% as a feed additive. In trial 2, increasing DGSM above 2% of the diet decreased productive performance and dressing percentage. Performance of broilers in trial 3 fed DGSM at 1.5% in the diet as Ca and P supplements was lower than that of the control diet. Results of trial 4 indicated that DGSM up to 6% in grower diets for broiler chicks had no negative effects on weight gains, FCR and the utilization of protein and energy when fed for a shorter period during 7–28 d of age. Tibia ash, breaking strength and mineral contents were not affected by different DGSM supplements in trials 2 and 3.

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INTRODUCTION

Animal production in the tropics is adversely affected by high cost and inadequate feed supply (Ahaotu *et al*., 2013). Feed contribute substantially to the cost of animal production and it is about 60% of total cost of production. The high cost of animal production results in low yield and high prices of its products in the market. This made them unaffordable by majority of consumers in Africa. Reducing feeding cost is a fundamental issue for amelioration of poultry production. This may be achieved by using a cheaper non-conventional feed resource in poultry diets as for example snail meal, but this may have a negative impact on environment. Giant Snail is widely spread throughout different parts of the world, where it is usually considered to be a pest of vegetable and other crops (Uwalaka and Ahaotu, 2013). In some areas it is present in large numbers and is a potential source of feed for village poultry farmers. Unfortunately, the whole dried snail meal contains a relatively high level of ash, which limits its recommended level for continuous feeding. Thus, few studies have used snail meal in diets for broilers and layers (Elmslie, 1982; Greswell and Habibie, 1982; Nadazdin *et al.,* 1988; Ulep and Buenafe, 1991). The snail bodies (meat) are reported to contain 60% CP on a dry matter basis (Gohl, 1975; Thomas and Ramachandran, 1976) and with the possible exception of methionine to be well balanced in amino acid content (Mead and Kemmerer, 1953). Creswell and Kompiang, 1981) found that snail meal (Achatina fulica) contained 60% CP, 2% Ca, 0.8% P, 4.35% lysine, 1.0% methionine and 0.6% cystine on a dry matter basis and 14.2 MJ ME/kg dry matter. They reported an anti-nutritional factor that depressed growth, which was obvious when the raw snails were fed above 10% of the diet. However, boiling for 15-20 min completely overcame this effect. Also, including up to 15% of the dried boiled snail meal in broiler diets gave similar weight gains to the control. Whereas, supplementing a diet containing 20% snail meal with 0.25% methionine completely reversed the negative effects on broiler performance. Elmslie (1982) showed that flesh of snail meal replacing fishmeal up to 15% of the diet had no negative effect on growth of broiler chicks. However, supplementing 20% or more snail meal (flesh) to diets decreased growth of broilers, as it was caused by the use of raw snail meal. Also, Ulep and Buenafe (1991) included snail meal in broiler diets at 0, 4, 8 and 12% and found that final body weight was not affected by feeding dried shelled snail meal and different protein sources (snail meal, fishmeal, meat and bone meal). They concluded that snail meal is a suitable protein source in broiler diets. It was found that ground snail shells could be used as a good source of minerals for poultry as they contain (g/kg) 387 Ca, 0.35 P, 0.25 Mg, 0.35 Na, and 0.066 Mn (Nadazdin *et al*., 1988). The present paper describes the impact of feeding dried Giant Snail meal (DGSM; *Archachatina achatina*) as an additive and feed component in different concentrations in broiler diets on performance, proportion of edible organs, mineral content and special characteristics of tibia, and moreover, on some blood parameters.

MATERIALS AND METHODS

Birds, housing and management

Giant Snail flesh (*Archachatina achatina*) was collected and sun dried after boiling for 20 min. The dry residue was grounded in a mixer and analyzed for its chemical analyses according to AOAC (2004). Mash diets in all trials were formulated based on the Tables of the NRC (1994) for feedstuffs and actual chemical analyses of DGSM. In all trials Anak broiler chicks were housed in battery-brooders (40 x 45 x 60 cm). Feed and water were offered *ad libium* throughout the experiments. Broiler chicks were fed a starter diet containing 22% CP, 12.6 MJ / kg, 0.90% total sulphur amino acids (TSAA), 1.20% lysine, 1.0% Ca and 0.45% AP during the preliminary experimental period in trials 1 (1-4 d of age) and 4 (1-7 d of age).

