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USE OF DIETARY FENUGREEK (*Trigonella foenum-graecum* L.) SEED FOR THE PRODUCTION OF SAFE BROILER LEAN MEAT

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ABSTRACT

An experiment was conducted for a period of 28 days to determine the dietary effect of fenugreek seeds (FGS) on the productive and economic performances of broilers. A total of 400 day-old Hubbard Classic straight run broiler chicks were randomly allocated to 5 iso-nitrogenous and iso-caloric dietary treatment groups, each having 80 chicks in 4 replications of 20 numbers, in a completely randomized design (CRD). Broilers were fed *ad libitum* on either basal diet with (positive control) or without (negative control) 0.1% antibiotic (used as antibiotic growth promoter; AGP) or basal diet containing 1.0%, 2.0% or 3.0% FGS. There were no differences in live weight, feed intake and feed conversion ratio (FCR) among the treatment groups for broilers up to 14 days of age ($P>0.05$). Broilers fed on the diet containing FGS exhibited significantly better productive performances than those fed on AGP ($P<0.01$). However, the highest productive performances were recorded for the 2.0% FGS-fed broilers in all treatment groups, followed by broilers received 1.0% and 3% FGS ($P<0.01$). Inclusion of dietary FGS at 2% level resulted in higher dressed carcass, breast, thigh and drumstick meat weight compared to any other level of the FGS inclusion in broiler diet ($P<0.01$). Unlike the AGP, addition of 2% FGS to the diet significantly reduced abdominal fat ($P<0.01$). With regard to economic performance, broilers fed on diet containing 2% FGS fetched highest profit in the dietary treatment groups. Inclusion of FGS in broiler diet resulted in lower feed cost and higher profit compared to the inclusion of AGP in the diet. It may be concluded that supplementation of FGS in diets may be useful for efficient and economic production of broiler. The inclusion of FGS at 2% level in broiler diet may be profitable in the production of lean meat of broilers.

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INTRODUCTION

It is well recognized that broiler farming is a highly lucrative business enterprise in poultry industry due mostly to the high efficiency of modern broiler strains for converting low quality feed to high quality meat for human consumption as well as their minimal land requirement and quick monetary turnover that in turn encouraging small, medium and large scale poultry farmers to get involved in broiler production. Moreover, the consumption pattern has been shifted from red meat (beef, mutton, lamb, pork) to white meat (broiler meat) due to high saturated fat and cholesterol content of the red meat (Daniel et al., 2011). A regular consumption of red meat has been shown to be directly associated with cardiovascular disease (Micha et al., 2010 and Pan et al., 2012), stroke (Kaluza et al., 2012), type 2 diabetes (Micha et al., 2010 and Pan et al., 2011), obesity (Wang and Beydoun, 2009 and Vergnaud et al., 2010), certain cancers (Cross et al., 2007, Ma and Chapman, 2009 and Pan et al., 2012) and earlier death (Pan et al., 2012). In consequence, the global production and per capita consumption of broiler meat have been increased rapidly in the recent years (Caracalla, 2009).

However, safe broiler meat production always requires maintaining good health, reducing disease outbreak and improving immunity of broilers, because the fast growing broilers are mostly susceptible to invasion of pathogenic microorganisms. Antibiotics are known as health care miracle. They are widely used in veterinary field for reducing the incidence of diseases caused by microorganisms. The routine uses of low-doses or sub-therapeutic-levels of antibiotics often referred to as AGP in broiler feed have been a common practice for more than 50 years to prevent potential diseases as well as to robust gut health, increase meat yield and improve feed efficiency of broilers (Gaskins et al., 2002). However, a large number of studies have provided clear evidence that haphazard use of AGP in broiler feed throughout the production cycle contributes to the accumulation of antibiotic residues in edible meat entering the human food chain, thereby hastening the emergence of antibiotic-resistant bacteria, which poses a dire risk to consumer health (e.g. erosion of the effectiveness of life-saving drugs, persistence of infections and treatment failure) (Nisha, 2008 and Jallailudeen, 2015).

