THE INFLUENCE OF DIFFERENT ENERGY, LYSINE AND METHIONINE LEVELS ON LAYER PERFORMANCE

LESEGO GABORONE AMOS SELALEDI

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Supervisor: Prof L.G. Ekermans

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DECLARATION

I, the undersigned, hereby declare that the work contained in this assignment is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

ABSTRACT

The study conducted was aiming on evaluating the influence of different levels of energy and amino acids, mainly lysine and methionine, on production performance of the layer bird. There were three treatments, namely the Control diet, a high energy, lysine and methionine diet (High spec.) and a low energy, lysine and methionine diet (Low spec.). The energy levels were 11.2 MJ/kg, 11.5 MJ/kg and 10.9 MJ/kg respectively. Lysine levels were 0.67%, 0.73% and 0.63% whereas methionine levels were 0.36%, 0.38% and 0.34% respectively. The experimental design was 3 x 4 factorial, which is 3 treatments with 4 replicates each. Results showed no significant difference ($P>0.05$) between treatments in egg production, egg mass, egg output, bodyweight and mortality. Feed intakes of the High spec. diet were significantly lower ($P<0.05$) than that of the control diet and the Low spec. diet.

OPSOMMING

Hierdie studiestuk handel oor die evaluering van die invloed wat die verskillende vlakke van die energie en aminosure, veral lisien en methionine op die produksie van 'n lê hoender het. Daar was gebruik gemaak van drie behandelings, naamlik die kontrole dieet, 'n hoë energie, lisien en methionien dieet (Hoë spesifikasie), en 'n lae energie, lisien en methionien dieet (Lae spesifikasie). Die energievlakke was 11.2 MJ/kg, 11.5 MJ/kg en 10.9 MJ/kg onderskeidelik. Lisienvlakke was 0.67%, 0.73% en 0.63% waarby methionienvlakke was 0.36%, 0.38% and 0.34% onderskeidelik. Die eksperimentele ontwerp was 3 x 4 fakulteitsfunksies: 3 behandelings met 4 replikas elk. Die resultate het geen noemenswaardige verskille (P>0.05) tussen die behandelinge in eierproduksie, eiergewig, eier-uitset, liggaamsgewig en mortaliteite nie. Die voerinnames van die hoë spesifikasie dieet was aansienlik laer (P<0.05) as die van die kontrole en lae spesifikasie dieet.

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ABBREVIATIONS

b	Bird
Cal	Calories
doz	Dozen
g	Grams
High spec.	High energy, lysine, methionine diet
HH	Hen Housed
Kcal	Kilocalories
Kcal/day	Kilocalories per day
Kg	Kilograms
Low spec.	Low energy, lysine, methionine diet
ME	Metabolizable energy
mg	Milligram
MJ/kg	Megajoule per kilogram
°C	Degrees Celcius
%	Percentage
/	Per

THE INFLUENCE OF DIFFERENT ENERGY, LYSINE AND METHIONINE LEVELS ON LAYER PERFORMANCE

CHAPTER 1: LITERATURE REVIEW

1.1. INTRODUCTION

A major cost factor in poultry feeding is meeting the energy requirement of the bird whereas the efficiency of utilization of the energy is of significant importance from a quantitative and economical view. The animal derives energy by partial or complete oxidation of carbohydrates, fats and proteins ingested and absorbed from the diet or from the breakdown of glycogen, fat or protein stored in the body. Layers need energy to keep a stable body temperature, for egg production and maintenance of muscular activity. Williams (1993) states that young layers will produce large numbers of eggs of optimum size when they receive enough energy. They will therefore optimize egg mass during the period following egg production if they receive adequate levels of nutrients such as methionine.

Twenty amino acids need to be present for protein to be synthesized. There are basically three classes of amino acids namely, essential amino acids which cannot be synthesized by the birds and therefore has to be supplied to the bird, semi-essential amino acids which are synthesized from essential amino acids in limited quantities, and finally the non-essential amino acids which can be adequately synthesized by the bird.

Amino acids provided in excess are not stored in the body for any length of time, they are therefore either catabolized or excreted. Meeting amino acid requirements of layer birds is very critical towards sustaining consistent egg production, egg output and maintenance.

1.2. METABOLISM OF ENERGY AND PROTEIN

Metabolism of carbohydrates, fats and amino acids (protein) takes place in the cells. Compounds are build for use in the body through a process known as anabolism and compounds are broken down into simpler units through catabolism for new uses or for excretion if not useful (Ensminger et al, 1990).

1.2.1. Energy metabolism

Energy is usually measured in calories. A calorie is the amount of heat necessary to raise the temperature of 1 gram of water by 1°C (Bolton & Blair, 1973). Approximately 4.1 kilocalories of heat is produced and about 0.6 grams of water is formed when the bird burns one gram of average carbohydrate. When the bird burns 1 gram of average fat, approximately 9.4 kilocalories of heat are produced and about 1.07 grams of water is formed. In chickens the burning of one gram of average protein produces only about 3.8 kilocalories of heat and lead to the formation of about 0.47 grams of water (Titus, 1955)

1.2.2. Protein metabolism

Proteins are absorbed as amino acids from the feed. The amino acids are then anabolized by the bird in their correct ratios in tissue, egg or feather protein. Any excess is broken down, one part is used as a source of energy and the remainder, which contains nitrogen is excreted via urine. When excess protein or protein imbalanced in essential amino acids is fed to the bird and is used by the bird as the source of energy, it is used wastefully because some of the potential energy is voided as urinary compounds. It is estimated that from the 5.65 Kcal/g potentially present in protein only 4.0 Kcal/g are available to the bird (Bolton & Blair, 1973). Titus (1955) states that about 58% of the protein absorbed in the form of amino acids may be converted into glucose or into glucose and fat.

1.3. FACTORS DETERMINING AMINO ACID REQUIREMENTS

1.3.1. Genetics

The two main causes of daily protein requirements caused by genetic differences are stated by Pilbrow and Morris (1974) to be as follow:

a) Egg output: It might be expected that differences in requirements would exist between stocks which have different rates of egg output or different body sizes to maintain. Normally these differences are correlated with measurable production traits and might be predicted if suitable coefficients are available.

b) Digestion or utilization of nutrients: Differences might exist in the efficiency of digestion or of utilization of absorbed amino acids with the result that one strain may need more protein than another for each unit of egg protein synthesized or unit of bodyweight maintained.

1.4. RESPONSE OF LAYING HENS TO DIFFERENT LEVELS OF ENERGY AND AMINO ACIDS

1.4.1. EGG PRODUCTION

Utilization of the energy and protein plays a critical role in maintenance and egg production. When protein is used to provide energy for maintenance there is an appreciable heat increment of about 0.2 Kcal/kg live weight, which is part of the energy required for uric acid synthesis. The efficiency of utilization of metabolizable energy by a laying hen for egg synthesis has been estimated as 0.60 - 0.65 (MacDonald et al, 1981).

There might be a reduction in egg production when diets containing less than 10 MJ/kg are used; diets containing more then 12 MJ/kg may increase body fat deposition, but not the number of eggs laid (Bondi, 1987).

An egg contains between 65 and 100 Kcal of energy depending on its size, that equates to about 1.6 Kcal per gram of egg. Due to the fact that the energy efficiency during digestion and metabolism is about 70%, an average sized egg will require about 121 Kcal of dietary energy. The 121 Kcal of the total daily intake of 306 Kcal of ME per bird will go into production of eggs if the birds are laying at a rate of 70% per day at an ambient temperature of 21.1°C (North & Bell, 1994).

The utilization of amino acids for egg production cannot be measured directly and varies in a complex manner with rate of lay. The coefficient of hens between the age of 18 - 40 weeks appears to be relatively constant and for practical purposes vary for different amino acid between 0.8 and 0.85. The amino acid requirements for egg production can be calculated as 1.2 x the amino acid content of the egg (an efficiency of 0.88). The factorial equation for calculating lysine and methionine requirements as illustrated by Rook and Thomas (1983) is:

Lysine requirements (mg/ day) = 9.5 E + 60 W

Methionine requirement (mg/day) = 4.2 E + 40 W

Where E = egg production (g/day)

W = bodyweight (kg)

The calculated requirements refer only to hens laying regularly during the early stages of production; they assume that there are no major discontinuities over the period concerned (Rook & Thomas, 1983). The protein requirements are influenced far more by the level of egg production than by live weight of the bird. Pilbrow and Morris (1974) state that it is necessary to know the form of the response curve, the cost of the amino acid for example lysine and the value of egg output in order to determine the optimum dose of that specific amino acid, in this case lysine.

The response curve can be constructed using the Reading Model (Fisher et al, 1973) by using reasonable values for variances of bodyweight and egg output. At the optimum the marginal cost unit of lysine input is equal to the value of the response obtained from a unit of input.

The optimum lysine intake is therefore reached when marginal cost unit of lysine input = q = 1/a x marginal value of unit egg output.

Where

q = proportion of the birds which have not yet reached their maximum output

1/a = rate of response

The formula below as illustrated by Pilbrow and Morris (1974) can be used to calculate the optimum lysine intake (mg/bird/day) for any flock and any cost ratio:

Formula: $L_{opt} = a\bar{E}_{max} + b\bar{W} + x\ \{\sqrt{a^2\sigma_{Emax} + b^2\sigma_W + 2ab\ cov_{EW}}\}$

Where:

L_{opt} = Optimum lysine intake

a = Production requirement in mg/g egg produced

b = Maintenance requirement in mg/kg liveweight

$\bar{E}_{max}$ = Maximum egg output (g)

σ_{Emax} = Standard deviation of maximum egg output (g)

$\bar{W}$ = Bodyweight (kg)

σ_W = Standard deviation of bodyweight (kg)

X = a*k or k = the cost of 1 mg of amino acid/profit associated with 1 g of egg

cov_{EW} = Covariance of egg weight (g)

Amino acid requirements for laying hens should not be stated as a proportion of the diet nor as ratios with dietary energy. The optimum daily intake of each amino acid should rather be calculated using the Reading Model discussed by Fisher et al. (1974) together with the optimum energy concentration (Gous et al., 1987). If the models are used to calculate levels to be used they will clearly indicate how birds will respond to each level of amino acids and energy concentration. Whereas if amino acids and energy are stated as proportion of the ration without being calculated, it is at times difficult to interpret the results because it is not clear whether the results obtained are due to the reaction to energy concentration or due to the response to amino acids concentration.

Under ideal management and environmental conditions a bird requires a daily intake of 280 kcal, 360 mg methionine and 720 mg lysine for maintenance and egg production (Leeson & Summers, 1997). Failure to meet the requirements will result in poor egg production. Coon (2001, personal communication) notes that production is likely to drop shortly after peak should birds receive insufficient energy before peak.

1.4.2. EGG WEIGHT AND EGG OUTPUT

The requirements of amino acids for egg production should not be seen as a fixed concentration in the feed but must take into account the relationship between amino acid intake and egg output which is depended on both feed intake and level of production. One or possibly two amino acids with the highest marginal costs will limit egg output of the flock because the marginal costs of essential amino acids are likely to vary one from the other. The amino acid supply that maximizes profit in a layer operation will be that which allows the flock to produce near maximal rate. Any effort to use nutritional means to reduce egg size will result in a decrease in rate of lay which will likely reduce profits (Cole & Haresign, 1989).

