Z Ernährungswiss 36: 299–302 (1997)

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Partitioning of fat and protein in energy retention of growing animals

Verteilung von Fett und Protein bei der Energieretention bei wachsenden Tieren

Summary With increasing intakes the body fat content increases and that of protein decreases. It is most often assumed that this is brought about because each increment in retention contains more fat and less protein. Experimental results, however, showed that this explanation is not true. In two experiments male broiler chickens were fed at levels between 60 and 100 % of recommended energy intake.

Body composition at 1500 g showed, as expected, that with increasing intakes body fat content increased and protein content decreased. Both fat and protein retention per day were linearly related to total energy retention (ER). This means that each increment in retention has the same protein and fat content. At zero fat retention only protein was retained, about 50 % of maximal retention. At zero ER protein was retained and fat mobilized.

Energy and N balance experiments confirmed the constant composition of each increment in retention.

The results of both experiments show that total ER consisted of two components: a basic constant daily protein retention and a variable additional ER, mainly consisting of fat. The basic protein retention is about half of maximal retention. With increasing energy intakes the basic protein retention is combined with an additional amount of protein and fat in a constant ratio.

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Zusammenfassung Mit steigender Aufnahme erhöht sich der Körperfettgehalt und der Körperproteingehalt nimmt ab. Es wird oft angenommen, daß jede Zunahme im Ansatz mit mehr Fett und weniger Protein verbunden ist. Experimentelle Ergebnisse widerlegen jedoch diese Annahme. In zwei Experimenten mit männlichen Broilerhühnern wurden die Tiere auf einem Niveau von 60 % und 100 % der empfohlenen Energieaufnahme gefüttert. Die Körperzusammensetzung bei 1500 g zeigte, wie erwartet, daß sich bei steigenden Aufnahmen der Körperfettgehalt vergrößert und der Körperproteingehalt abnimmt. Fett- und Proteinansatz waren linear mit der totalen Energieretention (ER) korreliert. Das bedeutet, daß jede Zunahme im Ansatz den gleichen Protein- und Fettgehalt besitzt. Wenn der Fettansatz gleich Null ist wird nur Protein, etwa 50 % des maximalen Ansatzes, retiniert. Wenn ER = 0 ist, wird Protein angesetzt und Fett mobilisiert. Energie- und N-Bilanzuntersuchungen bestätigen die konstante Zusammensetzung jeder Vergrößerung des Ansatzes. Die Ergebnisse beider Experimente zeigen, daß die ER aus zwei Komponenten besteht: einem basalen konstanten täglichen Proteinansatz und einer variablen zusätzlichen ER, die hauptsächlich aus Fett besteht. Der basale Proteinansatz beträgt etwa 50 % des maximalen Ansatzes. Mit steigenden Energieaufnahmen wird der basale Proteinansatz mit einer zusätzlichen Menge von Protein und Fett im konstanten Verhältnis ergänzt.

Key words Energy retention – protein retention – fat retention – growth – body composition – broilers

Schlüsselwörter Energieansatz – Proteinansatz – Fettansatz – Wachstum – Körperzusammensetzung – Broiler

Introduction

Growth is largely determined by genetic, environmental and nutritional factors. Energy intake and diet composition can greatly influence carcass composition of meat producing animals. The consumer is mainly interested in lean carcasses. At increasing intakes body fat content increases and protein content decreases. It is most often assumed that this is brought about because each increment in retention contains more fat and less protein. Experimental results, however, showed that this explanation is not true: the higher fat content is accomplished in another way.

Materials and methods

Two types of experiments were conducted with male broiler chickens fed at levels between 60 and 100 % of recommended energy intake.

Growth and body composition

Forty eight one-week-old animals were divided in 4 groups and fed 60 – 90 % of ad libitum intake individually until they reached a body weight of 1500 g. Then the animals were killed and body composition of 8 animals per group was determined.

Energy and N balance

A series of experiments were carried out with groups of 20-70 animals in the age of 3-7 weeks. The animals were fed in the range of 60 – 100 % of ad libitum intake.

Results and discussion

Growth and body composition

Body composition at 1500 g showed that protein content in dry matter of the body decreased gradually from 69 to 60 % when intake varied from 60 to 90 %, whereas fat content increased from 15 to 26 % (Fig. 1).

Final body weight per group was on average 1530 g. The growth period varied from 57 days on the 60 % level to 31 days at 90 %. The animals exhibited a growth rate of from 24 to 45 g/day.