In response to consumer concerns about the safety and ethics of poultry production, the European Union has banned the use of antibiotics in animal production since 2006 (Anonymous, 2005). Subsequently, other developed countries have also limited the antibiotic use in poultry production and most of the feed industries in the developed countries removed all types of antibiotics from poultry feeds and launched the "antibiotic-free" labeled feed (Cogliani, 2011 and Tavernise, 2013). However, the scenario of indiscriminate practice of AGP in poultry feed is still existing in developing countries. It has therefore become a crying need of the time to immediate stop haphazard practicing AGP and start searching for cost-effective and health-promoting alternatives to antibiotics. In the recent years, there has been an increasing trend towards using safe, non-toxic and residue free herbal feed additives (HFA) as potential alternative to AGP. Several studies have shown that inclusion of HFA in broiler diet improves performance, enhances feed utilization and promotes gut health of broiler without having any residual effect on edible meat (Hashemi and Davoodi, 2010). Fenugreek (*Trigonella foenum-graecum* L.) or Methi (Bengali, Hindi and Urdu name) is an annual spicy herbal legume native to Mediterranean regions. It is now cultivated in other parts of the world. It has been reported that FGS contain neurin, biotin, trimethylamine which tends to stimulate the appetite by their action on the nervous system and stimulate growth by increasing the cholesterolemic effects (Al-Jabre, 2003). Chemical analysis studies have revealed that FGS contain protein, fat (especially the linoleic acid), total carbohydrates, vitamins (B-complex, A, D), minerals (calcium, phosphorus, iron, zinc and magnesium), PABA (Para-Amino Benzoic Acid), lecithin, choline, saponins, flavonoids and antibiotic compounds (Michael and Kumawat, 2003; Dixit et al., 2005; Mullaicharam et al., 2013; Mamoun et al., 2014). Studies have shown that it has the properties of lowering blood sugar level, anthelmintic, antibacterial, anti-inflammatory, antipyretic and antioxidant (Xue et al., 2007 and Murlidhar and Goswami, 2012). Some of the beneficial effects of fenugreek in human health include improvement of respiratory, stomach and intestinal health, kidney and liver functions, purification of blood and stimulation of immune system.

In poultry, there have been a few recent studies that tested feasibility of using FGS in the diet for the health benefit of broiler (Ahmad, 2005). Fenugreek seed powder has been shown to decrease plasma total lipids and cholesterol level in commercial broiler (Duru et al., 2013 and Mamoun et al., 2014). Studies also have shown that supplementation of either fenugreek seed extract (Khan et al., 2011), seed powder (Elagib et al., 2013), seed blended with turmeric (Abdel-Rahman et al., 2014) or seed with enzyme (Qureshi et al., 2016) improves the productive performance of broiler chicks. However, no studies have investigated the efficacy of whole fenugreek seed in broiler diet for the production of antibiotic-free lean meat of broiler. Keeping the above facts in view, the current study was therefore designed to examine the effect of different dietary levels of fenugreek seeds on productive performance, carcass characteristics of broiler as well as to assess economic impact of using fenugreek seeds in the diet of broiler.

MATERIALS AND METHODS

This study was conducted with a total of 400 day-old as hatched Hubbard Classic broilers for a period of 28 days to investigate the dietary effect of fenugreek seed on growth performance, feed intake, feed to meat conversion ratio and cost effectiveness of broiler production.

Experimental design

A total of 400 day-old experimental broilers were weighed and randomly distributed to 5 treatment groups (T1 = Basal diet, considered as negative control; T2 = Basal diet supplemented with 0.1% antibiotic (Renamycin), considered as positive control; T3 = Basal diet containing 1.0% fenugreek seed; T4 = Basal diet containing 2.0% fenugreek seed; T5 = Basal diet containing 3.0% fenugreek seed) following a completely randomized design. Each treatment was divided into 4 replicates. Each treatment group had 100 broilers having 20 broilers per replicate. Broilers in each replicate were treated as the experimental unit and diet was treated as the factor.

Formulation of experimental diets

The experimental diets were formulated using locally available quality feed ingredients including fenugreek seed. The formulation of balanced broiler starter and grower diets was done using "user friendly feed formulation done again (UFFDA)" MS Excel program based on the standard nutrient requirement of Hubbard Classic commercial broiler specified in the production manual. After formulation, the 5 starter and 5 grower diets as per treatments were prepared following the standard hand mixing method during the starter (0-14 days) and grower phase (15-28 days), respectively, of broiler rearing. The composition of the ingredients used in the balanced ration formulation and the calculated nutrients profile to meet the nutrient requirement of the broilers are shown in Table 1.