Biological Evaluation

Trial 1

The objective of this trial was to use the whole DGSM as a feed additive in broiler diets. Sixty unsexed Anak broiler chicks were housed in battery-brooders (40 x 45 x 60 cm) during the preliminary (1-4 d of age) and the main experimental (4-42 d of age) periods. Fifty four day-old broiler chicks were randomly distributed to five experimental diets. Each diet was fed to two replicates, each containing five unsexed chicks. Dried Giant Snail meal was added at the top of the basal diet (Table 1) containing 12.2 MJ/kg diet and 22.1% crude protein (CP) at 0.0, 0.05, 0.1, 0.15 and 0.2% during 4-42 d of age. Trial 1 was used as a control diet.

Vitamins and minerals mixture of protein concentrate provided per kilogram of diet: vitamin A (as all-trans-retinyl-acetate) 12000 IU; vitamin E (all rac-a-tocopheryl-acetate) 10 IU; Vit. K_3 2mg; Vit. D3 2000 ICU; riboflavin 10 mg; Ca pantothenate 10 mg; niacin 15 mg; choline chloride 500 mg; vitamin B12 10 mg; vitamin B6 1.5 mg; thiamine (as thiamine mononitrate) 2.2 mg; folic acid 1 mg; D-biotin 30 mg. Trace minerals (milligrams per kilogram of diet): Mn 40; Zn 45; Fe 30; Cu 39; Se 0.1; I 0.3; Cobalt 0.2.

Trial 2

The purpose of this trial was to test the hypothesis that whole DGSM could be used as a feedstuff in broiler diets. Seventy-two unsexed one day-old Anak broiler chicks were housed in battery-brooders (40 x 45 x 60 cm) during the growing period (1-28 d of age) and the finisher period (28-56 d of age). Four broiler diets were formulated to contain 0, 2, 4, and 6% DGSM Tables 1. Each diet was fed to three replicates of six chicks each.

Trial 3

The 3rd trial was conducted to evaluate the use of the whole DGSM as Ca and P supplements in broiler diets. Thirty-six unsexed one day-old Hubbard broiler chicks were housed in battery-brooders (40 x 45 x 60 cm) during the grower (1-28 d of age) and the finisher periods (28- 56 d of age). Two experimental diets were formulated to include 1.5% of DGSM in the growing and finishing diets to replace 24.5 and 33.3% of the bone meal, respectively. Each diet was fed to three replicates of six chicks each (Tables 1 and 2).

Trial 4

It was the objective of this trial to replace different levels of the whole basal diet by the same percentage of the whole DGSM in grower diets for broiler chicks. Sixty unsexed Anak broiler chicks were housed in battery-brooders (40 x 45 x 60 cm) during the preliminary (1-7 d of age) and the main experimental (7-28 d of age) periods. Forty-eight seven day-old broiler chicks were randomly distributed to four experimental diets, containing 0.0, 2.0, 4.0 or 6.0% DGSM replacing the same percentage of the whole components of the basal diet (Table 2). Each diet was fed to two replicates, each containing six unsexed chicks.

