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Full Length Research Paper

Effects of amino acids and metabolizable energy on egg characteristics and broiler breeder performance

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A study was conducted to determine the effects of diet formulation type on egg characteristics and reproductive performance of broiler breeder (50 to 64 weeks of age). 140 female and 20 male breeders in four treatments with five replicates (7 females : 1 male) were used in the randomized 2 × 2 factorial design. Four experimental diets were formulated based on two factors: two levels of apparent and true metabolizable energy corrected for nitrogen of feedstuffs (AMEn and TMEn) and two levels of total amino acids (TAAF) and digestible (DAAF) feedstuffs. The results show that egg weight, egg production, fertility and hatchability were significantly different and affected by diet formulation based on energy (P<0.05). Diet formulation based on digestible amino acids of feedstuffs significantly increased albumen height and Haugh unit (HU). Hens on treatment 2 (AMEn + DAAF) were significantly different in egg weight (69.17 g), egg production (62.45%) and chicks/hen (40.23) (P<0.05). This study shows that the diets formulations for AMEn, TMEn, TAAF and DAAF have significant effects on egg characteristics and broiler breeders reproductive performance.

Key words: Broiler breeders, reproduction, amino acids, fertility, chickens.

INTRODUCTION

Current recommendation for diet formulation for broiler breeder hens is expressed as daily nutrient intakes based on apparent metabolizable energy (AME) and total amino acids (TAAF) rather than true metabolizable energy (TME) and digestible amino acids (DAAF) of feedstuffs. Energy and amino acids are the most important factors in broiler breeder hen's diet. Any change in the daily nutrients intake in broiler breeder hens must be done based on their requirements (Leeson and Summers, 2000). Therefore, knowing the requirements of metabolizable energy (ME) in broiler breeders at any age, phase of production and metabolizable energy value of feedstuffs in the diet is essential for their optimal production (NRC, 1994).

In many countries, total amino acids are still used for poultry diets formulation and to express requirements. However, not all amino acids in the feed are available for maintenance and production. The part of amino acids that is not digested can differ very much between feeds. Crude protein is used as a measure of the amino acid content of the feed. Anyway, it does not give any information about the actual amino acid levels. Formulating to minimum digestible amino acids will ensure both requirements matching and excesses, which need to be excreted and minimized. Critical amino acids in breeder feeds are: methionine, lysine, isoleucine and tryptophan. If feed is formulated to contain sufficient levels of these amino acids, egg production, fertility, egg size and metabolism will be optimized. Many amino acids in corn and soybean meal are about 90% digestible (NRC, 1994). Absorbent and retention rate of amino acids depends on two factors: (1) Digestibility (protein hydrolysis and absorption), and (2) amino acid retention rate. All amino acids are not available in the feedstuffs for maintenance and production. Parts of amino acids are indigestible and can vary among different feedstuffs. So to adjust poultry diets with digestible amino acids of feedstuffs is better and easier to meet birds' real

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requirements for maintenance and production (Leeson and Summers, 2000). Since feed intake is restricted in broiler breeder flocks, the amino acids availability in broiler breeders depends on composition and type of diets amino acids and amino acids intake (Fisher, 1987). Nutrition of broiler breeder hens can influence egg quality and is therefore extremely important for the embryo development and the successful hatching of high quality chick. The developing embryo and the hatched chick are completely dependent on their growth and development on nutrients deposited in the egg (Whitehead, 1989). The yolk and albumen in the egg supply the developing embryo with nutrients, water and minerals for normal growth. Yolk is an important nutritional component of the avian egg because it contributes 75% of the joules and provides all the lipids, and thus the energy for the developing embryo (Noble et al., 1996), as well as an important source of protein (Deeming, 2002). The yolk also provides all or most all the minerals, vitamin A and thiamine, and yolk lipids provide a range of essential components for tissue development and function. The albumen is an important reservoir for water, essential ions and protein, the latter forming 99% of the dry matter of albumen and also having useful anti-microbial properties (Deeming, 1997, 2002).

The objective of this experiment was to determine the effect of types of broiler breeder diets formulation on reproductive performance and egg characteristics. Diets were formulated based on two levels of energy of feedstuffs and two levels of amino acids of feedstuffs (total and digestible).

