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Methods for introduction of objective criteria for bioconversion of energy and nutrients along the feed-animal products chain in meat-type poultry farming

Методика за въвеждане на обективни критерии за биотрансформация на енергия и хранителни вещества по веригата фураж – животински продукти в месодайното птицевъдство

Dimo Penkov[1*] and Atanas Genchev[2]

[1]Agricultural University – Plovdiv, 12 D. Mendeleev Str., 4000 Plovdiv, Bulgaria, *correspondence: dimopenkov@gmail.com

[2]Trakia University, Faculty of Agriculture, Students' campus, 6000 Stara Zagora, Bulgaria

Abstract

The authors propose a new approach for the determination of the conversion of energy and nutrients from the consumed feed (primary unit) to animal products (secondary unit). For this purpose, specific criteria for the conversion of energy and nutrients ("Clarke of distribution of the energy" and "Clarke of transformation of the protein/amino acids") are introduced, so as an exemplary methodology for their calculation is shown. In the model calculations data from real experiments with Japanese quails are used. Although the proposed criteria are not economic, the authors suggest that their input will be a good basis for selection and technology assessment in the meet poultry breeding.

Keywords: Clarke of distribution of the energy, Clarke of transformation of the protein, fodder, poultry meat

Резюме

Авторите предлагат нов подход за установяване на конверсията на енергия и хранителни вещества от консумирания фураж (първично звено) към животински продукти (вторично звено). За това предложение са въведени критерии за конверсия на енергия и хранителни вещества ("Кларк на дистрибуция на енергията" и "Кларк на трансформация на протеина/аминокиселините"), като е показана и примерна методология за тяхното изчисление. В моделните изчисления са използвани данни от реални опити с Японски пъдпъдъци. Въпреки че предложените критерии не са икономически, авторите са на мнение, че тяхното въвеждане ще е добра основа за селекционния и технологичен прогрес в месодайното птицевъдство.

Ключови думи: Кларк на дистрибуция на енергията, Кларк на трансформация на протеина, фураж, птиче месо

Introduction

The transformation of energy and substances in trophic chains is an issue that has caught researchers' attention for a long time. In the past, it was considered mainly from ecological point of view (Baykov, 1994; Dobrovolskiy, 1998; Hristev et al., 2003; Baykov et al., 2005a, 2005b). The intensification of the agricultural sector necessitated by the strong need for feeding the continuously growing population, together with restricted land for food production imposes the implementation of objective criteria for evaluation of the extent of nutrients conversion from primary to secondary elements of the food chain. In livestock husbandry, such approach is especially imperative by reason of two groups of factors: satisfaction of people with products of higher biological value and its achievement through the introduction of intensive research-through technologies, e.g. transformation of the ecosystem from purely biological into ecotechnic through introduction of nature-atypical transformation energy.

In previous reports, examples for evaluation of the conversion of elements/nutrients in the ecotechnic system “soil-plant/genotype-melioration-production of nutrients” were provided (Yanchev et al., 1999; Delibaltova and Penkov, 2010).

In meat-type poultry farming (as for livestock farming in general), apart the purely economic factors as costs of the produce, the discovery of objective biological criteria accounting for the integral interaction of ecological and technological factors influencing nutrients conversion from a primary (feeds) to a secondary unit (animal product). From the point of view of human nutrition, the criteria for nutrients conversion from feed to edible parts and not to the entire carcass are more valuable. They would contribute both for breeding intensification, and for more proficient combination of environmental factors, e.g. proper feed combinations, optimization of other environmental factors etc.

The aim of the present study was to propose objective integral criteria for comparative purposes reflecting the bioconversion of energy and nutrients along the “feed-edible poultry parts” chain along with simple examples for their calculation.

Material and methods

For evaluation of bioconversion, 2 main criteria concomitant with modern approaches for determination of biological value of foods are proposed - “Clarke of distribution of the energy” (CDE) and “Clarke of transformation of the protein” (CTP), the latter could be used for evaluation of amino acids conversion. The terms and their determination are adopted in parallel to “Clarke” values proposed by Baykov et al. (2005) - “Clarce of concentration” of the elements in trophic eco-technic system.

The calculations are illustrated with data collected from experiments with Japanese quails, Pharaoh breed, intensively fattened until 31 days of age (Genchev, 2014).

