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A B S T R A C T

Three experiments were conducted to determine the influence of varying lengths of adaptation on metabolisable energy (AME and AMEn) content of maize and barley for broilers, turkeys and laying hens using the difference method. Three hundred and twenty-four Cobb 500 male broiler chicks (Experiment 1), 162 BUT 10 male turkey poults (Experiment 2) or 162 Lohmann brown laying hens (Experiment 3) were offered a nutrient-adequate pre-experimental diet for at least 11 days. The birds were then allocated to 9 dietary treatments (a 3 × 3 factorial arrangement of treatments) with each treatment replicated 6 times. The factors were three diet types (based on wheat-soybean meal (WS), maize-wheat-soybean meal (MWS) or barley-wheat soybean meal (BWS)) and three length of adaptation to dietary treatments (10, 7 or 4 d). The WS was the references diet whereas MWS and BWS were the assay diets. The adaptation period corresponded to 10, 7 or 4 days of feeding experimental diets prior to the end of each experiment. Excreta were collected on the last two days of each experiment. The AME of maize and barley in the assay diets, in each experiment, were calculated using difference method. On all the responses considered, there was no significant diet type × adaptation length interaction in any of the poultry species. Regardless of the poultry species, AME was greater ($P < 0.05$) for maize compared with barley. The AME (MJ/kg) for maize was 13.5, 13.5 and 13.6 for broilers, turkeys and laying hens, respectively whereas the corresponding AME (MJ/kg) of barley was 12.2, 11.8 and 12.6, respectively. The effect of adaptation length during AME assay was statistically significant in turkeys, tended to be significant in broilers but not significant for laying hens. It was concluded that irrespective of poultry species, the greater overriding factor affecting AME determined by the difference method is the particular feedstuff being assayed.

However, length of adaptation to experimental diets during the assay becomes more important in birds with relatively physiologically immature digestive tract.

Keywords: adaptation length, broilers, cereal grains, metabolizable energy, turkeys

Abbreviations: AME – apparent metabolisable energy; AMEn – nitrogen-corrected apparent metabolisable energy; BWS – barley wheat soybean meal diet; cEM – coefficient of energy metabolisability; CF – crude fibre; CP – crude protein; DM – dry matter; MWS – maize wheat soybean meal diet; N – nitrogen; WS – wheat soybean meal diet.

1. Introduction

The enactment of various legislations that led to the imposition of ban on some feed ingredients has drastically reduced the available feedstuff for animal nutrition. For instance, the abolishment of feed resources of animal origin due to the incidence of transmissible spongiform encephalopathy in most European countries (Veldkamp and Bosch, 2015). Therefore, the quest for novel feed resources is currently receiving attention more than ever before. To accurately compute the nutritive values of these potential ingredients, it is pertinent to investigate the influence of varying length of adaptation on energy utilisation of feedstuff, in order to determine the optimum adaptation period in studies involving energy utilisation of currently used and novel feed ingredients. This becomes imperative in order to comply with the recent advocacy on precision livestock feeding – which involves feeding of the animals as very close as possible to their requirements. To achieve this, a careful selection of methodology which gives a precise availability of energy in an ingredient should be considered. Poultry diets are formulated based on the AME content and this usually accounts for over 60% of total cost of feeding. So an accurate determination of available energy is essential for optimising the efficiency of the diet through reduction in feeding cost and excretion of nutrients into the environment.

Over the years, several studies have extensively studied the AME of various feedstuffs (Sibbald, 1975; Sibbald and Price, 1975; Sibbald, 1976; Farrell, 1978; Mollah et al., 1983). However, one prominent method used in these aforementioned studies was the evaluation of available energy from digestibility measurement. There are chiefly two procedures in evaluating digestibility, the total collection method, and the index method (Kong and Adeola, 2014). The total collection method is laborious and greatly relies on the quantitative measurement of feed intake and excreta output, whereas the index method depends solely on accurate chemical analysis of the index compounds. In each of the two methods, the birds are usually adapted to their cages and feed before sample collection. The adaptation usually lasts for about 3-14 days (Kong and Adeola, 2014) during which the animal is adjusted to a feeding level to remove extra work incurred through collection, drying and analysis of orts due to feed refusal by the birds. However, irrespective of the digestibility procedures, the energy contents of a feedstuff could be determined by direct, indirect (difference) or regression methods, depending on the contribution of the basal or test ingredient to the component of interest (Kong and Adeola, 2014).

