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Research article

Variations in the nutrient content of the commercial broiler feeds manufactured by different feed companies in Bangladesh

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A B S T R A C T

The study was undertaken to investigate the variations in the chemical composition of different broiler starter and finisher feeds produced by different feed companies in Bangladesh. The test results of two hundred twenty different broiler starter and finisher feeds were collected from the Poultry Research and Training Centre (PRTC) laboratory of Chattogram Veterinary and Animal Sciences University, Chattogram, Bangladesh. Samples were analyzed in triplicate for dry matter (DM), crude protein (CP), crude fiber (CF), ether extracts (EE) and total ash (TA). Results indicated that there were significant ($p<0.001$) variations in the CP, CF, EE, TA, and P contents of the broiler starter feeds with the recommended standards. The CP varied from 18.7 to 25.5, CF 2.9 to 7.5, EE 5.0 to 8.1, TA 5.2 to 8.1 and P 0.4 to 1.0. Similarly, the CF, EE, TA, Ca, and P contents of the broiler finisher feed differed ($p<0.001$) with the recommended standards. The CF varied from 3.4 to 8.2, EE 3.8 to 9.8, TA 4.5 to 7.0, Ca 0.6 to 3.1, and P 0.4 to 1.1. Multiple correlation coefficient matrices indicated that there were significant ($p<0.05$) positive relationships between CF and CP ($r=0.25$), TA and CP ($r=0.39$) and P and Ca ($r=0.57$). However, Ca and CF were significantly ($p<0.05$) negatively correlated ($r= -0.22$) in the broiler starter feeds. Accordingly, there were significant ($p<0.05$) positive relationships of CF with CP ($r=0.34$), EE with CP ($r=0.30$) and CF and P ($r=0.20$), TA with CP ($r=0.33$) and P with TA ($r=0.27$) and Ca (0.66) in the broiler finisher feeds. It was concluded that all the commercial broiler feeds should be tested by the reference laboratories before use.

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1. INTRODUCTION

The poultry sub-sector is an important avenue for fostering agricultural growth and to reduce malnutrition for the people of Bangladesh (Begum, 2005; Alam et al., 2009; Begum et al., 2012; Akbar et al., 2013; Khaled, 2015; Ami et al., 2020). It is an integral part of the farming systems in Bangladesh which has created direct and indirect employment opportunity including support services for about 6 million people (Chowdhury, 2011). By increasing the productivity of poultry meats and eggs, the existing gap between demand and supply of animal protein can be bridged up rapidly. Further, poultry meat contributes around 37% of the total animal protein supply in Bangladesh (Akbar et al., 2013) which can be increased efficiently and rapidly to fulfill the shortage of protein through the increased formulation of broiler feeds (Raha, 2007a). Thus, the optimized feed formulation with good quality feed ingredients satisfying increasing nutrient demand of the birds and consistency of the feed quality round the year is important for the broiler industry (Ukil and Paul, 1992; Raha, 2007b; Nupur, 2010; Ali and Hossain, 2012; Islam and Uddin, 2014).

Selection for the fast growth has been the major focus in the broiler industry, and dramatic improvements have been achieved for extreme growth potentials over the last 40 years (Khan, 1998; Tixier-Boichard et al., 2012; Tallentire et al., 2016; Mollenhorst and Haas, 2019). Genetic improvements in growth rates have been established by meeting the nutrient requirements for optimal performance (NRC, 1994). Broiler birds have the dramatic genetic potential to convert feed into meat efficiently within a short period.. Therefore, feed quality is the first and foremost constituent that has been considered earnestly by the nutritionist as well as the producers to uphold the optimal productivity of the broiler chickens (Costa, 1981; Gous and Morris, 2005; Hoehler et al., 2006; Tallentire et al., 2017). Supplying quality feed to the birds, therefore,is a continuous concern of the producers since a change of diet often results in depressed performance (Chewning et al., 2012).