Observations

Chicks were wing banded and weighed at the initiation and were then weighed at biweekly intervals in each experiment after initiation of each trial. At the same ages feed intake was recorded and feed conversion ratio (FCR) was calculated. At the end of trials 1 (42 d of age), 2, and 3 (56 d of age), three broiler chicks from each treatment were slaughtered for carcass evaluation. Carcass parts and internal organs were determined and right tibia was removed by direct excision method (Orban *et al.*, 1993) to measure tibia breaking strength. Chemical composition of the skinless and boneless fresh breast meat was determined in pooled triplicate samples according to AOAC (2004) as well as for the right tibia for ash, Ca, and P. Water holding capacity of breast meat was measured following the method of Grau and Hamm (1957) as modified by Volovinskaia and Merkolova (1958). Shearing force of thigh meat was measured using the method of Lyon *et al*. (1985, 1989) as modified by Sams *et al*. (1992). Simultaneously, blood samples were collected from slaughtered birds of each treatment in trial 2 and at 42 d of age in trial 3. Plasma was separated by centrifugation at 3000 rpm for 5 min and stored at 20^oC until analysis. Concentrations of plasma glucose (Matten and Heimer, 1970), total protein (Josephson and Gyllensward, 1957; Witt and Trendelenburg, 1982), and plasma glutamic oxaloacetic transaminase (GOT) and glutamic pyruvic transaminase (GPT) (Reitman and Frankel, 1957) were determined.

Table 1: Basal diet Proportion of snail meal in grower diets (Trial 2) Proportion of snail meal in finisher diets (Trial 2) used in trial 1

Ingredients %	Basal diet meal used in trial 1	Proportion of snail meal in grower diets				Proportion of snail meal in finisher diets			
		0.0%[1]	2.0%	4.0%	6.0%	0.0%[1]	2.0%	4.0%	6.0%
Yellow corn	55.5	57.0	56.0	54.0	53.0	57.0	57.0	56.0	56.0
Soybean meal	38.5	37.7	37.0	36.4	34.9	34.0	33.0	33.0	32.0
Snail meal	0.0	0.0	2.00	4.00	6.00	0.0	2.00	4.00	6.00
Bone meal	2.50	2.65	2.00	2.00	2.00	3.00	2.00	2.00	2.00
Limestone	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salt	0.50	0.30	0.30	0.30	0.30	0.35	0.35	0.35	0.35
Vit / Min Mix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DL-methionine	0.10	0.10	0.10	0.10	0.10	0.13	0.13	0.13	0.13
Vegetable oils	2.00	2.00	2.35	2.94	3.44	3.00	3.00	3.00	3.00
Washed sand	0.13	0.00	0.00	0.00	0.00	2.27	2.27	1.27	0.27
Total	100	100	100	100	100	100	100	100	100
Calculated Values MJ/									
Kg diet	12.18	12.32	12.32	12.32	12.32	12.35	12.35	12.35	12.35
Crude protein %	22.1	21.49	21.38	21.34	21.10	19.86	19.74	19.90	19.84
Methionine %	0.45	0.44	0.44	0.44	0.43	0.45	0.44	0.44	0.44
TSAA %	0.85	0.80	0.81	0.82	0.84	0.77	0.79	0.81	0.84
Lysine %	1.10	1.16	1.22	1.29	1.34	1.06	1.12	1.20	1.27
Ca %	1.00	0.84	1.14	1.63	2.10	0.93	1.13	1.57	2.10
Available P %	0.50	0.50	0.44	0.44	0.43	0.54	0.42	0.42	0.42
Crude fiber %	3.91	3.89	4.27	4.62	4.94	3.63	4.01	4.43	4.80

Table 2: Composition of the experimental diets fed in trials 3 and 4.

