Relationship between directly determined and predicted carcass energy in broiler chickens and turkeys

N.PRIYANKARAGE [1]*, S.P.ROSE [1], S.S.P. SILVA[2] and V.R. PIRGOZLIEV [3]

[1]The National Institute of Poultry Husbandry, Harper Adams University College, Newport, Shropshire TF10 8NB, [2] Veterinary Research Institute, Peradeniya, Sri Lanka, [3]ASRC, SAC, West Mains Road, Edinburgh, EH9 3JG, Scotland.
***e mail: priyankaragenimal@yahoo.com**

Carcass energy deposition is an important factor to determine the efficiency of energy retention in poultry nutrition experiments, however the direct determination of carcass energy is expensive and may give variable results. An experiment was conducted to determine the relationship between directly determined gross energy and predicted carcass energy (determined from carcass fat and protein deposition) of broiler chickens and turkeys fed different dietary proteins and lysine concentrations. 96 male Ross 308 broiler chicks and 96 male BUT Big 6 turkey poults were used for the experiment. Maize-based practical diets were formulated with two protein and six dietary lysine levels. The bioassay was started with broiler chickens at 10 days of age and at 15 days of age for turkeys and they were given a 12 day feeding period. At the end of the bioassay, birds were slaughtered and carcass crude protein, fat and gross energy determined. Energy from protein and fat were calculated using the energy values of 23.68 MJ/kg for protein and 39.12 MJ/kg for fat and energy content in the carcasses were predicted using these values. Linear regressions analysis was used to examine the relationship between directly determined and predicted carcass energy.
There was a strong positive relationship ($p<0.001$) between the directly determined and predicted carcass energy measurement. Turkeys had a lower carcass energy ($p<0.001$) than the broiler chickens. Dietary crude protein or lysine concentrations did not have ($p>0.05$) effect on relationship between directly determined and predicted carcass energy.
The data indicated that the carcass protein and fat determination can be used to predict the energy deposition in poultry carcasses.

Keywords: carcass energy; crude protein; fat; broiler chickens; turkeys

Introduction

Animals that are fed above their maintenance requirement retain energy in their body tissues as protein and fat. Determination of carcass energy is important to estimate the efficiency of energy retention in poultry nutrition experiments and comparative slaughter experiments are widely used method for determination of energy retention in poultry.

In comparative slaughter method, deposited energy can be measured either by direct determination of carcass energy or can be predicted by the amount of energy deposited in carcasses as protein and fat. Most studies have used the direct determination of deposited energy (Sanz *et al*, 2003, Sakumora *et al,* 2003; Lopez & Leeson, 2005). However, direct determination of energy is expensive, time consuming and may gat variable results. Works such as Okumara & Mori (1979) and Sibbald & Wolynetz (1986) predicted carcass energy composition from the crude protein and fat contents of the carcass. These techniques relative to gross energy determination are quicker and less expensive to complete. However there has not been any conclusive evidence to demonstrate that this method gives

relative and accurate results. Therefore an experiment was conducted to determine the relationship between directly determined and estimated carcasses energy.

Materials and methods

An experiment was conducted with 96 Ross 308 male broiler chicks and 96 BUT Big 6 male turkey poults. They were fed with their respective starter diets and at 7 days of age they were allocated to individual cages. A bioassay period was commenced with broilers at day 10 of age and with turkeys at day 15 of age. 12 day feeding periods were conducted for both species. The room temperature was maintained at 32º C at the start of the feeding period and gradually decreased to 28º C at the end of the experiment. Twenty three hours of light and one hour of darkness were given each day.

Maize-based treatment diets were formulated (Table 1 & 2) to meet the nutrient requirement of both species. Two dietary protein concentrations (210 g/kg and 260 g/kg) were formulated with six different dietary lysine levels (40, 52, 58, 65, 90 & 130 g/kg CP). Lysine concentrations were changed by the substitution of L-glutamic acid hydrochloride with L-lysine hydrochloride.

