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Influence of genotype, sex and age of chickens on metabolisable energy of poultry feeds

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ABSTRACT

The influence of genotype, age and sex on apparent metabolisable energy (AME) and on nitrogen-corrected AME (AMEn) was studied using male and female chickens of two different genotypes (RIR and Cornish lines) at 4 and 8 weeks of age. The experiment was carried out for the purposes of better understanding the effect of age on dietary AME and AMEn of high protein-low energy (LEHP) and low protein-high energy (HELP) diets. These types of diets are used in the determination of the AMEn content of feed ingredients. The influence of age on metabolisable energy values obtained for the feed ingredients was not consistent; thus, AME and AMEn values obtained for corn were not significantly different (P>0.05) at 4 and 8 weeks of age, but with respect to fish meal significant difference (P>0.05) was ascertained between the ages in both genotypes. The AME and AMEn values calculated for corn at both ages were the same for both genotypes and both sexes. Also, the level of corn intake had no influence on metabolisable energy at these two ages. However, variation in fish meal intake and its metabolisable energy content was dependent on the growing period. AME and AMEn values obtained for the LEHP diet, but not for the HELP diet, increased significantly between 4 and 8 weeks of age, representing a significant interaction between age and experimental diet. The AME and AMEn were significantly lower at four weeks than at eight weeks of age for LEHP, in contrast with the HELP diet.
(Keywords: metabolisable energy, sex, age, genotypes, feed ingredients)

ÖSSZEFOGLALÁS

Csirkék genotípusának, ivarának és korának hatása a baromfitakarmány hasznosítható energiájára

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A genotípus, a kor továbbá az ivar hatását vizsgálták a látszólagos metabolizálható energiára (AME) s a nitrogénre korrigált AME-re (AMEn) 4, ill. 8 hetes korú, két genotípusú (RIR és Cornish vonal) csirkében. A kísérletek célja az volt, hogy adatokat kapjanak nagy fehérje- és kis energiatartalmú (LEHP), valamint kis fehérje- és nagy energiatartalmú (HELP), referenciatakarmánynak a metabolizálható energiára gyakorolt hatásáról. Az energia- és a fehérjetartalmat kukorica, ill. halliszt arányának változtatásával állították be. Megállapították, hogy az életkor hatása - ha az energiát kukoricával biztosították - nem szignifikáns az AME és az AMEn értékekre a 4 továbbá 8 hetes állatokban. Ezzel szemben a halliszt szignifikáns különbségeket

mutatott a különböző korú valamint genotípusú csirkékben. Megállapítható volt tehát, hogy a kukorica társított vizsgálatokban még nagyobb arányban sincs hatással a metabolizálható energiára e két korcsoportban. A halliszt metabolizálható energiatartalma viszont függ az életkortól és a növekedési periódustól. Ezért a LEHP takarmányra kapott AME és AMEn értékek 4-8 hét között szignifikánsan nőttek, szignifikáns interakciót mutatva a kor, ill. a takarmány között. A látszólagos metabolizálható energia és a nitrogénre korrigált metabolizálható energia a 4 hetes állatok esetében a HELP takarmány etetésekor szignifikánsan alacsonyabb volt, mint a 8 hetes állatoké a LEHP takarmány esetében.
(Kulcsszavak: metabolizálható energia, ivar, kor, genotípus, beltartalmi vizsgálat)

INTRODUCTION

The apparent metabolisable energy (AME) content values for feedstuffs are not always constant, and may vary even when a feedstuff is fed to birds of the same type. Digestibility of feed ingredients may also be dependent on the genotype, age and sex of the birds (*Sibbald,* 1975; *Proudman et al.,* 1970; *March,* 1973; *Vincze*, 1979; *Vincze et al*., 1992; *Dublecz et al*., 1997; *Vincze et al*., 1997). Genotype and sex influence the metabolisable energy and digestibility of feedstuffs (*Sorensen and Chwalibog*, 1983; *Leenstra and Pit*, 1987; *Jorgensen and Sorensen*, 1990), and may be attributable to variations in the endogenous energy losses relative to the excreta energy of feed origin. *Slinger* (1964) observed that differences in AME values measured with broiler chickens and laying hens might have been due to variations in genotype, sex and age. *Sibbald and Slinger* (1963a) and *Spratt and Leeson* (1987) found that White Leghorn chicks metabolised more dietary energy than did White Rock chicks. Sex exerted no influence on metabolisable energy (*Zelenka*, 1997; *Adnan,* 1981; *Chwalibog et al*., 1978; *Scheele*, 1979). *Sibbald and Slinger* (1963a) reported no differences between AME values measured with male and female chicks. The influence of age on digestibility coefficient has been observed not to be consistent (*Ten Doeschate et al*., 1993). It can be concluded that the manner in which age influences digestibility is still not entirely clear, but that such an influence does exist. The effect of age on the dietary nitrogen-corrected AME (AMEn) of high protein-low energy (LEHP) and low protein-high energy (HELP) diets used in the permination of the AMEn content of grains when substituted for the entire diet (*Bartov*, 1995). However*, Shires et al*. (1980) also reported that the TME value of corn for chicks and roosters was affected by age. *Bayley* (1968) and *Zelenka* (1968) described variations with age in the AME values of feedstuffs. *Carew* (1972) and *Fernandez* (1996) reported age effect, in that the excretion of uric acid, ammonia and total N increases with age. *Miski* and *Quazi* (1981) found that FmE+UeE per unit body weight and size decrease with age, which would have the effect of increasing AME value. Knowing the degree of variability between two ages in the digestibility of a diet may help in isolating those dietary components that are more difficult to digest for the younger than the older chick. *Potter et al*. (1962) suggested that chicks fed fish meal diets converted the metabolisable energy to body energy more efficiently. *Shires* (1987); *Askbrant* (1990) and *Yutste et al*. (1991) also compared AME and TME bioassays for determining ME of feed ingredients for broilers. *Hochstetler* and *Scott* (1975) observed that the AMEn value of corn was not affected by the age of the bird. *Sibbald et al*. (1960) observed that the type of protein included in the basal diet may influence the energy availability of the test material, and that low-protein basal diets contained more ME than did those prepared with a high protein content. *Slinger* (1964), *Leeson et al.* (1974) and *Ten Doeschate et al*. (1993) noted that AME varies with strain and breed and with interaction due to different genotypes, sex and age. However *Laurin* (1985) suggested that the AME assay of greater precision used with birds fed ad libitum is the preferred assay, at least at an