Ingredients, %	Grower diet (Trial 3)	Finisher diet (Trial 3)	Proportion of snail meal in grower diets (Trial 4)			
			0.0%	2.0%	4.0%	6.0%
Yellow corn	55.4	58.0	57.5	56.4	55.2	54.1
Soybean meal	38.0	33.0	37.0	36.3	35.5	34.8
Snail meal	1.50	1.50	0.00	2.00	4.00	6.00
Bone meal	2.00	2.00	3.00	2.94	2.88	2.82
Limestone	0.00	0.00	0.00	0.00	0.00	0.00
Salt Vit Min	0.30	0.35	0.30	0.294	0.288	0.282
Mix1	0.25	0.25	0.25	0.245	0.240	0.235
DL-methionine vegetable	0.10	0.13	0.10	0.098	0.096	0.094
Oils	2.485	2.685	1.85	1.813	1.776	1.739
Washed sand	0.00	2.085	0.00	0.00	0.00	0.00
Total	100	100	100	100	100	100
Calculated values						
MJ/kg diet	12.3	12.4	12.3	12.1	12.0	11.8
Crude protein %	21.7	19.7	21.2	21.1	21.0	20.9
Methionine %	0.44	0.45	0.44	0.43	0.41	0.41
TSAA %	0.81	0.79	0.78	0.80	0.81	0.83
Lysine %	1.23	1.10	1.14	1.21	1.27	1.34
Ca %	1.03	1.01	0.94	1.40	1.87	2.33
Available P %	0.44	0.43	0.55	0.56	0.56	0.57
Crude fibre %	4.21	3.92	3.86	4.22	4.59	4.95

The mineral content of plasma was determined following wet-ashing of plasma (AOAC, 2004). Plasma Na and K were determined using the flame spectrophotometer, Ca and Mg were measured using the Atomic Absorption Spectrophotometer, whereas P was determined spectroscopically using the method of AOAC (2004).

Table 3: Effect of different levels of dried Giant Snail meal supplemented to broiler diets as a feed additive on performance, carcass characteristics and body organs of broiler chicks (Trial 1)

Parameter	Proportion of Giant Snail meal					SEM	P value
	0.0%	0.05%	0.10%	0.15%	0.20%		
Performance of broiler chicks							
Initial body weight, 4 day	79.0	81.8	79.6	78.2	78.0	2.89	NS
Body weight, 6 wk of age	1279	1279	1339	1338	1367	78.3	NS
Weight gains, 4-42 d of age	1200	1197	1259	1260	1289	77.5	NS
Feed intake g, 4-42 d of age	2798	2863	2848	2867	2844	113	NS
FCR g/g, 4-42 d of age	2.33	2.39	2.26	2.28	2.21	0.123	NS
Carcass characteristics and internal organs							
Total edible parts, %	73.3	74.4	75.3	74.7	74.8	1.30	NS
Liver, %	2.79	3.02	2.98	3.44	2.99	0.37	NS
Gizzard, %	2.16	2.07	2.14	2.11	2.00	0.117	NS
Pancreas, %	0.24b	0.29a	0.26ab	0.28ab	0.24b	0.012	0.05
Spleen, %	0.21	0.16	0.19	0.19	0.28	0.014	NS

a, b Means within the same row not sharing a common superscripts differ significantly P _ 0.05.

Statistical analysis

Data were analyzed using the GLM procedure of SAS1 (SAS Institute, 1985), utilizing one way ANOVA and Duncan New Multiple Range Test (Gordon and Gordon, 2004) to test mean differences at P>0.05.

RESULTS AND DISCUSSION

Proximate chemical composition of whole dried snail meal The chemical composition of the DGSM revealed 95.8% dry matter (DM), 15.2% CP, 1.68% ether extract (EE), 22.2% crude fiber (CF), 47.8% ash and 8.91% nitrogen free extract (NFE). The calculated energy value was 4.80 MJ / kg (based on chemical composition). The mineral contents of DGSM as percentages of ash were 24.2% Ca, 0.94% P, 0.47% Na, 0.31% K, and 16.2% Mg.

Trial 1

The results of trial 1 indicated that DGSM had no significant effect on growth, feed intake, and FCR of broilers as well as on total edible parts and most of internal organs (Table 3). Pancreas percentage was significantly affected by DGSM. Pancreas percentage of group's fed 0.05% DGSM was significantly higher than in the control and in the group fed 0.2% DGSM.

