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Effect of Chemical Composition and Dietary Enzyme Supplementation on Metabolisable Energy of Wheat Screenings

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ABSTRACT : Three trials were conducted to determine the available energy of different wheat screening varieties collected from different locations of Khorasan in Iran. In experiment 1, chemical composition and the nitrogen corrected true metabolisable energy (TMEn) were evaluated. A precision-fed rooster assay was used, in which, each wheat screening sample was tube fed to adult roosters, and the excreta were collected for 48-h. In Exp. 2 and 3, five and two wheat screening verities-based diets with or without xylanase and phytase were fed to 16-day old battery reared chicks respectively, and total feed consumption and excreta were measured during next three days. The variable nature of wheat screening varieties led to significant differences in mean TMEn values ($p<0.01$). The TMEn values of samples determined with adult roosters varied by ±5.03% of the mean value (3,097.65±49.32 kcal/kg) and ranged from 2,734.90 to 3,245.12 kcal/kg. There was a significant correlation ($p<0.05$) between crude fiber (CF), neutral detergent fiber (NDF), and acid detergent fiber (ADF) with TMEn, and the greatest correlation coefficient was observed between NDF and TMEn ($r = -0.947$; $p<0.001$). The optimal equation in terms of R^2 from using a single chemical analysis was obtained with NDF: TMEn = 4,152.09-27.80 NDF ($R^2 = 0.90$, $p<0.0001$), and the TME prediction equation was improved by the addition of the crude protein (CP) and ASH content to sequential analysis: TMEn = 3,656.97-28.65 NDF+32.54 CP+38.70 ASH ($R^2 = 0.98$, $p<0.0001$). The average AMEn values of 5 and 2 wheat screening varieties determined with young broiler chickens were 2,968.41±25.70 kcal/kg and 2,976.38±8.34 kcal/kg in Exp. 2 and Exp. 3, respectively. Addition of xylanase and phytase to wheat screenings resulted in significant ($p<0.01$) improvement in AMEn by 4.21 and 2.92%, respectively. (**Key Words :** Wheat Screening, Chemical Content, True Metabolisable Energy, Apparent Metabolisable Energy, Xylanase, Phytase)

INTRODUCTION

Wheat screening is a by-product which is obtained after harvesting, and processing of wheat in flour factory, macaroni factory and Plant breeding centre and is about 8-12% of annual wheat production in Iran (Golian and Parsaie, 1996; Rajabzadeh, 2001). Shrunken and broken wheat kernels should have nutritional value similar to wheat and comprise a large portion of wheat screenings (Audren, 2002). Wheat screenings can be used to replace a substantial portion of cereal in the diet of poultry and therefore, can reduce production costs. Wheat is an important ingredient in broiler diets because of its high starch (ST) and CP content, and is often the only cereal in grower and finisher diets. However, the chemical composition and energy availability of wheat can vary (Mollah et al., 1983; Kim et al., 2003). Therefore, there is a large variation in the chemical composition of wheat by-products because of different sources of wheat (e.g., soft vs. hard; Kim et al., 2003) and difference in processing techniques (Li and Posner, 1989). It has been reported that the starch, crude protein, and fiber are the most variable proximate components of wheat depending upon different varieties, growing locations, and climate, which in turn cause variability of ME value of wheat by-products (Kim et al., 2003). Since energy is one of the most expensive segments of a poultry ration, accurate knowledge of the available energy content of feedstuffs is necessary to formulate the most economical least-cost rations and to achieve profitable production (Sibbald, 1982). Feed ingredients of plant origin contain a number of components that cannot be digested by monogastric species because of the lack of or insufficiency of endogenous enzyme secretions. In addition to being unavailable to the animal, these components also lower the utilization of other dietary