early age. In the present study, metabolisable energy was determined using chromic oxide (Cr_2O_3) as an indicator. The accuracy of chromic oxide (an indicator technique) is more precise than the total collection method (*Sibbald et al*., 1960; *Olsson and Kihlen*, 1948; *Hill and Anderson,* 1958; *Sibbald* and *Slinger*, 1963b; *Aviniki* and *Vincze*, 1989). *Mollah and Bryden* (1983) reported that AME values determined using a rapid bioassay technique with growing broilers were considerably higher than values determined using the conventional procedure with growing broilers. *Sibbald* (1978) observed that TME values for adult birds on the same diet were less variable than those for chicks. The objective of this study was to determine the effects of genotype, age and sex on the AME and AMEn values for corn and fish meal substituted into a reference diet by two bioassay methods.

MATERIALS AND METHODS

Experimental birds

The chickens used in this experiment were 96 males and 96 females of two genotypes: Rhode Island Red (RIR) (layer type) and Cornish (meat type). The chickens were fasted for 12 hr to empty their alimentary tract of feed residues. All the one-day-old-chicks were individually weighed and allotted to cages. The chickens were reared in cages with wire floors (2 chicks per cage); aluminium trays were placed on the floor in the first week. The environmental temperature was gradually lowered from 32°C at one day of age to 18°C at 6 weeks. During the rearing period the building was lit continuously and water and feed were provided *ad libitum.* All the chicks were fed the same starter diet (AMEn 3.16 kcal/g (13,23 kJ/g) and CP 23%) and the same finisher diet (AMEn 3.08 kcal/g (12.90 kJ/g) and CP 19.36%).

The experimental period

Two points in the chick feeding period were designed for the AME assay: 4 weeks and 8 weeks of age. During the experimental period fresh water and feed were constantly available to the chicks. Weight changes and feed consumption data for the trial periods were recorded. On the three days of the assay period the dropping trays were collected twice a day. Spilt feed and dropped feathers and scales were removed from the excreta samples collected on each tray, which were then immediately frozen. The frozen excreta samples were dried in an oven at 80°C for 48 hours. Then the dried samples were weighed and ground in preparation for chemical analysis.

Indicator method

Chromic oxide (Cr_2O_3) was used as an unabsorbable indicator. It was mixed into the experimental diet in a proportion of 0.3%. The ground experimental diets, feedstuffs and excreta samples were analysed for gross energy using a bomb calorimeter (Parr Instrument Company 1261), while the nitrogen content of the samples was determined by a Kjeltec Auto 1030 equipment. Dietary ME values were calculated according to the following equations**.**

ME=heat of combustion of ration (GE kcal/g)(kJ/g)–

[(Cr_2O_3 in ration/Cr_2O_3 in excreta)×heat of combustion of excreta (GE kcal/g)(kJ/g)].

N-corrected ME=

classical ME–8.73[gN of ration–(Cr_2O_3 in ration/Cr_2O_3 in excreta)×g N of excreta)].

Calculation of ME of a test ingredient

ME per gramme substituted ingredient=

ME of test diet–(ME of reference diet×proportion of ference diet)/
proportion of test ingredient in the test diet.

Apparent digestibility of test diet(%)=

100–[100×(% indicator in feed/% indicator in faeces)×
(% indicator in faeces/% indicator in feed)].

Apparent digestibility of test ingredient(%)=

[% digestibility of test diet–(digestibility of reference diet×fraction of nutrient in test diet)]/ proportion of nutrient from test feed in test diet.

The experimental diets

The composition of the reference diets used in the experiments is shown in *Table 1*. One of the reference diets was used in each case and each sample of the corn and fish meal under study was incorporated into the appropriate reference diet. Corn was incorporated into the reference diet with low energy and high protein at a concentration of 40% or 80%, while the fish meal was incorporated at a level of 4% or 8% into the reference diet with high energy and low protein. The experimental diet was fed for a 4-day adaptation period followed by a 3-day collection period in which feed intake was recorded. The quantities of feed in the troughs were kept to a minimum to avoid wastage.