Additionally, several changes occur in the digestive tracts of the birds which may affect the outcome of the feeding experiments (Zavarize et al., 2012). Feed consumption influenced the development of digestive tract of birds (Gracia et al., 2003), and duodenum develops earlier than the jejunum and the ileum (Uni et al., 1999). This affects the rate of nutrient utilisation during the early stage of life (Uni et al., 1999). However, the intestinal development reached its peak earlier in broilers compared with laying hens (Zavarize et al., 2012). Most of the experiments involving energy utilisation are conducted in two phases (Bolarinwa et al., 2012; Adebiyi and Olukosi, 2015; Kong and Adeola, 2016). The birds are usually fed a basal diet for about 14 days (Adeola and Ileleji, 2009; Adebiyi and Olukosi, 2015) before assay diets are introduced to them. Thus, there is a feed changeover and consequently a requirement for adaptation to the assay diets prior to samples collection. The optimum length of the adaptation to the assay diet is not clearly defined but it is likely to be affected by the nature of the assay feedstuff. Cereals grains are majorly used as energy sources in poultry diets; however, the difference in their content and type of fibre often influence their utilisation (JøRgensen et al., 1996). The structural variation in dietary fibre sources often affect their nutritional, physical and biological properties (Theander et al., 1989). Therefore, the objective of the current studies is to examine the influence of adaptation period on the AME content of cereal grains having different fibre content and type.

2. Materials and methods

Bird management and sample collection procedures used in the studies were approved, as appropriate, by Scotland's Rural College Animal Experiment Committee or University of Kentucky Institutional Animal Care and Use Committee.

2.1. Animals and management

Three hundred and twenty-four Cobb 500 male broiler chicks (Experiment 1) or 162 BUT 10 male turkey poults (Experiment 2) or 162 Lohmann brown laying hens (Experiment 3) were used for the determination of AME and AMEn contents of maize and barley using the difference method. The broiler chicks and poults were obtained from local hatcheries and fed pre-experimental diets for at least 11 days posthatch. The laying hens were obtained at 32 weeks of age and fed pre-experimental diets for three weeks prior to the start of the experiment. The pre-experimental diets for all experiments were formulated to meet energy and nutrients recommendations in accordance with the specific breed requirements. Birds were reared in houses with facilities to regulate temperature, light, and humidity. The birds had *ad libitum* access to feed and water throughout the pre- and experimental periods. In each experiment, the birds were allocated to 9 dietary treatments in a randomised complete block design using initial body weight as blocking criterion. The treatments were in a 3 × 3 factorial arrangement. The factors were three diet types based on wheat-soybean meal (WS), maize, wheat-soybean meal (MWS) or barley, wheat-soybean meal (BWS) and three adaptation lengths for adaptation to dietary treatment (10, 7 or 4 days prior to the end of respective experiments). In all the three experiments, each treatment was replicated 6 times. However, experiment 1 contained six birds per replicate, whereas three birds per replicate were used in experiment 2 or 3.

2.2. Diets and sample collection

Three experimental diets were used in each of the three experiments. These diets composed of a wheat-soybean meal referenced diet, containing no maize or barley, and two assay diets containing 300 g/kg maize or barley, respectively. Energy yielding ingredients such as wheat, soybean meal, and soy-oil were substituted with maize or barley in a way their ratios were similar across all the experimental diets. This was necessary to determine the AME and AMEn of maize and barley using the difference method. Titanium dioxide (TiO_2) was added to all diets (5 g/kg diet) as an indigestible marker for determination of AME content by the index method. Experiment 1 diets were offered from d 14 to 24, 17 to 24 or 21 to 24 to give 10-, 7- or 4-d adaptation lengths, respectively. Experiments 2 and 3 diets were offered from d 11 to 21, d 14 to 21 or d 17 to 21 which correspond to 10-, 7- and 4-d adaptation lengths, respectively. The ingredient and chemical composition of the experimental diets used in the three experiments are shown in Table 1. Excreta were collected on the last two days of each experiment, pooled within a cage and dried in a convectional oven.

