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Apparent metabolizable and nitrogen-corrected apparent metabolizable energy values of local feedstuffs and by-products for broilers

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Abstract

The nutritional quality of feed ingredients varies due to differences in crop varieties, agronomic and climatic conditions, and industrial processing in different parts of the world. The objective of the present study was to analyze the apparent metabolizable energy (AME) and nitrogen-corrected apparent metabolizable energy (AMEn) values of wheat, corn gluten 30% and fish meal at different growth stages of commercial broilers. In addition, the effect of the inclusion of these feed ingredients was investigated on feed intake, growth rate and feed efficiency of broilers. Four experimental diets were formulated, a basal diet containing corn and soybean meal (diet-A), which was partially replaced with wheat (150 g/kg; diet-B), corn gluten 30% (84.5 g/kg; diet-C), and fish meal (40 g/kg; diet-D). Two hundred and forty day old broiler chicks were randomly divided into 24 pens (10 chicks per pen). Each experimental diet was fed to birds in6 replicate pens. The excreta were collected over a period of 48 h post feeding from each pen on day 22 and day 32 of experiment. The results showed that the weight gain, feed intake and feed conversion ratio increased with the advancement of age in all the dietary groups, however, birds fed on corn gluten 30% were more efficient in feed utilization compared to the other diets. The AME and AMEn values were significantly ($P<0.05$) differed between the experimental diets and age stages of the birds. The new obtained database on the AME and AMEn values of local feed ingredients can be very helpful to formulate the broiler rations by including these local feed ingredients to decrease the production cost without decline in growth rate.

Key words: wheat, corn gluten 30%, fish meal, apparent metabolizable energy, nitrogen-corrected apparent metabolizable energy, broilers

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Introduction

Extensive research has established that feed is the major contributor (around 70%) to the cost of broiler production (Atilgan et al., 2010), and energy is the largest and expensive component of the poultry ration. Better understanding of the requirements of metabolizable energy (ME) and the ME bioavailability of the feedstuffs are necessary to optimize feed efficiency and growth rate in terms of meat production for broilers. The ME value of feedstuffs depends upon the chemical composition which varies due to differences in climatic and agronomic conditions in different locations (Vohra, 1966). In addition to inherent variation in feed types, the ME of feed is influenced by age of birds, sex of birds, type of birds, enzyme supplementation and temperature (Sibbald et al., 1981; Bennett et al., 1995). The efficiency to utilize the energy and nutrients of feed increases with the advancement in age of broilers (Farrell, 1974). Fuente et al. (1998) found 4% higher apparent ME (AME) value for 30 days old birds compared to the 10 days old chicks. Moreover, performance of growing broiler and their meat composition are influenced by the ME intake (Morris, 2004). The ME intake is partitioned into energy retained in body tissues mainly as fat and protein, and as heat production (Lawrence and Fowler, 2002). Generally, broilers deposit energy into body tissues more efficiently compared to other poultry species (Leeson and Summers, 2001).

Most of the nutritionists in Pakistan and South Asian countries rely on average book values of the ME of feed ingredients for ration formulation. The quality of local feed ingredients commonly used in the broiler diets varies due to differences in climatic conditions, crop varieties and agronomic conditions (Lodhi et al., 1976). Due to the large inconsistencies in the quality of tropical feed ingredients, it is difficult to predict the actual ME of these feed ingredients without producing a reliable and reproducible data on the bioavailable energy content. In Pakistan, research has been done on the ME content of local feed ingredients with adult cockerels (Nadeem, 1998), but very limited information available in the literature for broilers. The inadequate information on the ME and AME values restricts the use of local feed ingredients in the broiler diets. The accurate information on the AME values of the local feed ingredients will help broiler farmers to incorporate these ingredients in broiler rations, which will not only decrease the feed cost but will also ensure the efficient use of available feed resources.

The objective of this study was to analyze the different local feed ingredients for AME and nitrogen-corrected AME (AMEn) values at two growing stages of commercial broilers. In addition, the effect of the inclusion of local feed ingredients in broiler ration was investigated on the feed intake, growth rate and feed efficiency.