Egg output is not influenced by energy concentration other than through its effects on food intake with consequent change in intake of the first limiting amino acids. The effect of energy concentration on egg output can be explained by expressing output as a function of intake of the limiting nutrient (Cole & Haresign, 1989). Egg weight may decrease when dietary energy level is decreased, by substituting sorghum or barley for corn. Egg output of laying hens is determined largely by intake of the first limiting nutrients in feed. The egg weight and rate of egg production will be reduced as the most limiting amino acid levels are decreased below the required level (NRC, 1994).

Protein and amino acids, mainly methionine may be used as a main tool to manipulate egg weight through the diet. Little increase in egg size will be noted by increasing the level of protein if the diets are sub-optimal in energy since the hen will utilize protein to meet requirements for energy. There is almost a linear increase in egg weight as the levels of methionine are increased. Waldroup et al. (1995) experienced a 5.6% increase in egg weight when methionine was increased from 0.23% to 0.38% between 25 – 32 weeks and a 6.7% increase when methionine was increased at same proportions between 38 - 44 weeks. The egg weight response to methionine changes slightly as the bird progress through the production cycle. Figure 1 clearly indicates a curvilinear response in egg weight to graded levels of methionine (Leeson & Summers, 1997).

1.4.2.1. Response of egg output (E, g/b/d) to amino acid intake (A, mg/bird/d)

There is an assumption that each individual bird has a characteristic maximum level of egg output (E_{max}) and that for each bird when egg output < E_{max}, then

Amino acid intake (mg/b/d) = aE + bW

where,

W = bodyweight in kg

E = egg output in g/bird/day

a = production requirement in mg/g egg produced

b = maintenance requirement in mg/kg liveweight

It is also assumed that when amino acid intake (A) $<$ bW, egg output = 0, this excludes negative egg production. Relationships are as indicated in Figure 2 (Fisher et al., 1973).

When using the Reading Model the requirements of a group of birds is made up of 2 parts, firstly the requirements of the average bird shown as X in Figure 3 is calculated directly from the equation A = aE + bW using appropriate values for W and E_{max}. Component γ in Figure 4 represent the extra requirement of those individuals in the flock which are more productive or heavier than the average and whose requirements are economically worth satisfying. The magnitude of γ depends on economic factors and on the shape of the curved part of the response which in turn depends on a, σ_{Emax}, σ_w and r_{EW}. It is possible to assure that x is constant for a specified price structure if sufficiently general estimates of a and b are available and thus to predict requirements using this equation $A = aE_{max} + bW + x$ (Fisher et al., 1973).

Cole et al. (1989) illustrates the response of egg output (g/bird/d) to amino acids intakes (mg/bird/d) at different dietary energy content by fitting the response curve in the Reading Model (Figure 4).

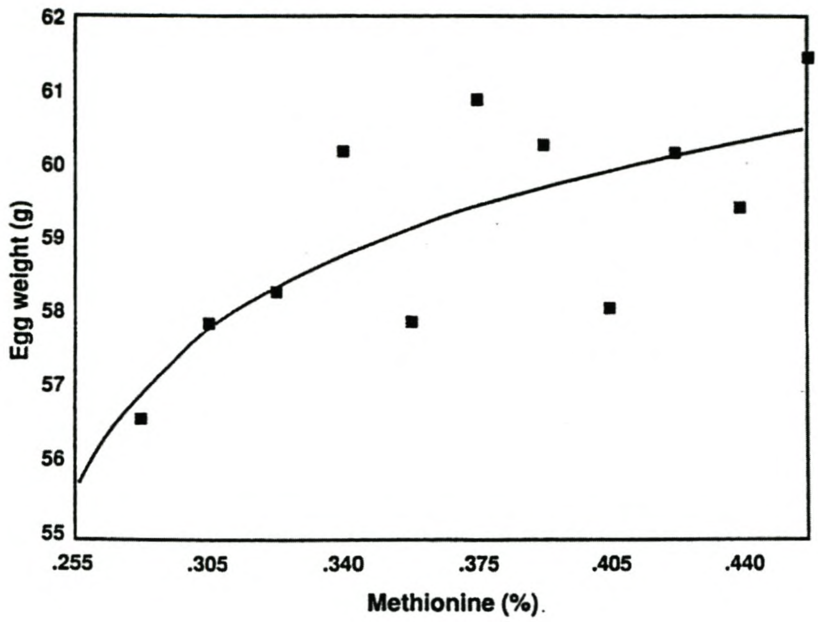
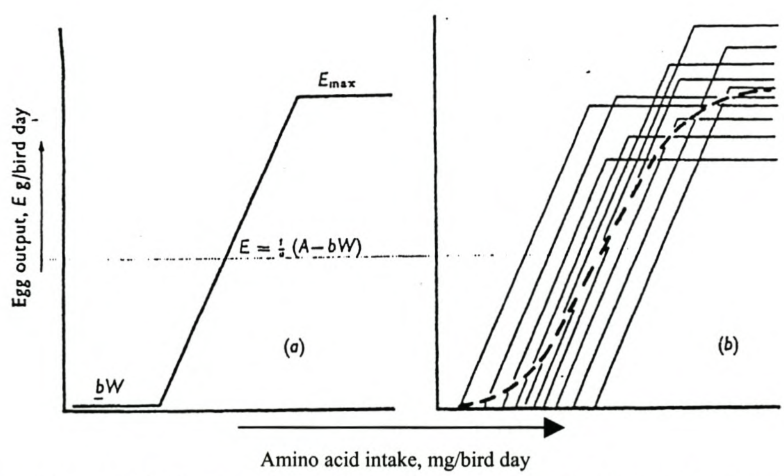


Figure 1: Egg weight response to increasing methionine levels (Leeson & Summers, 1997)



The model proposed for the response of laying hens to ammo acid intake *(a)* the response of an individual bird (*b*) individual (——) and mean (— —) responses for a small group of birds. for meaning of symbols.

Figure 2: The model proposed for the response of laying hens to amino acid intake (Fisher et al, 1973)

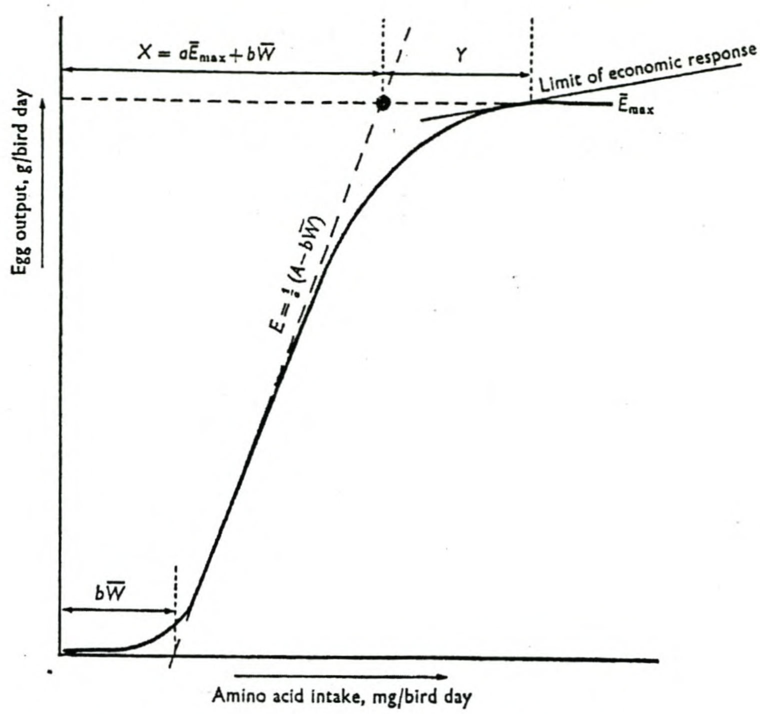


Figure 3: The relationship between the calculated amino acid requirement for the average bird in the flock indicated by • and the requirement of the whole flock in economic terms (Fisher et al, 1973)

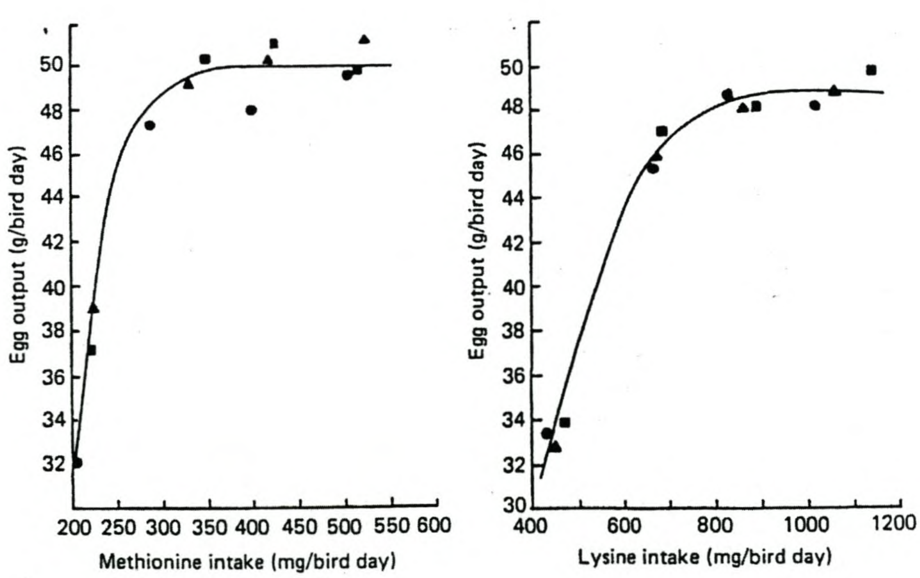


Figure 4: Response of laying hens to intakes of methionine and lysine at three energy concentrations (low •, medium Δ and high □)

(Cole & Haresign, 1989)

1.4.3. MAINTENANCE

Rook and Thomas (1983) state that the maintenance energy requirements in normally well feathered flocks change with temperature by approximately 9.2 and 8.4 kJ/day per °C for white and brown eggs respectively. For practical purpose maintenance energy requirements (MJ/day) can be calculated as follows:

MEM = W [480 + 9.2 (25 - T)] for white birds

MEM = W [375 + 8.4 (25 - T)] for brown birds

Where W = bodyweight (kg) and T = Environmental temperature (°C)

The equation that can be used to determine the daily calorie requirements considering the needs for maintenance, gain and egg mass as influenced by environmental temperature, is outlined by Leeson and Summers (1997) to be as follow:

$$ME\ (kcal/day) = W^{0.75}(173 - 1.95T) + 5.5\Delta W + 2.07EE$$

where

ME = Metabolizable energy (Kcal/day)

T = Temperature at bird level (°C)

W = Bodyweight (kg)

ΔW = Daily bodyweight change (g)

EE = Daily egg mass (g)

Example:

The calorie requirement of a 40 weeks old layer bird weighing 1.95 kg at a weight gain of 1.9 g per day as from 19 weeks with an egg mass of 60 g and kept under the environmental temperature of 30°C will be as follow:

ME (kcal/day) = $W^{0.75}(173 - 1.95T) + 5.5\Delta W + 2.07EE$

$= 1.95^{0.75}(1.73 - 1.95*30°C) +5.5 (1.9g) +2.07 (60.0g)$

= <u>324 Kcal/day</u>

An equation indicated below stated by Slagter and Waldroup (1984) can be used to calculate the amino acids requirement. This equation considers the need for maintenance, gain, egg mass and egg composition:

$AA = AmW/.85 + (\Delta W) (At) + \%P/100 X EW (62 Ay +59 Ao + 52 At)$

where

AA = Daily amino acid needs (mg)

Am = Amino acids need for maintenance (mg)

W = Bodyweight (kg)

ΔW = Daily bodyweight change (g)

At = Amino acid in body tissue as % of N X 6.25

%P = Percentage egg production

EW = Egg weight (g)

Ay = Amino acids in yolk as a percentage of N X 6.25

Ao = Amino acid in ovalbumen as a percentage of N X 6.25

Example:

The amino acids requirement (Lysine) of the bird with the needs stipulated below can be calculated as follow:

Am = 1.7%

W = 1.8 kg

At = 7.5%

%P = 90%

EW = 54 g

Ay = 5.5%

Ao = 6.4%

Therefore:

Daily lysine need = 1.7 x 1.8 ÷ 0.85 +1.9g x 7.5 + (90 ÷ 100) x 52 (62 (5.5) + 59 (6.4) + 52 (7.5)/100

= 557mg

The values for Am, Ao, At and Ay are as determined by Hurwitz and Bonstein (1973).