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nutrients, leading to depressed performance. Examples of such antinutritive components include pentosans in wheat, and phytic acid, which is found in all plant feed ingredients. In recent years, with the development of enzyme products targeting specific substrates, the use of feed enzymes to ameliorate the effects of these antinutritive factors has received more attention (Ravindran et al., 1999). The principal anti-nutritive factors in some cereal grains (e.g., wheat and barley) are soluble nonstarch polysaccharides (NSP, Annison and Choct, 1991; Smits and Annison, 1996). The main NSP in wheat are pentosans. Enzyme supplementation increases the ME values of wheat containing high levels of NSP, and decreases the variation in ME caused by these antinutritive factors (Hew et al., 1998). The arabinoxylans have been reported to give rise to highly viscous conditions in the small intestine of wheat-fed chickens and depress nutrient utilization and performance. These adverse effects can be overcome by supplementation with exogenous xylanases which have been shown to lower the viscosity of intestinal contents and to improve digestibility of starch, protein, fat, and AME in broilers fed on diets containing wheat (Annison and Choct, 1991; Bedford, 1995). Few studies are available regarding the effects of phytase on mineral availability, energy, and nutrient digestibility when used in diets based on other cereals such as wheat (Ravindran et al., 1999; Selle et al., 2000; Zyla et al., 2001; Wu et al., 2003). The efficacy of microbial phytase in improving overall phosphorus availability in poultry is now clearly established (Coelho and Kornegay, 1996). Also some evidences show that there are the additional benefits of improved protein and energy utilization (Ravindran et al., 1998, 1999). The objectives of the present study were to determine chemical composition of wheat screenings of different varieties, to provide accurate prediction models for estimating the TME values from chemical composition, and to examine the effect of xylanase and phytase addition on ME values of wheat screenings for poultry.

MATERIALS AND METHODS

Samples preparation and chemical analysis

Ten wheat screening samples of grade-1 from ten wheat varieties (each variety grown in different locations of Khorasan province in Iran) were obtained from a screening factory. The samples were ground through a 1-mm screen and were chemically analyzed for key nutritional characteristics such as dry matter (DM), ASH, CF, NDF, ADF, CP, and ether extract (EE) (AOAC, 1990).

Experiment 1

The precision-fed rooster assay (Sibbald, 1982) was used to determine the TMEn of ten wheat screening varieties (Shouri6, Sayonse, Alvand, Shouri4, Falat, Pishtase, Gaskojen, Azar2, Sabalan and Sardari). Fifty five adult cockerels (Hy- Line, average weight of 2,100 g) were housed in individual metabolic cages (30×40×45 cm) equipped with feed and water and fed a maintenance diet for two weeks of adaptation. A metal tray was placed under each cage to collect the excreta. On the third week, following a period of 24-h feed restriction, 25 g of each ground sample was fed to a bird by intubation with five birds per sample. Five cockerels were kept deprived of feed to estimate the endogenous energy and nitrogen losses. Total excreta voided over the following 48-h were collected, dried, weighed and ground for subsequent analyses. Gross energy (GE) of feed and excreta samples was measured in Bomb-calorimeter (Model 1266, PARR). Nitrogen (N) content of feed and excreta were also determined using Kjeldahl Method (AOAC, 1990) to calculate TMEn values (Sibbald, 1976). The TMEn of wheat screening samples was calculated using the formula reported by King et al. (1997).

$$AME = ((FI \times GE_f)-(E \times GE_e))/FI$$

$$TME = AME-(FEL/FI)$$

$$ANR = (FI \times N_f)-(E \times N_e)$$

$$TME_n = TME-(8.22 \times ANR/FI)-(8.22 \times FNL/FI)$$

Where AME is the apparent metabolisable energy, TME is the true metabolisable energy, GE_f is the gross energy of the feedstuff (kcal/g), FI is the feed input (g), GE_e is the energy excreted by the fed bird, E is the excreta weight (g), FEL is the fasting energy loss, N_f is the nitrogen input (g), Ne is the nitrogen excreted by the fed bird, ANR is the apparent nitrogen retained and FNL is the fasting nitrogen loss.