In Bangladesh, feed cost alone accounts 60-70% of the total cost of poultry production (Bulbul and Hossain, 1989). About 80% of the feed stuffs used in poultry ration are imported from outsides. As a result, the cost of feed prepared for poultry using grains are always high and is increasing over the time (Hossain et al., 2016). Therefore, the quality of ingredients available in the market as well as the readymade broiler feeds is questionable. Moreover, feed bags are not properly labeled by the manufacturers and sellers (Raha, 2007a)**.** Existing feed acts to monitor the quality of feed and their prices are weak. Moreover, quality control in the feed industry is very poor (Khan, 2002). Most of the feed millers minimize feed production cost either by the adulteration of inferior quality ingredients or inclusion of a lower proportion of valuable items like meat and bone meal, vitamin-mineral premix, soybean meal, maize etc. or by replacing with low-grade rice polish or other raw materials in the manufactured feeds.

Traditional broiler feeds are formulated in the small granule size in a very precise manner to ensure proper growth of chick carrying balanced nutrition with a comparatively higher content of crude protein and immune factors to maintain faster growth and challenge the stresses due to disease, climate and nutrition (Costa, 1981; Gous and Morris, 2005; Hoehler et al., 2006; Tallentire et al., 2017). Commercial broiler feeds have two major forms, i.e., crumble and pellet adapting the starter and finisher phases of boiler production. Boiler starter and grower feeds differ in nutritional composition to meet the varying levels of needs of broiler chickens at initial and later stages of production.The first two weeks of the life of broilers correspond to the major parts of their rearing period when the faster bone, muscle and immune system development takes place (Lilburn, 1998).Based on metabolic weight units, it was shown that the nutritional requirements of broiler chickens during the first two weeks of life were higher than the following weeks (Vieira and Moran, 1998)is very important to provide best quality feed at this stage. Systematic information regarding the consistency of the quality of broiler feeds manufactured in Bangladesh is scarce. We, therefore, aimed to investigate the extent of variations in the nutrient content of broiler feeds variable in the local market.

2. MATERIALS AND METHODS

The study was carried out in the laboratory of Poultry Research and Training Center (PRTC) at Chattogram Veterinary and Animal Sciences University, Khulshi, Chattogram-4225, Bangladesh. Test results of the two hundred twenty different broiler starter and finisher feed from different feed companies preserved in the offline documentary of PRTC laboratory were collected and recorded as secondary data. Other details, i.e., name of the companies, address, sample ID, data of receipt were recorded from laboratory register.

After collection, data were compiled in MS excel professional 2010. Data were sorted and compiled for further analysis. Sorting was done according to the date of receiving the sample. Data were analyzed for descriptive statistics, i.e., mean, minimum, maximum, standard error and confidence interval for CP, CF, EE, TA, Ca and P. One sample t-test was carried out using respective reference value to analyze the data in

Stata 14.1 SE (Stata Corp LP, College Station, Texas, USA).Distribution plots were fitted with the same statistical program.

For broiler starter feed, the reference standard thresholds were accepted 24, 5, 3.5, 5, 1.25 and 0.75 for CP, CF, EE, TA, Ca and P, respectively. For broiler finisher feed, the reference standards were 22, 3.5, 5, 5, 0.95 and 0.65 for CP, CF, EE, TA, Ca and P, respectively. Raw data were tested for the outliers and multicollinearity by inter-quartile range test and variance inflation factors. Normality of variable was examined by using a normal probability plot and equality of variances of the response variable was tested by the Shapiro Wilk test. Statistical significance was accepted at p<0.05 for Fisher's F-tests.

3. RESULTS

Broiler starter

The CP, CF, EE, TA, and P contents of the commercial broiler starter feedstested in the PRTC laboratory differed significantly (p<0.001) with the recommended standard specifications stated by the breeder's recommendations. The CP was lower, CF, EE, and TA were higher and Ca was as per requirements (Table 1).Multiple correlation coefficient matrices (Table 2) and distribution plot (Figure 1) indicated that there were significant (p<0.05) positive relationships between CF and CP (r=0.25), TA and CP (r=0.39) and P and Ca (r=0.57). However, Ca and CF were significantly (p<0.05) negatively correlated (r= -0.22).