Table 1

Composition of reference diets (%)

FEED INGREDIENT(2)	Reference diet(1)	
	LEHP*	HELP*
Corn grain (3)	0	40.3
Barley grain (4)	23	5
Wheat grain (5)	23	20
Wheat bran (6)	0	13
Soybean meal 48% CP (7)	50.2	18
Fish meal (8)	0	0
Calcium phosphate (9)	1.4	1.4
Oyster shell (10)	1.4	1.3
Vit. supplement **	0.5	0.5
Mineral suppl.***	0.5	0.5
ANALYSED COMPOSITION		
MEn (kcal/g)(kJ/g)	2.96 (12,39)	3.01 (12,60)
Crude protein (%) (11)	30.51	17.67

*Reference: low energy-high protein (LEHP) (*alacsony energia- és magas fehérjetartalmú takarmány)* and high energy-low protein (HELP) (*magas energia és alacsony fehérjetaratalmú takarmány).* **Supplied per kilogramme of diet (*a takarány vitaminkiegészítése kilogrammonként)*: vit. A, 4,400,000 IU; vit. D_3, 720,000 IU; vit. E 7,200 IU; vit. K_3, 1,000 IU; vit. B_1, 600 mg; vit. B_2, 2,400 mg; vit. B_3, 4,800 mg; vit. B_5, 12,000 mg; vit. B_6, 600 mg; vit. B_9, 400 mg; vit. B_{12}, 6.4 mg; choline chloride, 220,000 IU; vit. H_2, 40 mg, ***Supplied per kilogramme of diet (*a takarmány ásványi anyag kiegészítése kilogrammonként)*: manganese, 40,000 mg; zinc, 26,000 mg; copper, 2,000 mg; iodine, 400 mg; cobalt, 40 mg; calcium, 181,000 mg; selenium, 40 mg.

1. táblázat: A kontoll takarmány összetétele

Kontroll takarmány(1), Összetevők(2), Kukorica(3), Árpa(4), Búza(5), Búzakorpa(6), 48%-os fehérje tartalmú szójaliszt(7), Halliszt(8), Kalcium-foszfát(9), Kagylóhéj(10), Nyersfehérje(11)

RESULTS AND DISCUSSION

The effects of age, sex and genotype (meat or laying type) on the apparent metabolisable energy (AME) and nitrogen-corrected AME (AMEn) of the test diets and the test ingredients are illustrated in *Table 2*. The metabolisable energy values for the test diet and the trial ingredients (corn and fish meal) were obtained by means of the indicator method, according to *Sibbald et al*. (1960). The significant differences for the two genotype and sexes were not similar; therefore, AME and AMEn obtained for the test diet (protein source) for males of the two genotype was not significantly different (P>0.05), while in females significant difference (P<0.05) was ascertained with respect to the metabolisable energy of the two source test diets. The results of the analysis of the test ingredients showed no significant difference (P>0.05) in males of the two genotypes regarding metabolisable energy values obtained for corn substituted at different levels, with the exception of fish meal level. There was a significant (P<0.01) interaction between AME and AMEn values obtained for the trial diets and the levels of trial ingredients. The metabolisable energy values of the reference diet and the test ingredients determined during the two periods are shown in *Table 3*. AME and AMEn were significantly (P<0.05) lower at 4 weeks than at 8 weeks of age for the LEHP diet, but AME and AMEn in the LEHP diet were significantly (P<0.05) higher at 4 weeks than at 8 weeks. As the data indicate, none of the apparent metabolisable energy and nitrogen-corrected AME values obtained for the test ingredients showed significant (P>0.05) difference between the two ages, while AME and AMEn for the test ingredient corn at levels of 40% and 80% were not significantly different (P>0.05) between the two ages. However, the fishmeal diet did not follow the same pattern. At a level of 4% the AME values proved significantly (P<0.05) different, while the AMEn values were not significantly different (P>0.05); at a level of 8% both AME and AMEn showed significant difference (P<0.05) between 4 and 8 weeks of age (*Table 3*). The AME and AMEn values obtained for the reference diets showed significantly different (P<0.05) effect of the two genotypes, but there was difference between the two genotypes in the AME and AMEn values obtained for both reference diets, with the exception of AMEn for LEHP reference diet. However, the AME and AMEn values for HELP were not significantly different (P>0.05) between the sexes but there was significantly different (P<0.05) for LEHP reference diet (*Table 4*).

