# ECONOMIC ANALYSIS OP EGG PRODUCTION USING DIFFERENT PROTEIN AND ENERGY LEVEL RATIONS.
## ( A CASE STUDY OF SHIKA EXPERIMENTAL POULTRY FARM )

BY

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JULY, 1983

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## DECLARATION

I hereby declare that this thesis is my original work and that it has never in any form been presented to any Institution or any body of Organizations. The materials cited or quoted in the write up of the thesis have been duly acknowledged.

J.M. Mshelia

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## DEDICATION

This piece of work is dedicated to my wife, Mrs. Jummai Joshua Mshelia, who was left behind with all the family problems without any complaints even though she was struggling with her studies at the time; and to our son, Mr. Jonathan Joshua Mshelia, who having been born in the same period as I left home, was denied fatherly love at a very tender age.

## ABSTRACT

An economic analysis of experimental data was conducted to determine the optimum levels of the feed ingredients and to assess their individual contributions to egg production. Twelve experimental rations were subjected to three production function analysis, namely quadratic, square root and Cobb—Douglas functions. The Cobb-Douglas function was found to be the best fit for the data.

The result showed that, economic output of 33.11 dozen eggs was achieved by 24 birds in 4 weeks. The total feed level at this output level was 31.66 Kg with groundnut meal contributing 29.74%? yellow maize, 32.44% and wheat offal, 31.88% Wheat offal was however found to have been overused. Groundnut meal contributed significantly to egg production than yellow maize and wheat offal.

It was also found that feed cost formed about 73.17% of the total variable costs in *egg* production. With groundnut meal contributing more to the production process, its use could be increased for profitable production. It seems however that, the supply is the major factor and therefore, alternative sources of protein feeds should be sought for.

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# CHAPTER ONE

## INTRODUCTION

### 1.1 Poultry as a quick source of protein

The deteriorating food situation in the country had its beginning right from the advent of the petroleum industry in the early 1960s. This was accompanied by the Nigerian civil war of 1967 to 1970 which was also followed closely by the drought of 1973/74 in the Northern parts of the country. This state of affairs was aggravated by the ever increasing population which was growing at a faster rate than agricultural production. These problems have crystallized into the giant 'monster' which the country is facing today. The Government then, in its efforts to avert this ugly position, started to import large quantities of meat to avoid any serious protein shortage in the peoples' diet.

Today, the Government is facing the problem through direct involvement by establishing the River Basin Development Authorities, the National Grains Company, the National Livestock Production Company, the National Poultry Production Company etc. in the bid to increase food production for the country. The place of poultry in this regard therefore cannot be over emphasised.

In this study, poultry simply means the domestic fowl, Gallus domesticus. This specie of poultry readily provides humans with protein and other food nutrients for better health and growth through its meat and eggs. In the past, chicken and eggs were used in rituals in addition to human consumption in either fried or boiled forms.

As a result of its scarcity, not much of it could be got by the majority of the families; more especially in developing countries where the living standard of the people are generally low. The consumption of such commodities were therefore associated with the high income group in the society.

Nowadays, it has become a known fact that eggs rank only with cow milk in being the most economically produced animal protein while the meat surpasses other domestic animals in economy of production as observed by Okon (1975). Furthermore, the eggs contain more nutrients than any other food. They are palatable, easily digested and can be used in baking, icing, ice creams, custard, ovaltine and several other beverages. The meat too is very palatable and popular. It may be served as roasted, fried, in stews, salads, sandwiches and sauses. Poultry thus ranks very high as an important source of varied protein diet for man.

The birds provide the raw materials for many other industries like in the preparation of vaccines, animal feeds and fertilizers, pharmaceutical products, varnishes, paints and many others. The albumen is useful in leather tanning, textile drying, photography and book binding industries. The yolks are used in the manufacture of paints, soaps and shampoos. The shells are used in mineral feeds and fertilizers. The feathers are used in making cushions, pillows, matresses, dusters, local fans, animal feeds and fertilizers.

The emphasis on the protein content of the human diet is perhaps the most important especially in the developing countries.

Infact, protein defficiency is believed to be a major problem of malnutrition in all developing countries. The lower income group who form a large majority of the population get even smaller quantities of it their diets, According to Lowry (1970), 70 grams of protein per day are required to prevent a defficiency condition in adults; while children below the age of 5 years, who are fast growing and require body-building protein in sufficient quantities need about 2 grams per kilogram body weight a day to maintain them, and about 80% of these children suffer to varying degrees from malnutrition.

In Nigeria, the Third National Development Plan, 1975/80 showed that the crude protein intake was 56.46 grams per day. The Government then, planned to achieve a level of 60 - 65 grams through livestock development. During the period, demand for more and better staple food as well as for animal proteins were expected to grow at the rate of about 5% and 7% per annum respectively (F.M.E.D.R. 1975).

Improvement in the livestock sector of the economy would undoubtedly increase the animal protein intake in the country. Unfortunately, at the moment, livestock improvement is stil at the research levels; while individual owners are still operating on the traditional basis where the animals are allowed to wander freely around the village and its surrounding areas without much care from their owners.

Poultry seems to be the most promising as improved breeds are available in many parts of the country today. Commercial production employing the intensive systems are quite common in many places.

There is also a marked increase in the number of 'backyard' units in urban areas utilizing the intensive methods to produce meat and eggs to the requirement of the family and a little surplus for the neighbours (Abalu et.al, 1981).

Estimated Nigerian meat supply composition FAO (1966), indicated that from 1963/64 to 1979/80, poultry meat would have increased by 237%; which was very much higher than any other meat supply in the country. The current Government policy on agriculture and agricultural loans is increasing poultry farming even the more; thereby increasing the country's animal protein intake.

It is however noticed, that economic studies in the field of poultry production is lacking in Nigeria (Nuru, 1980). Since feeds are the most crucial in this industry (Heady and Dillon, 1969), any economic study on the feed composition and requirements of poultry could be of much help to poultry farmers whether on large or small scale basis.

## 1.2 Problems and justification of the study

In recent times, poultry farming is becoming one of the most rapidly developing enterprises in agriculture. As a result of this, greater and greater competition will become apparent. This in turn will bring about the use of sophisticated production tools and methods. This also require a lot of analytical and management tools. Since the application of precise economic or decision principles is very neccessary, the availability of input/output data relevant to

the production process is important.

A lot of emphasis has been placed on the protein and energy levels that will optimize egg production (Agudu, 1971; Cooke and Perry, 1980 and Palafox, 1975), but so far there are no defined levels. It is therefore possible to use appropriate feed ingredients to manipulate the ration in order to get the best combination of the nutrients. With variations in the prices of feedstuffs affecting the plan for egg production with respect to what to feed, when to dispose of the flocks and at what price to sell the products, the use of appropriate analytical techniques will definitely help in solving some of the problems associated with egg production.

It is our opinion that a study of this kind will throw some light on the problems which poultry farmers face and will provide useful information on how to advise them concerning the best way to combine their available resources for profitable egg production.

This study tries to supplement the current experimental studies undertaken at Shika experimental poultry farm by looking at one of the several experiments from an economic point of view. We should however state here, that conflicting coments with the original findings of the experimental data should not be taken as an infringement on proffesional expertise but rather as an addition to the research findings.

## 1.3 Objectives of the study

Experiments on egg production have shown that there is no defined protein and energy level rations that will maximize egg production. As a result of this, many people have come up with different results, depending upon the environment where the various experiments were conducted. An economic analysis can therefore be used to identify the most profitable feed combinations.

The main objectives of this study therefore is to find an economic strategy through which higher egg production could be achieved. The specific objectives of the study are:

1. To determine the various input requirements in egg production.
2. To specify the production function for egg production.
3. To evaluate the least-cost combination of feed ingredients for profitable egg production.
4. To evaluate the performance of the farm using gross margin analysis.
5. To examine the implication of the above analysis with reference to research, extension and policy.

## 1.4 Organization of the thesis

Chapter one discusses the importance of poultry as a source of protein and the need to improve it. The chapter also specifies the justification and objectives of the study. Chapter two is devoted to the literature review on the development of poultry industry in

Nigeria, the acceptability of poultry products, efforts of research to increase profitability and recommendations so far. Chapter three discusses the theoretical framework and the methodology of the study. Chapter four gives the results and discussions on the data analysis. Finally, chapter five gives the summary and conclusions of the study.

# CHAPTER TWO

## LITERATURE REVIEW

### 2.1 The development of poultry industry in Nigeria

Poultry industry in Nigeria is rather new. This is because poultry keeping was never considered as a business but rather as a hobby. It was the traditional free range system whereby the birds were allowed to roam about freely around the village and surrounding areas fending for themselves with little or no formulated rations at all (Richard, 1977).

The industry started about 20 years ago but it is only now that its impact is being felt. Halbrook (1962) reported that there were only about 30 million chickens in the Northern Region of Nigeria as at the time of his report. There were no commercial poultry farms, but only two Government units at Riyom, 40 kilometers South West of Jos and Mando, 16 kilometers North of Kaduna. There were however, small poultry units found in almost every village with small indeginous birds which were crossed with larger imported breeds in some places. Poultry production facilities were also lacking.

Although there were no statistics on egg production, it was estimated that about 80% of the eggs sold through stores were imported and that most of them came from Holland. But in the Southern part of the country, the story was different. The report had it that the industry started earlier especially when the then Regional

Governments, through the Ministry of Agriculture and Natural Resources introduced the farm settlement schemes and educated farmers on modern agriculture.

According to Halbrook's consultant report, the Eastern Region poultry programmes were described as the best in the 60s. It was said to be complete in every respect with both plans and action on providing a supply of chicks, making feeds available, arranging for vaccination, training and follow-up field services or extension and finally, help in marketing the products.

An information memo on Muntaka Commasie's poultry farm by McNiven (1963) also indicated that, at the time Muntaka started poultry farming in 1952, little was known in the way of modern methods of raising poultry in the Northern parts of the country, and that the poor grade of local chickens were fed on what they could scratch for themselves and on household scraps. There was a poultry station at the school of agriculture, Samaru for many years, but its programmes were slanted towards training poultry extension staff rather than having the small or householders organized and trained on how to manage poultry. In 1960, the then Northern Government sent interested individuals to observe methods of poultry management at Government and private farms at Fashola and Agege near Oyo in the then Western Region.