2.3. Chemical analysis

Samples of diets, wheat, maize, barley, and excreta were ground to pass through 0.5 mm screen using a mill grinder (Retsch ZM 100, F. Kurt Retsch GmbH & Co.KG, Haan, Germany) before chemical analysis. Samples of diets, maize, barley and excreta were analysed for N, GE, DM and TiO_2 where necessary. To determine DM content, samples were dried at 105^{o}C for 24 h using AOAC method 934.01 (AOAC, 2006) in a drying oven (Uniterm, Russel-Lindsey Engineering Ltd., Birmingham, England, UK). The analysis of GE was done using a bomb calorimeter (Parr adiabatic bomb calorimeter, model 6200, parr instruments, Moline, IL, USA) using benzoic acid as a calibration standard. Titanium dioxide was analysed as described by Myers et al. (2004) for Experiment 1 or Short et al. (1996) for Experiments 2 and 3. Nitrogen was determined by the combustion method using AOAC method 968.06 (AOAC, 2006).

2.4. Calculations and Statistical analysis

Coefficient of nitrogen or energy retention (En) was calculated using the index method as described in the equation: $En = 1 - [(Ti/To)X\ (Eo/Ei)]$; where Ti is the concentration of marker in feed; To is the concentration of marker in the excreta; Eo is the concentration of energy or N in the excreta, and Ei is the concentration of energy or N in the feed.

Metabolizable energy (kcal/g) was calculated using this relation: $AME = GE_i - \left(GE_o \times \left(\frac{T_i}{T_o}\right)\right)$ where GE*i* and GE*o* are the gross energy (MJ/kg) in feed and excreta, respectively; T*i* and T*o* are the concentration of titanium in the diet and excreta, respectively.

The cEM of test feedstuffs were calculated using the indirect method after correcting for the non-energy yielding fractions in the diets as described by Olukosi and Adeola (2009). The test ingredient cEM was calculated using the equation: $EM_{ti} = \frac{\left\{EM_{td} - \left[EM_{rd} \times \left(1 - FC_{ti/td}\right)\right]\right\}}{FC_{ti/td}}$, where EM_{ti} is the coefficient of energy metabolizability of the test ingredient, EM_{td} is the coefficient of energy metabolisability of the assay diet, EM_{rd} is the coefficient of energy metabolisability of the reference diet, $FC_{ti/td}$ is the fractional contribution of the test ingredient to the assay diet.

The AME (MJ/kg) of test feedstuffs was calculated using the equation $AME_{ti} = EM_{ti} \times GE_{ti}$, where AME_{ti} and GE_{ti} are the metabolisable and gross energy, respectively, of the test feedstuff. EM_{ti} is as defined previously. To determine the AMEn, the caloric value of 34.39 kJ/g was used (Hill and Anderson, 1958).

Data were analysed using the Generalised Linear Models of IBM SPSS statistical package (version 22). Statistical significance was set at $P \leq 0.05$ for all means comparisons. The digestibility of the diets (both DM and N), dietary AME and AMEn were analysed as a 3 × 3 factorial of diet type (WS, MWS or BWS) and varying adaptation lengths (10 days, 7 days or 4 days) using ANOVA procedures (presented as supplementary data). Similarly, the AME, AMEn, and cEM of test ingredients were analysed as a 2 × 3 factorial of cereal grains (maize or barley) and different adaptation lengths (10 days, 7 days or 4 days) using ANOVA procedures. The main effects of diets, test ingredients and adaptation lengths and their possible interactions on AME and AMEn of both diets and cereals, and total tract retention were analysed, and data were presented with both the main and simple effects.

3. Results

The analysed nutrient composition of wheat, barley, and maize used in the current study are shown in Table 2. The CP and ash contents in barley and maize were lower compared with wheat. Conversely, the crude fat content in maize and barley were higher compared with wheat. The CF content in barley was higher compared to wheat which was higher than that of maize.

The AME, AMEn and cEM of maize and barley in broilers receiving experimental diets for different adaptation lengths are presented in Table 3. There was neither significant cereal grain × adaptation length interaction nor significant main effect of adaptation length for AME, cEM and AMEn. On the other hand, AME, cEM and AMEn were greater ($P < 0.01$) in maize compared with barley.