Broiler finisher

Similar to broiler starter, the CF, EE, TA, Ca, and P contents of the commercial broiler finisher feeds tested in the PRTClaboratory differed significantly (p<0.001) with the recommended standard specifications stated by the breeder's recommendations. The CP, CF, EE, TA, and Ca were higher than the requirements (Table 3). Multiple correlation coefficient matrix (Table 4) and distribution plot (Figure 2) indicated that there were significant (p<0.05) positive relationships of CF with CP (r=0.34), EE with CP (r=0.30) and CF (r=0.20), TA with CP (r=0.33) and P with TA (r=0.27) and Ca (r=0.66).

Table 1. Estimated CP, CF, EE, TA, Ca and P contents of the tested broiler starter feeds.

Parameter[1]	Obs.	Mean	Min[2]	Max[3]	CV[4]	95% CI[5] Lower	95% CI[5] Upper	Sig[6].
CP	72	22.8	18.7	25.5	6.2	22.5	23.2	***
CF	97	5.4	2.9	7.5	16.4	5.2	5.7	***
EE	92	6.1	5.0	8.1	10.1	5.9	6.3	***
TA	97	6.3	5.2	8.1	7.6	6.1	6.4	***
Ca	92	1.2	0.7	3.2	27.9	1.1	1.3	NS
P	92	0.7	0.4	1.0	18.2	0.6	0.7	***

[1]CP = Crude protein, CF = Crude fiber, EE = Ether extract, TA = Total ash, Ca = Calcium, P = Phosphorus;[2]Minimum; [3]Maximum; [4]Coefficient of variation; [5]Confidence interval; [6]NS = Non-significant (p>0.05), *** = Significant (p<0.001).

Table 2. Multiple correlation coefficient matrices of the CP, CF, EE, TA, Ca and P contents of the tested broiler starter feeds[1].

Parameters	CP	CF	EE	TA	Ca	P
CP	1					
CF	0.2528*	1				
EE	-0.0331	0.0669	1			
TA	0.3853*	0.1707	-0.1816	1		
Ca	-0.1473	-0.2205*	0.0121	-0.1851	1	
P	0.0555	0.0435	-0.1127	-0.0233	0.5741*	1

[1]CP = Crude protein, CF = Crude fiber, EE = Ether extract, TA = Total ash, Ca = Calcium, P = Phosphorus; * = Significant (p<0.05).

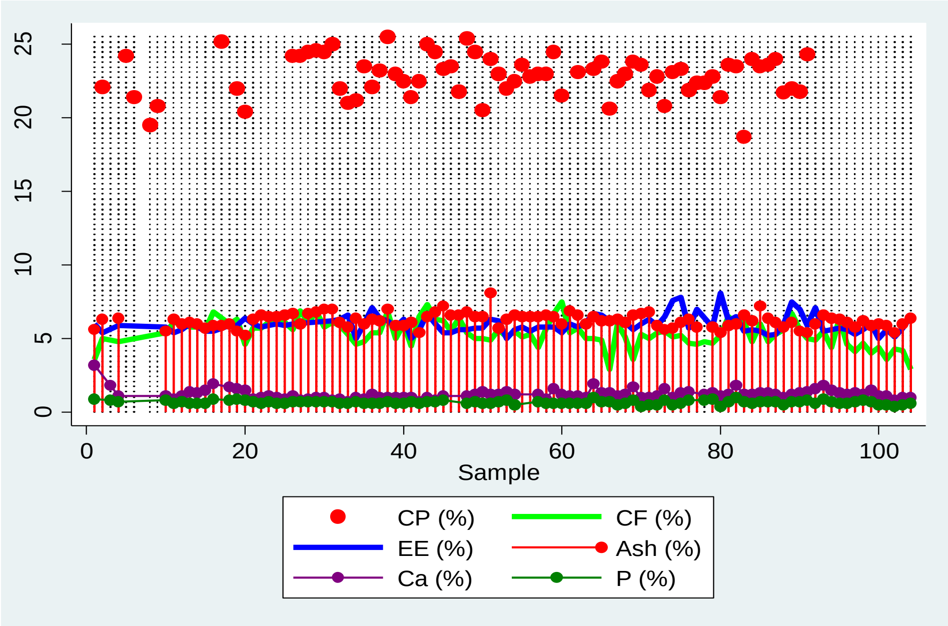

Figure 1. Distribution plot of the nutrient components in the broiler starter feeds (CP, scatter plot; CF, EE, line plot; Ash, spike plot and Ca, P, connected plot fitted with Stata 14.1 SE (Stata Corp LP, College Station, Texas, USA)).