It is however interesting to know that the development of poultry as a business has been very rapid in recent times. It is fast moving from the traditional method of extensive system to the

more commercialized intensive system. This is due mainly to economic factors such as getting more output per unit input, space and easy management, ready market and quick returns in the business. This trend has increased the population of poultry in the country since 1962. In 1980, it was put at about 133.4 million, out of which 123.8 million were village flocks (AERLS and NAPRI, 1980).

Recent attepts to solve some of the production and disease problems militating against poultry production in Nigeria by various individuals in our universities, colleges of technology and very few research institutions have contributed in no small measure in poultry development (Nuru, 1980). Halbrook (1962) described poultry as being the most promising than any other livestock business. In his view, poultry development would pay more for the country than any other animal production programme; and that there is a potential for it.

## 2.2 Acceptability of poultry products and efforts of researches to increase profitability

Poultry products are acceptable to all races. Infact, this group of birds are among the most adaptable and domesticated animals, and there are only a few places on the globe where climatic conditions make the keeping of poultry flock impossible (Thomann, 1968). Stadelman (1977) described eggs as one of the few foods that are used throughout the world and that it has been an important part of the human diet since the dawn of recorded history. In modern times,

eggs have been an important commodity in international trade. According to Swanson (1977), agriculture with all its technological changes, has revealed itself in the dramatic changes in commercial egg production. He pointed out that, less than a generation ago, the main supply of eggs came from small units of a few hundred birds maintained as general farm and backyard flocks. But today, production is becoming highly specialised with units of 30,000 or more layers not uncommon in many countries.

Richardson (1975) observed that growth in world egg production has been phenomenal and even more so in the developing countries. He also asserted that the poultry industry has more feed conversion rate than other livestock industries, hence its lucrativeness. The protein conversion efficiency rate for egg production is 24%; for pig, 13%; for beef, 6%; for sheep, 3%; for broiler, 23% and for turkey is 22%. It is therefore in order for Governments to encourage this industry for cheap protein source. In his book, "The Chicken War", Ross (1978) quoted Edward in 1965 as saying that; the pace and nature of technological change in the poultry industry to have no parallel in the record of animal agriculture.

Despite the fact that the industry is moving fast, there are still a lot of problems to be overcome for successful and profitable returns. These problems include; nutrition, management, disease control, storage and marketing. Richardson (1975) expressed concern about world-wide problems due to sharp rise in the cost of production caused by the effect of inflation and substantial increase in the

cost of feeding. He advocated for more information about egg products, particularly covering production, utilization and consumption data. Nuru (1980) agreed that, since feed cost constitutes 60 -75% of the input in poultry production, any research that can reduce the feed component of the cost will be a great break-through in any part of the world. He very much argued that at the moment, there is no firm research guidelines for formulating diets to contain the optimum levels of protein and energy required for the exotic breeds under Nigerian conditions; and that more information is required on spacing and lighting as they affect egg production. Research in methods of storage of poultry products should be given attention. A lot of efforts are being done in this regard by some researchers elsewhere in order to increase profitability, but specific recommendations are yet to be made. Some of the few writers who made some suggestions to improve the storage of poultry products include; Mast (1978) who suggested curing and smoking of poultry meat for longer storage. Nakamura (1977) suggested the use of low temperatures, carbondioxide, oils, liquid parafins and some kinds of emulsion for keeping eggs fresh.

As regards protein and energy levels for optimum egg production, there are very many suggestions based on the climatic conditions and experimental set ups. McDonald (1978) is of the view that, there are quite a number of alternative equations for predicting metabolizable energy (ME) intake of laying pullets. But that these equations may predict within a standard deviation of about 7 Kcal/day.

He went on to explain that there are a number of factors influencing the accuracy of the prediction. These factors include such things like genotypes, managment factors like environmental temperatures, air velocity, housing systems and number of birds per cage. Also feed restriction during the laying phase can affect the accuracy. As for temperatures, Boushy and Marle (1978) described the confort zone for laying birds as between 10 and 20°C. 5 to 10 and 20 to 25°C also acceptable, but below 5°C and above 25°C are bad and could reduce production. 15°C is the most acceptable and ideal. According to them, feed consumption may be reduced by 10 to 15% in hot climates. In such a situation, one must reduce the calorie/protein ratio by 10 to 15% also.

Thomann (1968) however, argued that high producing flocks might stand temperatures higher than 28°C and produce well at 32 to 35°C if their management and feeding are properly adjusted. While a hen from an unselected local breed without nutritional care lay as many as 40 to 50 eggs annually (most of which are used for hatching), a hen from a highly selected laying breed, given slightly more care may lay from 180 to 200 eggs or more annually. There are many of the highly selected breeds in Nigeria today (Olomu, 1980) which include; Warren, $\text{Babcock}_{380}$, Tetra, Hyline $B_{11}$ and a host of others.

Experimental studies in Shika, show that 14% protein and 2,000 Kcal/Kg or 16% protein and metabolizable energy of 2,200 Kcal/Kg feed will give the highest physical maximum of egg production (Olomu et.al, 1980). Cooke and Perry (1980) and Agudu (1971) agrred that egg numbers tend to increase with protein levels. Agudu however,

found that protein levels reduced to 18 or 16% has no deleterious effect on the laying performance. Summers (1975) argued that high energy diet is not neccessary for laying hens.

An experiment on the performance of Single-comb White Leghorn fed 14 and 16% protein by Ross and Herrick (1973) showed no significant difference in egg production, feed and mortality. There was however, a slight gain in weight by layers fed on 16% protein even though they consumed a little less feeds. The hens fed the 14% protein also showed higher egg size production. From this, they concluded that layers could be fed low protein rations without reducing the performance of the chickens or cost since protein feeds normally cost higher than energy feeds.

Another experiment on the effect of 16% protein starter diets on subsequent performance of growing and laying of Single-comb White Leghorn pullets by Palafox (1975) showed that birds fed high energy levels of up to 3,096 Kcal/Kg at the starting period consumed less feeds than birds fed on less energy levels of 2,872 Kcal/Kg. Those fed on low energy feeds consumed more and therefore consumed more protein for faster growth. Protein concentration in the starter diet did not however affect feed consumption during the laying period significantly. Layers fed high energy diets produced more eggs than layers fed on low energy diets. From this finding, he concluded that the level of energy in the diet is probably more crucial than in the starting diet for overall egg production; and that 16% protein could be fed to day-old chicks without affecting their subsequent overall performance. Meanwhile, the Agricultural

Extension and Research Liason Services of the Ahmadu Bello University, Samaru, Zaria recommends 18 to 22% protein for broilers, 18 to 20% for chicks 0 - 7 weeks, 15% for growers ration 8 - 20 weeks and 16% for layers ration 20 weeks and above. There is however, no specific recommendations on energy levels.

## 2.3 Feeds, marketing, disease control and consumption patterns in Nigeria

Some few years ago, poultry feed used to be a big problem to poultry farmers. The situation has however changed since the various Governments started to be involved in the drive for more and better food and meat production programmes. These programmes include; the River Basin Development Authorities, the Agricultural Development Projects, the Federal Livestock and Meat Authority, the National Poultry production Company, the Operation Feed the Nation (OFN) and now the Green Revolution Programme. There are more than 40 nutritional types of feeds manufactured for all classes of livestock in Nigeria today (Kekeocha, 1978). Commercial feed producers like Arewa, Pfizer and a host of others plus state Governments feed mills are alleviating the problems of poultry feeds in the country.

In the area of marketing, not much attention has been given to poultry products. This could be as a result of the insufficient quantity of eggs and poultry meat in the markets. There seem to be a ready market for them due to increasing demands for them generally in the country. But with time, and with the increasing number of people entering into the business, it will come to be another concern.

With regards to poultry diseases, Nigeria has been lucky in that, with adequate prophylactic routine measures, the various economic diseases have been well contained in commercial enterprises (Nuru, 1980). There are however new diseases like Marek's disease/ avian Leukosis and Gumboro disease coming with the breeds (exotic) which need to be given attention. It is hoped that with more research and increasing number of veterinary services, poultry may not pose too much problems. It is generally accepted that good management practices and strict sanitory programmes will solve a lot of poultry production problems especially with respect to climate and disease conditions.

Pertaining to the consumption pattern of poultry products in Nigeria, the trend has always been on the increase. 1959/60 estimates showed that 0.94 Kg per capita per year was consumed; while in 1968/69, poultry products contributed about 0.4% to the total protein intake on per capita basis (Abalu et.al, 1981). In the Third National Development Plan, projections for poultry meat was put at 0.086 million tonnes, with a growth rate of 6% (F.M.E.D.R., 1975). If such projections could be achieved, it means that more poultry products would be consumed and therefore more protein, especially from eggs. This is because egg have been described as one of the rare foods which are high in nutritional value. According to Thomann (1968), two eggs per day will supply a person with the following nutrients (Table 2.1).

Table 2.1: Nutrient content of two eggs supplied per day.

| Nutrients | Units |
|---|---|
| Protein | 13 grams |
| Calories | 167 calories |
| Calcium | 51 Mg |
| Phosphorus | 232 Mg |
| Vitamin A | 1,030 I.U. |
| Thiamin ($B_1$) | 0.10 Mg |
| Riboflavin ($B_2$) | 0.31 Mg |
| Vitamin D | 100 I.U. |

Source: Thomann, W. (1968), Poultry Keeping in Tropical Areas. FAO, Rome, 1968. pp. 1 - 2.

The figures in the Table (2.1) emphasises the need for more egg products which will subsequently bring about more protein and other food nutrients to supplement the ones obtained from plants which are said to be of lower quality as compared to the animal protein.

## 2.4 Economic studies on egg production

The egg industry is characterized by several problems; some of which centres around feed mix, feed quality, management and expansion in order to achieve scale in production. The lag period from the day-old chicks to the point of lay at the age of about 20 to 21 weeks may seem too long for some beginners entering the industry.