The AME, cEM and AMEn of maize and barley in turkeys receiving experimental diets for different adaptation lengths are presented in Table 4. There was no significant cereal grain × adaptation length interaction on AME, cEM, and AMEn. The main effect of cereal grain was significant ($P < 0.05$) on AME, cEM and AMEn in turkeys being greater ($P < 0.01$) for maize compared with barley. There was significant ($P < 0.05$) main effect of adaptation length on AME and cEM but not on AMEn. The AME was greater ($P < 0.05$) when determined at 4-d compared with at 7-d whereas 10-d was intermediate. cEM was greater ($P < 0.05$) at 10-d and 4-d adaptation lengths compared with at 7-d adaptation length.

The AME, cEM and AMEn of maize and barley in laying hens receiving experimental diets for different adaptation lengths are presented in Table 5. There was no significant cereal grain × adaptation length interaction ($P > 0.05$) nor significant main effect of adaptation length for AME, cEM and AMEn. Conversely, the main effect of cereal grain was significant for AME, cEM and AMEn. The AME, cEM and AMEn were greater ($P < 0.05$) in maize compared with barley.

4. Discussion

The current experiments were carried out to investigate the impact that varying lengths of adaptation length during AME assay, using different poultry species, could have on AME value of two cereal grains with different fibre profiles.

The nutrient composition of wheat, barley, and maize used in this current study are comparable with values reported previously (Lin et al., 1987). The results obtained in the current study shows that irrespective of the species of poultry birds, increasing the fibre contents of the diet (via test ingredient) results in lower metabolisability and consequently lower AME content. Furthermore, high-fibre feedstuff led to lower total tract DM and N retention. These could be attributed to limited amounts of endogenous enzymes necessary to enhance release of available energy in the cereals grains.

Masey O'Neill et al. (2014) noted that starch supplies the majority of the available energy in cereals grains, however, this is encapsulated in the cell wall which makes it inaccessible to poultry birds due to their inability to produce sufficient amounts of endogenous enzymes in hydrolysing plant materials (Bedford, 1995). Maize contains more starch than barley. Depressed starch digestibility lower metabolisable energy content of cereals (Mollah et al., 1983; Rogel et al., 1987). Additionally, high fibre feedstuffs like barley contain NSP which have been reported to increase the viscosity of the digesta in poultry. The presence of B-glucans in barley primarily increase the viscosity of the digesta (Burnett, 1966). Increased viscosity could reduce the digestibility and availability of nutrients to the animals (Bedford, 1995; Choct et al., 1996; Masey O'Neill et al., 2014). The increased viscosity and bulk of intestinal content impede the rate of diffusion of substrate and consequently hinder their effective interaction at the mucosal surface (Choct et al., 1996).

Additionally, the viscosity of digesta could decrease DM intake due to the increase in satiety value. Further calculations in the current study showed that the DM intake of birds on maize-based diets was higher compared with the other two diets. Dietary fibre may lower N retention in poultry birds (Janssen and Carré, 1985; Mateos et al., 2012). As expected, the total N retention of broilers decreased with increasing fibre level in the diet. With the highest total N retention observed in MWS compared with WS and BWS. The NSP content of cereals reduced protein digestibility (Choct and Annison, 1992). On the other hand, increasing the fibre content of the diet through addition of wheat and barley as oppose to maize did not decrease total N retention in laying hens and turkeys. Laying hens retained more N in their body compared to broilers and turkeys.

The neutral detergent fibre (NDF) content in barley was nearly three-fold that recorded in maize, which is an indication of the level of fibre present in the two test ingredient. The determined AME (MJ/kg) of barley for broilers (12.2) and laying hens (12.6) in this experiment correspond with the values reported by Choct et al. (2001). However, these values were slightly higher than that observed in turkeys. This variation could be associated with the difference in the physiological age of the birds. Although, turkeys and broilers used in this current experiment were of similar age but broilers have more physiologically matured digestive tract than turkeys.