1.4.4. FEED INTAKES

Intakes are controlled primarily by the concentration of the first limiting nutrient in the diet with energy occasionally being the first limiting nutrient (Gous et al., 1987). In contrast to that, Cole and Haresign (1989) stated that birds will consume different amounts of energy when fed ad libitum depending on the nature of the diet presented to them. They tend to consume less feed as the energy level of the feed increase. This is because the bird attempts to maintain a given intake each day (Leeson & Summers, 1997). The relationship between the environmental temperature and energy intake is curvilinear with food intake declining more steeply as ambient temperature approaches body temperature (Cole & Haresign, 1989).

Rook and Thomas (1983) states that a typical energy balance for a 2 kg hen is as indicated below:

- ME intake: 1530 kJ per day.
- Energy secreted in a 50 g egg: 335 kJ per day. (22% of intake).
- Energy stored in 0.75 g body tissues: 15 kJ per day (1% of intake).
- Energy lost as heat: 1180 kJ per day (77% of intake)

Analysis of several experiments found that small birds eating approximately 1300 kJ/day increased their energy intake by 2 to 3% for each 10% increase in dietary energy content. The corresponding value for larger birds eating 1880 kJ/day was 4 to 5%. These small differences in energy intake do not influence egg production and most of the energy consumed in excess of that required for egg production is deposited as fat leading to small differences in bodyweight gain during lay (Rook & Thomas, 1983).

The lysine required each day by a white egg laying hen is 690 mg or 0.69 g. Thus the diet of a white egg laying hen eating 100 g of feed per day should have a lysine concentration of 0.69%. A dietary lysine concentration for hens eating 80 g of feed per day should be 0.86% to obtain 0.69 per day whereas hens eating 120 g per day need a dietary lysine concentration of only 0.58% in order to obtain 0.69 g per day. The basic concept is that low nutrients concentration is permitted by high daily consumption and low daily feed consumption demand high nutrient concentrations (NRC, 1994).

If methionine is first limiting, the feed intake may increase as the methionine content of the diet increases. This increase in feed intake will be a result of an increased energy need for the increase in egg production. Intakes may be influenced by methionine and energy (Harms and Russel, 1998).

1.5. OBJECTIVES OF THE STUDY

Feeding a layer bird is becoming more expensive every year and it is therefore critical to determine the optimum way of feeding these birds. The current study was therefore focused on evaluating the influence of different levels of energy and amino acids, mainly lysine and methionine, on production performance of the layer bird. The target aim was to find out if there will be improvement in production performance at higher energy, lysine and methionine levels and whether the low energy, lysine and methionine will have any negative impact on production.

The energy was considered in this study because it has a significant influence on intakes and on feed price since the main source of energy in layer feeds is mainly maize which is becoming more expensive. Lysine and methionine were chosen because they are commonly the first limiting amino acids in the diet for laying hens.

CHAPTER 2

MATERIAL AND METHODS

2.1. Trial house layout

The experiment was conducted at the Paardeberg experimental unit*. The trial unit consists of 12 rows of 144 cages per row at three birds per cage; this means that the house can accommodate 5184 birds. Each row is divided into two groups to make 24 groups, each group consisting of 72 cages. From the 12 rows only 6 rows were used for this experiment. Birds drunk from nipples with drinker cups and they were manually fed in feeder troughs.

2.2. Treatments, treatment allocation and design

There were 3 nutritional treatments with different energy and amino acids levels (Table 2.1).

Table 2.1: Treatments and treatment description

	Control diet	High spec.	Low spec.
Energy	11.2 MJ/kg	11.5 MJ/kg	10.9 MJ/kg
Lysine	0.67%	0.73%	0.63%
Methionine	0.36%	0.38%	0.34%

***Paardeberg experimental unit, P.O.Box 2043, Klipheuwel**

The 3 x 4 factorial design was used since there were 3 treatments with 4 replications per treatment. Each treatment consisted of 864 birds. A colour code was allocated to each treatment for identification, the pens unto which the specific treatment was to be used was painted with the respective colour (Table 2.2). Treatments were allocated randomly between pens (Table 2.3).

Table 2.2: Treatments colour codes

	Treatments	Colour code
A	Control diet	Red
B	High spec.	Blue
C	Low spec.	Green

Table 2.3: Randomised allocation of treatments

Rows	Cage 1 - 72	Cage 73 - 144
1	A	B
2	C	A
3	B	C
4	A	B
5	C	A
6	B	C

2.3. Diet Composition

The dietary treatments were manufactured and supplied by one of the local feed factories*. The nutrient compositions of the dietary treatments were for Phase 1 (a layer feed type that is fed during the first period of laying (18 – 40 weeks) to meet the birds nutritional requirement during that period). Feed samples were taken every time a new batch of feed was delivered for lab analysis. The formulas of the experimental diets were as indicated in Table 2.4 and the specification were as in Table 2.5.

***Bokomo Feeds, P.O. Box 700, Malmesbury**

Table 2.4: Formulas of the experimental diets according to the formulation

Raw materials	Control diet	High spec.	Low spec.
Maize	39.9	40.69	39.61
Acid Oil	3.53	4.5	2.0
Soya oilcake	9.46	9.94	9.28
Sunflower	10.1	10.0	10.0
Hominy Chop	12.1	12.0	12.0
Wheat Middlings	15.1	12.68	15.0
Limestone	3.0	3.0	3.0
Monocalcium Phosphate	0.917	0.933	0.91
Lysine	0.159	0.203	0.109
Methionine ALIMET	0.164	0.199	0.136
Sodium bicarbonate	0.310	0.314	0.310
Choline chloride	0.023	0.023	0.023
Salt	0.172	0.173	0.171
Vitamin Premix	0.1	0.1	0.1

Table 2.5: Nutrient composition of the experimental diets according to the Formulation (Specifications). All values are in percentages, unless otherwise stated.

	Control diet	High spec.	Low spec.
ME (MJ/kg)	11.2	11.5	10.9
CP	16	16	16
Lysine	0.67	0.73	0.63
Methionine	0.36	0.38	0.34
Methionine + Cystine	0.58	0.62	0.54
Threonine	0.45	0.45	0.45
Tryptophan	0.17	0.17	0.17
Arginine	0.9	0.9	0.9
Isoleucine	0.56	0.56	0.56
Leucine	1.32	1.32	1.32
Valine	0.77	0.77	0.77
Histidine	0.4	0.4	0.4
Fat	6.8	7.7	5.27
Calcium (Ca)	3.5	3.5	3.5
Phosphorus (P)	0.34	0.34	0.34
Sodium (Na)	0.17	0.17	0.17
Potassium	0.67	0.67	0.67
Manganese	0.22	0.22	0.22
Chloride	0.16	0.16	0.16

2.4. EXPERIMENTAL OBSERVATIONS

- **Mortality:** Daily mortality records were kept per group and per treatment.

- **Livemass:** Five cages per group and per treatment were marked and birds were weighed at 18, 22, 26, 30 and 40 weeks of age.

- **Egg Production:** Daily egg production was recorded per group and per treatment. Eggs were classified as good, cracks, dirty, rejects and smash.

- **Egg Mass:** A sample of three trays (90 ungraded eggs) were weighed daily per group and per treatment.

- **Feed intake:** Feed for each group was weighed daily and recorded on the record chart. Weekly consumption per group and per treatment was calculated at the end of each week and the daily intakes were then determined.

- **Temperature:** The house minimum and maximum temperatures were recorded daily.

Feed sample: Samples were taken from each batch delivered and sent to the Quantum Lab* for analysis of calcium, phosphorus and protein. All other nutrients were calculated from the standard commercial feed matrix, which is regularly monitored by individual raw material analysis.

***Quantum Laboratories, P.O. Box 648, Malmesbury**

The method, which was used to measure the final nutrients in the experimental diets was to check the actual production formulas and compare it to the formulated formula.

2.5. RAW MATERIAL ANALYSIS

Samples of raw materials that were to be used to manufacture the experimental feed were taken to Quantum Laboratory for analysis of crude protein, calcium and phosphorus using procedures discussed in section 2.6.

2.6. FEED SAMPLE ANALYSIS

2.6.1. Determination of crude protein

Crude protein was determined by firstly determining the total nitrogen content of the feed by auto analyzer. The determination of nitrogen is based on the Barthelot reaction, in which a phenol derivative forms a coloured compound in the presence of ammonia and hypochlorite. In alkaline medium, the indophenol thus formed has a green-blue colour, of which the absorbance is measured at a wavelength of 660 nm. This is a measure for the concentration of ammonia formed by the nitrogen compounds in the sample (Anonymous, 1998).

2.6.2. Determination of calcium

The method used to determine calcium was the EDTA method. This method is based on the complexometric reaction between calcium ion and EDTA. After dry ashing of the sample, an excess of standardized EDTA solution was added and titrated with standard calcium solution (Anonymous, 1998).

2.6.3. Determination of phosphorus

The phosphorus determination was done by calorimetry. With this method the phosphorus concentration in the solution of digested sample is determined spectrophotometrically as the yellow phospho-vanado-molybdate complex (Anonymous, 1998).

2.7. STATISTICAL ANALYSIS

Mini-tab release 7, analysis program was used to analyze the results from each treatment at the end of the experiment, using ANOVA.

CHAPTER 3

RESULTS AND DISCUSSION

3.1. FEED ANALYSIS RESULTS

The raw material analysis results indicated that the nutrient levels of each raw material used were up to standard. The analytical results of the experimental diets indicated that the variance of the actual nutrients levels mainly protein, calcium and phosphorus from the formulated specifications were within the minimum and maximum variance limits.