Since feed alone constitutes about 50 - 75% of the total cost of production (Nuru, 1980; Heady, 1952), the initial outlay may be high. These problems not withstanding, there is still a great potential in egg production. Efforts to fully exploit this existing potential cannot yield the desired results without a knowledge of the production functions in the industry. This is because such knowledge is basic to the understanding and assessment of the productivity of resources already comitted in the industry and the extent to which egg output can be increased from such stock of existing resources. Such knowledge can also be useful as a diagnostic tool by way of providing general guidance to individual egg producers as to what quantity or mix of resources to use and of egg output to produce to maximize profits (Olutoba, 1977).

Unfortunately, it seems there is little information about the economics of egg production, especially with respect to the input/output relationships. Heady et.al (1966) agreed that for several decades now, little is yet known about the nature of the production function in egg production. They also reported an analysis from production function for egg from farm record data which indicated a diminishing marginal resource productivity. In their analysis, the Cobb-Douglas function was adopted but they were of the opinion that other algebraic forms of functions should be tried, since there is no a-priori reason to believe that constraints of the Cobb-Douglas equation in respect to constant elasticities of production and substitution should prevail at the farm level for particular input categories.

Olutoba (1977) carried out an input/output relationships study in the egg industry of the Western State of Nigeria with two sets of data, one from the farm settlers and the other from private poultry farmers. In his analysis, he included; egg output/bird, labour in man-hours/bird, feed consumption/bird and other costs/bird, as his varialbles. After trying the linear, quadratic, exponential, Cobb-Douglas and the square root functions, the quadratic form was chosen as the best fit. His results showed that a physical maximum output of 10 dozen eggs was achieved per bird in 6 months. But the economic maximum of 3 dozens per bird was achieved in the 6 months. He however concluded that the farm settlers performed slightly better than the private egg producers. This he said, could be due to the fact that the farm settlers used their resources more efficiently.

# CHAPTER THREE

## THEORETICAL FRAMEWORK AND METHODOLOGY OF THE STUDY

### 3.1 Some quantitative economic models used in egg production

Quantitative economic tools of data analysis are usually framed in the form of models for easy conceptualization. These models therefore imply some kind of representation of the actual form of what exist in reality. They can either be descriptive or mathematical in nature. A great deal of mathematical models are available today with different disciplines using different types for different purposes.

According to Jones (1975), models can be classified into static and dynamic, stochastic and deterministic and biological and economic models. When the values of the variables and the relationship between them do not change with time, the models containing them are described as static. Although relationships may exist between variables, no change in any variable is time dependent. Linear programming and production functions are examples of static models. The outputs of such models will not change with time. Dynamic models are those whose values of outputs are time dependent. The values of the outputs and variables will depend on the initial values assigned to the variables and length of time which has elapsed since then. Such models are capable of representing the state of the system at any given time, and although they may produce at the same point in time as a static model, they have done so by a process

of continous updating of the components of the model. When the probabilities of components having particular values are incorporated into the model, then it is termed stochastic. But when no account is taken of the variability associated with the values assigned to components, then the model is described as deterministic. Biological and economic models in agriculture bring about the synthesis of biological and economic elements together for easy workability.

There are many models used in egg production, but the widely available and successfully used, according to Griffis (1975) include:

1. Linear programming - the value of this technique for maximizing or minimizing a single objective function subject to linear constraints is widely accepted. It is the most widely available and adopted operational research technique. It is the standard dietary formulation technique. It is also used in many other enterprises and industries. But it has got several disadvantages also. One major disadvantage is that, increase in input will give the same proportional increase in the output which may not be true. Secondly, the technique does not consider price changes over time. Thirdly, since it provides for an optimum solution to the problem, there is less or limited choice of several activities. Fourthly, some fixed constraints of costs may also affect the choice of an activity since linear programming does not take fixed costs or assets into consideration. These are just a few among the problems one would face in the use of linear programming technique.

2. Monte Carlo programming - this is a method of producing solutions to matrix problems. This differs fundamentally from linear programming in that; instead of seeking the unique optimum solution, the method produces a large number of alternatives or alternative feasible solutions. Attepts have been made to apply this to dietary formulation, but it has no advantage over linear programming.

3. Dynamic programming - this approach is concerned with processes involving a sequence of decisions over time. Many examples of such processes can be described in agriculture, including the egg production industry. It is a conceptual approach rather than a single technique and it is consequently neccessary to construct models for each period with respect to the problem to be studied. It seems to be relevant to a number of replacement problems such as machinery, and to continously operating livestock enterprises such as beef, milk, eggs and broiler production. But a number of practical problems prevent the wide-spread application of the dynamic programming like developing a model for each type of problem to be examined. The availability of data is also a serious problem because the model builder must define coefficients not only for the current plan but also for the subsequent plans.

4. Simulation - this refers to models that are not concerned with optimizing techniques such as linear programming. It is not a technique, but an approach requiring the development of a model and then experimenting with it. The complex stochastic

and dynamic nature of the system can be taken into account so that a more realistic model is developed. The disadvantage of it is the necessity to develop a new model for each system to be studied. This is a time consuming task requiring a combination of skills seldomly found in one individual.

5. Multiple regression - this is a general statistical technique through which one can analyse the relationship between dependent variable and a set of independent variables. It can be viewed either as a descriptive tool by which the dependence of one variable on others is summarised and decomposed, or as an inferential tool by which the relationships in the population are evaluated from the examination of the sample data (Nie et.al, 1975). The multiple regression technique is used most as a descriptive tool for, it makes it possible to:

   (a) Find the best prediction equation and evaluate its prediction accuracy.

   (b) Control for other confounding factors in order to evaluate the contribution of a specific variable or set of variables.

   (c) Find structural relations and provide explanations for seemingly multivariate relationships. The technique makes use of production functions, consumption functions, supply functions, demand functions and so many other relationships.

In agriculture, especially in crop and livestock production, many forms of the production functions can be used.

3.2 Source of data

The data used in this study were collected from Shika experimental poultry farm. This experiment was designed to obtain the optimum protein and energy levels for brown type chickens. These chickens were the Warren type pullets.

These Warren pullets were reared on conventional starter ration until they were 20 weeks of age. They were then fed a common layers ration until they were 22 weeks old. They were weighed, divided into similar groups of 24 birds each and distributed into 36 Cm wide by 36 Cm deep laying cages, two per cage. The layout of the experimental design was the completely randomized block design of the form, 24 by 4 by 12. The cages were housed in an open-sided poultry house. Each of the experimental rations (Table 3.1) was fed to four groups of 24 birds per group for a period of 308 day, divided equally into eleven-28 day periods.

The rations were of three protein levels ( 14, 16 and 18% ) each fed at four metabolizable energy (ME) levels of 2,000, 2,200, 2,400 and 2,600 Kcal/Kg feed. The calcium and phosphorus contents of the rations were held constant at 3.75 and 0.95% respectively. Dietary nutrient levels were based on laboratory analysis of individual ingredients (Table 3.2). Common ingredients contained (as % of diet), fish meal, 2.50; bone meal, 2.25; periwinkle shell, 7.00; common salt, 0.25 and premix, 0.15. Premix supplied per Kg of ration: vitamin A, 11,250 I.U.; vitamin $D_3$, 2,250 I.C.U.; vitamin E, 3.75 Mg; vitamin K, 2.25 Mg; thiamin, 1.50 Mg; riboflavin, 4.125 Mg;

DL calcium pantothonate, 7.5 Mg; niacin, 18.75 Mg; copper oxide, 1.90 Mg; choline chloride, 90.0 Mg; vitamin $B_{12}$, 7.5 Mg; manganese oxide, 24.2 Mg; zinc oxide, 18.75 Mg; ferrous carbonate, 30.5 Mg; cobalt sulphate, 4.25 Mg and potassium iodide, 5.30 Mg.

Feed and water were supplied ad libitum. No artificial lighting was provided. Records were kept on daily group average egg production, mortality, feed consumption, haugh unit value once every four weeks, egg weight (average of each group on one day of each week) and body weight at start and end of the experiment. From March, 1979 through February, 1980, the minimum temperatures ranged between 12.2 and 21.3°C; maximum temperatures ranged between 28.3 and 35.8°C. The relative humidities ranged between 13.4 and 82.3%.

Table 3.1: Percent composition of experimental diets.

| Ingredients | Rations | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Yellow maize | 36.25 | 32.75 | 24.25 | 43.85 | 40.35 | 36.85 |
| Groundnut meal | 5.75 | 11.75 | 17.45 | 7.45 | 13.45 | 19.45 |
| Wheat offal | 45.85 | 43.35 | 40.85 | 36.55 | 34.05 | 31.55 |
| Common ingredients | 12.15 | 12.15 | 12.15 | 12.15 | 12.15 | 12.15 |
| Crude protein (%) | 14.20 | 16.20 | 18.10 | 14.20 | 16.20 | 18.10 |
| ME, Kcal/Kg feed | 2,000 | 2,000 | 2,000 | 2,200 | 2,200 | 2,200 |
| | 7 | 8 | 9 | 10 | 11 | 12 |
| Yellow maize | 51.45 | 47.95 | 44.45 | 59.05 | 55.55 | 52.05 |
| Groundnut meal | 9.15 | 15.15 | 21.15 | 10.85 | 16.85 | 22.85 |
| Wheat offal | 27.25 | 24.75 | 22.25 | 17.95 | 15.45 | 12.95 |
| Common ingredients | 12.15 | 12.15 | 12.15 | 12.15 | 12.15 | 12.15 |
| Crude protein (%) | 14.20 | 16.20 | 18.10 | 14.20 | 16.20 | 18.10 |
| ME, Kcal/Kg feed | 2,400 | 2,400 | 2,400 | 2,600 | 2,600 | 2,600 |

Source: Olomu, J.M. et.al (1980), Optimum protein and energy for brown egg type chicken in the tropics. 6 European conference, Humburg, 8 - 12 September, 1980. Published by World's Poultry Science Association. German Branch (FED), Vol. 111, pp. 155 - 162.