Likewise, adults laying hens were used in this bioassay. Adults birds have the ability to utilise NSP more effectively, thus the higher the NSP level in the grain, the larger the difference in metabolisable energy (Choct et al., 2001). Choct et al. (1996) noted that NSP depress the AME content of feedstuff due to their tendency to inhibit digestion of starch, protein and lipid. The AME content of maize reported for the three poultry species are similar and this could be traced to the less viscous nature of the grain. Choct et al. (2001) argued that the variation in

AME content of cereals in young and mature birds could as well be due to the degree of viscosity of the grain. With the effect more pronounced in high viscous grain (barley) than less viscous ones like maize.

In order to acclimatise the birds to a specific feedstuff or eliminate the possible confounding effects of changing over feeds (from pre-experiment diet to test, or assay, diets) in experiments, it is common practice to adapt the experimental animals to test ingredients or feeds for a certain number of days followed by the actual feeding and samples collection periods. There seems to be no consensus on the actual number of days to be used as adaptation period. During this period, several changes occur in the digestive tract which may eventually influence the results of the study. Adaptation length varies from 3-14 days in most experiments. Steenfeldt et al. (1998) employed 3 days of adaptation when determining the digestibility and AME of wheat-based diet in broilers. Hew et al. (1998) and Adebiyi and Olukosi (2015) utilised 7 days of adaptation in determining the AME content of wheat and wheat-DDGS respectively, in broilers. 10-d adaptation period was used by Cowieson and Ravindran (2008) in investigating the effect of exogenous enzymes on energy digestibility of maize-based diets in broilers. Likewise, conventional grower diet was fed for 10-d adaptation period in determining the influence of enzyme supplementation on metabolisable energy of solvent extracted rapeseed and sunflower seed meal in chicken, quail and guinea fowl (Mandal et al., 2005). It is possible however, that adaptation period required may differ depending on fibre type and content of test feedstuff or on the age of the birds or their combination.

The data from the current experiment suggest that adaptation periods influenced the metabolisable energy content of cereal grain and assay diets more markedly in turkeys but to a less extent in broilers and hardly at all in laying hens. However, the effect of adaptation period on AME content of cereal grain in turkeys was inconsistent with shortening length of adaptation, as the highest determined AME was observed with 10-d and 4-d adaptation period compared with 7-d. In broilers, metabolisable energy content of cereal grain and assay diets only marginally reduced with decreasing length of adaptation period. The determined metabolisable energy of cereal grain and assay diets was similar for the three different adaptation periods in laying hens.

The differences in physiological maturity among the different birds used in the current experiment may partly explain why there were differences in the effect of adaptation length during AME assay in broilers, turkey and laying hens. The data from the current study indicate that the effect of varying length of adaptation was more apparent in birds with less matured digestive system, namely broiler and turkeys, rather than the laying hens. Turkeys are likely less physiologically mature at the same age with broilers in view of their different rates of growth as has been demonstrated between turkeys and duck (Applegate et al., 2005). This may explain why the effect of adaptation length was clearly significant in turkey, tended to be significant for broilers but not significant for laying hens. Uni et al. (1995) demonstrated that villi height and width increased 25 to 100% in all segment of small intestine between 4 and 10 d of age. Additionally, digestive enzymes may be limiting for adequate nutrient utilisation posthatch in chick (Nitsan et al., 1991) and poults (Sell et al., 1991) and these enzymes concentration increase with age. Therefore, during the development and maturation of the digestive system in young poultry, dietary nutrients may be poorly utilised, most especially during the first ten days after hatching (Batal and Parsons, 2002).

The lowest AME values was observed between 4 and 7 d post-hatching in chicks (Zelenka, 1968) and turkeys (Sell, 1996) and this later increased with age. Siregar and Farrell

(1980) found that AME values were not affected by age, whereas Bartov (1988) reported a decrease in AME with birds grew older. Similarly, AMEn value increased from d 0 to d 14 for New Hampshire × Columbian chicks whereas the increase lasted until d 21 of age with the commercial chick (Batal and Parsons, 2002). Also, there was evidence that AME and AMEn varied with age of birds in the study of Lopez and Leeson (2008). There is also the possibility that stability in the microbial population of the digestive tract with age (Lu et al., 2003) influences how birds at different ages respond to the influence of adaptation length on AME of feedstuffs. The variation in energy content of a single feedstuff determined at different period after hatching corroborate the findings in this experiment where adaptation period influenced the metabolisability of energy in cereal grains and assay diets in turkeys and broilers but not in laying hens.