Protein, fat, and ash content of the body were analyzed. The remaining part of dry matter (REST) was calculated and is assumed to consist mainly of glycogen.

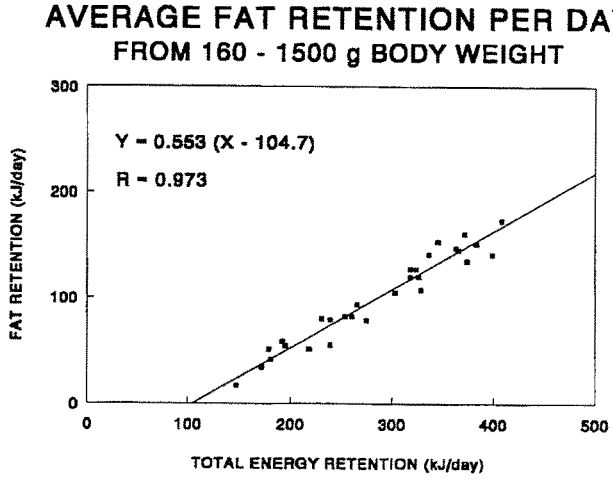

Fig. 2 Average retention of fat during the growth period of 160 g to 1500 g body weight. Individual data per animal.

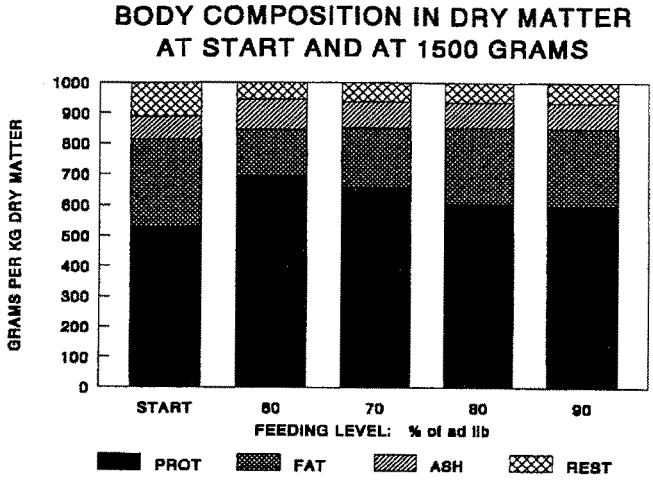

Fig. 1 Average body composition at start and at the end of the experiment. Groups of animals were fed 60 – 90 % of ad libitum intake. REST = Dry Matter - Protein - Fat-Ash

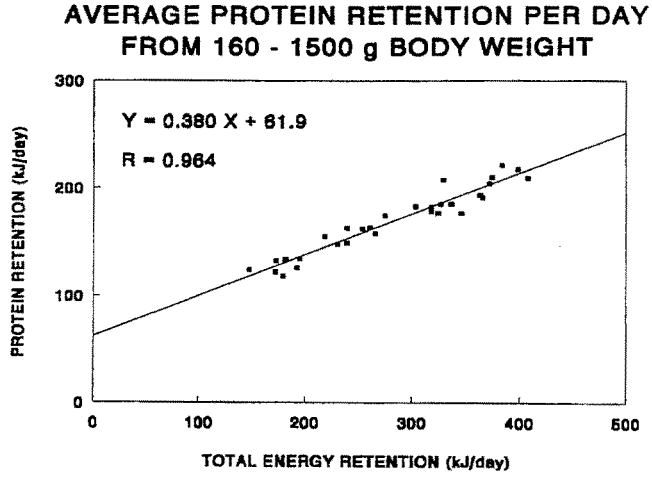

Fig. 3 Average retention of protein during the growth period of 160 g to 1500 g body weight. Individual data per animal.

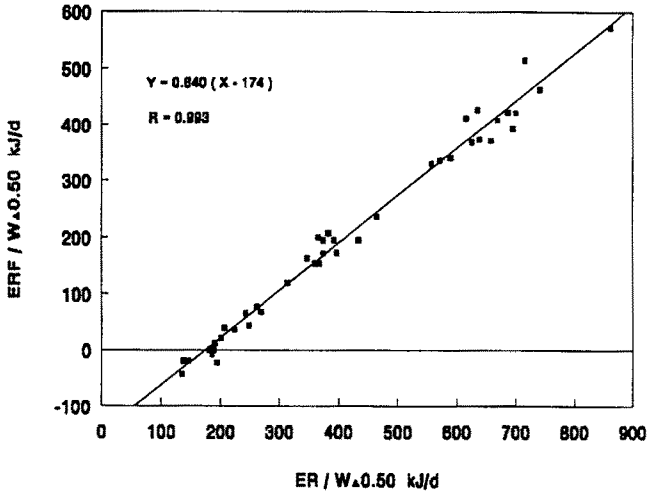

Fig. 4 Linear relation between energy retained in fat (ERF) and total energy retention (ER). Results of energy balance experiments with groups of chickens (20-70). Data are expressed to $W^{0.5}$