Table 3.2: Nutrient contents of ingredients used in the experiment (air dry basis).

| | Yellow maize | Wheat offal | G/nut meal | Fish meal | Bone meal | Periwinkle shell[x] |
|---|---|---|---|---|---|---|
| Crude protein | 8.90 | 15.30 | 45.00 | 60.00 | --- | --- |
| ME, Kcal/Kg | 3,476 | 1,145 | 2,500 | 2,866 | --- | --- |
| Calcium (%) | 0.10 | 0.10 | 0.15 | 3.00 | 28.63 | 39.82 |
| Phosphorus (%) | 0.25 | 1.20 | 0.55 | 2.00 | 13.21 | --- |
| Amino acid (%) | | | | | | |
| Arginine | 0.44 | 1.26 | 6.01 | 3.97 | --- | --- |
| Cystine | 0.16 | 0.30 | 0.60 | 0.56 | --- | --- |
| Glycine | 0.34 | 1.07 | 2.74 | 4.20 | --- | --- |
| Histidine | 0.29 | 0.62 | 1.70 | 2.08 | --- | --- |
| Isoleucine | 0.36 | 0.58 | 1.38 | 3.02 | --- | --- |
| Leucine | 0.15 | 0.05 | 2.99 | 5.23 | --- | --- |
| Lysine | 0.26 | 0.80 | 2.50 | 5.44 | --- | --- |
| Methionine | 0.18 | 0.20 | 0.88 | 2.23 | --- | --- |
| Phenylalanine | 0.48 | 0.73 | 2.00 | 2.61 | --- | --- |
| Threonine | 0.39 | 0.64 | 1.45 | 3.06 | --- | --- |
| Tyrosine | 0.38 | 0.39 | 1.39 | 2.24 | --- | --- |
| Valine | 0.44 | 1.01 | 1.75 | 3.20 | --- | --- |

[x]Periwinkle shell was the best source of calcium at the time of the experiment.

Source: Olomu, J.M. et.al (1980), Optimum protein and energy for brown egg type chickens in the tropics. 6 European conference, Humburg, 8-12 September, 1980. Published by World's Poultry Science Association. German Branch (FED), Vol. 111, pp. 155 - 162.

3.3 Estimation of egg production functions

The 12 experimental rations which were fed to the birds beginning from the age of 22 weeks, with the birds divided into groups each of 24 birds were replicated four times for each group. The egg output and feed consumption which was based on daily average recordings were used to determine the respective feed ingredients in each of the rations. This was possible because, each of the rations had specific percentage of each ingredient that constitutes it. All the cases in the calculation were based on the 24 birds per group and on the 28-day periods as specified by the design of the experiment.

After processing the various ingredients, the egg output was specified as the dependent variable, Y, while the various ingredients were specified as the independent variables, $X_i$. Common ingredients as specified in the rations carried a constant percentage of 12.15% in all the 12 rations, and therefore it was not included in the functional estimate. This was because it was assumed that any of the rations that was chosen, 12.15% of the common ingredients would still have to be added for balanced vitamins and minerals. It was however used in the gross margin analysis.

Having processed the data, the various variables were specified as follows:

Y = dozen eggs produced by 24 birds in 28 days on cumulative basis.

$X_1$ = groundnut meal consumed by 24 birds in the 28 days on cumulative basis.

$X_2$ = yellow maize consumed by 24 birds in 28 days on cumulative basis.

$X_3$ = wheat offal consumed by 24 birds in 28 days on cumulative basis.

In order to get enough number of cases, analysis of variance was performed so as to find out whether there was any significant difference between the means of the replications or not. When this was done, it was found that there was no significant difference between the means and therefore all the replications were considered as though they were sampled from the same population. From this, 40 cases each were got for all the 12 rations.

Even though there are a number of functional forms that can be used in productivity studies, three forms of production functions were tried for all the 12 rations. These were chosen based on the fact that they are easier to understand and also because they have been used elsewhere with great success. After trying all the functional forms for all the 12 rations, it was discovered that some of the rations did not give good statistical results hence they were dropped (Appendix A).

## 3.4 Conceptual framework of tool of analysis

One of the problems in the choice of any functional form in any study is the selection of the algebraic form of the function. Guides on the appropriate algebraic forms as Heady and Dillon (1969) stated may come from previous investigations and the theories of the sciences involved. There are so many functional forms used in production functions but because there is no single form that can characterize any agricultural production under all environmental

conditions, the choice of any specific type of equation to express production phenomena automatically imposes certain constraints or assumptions in respect to the relationships involved and the optimum resource quantities which are specified. These problems not withstanding, some equations are more flexible than others.

In this study, multiple regression analysis was used in conjuction with three different forms of production functions. These three functions were used so as to be able to choose one form that best fitted the data. These functions were chosen for their ease of understanding.

All the three models have the same basic functional relationships in the form:

$$Y = f(X_1, X_2, X_3/X_4, \ldots..X_n) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.1)$$

This means that output of eggs, Y depends on the inputs, $X_1$, $X_2$, $X_3$ where $X_1$, $X_2$ and $X_3$ are the quantities of groundnut meal, yellow maize and wheat offal in Kg respectively. $X_4$ to $X_n$ are fixed inputs. This indicates that we are only interested in observing the effect of applying the inputs, groundnut meal, yellow maize and wheat offal on the egg production. Equation 3.1 can be put into the regression model as follows:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + e \quad \ldots\ldots\ldots\ldots (3.2)$$

where Y = egg output in dozens

$a$ = constant term

$b_i$ = transformation ratios when $X_i$ are at different magnitudes.

$X_i$ = inputs, groundnut meal, yellow maize and wheat offal in Kg respectively.

e = error term with a normal distribution and a zero mean.

The various production function forms tried are the Cobb-Douglas, quadratic and the square root functions.

3.4.1 The Cobb-Douglas function

This function has the form;

$$Y = aX_1^{b1}X_2^{b2}X_3^{b3}e \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.3)$$

where Y, a, $b_i$, $X_i$ and e are the same parameters as mentioned previously. With this form, the various marginal products are derived as follows:

$$\frac{dY}{dX_1} = ab_1X_1^{b1-1}X_2^{b2}X_3^{b3} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.4)$$

$$\frac{dY}{dX_2} = ab_2X_1^{b1}X_2^{b2-1}X_3^{b3} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.5)$$

$$\frac{dY}{dX_3} = ab_3X_1^{b1}X_2^{b2}X_3^{b3-1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.6)$$

The exponents or b coefficients are the elasticities of production and can be used directly (Heady and Dillon, 1969). The equation can be estimated in logarithmic form as;

$$\text{Log } Y = \text{Log } a + b_1 \text{Log } X_1 + b_2 \text{ Log } X_2 + b_3 \text{ Log } X_3 \quad . \quad . \quad . \quad (3.7)$$

In this form, it can be fitted into the regression model. This

function allows for either constant, increasing or decreasing marginal productivity but does not allow an input/output curve embracing all the three. Also with other inputs held constant in magnitude, the marginal product is expected to decline. The function assumes a constant elasticity of production over the entire input/output curve. This means that successive equal increments of input add the same percentage to total output.

The Cobb-Douglas function cannot be used satisfactorily for data where there are ranges of both increasing and decreasing marginal productivity; neither can it be used satisfactorily for data which might have both positive and negative marginal products. Also, since the rate of decline in the marginal product decreases with input magnitudes, the function provides a curve that has no defined maximum. This means that the function may overestimate the input which equates the marginal revenue with marginal cost.

The function has three major advantages as Heady and Dillon (1969) put it. It provides for:

(a) Adequate fit of the data.

(b) Computational feasibility and

(c) Sufficient degrees of freedom unused to allow for statistical testing.

This means that the function is an efficient user of degrees of freedom. Such efficiency is important where research resources are limited and collection of farm-firm data is expensive.

3.4.2 The quadratic function

This function has the form:

$$Y = a \pm b_1X_1 \pm b_2X_2 \pm b_3X_3 - b_4X_1^2 - b_5X_2^2 - b_6X_3^2 \pm b_7X_1X_2 \pm b_8X_1X_3 \pm b_9X_2X_3 \pm e \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.8)$$

The parameters are the same as discussed previously. The minus signs denote the negative marginal products. This function allows for both declining and negative marginal productivities but not both increasing and decreasing marginal products. It also has a defined maximum total product. The elasticity is not constant as in the case of the Cobb-Douglas function, but declines with input magnitudes. From equation 3.8, the marginal products can be derived as follows:

$$\frac{dY}{dX_1} = b_1 - 2b_4X_1 \pm b_7X_2 \pm b_8X_3 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.9)$$

$$\frac{dY}{dX_2} = b_2 - 2b_5X_2 \pm b_7X_1 \pm b_9X_3 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.10)$$

$$\frac{dY}{dX_3} = b_3 - 2b_6X_3 \pm b_9X_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.11)$$

3.4.3 The square root function

This function has the form:

$$Y = a - b_1X_1 - b_2X_2 - b_3X_3 \pm b_4X_1^{.5} \pm b_5X_2^{.5} \pm b_6X_3^{.5} \pm b_7X_1X_2 \pm b_8X_1X_3 \pm b_9X_2X_3 \pm e \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.12)$$

The parameters remain the same as discussed previously. This function provides a single compromise between the power or exponential equation and the quadratic equation. It allows for a decreasing or diminishing total product and also provides marginal products which decline at a diminishing rate. The marginal product may be great at low input levels, and decline at slower rates as input levels increase although a sufficiently large amounts may depress the total yields. The elasticity of such function declines with increase in input and output magnitudes. Maximum total physical products can also be defined.

From equation 3.12, the marginal products are derived as follows:

$$\frac{dY}{dX_1} = -b_1 + .5b_4X_1^{-.5} + b_7X_2 + b_8X_3 \quad \ldots\ldots (3.13)$$

$$\frac{dY}{dX_2} = -b_2 + .5b_5X_2^{-.5} + b_7X_1 + b_9X_3 \quad \ldots\ldots (3.14)$$

$$\frac{dY}{dX_3} = -b_3 + .5b_6X_3^{-.5} + b_8X_1 + b_9X_2 \quad \ldots\ldots (3.15)$$

3.4.4 Marginal products and marginal value products

The marginal product ($MPP_{Xi}$) is a measure of the expected increase in output forthcoming from the use of an additional unit of the relevant input, the level of other remaining inputs held constant. In all the production functions discussed, the optimum

level of inputs to be used in the production process is got by equating the marginal physical product equations to their input/ output price ratios. By solving for the respective input variables, the optimum economic levels are got. This gives the best combination of the various inputs which are used in the production process.