Experiment 2

Two hundred one-day-old male broiler chicks were obtained from a commercial hatchery and raised in battery brooders. The birds received a commercial broiler starter diet from d 1 to 10. They were transferred to battery cages at d-11 and received diet containing 20% wheat screenings. At 16-d of age, birds were weighed to have similar mean weights and randomly divided between fifty cages (each cage having four birds). Experimental rations were included five wheat screening varieties (Sayonse, Pishtase, Falat, Gaskojen and Sabalan) with or without enzyme supplementation (ten treatments with five replications). The assay diets contained 962.5 g/kg wheat screening, which was used as the only source of energy and protein, and fortified with minerals and vitamins. The composition of

diets used in this experiment is shown in Table 1. The enzyme was added to diets at inclusion rate of 500 units per kg (U/kg) of diet, to provide a guaranteed minimum activity of 1,200 IU xylanase and 440 IU β-glucanase per kg of feed. The birds were fed the assay diets for 7-d, with the first 3-d serving as an adaptation period. During the last 4-d, feed intake was monitored, and the excreta was collected daily, dried for 24-h at 80°C in a forced-air oven, and pooled for analysis. Care was taken to avoid contamination from feathers, scales, and debris. The dried excreta were allowed to equilibrate to atmospheric conditions before being weighed and then ground to pass through a 0.5-mm sieve. Samples of diets and excreta were analyzed for DM, N and GE. The gross energy of diet and excreta samples was determined using an adiabatic bomb calorimeter standardized with benzoic acid. The AMEn values of the diets were calculated using the formula reported by Ravindran et al. (2007).

$$AME_d = ((FI \times GE_f)-(E \times GE_e))/FI$$

$$ANR = (FI \times N_f)-(E \times N_e)$$

$$AME_{nd} = AME-(ANR \times 8.72/FI)$$

$$AME_{nws} = AME_{nd}/DLS$$

Where AME_d is the apparent metabolisable energy of diet, AME_{nd} is the nitrogen corrected apparent metabolisable energy of diet, AME_{nws} is the nitrogen corrected apparent metabolisable energy of wheat screenings and DLS is the dietary level of sample.

Experiment 3

The procedure of this experiment was similar to experiment 2. Eighty birds at 16-d of age were weighed and randomly divided between twenty cages (each cage having four birds). Experimental rations were included two wheat screening varieties (Pishtase and Gaskojen) with or without enzyme supplementation (four treatments with five replications). Diets were formulated to have wheat screening samples as the sole source of energy. The composition of diets used in this experiment is shown in Table 1. Phytase (500 U/kg) was added to diets as experimental enzyme.

Table 1. Composition of diets in experiment 2 and 3

Ingredients (g/kg)	Exp. 2[1]	Exp. 3[2]
Wheat screening	962.5	993
Calcium carbonate	11.5	-
Dicalcium phosphate	19.0	-
Sodium chloride	2.0	2.0
Vitamin-mineral premix[3]	5.0	5.0

[1] Five hundred ppm enzyme including1,200 IU xylanase and 440 IU β-glucanase was added to diets with enzyme.

[2] Phytase (500 U/kg of diet) was added to diets with enzyme.

[3] Provides per kg of diet: vitamin A, 8,800 IU; (retinyl palmitate) cholecalciferol, 3,300 IU; vitamin E, 40 IU (dl-α-tocopheryl acetate); thiamin, 4 mg; riboflavin, 8.0 mg; pyridoxine, 3.3 mg; biotin, 0.22 mg; pantothenic acid, 15.0 mg; vitamin B_{12}, 12 mg; niacin, 50 mg; choline, 600 mg; vitamin K, 3.3 mg; folic acid, 1 mg; ethoxyquin, 120 mg; manganese, 70 mg; zinc, 70 mg; iron, 60 mg; copper, 10 mg; iodine, 1 mg; and selenium, 0.3 mg.