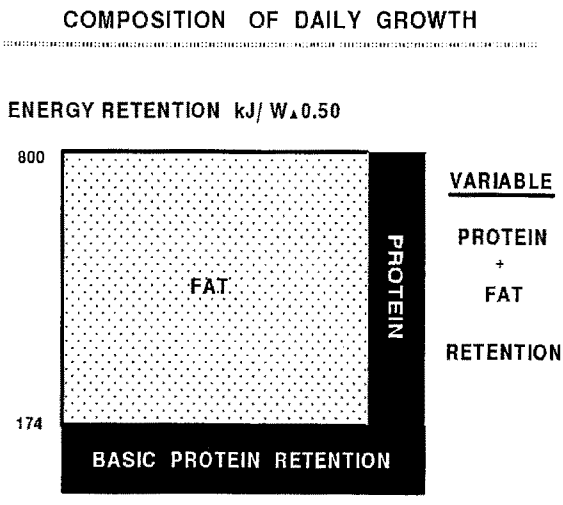

Fig. 5 Daily total energy retention consists of a constant basic protein retention plus a variable ER with a constant ratio of protein and fat.

Average fat retention and protein retention per day were linearly related to total energy retention (Figs. 2 and 3). This means that each increment in retention has the same protein and fat content.

At an increasing energy retention (ER) 55 % of energy was retained as fat and 38 % as protein. At zero fat retention (ER= 104.7 kJ/d) nearly only protein was retained (101.7 kJ/d). At zero ER protein is retained (61.9 g), whereas fat is mobilized.

At maximal intake level (about 3 times maintenance) ER was about 400 kJ/day. At zero fat retention (ER= 104.7 kJ/d) the intake level is about 1.5 times maintenance, so much higher than maintenance. Protein retention at that level was about 50 % of maximal protein retention. Comparison of fat and protein retention at this level reveals that protein has a high priority in retention.

Energy and N balance

In the balance experiments daily retention of protein and fat were linearly related to energy retention ($ER/W^{0.5}$), whereas fat content in total retention increased as expected (Fig. 4).

$$\text{ER in Fat}/W^{0.5} = 0.84\ (ER/W^{0.5} - 174), \qquad R = 0.99$$

In the balance experiments ER in fat was calculated as the difference of total ER and ER in protein. So glycogen retention is included in fat retention.

The linear (and not curvilinear) relationship means that each additional increment in energy supply resulted in an additional retention of protein and fat of constant composition (84 E % fat and 16 E % protein or 1 g protein is retained with 3.2 g fat). As in the former experiment, zero protein and fat retention were not reached at the same level of energy intake. At zero ER, fat was mobilized whereas protein was retained. At an ER of 174 $kJ/W^{0.5}$ only protein was retained. At different energy intakes total ER per day consists of a constant basic protein retention (174 $kJ/W^{0.5}$) plus a variable additional ER with a constant composition of protein and fat (Fig. 5). The basic protein retention is always the greater part of total protein retention and, thus, of high relevance.

The results of both types of experiments show that total ER consists of two components: a basic constant daily protein retention and a variable additional ER, mainly consisting of fat. The basic protein retention, about half of maximal retention, is not dependent of energy intake. With increasing energy intakes the basic protein retention is combined with an additional amount of protein and fat in a constant ratio. At low energy intakes mainly protein is retained, whereas at high intakes fat retention predominates and so fat content of daily retention increases with intake.

The concept of a constant daily protein retention and a variable additional ER (fat + protein) also reveals why animals grown to the same final body weight, but at different intake levels differ in body composition. At a low intake level growth lasts more days and so more energy is retained as basic protein and less energy is retained as a result of variable energy retention. This is the reason that slower growth results in a higher protein content.

The distinction between basic protein retention and additional daily deposition of protein and fat is important when using models for estimating growth from intake and metabolism.

These findings are in agreement with results of experiments with lambs, pigs, broilers, rats, and bulls, from which it could be deduced that in young growing animals each additional unit of gain is composed of similar amounts of protein and fat. However the ratio between protein and fat will differ with species, age, sex, and other factors.

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