The marginal value products (MVP) for all the inputs can be calculated using the formula;

$$MVP_{Xi} = MPP_{Xi} P_Y \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.16)$$

Where $MPP_{Xi}$ is the marginal physical product of the input $X_i$ and $P_Y$ is the price of the output, Y. The marginal value product (MVP) can then be compared with the prices of the inputs so as to determine whether the input should be increased or decreased in its usage. This means that, the MVP measures the efficiency of resource use. Maximum efficiency in resource use occurs when the MVP of the resource is equal to its own price. When the MVP of the resource is less than its price, it means the resource has been over used. But when the MVP of the resource is greater than its price, then more of the resource should be used because it is being under utilized.

### 3.4.5 Elasticity of production

Elasticity of production coefficients indicate the percentage increase or decrease in production that would occur if the amount of the input resource is increased or decreased by one percent, while other inputs are held constant. The summation of the

elasticities of the various input variables measure the scale of production in the production process. When the summation is less than one, it is a decreasing return to scale. When the summation is equal to one, it is a constant return to scale; and when it is greater than one, it is an increasing return to scale.

## 3.5 Gross margin analysis

Gross margin is simply the gross output value less variable costs. This is not pure profit because it can be reduced by fixed costs. However, Ford (1967) observed that gross margin represents the contribution made by a farm enterprise to the over-head costs. It also shows the gains and losses that can be expected if an enterprise is increased or reduced in size. The gross margin allows only for variable costs and there are occasions especially if a large change is made to the farm plan when the fixed costs do alter.

The variable costs incurred in egg production includes, feeding stuffs, veterinary expenses, casual labour etc. These will change with increase or decrease in the size of the farm. Fixed costs are those incurred on machines, regular labour, rent and other over-head costs. These costs do not vary directly according to the crop or livestock kept. Just like machines, they tend to run or depreciate whether proper use is made of them or not.

So in order to get net profit of the enterprise, the fixed costs must be subtracted from the gross margin. Thus, the net profit is the gross margin less the fixed costs. The higher the gross margin the better.

# CHAPTER FOUR

# RESULTS AND DISCUSSIONS

## 4.1 Introduction

Production function studies are used in order to be able to emperically determine some specific characteristics like total products, marginal products, average products, marginal value products, scale effects and elasticity of production to various feeds. All these give some basis for economic decision-making.

In this chapter, the various functions used for the data are discussed in terms of their estimated statistics such as the F-ratios, the coefficient of multiple determination, $R^2$, and the individual contribution of the variables to the production as measured by the t-ratios. From the discussions of the statistics of the various functions, a choice has been made of the best function that fitted the data. The coefficients and related statistics are also presented in tabular forms for better comparisos.

### 4.1.1 The quadratic function

The results obtained is summarised in Table 4.1; where,

Y = dozen eggs produced by 24 birds in 28 days on cumulative basis.

$X_1$ = groundnut meal (Kg) consumed by 24 birds in 28 days on cumulative basis.

$X_2$ = yellow (Kg) consumed by 24 birds in 28 days on cumulative basis.

$X_3$ = wheat offal (Kg) consumed by 24 birds in 28 days on cumulative basis.

From these results, it shows that the $R^2$ value is 0.63, indicating that 63% variation in the output is atributed to the independent variables in the equation; that is, groundnut meal, yellow maize and wheat offal. The F-value is 5.680, and it is significant at 5% level. The individual contribution of the variables to the production process however, shows that only the interaction terms between yellow maize and wheat offal is significant at 5% level; meaning that when the two inputs are used together, they would contribute more to the production than when used individually.

Table 4.1: Regression statistics for the quadratic function.

| Variables | Regression coefficients | t value | $R^2$ value | F value |
|---|---|---|---|---|
| $X_1$ | - 19.688 | - 1.115 | | |
| | (17.665) | | | |
| $X_2$ | - 8.039 | - 1.819 | | |
| | (4.419) | | | |
| $X_3$ | - 1.816 | 0.481 | | |
| | (3.780) | | | |
| $X_1^2$ | 1.646 | 1.428 | | |
| | (1.153) | | | |
| $X_2^2$ | 0.204 | 0.701 | 0.63 | 5.680 |
| | (0.291) | | | |
| $X_3^2$ | - 0.242 | - 0.598 | | |
| | (0.404) | | | |
| $X_1X_2$ | 0.369 | 1.150 | | |
| | (0.321) | | | |
| $X_1X_3$ | - 0.204 | - 1.096 | | |
| | (0.186) | | | |
| $X_2X_3$ | 0.133 | 2.166[x] | | |
| | (0.614) | | | |
| Constant | 251.091 | 1.955 | | |
| | (128.447) | | | |
| n = 40 | | | | |

x = significant at 5% level

4.1.2 The square root function

The results of the square root function is presented in Table 4.2, where Y, $X_1$, $X_2$ and $X_3$ are egg output in dozens; groundnut meal, yellow maize and wheat offal in kilograms respectively.

The results of this function also show a similar trend as the quadratic form, with the $R^2$ value of 0.63, same as the previous function that indicates that 63% variation in production is explained by the variables in the equation. Collectively, they have an F value of 5.672 which is significant at 5% level. This means that all the variables in the equation combined are contributing to the production process at that level of signficance.

Individual contributions however, shows that only the interaction terms between yellow maize and wheat offal that is significant at 5% level. This means that, when the two inputs are used together, they would contribute more to the production process than when used individually.

Table 4.2: Regression statistics for the square root function.

| Variables | Regression coefficients | t value | $R^2$ value | F value |
|---|---|---|---|---|
| $X_1$ | 35.735 (30.720) | 1.163 | | |
| $X_2$ | - 3.284 (3.524) | - 0.932 | | |
| $X_3$ | - 7.362 (6.912) | - 1.065 | | |
| $X_1^{.5}$ | - 172.400 (121.917) | - 1.414 | 0.63 | 5.672 |
| $X_2^{.5}$ | - 37.931 (56.007) | - 0.677 | | |
| $X_3^{.5}$ | 45.966 (83.020) | 0.554 | | |
| $X_1X_2$ | 0.357 (0.311) | 1.149 | | |
| $X_1X_3$ | - 0.204 (0.184) | - 1.120 | | |
| $X_2X_3$ | 0.132 (0.606) | 2.178[x] | | |
| Constant | 379.429 | 1.131 | | |
| n = 40 | | | | |

x = significant at 5% level.

4.1.3 The Cobb-Douglas function

Results of the Cobb-Douglas function are summarised in Table 4.3, where the dependent and the independent variables remain the same as discussed earlier.

Table 4.3: Regression statistics for the Cobb-Douglas function.

| Variables | Regression coefficients | t value | $R^2$ value | F value |
|---|---|---|---|---|
| $X_1$ | 0.560 (0.106) | 5.299[x] | | |
| $X_2$ | 0.243 (0.167) | 1.460 | 0.50 | 11.758 |
| $X_3$ | - 0.306 (0.154) | - 1.388 | | |
| Constant | 1.277 (0.312) | 4.089[x] | | |

n = 40

x = significant at 5% level.

The regression results of this function reveal quite a different statistics when compared with the other two functions discussed previously. The function shows that, the $R^2$ value is 0.50 and the F value is 11.758. As for the t values, it shows that groundnut meal is significant at 5% level while yellow maize and wheat offal are not significant at 5% level. The t value for the constant is also significant at 5% level unlike the other two

functions where their constants are not significant at the 5% level.

## 4.2 Choice of function for predicting economic values

The problem of any production function research is that, the true algebraic form of the function will never be known. So in general, the only knowledge available to the researcher is the broad information on the shape of the surface (Heady and Dillon, 1969). Several criteria could however be used to choose the right form of the function to use in the predicting of economic values. This can be done only after trying several forms of the functions.

Heady and Dillon (1969) recommend that; for testing the statistical adequacy of the fitted function, three procedures are generally available when experimental data has been fitted by regression procedures. They are based on the size of the coefficient of multiple determination, $R^2$; an F test of the regression means square and a comparison of the lack of fit and error mean squares.

In this study, the choice of the best function was based on the following criteria as recommended by Nie et.al (1975).

(a) The coefficient of multiple determination, $R^2$, which indicates the percentage of the variation in the n observed Y values that is explained by the fitted regression equation. This is a measure of goodness of fit of the estimated regression equation, and the higher the value, the better the fit.

(b) The value of the F statistics which provides an overall

test of significance of the regression. It also provides a test for the null hypothesis that $b_1 = b_2 = b_3 = 0$. If the calculated F value from the regression equation is larger than the F value in the Table at a desired probability level, then the null hypothesis is probably not true; and that the alternative hypothesis that at least one of the $b_i$s is different from zero is accepted.

(c) The value of the t statistics which provides for the test of significance whether the sample regression coefficient $b_i$ is significantly different from zero at some desired probability level. This measures the individual contribution of each of the variables in the equation. If the t value from the regression equation is larger than the Table t value, then $b_i$ is significantly different from zero at that level of probability.

Based on the three criteria discussed, the Cobb-Douglas function was considered better than the other two functions. This was so because, even though they have a higher $R^2$ value, their F values and t values are lower; suggesting that the explanatory power of these functions are not as good as the Cobb-Douglas function. In the case of the Cobb-Douglas function, the F value is higher, the t values are higher than the other two functions. The $R^2$ value however is a little lower than the other two functions.

We therefore decided to select the Cobb-Douglas function as the best fit for the data. Heady and Dillon (1969) are also of

the opinion that, an animal feeder who wishes to feed only one ration throughout the production period that averages lowest in cost, should use the Cobb-Douglas function because the marginal substitution rates between feeds along any ration line are constant. This means that isoclines are regarded as linear and passing through the origin of the input axis. Equating the price ratio with the slope of the output isoquants gives an average least-cost ration for the whole production period. In this study, a single ration was used in the production process throughout the laying period.