3.2. EGG PRODUCTION

The total eggs per hen housed of the Low spec. diet was 2 eggs less than that of the control diet at 40 weeks. These differences were not significant (P>0.05). Increasing the energy by 0.3 MJ/kg, lysine by 0.06% and methionine by 0.02% had no beneficial effect on egg production. Differences between all treatments were not significant (P>0.05). Results were as indicated in Tables 3.1, 3.2 and Figures 3.1 and 3.2. To give a logical explanation to these findings, Haresign and Cole (1987) stated that production of the laying hen was not be influenced by nutrient densities except at extremes levels.

Although increasing the energy level of a diet in this experiment did not result in significantly higher egg production, Xavier et al. (1997) observed a best response in egg production at higher energy levels of 11.5 MJ/kg and 11.9 MJ/kg as compared to lower levels of 11.0 MJ/kg and extremely high levels of 12.33 MJ/kg.

As indicated in Tables 3.1 and 3.2, lowering the energy level of the diet by 0.3 MJ/kg did not have a significant negative impact on egg production because this diet had the same protein value as the Control and High spec. diet. This indicates a correlation between the protein value of the diet and the energy. The similar reaction was experienced by Holoubek et al. (1998) when they observed a higher laying intensity from the birds fed a higher protein value (±18%) at a lower energy value (10.87 MJ/kg) as compared to those fed a lower protein value (16.2%) at higher energy (11.04 MJ/kg).

Even though the benefit of increasing the lysine level of the diet was not clearly visible in this study, Pilbrow and Morris (1974) observed an increase in egg production as the levels of lysine increased. Some birds responded positively to higher levels of about 0.70% lysine. Lysine deficient diets caused decreases in egg production about a week after the diets were introduced (Pilbrow and Morris, 1974). In correlation to these findings Holoubek et al. (1998) recently observed a higher laying intensity with diets containing higher proportion of lysine as compared to those with lower proportions.

Table 3.1: Influence of different energy, lysine and methionine levels on weekly egg Production (Hen day)

Age (weeks)	Control diet	High spec.	Low spec.
19	6.2	6.5	6.9
20	20.9	20.7	22.2
21	36.7	36.4	37.1
22	48.5	48.0	47.9
23	56.7	56.1	55.9
24	62.5	61.9	61.6
25	66.8	66.2	66.0
26	70.2	69.2	69.4
27	72.8	72.3	72.1
28	75.0	74.5	74.2
29	76.8	76.4	76.0
30	78.4	78.0	77.6
31	79.7	79.3	78.9
32	80.9	80.4	80.1
33	81.7	81.3	80.9
34	82.7	82.3	81.8
35	83.4	83.0	82.5
36	84.1	83.6	83.1
37	84.5	84.1	83.7
38	85.0	84.5	84.1
39	85.4	84.9	84.5
40	85.8	85.3	84.9
	NS	NS	NS

NS: No significant differences (P>0.05)

Table 3.2: Influence of different energy, lysine and methionine levels on cumulative eggs per hen housed

Age (weeks)	Control diet	High Spec.	Low Spec.
19	0.87	0.92	0.97
20	4.39	4.35	4.66
21	10.27	10.20	10.37
22	16.94	16.81	16.75
23	23.77	23.55	23.45
24	30.57	30.32	30.15
25	37.34	37.09	36.86
26	44.12	42.85	43.51
27	50.90	50.61	50.27
28	57.65	57.34	56.90
29	64.41	64.09	63.56
30	71.22	70.87	70.26
31	77.98	77.62	76.90
32	84.94	84.31	83.84
33	91.27	90.84	89.97
34	98.07	97.65	96.68
35	104.73	104.27	103.20
36	111.35	110.81	109.67
37	111.81	117.29	116.12
38	124.28	123.76	122.51
39	130.81	130.26	128.88
40	137.27	136.74	135.21
	NS	NS	NS

NS: No significant difference (P>0.05)

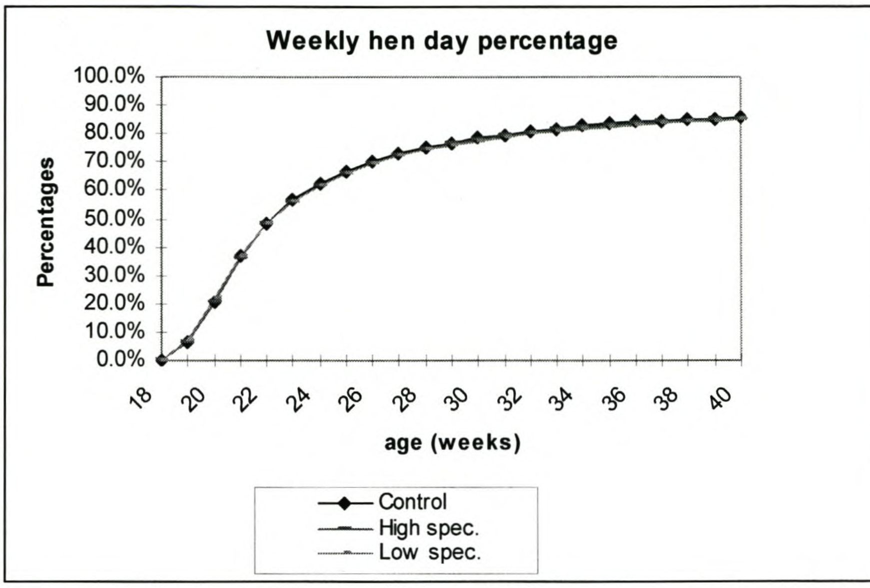


Figure 3.1: Influence of different energy, lysine and methionine levels on egg production

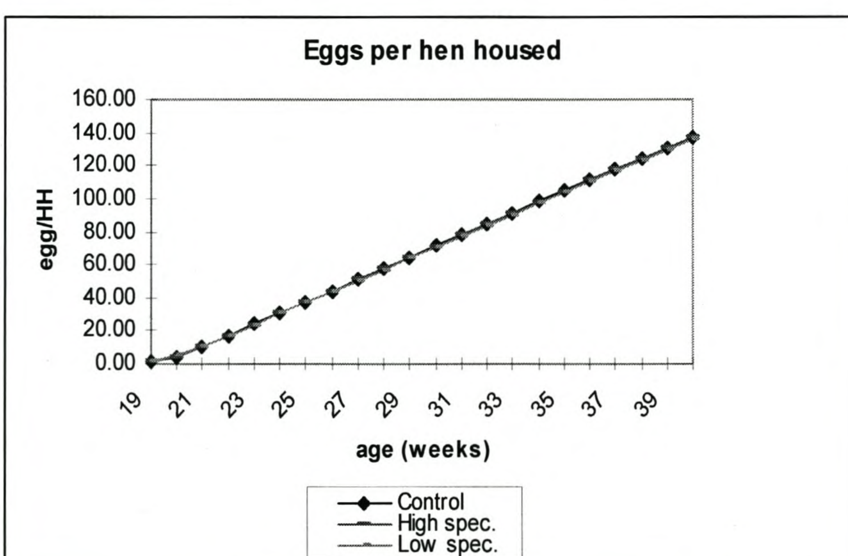


Figure 3.2: (a) Influence of different energy, lysine and methionine levels on eggs per hen housed (weekly figures)

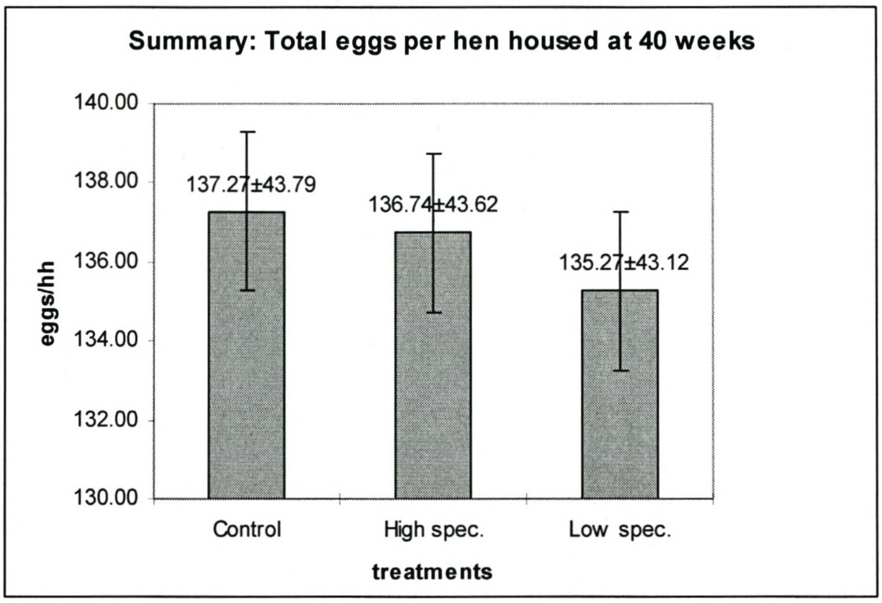


Figure 3.2: (b) Influence of different energy, lysine and methionine levels on total eggs per hen housed (40 weeks)

3.3. EGG MASS AND EGG OUTPUT

The egg mass and egg output of the High spec. diets were slightly higher than that of other treatments whereas the egg mass and egg output of the Low spec. diet were lower than that of other treatments. These differences were not significant (P>0.05). Tables 3.3 and 3.4 and Figures 3.3 and 3.4 indicate the results.

The most contributing nutrients towards egg mass and egg output between energy, lysine and methionine is mainly energy and methionine. Gous et al. (1987) discovered that the energy does not influence the egg output directly but only indirectly through its effect on feed intake and hence on amino acid intake. A study by Xavier et al. (1997) indicated a best response in egg mass at moderately higher energy levels of 11.5 MJ/kg and 11.9 MJ/kg as compared to low energy levels of 11.0 MJ/kg and extremely high energy levels of 12.33 MJ/kg. In relation to this findings Faria et al. (2000) observed a decrease in egg weight at higher energy levels of 12.9 MJ/kg. The concept brought forward by these authors is that increasing energy to reasonably high levels will improve the egg weight whereas extremely high energy levels will have a negative impact on egg weights.

Egg weight is also influenced by the energy:methionine ratio as the egg weight will be higher at higher energy:methionine ratio. This concept was discovered in a study by Harm and Russels (1999) in which egg weights were heavier at higher energy to methionine ratio than at lower ratios. The egg output is expected to increase as methionine intakes increases. The amount of methionine required to produce 1 gram of egg output is also expected to increase as the egg output increases (Harms and Russel, 1998). A study by Baiao et al. (1999) indicated a better egg mass with increasing methionine levels.