Statistical analysis

Statistical analyses were performed using SAS (SAS Institute, 2003). One way analysis of variance was used to determine significant differences among treatments for TMEn in Exp. 1. Correlation and sequential multiple linear regression analysis (stepwise procedure) were employed using DM, CP, CF, NDF, ADF, EE, GE, and ash as independent variables and TMEn as the dependent variable. The variance was considered to be significant when $p<0.05$. In the proposed equations, the inclusion of independent variables was only considered when they caused a significant improvement ($p<0.05$). In Exp. 2 and 3, data were statistically analyzed as a 2×5 and 2×2 factorial design respectively. The statistical model for diets included the following effects: the main factors including enzyme and wheat screening variety, and their interaction terms. Means were separated by the probability of difference by using LSMEANS and PDIFF statements.

RESULTS AND DISCUSSION

Experiment 1

Chemical composition and TMEn of the ten wheat screening varieties are given in Table 2. The mean values of CP, EE, CF, NDF, ADF and Ash for ten varieties were 12.98, 1.80, 4.99, 37.92, 6.96 and 2.71% respectively, similar to values reported by other researchers (Stapleton et al., 1980; Audren et al., 2002). Biely and Pomeranz (1975) demonstrated that mean values of CP, Ash, CF and EE of 12 wheat screening samples were (13.7, 2, 2.5 and 3.14%), respectively. Golian and Parsaie (1996) and Saki and Alipana (2005), showed that CP and EE of wheat screenings were (15.19 and 2.63%) and (11.21 and 4.14%) respectively. Although little variation occurred in the CP, DM, EE and GE, a great range for some other components was observed, especially a noticeable range for CF (3.1 to 8.37%), ADF (5.17 to 11.06%) and Ash (2.06 to 4.50%). A big variation in the content of CF and ADF indicated that the fiber fraction in the wheat by-products is more susceptible to vary with the source of grains than other proximate components. However, little variation was observed for DM and CP content, which is similar to variation reported by Blas et al. (2000) and Cromwell et al.

Table 2. Chemical composition and TMEn of the ten wheat screening varieties

Variety	DM (%)	CP (%)	EE (%)	Ash (%)	CF (%)	NDF (%)	ADF (%)	GE (kcal/kg)	TMEn (kcal/kg)
Shouri6	92.69	12.89	2.21	4.05	3.46	33.56	5.31	4,190.94	3,245.12[a]
Sayonse	93.47	11.4	1.83	2.11	3.26	31.14	5.17	4,083.48	3,241.63[a]
Alvand	94.35	13.5	2.05	2.08	3.73	35.08	5.22	4,140.79	3,191.71[ab]
Shouri4	94.48	12.98	1.78	3.12	3.62	35.47	6.14	4,059.60	3,184.24[ab]
Falat	94.11	12.99	1.81	2.23	3.57	34.23	5.18	4,116.91	3,165.50[abc]
Pishtase	94.26	13.9	1.75	2.30	3.65	36.07	6.08	4,121.69	3,138.08[c]
Gaskogen	93.69	15.04	1.67	2.06	3.88	40.17	6.11	4,107.36	3,090.61[c]
Azar2	93.99	12.77	1.71	4.50	8.3	44.53	10.2	4,040.50	2,997.09[d]
Sabalan	93.78	12.52	1.62	2.31	8.07	41.14	9.13	4,107.36	2,987.64[d]
Sardari	93.94	11.86	1.64	2.33	8.37	47.87	11.06	4,097.81	2,734.90[e]
Mean	93.87	12.98	1.81	2.71	4.99	37.92	6.96	4,106.64	3,097.65
SD	0.52	1.02	0.19	0.89	2.25	5.31	2.27	41.91	155.96
CV	0.55	7.85	10.38	32.67	45.15	14.01	32.59	1.02	5.03

DM = Dry matter, CP = Crude protein, EE = Ether extract, CF = Crude fiber, NDF = Neutral detergent fiber, ADF = Acid detergent fiber, GE = Gross energy, TMEn = Nitrogen corrected true metabolisable energy.
The TMEn means with no common superscript are significantly different ($p<0.01$).