Table 2

Mean AME and AMEn values for the test diets and the test ingredients with respect to different genotypes[1]

Genotype[2](1)	Cornish		RIR	
Sex	**Male(2)**	**Female(3)**	**Male**	**Female**
Test diet[3](4)	**AME, kcal/g (kJ/g)**			
60% LEHP+40% corn	2.95±0.196^{fg} (12.35±0.82)	3.40±0.076^{a} (14.24±0.32)	3.189±0.043^{cd} (13.35±0.39)	3.237±0.092^{bc} (13.55±0.39)
20% LEHP+80% corn	3.36±0.044^{ab} (14.07±0.18)	3.35±0.035^{ab} (14.03±0.15)	3.04±0.144d^{ef} (12.72±0.60)	3.47±0.04^{cd} (14.53±0.17)
96% HELP+4% fish meal	2.94±0.075^{fg} (12.31±0.31)	3.16±0.032^{cd} (13.23±0.13)	2.86±0.01^{g} (11.97±0.04)	2.98±0.107^{fg} (12.48±0.45)
92% HELP+8% fish meal	3.03±0.957^{def} (12.69±4.01)	3.12±0.085^{cdf} (13.06±0.36)	3.02±0.243^{efg} (12.64±1.02)	2.77±0.074^{g} (11.60±0.31)

Continued. *A táblázat a következő oldalon folytatódik.*

Continued from previous page. *Folytatás az előző oldalról.*

Test ingredients(5)				
Corn 40%	2.74±0.44^{ef} (11.47±1.84)	3.77±0.22^{d} (15.78±0.92)	3.4±0.183^{de} (14.24±0.77)	3.66±0.399^{de} (15.32±1.67)
Corn 80%	3.43±0.063^{de} (14.36±0.26)	3.40±0.048^{de} (14.24±0.20)	3.04±0.168^{de} (12.73±0.70)	3.60±0.079^{de} (15.07±0.33)
Fish meal 4%	9.12±1.1^{a} (38.18±4.61)	5.68±0.159^{c} (23.78±0.67)	1.95±0.24^{f} (8.16±1.00)	5.91±1.85^{bc} (24.74±7.75)
Fish meal 8%	3.99±0.76^{d} (16.71±3.18)	3.94±0.756^{d} (16.50±3.17)	6.76±1.67^{b} (28.30±6.99)	2.09±0.36^{f} (8.75±1.51)
Test diet	**AMEn, kcal/g (kJ/g)**			
60% LEHP+40% corn	2.68±0.1^{h} (11.22±0.42)	3.19±0.069^{b} (13.36±0.29)	3.01±0.038^{cd} (12.60±0.16)	3.05±0.082^{c} (12.77±0.34)
20% HELP+80% corn	3.27±0.04^{ab} (13.69±0.17)	3.28±0.03^{ab} (13.73±0.13)	3.02±0.136^{cd} (12.64±057)	3.38±0.0.36^{a} (14.15±0.15)
96% LEHP+4% fish meal	2.82±0.068^{ab} (11.81±0.28)	3.01±0.029^{cd} (12.60±0.12)	2.74±0.009^{fgh} (11.47±0.04)	2.85±0.097^{efg} (11.93±0.41)
92% HELP+8% fish meal	2.87±0.051^{de} (12.02±0.21)	2.97±0.076^{cde} (12.43±0.32)	2.89±0.216^{ef} (12.10±0.90)	2.64±0.066^{gh} (11.05±0.28)
Test ingredients				
Corn 40%	2.80±0.39^{d} (11.72±1.63)	3.64±0.199^{d} (15.24±0.83)	3.36±0.16^{d} (14.07±0.67)	3.55±+0.35^{d} (14.86±1.47)
Corn 80%	3.38±0.057^{d} (14.15±0.24)	3.38±0.043^{d} (14.15±0.18)	3.06±0.15^{d} (12.81±0.63)	3.55±0.069^{d} (14.86±0.29)
Fish meal 4%	8.32±1.147^{a} (34.83±4.80)	4.76±0.139^{c} (19.93±0.58)	1.76±0.502^{e} (7.37±2.10)	5.35±1.434^{bc} (22.40±6.00)
Fish meal 8%	3.64±0.497^{d} (15.24±2.08)	3.30±0.67^{d} (13.82±2.81)	6.00±1.38^{b} (25.12±5.78)	1.88±0.117^{e} (7.87±0.49)

^{a,b,c,d,e,f,g}Means within the same column with different letters differ significantly (P<0.05). (*A különböző betűvel jelölt értékek ugyanazon oszlopon belül szignifikánsan különböznek.*), [1]Value mean±standard error mean for two genotypes. (*Átlag±az átlag standard hibája a két genotípusban.*), [2]Rhode Island Red (layer type) and Cornish (meat type) lines. (*Rhode Island Red (tojó típus) és Cornish (hús típus) vonalak.*), [3]LEHP=low energy and high protein (*alacsony energia és magas fehérje*), HELP=high-energy low protein (*magas energia és alacsony fehérje*).