Table 3**.** Estimated CP, CF, EE, TA, Ca and P contents of the tested broiler finisher feeds.

Parameter[1]	Obs.	Mean	Min[2]	Max[3]	CV[4]	95% CI[5]		Sig[6].
CP	74	21.8	19.5	24.6	5.6	21.5	22.1	NS
CF	109	5.5	3.4	8.2	17.3	5.3	5.8	***
EE	106	7.3	3.8	9.8	12.8	7.0	7.5	***
TA	110	6.0	4.5	7.0	8.5	5.8	6.1	***
Ca	104	1.1	0.6	3.1	32.2	1.0	1.2	***
P	103	0.6	0.4	1.1	21.7	0.6	0.7	***

[1]CP = Crude protein, CF = Crude fiber, EE = Ether extract, TA = Total ash, Ca = Calcium, P = Phosphorus; [2]Minimum; [3]Maximum; [4]Coefficient of variation; [5]Confidence interval; [6]NS = Non-significant ($p>0.05$), *** = Significant ($p<0.001$).

Table 4. Multiple correlation coefficient matrices of the CP, CF, EE, TA, Ca and P contents of the tested broiler finisher feeds.

Parameters	CP	CF	EE	TA	Ca	P
CP	1					
CF	0.3447*	1				
EE	0.3042*	0.2019*	1			
TA	0.3303*	0.1614	0.0957	1		
Ca	-0.1472	-0.0948	0.0248	0.1401	1	
P	-0.0267	0.037	-0.0477	0.2724*	0.6635*	1

[1]CP = Crude protein, CF = Crude fiber, EE = Ether extract, TA = Total ash, Ca = Calcium, P = Phosphorus; * = Significant ($p<0.05$).

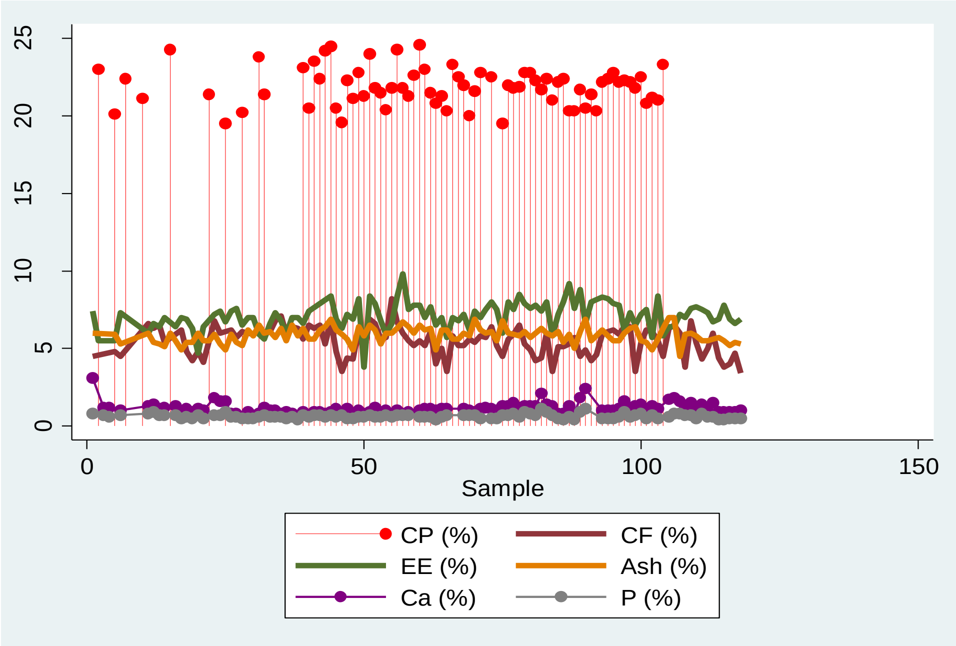

Figure 2. Distribution plot of the nutrient components in the broiler finisher feeds (CP, dropline plot; CF, EE, Ash, line plot and Ca, P, connected plot fitted with Stata 14.1 SE (Stata Corp LP, College Station, Texas, USA)).