Table 3.3: Influence of different energy, lysine and methionine levels on egg mass (g)

Age (weeks)	Control diet	High spec.	Low spec.
19	41.4	41.8	40.9
20	43.8	44.0	43.6
21	45.7	46.0	45.4
22	47.1	47.4	56.8
23	48.2	48.5	48.0
24	49.2	49.5	49.0
25	50.0	50.3	49.9
26	50.7	51.0	50.7
27	51.3	51.6	51.4
28	51.8	52.1	51.9
29	52.3	52.6	52.4
30	52.7	53.0	52.7
31	53.0	53.3	53.1
32	53.3	53.6	53.4
33	53.6	53.9	53.6
34	53.9	54.2	53.9
35	54.1	54.4	54.1
36	54.3	54.6	54.3
37	54.5	54.8	54.5
38	54.7	55.0	54.7
39	54.8	55.1	54.9
40	54.9	55.2	55.0
	NS	NS	NS

NS: No significant difference (P>0.05)

Table 3.4: Influence of different energy, lysine and methionine levels on egg output (g/b/d)

Age (weeks)	Control diet	High spec.	Low spec.
19	2.58	2.74	2.82
20	9.15	9.11	9.59
21	16.77	16.75	16.80
22	22.81	22.75	22.40
23	27.32	27.22	26.81
24	30.71	30.62	30.19
25	33.38	33.31	32.87
26	35.56	35.49	35.12
27	37.37	37.34	36.97
28	38.87	38.85	38.47
29	40.15	40.13	39.75
30	41.30	41.29	40.90
31	42.28	42.28	41.88
32	43.41	43.13	42.71
33	43.80	43.81	43.36
34	44.53	44.56	44.09
35	45.14	45.15	44.67
36	45.66	45.64	45.16
37	46.07	46.06	45.62
38	46.45	46.44	46.01
39	46.81	46.79	46.35
40	47.09	47.10	46.65
	NS	NS	NS

NS: No significant difference (P>0.05)

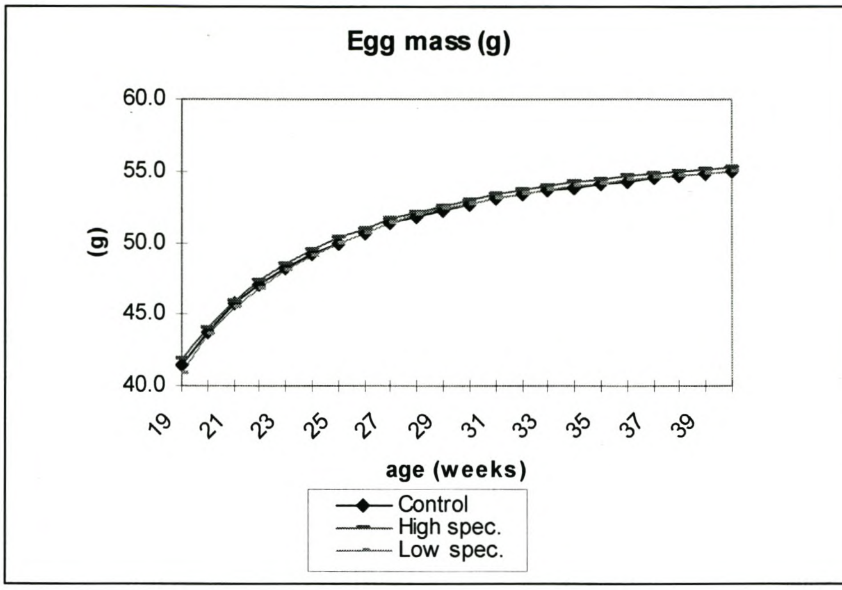


Figure 3.3: Influence of different energy, lysine and methionine levels on egg mass

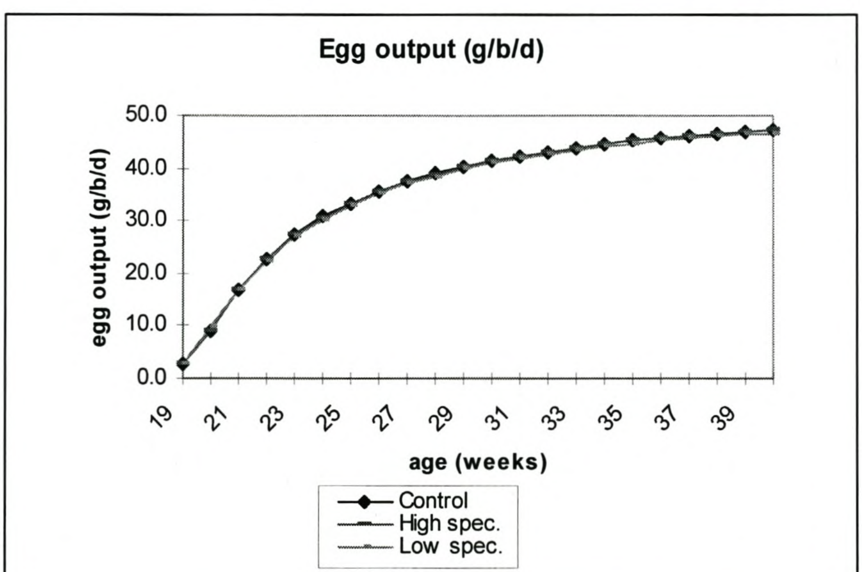


Figure 3.4: Influence of different energy, lysine and methionine levels on egg output (g/b/d)

3.4. FEED INTAKES

Intakes of the High spec. diet were significantly lower ($P<0.05$) than that of the Control and Low spec. diets. Intakes of the Low spec. diet were 2 g higher than that of the Control but this differences were not significant ($P>0.05$). Results are outlined in Tables 3.6, 3.7 and Figure 3.5. In correlation to the outcome of this experiment Xavier & Peixoto (1997) obtained best feed efficiency at higher energy levels than at lower levels.

Experiments conducted by Pilbrow & Morris (1974), Wethli & Morris (1978) and Griessel & Morris, 1987, indicated an increase in feed intake as the concentration of the dietary amino acids decreased. This is because the birds attempt to eat more food to compensate for marginal deficiency of the first limiting amino acids. The feed intakes decreased as the deficiency became severe (Haresign & Cole, 1989). Discoveries by these authors clearly indicate the contribution of amino acids concentration on intakes, but with the current study it is not easy to state the contribution of amino acids on intakes because a balance was kept between the energy and amino acids. Harm & Russel (1998) and Baiao et al. (1999) reported that intakes will decrease as methionine levels of the diet increases especially if methionine is the first limiting amino acid.

3.4.1. Feed conversions

A slightly better feed conversion in terms of kg feed/dozen and kg feed/kg of egg produced was achieved with High spec. diets as compared to other treatments whereas the Low spec. diet had the worst feed conversion for both kg/dozen and kg/kg. All these differences were not significant (P>0.05). Results are shown in Tables 3.8 and 3.9 and Figures 3.7 to 3.10.

Table 3.5 by North & Bell (1994) illustrate the same pattern of response of feed conversion (kg/doz) to increasing dietary energy like the one indicated in Table 3.10.

Table 3.5: Energy levels and intakes per dozen eggs (North & Bell, 1994)

MJ/kg	FCR (kg/doz)
11.0	1.86
11.5	1.77
11.9	1.73
12.4	1.59

The increase in feed conversions as the methionine levels of the diet decreases as indicated in Table 3.10 was also experienced by Yamazaki et al. (1997) when they found a significantly higher feed conversion in diets with lower methionine as compared to those with higher levels.

Table 3.6: Influence of different energy, lysine and methionine levels on weekly feed intake (g/b/d)

Age (Weeks)	Control diet	High spec.	Low spec.
18	105	103	102
19	115	112	112
20	114	113	114
21	114	111	116
22	114	113	118
23	114	110	116
24	115	112	118
25	119	115	121
26	118	114	121
27	120	116	122
28	119	116	122
29	116	114	120
30	118	115	121
31	120	116	124
32	119	114	120
33	115	113	118
34	117	113	117
35	117	113	117
36	114	110	116
37	119	115	119
38	122	114	121
39	116	111	117
40	117	111	117
	NS	*	NS

*** Significantly different (P<0.05)** **NS: No significant difference (P>0.05)**

Table 3.7: Influence of different energy, lysine and methionine levels on average feed intake (g/b/d)

	Mean	STDEV
Control	116	2.82
High spec.	113	2.62
Low spec.	118	4.65

Table 3.8: Influence of different energy, lysine and methionine levels on weekly feed conversion (kg/doz)

Age (Weeks)	Control diet	High spec.	Low spec.
20	6.45	6.40	5.98
21	3.67	3.63	3.62
22	2.79	2.76	2.83
23	2.39	2.36	2.44
24	2.17	2.15	2.22
25	2.04	2.02	2.09
26	1.95	1.92	2.00
27	1.89	1.86	1.94
28	1.84	1.81	1.89
29	1.80	1.77	1.85
30	1.77	1.73	1.82
31	1.74	1.71	1.79
32	1.72	1.69	1.77
33	1.70	1.67	1.75
34	1.68	1.65	1.73
35	1.67	1.63	1.71
36	1.65	1.62	1.70
37	1.65	1.61	1.69
38	1.64	1.61	1.68
39	1.63	1.60	1.68
40	1.63	1.59	1.67
	NS	NS	NS

NS: No significant difference (P>0.05)

Table 3.9: Influence of different energy, lysine and methionine levels on weekly feed conversion (kg/kg)

Age (Weeks)	Control diet	High spec.	Low spec.
20	12.29	12.12	11.44
21	6.70	6.57	6.64
22	4.93	4.86	5.04
23	4.12	4.06	4.23
24	3.68	3.62	3.78
25	3.41	3.34	3.50
26	3.21	3.14	3.29
27	3.07	3.00	3.14
28	2.96	2.89	3.03
29	2.87	2.80	2.94
30	2.79	2.73	2.87
31	2.74	2.67	2.81
32	2.69	2.62	2.76
33	2.64	2.58	2.72
34	2.60	2.54	2.67
35	2.57	2.50	2.64
36	2.54	2.47	2.61
37	2.52	2.45	2.58
38	2.50	2.43	2.57
39	2.49	2.41	2.55
40	2.47	2.40	2.53
	NS	NS	NS

NS: No significant difference (P>0.05)

Table 3.10: Influence of different energy, lysine and methionine levels on average feed conversion (kg/doz)

MJ/kg	Methionine	FCR (kg/doz)
10.9	0.34	1.67
11.2	0.36	1.63
11.5	0.38	1.59

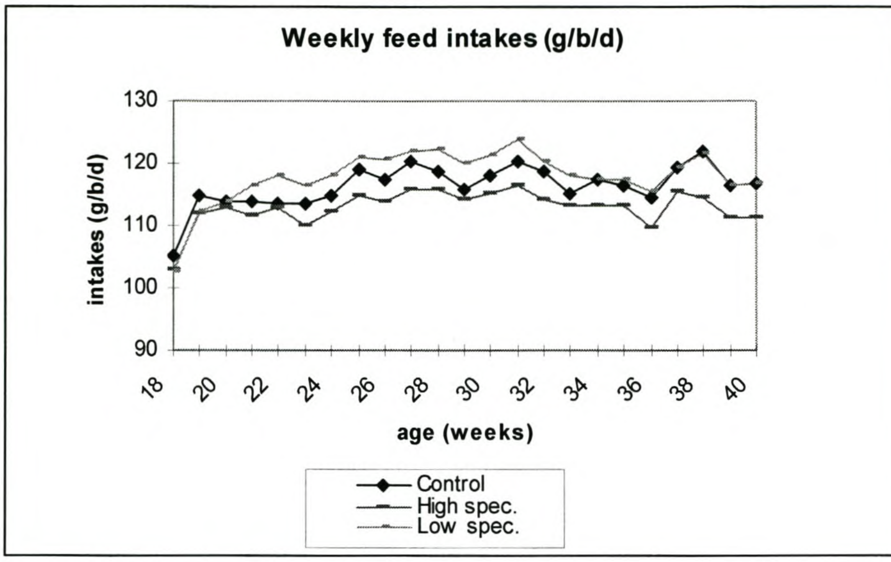


Figure 3.5: Influence of different energy, lysine and methionine levels on weekly feed intake (g/b/d)