2. táblázat: A különböző genotípusok által fogyasztott kísérleti tápok és összetevők átlagos AME valamint AMEn értékei

Genotípus(1), Hímivar(2), Nőivar(3), Kísérleti táp(4), Táp összetevők(5)

The effect of genotype, sex, test diet and test ingredient at different ages on the mean AME and AMEn values are shown in *Table 5*. As the data indicate, the AME and AMEn values obtained for the Cornish line at 4 weeks of age were 3.11 and 3.04 kcal/g (13.02, 12.73 kJ/g), and at 8 weeks 3.19 and 3.0 kcal/g (13.36, 12.6 kJ/g). For RIR the corresponding values were 2.94 and 2.83 kcal/g (12.31, 11.85 kJ/g) at 4 weeks and 3.13 and 2.98 kcal/g (13.10, 12.48 kJ/g) at 8 weeks, respectively. When these values were compared significant differences were ascertained between the two genotypes. However AME values at 4 week of age were generally lower than AME values at 8 weeks of age. Regarding sex of bird, the results obtained followed the same pattern as the values given in *Table 5.*

Table 3

Mean AME and AMEn values for the reference diets and levels of test ingredients at two ages for both genotypes[1]

Age(1)	4 weeks		8 weeks	
	AME	**AMEn**	**AME**	**AMEn**
Reference diets[2](2)	**kcal/g, (kJ/g)**			
LEHP	2.953±0.082[b] (12.36±0.34)	2.713±0.07[b] (11.36±0.29)	3.169±0.01[a] (13.27±0.04)	2.898±0.012[a] (12.13±0.05)
HELP	3.105±0.095[d] (13.00±0.40)	2.98±0.048[c] (12.48±0.20)	2.981±0.043[c] (12.48±0.18)	2.877±0.037[b] (12.05±0.16)
Level of test ingredient(3)				
Corn 40%	3.577±0.591[c] (14.98±2.47)	3.51±0.0507[b] (14.70±0.21)	3.215±0.168[c] (13.46±0.70)	3.19±0.56[b] (13.36±2.34)
Corn 80%	3.384±0.232[c] (14.17±0.97)	3.36±0.203[b] (14.07±0.85)	3.361±0.035[c] (14.07±0.15)	3.34±0.032[b] (13.99±0.13)
Fish meal 4%	5.34±2.12[b] (22.36±8.88)	5.09±1.89[a] (21.31±7.91)	6.00±1.69[a] (25.12±7.08)	5.002±1.56[a] (20.93±6.53)
Fish meal 8%	2.43±0.417[d] (10.17±1.75)	2.38±0.357[c] (9.96±1.50)	5.98±1.52[a] (24.66±6.36)	5.05±1.38[a] (21.14±5.78)

[a,b,c,d]Means within the same column with different letters differ significantly (P<0.05),. [1]Value mean±standard error mean for two genotypes, [2]LEHP=low energy and high protein; HELP=high-energy low protein (*l. 2. táblázat).*

3. táblázat: A kontroll és kísérleti tápok átlagos AME valamint AMEn értékei a két genotípus két korcsoportjában

Életkor(1), Kísérleti táp(2), Táp összetétel(3)

Table 4

The effect of genotype, age and sex on the AME and AMEn of the reference diets[1]

Reference diet[3](1)	LEHP	HELP	LEHP	HELP
Genotype[2](2)	**AME, kcal/g (kJ/g)**		**AMEn, kcal/g (kJ/g)**	
Cornish	3.119±0.034[a] (13.059±0.142)	3.162±0.08[a] (13.239±0.335)	2.857±0.029[a] (11.962±0.121)	2.987±0.09[a] (12.506±0.377)
RIR	2.998±0.103[b] (12.552±0.431)	2.975±0.029[b] (12.456±0.121)	2.747±0.089[a] (11.501±0.373)	2.877±0.025[b] (12.045±0.105)
Sex(3)				
Male(4)	3.069±0.049[b] (12.849±0.205)	3.081±0.105[a] (12.900±0.440)	2.805±0.044b (11.744±0.184)	2.967±0.094[a] (12.422±0.394)
Female(5)	3.049±0.108[a] (12.766±0.452)	3.003±0.038[a] (12.573±0.159)	2.835±0.050a (11.870±0.209)	2.897±0.032[a] (12.129±0.134)

[a,b]Means within the same column with different letters differ significantly (P<0.05), [1]Value mean±standard error mean for two genotypes, [2]Rhode Island Red (layer type) and Cornish (meat type) lines, [3]LEHP=low energy and high protein; HELP=high-energy low protein (*l. 2. táblázat).*

4. táblázat: A genetikai vonal és az ivar hatása a kontroll táp AME és AMEn tartalmára

Kísérleti táp(1), Genotípus(2), Ivar(3), Hímivar(4), Nőivar(5)

With respect to the test diet, when corn was mixed with the reference diet at levels of 40 and 80%, the AME and AMEn values determined at 4 and 8 weeks of age showed no significant (P>0.05) difference. The AME and AMEn values measured for 40% corn at 4 weeks were 3.20 and 3.03 kcal/g (12.40, 12.69 kJ/g) and at 8 weeks 3.18 and 2.94 kcal/g (13.31, 12.31 kJ/g); for 80% corn values of 2.29 and 3.22 kcal/g (9.59, 13.48 kJ/g) at 4 weeks and 3.32 and 3.24 kcal/g (13.90, 13.57 kJ/g) at 8 weeks were determined, respectively. When fish meal was incorporated at levels of 4 and 8%, the values of AME and AMEn obtained showed statistically significant (P<0.05) difference. There was no significant effect of age on AME and AMEn values for corn, while for fish meal there was significant (P<0.05) difference by the effect of age. Thus, the AME values for fish meal at 4 weeks of age were lower than those obtained at 8 weeks of age. Corn gave different results to determined for fish meal, with the exception of AME at 8 weeks of age, in which corn and fish meal followed the different pattern (*Table 5*).