From Table 4.3, the overall F value of 11.758 indicates that all the variables in the equation are collectively significant at 5% level. This also disproves the null hypothesis that $b_1 = b_2 = b_3 = 0$, and that the alternative hypothesis that at least one of the $b_i$s is significantly different from zero is accepted. The $R^2$ value of 0.50 indicates that 50% of the variation in output is explained by the three variable inputs in the equation, groundnut meal, yellow maize and wheat offal. The low $R^2$ value under such a production situation may be attributed to the other fixed and variable inputs in the production process but which were not included in the functional form of the equation. Also, there could be some other external factors which are not directly part of the production process but could still influence the results of the output. Consequently, the remaining 50% variation in the production could be as a result of the other factors not in the equation.

## 4.3 Input/output relationships for the three variable inputs

The input/output relationships in this case is the relationship between the output of eggs in dozens and the ingredients used in the production process, groudnut meal, yellow maize and wheat offal all in kilograms. Table 4.4 shows the input/output relationships which were generated from the regression equation at various input levels.

Table 4.4: Input/output relationships for the three variable inputs.

| Feed(Kg) | output Y | input $X_1$ | input $X_2$ | input $X_3$ | $MPPX_1$ | $MPPX_2$ | $MPPX_3$ |
|---|---|---|---|---|---|---|---|
| 10.00 | 1.63 | 0.60 | 3.60 | 4.60 | 1.52 | 1.11 | - 0.11 |
| 20.00 | 16.98 | 1.20 | 7.20 | 9.20 | 7.93 | 0.57 | - 0.57 |
| 30.00 | 20.80 | 1.80 | 10.80 | 13.80 | 6.47 | 0.46 | - 0.47 |
| 40.00 | 23.93 | 2.40 | 14.40 | 18.40 | 5.58 | 0.40 | - 0.40 |
| 50.00 | 26.67 | 3.00 | 18.00 | 23.00 | 4.98 | 0.36 | - 0.36 |
| 60.00 | 29.17 | 3.60 | 21.60 | 27.60 | 4.54 | 0.33 | - 0.33 |
| 70.00 | 30.62 | 4.20 | 25.20 | 32.20 | 4.08 | 0.29 | - 0.30 |
| 80.00 | 33.65 | 4.80 | 30.80 | 36.80 | 3.93 | 0.28 | - 0.28 |
| 90.00 | 35.65 | 5.40 | 32.40 | 41.40 | 3.70 | 0.26 | - 0.27 |
| 100.00 | 37.50 | 6.00 | 36.00 | 46.00 | 3.50 | 0.25 | - 0.25 |

The input/output relationship conforms with the AERLS (1975) recommendation that light laying birds would consume 66.52Kg/100 birds per week, and heavy laying birds would consume 88.69 Kg/100

birds per week. This means that each bird would consume 0.6652 Kg and 0.8869 Kg per week for light and heavy breeds respectively.

For this study, the 0.6652 Kg value was considered as a basis for comparison since the average weight of the experimental birds throughout the production period was given as 2.23 Kg (Olomu et.al, 1980). This falls under the light breed category. So for 24 birds in 4 weeks, the consumption would be 63.8592 Kg. At this input level, the egg output is just about 30 dozens. This gives an average of 15 eggs per bird per month. The National Academy of Sciences, U.S.A. (1971) reported that birds in the same category of body weight would consume 34.50 Kg per bird to produce 200 eggs. However for this study, the consumption per bird is about 33.28 Kg of feed producing on the average of 180 eggs per bird per year. On the average basis, the reports of the National Academy of Sciences gives about 17 eggs per bird while this report gives an average of 15 eggs per bird per month; leaving a difference of 2 eggs per bird.

Olutoba (1977) did an input/output relationships study in the egg industry in the Western State of Nigeria and found that, economic optimum of 3 dozen eggs per bird could be achieved in 6 months. This gives about 10 eggs per bird per month. This value seem to be low as compared with this study although the breed group is not known. Since these results are experimental in design and execution, any poultry farmer that obtains his results within this range may suggest that he is using his resources satisfactorily.

## 4.4 Total product, marginal product and marginal value product

In any production studies, the principles that underly the fitted form of the function becomes the most important for effective economic decision. This is so because, without the underlying principles, the function becomes more or less useless. One of the most important principles in this regard is the marginal productivity of the input resource. This brings into mind the most widely accepted laws applicable in any input/output relationships. This is the law of diminishing returns which says that; " if a quantity of an input resource is increased by equal amounts with the quantities of the other resources held constant, then the increments to the total product will first increase at an increasing rate, increase at a decreasing rate and then eventually reach a zero point and may even become negative" (Heady, 1952). This law refers to the marginal productivity curve of resource. By definition, the marginal product of a factor is the change in output resulting from a very small change in the input factor keeping the level of other inputs constant. In principle, the marginal product of a factor can be positive, zero or negative.

In this study, the marginal products could be derived from the selected load equation as follows:

$$\frac{dY}{dX_1} = 0.72X_1^{-.44}X_2^{.24}X_3^{-.31} \quad \ldots\ldots\ldots\ldots \quad (4.1)$$

$$\frac{dY}{dX_2} = 0.31X_1^{.56}X_2^{-.76}X_3^{-.31} \quad \ldots\ldots\ldots\ldots \quad (4.2)$$

$$\frac{dY}{dX_3} = -0.97X_1^{.56}X_2^{.24}X_3^{-1.3} \quad \ldots\ldots\ldots\ldots \quad (4.3)$$

But for simplicity of calculation, one could as well use the b coefficients multiplied by the average product since the b coefficients are the elasticities of production with respect to the Cobb-Douglas function; thus,

$$MPPX_i = \frac{d\hat{Y}}{dX_i} = \frac{b_i\hat{Y}}{dX_i} \quad \ldots\ldots\ldots\ldots \quad (4.4)$$

Where Log $X_i$ assumes its arithmatic mean and $\hat{Y}$ is the estimated level of output (Heady and Dillon, 1969, Upton, 1979). The values of the calculated results are shown in Table 4.5 using the formula specified in Appendix B (17: 69).

Table 4.5: Profit maximization levels of input and output.

| Variable inputs | Output doz./4 wks | Level of inputs | MPP | MVP | Input price (₦/Kg) |
|---|---|---|---|---|---|
| G/nut meal | | 10.01 | 1.85 | 2.96 | 0.29 |
| Yellow maize | ( 33.11 ) | 10.92 | 0.73 | 1.17 | 0.31 |
| Wheat offal | | 10.73 | - 0.96 | -1.54 | 0.12 |

Price of output = ₦1.60/dozen

Table 4.5 shows that the quantities of all the three inputs put together gives a total of 33.66 Kg with an output of 33.11 dozen eggs. This means that consumption is just about 0.96 Kg per dozen eggs produced. This seems to be too low for both maintainence and production if the the only ingredients used in the equation are considered.

From the original ration, groundnut meal formed only 5.75%; yellow maize, 36.25%; wheat offal, 45.85%and common ingredients, 12.15%. But from the optimum levels, groundnut meal constitutes 29.74%; yellow maize, 32.44% and wheat offal, 31.88%. This shows that groundnut meal can substitute more of yellow maize and wheat offal in the production process. The high percentage of groundnut meal in the ration may render the protein percentage too high which may not be neccessary for laying birds since it may not affect their laying performance (Ross and Henrick, 1973). In this particular case however, since the price of groundnut meal is lower than the price of yellow maize, more of the groundnut meal in the ration may be good for more production.

Looking at the marginal products, it is obvious that wheat offal has been overused in the production process since it has a negative value. Groundnut meal and yellow maize could however be increased for profitable production since their marginal value products are still higher than their input prices. The economic use of a resource is obtained when the marginal value product (MVP) is equal to the price of the resource. The MVP is calculated using the formula:

$$MVP_{Xi} = MPP_{Xi} P_Y \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4.5)$$

Where $MVP_{Xi}$ is the marginal value product of $X_i$.

$MPP_{Xi}$ is the marginal physical product, and $P_Y$ is the price of the output. The marginal product is a measure of the efficiency of resource use. The $MVP_{Xi}$ can then be compared with its own price.

Any MVP that is greater than the corresponding price should be increased because it will be economical to increase its use since more income could be got from its use. But when the MVP is less than the resource price, then it pays more to reduce its use since it is overused (Upton,1979). This is why the inputs, groundnut meal and yellow maize could have been increased in the production process while the wheat offal which was overused, could have been reduced for profitable production.

## 4.5 Elasticity of production and the scale effect.

Elasticity of production is the expected percentage increase or decrease in production that would occur if the amount of the input is increased or decreased by 1% while other inputs are held constant (Heady and Dillon, 1969; Upton, 1979). It measures the scale of production; whether it is a constant, decreasing or increasing returns to scale. This is measured by the summation of the production coefficients. With the Cobb-Douglas function, the summation of the partial regression coefficients are used directly as elasticities of production (Heady and Dillon, 1969). This is done only when all the factors of production or all the relevant factors are included in the production function equation. On the other hand, according to Heady and Dillon, if the resouce user believes that constant returns to scale prevail; then the summation of the regression coefficients may be regarded as indicating the importance of the omitted variables if the summation is less than unity, or as roughly indicating the extent of anomalies

in the mode of aggregation if it is greater than unity. So if the sum of the b coefficients is 1, it means it is a constant return scale. A value of less than 1 is a decreasing returns to scale. A value of more than 1 is an increasing returns to scale.

In this analysis, the ingredients used are considered to be the most relevant to the production and therefore, the summation of the elasticities could reflect the scale effect. The total sum of the coefficients in this regard is 0.49. This value is less than 1 and therefore, it is a decreasing returns to scale. The implication of this is that, any increase in the inputs by 1% will only give an increase in production by only 0.49%. At this level, there should be no more increase in the use of the resources since the return are lower than their proportional usage.

## 4.6 Input/output relationships for the two variable inputs

Having discussed much about the production involving three variable inputs, groundnut meal, yellow maize and wheat offal, it becomes neccessary to find a function for two variable inputs so as to be able to show graphically the isoquant curves, the marginal rate of substitution and the least-cost combination of the feed ingredients.

The choice of the two variables, groudnut meal and yellow maize was based on the significant levels in the lead equation. From Table 4.3, groundnut meal was significant at 5% level, while yellow maize and wheat offal were both not significant at the 5% level. The

Yellow maize had a higher coefficient and also positive but wheat offal had a lower coefficient and it was also negative. On the basis of their coefficients then, groundnut meal and yellow maize were chosen for another regression function estimate. This estimated equation is specified as:

$$Y = 0.937X_1^{.586}x_2^{.129} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4.6)$$

Where Y is output of eggs in dozens.