5. Conclusions

The results of the current study show that irrespective of the species of poultry birds, the greater overriding factor for energy values of feedstuff is the specific ingredient being assayed. However, the influence of adaptation period during AME assay becomes relevant when the assay utilises birds with relatively physiologically immature digestive tract.

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Table 1

Ingredient and chemical composition (g/kg) of experimental diets to determine apparent metabolisable energy content of maize and barley fed for different adaptation lengths in broilers, turkeys and laying hens.

Item	Broilers			Turkeys			Laying hens		
	1	2	3	1	2	3	1	2	3
Items									
Wheat	602.2	411.9	411.9	492.8	333.4	333.4	654.1	433.4	433.4
Soybean meal	300.0	205.2	205.2	400	270.7	270.7	210	139.1	139.1
Soy oil	47.0	32.2	32.2	35.0	23.7	23.7	25.0	16.6	16.6
Dicalcium phosphate	17.5	17.5	17.5	26	26	26	9.5	9.5	9.5
Limestone	14.0	14.0	14.0	17.7	17.7	17.7	85.0	85.0	85.0
Titanium dioxide[a]	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Maize	0	300	0	0	300	0	0	300	0
Barley	0	0	300	0	0	300	0	0	300
Vitamin-mineral premix[b]	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
L-Lysine HCl	3.6	3.6	3.6	8.0	8.0	8.0	1.0	1.0	1.0
DL-Methionine	1.9	1.9	1.9	3.9	3.9	3.9	1.4	1.4	1.4
L-threonine	0.7	0.7	0.7	2.6	2.6	2.6	0.8	0.8	0.8
Salt (NaCl)	3.1	3.1	3.1	4.0	4.0	4.0	3.2	3.2	3.2

Total	1000	1000	1000	1000	1000	1000	1000	1000	1000
Analysed energy and nutrient composition[c]									
Dry matter, g/kg	898.9	896.9	903.1	892.2	894.4	894.1	893.0	896.8	896.8
Gross energy, MJ/kg	17.4	17.0	17.0	16.4	15.9	15.8	14.7	14.6	14.6
Crude protein (N x 6.25), g/kg	240.6	195.0	199.4	253.1	195.6	206.3	182.5	137.5	142.5

[a] Prepared as 1g titanium dioxide added to 4g of ground corn.

[b] Vitamin A, 5484 IU; vitamin D3, 2643 ICU; vitamin E, 11 IU; menadione sodium bisulfite, 4.38 mg; riboflavin, 5.49 mg, d-panthothenic acid, 11 mg; niancin, 44.1 mg, choline chloride, 771 mg; vitamin B12, 13.2 ug; biotin, 55.2 ug; thiamine mononitrate, 2.2 mg; folic acid, 990 ug; pyridoxine hydrochloride, 3.3 mg; iodine, 1.11 mg; manganese, 66.06 mg; copper, 4.44 mg; iron, 44.1 mg; zinc, 44.1 mg; selenium, 300 ug.

[c] Values are means of duplicate analyses.

Table 2
Analysed chemical composition of wheat, barley and maize (g/kg, as-is basis).

Item	Wheat	Barley	Maize
Dry matter	882.3	892.9	871.9
Crude protein (N x 6.25)	159.9	109.3	84.4
Gross Energy (MJ/kg)	-	17.9	18.1
Crude fat	11.7	47.4	31.2
Crude fiber	21.7	38.8	15.2
Ash	19.7	15.6	13.0
Acid detergent fiber	41.1	67.9	23.6
Neutral detergent fiber	273.1	186.5	68.5

Table 3

Apparent metabolisable energy, coefficient of energy metabolisability and nitrogen-correct metabolisable energy of maize and barley in broilers receiving experimental diets for different adaptation lengths[1].