Table 5

The effects of genotype, sex on AME and AMEn values of test diets and test ingredients at 4 and 8 weeks of age[1]

Age(1)	**4 weeks**		**8 weeks**	
Genotype[2](2)	**AMEn kcal/g (kJ/g)**	**AME kcal/g (kJ/g)**	**AMEn kcal/g (kJ/g)**	**AME kcal/g (kJ/g)**
Cornish	3.11±0.015[b] (13.02±0.063)	3.04±0.013[a] (12.73±0.054)	3.190±0.0075[a] (13.356±0.031)	3.00±0.0054[b] (12.56±0.02)
RIR	2.94±0.041[c] (12.31±0.172)	2.83±0.04[c] (11.85±0.17)	3.13±0.007[b] (13.10±0.03)	2.98±0.0073[b] (12.48±0.03)
Sex				
Male(3)	2.964±0.085[c] (12.410±0.356)	2.916±0.08[c] (12.209±0.335)	3.153±0.054[a] (13.201±0.226)	2.98±0.052[b] (12.48±0.22)
Female(4)	3.103±0.093[b] (12.992±0.389)	2.954±0.088[b] (12.368±0.368)	3.174±0.041[a] (13.289±0.172)	3.016±0.045[a] (12.627±0.188)
Test diet(5)				
Corn 40% + LEHP 60%	3.203±0.178[c] (13.410±0.745)	3.03±0.149[bc] (12.69±0.624)	3.187±0.052[c] (13.343±0.218)	2.94±0.048[c] (12.31±0.20)
Corn 80% + LEHP 20%	3.298±0.143[ab] (13.808±0.599)	3.227±0.126[a] (13.511±0.528)	3.322±0.022[a] (13.909±0.092)	3.248±0.02[a] (13.599±0.084)
Fish meal 4% + HELP 96%	2.876±0.059[e] (12.041±0.247)	3.01±0.052[bc] (12.60±0.22)	3.102±0.061[d] (12.987±0.255)	2.944±.0.055[c] (12.326±0.230)
Fish meal 8% + HELP 92%	2.761±0.081[f] (11.560±0.339)	2.64±0.067[d] (11.05±0.28)	3.221±0.097[bc] (13.486±0.406)	3.07±0.09[b] (12.85±0.38)
Test ingredient(6)				
Corn	3.48±0.41[c] (14.75±1.72)	3.43±0.35[c] (14.36±1.47)	3.288±0101[c] (13.766±0.423)	3.259±0.044[c] (13.645±0.184)
Fish meal	3.88±1.27[b] (16.24±5.32)	3.73±1.12[b] (15.62±4.69)	5.993±1.60[a] (25.091±6.699)	5.02±1.47[a] (21.02±6.15)

[a,b,c,d,e,f]Means within the same column with different letters differ significantly (P<0.05), [1]Value mean±standard error mean for two genotypes, [2]Rhode Island Red (layer type) and Cornish (meat type) genotypes (*l. 2. táblázat)*.

5. táblázat: A genotípus, az ivar, a kísérleti tápok és összetevők hatása 4 valamint 8 hetes korban az AME továbbá az AMEn tartalomra

Életkor(1), Genotípus(2), Hímnem(3), Nőnem(4), Kísérleti táp(5), Táp összetétel(6)

The three-way interactions between trial ingredient of either sex and genotype were not significant (P>0.05) at both ages. Therefore, interaction between trial ingredient and genotype were significant different (P<0.05) at 4 and 8 weeks of age (*Table 5*).

On comparison of the values obtained it is interesting to note that the values for males were lower than those for females. It is generally accepted that nitrogen balance in birds is influenced by diet composition. The results of this experiment show that the variations in nitrogen balance observed were due to the LEHP and HELP dietary sources. Absolute nitrogen retention in RIR and Cornish genotype fed on a diet derived from the high protein reference diet, or with substitution in the reference diet of increasing proportions of the fish meal trial ingredient, as a source of protein, proved consistently greater than that in genotypes fed on diets derived from HELP, or with various proportions of corn as the source of energy. This was expected, as decrease in the protein content of the diet would tend to result in a decrease in absolute nitrogen retention. Whatever the cause, increased nitrogen retention was observed with increase in dietary protein and with increase in the proportion of fish meal in the Cornish line at both ages, but in the RIR line decreased nitrogen retention was ascertained at both ages with increased dietary protein or fish meal level. As the data show, nitrogen retention proved significantly (P<0.05) different in the two genotypes and sexes between the ages. Nitrogen retention appeared significantly (P<0.05) different between the two sexes of the meat type (Cornish line), but this situation was not the same for the layer type (RIR). However, the layer type showed significantly (P<0.05) increased nitrogen retention for both sexes between the two respective ages (*Table 6*).