MATERIALS AND METHODS

To determine the effects of diet formulation on the Arian broiler breeder performance, a study was conducted with 140 females and 20 males (50 to 64 week). The experimental design was a completely randomized 2 × 2 factorial design treatment structured with 5 replicate pens per treatment. The first factor included was two levels of apparent and true metabolizable energy corrected for nitrogen (AMEn and TMEn) of feedstuffs and the second factor included was two levels of total amino acids (TAAF) and digestible amino acids of feedstuffs (DAAF). At 50 weeks of age, broiler breeders were weighted, and allocated to treatment groups on the basis of mean body weight (g), female (3550 ± 25) and male (4390 ± 30). Birds were housed in 20 floor pens of 1.2 × 2 m with 1 bell-type drinker. Light program was provided with 16 h of light per day from 7 am to 23 pm (50 to 64 weeks). The pattern of total and digestible amino acids and also nitrogen corrected apparent and true metabolizable energy were determined for feedstuffs (Yaghobfar and Boldaji, 2002, Yaghobfar and Zahedifar, 2003). Diets were adjusted based on the requirements of Arian broiler breeder (Manual, 2002) at two levels of the total and digestible amino acids requirements. The diets were formulated isoenergetically based on AMEn requirements. Composition and calculated contents of the diets are shown in Table 1. Feeds provided were in mash form and were milled with a 3 mm screen to obtain a similar particle size in all diets. Both male and female broiler breeders received the same diets at 8 am. Diets provided were 420 Kcal MEn and 21/2 g protein on a daily basis. The differences observed between the treatments on a daily basis, were the type of MEn and amino acids of feedstuffs.

Eggs were collected at 52, 56, 60 and 64 week of age. Eggs laid before 08:00 h were removed from the nest boxes and discarded from the experiments. Eggs were collected from nests between 08:30 and 12:30 h, placed in setter trays (150 eggs per tray), and transported into the storage room near the poultry houses. 240 eggs were collected every day and stored in the room at 16°C and 78% relative humidity. Eggs were culled in order for them to be excluded from the experiment, including those that were cracked, visibly dirty or extreme in size (those weighing less than 51 g or more than 75 g). After removing culled eggs, a random sample of egg production per day from each replicate (20 eggs total/day) was collected to determine egg characteristics, 376 eggs were used to measure egg characteristics in the weeks of the experiment (7 eggs for every replicate). At the end of the experiment, eggs (about 25 eggs for every replicate) were set in a Maino, force-draft incubator (Model II, Maino Enrico Co., Italy).

On the 18th day of incubation, eggs were individually candled in the transfer-room (about 24°C and 60% relative humidity), using a hand candling lamp. The remaining eggs which with apparently living embryos were transferred to hatching baskets are randomly distributed in the same trolley. All chicks were removed at 21.5 days of incubation. The numbers of saleable chicks and culls were determined. From the data, both hatchability (number of saleable chicks hatched per all eggs set × 100), fertility (number of fertile eggs set per all eggs set × 100) and numbers of chickens per hen (chicks/hen) were calculated.

To evaluate eggs quality, fresh eggs were opened in a laboratory at approximately 17°C to measure egg quality such as albumen height, albumen weight, yolk weight and Haugh unit (HU). The albumen height and HU was calculated using the Futura (Germany). The egg yolk was separated from the albumen and then rolled on a damp paper towel to remove any adhering albumen. Data were analyzed by GLM procedure (SAS 2001) and when significance occurred, means were compared with the Duncan multiple range tests. Output data were expressed as means with SEM.

RESULTS AND DISCUSSION

The effects of ME and AA diet formulation on egg quality and broiler breeders performance are summarized in Table 2. Egg weight and egg production were significantly higher in birds fed with the diet based on feedstuffs AMEn (68.69 and 56.74% than TMEn diet (67.58 g vs. 51.71%); ($P<0.05$). This result agrees with Leeson and Summers (2000) who showed that increased energy intake had significant positive effects on egg weight. ME levels in the diet of broiler breeders are very important. A deficiency may lead to a poor performance, as well as an increase in body fat due to an excess in energy levels. The main effects of diet formulation based on MEn and amino acids of feedstuffs had no effect on yolk and albumen weight. Diet formulation based on digestible amino acids of feedstuffs had significant difference on albumen height and HU ($P<0.05$).