Management of experimental broilers

The broilers were reared in an open-sided, gable type broiler house with concrete floor. The area of the house was divided into 20 equal sized pens partitioned by wire mesh. Rice husk was placed at a depth of 5cm in individual pens. Brooding temperature was maintained at 33˚C for the first week by fixing a 200W-incandescent bulb to each pen. Temperature was then gradually decreased by 2.5˚C each week until the broilers got acclimatized with room temperature. Broilers were exposed to a continuous period of 23 hours lighting and a 1 hour of dark in every 24 hours to encourage full feeding during the period of experiment. Broilers under different feeding regimen were fed on starter diets during the first 14 days, thereafter fed on grower diets until they become 28 days of age. In all cases, feeds were offered *ad libitum* to all broilers. Potable water was made available at all times. Broilers were vaccinated during the experimental period as per recommendation of the manufacturer (Table 2).

Table 1. Composition of broiler starter (0-14 days) and grower (15-28 days) diets and nutrient profiles according to the treatments

Ingredient (%)	Dietary Treatment									
	Negative Control (Basal Diet; BD)		Positive Control (BD with antibiotic)		Fenugreek Seed (%)					
					1		2		3	
	Starter	Grower	Starter	Grower	Starter	Grower	Starter	Grower	Starter	Grower
Maize	60.83	63.83	60.83	63.73	60.22	63.33	59.33	62.33	59.00	61.34
Soybean meal	25.18	22.18	25.10	22.18	25.00	22.00	24.89	21.68	24.52	21.67
Propak	7	6.72	7	6.72	7	6.40	7	6.72	7	6.72
Soybean oil	4	4	4	4	4	4	4	4	3.7	4
Fenugreek seed	0	0	0	0	1	1	2	2	3	3
Dicalcium Phosphate	2.21	2.21	2.19	2.21	2.00	2.21	2.00	2.21	2.00	2.21
Common Salt	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
VMA premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.08	0.16	0.08	0.16	0.08	0.16	0.08	0.16	0.08	0.16
L-Lysine	0.12	0.32	0.12	0.32	0.12	0.32	0.12	0.32	0.12	0.32
Renamycin	0	0	0.1	0.1	0	0	0	0	0	0
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Values of Nutrient Content (%)										
ME (Kcal/kg)	3010	3230	3004	3210	3002	3206	2998	3200	3010	3196
Crude Protein	22.07	20.50	21.93	20.43	22.01	20.32	21.87	20.24	22.07	20.29
Crude Fiber	3.70	3.90	3.70	3.90	3.94	3.98	4.19	4.15	4.25	4.29
Calcium	0.98	0.95	0.95	0.95	0.94	0.95	0.93	0.95	0.93	0.94
Available Phosphorus	0.48	0.48	0.46	0.48	0.45	0.48	0.46	0.48	0.48	0.48
Lysine	1.00	0.97	1.00	0.97	1.00	0.97	1.00	0.97	1.00	0.97
Methionine	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Methionine + Cysteine	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Tryptophan	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sodium	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17

*VMA premix, Vitamin-mineral-amino acid premix.

Table 2. Vaccination schedule followed for the experimental broilers

Age (Days)	Name of Disease	Name of Vaccine	Trade Name	Type of Vaccine	Dose	Route of Vaccination
5	ND	BCRDV	BCRDV#	Live	One drop	Ocular
10	IBD	IBD	D-78*	Live	One drop	Ocular
21	IBD	IBD	D-78*	Live	One drop	Ocular

ND, Newcastle Disease; IBD, Infectious Bursal Disease; BCRDV, Baby Chick Ranikhet Disease vaccine, #Directorate of Livestock Services (DLS), Dhaka, Bangladesh; *Intervet International, B.V. BOXMEER, The Netherlands.

Processing of broilers

At the end of feeding trial, one broiler having near to pen average weight was taken from each pen for determining meat yield characteristics. Broilers were slaughtered and allowed to bleed completely. All slaughtered broilers were subjected to semi-scalding (51-55°C) for 120 seconds in order to loose feathers followed by removal of feathers by hand pinning. The procedure of carcass evisceration and dissection was followed as per standard method described by Jones (1984). The viscera, giblet (heart, liver and gizzard) and abdominal fat were removed and weighed for determination of meat yield characteristics. The hot carcass and the individual organs were separately weighted and they expressed as a percentage of live weight. The breast, thigh and drumstick were weighed individually and deboned to yield meat data.