(2000). The mean gross energy value of wheat screenings was 4,106.64 kcal/kg that is lower than the amounts reported by Biely (1975), and Saki (2005) (4,665 and 4,457.65 kcal/kg respectively). In spite of low variability in GE, the TMEn of samples varied in a large range. As expected, the greater the fiber content, the lower the TME values of wheat screening. The TMEn values were significantly different ($p<0.01$) for different varieties. The Shouri6 and Sardari varieties showed the highest and the lowest TMEn values, respectively (3,245.12 vs. 2,734.90 kcal/kg). The cultivars of wheat, the quantity of wheat, and the type of weed seeds present in the samples may influence the TMEn of samples. Saki and Alipana (2005), showed a large difference in TMEn values of two wheat screening samples (3,243.27 vs. 2,486.80 kcal/kg).

The simple correlation matrics analyses were conducted to evaluate the correlation between chemical composition and TMEn values. The correlation between CP, GE, and ASH with TMEn (Table 3) was not significant, whereas the CF, NDF and ADF were highly but negatively correlated with TMEn, and the greatest correlation coefficient was observed between NDF and TMEn ($r = -0.947$; $p<0.001$). Wan et al. (2009) also reported the greatest correlation coefficient ($r = -0.969$) between NDF and TMEn. This result is in general agreement with other reports showing that variable fiber fraction probably is the predominant factor influencing the TME of wheat by-products (Villamide and San Juan, 1998; Wan et al., 2009). There are many factors affecting the chemical composition and nutritional value of wheat, including growing condition, wheat variety, and postharvest storage (Gutierrez-Alamo et al., 2008). Kim et al. (2005) reported a wide range of variations in the fiber fraction of wheat by-products because of the wheat variety. Wheat variety and chemical composition are the most important factors affecting the TMEn value of wheat. It is reported that soft wheat varieties tend to have greater starch and greater starch digestibility and AMEn for broiler than hard-wheat varieties (Gutierrez-Alamo et al., 2008). With regard to the significant correlation of CF, NDF and ADF with TMEn in current

Table 3. Correlation coefficients among representative wheat screening samples in chemical composition and TMEn

Correlation matrix	CP	EE	Ash	CF	NDF	ADF	GE	TMEn
CP	1.000	0.007	-0.121	-0.348	-0.305	-0.325	0.222	0.216
EE			0.292	-0.568	-0.630	-0.613	0.704*	0.657*
Ash				0.255	0.162	0.264	-0.122	0.036
CF					0.890**	0.975**	-0.411	-0.870**
NDF						0.938**	-0.389	-0.947**
ADF							-0.467	-0.923**
GE								0.328
TMEn								1.000

CP = Crude protein, EE = Ether extract, CF = Crude fiber, GE = Gross energy, TMEn = Nitrogen corrected true metabolisable energy.
* $p<0.05$; ** $p<0.01$.

study, fiber is probably the most important factor affecting TMEn. The EE was positively correlated with TMEn, although the correlation coefficient was less than that of some fiber measurements (r = 0.657 for EE, vs. 0.870, 0.947, and 0.923 for CF, NDF, and ADF, respectively). It is suggested that EE as an important energy source, displays a positive contribution to TME of wheat screenings. A positive correlation of GE and TMEn is not surprising since GE is the basis for TMEn calculation (Robbins et al., 2006).