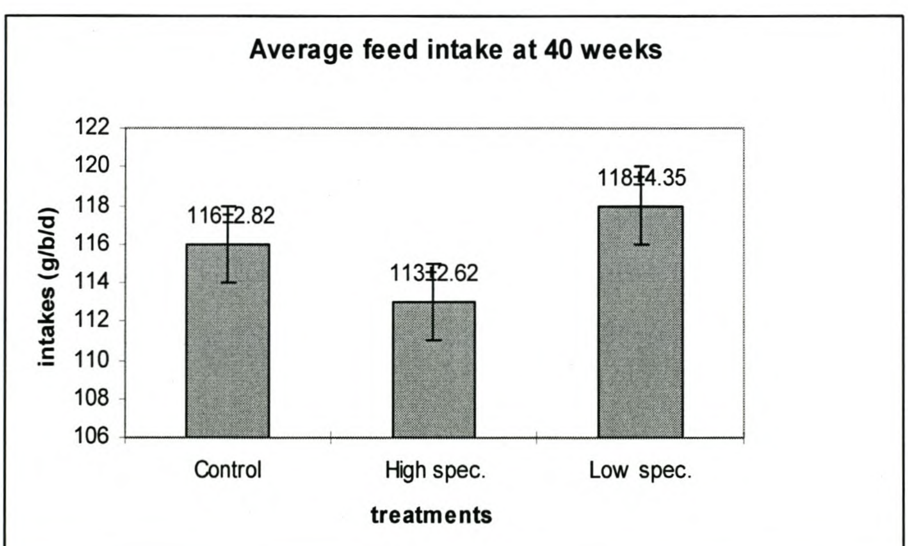


Figure 3.6: Influence of different energy, lysine and methionine levels on average feed intake (g/b/d) at 40 weeks

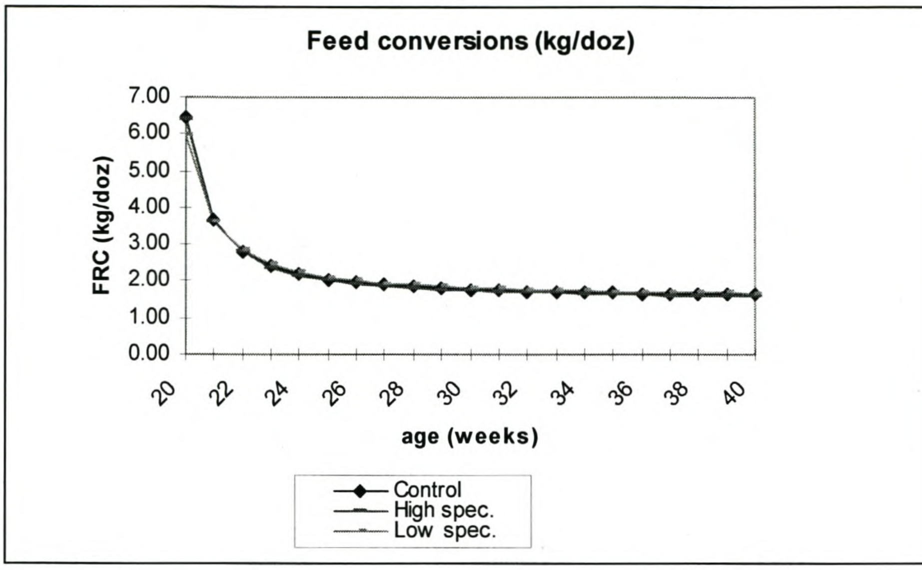


Figure 3.7: Influence of different energy, lysine and methionine levels on weekly feed conversion (kg/doz)

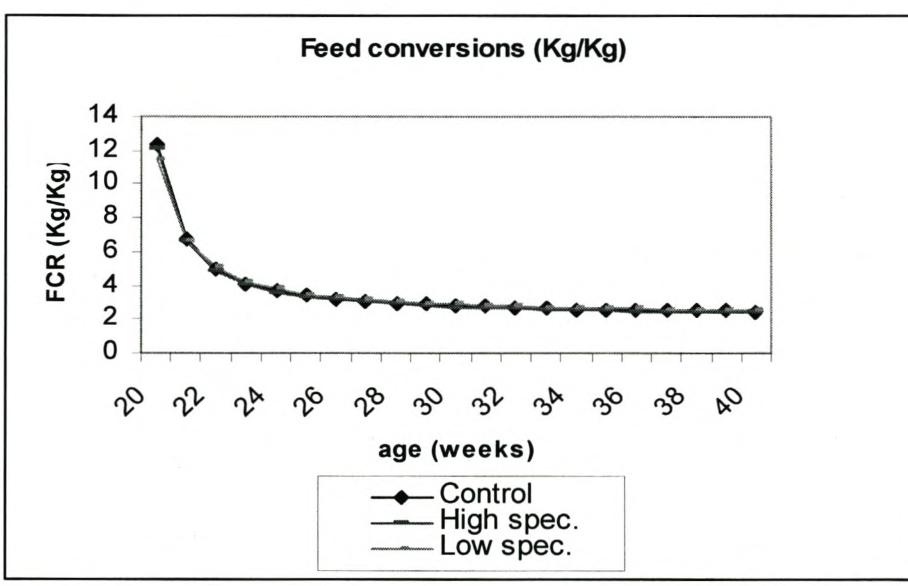


Figure 3.8: Influence of different energy, lysine and methionine levels on weekly feed conversion (kg/kg)

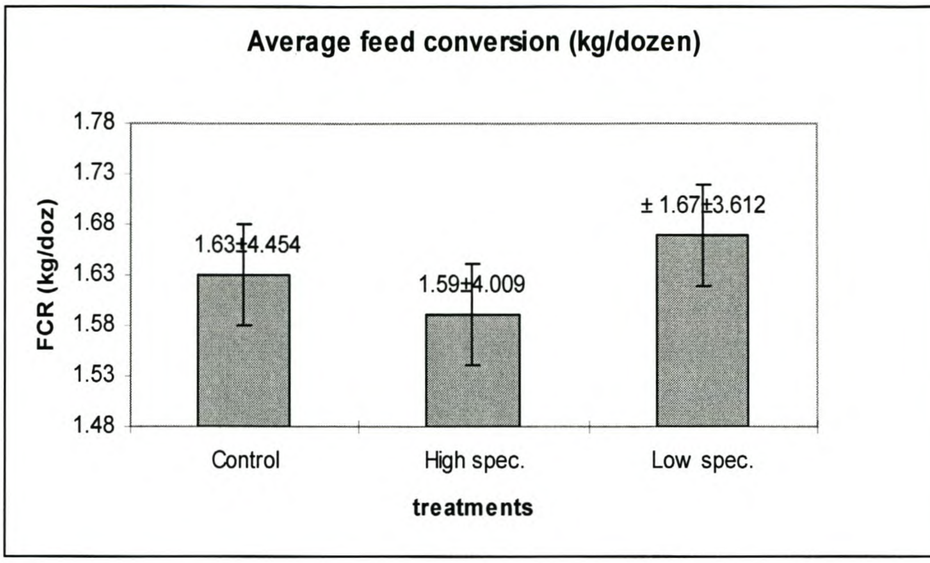


Figure 3.9: Influence of different energy, lysine and methionine levels on average feed conversion (kg/doz) at 40 weeks

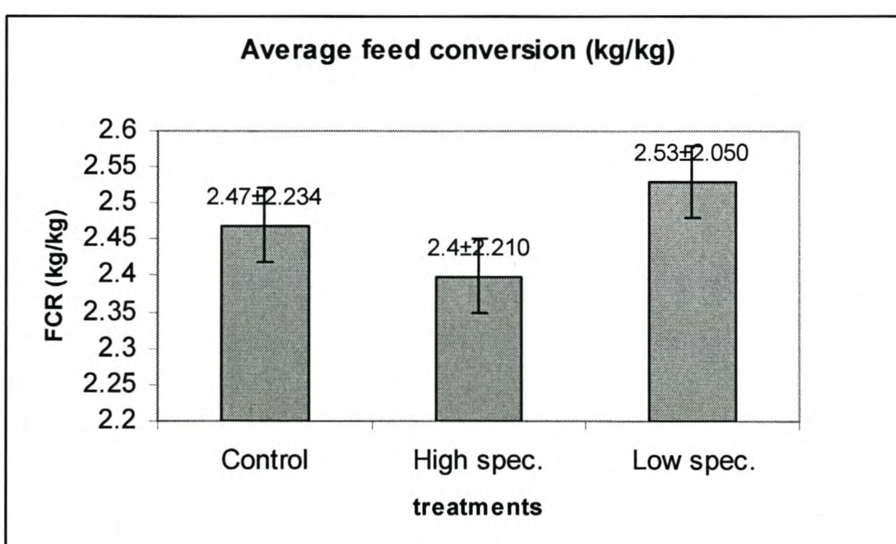


Figure 3.10: Influence of different energy, lysine and methionine levels on average feed conversion (kg/kg) at 40 weeks

3.4.2. Prediction of feed intakes and daily energy and amino acids requirements

3.4.2.1. Feed intake prediction

Accurate prediction of feed intakes in laying hens would be desirable in developing feeding programs as a basis for more flexible tables of nutrients requirements. The hen is able to adjust her feed intake to maintain a constant metabolizable energy intake determined by her current activity over a wide range of metabolizable energy levels of the diet (MacDonald, 1978).

In the current study the equation used by Leeson and Summers (1997) to predict daily energy requirements was put into practise by using the Lohmann* Brown Silver breed standard values to calculate the daily energy required per bird at different environmental temperatures (Tables 3.11 – 3.14). Temperatures were measured by means of a thermometer and were recorded daily. The predicted daily energy requirements were then compared to the actual energy consumed daily per bird per treatment in this experiment. The predicted energy requirements were at some points approximately the same as the actual energy consumed and where there was a difference the difference was very small (Tables 3.11 – 3.14).

***Lohmann Tierzucht, info@ltz, Germany**

The predicted and actual ME requirement of the current study decreased as the temperature increased (Tables 3.11 – 3.14). This decreasing pattern of ME requirement was also observed by Farrell et al (1978) and Slaugter & Waldroup (1984), as they observed a decline in maintenance ME requirement with increasing temperatures

Feed intakes predictions were also calculated at different temperatures (Tables 3.15 – 3.18). Calculated intakes were then compared to the observed intakes as indicated in Table 3.19. Intakes were calculated by dividing the daily energy requirement (MJ/bird/day) by energy content of the feed.