Statistical analysis

All recorded data (body weight, body weight gain, feed intake, FCR, production cost, profitability, dressing yield and dressing percentage) were compiled in Microsoft Excel 2007 and were subjected to analysis of variance (ANOVA) in CRD employing SAS (2009) statistical package program. All significant and non-significant effects were identified by Duncan's New Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Live weight

The day-old broiler chicks were weighed individually at the time of random allocation to different dietary treatments. The initial live weights did not differ significantly (P>0.05) between the chicks (Table 3). The differences in body weights of broiler were not significant (P>0.05) during the first and second week of age. However, in relation to age body weights of broilers between the treatment groups tended to differ in response to their different feeding regimen (Table 3). Inclusion of FGS in either broiler starter or grower diet resulted in higher live weight compared to the control diet. Although AGP in the basal diet improved broiler growth, its efficacy was significantly (P<0.05) lower than did the FGS during the last two weeks of age of broiler. Body weight of broilers increased gradually with the increase of FGS inclusion level up to 2% in the diet. Broilers fed on high level (3%) of FGS exhibited significantly (P<0.05) lower growth performance than those on other levels of FGS (Table 3). The highest body weight was observed for the broilers fed on the diet containing 2% FGS during the whole period of feeding trial. Increase of live weight of broilers for the inclusion of FGS in the diet in the current experiment is coincided with the results reported by Abu-Dieyeh and Abu-Darwish (2008), Alloui et al. (2012) and Qureshi et al. (2015). They reported that addition of either whole, crushed or powder form of FGS at various levels in broiler diets increased live weight of broilers. However, the result of the present study contradicts with the findings of Abbas and Ahmed (2010), who reported that broilers supplemented with diet containing 1% or 2% FGS showed low live weight gain. The improvement of live weight of the broilers by FGS might be due to the fact that the FGS contain essential fatty acids and high quality proteins (Murray et al., 1991) as well as have stimulating effect on the villus height of digestive system of broilers (Hernandez et al., 2004; Hind et al., 2013; Mamoun et al., 2014; Mahmood et al., 2015).

Feed intake

The intake of feed by the broilers was increased gradually with the advancement of their age. It is revealed that the feed intake values during the first two weeks were merely numerically different but not statistically significant (P>0.05; Table 3) for the broilers in different dietary groups. Broilers received diet containing 2% FGS consumed the highest amount of feed at all ages followed by the broilers received 1% FGS, 3% FGS, AGP in the diet and basal diet alone. In this study it has been found that FGS when added in the diet up to the level of 2% stimulated feed intake of broilers which are in agreement with the findings of Michael and Kumawat (2003) and Alloui et al. (2012). It has also been shown that FGS contain galactomannans, neurin, biotin, trimethylamine which tends to stimulate the appetite, improve palatability and digestive process by their action on the nervous system and gut microflora which could be attributed to the increase in feed consumption (Michael and Kumawat, 2003 and Alloui et al., 2012). However, the affected feed consumption by the broilers in 3.0% FGS group in the current study might be due to the presence of bitter taste and pungent odor in FGS (El-Kloub, 2006). Other studies have also shown that addition of high level of ground FGS to the broiler diet decreased feed intake (Durrani et al., 2007 and Abbas and Ahmed, 2010).

Table 3. Live weight, feed intake, feed conversion ratio of broilers fed on different treatments

Variable (g/broiler)	Age (days)	Dietary Treatment					Level of significance (LSD⁺)
		Negative Control[A]	Positive Control[B]	Fenugreek seed (%)			
				1	2	3	
Live weight	0	42.9	42.3	42.7	43.1	42.2	NS (1.3)
	7	148.8	155.7	159.5	170.2	156.8	NS (24.7)
	14	350.2	368.8	392.9	402.2	371.9	NS (38.3)
	21	782.2^{a}	815.5^{a}	852.9^{b}	897.2^{bc}	822.5^{ab}	* (69.5)
	28	999.8^{a}	1065.9^{a}	1172.4^{b}	1251.6^{c}	1101.0^{ad}	* (68.9)
Feed intake	7	125.3	126.4	128.3	134.7	127.2	NS (8.1)
	14	409.9	428.6	430.9	453.0	429.9	NS (56.8)
	21	1236.4^{a}	1257.8^{ab}	1281.3^{b}	1316.3^{c}	1258.8^{ab}	* (28.7)
	28	2067.3^{a}	2084.2^{ab}	2115.9^{b}	2158.2^{c}	2092.4^{ab}	* (45.7)
Feed conversion ratio	7	1.19	1.12	1.10	1.06	1.11	NS (0.1)
	14	1.34	1.33	1.32	1.26	1.31	NS (0.2)
	21	1.67^{a}	1.64^{ab}	1.58^{b}	1.54^{bc}	1.62^{b}	* (0.04)
	28	2.16^{a}	2.04^{ab}	1.88^{b}	1.79^{bc}	1.98^{b}	* (0.1)

[A] Negative control, Basal diet; [B] Positive control, Basal diet containing 0.1% Renamycin. [abcd] mean values with dissimilar superscripts are significantly different (P<0.05). ⁺LSD, data in the parenthesis indicate the least significant difference value. NS, non-significant, P>0.05; *, P<0.05.