To obtain equations for predicting the TMEn of wheat screening, stepwise regression analyses were performed using a different chemical composition values. The equations obtained from multi-step regression analysis indicated that NDF was the best single predictor for TMEn (R^2 = 0.90; Table 4). This was in agreement with Wan et al. (2009) who reported NDF as the best predictor for TMEn with R^2 = 0.94. Previous work conducted on the wheat and wheat by-products showed that fiber content is the optimal predictor for predicting the ME and DE (Blas et al., 2000). In current study, we demonstrated that NDF among the fiber fraction could be used as an effective indicator estimating the TMEn of wheat screenings. It is commonly accepted that the NDF represent most of the fiber fraction of feedstuffs, which are poorly digested by poultry because of the lack of enzymes that can effectively degrade these complex carbohydrates (Villamide and San Juan, 1998). It is also reported that the digestibility of fiber in grain is less than 20% in poultry (Terence et al., 2000). Therefore, energy utilization efficiency of wheat screenings is negatively and prominently affected by the NDF content, which serves to make NDF an effective predictor of TMEn. The accuracy of prediction for TMEn could be improved to 0.98 by adding CP and ASH as predictor variables rather than NDF alone. These equations suggest that the proximate composition of the product can serve to calculate the TME of the product.

Experiment 2

The AMEn values of five wheat screening varieties determined with broilers varied by 3.35% of the mean value (2,968.41±25.70 kcal/kg) and ranged from 2,811.12 to 3,122.67 kcal/kg. Additions of xylanase resulted in a significant improvements ($p<0.01$) in AMEn (4.41%). Several physical and chemical factors influence wheat AMEn, including specific weight (McCracken and Quintin, 2000), viscosity and hardness (Carre et al., 2002), pelleting (Scott, 2000), starch, CP, NSP, and ether extract contents (Svihus and Gullord, 2002; Pirgozliev et al., 2003). However, the relationship between the physiochemical properties of wheat and its AMEn content has not been fully defined. Wheat contains NSP in the cell wall. Wheat by-products have a greater NSP content than does wheat (Slominski et al., 2004). The mechanisms by which exogenous enzymes enhance nutrient digestion and utilization in wheat are not clearly understood, but disruption of endosperm cell wall integrity and the breakdown of the highly viscous non-starch polysaccharides are thought to be the major factors involved. It is proposed that these viscous non-starch polysaccharides interfere with the rate of diffusion, or act as a physical barrier between substrates, enzymes and digestion end-products (Pettersson and Aman, 1989). Exogenous xylanases increase the solublization of arabinoxylans to low-molecular weight components and decrease digesta viscosity which improves nutrient digestion and absorption (Hew et al., 1998).

Enzyme addition improved AMEn of Sabalan variety more than other varieties due to its high fiber fraction (Tables 1 and 5). The extent of response to xylanase depended on the wheat screening variety. Different wheat screenings contains different proportions of NSP, including arabinose, xylose, and galactose. Variations exist among different wheat screening varieties for NSP. These factors may contribute to the different effects of xylanase among wheat screenings. The greater improvement of TMEn for a by-product might be due to the greater amount of NSP contents in that by-product. Logically, greater arabinoxylan content in a feed or feedstuff will increase the quantity of entrapped nutrients and thus provide a greater positive effect with xylanase supplementation (Nortey et al., 2008).

Experiment 3

Effect of phytase addition on AMEn of two wheat screening varieties for broiler chickens is shown in Table 5. The AMEn values were 2,967.85 and 2,984.91kcal/kg for Gaskojen and Pishtase, respectively. The addition of phytase resulted in significant improvements ($p<0.01$) in AMEn (2.92%).

The positive effect of phytase on available energy of wheat based diets was reported previously (Ravindran et al.,

Table 4. Prediction of TME from chemical composition of wheat screening

Number in model[1]	Regressive equation	R^2	p
1	TMEn = 4,152.09-27.80NDF	0.90	<0.0001
2	TMEn = 4,094.32-28.72NDF+34.21ASH	0.93	<0.0001
3	TMEn = 3,656.97-28.65NDF+32.54CP+38.70ASH	0.98	<0.0001

CP = Crude protein, EE = Ether extract, CF = Crude fiber, GE = Gross energy, TMEn = Nitrogen corrected true metabolisable energy.
[1] Only equation with greatest R^2 has been shown in this table.