Materials and Methods

Experimental diets

Four experimental diets were formulated at Institute of Animal Nutrition and Feed Technology, University of Agriculture Faisalabad, Pakistan. The diets were formulated from mainly five feed ingredients (corn, soybean meal, wheat, corn gluten 30% and fish meal); which are most commonly used in poultry rations in Pakistan and other Asian tropical countries. The basal diet (diet-A) contained mainly corn and soybean meal. In other diets, the corn was partly replaced with wheat (150 g/kg; diet-B), corn gluten 30% (84.5 g/kg; diet-C) and fish meal (40 g/kg; diet-D). Ingredient composition of the experimental diets is presented in Table 1.The four diets were formulated on iso-nitrogenous and iso-caloric basis. The chemical composition of all the experimental diets is presented in Table 2.

Birds, feeding and housing

Two hundred and forty broiler chicks were weighed on first day and after brooding (7 days) they were randomly divided into 24 experimental pens (10 chicks per pen). The area of each experimental pen was 12 square feet. The chicks were fed on ground maize for first 3 days. Standard commercial ration was fed to the birds from day 4 to day 11 of experiment. From day 12 to day 42, experimental diets were fed to the birds. Each experimental diet was fed to birds of six experimental pens (six replicates per experimental diet). The birds were fed ad libitum and had 24 h/d access to fresh water. The birds were exposed to continuous fluorescent light and proper ventilation was provided.

Table 1. Ingredient composition (g/kg DM) of four experimental diets.

Feed ingredients	Diet-A	Diet-B	Diet-C	Diet-D
Corn	612.9	500.0	500.0	600.0
Soybean meal	329.0	300.9	334.5	295.8
Wheat	0	150.0	0	0
Corn gluten 30%[1]	0	0	84.5	0
Fish meal	0	0	0	40.0
Vegetable oil	20.0	12.8	42.5	23.1
L-Lysine	0.5	0.3	0.5	0
DL-Methionine	1.2	1.0	1.5	1.1
Limestone	16.4	15.0	16.5	20.0
Dicalcium phosphate	10.0	10.0	10.0	10.0
Premix	10.0	10.0	10.0	10.0

[1]Corn gluten contained 30% crude protein.

Table 2. Chemical composition (%) of experimental diets[1].

Variable	Diet-A	Diet-B	Diet-C	Diet-D
Dry matter	89.6	89.2	89.9	89.8
Crude fibre	2.5	3.6	2.7	3.2
Crude protein	20.0	19.8	19.9	19.9
Calcium	1.0	1.0	1.0	1.2
Potassium	0.9	0.8	0.8	0.7
Phosphorous	0.5	0.6	0.5	0.6
Lysine	1.1	1.1	1.1	1.1
Methionine	0.5	0.5	0.5	0.5
Metabolizable energy (kcal/kg)	3189	3195	3190	3194

[1]Diet-A, basal diet (corn and soybean meal); Diet-B, basal diet partially replaced with wheat (150 g/kg DM); Diet-C, basal diet partially replaced with the corn gluten (84.5 g/kg DM); Diet-D, basal diet partially replaced with fish meal (40 g/kg DM).

Vaccination schedule, data recording and excreta collection

Birds were vaccinated against Newcastle and Gumboro on day 7. Gumboro vaccination was repeated on day12, 18 and 26, and Newcastle on day 30 of experiment. During the experimental period, the data on body weight gain and feed consumption was recorded on weekly basis and the feed conversion ratio (FCR) was calculated.

Excreta were collected over a period of 48 h post feeding from each pen on day 22 and day 32 according to the procedure used by Waqas et al. (2011). Plastic sheets were spread on the floor of each pen to avoid contamination with the bedding material. After every six hours, excreta were collected from each pen. Feathers and foreign particles were thoroughly removed from the excreta. The collected excreta samples were placed in the ice box and immediately transported to the laboratory. Excreta samples were weighed, homogenized, oven dried and ground for chemical analysis.