$X_1$ is groundnut meal consumed by 24 birds in 28 days in Kg.

$X_2$ is yellow maize consumed by 24 birds in 28 days in Kg.

The statistics for the regression equation is given in Table 4.6.

Table 4.6: Regression statistics for two variable inputs.

| Variables | Regression coefficients | t value | $R^2$ value | F value |
|---|---|---|---|---|
| $X_1$ | 0.586 (0.109) | $5.380^x$ | | |
| $X_2$ | 0.129 (0.163) | 0.792 | 0.44 | 14.505 |
| Constant | 0.937 (0.271) | $3.452^x$ | | |
| n = 40 | | | | |

x = significant at 5% level.

As shown in Table 4.6, after dropping wheat offal from the equation, the $R^2$ value was reduced. This is because the proportion contributed by the wheat offal in explaining the prediction of the production is no more there. The F value was however increased. This could be as a result of the relative importance of the two variables, groundnut meal and yellow maize as compared with wheat offal.

The equation with two variable inputs, shows that yellow maize is not significant even at 10% level but groundnut meal is significant at 5% level. This shows the superiority of groundnut meal over yellow maize. The $R^2$ value of 0.44 indicates that 44% variation in output is attributed to the variables in the equation, while the rest must be due to some other factors not in the equation.

Some input/output values were generated for this function as in Table 4.7 with their marginal physical products and marginal value products at various feed levels. When 10 Kg of feed was fed to a group of 24 birds per month, there was no output. This could be due to the fact that at that level feed, the quantity was just enough for body maintenece. The marginal products of these ingredients exhibit diminishing marginal values. But the marginal value product for yellow maize is equal to its own price at a feed level of 40 Kg. This means that feeding more than 40 Kg of the feed with more than 14.40 Kg of the ingredient in the feed may not yield much income since at that level, the marginal value product will be less than the price. It is however different with the groundnut meal where the marginal value product is very much higher than the price of the input. This indicates that one could still feed more than 100 Kg of

groundnut meal and still be operating economically.

Table 4.7: Input/output relationships for two variable inputs.

| Feed (Kg) | Output (Y) | Input ($X_1$) | Input ($X_2$) | MPP ($X_1$) | MPP ($X_2$) | MVP ($X_1$) | MVP ($X_2$) |
|---|---|---|---|---|---|---|---|
| 10.00 | 0.00 | 0.60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20.00 | 12.86 | 1.20 | 7.20 | 6.32 | 0.23 | 10.12 | 0.37 |
| 30.00 | 17.18 | 1.80 | 10.80 | 5.63 | 0.21 | 9.02 | 0.33 |
| 40.00 | 21.13 | 2.40 | 14.40 | 5.20 | 0.19 | 8.31 | 0.31 |
| 50.00 | 24.72 | 3.00 | 18.00 | 4.86 | 0.18 | 7.78 | 0.29 |
| 60.00 | 28.25 | 3.60 | 21.60 | 4.63 | 0.17 | 7.41 | 0.27 |
| 70.00 | 31.62 | 4.20 | 25.20 | 4.44 | 0.16 | 7.11 | 0.26 |
| 80.00 | 34.83 | 4.80 | 28.80 | 4.28 | 0.16 | 6.85 | 0.25 |
| 90.00 | 37.81 | 5.40 | 32.40 | 4.13 | 0.15 | 6.61 | 0.24 |
| 100.00 | 40.82 | 6.00 | 36.00 | 4.02 | 0.15 | 6.42 | 0.24 |

## 4.7 Isoquants, marginal rates of substitution and the least-cost combination

Isoquants are curves that describe the various combinations of inputs that give a specified level of output. Here, discusion is based on the two inputs, groundnut meal and yellow maize as specified in section 4.6. The isoquant equation used to calculate the various values was derived from the specified equation, 4.6 and the values are given in Table 4.8.

The isoquant equation is given as:

$$X_1 = \left( \frac{Y}{.94X_2^{.13}} \right)^{\frac{1}{.59}} \quad \ldots\ldots\ldots\ldots\ldots \quad (4.7)$$

The graphical presentation is given in Figure 1 with the assumption that 24 birds cannot lay more than 40 dozen eggs in 4 weeks.

From marginal rate of substitution principles, a given out of eggs can be obtained by using relatively little groundnut meal and a relatively large amount of yellow maize. The same output can be achieved by using more of groundnut meal and less of yellow maize. But it is unlikely that groundnut meal will substitute for yellow maize entirely. The implication of this is that; layers ration is normally formulated with predetermined ratios of protein to energy. There is therefore a limit to how much groundnut meal can substitute for yellow maize.

With information on the rate of substitution between the two inputs, the least-cost combination can be estimated. In Table 4.8, the total cost of groundnut meal and yellow maize is given in column EV, where groundnut meal costs ₦0.29/Kg and yellow maize costs ₦0.31/Kg. So for 20 dozen eggs, the least-cost of ₦3.66 occurs where 5 Kg of groundnut meal and 7.13 Kg of yellow maize are used. The cost is at a minimum because the extra cost of substituting groundnut meal for yellow maize is less than the saving in yellow maize cost. For example, at 4 Kg of groundnut meal, the extra cost of 1 more unit is ₦0.29. But the saving in yellow maize cost is ₦0.31. So it is better to substitute groundnut

meal for yellow maize. It is also true that if more than 5 Kg of groundnut meal is used, the extra cost of substituting groundnut meal for yellow maize is greater than the saving in yellow maize cost. This is so because the sixth unit of groundnut meal is still only ₦0.29. But the saving in the yellow maize cost is only ₦0.21. It is no longer profitable to substitute groundnut meal for yellow maize. So at the least-cost combination of resources, the rate of technical substitution is equal to the inverse price ratio. In this case, the ratio is ₦0.29/₦0.31 which is ₦0.94 and the $RTSX_1X_2$ equal to 0.94 is at the 5th unit of groundnut meal, and this represents t the least-cost combination. For the 40 dozen eggs output, the $RTSX_1X_2$ equals to the inverse price ratio occurs at about 10 Kg of groundnut meal and 9.30 Kg of yellow maize. This then represents the least-cost combination. If the prices of the inputs change, then the inverse price ratio will change and that will result into different least-cost combinations.

Table 4.8: Isoquants and least-cost combinations in egg production

| I | II | III | IV |
|---|---|---|---|
| Units of G/nut meal $X_1$ | Units of yellow maize $X_2$ | $RTSX_1X_2$ Decrease of $X_2$ / Increase of $X_1$ | Total cost of input (₦) $.29X_1 + .31X_2$ |
| (a) 20 dozen eggs of output | | | |
| 1 | 17.30 | --- | 5.65 |
| 5 | 7.13 | 2.54 | 3.66 |
| 10 | 4.88 | 0.94 | 4.41 |
| 15 | 3.90 | 0.45 | 5.56 |
| 20 | 3.33 | 0.20 | 6.83 |
| 25 | 2.95 | 0.14 | 8.17 |
| 30 | 2.66 | 0.08 | 9.53 |
| 35 | 2.45 | 0.06 | 10.91 |
| 40 | 2.28 | 0.04 | 12.31 |
| (b) 40 dozen eggs of output | | | |
| 1 | 33.01 | --- | 10.52 |
| 5 | 13.62 | 4.85 | 5.67 |
| 10 | 9.30 | 1.78 | 5.78 |
| 15 | 7.45 | 0.86 | 6.66 |
| 20 | 6.36 | 0.37 | 7.77 |
| 25 | 5.62 | 0.22 | 8.99 |
| 30 | 5.09 | 0.15 | 10.28 |
| 35 | 4.67 | 0.11 | 11.60 |
| 40 | 4.38 | 0.08 | 12.95 |

Price of groundnut meal = ₦0.29/Kg

Price of yellow maize = ₦0.31/Kg

The inverse price ratio = ₦0.29/₦0.31 = 0.94

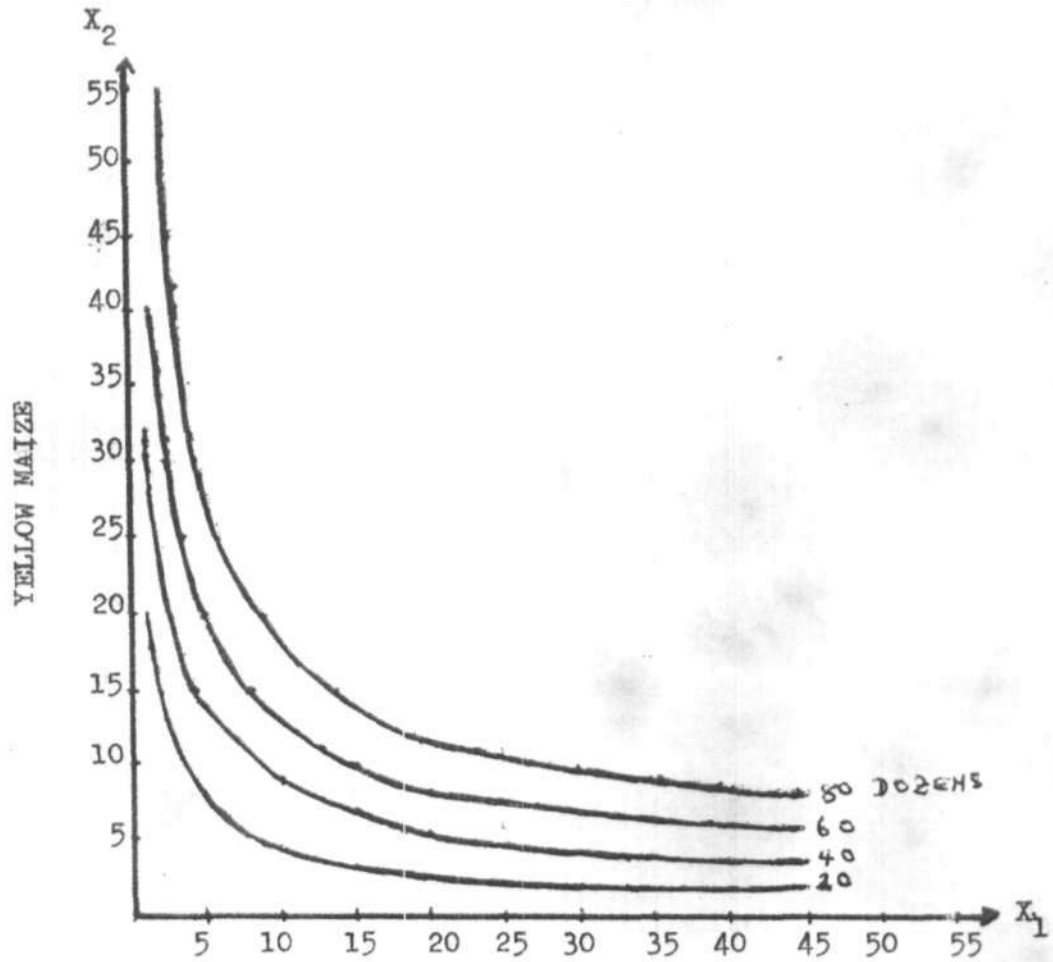



FIGURE 1: Isoquants for groundnut meal and yellow maize.