Feed Conversion Ratio

Inclusion of FGS in broiler diet resulted in lower FCR compared to the AGP inclusion in feed throughout the experiment. Broilers fed on basal diet alone exhibited the highest FCR at all ages. The differences in FCR were significant (P<0.05; Table 3) between the dietary treatment groups following the second week of age of the broilers. High inclusion (3%) level of FGS in the diet gave rise to higher FCR than any other inclusion level of FGS (Table 3). The present study revealed that FCR was lowered by the feeding FGS to the broilers compared to AGP feeding to broilers which is coincided with the study by Abu-Dieyeh and Abu-Darwish (2008) and AL-Beitawi and El-Ghousein (2008). Improvement in feed efficiency by FGS might be related to the development of the broiler chicks gut morphological changes of gastrointestinal tissues (Alloui et al., 2012; Amal et al., 2013; Mukhtar et al., 2013; Weerasingha and Atapattu, 2013)

Meat yield characteristics

Significant differences were obtained for the percentage of dressed weight, breast meat and abdominal fat between the treatment groups (P<0.05; Table 4). Broilers fed on diet containing 2% FGS yielded the highest meat in the breast and the lowest fat in the abdomen (Table 4). Inclusion of AGP in the diet however resulted in higher deposition of abdominal fat in broilers. Feeding control diet (basal diet alone) resulted in increased liver weight of broilers. There were no significant differences among treatment groups for the non-carcass (heart, liver and gizzard) yields (P>0.05; Table 4). It has been appeared from the present study that the weights of dressed carcass, thigh, drumstick and breast of broilers were increased and the weights of gizzard, liver and heart were decreased due to the inclusion of FGS in the diet. These results are in line with the findings of Durrani et al. (2007), Abbas and Ahmed (2010) and Alloui et al. (2012) who showed that broilers fed on 1% and 2% fenugreek seed powder exhibited higher dressing percentages compared to unsupplemented group. The current study results are in agreement with the reports of Mukhtar et al. (2013), who showed that feeding fenugreek seed powder to broilers decreased non carcass component (liver, gizzard and heart) weight. However, El-Ghammry et al. (2002) found that broiler chicks fed on diet containing very low levels (0.2% and 0.4%) of crushed FGS had low dressing percentage. However, in contradiction with the results of the current research Al-Beitawi and El-Ghousein (2008) reported that the supplementation of different levels of crushed or uncrushed fenugreek seed did not affect any of the carcass characteristics parameters. However, feeding FGS at 2% level clearly reduced the abdominal fat content in the present study. The abdominal fat is harmful for human health. Studies have shown that the FGS have the fat reducing activity by the presence of lecithin and choline in FGS (Dixit et al., 2005).

Table 4. Meat yield characteristics of broilers fed on different treatments

Variable (%)	Dietary Treatment					Level of significance LSD+
	Negative Control[A]	Positive Control[B]	Fenugreek seed (%)			
			1	2	3	
Dressed weight	54.33[a]	55.6[a]	61.10[b]	67.20[c]	57.10[a]	*(2.80)
Breast meat	11.54[a]	12.63[b]	13.77[c]	15.14[d]	2.34[b]	*(0.52)
Thigh meat	7.90	8.78	9.23	10.15	8.64	NS (1.63)
Drumstick meat	5.31	5.56	5.64	6.24	5.55	NS (0.80)
Abdominal fat	1.24[a]	1.48[b]	1.12[a]	0.94[c]	1.26[a]	*(0.15)
Gizzard	2.06	1.84	1.77	1.73	2.02	NS (1.04)
Heart	0.56	0.55	0.51	0.52	0.50	NS (0.06)
Liver	2.79	2.49	2.43	2.41	2.36	NS (0.57)

[A] Negative control, Basal diet; [B] Positive control, Basal diet containing 0.1% Renamycin. [abcd] mean values with dissimilar superscripts are significantly different (P<0.05). +LSD, data in the parenthesis indicate the least significant difference value. NS, non-significant, P>0.05; *, P<0.05.