4. DISCUSSION

Requirements of ME

Our study exhibited that the metabolizable energy (ME) contents of the tested feeds were variable. Estimating exact requirement of ME is complicated. Because, in poultry, heat production and its associated components have rarely been assessed (Noblet et al., 2010), and, thus inconsistent information on the efficiency of utilization of ME for fat and protein deposition is available (Boekholt et al., 1994). Growing broilers represent 52 to 64% of the total ME intake in heat production (Noblet et al., 2010)which is directly associated with the ME requirements for maintenance and production. Enhancement of the energy level of the diet in the finishing stage and a simultaneously slight decrease in protein level causes the birds to consume more calories for growth. It is partly because of the slight deficiency of protein and partly because of the high energy content of the diet. This excess energy is converted into body fat, thereby producing the desired body finish for the market broiler (Griffin et al., 1992; Summers et al., 1992; Zubair and Leeson, 1996; Tůmová and Teimouri, 2010).

The method of calculating ME seems to influence the partition of energy between maintenance and growth as fat and protein interfere efficiency of energy use. Close (1990) indicated that the differences in ME are affected by the changes in body compositionsince fat tissue contributes little to heat production compared with that of muscle. It was rather suggested that the requirements for ME are lower in fat animals than in lean animals (Close, 1990). In our country, commercial ration for broiler usually contains high CP and low energy for the starter and low CP and high energy for the finisher ration. But the experiment of (Lopez and Leeson, 2005) differed from our feeding program for broilers because a single diet with 18% CP and 3,100 kcal of ME/kg was used throughout the entire experimental period of 42 days (Leeson et al., 1996).

The maintenance of calorie protein ratio is necessary to get better FCR, body weight gain, and carcass quality for broilers. Reginatto et al. (2000) in two experiments with a different energy to protein ratio showed that protein utilization was improved with higher levels of dietary energy and with lower levels of dietary CP. Collin et al. (2003) noted that fat accretion increases when the energy to protein ratio of broiler diets increase. A range of calorie: protein ratio of 132 to 155:1 for broiler chicken was suggested which could be lowered to between 155 and 195 or 10% of the recommended levels when broilers are fed low crude protein concentration (Aftab et al., 2006).

Dairo et al. (2010) demonstrated that the calorie: protein values of low energy low protein (LELP) at the starter and finisher phases met the recommended values except for the low energy high protein (LEHP) (109.86:1 and 126.41:1). This perhaps explains the poor performance of broiler chickens fed with LEHP diet. The body fat deposition significantly increased in the birds fed high and normal energy inclusion in the diets resulting into a high calorie: protein ratio which agrees with the report of (Swennen et al., 2006). It can be concluded that with an adequate balance of calorie and protein diet could be fed broiler chickens for a good performance.

Requirements of protein

Protein is a vital nutrient for poultry and all other classes of animals. In virtue of its amino acid constituents, protein plays a significant role in growth, egg production, immunity, adaptation to the environment, and in many other biological functions. Optimization of protein supply requires a thorough understanding of the protein requirements of chickens and manipulation of protein supply to better suit various environmental conditions, health status of birds, and economics of feeding.

Broiler feeds are often formulated with 21-24% crude protein for the starter feed and 17-22% for the finisher feed. Our study indicated that the CP level of broiler starter and broiler finisher feeds were 22.8% and 21.8% in the tested diets. The starter diet with 22% CP promoted higher weight gain and better feed conversion ratio (Everaert et al., 2010). It is well established that rations low in protein cause an increased deposition of fat in the tissues due to the inability of the chicken to make productive use of the energy (Scott et al., 1976). The reason for this is that the diet does not contain sufficient protein for optimum growth and, so, the extra energy is converted to fat.