The calculations took account from minimum allowable fattening, slaughter and chemical parameters specific for a proper meat-type poultry farming.

Results

In Tables 1, 2 and 3 are shown the data, underlying the calculation of the proposed criteria.

Due to the limitation of the volume, model calculations were done only on the performance of energy distribution and transformation of crude protein. When additional data for the percentage of other edible and non-edible parts as well as their chemical (amino acid, energy) composition are available, additional indicators “Clarkes of distribution/transformation” may be added.

Calculation of the “Clarc of distribution of the energy” (CDisE)

Calculation of the fodder’s energy consumption feed for 1 kg growth (EF):

EF = MES * FCS * (TDS/TDT) + MEF * FCF * (TDF/TDT) +………. (if there are other fodders, e.g. grower, pre-starter etc.)

where:

MES – metabolizable energy in the fodder-starter, MEF - metabolizable energy in the fodder-finisher, FCS – fodder conversion from fodder-starter, FCF – fodder conversion from fodder-finisher, TDS - number of days of fodder-starter use, TDF – number of days of fodder-finisher use, TDT – period of total fattening.

In the case: 11.444 * 1.97 * (17/31) + 11.977 * 4.05 * (14/31) = 34.269 MJ

Calculation of energy distribution (ED) in one unit secondary meat production (breast and leg’s muscles):

For the breast’s muscles (+ os sternum):

ED = EF * PB/10,000

where:

EF – fodder’s energy consumption for 1 kg growth, PB – percentage of the breast muscle (+os sternum) in 1 kg growth;

PB = PG * PBG

where:

PG – percentage of grill in 1 unit growth, PBG – percentage of breast In 1 unit of grill,

10,000 – coefficient of transformation of both of the percentages (100*100).

Table 1. Composition and contents of the combined fodders in biphasic fattening quails (Pharaoh – breed)

Components (g/kg)	Starter (1-17 day of age) (g/1,000 g)	Finisher (18-31 day of age) (g/1,000 g)
Maize	260	460.9
Wheat	90	107
Soybean meal 44	425	210
Sunflower meal 37	85	135
Fish meal	80	15
Sunflower oil	25	33.5
Calcium phosphate	21	25.2
Chalk	5.5	4.5
Vitamin – mineral premix	5	5
Salt	3	3
DL methionine	0.5	0.9
Content in 1 kg fodder		
Metabolizable energy (ME) (MJ)*	11.444	11.977
Crude protein (CP) (g)*	313.36	197.66
Lysine (g)	17	10
Methionine + cysteine (g)	10	7.3
Ca (g)	13	10
Available P (g)	6	4.3

*The levels of ME and CP are calculated according to data for their content in the components (official Bulgarian data, Todorov et al. (2016)).

Table 2. Some indexes of quails (Pharaoh – breed), fatted up to 31 day of age (mean from both of the sexes)

Indexes	x ± Sx
Live weight (LW): 31 day of age (g)	185.59 ± 2.68
Fodder conversion: 1-17 day of age (kg/kg)	1.97
Fodder conversion: 18-31 day of age (kg/kg)	4.05
Grill from the LW (%)	62.96 ± 0.29
Breast muscle + os sternum from grill (%)	44.57 ± 0.32
Leg's meat with bones from grill (%)	27.02 ± 0.16

Table 3. Chemical composition and content of gross energy (GE) of breast and leg's muscles of 31 days old "Pharaoh" quails (mean from both of the sexes)

Indexes	Contents in fresh substance	
	Breast muscle	Leg's muscle
Dry matter (%)	26.09 ± 0.4	24.02 ± 0.2
Crude protein (%)	21.93 ± 0.36	19.48 ± 0.57
Crude fats (%)	2.51 ± 049	2.87 ± 0.55
NPE (%)	0.3 ± 0.02	0.5 ± 0.03
Gross energy (GE) (MJ/kg)*	6.273	5.849

*The GE is calculated by using the formula from Schiemann et al. (1971).

In the case: ED = 34.269 * 62.96 * 44.57/10,000 = 9.616 MJ are distributed to the breast muscles.

For the leg's muscles (+ bones) the calculations are equal, with the substitution of the percentages for the leg's muscles.

In the case: ED = 34.269 * 62.96 * 27.02 /10,000 = 5.83 MJ are distributed to the leg's muscles.