Trial 2

Table 4 shows the results of trial 2, it was concluded that feeding DGSM above 2% of the growing and finishing diets for broiler chicks significantly decreased growth and insignificantly impaired FCR. There were no significant effects of different DGSM on total edible parts and internal organs and most of plasma constituents, except for GPT which increased significantly when DGSM was fed at 6% (Table 4). The level of DGSM affected none of the tibia mineral contents as well as breaking strength or moisture, protein, fat, and ash contents of breast meat and mineral constituents of plasma (Table 4).

Trial 3

Results of trial 3 (Table 5) showed that feeding DGSM at 1.5% in the growing and finishing diets for broiler chicks significantly reduced growth and insignificantly impaired FCR. Insignificant differences between the control and 1.5% DGSM diets were shown

Table 4: Effect of different dietary levels of dried Giant Snail meal on performance, carcass characteristics and body organs, as well as plasma constituents of broiler chicks (Trial 2)

Parameter	Proportion of Giant Snail meal SEM P value					
	0.0%	2.0%	4.0%	6.0%	SEM	P Value
Performance of broiler chicks						
Initial body weight g, 1 day of age	48.0	49.0	48.0	48.0	1.23	NS
Body weight g, 8 wk of age	1833 a	1798 a	1520 b	1474 b	104	0.01
Weight gains, 1-56 d of age	1785 a	1749 a	1472 b	1426 b	103	0.01
Feed intake g, 1-56 d of age	4107	4285	3942	3855	112	NS
FCR g/g , 1-56 d of age	2.30	2.45	2.68	2.70	0.179	NS
Carcass characteristics and internal organs						
Total edible parts, %	71.5	70.2	68.4	69.4	1.25	NS
Breast, %	19.0	17.6	19.3	17.5	1.24	NS
Back, %	15.4	15.5	15.5	14.8	0.60	NS
Thigh, %	21.5	21.1	20.1	21.0	0.49	NS
Liver, %	2.31	2.25	2.46	2.76	0.28	NS
Gizzard, %	2.22	2.37	2.03	2.00	0.12	NS
Pancreas, %	0.25ab	0.26a	0.26a	0.24b	0.036	0.05
Spleen, %	0.18	0.21	0.25	0.19	0.059	NS
Plasma constituents						
Plasma glucose (mg%), 56 d of age						
Plasma protein (g/100ml) 56 d of age	153	143	139	126	9.94	NS
GOT (IU/L), 56 d of age	4.12	3.42	4.14	3.80	0.49	NS
GPT (IU/L), 56 d of age	3.68	3.76	4.48	3.76	0.41	NS
Tibia breaking strength (kg), ash, Ca and P, %	11.8b	7.53c	18.6b	40.7a	1.67	0.05
Tibia breaking strength, kg	6.68	6.68	6.67	6.69	0.201	NS
Tibia ash, %	36.3	39.0	38.1	35.1	1.99	NS
Tibia Ca, %	12.5	14.8	14.0	11.6	1.01	NS
Tibia P, %	6.40	6.51	6.24	5.73	0.27	NS
Breast meat analyses and water holding capacity and shearing force of thigh meat						
Moisture, %	72.0	70.4	70.8	71.8	0.48	NS
Protein, %	23.4	22.7	23.2	20.9	1.72	NS
Ether extract, %	3.36	2.89	3.13	3.51	0.49	NS
Ash, %	1.21	1.18	1.27	1.10	0.09	NS
WHC, % bound water	90.3	89.5	91.6	90.6	2.27	NS
Shearing force kg/40 g meat	189	139	149	12.1	132	NS
Plasma mineral constituents						
Ca, mg/100 ml	9.84	9.76	6.11	5.80	0.77	NS
P, mg/100 ml	3.68	3.53	2.90	2.60	0.41	NS
Na, meq/L	118	115	112	110	4.36	NS
K, meq/L, %	10.5	7.17	5.43	5.43	0.77	NS
Mg. Mg/100 ml	3.80	3.70	3.12	3.07	0.48	NS

a-c Means within the same row not sharing a common superscripts differ significantly (P<0.05).

for total edible parts, internal organs, plasma glucose and total protein. Including DGSM as Ca and P supplements affected neither the tibia breaking strength nor its mineral contents. Breast meat moisture, protein, fat, and ash contents and plasma mineral constituents were not affected, too.