Table 5. Effect of wheat screening variety and xylanase addition on AMEn of broilers (mean values)

Effect	AMEn	% Improvement
Variety		
Sayonse	3,123.04[a]	
Pishtase	3,085.45[ab]	
Falat	3,039.19[bc]	
Gaskojen	3,008.31[c]	
Sabalan	2,913.37[d]	
SE	24.20	
Enzyme		
-	2,968.41[b]	
+	3,099.33[a]	4.41
SE	15.31	
Variety×enzyme		
Sayonse		
-	3,065.66[bcd]	
+	3,180.41[a]	3.74
Pishtase		
-	3,021.21[cde]	
+	3,149.69[ab]	4.25
Falat		
-	2,971.78[de]	
+	3,106.60[abc]	4.53
Gaskojen		
-	2,950.96[e]	
+	3,065.66[bcd]	3.88
Sabalan		
-	2,832.44[f]	
+	2,994.31[de]	5.71
SE	34.23	

Means within a given column with no common superscript are different ($p<0.01$).

Table 6. Effect of phytase addition on AMEn of two wheat screening varieties for broiler chickens (mean values)

Effect	AMEn	% Improvement
Variety		
Pishtase	3,027.15[a]	
Gaskojen	3,012.67[a]	
SE	12.48	
Enzyme		
-	2,976.38[b]	
+	3,063.44[a]	2.92
SE	12.48	
Variety×enzyme		
Pishtase		
-	2,984.91[b]	
+	3,069.39[a]	2.83
Gaskojen		
-	2,967.85[b]	
+	3,057.50[a]	3.02
SE	17.65	

Means within a given column with no common superscript are different ($p<0.01$).

1999b), and the present results confirmed this effect. Ravindran et al. (1999) found that the addition of phytase or xylanase improved AME of wheat by 5.3 and 9.7%, respectively. When the diet was supplemented with a combination of the two enzymes, the AME was improved by 19.0%. Ravindran et al. (2001) also reported that addition of phytase at the rate of 500 FTU/kg diet improved the AME value by 2.3% which this improvement is almost the same as the amount we observed in present study (2.92%).

It is proposed that mineral-phytate complexes may contribute to the formation of insolublemetallic soaps in the gastrointestinal tract, which decrease lipid utilization. Phytase can reduce the degree of soap formation in the gut and increase the utilization of energy derived from lipids by preventing the formation of mineral-phytate complexes. Dietary levels of calcium and saturated fats would have particular relevance to this proposed mode of action (Ravindran et al., 2001). Starch digestibility of poultry diets is not usually considered to be limiting, but another possible aspect of the mode of action of phytase is the removal of the adverse effects of phytic acid on starch digestion. Thompson and Yoon (1984) suggested that phytate may affect starch digestibility via interactions with proteins closely associated with starch or direct binding with starch via phosphate links. In the case of wheat, an additional mode of action is recently proposed to explain improvements in AME with added phytase (Ravindran et al., 1999b). Based on the observation that phytate is an integral component of the cell wall matrix in wheat (Frolich, 1990), it is considered that microbial phytase may be acting in a manner similar to that of exogenous xylanases by disrupting cell walls and enhancing contact between digestive enzymes and cell contents (Ravindran et al., 2001).

IMPLICATIONS

In conclusion, different wheat screenings varieties are kind of the feed ingredients that are almost variable in chemical components, particularly the fiber content and metabolisable energy values. The CF among the chemical compositions is the key factor in the selection of a better prediction equation of TMEn for wheat screenings. The accuracy of prediction equation of TMEn could be further improved when other chemical characteristics are taken into consideration. Wheat screenings combined with exogenous xylanase or phytase can potentially replace energy-yielding feedstuffs in broiler diets. The beneficial effects of xylanase or phytase on digestible energy content are variable and

depend on the wheat screening variety. Different wheat screening varieties have different fiber compositions that affect enzyme efficacy.

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