Table 6

Mean effect of genotype and sex at different ages on nitrogen balance[1]

Age(1)	**4 week**		**8 week**	
Genotype[2](2)	**RN%**		**RN%**	
Cornish, male	1.6±0.16^{c}	73.41±2.5^{cd}	0.89±0.11^{d}	74.47±0.95^{bc}
Cornish, female	1.73±0.2^{c}	77.54±3.34^{a}	0.9±0.08^{d}	78.11±2.2^{a}
RIR, male	4.07±58^{a}	71.07±3.4^{d}	2.3±0.47^{b}	78.85±1.53^{a}
RIR, female	4.0±0.54^{a}	70.58±3.74^{d}	1.88±0.28^{c}	76.7±2.24^{ab}

^{a,b,c,d,}Means within the same column with different letters differ significantly (P<0.05), [1]Value mean±standard error mean for two genotypes, [2]Rhode Island Red (layer type) and Cornish (meat type) lines (*l. 2. táblázat).*

6. táblázat: A genetikai vonal és az ivar átlagos hatása a nitrogénmérlegre különböző életkorban

Életkor(1), Genotípus(2)

CONCLUSIONS

Genotype

The results of this study indicate that the differences found between the two genotypes were in agreement with the results of *Sorensen and Chwalibog* (1983), *Leenstra and Pit* (1987) and *Jorgenson and Sorensen* (1990), who reported influence of genotype on digestion. Accordingly, the metabolisable energy and nitrogen-corrected AME values determined in

this experiment were significantly different (P<0.05) at 4 and 8 weeks of age. Similar results regarding the difference in metabolisable energy and nitrogen digestibility related to genotype to have been described by *Leenstra and Pit* (1987). The AME and AMEn of the reference diet were significantly different with two genotypes (Cornish and RIR), with the exception of the AMEn of LEHP. These findings are in agreement with those of *Sibbald et al.* (1960), suggesting that the type of protein incorporated into the basal diet might have influenced the availability of energy in the trial material. Therefore, the feeds prepared from the low protein basal diet contained more ME than did those prepared from the high protein basal diet. *Proudman et al.* (1970) and *March and Biely* (1971) also reported differences in energy utilisation between different strains of chicks, but *Washburn et al*. (1975) and *Sibbald* (1976) found no differences between meat and egg type hens. In this experiment, apparent metabolisable energy and nitrogen-corrected AME were significantly lower at four weeks than at eight weeks of age with the LEHP diet, but the AME and AMEn of the HELP diet were not similar. *Sibbald and Slinger* (1963) found that values determined for AME for White Leghorn chicks were higher for both high- and low-energy diets than the corresponding values determined for White Rock chicks. In this experiment the apparent metabolisable energy and AMEn values obtained with the test diet containing corn were not significantly different at the two ages, but with fish meal as the protein source there was significant difference between the values determined at the different ages. *Potter et al.* (1962) stated that metabolisable energy values for fish meal diets were from 2 to 7 per cent lower than those for a basal diet. He suggested that chicks fed fish meal diets converted the metabolisable energy into body energy more efficiently. According to *Sibbald et al.* (1960) the metabolisable energy values varied when corn was combined with different basal diets. It was found that a broiler strain converted 20% more dietary AME to PE than did layer strains of chickens. *Ten Doeschate et al.* (1993) reported that dry matter and nitrogen digestibility were related to food intake in the same way as was found for the genotype effect. *Slinger* (1964) stated in several reports that bioavailable energy values vary according to the type of bird used: for chickens higher AME values were obtained with high-energy diets and lower AME values with low energy diets.

Sex

The effect of sex on ME values for the test diets and test ingredients showed significant difference. These results contrast with those obtained by *Chwalibog et al.* (1978) and those of *Sibbald and Slinger* (1963). They found no differences among AME values determined for female chicks. However, in this experiment significant differences observed in metabolisable energy values were related to sex and age. So the lower values determined for the males than for the females at both ages confirmed the results obtained by *Ten Doeschate et al.* (1993). Thus, sex influences digestibility coefficients, and both metabolisability and nitrogen digestibility proved slightly better in the female broiler chickens. It could be assumed that this higher digestibility was related to higher feed conversion ratio. These data are in agreement with those of *Sibbald and Price* (1975). They suggested that differences in AME values measured for broiler chickens and laying hens might be due to genotype, sex and age. However *Zelenka* (1997) reported that the effect of sex on AMEn values was not significant.

Age

The results of this experiment show agreement with those of *Sibbald and Price* (1975), who suggested that some of the differences in AME values associated with age, strain and species may be attributable to variations in FmE+UeE losses relative to excreta energy