Trial 4

It was found that including different levels of DGSM in broiler diets replacing the same percentage of the control diets had no adverse effects on growth, feed intake, FCR, as well as on protein and energy utilization of broilers (Table 6). The negative impact of Giant Snail in the environment has been reported, previously (Mead, 1961). Even though, DGSM contains a considerable amount of nutrients and minerals for animal nutrition. The lower contents of protein 15.2% CP and energy 4.80 MJ/kg of DSGM may be due to its higher contents of ash 47.8%, Ca 24.2% and crude fiber 22.2%, too. These results reflected the effect of shell on nutrients and mineral contents of snail meal. In this regard Creswell and Kompiang (1981) and Elmslie (1982) found that the meat of snail meal contained 60% CP, 2% Ca, 0.8% P, 4.35% lysine, 1% methionine and 0.6% cystine on a dry matter basis. Others (Nadazdin *et al*., 1988) analyzed the shells of the grape snail (Helix pomatia) and reported that it contained 97.1% ash, 387 Ca, 0.35 P, 0.25 Mg, 0.35 Na, and 0.66 K g/kg. The differences in nutrient contents in snail meal between the aforementioned studies and the present one may be due to the use of the whole DGSM (meat shell) herein and meat only in others. Furthermore, the chemical analysis of snail meal depends on the kind of snails and origin as reported by Venugopalan *et al.*, (1976). Results of trial 1 indicated that using 0.2% of DGSM in broiler diets improved growth by 7.42% and FCR by 9.28%. This improvement is corrected by the slight higher feed intake (1.64%) of this group compared to the control group (Table 3), indicating that DGSM improved the palatability as well as mineral contents of the diets and enhanced nutrient utilization. Thomas and Ramachandran, (1976) indicated that there was no adverse effect of snail meal on palatability of pig diets. It was found that mortality rate was not affected by different DGSM levels in trials 1–4, indicating that DGSM had no adverse effect on live ability of broilers. Also, Elmslie (1982) showed that flesh of snail meal replacing fishmeal up to 15% of the diet had no negative effect on performance of broiler chicks. Including DGSM in broiler diets above 2% in trial 2 and at 1.5% in trial 3 depressed growth and impaired FCR. Low availability of nutrients in snail meal could account for the decline in broiler performance (Maurice *et al*., 1984), due to the negative effects of the higher levels of Ca and ash as well as crude fiber on nutrients and ME utilization (Carroe´, 1990). Also, Ca and P imbalance in DGSM and accordingly dietary Ca and P% as well as the gradual increase in dietary crude fiber (Tables 1 and 2) may be a contributing factor to the depressed growth and poor FCR shown in trial 2 and 3. Dietary imbalance of Ca and P was shown to decrease broiler performance (Nelson *et al.*, 1990; Ewing *et al.*, 1995; El-Deeb *et al.*, 2000). Additionally, increasing dietary magnesium contents especially when

Table 5: Effect of using dried Giant Snail meal as mineral supplement on performance, carcass characteristics and body organs as well as plasma constituents of broiler chicks (Trial 3)