A measured quantity of feed was provided daily to each individual bird that to provide 90% of its *ad libitum* daily feed intake throughout the bioassay period for both broilers and turkeys. Fresh clean water was provided freely throughout the experiment.

At the end of the experimental feeding period, all the broilers and turkeys were killed by cervical dislocation without any blood loss. The carcasses of killed birds were stored at -20^0C.

The frozen samples were left at room temperature for 24 hours to defrost. Then the partly unfrozen whole carcasses were minced (Crypto Peerless, IC 32 M). and homogenised (Tecator 1094 Homogeniser)**.** A known quantity of sub samples were taken and then freeze-dried. The freeze dried samples were then ground for subsequent analysis.

Gross energy values of minced carcasses were measured by using the adiabatic bomb calorimeter (Model: 1261 Isoperibol Bomb Calorimeter, Parr Instrument Company, USA). Nitrogen was analysed using a Leco nitrogen analyser (Leco FP-528, Leco Corporation, USA) according to the AOAC 968.06 (AOAC 2000) and crude protein values were obtained by multiplying the nitrogen concentration by 6.25. Ether extract (fat) was determined according to the AOAC 920.39 method (AOAC, 2000) using soxhlet extraction with petroleum spirit.

Energy from protein and fat were calculated using the energy values of 23.68 MJ/kg for protein and 39.12 MJ/kg for fat as described by Okumara & Mori, 1979 and energy content of the minced carcasses were predicted using these values.

Statistical analysis was carried out using Genstat statistical package. Simple linear regression was carried out to observe the relationship between directly determined and predicted carcass energy.

Table 1. Comcposition of low protein diet with different lysine levels

	Lysine Concentrations (g/kg Crude Protein)					
Ingredient (g/Kg)	**40 g**	**52 g**	**58 g**	**65 g**	**90 g**	**130 g**
Ground maize	709.4	709.4	709.4	709.4	709.4	709.4
Maize gluten meal	30.0	30.0	30.0	30.0	30.0	30.0
Dehulled soya bean meal	131.0	131.0	131.0	131.0	131.0	131.0
Potato protein	44.0	44.0	44.0	44.0	44.0	44.0
Lysine hydrochloride	1.4	4.7	6.5	8.3	15.4	26.4
Glutamic hydrochloride	25.0	21.7	19.9	18.1	11.0	0.0
Methionine	4.6	4.6	4.6	4.6	4.6	4.6
Threonine	2.1	2.1	2.1	2.1	2.1	2.1
Tryptophan	0.7	0.7	0.7	0.7	0.7	0.7
Arginine	8.1	8.1	8.1	8.1	8.1	8.1
Limestone	10.0	10.0	10.0	10.0	10.0	10.0
Di Calcium Phosphate	10.7	10.7	10.7	10.7	10.7	10.7
Salt	3.0	3.0	3.0	3.0	3.0	3.0
Vitamin/Mineral Premix *	20.0	20.0	20.0	20.0	20.0	20.0
Calculated Nutrient Composition (g/kg)						
Metabolisable energy (MJ/kg)	13.0	13.0	13.0	13.0	13.0	13.0
Crude protein	216	216	216	216	216	216
Calcium	10.9	10.9	10.9	10.9	10.9	10.9
Phosphorus	4.8	4.8	4.8	4.8	4.8	4.8
Linoleic acid	16.5	16.5	16.5	16.5	16.5	16.5
Choline	0.8	0.8	0.8	0.8	0.8	0.8
Lysine	8.7	11.3	12.7	14.1	19.6	28.2
Methionine	8.4	8.4	8.4	8.4	8.4	8.4
Methionine+ Cysteine	10.4	10.4	10.4	10.4	10.4	10.4
Tryptophan	2.5	2.5	2.5	2.5	2.5	2.5
Threonine	8.7	8.7	8.7	8.7	8.7	8.7
Glycine + Serine	15.5	15.5	15.5	15.5	15.5	15.5
Leucine	16.7	16.7	16.7	16.7	16.7	16.7
Isoleucine	7.0	7.0	7.0	7.0	7.0	7.0
Valine	8.8	8.8	8.8	8.8	8.8	8.8
Histidine	4.5	4.5	4.5	4.5	4.5	4.5
Arginine	14.6	14.6	14.6	14.6	14.6	14.6
Phenylalanine+ Tyrosine	16.3	16.3	16.3	16.3	16.3	16.3