In tropical countries, a reduced feed intake implies a reduction in protein intake. It was reportedthat the improved weight gain and feed efficiency with high energy and high CP (25% in starter and 23.5% in finisher) in the diets of the broiler grown under acute heat stress of 29 to 42°C temperature and 45 to 89% relative humidity. Cheng et al. (1997) reported that feeding high CP diets with heat-stressed broilers adversely affected weight gain, carcass composition and efficiency of feed, protein and energy utilization.

The protein requirement of growing chicken includes the amount of protein needed for maintenance plus the amount needed for tissue growth with an allowance for the losses in the digestion and metabolism (Summers et al., 1964; Morris and Njuru, 1990; Leclercq and Guy, 1991; Kingori et al., 2003). Chickens may respond differently to the increased protein level in the diet, depending mainly on the protein quality and the amino acid profile thereof. With low-quality protein having inadequate and imbalanced amino acids, increasing dietary protein, in this case,maynot affect performance in terms of growth, feed efficiency and carcass traits, but may rather lead to the high mortality and leg problems, particularly in the finishing phase (Konashi et al., 2000; Swennen et al., 2007).

Requirements of crude fiber

Normally, dietary crude fiber (CF) has been considered an anti-nutritional factor and a diluent in non-ruminant diets. Many nutritionists have considered that the requirements of the broiler for CF are low and recommended to reduce its content in diets for broiler chick to less than 3.0-4.0% depending on the age (Swennen et al., 2010). Janssen and Carré (1985) indicated that the fibrous components of the food had negative effects on growth performance of the broiler chicks. In fact, these authors reported a strong negative correlation between CF of the diet and protein and ether extract digestibility. Increasing the CF content of the diet from 3 to 9% reduced growth performance and impaired nutrient retention in turkeys reported by Sklan et al. (2003). Recent studies have documented the beneficial effects of CF on the growth performance and influence on gut health including non-specific colitis and other enteric disturbances, changes in the intestinal microflora and also gizzard activity and motility of the gastrointestinal tract. It has also been proposed that the inclusion of the moderate amount of fiber in diets for broilers may have positive effects on gizzard activity, motility of the GIT, gut health, and growth performance of non-ruminant animals (Montagne et al., 2003).

Chemical composition and fermentative capability, as well as the grade of lignification of the source of CF, may affect growth and distribution of the species and the total population of the resident microflora in the GIT. Also, the lack of fiber in the diet may cause dilation and poor development of the walls of the Proventriculus and gizzard (Svihus, 2011) that might affect their functionality. The inclusion of structural crude fiber increases the size and holding capacity of the gizzard (Svihus, 2011; Jiménez-Moreno et al., 2013). The gizzard is responsible for a complete grinding of feed and a well-regulated feed flow as well as whole GIT motility. Grinding of the fibrous ingredients might modify the native structure of the fiber and in consequence, the physicochemical properties of the digesta, the passage rate and development of GIT (Amerah et al., 2007; Jiménez-Moreno et al., 2010).

Fiber represents the indigestible component in poultry diets. It was reported that (Amerah et al., 2007; Jiménez-Moreno et al., 2010) reported a strong negative correlation between CF content of the diet and protein and fat digestibility in broilers and concluded that low CF diets improve poultry performance. Contrastingly, Hetland et al. (2003) reported that the inclusion of 10% insoluble fiber in the diet increased the ileal digestibility of starch and stimulate gizzard activity. Diets high in fiber usually contain a low energy density that may decrease feed intake and feed conversion ratio in broilers. The inclusion of crude fiber that leads to more acid mucins such as insoluble fiber, appears to increase the potential of mucus to resist attack by bacterial enzymes favor the elimination of pathogens. Kalmendal et al. (2011) reported that the inclusion of sunflower meal, an insoluble source of crude fiber, was associated with a significant decrease in colony counts of Clostridium spp. Under commercial conditions, birds require a minimum amount of fiber for optimal performance.