Parameter	Proportion of Giant Snail meal		SEM	P value
	0.0%	1.5%		
Performance of broiler chicks				
Initial body weight g, 1 day of age	49.0	48.0	2.27	NS
Body weight g, 8 wk of age	1926 a	1668 b	120.5	0.05
Weight gains, 1-56 d of age	1877 a	1620 b	114.2	0.05
Feed intake g, 1-56 d of age	4340	4190	76.4	NS
FCR g/g , 1-56 d of age	2.31	2.59	0.049	NS
Carcass characteristics and internal organs				
Total edible parts, %	71.5	73.2	1.56	NS
Breast, %	19.0	20.1	1.34	NS
Back, %	15.4	16.0	0.87	NS
Thigh, %	21.5	20.0	1.01	NS
Liver, %	2.31	2.28	0.28	NS
Gizzard, %	2.22	2.02	0.90	NS
Pancreas, %	0.25	0.21	0.24	NS
Spleen, %	0.18	0.16	0.023	NS
Plasma constituents				
Plasma glucose (mg%), 42 d of age				
Plasma total protein (g/100ml) 42 d of age	152	142	1.54	NS
Tibia breaking strength (kg), ash, Ca and P, %	3.55	3.19	0.34	NS
Tibia breaking strength, kg	6.68	6.68	0.012	NS
Tibia Ca, %	12.5	14.3	0.79	NS
Tibia P, %	6.40	6.44	0.186	NS
Breast meat analyses and water holding capacity and shearing force of thigh meat				
Moisture, %	72.0	72.0	2.54	NS
Protein, %	23.4	23.2	2.21	NS
Ether extract, %	3.36	3.65	0.49	NS
Ash, %	1.21	1.10	0.10	NS
WHC, % bound water	90.3	90.3	1.53	NS
Shearing force kg/40 g meat	189	160	19.0	NS

a-b Means within the same row not sharing a common superscripts differ significantly (P<0.05).

DGSM was fed at 4 or 6% may also contribute to the observed depression in growth rate of broilers shown in trial 2, but not in trial 3 (Bondi and Drori, 1987). It should be mentioned, however, that the decrease in performance in trial 2 was also correlated with significantly higher serum GPT levels when DGSM was fed at 6%, which may reflect toxic changes in liver and intestine (Arockiam *et al.*, 1992). In this regard, Creswell and Kompiang (1961) stated that an inhibitor was present in the raw snails that depressed growth when the meal was including in the diets at levels above 10%, meanwhile boiling the snails for 15-20 min completely overcame the negative impact which may be confirmed by the present findings. The results of trial 4 showed that DGSM had no negative effects on performance and protein and energy utilizations of broilers when fed for shorter feeding period during 7-28 d of age (Table 6). The differences in response to dietary DGSM observed herein could be elucidated by the length of feeding trial, suggesting that DGSM may be fed at 6% only in grower or finisher diets for broilers. Similarly Creswell and Kompiang (1981) indicated that snail meal without shell either raw or boiled gave excellent performance of broilers. Also, Ulep and Buenafe (1991) included snail meal in broiler diets at 0, 4, 8 and 12% and found that final body weight was not affected by feeding dried-shelled snail meal. The results indicated that DGSM had no adverse effects on total edible parts percentage as well as body organs due the lack of the significant effects on these parameters (Tables 3, 4, 5). These results are expected due to the similarity in protein level within each experiment. This was further confirmed by the lack of the adverse effects of different levels of DGSM used in trials 2 and 3 on the chemical compositions and WHC of breast meat as well as shear force of thigh meat. It is also clear that DGSM meal provided enough Ca and inorganic P for optimum bone deposition in trials 2 and 3, since there was a lack of significant differences in bone ash, Ca, and P as well as bone breaking strength (Tables 4, 5). However, there were slightly insignificant decreases in tibia ash and Ca when DGSM was fed at 6% (Table 4). This was further confirmed by the lack of significance in plasma mineral content measured in trial 2 (Table 4). Results also indicated that Ca and P required for optimum bone deposition is higher than that needed for growth and FCR. Since increasing Ca and P content of the diet as a result of increasing dietary snail meal depressed growth and FCR in trials 2, 3, and had no significant effects on tibia parameters.

Conclusion

It is concluded that DGSM could be included in broiler diets up to 2% without adverse effects on performance, total edible parts and internal organs. However, middle or a large scale experiment is required to confirm results of performance and relative weight of organs. However, more research is needed to optimize its use in poultry feeding and to eliminate its negative impact on the environment.

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