Chemical analysis and calculations

Feed and excreta samples were analyzed for dry matter (DM), ash, crude protein (CP) and gross energy (GE). The DM content was determined by drying samples in the oven at 105°C overnight and ash content by incineration at 550°C for 8 h. The nitrogen (N) was determined using the Kjeldahl method (AOAC, 1990) and CP was calculated as N×6.25. Feed and fecal samples were analyzed for GE using Bomb Calorimeter (Parr Instrument Company, Moline, USA) according to the method used by Harris (1970).

The AME values of all the experimental diets and fecal samples were calculated by the method described by Sibbald (1976):

$$AME = \frac{GE_{intake} - GE_{excreta}}{Feed\ intake}$$

The AMEn values of experimental diets were calculated with the formula used by King et al. (1997):

$$AMEn = AME - \left(\frac{8.22 \times ANR}{Feed\ intake}\right)$$

where ANR is the apparent nitrogen retained.

Statistical analysis

The data on feed intake, body weight gain, FCR, AME and AMEn were analysed using PROC GLM procedure of Statistical Analysis System (SAS, 2009) in the completely randomized design. The means were compared using Tukey test and the differences were checked for statistical significance (P<0.05).

Results and Discussion

To minimize the feed cost, locally produced grains and by-products like corn, wheat, corn gluten and fish meal are commonly used in broiler rations in the South Asian tropical countries including Pakistan.These ingredients and by-products are often included in the broiler rations on the basis of their nutrient contents and literature values of nutrients bioavailability, determined elsewhere. The quality of these feed ingredients and by-products, however, varies because of different factors such as composition of raw materials, processing techniques and storage conditions (Nadeem, 1998). The present study was conducted to obtain accurate and reproducible values for the AME and AMEn of the commonly used feed ingredients and by-products in the broiler ration, and to determine the effect of broiler's age on these values.

Data on feed intake, body weight gain, FCR, AME and AMEn values of experimental diets on day 22 of experiment is presented in Table 3.Average feed intake and body weight gain of bird significantly differ (P>0.05) between the experimental diets.

The average feed intake ranged from 72 (fish meal) to 78 g (corn gluten 30%). The diet containing corn

Table 3. Average feed intake, body weight gain, feed conversion ratio, apparent metabolizable energy (AME) and apparent metabolizable energy values corrected for zero nitrogen balance (AMEn) of experimental diets[1] at day 22 of experiment.

Variable	Diet-A	Diet-B	Diet-C	Diet-D	SEM	P-value[2]
Feed intake (g)	73^{b}	73^{b}	78^{a}	72^{b}	2.71	*
Body weight gain (g)	43^{a}	39^{b}	45^{a}	41^{b}	2.58	*
Feed conversion ratio	1.69^{a}	1.61^{a}	1.52^{b}	1.56^{b}	0.04	*
AME (kcal/kg)	2968^{b}	2981^{a}	2852^{c}	2889^{c}	31.07	*
AMEn (kcal/kg)	2880^{b}	2921^{a}	2778^{d}	2815^{c}	32.07	**

Mean values in rows with different superscripts (a-d) are significantly (P<0.05) differed.
[1] Diet-A, basal diet (corn and soybean meal); Diet-B, basal diet partially replaced with wheat (150 g/kg DM); Diet-C, basal diet partially replaced with the corn gluten (84.5 g/kg DM); Diet-D, basal diet partially replaced with fish meal (40 g/kg DM).
[2] *, 0.01>P<0.05; **, 0.001>P<0.01.

Table 4. Average feed intake, weight gain, feed conversion ratio, apparent metabolizable energy (AME) and apparent metabolizable energy values corrected for zero nitrogen balance (AMEn) of experimental diets[1] at day 32 of experiment.

Parameters	Diet-A	Diet-B	Diet-C	Diet-D	SEM	P-value[2]
Feed intake (g)	92^{a}	88^{b}	93^{a}	89^{b}	1.19	*
Body weight gain (g)	55^{a}	55^{a}	57^{a}	47^{b}	1.65	*
Feed conversion ratio	1.67^{c}	1.76^{b}	1.64^{c}	1.89^{a}	0.05	*
AME (kcal/kg)	3087^{a}	3061^{b}	3076^{a}	2909^{c}	41.76	*
AMEn (kcal/kg)	3010^{a}	2998^{b}	3012^{a}	2824^{c}	49.24	**