The predicted and observed intakes were very close and the variance between the two was below 5% (Table 3.19). This was also experienced by MacDonald (1978) when comparing predicted and observed intakes from countries such as Ireland, Israel and Texas which reflected a highly significant correlation between observed and predicted ME intakes as the predicted ME intakes were with 5% of the observed.

The formula used by Leeson and Summers (1997) to predict the daily energy requirement varies from the formulas outlined by MacDonald (1978) in two ways, firstly it takes into consideration the environmental temperatures and secondly it does not consider the egg production percentage.

One of the formula by MacDonald (1978) is as follow:

$C = 1.45\ W^{0.653} + 3.13G + 3.15\ X\ R$

Where

C = daily ME intake of the hen in Kcal

W = average bodyweight in grams

G = daily weight gain in grams

E = average egg weight in grams

R = rate of lay percent/100

.

Table 3.11: Predicted vs. Actual daily energy requirement (Kcal/day) at 20°C

Age (weeks)	Predicted	Control	High spec.	Low spec.
20	301	312	312	310
22	318	322	323	317
24	327	327	326	323
26	332	333	332	330
30	337	341	342	339
40	346	342	346	342

Table 3.12: Predicted vs. Actual daily energy requirement (Kcal/day) at 25°C

Age (weeks)	Predicted	Control	High spec.	Low spec.
20	287	297	296	295
22	303	307	307	302
24	312	311	310	307
26	316	317	316	314
30	321	325	326	323
40	330	326	330	326

Table 3.13: Predicted vs. Actual daily energy requirement (Kcal/day) at 29°C

Age (weeks)	Predicted	Control	High spec.	Low spec.
20	275	284	284	282
22	291	294	295	290
24	299	299	298	295
26	304	305	304	302
30	309	312	313	310
40	317	313	317	313

Table 3.14: Predicted vs. Actual daily energy requirement (Kcal/day) at 35°C

Age (weeks)	Predicted	Control	High spec.	Low spec.
20	259	266	266	264
22	273	275	276	271
24	280	280	279	277
26	285	286	285	283
30	290	292	294	291
40	297	294	298	294

Table 3.15: Predicted feed intake (g/b/d) at 20°C

Age (weeks)	Control	High spec.	Low spec.
20	117	113	119
22	120	117	122
24	122	119	124
26	124	121	127
30	127	124	130
40	128	126	131
Average	123	120	125

Table 3.16: Predicted feed intake (g/b/d) at 25°C

Age (weeks)	Control	High spec.	Low spec.
20	111	108	113
22	115	112	116
24	116	113	118
26	118	115	121
30	121	119	124
40	122	120	125
Average	117	114	119

Table 3.17: Predicted feed intake (g/b/d) at 29°C

Age (weeks)	Control	High spec.	Low spec.
20	106	103	108
22	110	107	111
24	111	108	113
26	114	110	116
30	116	114	119
40	117	115	120
Average	112	110	115

Table 3.18: Predicted feed intake (g/b/d) at 35°C

Age (weeks)	Control	High spec.	Low spec.
20	99	97	101
22	103	100	104
24	105	101	106
26	107	104	109
30	109	107	112
40	110	108	113
Average	105	103	108

Table 3.19: Average Predicted feed intake vs Average Observed (g/b/d) at 25°C

	Control	High spec.	Low spec.
Predicted	117	114	119
Observed	116	113	118

3.4.2.2. Prediction of amino acid requirements (mg/day)

The daily amino acid requirements were calculated using data indicated in Table 3.20 with a formula by Slaughter and Waldroup (1984). The values for At, Ay, Am and Ao were those given by Hurwitz and Bornstein (1973). According to the calculations the daily amino acid requirements for birds that received the Low spec. were lower than those that received the Control and High spec. diet. The High spec. daily amino acids requirements were slightly lower than that of the Control diet. These predictions clearly indicates that the daily amino acids requirements will increase as the production, egg weight, and bodyweight increases.

When comparing these calculated requirements to the requirements obtained by Hurwitz and Bornstein (1973) and Smith (1978), using the same prediction equation, the variance between literature and the current study values ranged between 0 – 40% (Table 3.21). The requirements obtained by Hurwitz and Bornstein (1973) and Smith (1978) are higher than the ones obtained in this study.

Table 3.20: Values used to predict daily amino acid requirements (mg/d)

	Control	High spec.	Low spec.	Hurwitz et al. (1973)	Smith (1978)
Egg production (%)	95.6	94.4	91.4	No value	No value
Egg weight (g)	47.1	47.4	46.8	45	44
Bodyweight (kg)	1.87	1.87	1.82	1.8	1.85
Weight gain (g)	1.9	1.95	1.9	No value	No value

Table 3.21: Comparison of amino acids requirements (mg/d) using Slagter and Waldroup (1983) prediction equation

	Control	High spec.	Low spec.	Hurwitz et al. (1973)	Smith (1978)
Arginine	548	545	521	770	759
Histidine	162	161	154	160	162
Isoleucine	489	486	465	620	618
Leucine	659	655	627	880	882
Lysine	517	514	492	570	572
Methionine	260	259	248	390	388
Phenylalanine	419	416	398	400	468
Threonine	370	368	352	500	500
Tryptophan	102	101	97	140	138
Valine	607	603	577	720	716

3.5. BODYWEIGHTS

Birds receiving a High spec. diet had slightly higher bodyweight than birds that received other diets. The difference in bodyweights between treatments was not significant (P>0.05). Results are as indicated in Table 3.22 and Figures 3.11 and 3.12.

In relation to the pattern obtained in this experiment the study by Pilbrow and Morris (1974) indicated that birds that received diets adequate in lysine gained weight rapidly until 30 weeks and thereafter increased in weight slowly but regularly until the end.

3.6. MORTALITY

The High spec. diet had the lowest mortality whereas the Low spec. had the highest mortality. These differences were not significant (P>0.05). Results are as indicated in Table 3.23 and Figure 9.13. The reason for the variation in mortality is not known. There is no certainty of whether it was because of nutritional reasons or disease.

Table 3.22: Influence of different energy, lysine and methionine levels on bodyweights (kg)

Age (weeks)	Control	High spec.	Low spec.
18	1.62	1.56	1.59
21	1.87	1.87	1.82
24	1.87	1.88	1.83
27	1.91	1.91	1.87
30	1.91	1.95	1.91
40	1.95	1.96	1.93
Weight gain	0.33	0.40	0.34
	NS	NS	NS

NS: No significant difference

Table 3.23: Influence of different energy, lysine and methionine levels on mortality (Cumulative figures at 40 weeks)

Control	High spec.	Low spec.
1.6%	1.0%	2.3%
NS	NS	NS

NS: No significant difference (P>0.05)

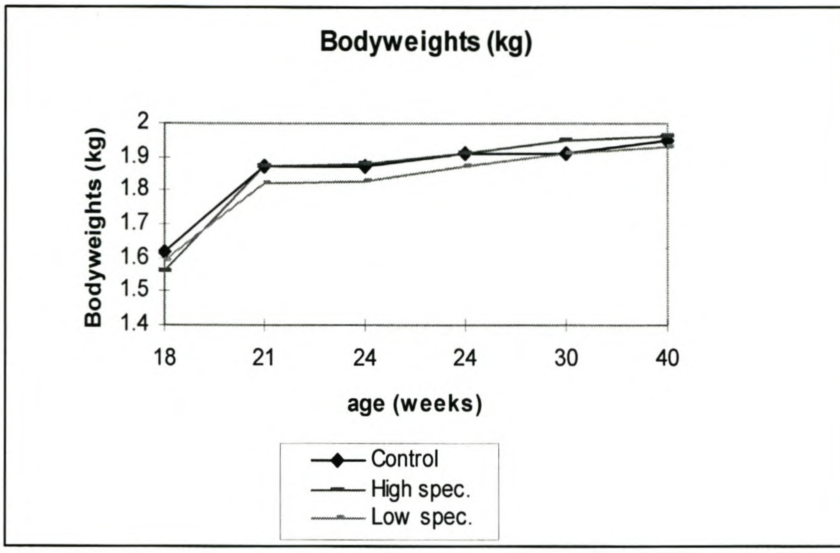


Figure 3.11: Influence of different energy, lysine and methionine levels on bodyweights (kg)

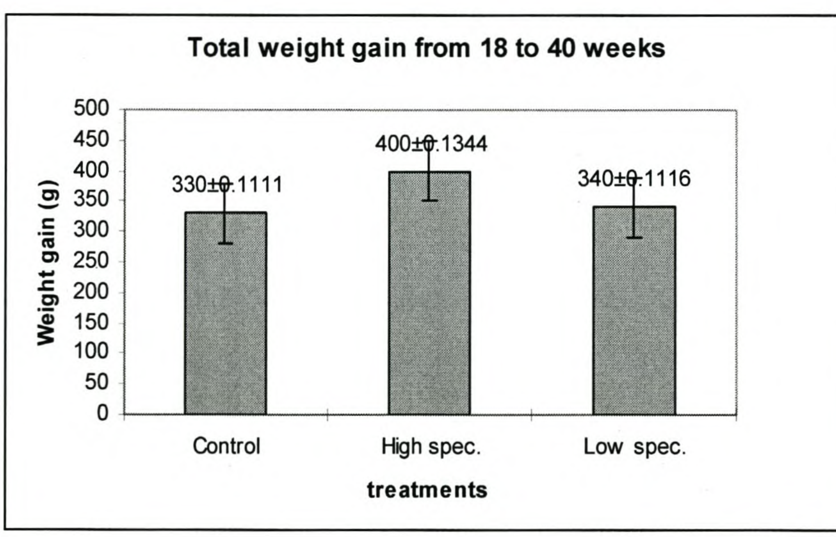


Figure 3.12: Influence of different energy, lysine and methionine levels on weight gain (kg)

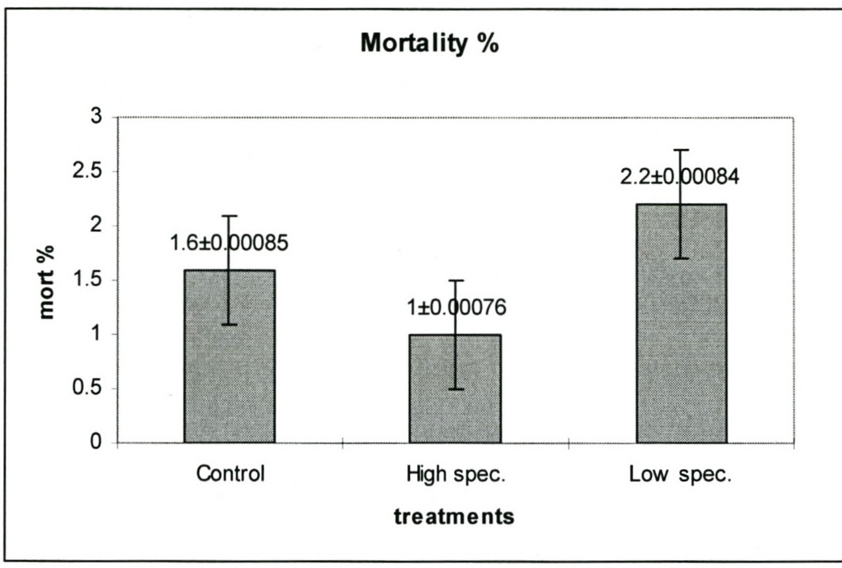


Figure 3.13: Influence of different energy, lysine and methionine levels on mortality %

CHAPTER 4

ECONOMICAL VALUE OF EXPERIMENTAL DIETS

4.1. Least cost formulation

Protein and energy are the major nutrient cost for most diets as a result the economic comparison taking into account these nutrients gives an 85 – 90% estimation of the overall economic worth. As corn and soyabean meal are in most cases major energy and protein sources in poultry diets they can be used as basis for comparison. If one knows the current price of corn and soyabean meal and their contribution of protein and energy one can evaluate the relative worth of any other ingredient (Leeson & Summers, 1997).