Broiler breeder hens fed DAAF diet had a higher egg weight, egg production and albumen weight. This difference is not statistically significant ($P>0.05$). The

Table 1. Composition and calculated contents of the experimental diets.

Metabolism energy	**Apparent**		**True**	
Amino acid of feed	**Total**	**Digestible**	**Total**	**Digestible**
Item \ **Treatment**	**1**	**2**	**3**	**4**
Corn, Grain	54.00	54.00	33.00	33.00
Wheat	12.00	13.00	27.00	27.00
Wheat Bran	13.00	11.20	20.00	20.33
Soybean Meal (48%)	12.37	13.00	11.00	10.80
Oyster Shells	7.00	7.00	7.00	7.00
Dical. Phos.	1.00	1.00	1.00	1.00
Common Salt	0.03	0.20	0.20	0.20
Vitamin Premix*	0.25	0.25	0.30	0.30
Mineral Premix*	0.25	0.25	0.30	0.30
DL-Methionine	0.05	0.05	0.15	0.02
L-Lysine HCl	0.05	0.05	0.05	0.05
Total	100	100	100	100
Calculated contents				
Metabolosable Energy (Mcal/kg)	2.70	2.70	2.70	2.70
Protein (%)	14.00	14.00	14.00	14.00
Ether Extract (%)	2.29	2.29	2.03	2.03
Fiber (%)	4.7	4.7	5.2	5.2
Linoleic Acid (%)	1.05	1.05	1.05	1.05
Calcium (%)	3.00	3.00	3.00	3.00
Avail. Phosphorus (%)	0.40	0.40	0.40	0.40
Potassium (%)	0.60	0.60	0.60	0.60
Chlorine (%)	0.20	0.20	0.20	0.20
Sodium (%)	0.16	0.16	0.16	0.16
ARG (%)	0.69	0.69	0.69	0.69
GLY (%)	0.64	0.64	0.64	0.64
SER (%)	0.70	0.70	0.70	0.70
HIS (%)	0.37	0.37	0.37	0.37
ILE (%)	0.56	0.56	0.56	0.56
LEU (%)	1.11	1.11	1.11	1.11
LYS (%)	0.65	0.65	0.65	0.65
MET (%)	0.30	0.30	0.30	0.30
CYS (%)	0.27	0.27	0.27	0.27
PHE (%)	0.66	0.66	0.66	0.66
TYR (%)	0.52	0.52	0.52	0.52
THR (%)	0.50	0.50	0.50	0.50
TRP (%)	0.17	0.17	0.17	0.17
VAL (%)	0.58	0.58	0.58	0.58

This premix supplied the following per kilogram of feed: 12,000 IU of vitamin A, 2,100 IU of vitamin D3, 27.5 IU of vitamin E, 2 mg of vitamin K3, 1 mg of thiamin, 6 mg of riboflavin, 10 mg of pantothenic acid, 20 mg of niacin, 2 mg of pyridoxine, 0.8 mg of folic acid, 0.020 mg of cyanocobalamin, 0.15 mg of biotin, 200 mg of choline, 80 mg of Mn, 40 mg of Zn, 40 mg of Fe, 10 mg of Cu, 1 mg of I and 0.5 mg of Se.

results of this experiment was the same with the report of Butts and Cunningham (1979), who reported that a reduction in albumen weight and height is observed when birds receive low-protein diets (TAAF), suggesting that

Table 2. Main effects of diet formulation based on MEn and amino acids of feedstuffs on egg characteristics and broiler breeder performance (50 to 64 weeks).