* Vitamin Premix and trace elements contained Retinol 800mg/kg, Cholecalciferol 150mg/kg, Tocopherol 1.25g/kg, Thiamin 150mg/kg, Riboflavin 500mg/kg, Pyridoxine 150mg/kg, Cyanocobalamin 750mg/kg, Nicotinamide 3g/kg, Pantothonic acid 0.5g/kg, Folic acid 75mg/kg, Biotin 6.25g/kg, Choline chloride 12.5g/kg, Iron 1g/kg, Cobalt 50mg/kg, Manganese 5g/kg, Copper 0.5g/kg, Zinc 4g/kg, Iodine 50mg/kg, Selenium 10mg/kg, Molybdenum 25mg/kg. This product was supplied by Ian Hollows Feed Supplement, Whitchurch, Shropshire.

Table 2. Composition of high protein diet with different lysine levels

Ingredient (g/kg)	Lysine Concentrations (g/kg Crude Protein) 40 g	52 g	58 g	65 g	90 g	130 g
Ground maize	631.0	631.0	631.0	631.0	631.0	631.0
Maize gluten meal	53.3	53.3	53.3	53.3	53.3	53.3
Dehulled soya bean meal	153.0	153.0	153.0	153.0	153.0	153.0
Potato protein	70.00	70.00	70.00	70.00	70.00	70.00
Lysine hydrochloride	1.2	5.1	7.3	9.4	17.9	31.2
Glutamic hydrochloride	30.0	26.1	23.9	21.8	13.3	0.0
Methionine	5.5	5.5	5.5	5.5	5.5	5.5
Threonine	1.9	1.9	1.9	1.9	1.9	1.9
Tryptophan	0.8	0.8	0.8	0.8	0.8	0.8
Arginine	9.6	9.6	9.6	9.6	9.6	9.6
Limestone	10.0	10.0	10.0	10.0	10.0	10.0
Di Calcium Phosphate	10.7	10.7	10.7	10.7	10.7	10.7
Salt	3.0	3.0	3.0	3.0	3.0	3.0
Vitamin/Mineral Premix *	20.0	20.0	20.0	20.0	20.0	20.0
Calculated Nutrient Composition (g/kg)						
Metabolisable energy (MJ/Kg)	13.0	13.0	13.0	13.0	13.0	13.0
Crude protein	260	260	260	260	260	260
Calcium	10.0	10.0	10.0	10.0	10.0	10.0
Phosphorus	4.9	4.9	4.9	4.9	4.9	4.9
Linoleic acid	15.4	15.4	15.4	15.4	15.4	15.4
Choline	0.8	0.8	0.8	0.8	0.8	0.8
Lysine	10.6	13.6	15.3	16.9	23.6	34.0
Methionine	10.0	10.0	10.0	10.0	10.0	10.0
Methionine + Cysteine	12.4	12.4	12.4	12.4	12.4	12.4
Tryptophan	3.0	3.0	3.0	3.0	3.0	3.0
Threonine	10.2	10.2	10.2	10.2	10.2	10.2
Glycine + Serine	19.2	19.2	19.2	19.2	19.2	19.2
Leucine	20.7	20.7	20.7	20.7	20.7	20.7
Isoleucine	8.7	8.7	8.7	8.7	8.7	8.7
Valine	10.8	10.8	10.8	10.8	10.8	10.8
Histidine	5.3	5.3	5.3	5.3	5.3	5.3
Arginine	17.5	17.5	17.5	17.5	17.5	17.5
Phenylalanine + Tyrosine	20.2	20.2	20.2	20.2	20.2	20.2