Cereal grain	Adaptation length	AME (MJ/kg)	cEM	AMEn (MJ/kg)
		Means for main effect of cereal grain		
Maize		13.5	0.747	13.4
Barley		12.2	0.685	12.1
Pooled SEM[2]		0.233	0.013	0.240
P-values of diet type		0.001	0.003	0.001
		Means for main effect of adaptation length		
	10 days	13.3	0.740	13.2
	7 days	13.0	0.720	12.8
	4 days	12.4	0.688	12.2
Pooled SEM[2]		0.285	0.016	0.295
P-values of adaptation length		0.089	0.093	0.062
		Means for simple main effects		
Maize	10 days	13.9	0.766	13.8
	7 days	13.5	0.749	13.5
	4 days	13.1	0.727	13.0
Barley	10 days	12.8	0.713	12.7
	7 days	12.4	0.691	12.2

	4 days	11.6	0.650	11.4
Pooled SEM[2]		0.403	0.023	0.417
Cereal grain × adaptation length		0.865	0.826	0.885

[1]n of 6 for the simple effect, 18 for main effect of adaptation length and 27 for main effect of cereal grain. AME = Apparent metabolisable energy; cEM = Coefficient of energy metabolisability; AMEn = Nitrogen-corrected apparent metabolisable energy.

[2]SEM = Standard error of difference of mean.

Table 4

Apparent metabolisable energy, coefficient of energy metabolisability and nitrogen-correct metabolisable energy of maize and barley in turkeys receiving experimental diets for different adaptation lengths[1].

Cereal grain	Adaptation length	AME (MJ/kg)	cEM	AMEn (MJ/kg)
		Means for main effect of cereal grain		
Maize		13.7	0.756	13.3
Barley		11.6	0.649	11.2
Pooled SEM[2]		0.340	0.019	0.369
P-values of diet type		0.001	0.002	0.002
		Means for main effect of adaptation length		
	10 days	12.9^{ab}	0.716^{a}	12.7
	7 days	11.7^{b}	0.651^{b}	11.4
	4 days	13.3^{a}	0.741^{a}	12.8
Pooled SEM[2]		0.446	0.025	0.491
P-values of adaptation length		0.046	0.013	0.073
		Means for simple main effects		
Maize	10 days	14.4	0.795	14.2
	7 days	12.7	0.703	12.4
	4 days	13.9	0.771	13.4
Barley	10 days	11.4	0.637	11.2
	7 days	10.7	0.600	10.3

	4 days	12.7	0.710	12.1
Pooled SEM[2]		0.552	0.031	0.736
Cereal grain × adaptation length		0.417	0.330	0.371

[1]n of 6 for the simple effect, 18 for main effect of adaptation length and 27 for main effect of cereal grain. AME = Apparent metabolisable energy; cEM = Coefficient of energy metabolisability; AMEn = Nitrogen-corrected apparent metabolisable energy.

[2]SEM = Standard error of mean.

[a-b] Means in the same column but with different superscripts are significantly different ($P < 0.05$).

Table 5
Apparent metabolisable energy, coefficient of energy metabolisability and nitrogen-correct metabolisable energy of maize and barley in laying hens receiving experimental diets for different adaptation lengths[1].

Cereal grain	Adaptation length	AME (MJ/kg)	cEM	AMEn (MJ/kg)
		Means for main effect of cereal grain		
Maize		13.6	0.751	13.5
Barley		12.6	0.703	12.5
Pooled SEM[2]		0.247	0.014	0.282
P-values of diet type		0.022	0.017	0.029
		Means for main effect of adaptation length		
	10 days	13.2	0.734	13.2
	7 days	12.6	0.702	12.5
	4 days	13.4	0.746	13.4
Pooled SEM[2]		0.312	0.017	0.354
P-values of adaptation length		0.271	0.164	0.267
		Means for simple main effects		
Maize	10 days	13.5	0.745	13.4
	7 days	13.2	0.727	13.0
	4 days	14.1	0.777	14.0
Barley	10 days	12.9	0.722	12.9
	7 days	12.1	0.676	12.0

	4 days	12.8	0.714	12.7
Pooled SEM[2]		0.437	0.002	0.503
Cereal grain × adaptation length		0.822	0.740	0.799

[1]n of 6 for the simple effect, 18 for main effect of adaptation length and 27 for main effect of cereal grain. AME = Apparent metabolisable energy; cEM = Coefficient of energy metabolisability; AMEn = Nitrogen-corrected apparent metabolisable energy.

[2]SEM = Standard error of mean.