losses of feed origin. However, *Bayley* (1968), *Zelenka* (1968) and *Lodhi et al.* (1969) reported that AME values of feedstuffs have also been shown to vary with the age of birds. In this study age had a marked influence on the utilisation of the metabolisable energy of the level of trial ingredient incorporated (fish meal at 4% and 8%). *Hochstetler and Scott* (1975) reported that AMEn values for corn were not affected by the age of the bird. In contrast, *Shires* (1987) reported that TME values for corn with respect to chicks and roosters were affected by difference in age. Apparent metabolisable energy and AMEn value varied with age in the case of both the LEHP and the HELP diet. Thus, AME and AMEn values for the LEHP diet increased between 4 and 8 weeks of age, but those for the HELP diet showed a decrease. As stated by *Laurin* (1985), the AME assay of greater precision used with birds fed ad libitum is the preferred assay, at least at an early age. It is interesting that the AME and AMEn values obtained for the different genotypes and sexes at 8 weeks of age were significantly ($P<0.05$) higher than those determined at 4 weeks (*Table 5*). These data are in agreement with those, who reported consistent differences in AME values determined from excreta samples from young (7 d.) and older (21 d.) broilers. Knowing the degree of variability between two ages in the digestibility of a diet may help in isolating those dietary components that are more difficult to digest for the younger than the older chick. Different responses due to age may be due to an immature gut (e.g. capacity), an immature endogenous enzyme system, or an immature population of microorganisms in the gut. *Ten Doeschate et al*. (1993) described the influence of age on digestibility coefficients as not consistent. They reported that female birds showed digestibility coefficients which were, in general, 3% higher than those of male chickens. This report also confirms the results obtained in this experiment (*Table 5*). It can be concluded that it is still not entirely clear how age influences digestibility, but that influence of age on digestibility does exist. Accordingly, the AME and AMEn values determined at 8 weeks of age were higher than those obtained at 4 weeks. Neither age showed significant ($P>0.05$) differences in the AME and AMEn values for the low (40%) and high (80%) corn levels when these were incorporated into the reference diet. However, when fish meal was incorporated into the reference diet with high energy-low protein a significant decrease in values were observed (*Table 5*). These results are in agreement with those reported by *Bartov* (1995). It is interesting to note that he also used HELP and LEHP diets in determining AMEn content of grain. He found that during three age periods chicks consumed less LEHP diet than those fed on the HELP diet, and that the AMEn of the LEHP diet at 22 days of age was lower than that from 11 to 17 days. Therefore, there was an interaction between age and diet: age led to a decrease in dietary AMEn mainly through its effect of reducing the utilisation of the energy from a LEHP diet. The AME and AMEn values obtained for the trial ingredients in this experiment increased by the effect of levels of corn and fish meal incorporated into the reference diets. In fact, the influence of age on metabolisable energy was slightly reduced in the case of corn, but with fish meal there was an increase at 8 weeks. These data show agreement with those of *Sibbald and Slinger* (1962). He found that cereal grains had no direct influence on protein level or on energy availability. In another study *Scheele* (1979) found values determined with adult cocks to be higher than those measured in chickens.

RN

The nitrogen retention data for the two genotypes were lower in the case of the low protein diet than with the high protein diet (*Table 6*). In a contrasting report *Bartov* (1995) suggested that nitrogen retention in birds fed a LEHP diet was consistently lower than that in those fed a HELP diet. In this study effect of age on nitrogen

retention was ascertained only with the LEHP diet. Therefore, at an early age, chicks fed on a LEHP diet will consume less food than those fed on a HELP diet. So, the possibility that the effect of age in reducing the AMEn of LEHP diets might also be related to an interaction effect between age and diet. Therefore, RN of a protein source (fish meal) mixed with a reference diet in two proportions would be greater than that of an energy source or trial ingredient (such as corn). It was also showed that ME values for individual feedstuffs can be related to their chemical composition. The results of this experiment indicate that ingredient level affects nitrogen retention. As the data show, with increasing dietary protein or fish meal, nitrogen retention decreased in the RIR line (laying type), but not in the Cornish line (meat type). Overall review indicates that RN was lower at 4 weeks of age than at 8 weeks for both sexes in this experiment. However, *Laurin* (1985) found a higher nitrogen correction factor at 1 week of age, since broilers retain more nitrogen at earlier age. *Fernandez* (1996) stated that the excretion of uric acid, ammonia and total N increases with age. In this study nitrogen retention in the two genotypes increased significantly between 4 and 8 weeks of age. These data are in agreement with those obtained by *Sorensen and Chwalibog* (1983), who reported that there was no difference in nitrogen retention between two lines. However, *Polin and Hussein* (1982) also reported an increase in retention nitrogen from 1 to 3 weeks of age. As can be seen in *Table 6*, the percentage of nitrogen retention increased between 4 and 8 weeks of age. This increase was higher in the RIR line than in the Cornish line. These data conform to those, who showed that over the normal age span of broiler chickens the percentage of nitrogen retained is between 35 and 39%. In addition, *Summers et al*. (1964) found that the percentage of dietary nitrogen retained by chicks fed diets containing from 10 to 26% protein varied between 36 and 53%.

Interaction

The interaction observed in this experiment between genotypes, sex, age and diet are as follows.

- There was significant interaction between test diet and test ingredients (corn and fish meal).
- There was interaction between sex and genotype.
- Significant differnce of interaction between sex, age, reference diet and test ingredient for AME and nitrogen-corrected AME was determined. These data confirm the findings of *Ten Doeschate et al*. (1993). Under the condition of this experiment it was found that with respect to metabolisability of energy interactions between genotype and sex and between genotype and age did exist. In addition it was also observed that in females interaction affecting energy metabolisability between genotype and sex and between genotype and age only corresponded to digestibility measurements. More research is required for the purpose of determining AME and AMEn values for every feedstuffs.

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