Fortunately the need to consider the economic value of ingredients has been replaced by the least cost formulation program. With this program the formulator select the raw materials to be included in the diet and specify the required nutrients for the specific diet. The program will therefore work out which raw material combinations from the selected ones must be used and at what levels must they be used to produce a diet that will meet the specified bird requirements of a bird at reasonable cost.

The least cost formulation is of significant importance especially now because of the current increase of feed ingredient prices. The feed ingredients in poultry diets has increase by as much as 70% since July 2001, the maize price alone has increased between July 2001 and March 2002 by 114%, soya by 40%, sunflower by 47% and fish meal by 43% (Anonymous, 2002).

The Format program* was used to formulate the diet used in these experiment using least cost formulation. It indicates that increasing or decreasing energy, lysine and methionine will have the following impact on the current feed raw material cost;

- Increasing/decreasing the energy by 0.3 MJ/kg with increase/decrease the cost of producing this feed by R35.00/ton (Figure 4.1).
- Increasing/decreasing the lysine levels by 0.02% will increase/reduce the cost of producing this feed by R5.16/ton (Figure 4.2).
- Increasing/decreasing methionine by 0.02% will increase/reduce the cost of producing this feed by R4.98/ton (Figure 4.3).

It is thus economical to produce the Low spec. diet because it is R30.00 cheaper than the control and R65.00 cheaper than the High spec. diet. The feed producer will surely prefer to produce the Low spec. diet but the egg producer must decide whether he is prepared to loose 2 eggs/bird at the end of the first phase of laying period (18 – 40 weeks) in order to make a saving on feed cost. A large commercial feed manufacturer in Pennsylvania reduced the cost of their ration by $0.25 (R2.81) to $3.00/ton (R33.75/ton) by using the Stochastic programming and the nutrient consistency of finished feed was improved by 40% (Cravener et al, 1994).

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Cravener et al (1994) reported that stochastic nonlinear programming can be used as a feed formulation approach that incorporates nutrient variability of ingredients into the computer formulation process, this will result in lower cost ration that more closely approximates the requested probability of meeting the animal's requirements.

4.2. Cost of feeding each experimental diet

The cost of producing a dozen eggs with the High spec. diet will be the same as when using the control diet but cheaper than when feeding the Low spec. diet. This is because of lower intakes of the High spec. diet even though the selling price is higher. Whereas the cost of producing a kilogram eggs with the High spec. diet will be R0.02 cheaper than that of the control and the Low spec. because the High spec. produced slightly higher kilogram eggs at lower intakes.

On the other hand the cost of producing a dozen eggs with the Low spec. will be R0.01 more expensive than that of the Control and High spec. This is due to high intakes with less eggs. Whereas the cost of producing a kilogram eggs with the Low spec. will be the same as that of the Control but more expensive than that of the High spec. Calculated figures are in Tables 4.1 and 4.2.

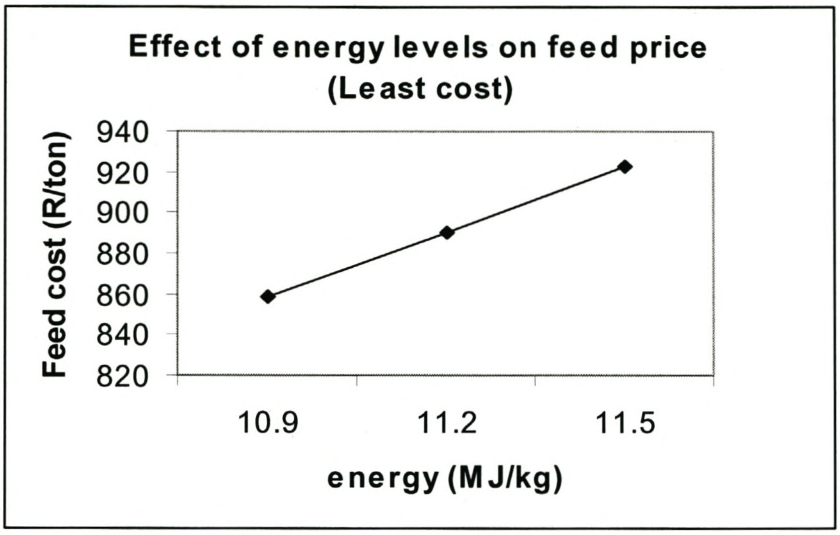

Figure 4.1: Effect of energy levels on feed cost

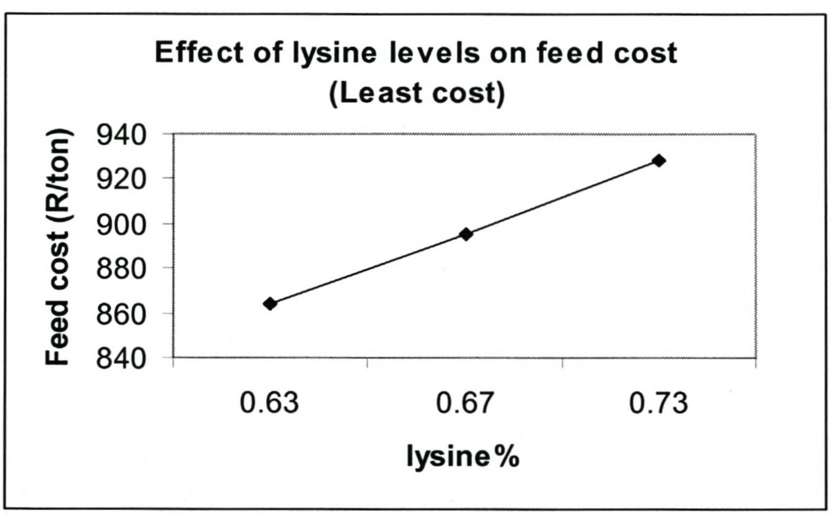

Figure 4.2: Effect of lysine levels on feed cost

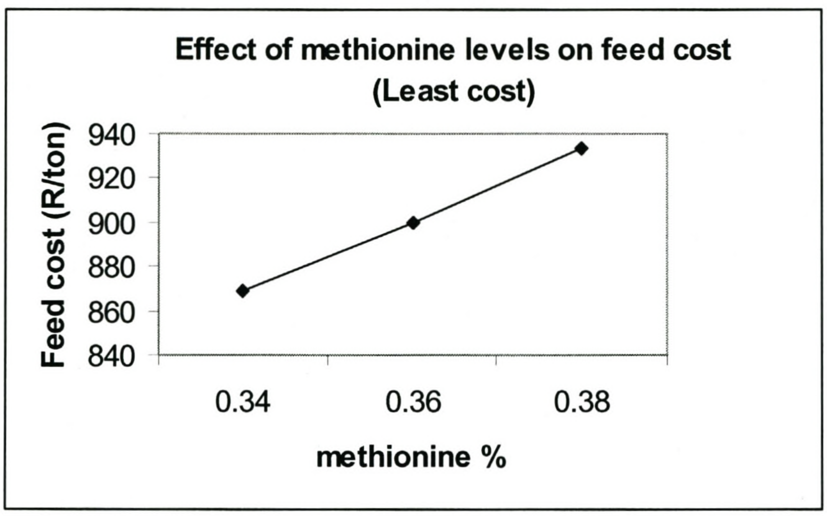

Figure 4.3: Effect of methionine levels on feed cost

Table 4.1: Cost of producing dozen eggs

	Control	**High spec.**	**Low spec.**
FCR (kg/doz)	1.63	1.59	1.67
Feed cost	1418	1453	1388
Cost/doz	2.31	2.31	2.32

Table 4.2: Cost of producing kg eggs

	Control	**High spec.**	**Low spec.**
FCR (kg/kg)	2.47	2.4	2.53
Feed cost	1418	1453	1388
Cost/kg	3.51	3.49	3.51

Eggs were not graded as small, medium, large, X large and Jumbo

4.3. CONCLUSION

Birds eating high energy diets are said to have a better feed efficiency than those eating low energy diets. It is said that energy does not affect egg output directly but indirectly by affecting feed intakes. This was also evident in the current study. Increasing the energy, together with lysine and methionine did not improve production performance of the birds. Even so authors like Xavier et al. (1997) have experienced positive results with higher energy diets but they clearly indicated that extremely high energy levels will surely have a negative impact on production. It is therefore not logical nor economical to provide the bird with more energy than it really requires. It is thus better to calculate the required energy as it has been shown by calculation that the energy requirement of the bird can be influenced by the environmental temperature, as the requirements tend to decrease as temperatures increase.

Feeding the Low spec. on the other hand did not have any significant negative impact on production but the intakes were significantly higher. This clearly verifies the statement made by Rook and Thomas (1983) that the bird will eat more food when supplied with low energy diet in an attempt to meet the daily requirements.

It is evident that lysine and methionine are important amino acids in layer feed since they are mostly the first limiting amino acids. Pilbrow and Morris (1974) and Holoubek et al. (1998) have experienced improvement in production at higher levels of these amino acids. Methionine is said to play an important role in egg output; authors like Leeson and Summers (1997) has experience an increase in egg mass as the dietary methionine levels increases.

Just like in the case of energy there are equations that can be used to calculate the response and the amino acids requirements of the birds. Amino acid requirements were calculated and compared to literature. This comparison indicated that the literature's calculated requirements were higher than the ones calculated in this study.

The current study has indicated that increasing the density to be higher than the control diet will not improve production but will provide lower intakes with better feed conversion. Whereas reducing the feed density will produce approximately 2 eggs less per bird at the end of the production cycle with higher intakes and higher feed conversions. From the economic point increasing feed density will increase the cost of producing that feed together with the selling price whereas reducing feed density will lower cost of producing feed as well as the selling price. It might seem good to reduce the density of feed because it reduces the cost of feed per ton, but reducing nutrients like energy give rise to high intakes thus increasing the cost of producing a of dozen eggs.

In summary the objective of this study, which was to evaluate the influence of different levels of energy, lysine and methionine indicates a diet comprising of 11.2 MJ/kg energy, 16% protein, 0.67% lysine and 0.36% methionine to be the most cost effective in terms of financial returns.

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