Fats and oil in broiler nutrition

In addition to ME and CP, fat is another typical nutrient that should present in the broiler diet at standard level. The addition of fat to diets, besides supplying energy, improves the absorption of fat-soluble vitamins, diminishes the pulverulence, increases the palatability of the rations, and increases the efficiency of the consumed energy. Furthermore, it reduces the passage rate of the digesta in the gastrointestinal tract, which allows better absorption of all the nutrients present in the diet. Fats and oils in commercial broiler feeds are expressed as ether extract (EE). In poultry diets, animal fats and vegetable oils are mostly included in diets because of their high energy concentration to support growth performance (Blanch et al., 1995). Birds are not able to synthesize all the fatty acids and thus, some are considered essential fatty acids. Linoleic (18:2, n-6) and linolenic (18:3, n-3) fatty acids are recognized as metabolically essential. Noy and Sklan (1995) studied the digestion and absorption of fats in young birds (1-21 days) and have reported that the true digestibility of the unsaturated fat in four-day-old birds was higher than 85% increasing a little on the subsequent days. This demonstrates that the activity of lipases and bile salts on the fourth day of age were enough for the complete fat digestion. It was concluded that fat digestibility is not a limiting factor for the growth of young birds. According to Freitas et al. (2011), broilers show high digestibility of fat on the first week of life and the inclusion of oil in the initial diet promotes a better performance of the chickens until 21 days of age. During the first three weeks of age, chicks fed diets with oil have shown higher apparent digestibility values of ether extract than the ones that received rations without oil. It was also found that higher abdominal fat was observed in broilers that consumed ration with palm oil which is rich with saturated fatty acids. In this context, Sanz et al.(2000) reported that the utilization of saturated fats resulted in greater abdominal fat deposits than unsaturated fats which may be used for other metabolic purposes.

Requirements of other nutrients

Calcium (Ca) and total phosphorus (P) levels should be minimum 1% and 0.7%, respectively while available phosphorus is necessary to be minimum 0.45% in all types of broiler rations. The NRC, (1994) recommended Ca levels are 1.00, 0.90, and 0.80% for the starter (0 to 21 d), grower (21 to 42 d), and finisher (42 to 56 d) feeds, respectively. The amount of Ca in the broiler diet has economic importance. Excess dietary Ca interferes with the availability of other minerals, including phosphorus, magnesium, manganese, and zinc (NRC, 1994). High levels of Ca may reduce the energy value of the diet by chelating a portion of the available lipid fraction, thus rendering some lipids unavailable for absorption (Driver et al., 2005; Beski et al., 2015). The decreased amount of Ca in the broiler diet may improve performance and increase profitability; however, this can occur leg problems. The (NRC, 1994) requirement for Ca during the grower phase is largely based upon studies conducted by several investigators (Waldroup et al., 2000; Yan and Waldroup, 2006) showed that Ca was required at significantly greater concentrations in the diet for maximum bone mineralization compared with growth.

In broiler diets, DCP, limestone, oyster shell etc. are used as a source of calcium and phosphorus. Furthermore, diets during the grower phase were formulated to contain either a low (17%) or a high (23%) level of protein, for poor and superior feed efficiency, to emulate the effect on Ca requirements of the superior feed efficiency of the modern broiler compared with older, less efficient broilers. Rao et al. (1999) reported that high or low dietary phosphorus content may adversely affect bird performance. However, in the current study, when dietary Ca:P ratio was 2:1 for 1-21-day-old broilers, an improvement was observed with graded dietary P. Broilers require high levels of available phosphorus at the starter phase. However, during the grower and finisher phases, this amount may be reduced. At the starter phase of rearing (1-10 days of age), a high level of phosphorus is required to maximize bone parameters. The use of Ca:P ratio at 2:1 led to a reduction of dietary levels of phosphorus without compromising the performance and mortality of birds.

In addition to the major components broiler diet also contain a certain amount of vitamins, minerals and essential amino acids to maintain optimum production. However, these compositions vary widely among different feed companies. This unusual variation in the composition of broiler feeds contributes in uneven production that makes a complex situation and therefore, the current study was conducted to analyze the variations in the nutrient content of broiler feeds available in market around the year.

5. CONCLUSION

The quality of broiler feeds tested in the PRTC laboratory appears variable. But these variation thresholds do not exceed standard margins. All commercially manufactured broiler feeds should pass the systematic quality test in the reference laboratories before using them for feeding broilers.

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