Mean values in rows with different superscripts (a-c) are significantly (P<0.05) differed.
[1] Diet-A, basal diet (corn and soybean meal); Diet-B, basal diet partially replaced with wheat (150 g/kg DM); Diet-C, basal diet partially replaced with the corn gluten (84.5 g/kg DM); Diet-D, basal diet partially replaced with fish meal (40 g/kg DM).
[2] *, 0.01>P<0.05; **, 0.001>P<0.01.

gluten 30%, showed higher feed intake and daily weight gain, and lower FCR compared to the other diets. At day 22 of experiment, the AME values of experimental diets ranged from 2852 to 2981 kcal/kg, whereas the AMEn values ranged from 2778 to 2921 kcal/kg. The higher (P<0.05) AME and AMEn values were obtained for the diet contains wheat grains (diet-B). The data on feed intake, body weight gain, FCR, AME, and AMEn values on day 32 of the experiment is summarized in Table 4. The average feed intake and body weight gain were significantly (P<0.05) differed between the experimental diets. The feed intake of birds ranged from 88 (wheat) to 93 g (corn gluten 30%).

At day 32, the diet containing corn gluten 30% showed higher daily weight gain and lower FCR compared to other diets, indicating that the corn gluten was efficiently digested by broilers. The feed cost can be decreased by replacing corn with corn gluten 30% which is the by-product of corn. The AME and AMEn values of experimental diets ranged from 2909 to 3087 and 2824 to 3012 kcal/kg, respectively.

The higher (P<0.05) AME (3076) and AMEn (3012 kcal/kg) values were obtained for corn gluten 30% compared to the other diets. In the present study, the AME and AMEn values for broiler birds at day 32 were higher than the values obtained at day 22 of the experiment. The AME and AMEn values increased with increasing age of broiler birds, irrespective of the diet composition. Similar findings on the age effect were reported by Fuente et al. (1998) and Scott et al. (1998) for AME and AMEn values of different feedstuffs. The bird's digestive system develops with the advancement of age and their ability to digest the high caloric diet increases (Scott and Boldaji, 1997). In the present study, the broilers at day 32 of age efficiently used energy of the experimental diets compared to day 22 of their age. Plavnik et al. (2000) also found in turkeys that the bird's efficiency to utilize the energy of feedstuffs increases with increasing age whereas Ten Doeschate et al. (1993) concluded that the influence of age was not consistent for digestibility coefficients in broilers.

The energy values of all the feed ingredients used in the present study were also lower than NRC (1994) values which shows that the caloric value of feedstuffs vary in different parts of the world, and there is a need to measure the energy values of local feed ingredients to formulate feed more accurately to fulfill the bird's requirements and to get optimum production. This will increase the economic profitability of the small scale subsistence broiler farmers. In the present study, higher values were obtained for AME compared to AMEn at both excreta collection days. The higher AME values might be due to the ad libitum feeding of birds. Wolynetz and Sibbald (1984) also found higher AME values under ad libitum feeding condition with positive N retention.

In the present study, the AME values of wheat grains, corn gluten 30% and fish meal were found lower than those reported by Sibbald (1986), Scott et al. (1998) and Adeola (2003), however, the similar increasing trend with age was found in the present study and the previous studies. The different values obtained might be due to the variation in the chemical composition of these feed ingredients used in the present study compared to previous studies. The renewed information on the energy values of local feed ingredients can be very helpful to formulate the broiler rations by including these local feed ingredients and by-products which cannot only increase the economic profitability of commercial broiler farms but also improve the ecological footprint by using local resources.

Conclusions

The growth performance of broilers and feed efficiency were significantly (P<0.05) improved by the partial replacement of basal diet (corn + soybean meal) with wheat, corn gluten 30% and fish meal. The AME and AMEn values were significantly (P<0.05) differed between the experimental diets, and higher values were recorded for corn gluten 30%. Moreover, the AME and AMEn values of all the experimental diets increased with advancement of broilers age. The new database AME and AMEn of wheat, corn gluten 30% and fish meal obtained under tropical conditions can be used for the formulation of broilers ration based on these local (economical) feed ingredients and by-products.

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