* Vitamin Premix and trace elements contained Retinol 800mg/kg, Cholecalciferol 150mg/kg , Tocopherol 1.25g/kg, Thiamin 150mg/kg, Riboflavin 500mg/kg, Pyridoxine 150mg/kg, Cyanocobalamin 750mg/kg, Nicotinamide 3g/kg, Pantothonic acid 0.5g/kg, Folic acid 75mg/kg, Biotin 6.25g/kg, Choline chloride 12.5g/kg, Iron 1g/kg, Cobalt 50mg/kg, Manganese 5g/kg, Copper 0.5g/kg, Zinc 4g/kg, Iodine 50mg/kg, Selenium 10mg/kg, Molybdenum 25mg/kg. This product was supplied by Ian Hollows Feed Supplement, Whitchurch, Shropshire.

Results and Discussion

Statistical analysis indicated that the crude protein level or lysine level did not have an effect ($p>0.05$) on directly determined or predicted carcass energy. However there was significant ($p<0.001$) species effect on directly determined and predicted energy contents. Turkeys had low carcass fat deposition and high protein deposition. Carcass fat deposition was 53 % lower and carcass protein deposition was 21% higher in turkeys than broilers (Table 3). High fat deposition in broilers would partly be associated with the high energy retention since the efficiency of energy utilisation is high during fat synthesis (Macleod 1991). Body size of turkeys at early ages (15 days-28 days) was smaller than broilers and they required more energy for body maintenance (Nixey, 1989) and less surplus dietary energy available for the carcass deposition. In addition, carcass protein deposition was also higher in turkeys. The energy requirement for protein synthesis is higher (De Groote, 1974) than for fat synthesis and this would possibly explain the lower energy retention in turkeys than broilers.

Table 3: Summary statistics for retained energy as protein (ER_P), fat (ER_F), predicted and directly determined energy in carcasses of broiler chickens and turkeys.

	Carcass protein (g/kg)	Carcass fat (g/kg)	Retained Energy as protein (MJ/kg) (ER_P)	Retained Energy as fat (MJ/kg) (ER_F)	Predicted Energy (MJ/kg)	Determined Energy (MJ/kg)
Broilers						
Mean	605.4	253.8	14.34	9.93	24.26	24.07
Median	599.8	259.0	14.20	10.13	24.40	24.05
Range	169.2	157.7	4.01	6.17	3.47	2.78
Lower quartile	572.4	213.5	13.56	8.35	23.40	23.48
Upper quartile	631.8	292.8	14.96	11.46	24.91	24.69
Standard deviation	40.6	44.2	0.96	1.73	0.87	0.72
Turkeys						
Mean	738.5	117.4	17.49	4.60	22.08	21.76
Median	731.6	118.4	17.32	4.63	22.14	21.73
Range	175.3	133.3	4.15	5.22	4.67	2.84
Lower quartile	713.9	95.0	16.90	3.72	21.60	21.39
Upper quartile	760.7	134.7	18.01	5.27	22.57	22.11
Standard deviation	36.2	27.8	0.86	1.09	0.76	0.52

Regression analysis indicated that there was a significant relationship ($p<0.001$) between directly determined and predicted energy (Table 4). Correlation coefficients (r^2) for both species were 0.989 for broilers, 0.984 for turkeys and 0.992 for pooled data. Even though there was a relationship, higher variability in the relationship was observed in the birds with lower carcass energy concentrations (Figure 1).