Parameter	Egg weight (g)	Egg production (%)	Yolk weight (g)	Albumen weight (g)	Albumen height (mm)	Haugh unit	Fertility (%)	Hatchability (%)	Chick/hen (No)
MEn (Feedstuffs)									
Apparent	68.69[a]	56.74[a]	21.57	38.09	7.37	82.61	85.26[a]	73.91[a]	38.76[a]
True	67.58[b]	51.71[b]	21.13	38.8	7.44	82.72	75.63[b]	63.97[b]	32.04[b]
P-value	0.04	0.004	0.163	0.172	0.711	0.934	0.001	0.000	0.015
Amino acids (feedstuffs)									
Total	67.99	52.89	21.47	38.09	7.03[b]	80.36[b]	80.87	72.18[a]	35.19
Digestible	68.26	55.33	21.23	38.9	7.79[a]	84.96[a]	79.23	65.69[b]	35.55
P-value	0.183	0.131	0.443	0.173	0.000	0.000	0.12	0.007	0.409
SEM	0.16	1.136	0.223	0.414	0.131	0.908	1.34	1.155	1019

[a-d]: Means within the same column not sharing a common superscript differ significantly (P<0.05).

these diets are lower in essential amino acids (EAA). This diet leads to insufficient protein synthesis to meet the needs for egg formation (Ingram et al., 1951; Naber, 1979). Chemical composition of eggs can be influenced by dietary protein level (Butts and Cunningham, 1979; Fisher, 1969).

The egg size and internal quality of eggs are important for hatching eggs. Fertility and hatchability are the major economical traits in broiler breeder reproductive performance. Main effects of amino acid of feedstuffs was significant in hatchability (P<0.05). The fertility, hatchability and chicks/hen were significantly greater (Table 2) on treatment fed diet formulation based on AMEn with 82.96%, 68.86% and 38.76 than TMEn with 73.63%, 59.15% and 32.04,respectively (P<0.05). Attia et al. (1995), Bornstein et al. (1979) and Bornstein and Lev (1982) observed that broiler breeder hens (21 to 61 weeks) had a significant positive correlation between energy intake (396, 423 and 450) and fertility and hatchability. In this study, hens fed diet formulation based on AMEn was better in egg weight, egg production, fertility, hatchability and chicks/hen than hens fed diet formulation based on TMEn of feedstuffs. This difference was statistically significant (P<0.05).

Albumen weight and height and HU were greater in hens fed diet formulation based on TMEn than AMEn and DAAF than TAAF (P≤0.05 for AH and HU). So, fertility and hatchability were higher in treatment of diet formulation based on AMEn with 85.26 and 73.91%, respectively (P<0.05). The hatchability was significantly greater in treatment fed diets formulation based on TAAF of 72.18% than DAAF of 65.69% (P<0.05). Main effects of energy and amino acids of feedstuffs showed negative correlation between albumen weight and height and HU with fertility and hatchability. These results are in agreement with the findings of Benton and Brake (1996) who reported that the egg water loss rate during incubation was not influenced by albumen quality but suggested that thick albumen may slow vital gas diffusion, limit nutrient availability to the embryo, and subsequently increase the incidence of embryonic death. This conclusion was supported by findings in a report by Benton et al. (1997), who showed that high quality albumen increased incubation time and had a significant negative effect on hatchability of eggs from young broiler breeder flocks (30 to 33 week of age). According to some authors, decreased albumen height enhances the flow of water and solutes across the vitelline membrane or into the yolk (Burley and Vadehra, 1989; Stern, 1991).

In particular, it has been shown that excess protein reduces fertility. Furthermore, consideration must be given to protein quality and the nutritionist must ensure that a balanced amino acids is supplied from good quality protein sources. The yolk supplies 90% of the caloric needs of the developing embryo. In the egg,

Table 3. The interaction between diet formulation based on MEn and amino acids of feedstuffs, and egg characteristics and broiler breeder performance (50 to 64 weeks).