Table 5. Cost of production and profit of broilers fed on different treatments

Variable	Dietary Treatment					Level of significance (LSD+)
	Negative Control[A]	Positive Control[B]	Fenugreek seed (%)			
			1	2	3	
Final body weight (kg/broiler)	999.8[a]	1065.9[a]	1172.4[b]	1251.6[c]	1101.0[ad]	*(68.9)
Total feed intake (kg/broiler)	2067.3[a]	2084.2[ab]	2115.9[b]	2158.2[c]	2092.4[ab]	*(45.7)
Feed price (BDT/kg)	33.05	33.62	33.20	33.60	33.80	-
Feed cost (BDT/kg broiler)	68.37[a]	65.80[a]	60.01[b]	57.99[b]	64.42[a]	*(4.47)
Feed cost (BDT/broiler)	68.32[a]	70.07[b]	70.25[b]	72.51[c]	70.72[b]	*(1.52)
Other costs (BDT/broiler)	40.00	40.00	40.00	40.00	40.00	-
Total production cost (BDT/broiler)	108.32[a]	110.07[b]	110.25[b]	112.51[c]	110.72[b]	*(1.51)
Total production cost (BDT/kg broiler)	108.37[a]	105.80[a]	100.01[bd]	97.99[cd]	104.42[ab]	*(4.47)
Return/broiler (Sale price BDT120.00/kg broiler)	119.98[a]	127.91[a]	140.69[b]	150.19[c]	132.12[a]	*(8.27)
Profit (BDT/broiler)	11.65[a]	17.84[ab]	30.44[c]	37.67[c]	21.39[b]	*(8.92)
Profit (BDT/kg broiler)	11.61[a]	16.64[ab]	25.82[c]	30.02[c]	19.13[b]	*(6.57)
Profit (BDT/kg broiler) over the control	-	5.03[a]	14.21[bc]	18.41[cd]	7.52[ab]	*(7.13)

[A] Negative control, Basal diet; [B] Positive control, Basal diet containing 0.1% Renamycin. [abcd] mean values with dissimilar superscripts are significantly different (P<0.05). +LSD, data in the parenthesis indicate the least significant difference value. NS, non-significant, P>0.05; *, P<0.05. BDT, Currency in Bangladesh. Conversion: 1 BDT = 0.013 USD or 0.012 EUR or 0.010 GBP.

Cost-effectiveness of broiler production

The calculated per kg feed prices for the basal diet alone, basal diet containing AGP, 1% FGS, 2% FGS and 3% FGS were BDT 33.05, BDT 33.62, BDT 33.20, BDT 33.60 and BDT 33.80, respectively. The price of feed per kg was increased for the inclusion of either AGP or FGS in the basal diet. However, higher feed price was recorded for the high inclusion level (2% and 3%) of FGS compared to either AGP or low level (1%) of FGS inclusion in the basal diet. The calculated total production costs per kg broiler were very high, high, moderate, low and very low for the basal diet alone, basal diet containing AGP, 3% FGS, 1% FGS and 2% FGS, respectively (P<0.05; Table 5). The net income in terms of per broiler generated from the sale of live broiler was the highest for 2% FGS treatment group followed by 1% FGS, 3% FGS, AGP and negative control group (Table 5). Consequently, the net profit per kg broiler was also recorded highest for the broilers fed on

2% FGS followed by 1% FGS, 3% FGS, AGP and basal diet alone (P<0.05; Table 5). Inclusion of FGS in broiler diet resulted in lower feed cost and higher profit compared to the inclusion of AGP in the diet. The present study clearly indicates that feeding FGS was the most cost-effective and had beneficial effect on profitability of broiler. These results were in line with the findings of Mukhtar et al. (2013), who reported that supplementation of fenugreek seed powder to broiler diet resulted in economic benefits. Mamoun et al. (2014) also recorded profit for the broilers fed on diets containing 1% FGS compared to 3% FGS group. Increase in the profitability of broilers fed rations containing herbal growth promoters may be attributed to the better efficiency of feed utilization, which resulted in more growth and better conversion feed to live weight gain.

CONCLUSIONS

On the whole, it is therefore concluded that the 2% level of FGS was superior in terms of live weight, FCR and cost-effectiveness over AGP and other levels of FGS in the diet. The 2% level of FGS can be used in broiler diets as an alternative to AGP for economic and efficient production of lean broilers.

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