Table 4: Simple linear regression of directly determined energy and predicted energy in carcasses of broiler chickens and turkeys

	Regression coefficient	SE	t	r^2	SE observation
Broilers	0.992	0.0016	p< 0.001	0.989	0.323
Turkeys	0.985	0.0027	p< 0.001	0.984	0.535
Pooled	0.988	0.0015	P<0.001	0.992	0.446

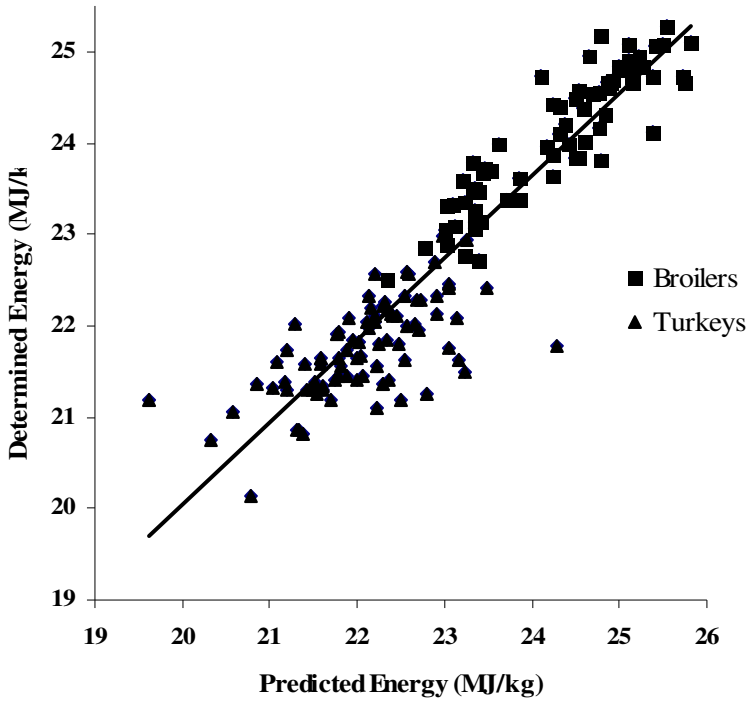

Figure1: Relationship between directly determined and predicted carcass energy in broiler chickens and turkeys.

In conclusion, there was a good relationship between directly determined carcasses energy and predicted carcasses energy in both spices. Therefore, use of energy values from carcass protein and fat for the determination of carcass energy in broilers and turkeys appears to be an accurate and reliable method.

References

De Groote, G., (1974) Utilisation of metabolisable energy. *In: Energy Requirements of Poultry* (Ed: T.R. Morris & B.M. Freeman, British Poultry Science Ltd, Edinburgh) pp 113-133

Lopez, G., Leeson, S., (2005) Utilisation of metabolisable energy by young broilers and birds of intermediate growth rate. *Poultry science,* **84:** 1069-1076

MacLeod, M.G., (1991) Fat deposition and heat production as responses to surplus dietary energy in fowls given a wide range of metabolisable energy: protein ratios. *British Poultry Science*, **32**: 1097-1108

Nixey, C., (1989) Nutritional responses of growing turkeys. *In. Recent Advances in Turkey Science, 21st Poultry Science Symposium,* (Ed. C.Nixey, T.C.Gray, Butterworths, London) pp 183-199

Okumura, J.I., Mori, S., (1979) Effect of deficiencies of single essential amino acids on nitrogen and energy utilisation in chicks. *British Poultry Science* **20**: 421-429

Sakomura, N.K., Silva, R., Coute, H.P., Coon, C., Pacheco, C.R., (2003) Modeling metabolisable energy utilisation in broiler breeder pullets. *Poultry Science,* **82:** 419-427

Sanz, M., Flores, A., Lopez-Bote, C.J., (2000) The metabolic use of energy from dietary fat in broilers is affected by fatty acid saturation. *British Poultry Science,* **41:** 61-68

Sibbald, I.R., Wolynetz, M.S., (1986) Effects of dietary lysine and feed intake on energy utilisation and tissue synthesis by broiler chicks. *Poultry science,* **65:** 98-105