T	MEn (feedstuff)	Amino acid (feedstuff)	Egg weight (g)	Egg Production (%)	Yolk weight (g)	Albumen weight (g)	Albumen height (mm)	Haugh Unit	Fertility (%)	Hatchability (%)	Chick/hen (no)
1	Apparent	Total	68.21^{ab}	50.5^{c}	21.63	37.35	7.02	80.41	85.69^{a}	78.03^{a}	37.2^{ab}
2	Apparent	Digestible	69.17^{a}	62.45^{a}	21.51	38.84	7.72	84.81	84.23^{a}	69.79^{b}	40.3^{a}
3	True	Total	67.75^{b}	55.28^{b}	21.31	38.83	7.03	80.32	76.05^{b}	66.32^{b}	33.2^{b}
4	True	Digestible	67.38^{b}	48.21^{c}	20.95	38.96	7.85	85.11	75.22^{b}	61.59^{c}	30.8^{b}
	P-Value		0.001	0.000	0.704	0.247	0.751	0.883	0.815	0.476	0.023
	SEM		0.398	1.058	0.315	0.585	0/185	1.285	1.438	2.198	2.855

$^{a-d}$: Means within the same column not sharing a common superscript differ significantly (P<0.05).

Freeman and Vince (1974) and Pearson and Herron (1981) have observed a significant decrease in fertility which is associated with consumption of 450 kcal of energy/bird/day in the last laying period. But it is difficult to differentiate between decreased fertility due to high energy and weight gain of broiler breeder, because both could have negative effects on fertility. The results of this experiment agree with Burke and Jensen (1994), who showed positive effects of increased energy in broiler breeder hens (21 to 61 weeks) in egg production and fertility. Egg weight is a direct proportion of albumen, yolk and shell. Changes in hatchability in broiler breeder females have been reported to be related to many factors, such as storage time (Mather and Laughlin, 1979; Kirk et al., 1980), incubation position, incubation conditions (Kirk et al., 1980; Tullett and Burton, 1982) and shell quality (McDaniel et al., 1979, 1981; Bennett, 1992). Other researchers have found that bird age (Mather and Laughlin, 1979) and egg size (Morris et al., 1968) also affect hatchability but this experiment showed that broiler breeders hens fed AMEn (420 kcal/day) diets had a higher egg weight, egg production, fertility and hatchability. This difference was significant (P<0.05).

The interaction between energy and amino acids of feedstuffs had significant difference on egg weight and egg production. The fertility and hatchability were significantly higher in treatment fed diet formulation based on AMEn + TAAF of 85.69 and 78.03%, than other treatment (P<0.05).

The diet formulation based on AMEn + DAAF had best performance in egg weight (69.17 g), egg production (62.45%) and chicks/hen (40.3) (Table 3). This difference was significant (P<0/05). There are very few reports on interactions between the effects of diet formulation based on MEn and amino acids of feedstuffs, and requirements as they influence reproductive performance of broiler breeders. Several factors affect broiler breeder eggs size, which includes: genetic (Chamber et al., 1974), chronological age (Pearson and Herron, 1981; Spratt and Leeson, 1987), photoperiod (Payne, 1975; Brake et al., 1989) and sexual maturity (Leeson and Summers, 1983), although, other studies reported body weight (McDaniel et al., 1981) and diet as factors affecting egg weight (Pearson and Herron, 1981, 1982; Spratt and Leeson, 1987). This experiment showed the effects of diet formulation types on egg weight.

Conclusions

1. This experiment showed that the type of formulation of diets had significant effects onbroiler breeder reproductive performance.
2. According to the results from this study, it can be concluded that the type of diet formulation had significance based on AMEn of feedstuffs in egg weight, egg production, fertility, hatchability and number of chickens per hen (chicks/hen).
3. Feeding broiler breeders AMEn diets increased significantly egg weight, egg production, fertility, hatchability and number of chickens per hen (chicks/hen) by 1.11 g, 5.03%, 9.63%, 9.94% and 6.72 more than broiler breeders fed TMEn diets, respectively.
4. Dietary digestible amino acids of feedstuffs affects egg weight, egg production, albumen weight, albumen heightand HU. Formulating broiler breeder diet based on digestible amino

acids of feedstuffs give a better prediction of dietary protein quality and bird performance than when it is based on total amino acids of feedstuffs.

5. Dietary AMEn + DAAF affect egg weight, egg production and fertility. The interaction between digestible amino acids of feedstuffs and AMEn allows the full expression of the genetic potential for production traits in Arian broiler breeders.

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