The distributed metabolizable energy of the fodder to both of the edible parts is 15.446 MJ.

Calculation of the Clarc of distribution (CDIS) of the metabolizable energy of the fodder to the breast and leg's muscles (with the bones):

CDIS = DISE/EF

where DISE – distributed energy to the edible part, EF – consumed energy for 1 kg growth.

In the case:

CDIS (breast) = 9.616/34.269 = 0.2806 (28.06%)

CDIS (leg's) = 5.830/34.269 = 0.1701 (17.01%)

CDIS (breast+leg's) = 0.4507 (45.07%)

Calculation of the "Clarc of transformation of the (crude) protein" (CTRP)

The calculation of the consumed protein (in the case - crude, could be digestible) for 1 kg growth:

The protein in the fodder (PF) is done in the same manner as for the energy, but instead the contents of energy, the contents of crude protein in the compound feed in grams is used.

In the case: PF = 313.36 * 1.97 * (17/31) + 197.66 * 4.05 * (14/31) = 700.2 g

Calculation of distributed in the different parts of the carcass protein (DP) – in the case in breast and leg's muscles:

Calculation of the mass of breast muscles (+ os sternum) as grams in 1 unit growth (BMM):

BMM = PG * PB/10

where: PG – percentage of grill from the live weight, PB – percentage of breast (+ os sternum) from the grill, 10 – coefficient of retransformation from percentage to gram

In the case: BMM (breast) = 62.96 * 44.57/10 = 280.61 g

Calculation of the grams of protein, cumulated in the breast's muscles (CPB):

CPB = BMM * PC(B)/100

where: PC(B) – protein content in the breast meat (%).

In the case: CPB = 280.61 * 21.93/100 = 61.538 g

Calculation of the distributed protein in leg's muscles (CPL) is done in the same manner, but in the formula the data for the percentage of leg's muscles (+ bones) to the grill's percentage and the crude protein's percentage in leg's muscles are put.

In the case:

BMM (legs) = 62.96 * 27.02/10 = 170.12 g

CPL = 170.12 * 19.48/100 = 33.139 g

Calculation of "Clarc of transformation" of the fodder protein (CTRP):

CTRP (breast) = CPB/PF

In the case: 61.538/700.2 = 0.0878 (8.78%)

CTRP (legs) = 33.139/700.2 = 0.0473 (4.73%)

CTRP (breast + legs) = 0.1351 (13.51%)

Discussion

The determination of spent energy and protein (amino acids) on the basis of feed consumption per unit produce (here - weight gain) is entirely objective and its discussion not needed, all the more than the calculation does not depend on the stages of feeding. As crude protein (amino acids) are determined in the secondary product (meat), it is logical that this parameter would be considered in the feed as well.

This approach differs from those used so far for energy distribution evaluation with intricate biochemical calorimetrical and other methods requiring expensive equipment and often associated with poor welfare of experimental animals.

The calculation of energy and substances distribution to the different parts of the carcass could be discussed with more details.

The authors of this research believe that the calculations proposed are in line with existing methods for weight distribution of carcass parts and that they are valid for all farmed fowl species. The same is true for the chemical (amino acid) and energy composition of secondary products (in the case – meat, but in some cases could be in the sub-products).

It could be discussed whether the carcass cuts should be measured with or without the bones, but in the opinion of the authors of this research bones should be present in calculation as meat is separated from the bones only after cooking (in this bird species, after more prolonged cooking) which could have a negative impact on chemical and amino acid analysis in particular. On the other hand, even after most precise separation of raw meat, it could not be absolutely certain whether some meat is not left to bones, where would cartilages remain etc.

It should be emphasized once again that the determination of both “Clark” values is rather a biological than an economical approach. In a broader sense, it could influence also economical parameters consequently to a rapid change in technical ones. What is more, they are a background for objective comparison of applied innovations in genetic and ecotechnological factors modelling in livestock husbandry.

Conclusions

The introduction of “Clarce value of distribution of the energy” (CDE) and “Clarke of transformation of the protein/amino acids” (CTP/CTAA) contributes to the objective evaluation of effects of conversion of main nutrients from a primary (feed) to secondary food chain element (animal products for human consumption).

Unification of methods for their application could result in their use as universal parameters for comparison of these transformations in different production conditions to find more rapid and optimal genetic and technological solutions for optimization of poultry farming efficiency.

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