## 4.8 Gross margin analysis

The aim of this analysis was to find the gross profit over variable costs. Net profit could be computed through this, but unfortunately this could not be possible because information on the fixed costs were not available. In this regard, assumptions were employed with respect to the cost aspect during brooding, rearing and medication. Also based on the poultry standards for Nigeria (Ogundipe, 1982) and the price lists obtained from the Research Station, the following costs have been identified.

Gross variable costs

| Items | Quantity (Kg) | Price(₦/Kg) | Total(₦) |
|---|---|---|---|
| 1. Groundnut meal | 221.96 | 0.29 | 64.368 |
| 2. Yellow maize | 1410.90 | 0.31 | 437.379 |
| 3. Wheat offal | 1674.66 | 0.12 | 200.959 |
| 4. Common ingredients | 447.00 | | |
| (a) fish meal | 91.98 | 0.80 | 73.584 |
| (b) bone meal | 82.78 | 0.08 | 6.622 |
| (c) periwinkle shell | 257.53 | 0.20 | 51.506 |
| (d) common salt | 9.20 | 0.44 | 4.048 |
| (e) premix | 5.52 | 6.00 | 33.120 |
| 5. Cost of 96 plus 10% for mortality of day-old chicks at ₦0.85 each . . . . . | | | 90.100 |
| 6. Cost of chick mash for 8 weeks for 106 birds at 2.1 Kg/chick at the cost of ₦0.356/Kg . . . . . | | | 79.246 |

| | | |
|---|---|---|
| 7. | Cost of growers ration from 9 - 20 weeks for 106 birds at 7 Kg/bird at the cost of ₦0.312/Kg . . . . . | 231.504 |
| 8. | Brooding cost for 106 birds at ₦0.15/bird . . . . . | 15.900 |
| 9. | Vaccination and medication for 106 birds at ₦0.10/bird | 10.600 |
| 10. | Medication during laying for 96 birds at ₦0.10/bird . | 9.600 |
| 11. | Labour cost for 106 birds during rearing and laying phases at 3.07 man-hours per day for 72 weeks at the rate of ₦1.39/man-hour[1] . . .. . . . . . | 307.246 |
| | Total variable costs per 106 birds | ₦1615.782 |
| | Total variable costs per bird | ₦15.432 |

Gross sales

| | | |
|---|---|---|
| 1. | Sales of spent birds (96 birds less 5% mortality during laying = 86 birds at ₦4.00/bird) . . . | ₦344.000 |
| 2. | Sales of 1495.252 dozen eggs at ₦1.60/dozen . . | ₦2392.403 |
| | Total gross sales | ₦2736.403 |

Gross margin = Gross sales - total costs

GM = ₦2736.403 - ₦1615.782 = ₦1120.621

Gross margin/bird = ₦10.572

[1] National minimum wage was used for labour cost.

The gross margin shows that on the average, ₦15.432 was spent on each bird and that the gross return was ₦10.572. The total gross margin was ₦1615.782 and that if the net profit should be obtained, the fixed costs must be subtracted from the total gross margin. But since information on the fixed costs are not available, the various variable costs that constitute the costs in egg production would be discussed.

Feed cost constitute about 60 to 75% of the total cost in poultry production (Heady and Dillon, 1969; Nuru, 1980; Olomu, 1980). In this study, the feed costs accounted for about 73.17% of the total variable costs. Groundnut meal was 3.98%; yellow maize, 27.07%, wheat offal, 12.44% and common ingredients, 10.44%. Chick mash formed 4.91% and growers ration formed 14.33%. The rest of the costs came from the labour costs, vaccination, medication and brooding costs. These costs are not as high as the feed costs.

Since the analysis was based on what obtained a few years ago, it should be noted that this situation does not obtain in reality today with the poultry farmers. Secondly, prices are not the same all through and therefore, changes in prices can reduce the total gross margin.

# CHAPTER FIVE

## SUMMARY AND CONCLUSIONS

### 5.1 The input/output analysis

This study was designed in order to be able to make some contribution to the understanding of the input/output relationships in egg production and to be able to make suggestions with respect to the best use of the resources.

At the beginning of the research, the twelve experimental rations obtained from Shika experimental poultry farm were processed into their various feed ingredients based on their percentage composition. The egg output was measured in dozens, while the ingredients, groundnut meal, yellow maize and wheat offal were measured in kilograms. The egg output was specified as the dependent variable while groundnut meal, yellow maize and wheat offal were specified as the independent variables. All the twelve rations were processed and subjected to three different forms of production functions namely, quadratic, square root and Cobb-Douglas functions. This was done in order to find the best function that fitted the data and to determine their economic values.

Due to poor statistical results of the regression equations, eleven of the rations were dropped from the discussions (Appendix A). Out of the three functions, Cobb-Douglas was considered to be the best fit for the data.

From the results of the analysis, the following observations were made:

(a) The three input variables, groundnut meal, yellow maize and wheat offal contributed significantly to the production of eggs. This was shown by the overall F value of 11.758 which was significant at 5% level.

(b) The individual contribution of the inputs showed that groundnut meal was the only input that was significant at 5% level. This means that groundnut meal was more important than the other two variables.

(c) The marginal value products of groundnut meal and yellow maize indicated that more of the various inputs could have been used in order to maximize output. While the marginal value products of groundnut meal and yellow maize were more than their prices, the marginal value product for wheat offal was less than its own price and therefore it could have been more economical to reduce its quantity in the production process. This is so because it was overused.

(d) Elasticity of production measures the scale of production when all the relevant factors are included in the production equation. In this study, it was assumed that the feed ingredients used were very relevant to the production of eggs and therefore, the summation of the elasticities can be used to describe the scale of production. In this case, the sum of the input elasticities of production was 0.49. This value is less than one and therefore it is a decreasing

returns to scale. The implication of this is that, any increase in the inputs by 1% will only give an increase in production by only 0.49%.

(e) Two of the important ingredients, groundnut meal and yellow maize were regressed and the least-cost combination determined. At 20 dozen eggs of output, the quantities of groundnut meal and yellow maize used were 5 Kg and 7.13 Kg respectively. With a least-cost of ₦3.66; and at 40 dozen eggs of output, the quantities used were 10 Kg and 9.30 Kg respectively. At this combination, the total cost was ₦5.78, which is the least cost.

5.2 Gross margin analysis

The gross margin analysis revealed that the total feed costs accounted for about 73.17%. Out of this feed costs also, the layers ration which was the experimental ration, formed 53.93% of the costs. Chick mash and growers ration formed about 19.17%. The high percentage of the layers ration in the feed cost component is due to the fact that the birds were bigger during the laying phase and therefore their consumption was higher. Secondly, the feeds concerned was for both maintenance and for egg production. The other costs were relatively lower than the feed costs even though there were no properly documented values on the other costs outside the feed component.

## 5.3 Implications and suggestions of the study

From the gross margin analysis, feed costs contributed about 73.17% of the variable costs. Groundnut meal formed 3.98%; yellow, 37.07% and wheat offal, 12.44%. Contrary to the general belief that protein feeds cost more than energy feeds (Ross and Herrick, 1973), this study had it that groundnut meal which contained 45% protein costed less than yellow maize (Appendix E).

From the regression results, groundnutmeal contributed more significantly to the production of eggs than yellow maize and wheat offal. Infact, in the ration, it was specified that it formed 5.75%. But in the economic level from the regression results, it contributed up to 29.74%. Even though the price of groundnut meal was lower than yellow maize and it contributed more to the production of eggs, the general decline in its production in the country may call for some more substitutes of feeds of high protein. Such feeds like soya beans, cow peas and fish meal could be good substitutes if they are available and cheap.

With respect to maize, it has low protein content (8.9%) and high price per kilogram (₦0.31/Kg). But it has high energy (3510 Kcal/Kg), yellow colouring matter as a precursor of vitamin A and it gives the yellow colouring to the yolk which gives the egg the nice appeal to some consumers. Also its production in the country is on the increase and therefore, it will not be difficult to obtain even in the 'open' markets. So, despite its relatively high price, its availability will provide the birds with feeds quite

readily more especially when the ration is mixed locally as it was done in this case.

As for wheat offal, its price is relatively cheap and has 17.10% protein. But is has low energy (1600 Kcal/Kg) when compared with groundnut meal and yellow maize. It has more roughage than the other two feed ingredients. Eventhough it is cheap, since it does not contribute much to the output when compared to the other two ingredients, caution must be taken in its usage. Secondly, the birds are monogastrics and not ruminants and therefore, too much roughage may not be neccessary. Furthermore, its too much use reduces egg production (Oni: personal communication).

From the foregoing observations, the following suggestions have been made:

(a) That since groundnut meal contributed more and formed a major factor in the poultry feed, both the State governments and the Federal Government should encourage its production in areas where it can be grown instead of importing it. When this is done, a lot of foreign exchange could be saved.

(b) More information should be obtained on the aspects of costs of egg production especially labour, medication, vaccination and other related costs which could give important information to researchers especially those in the field of economics.

(c) Alternative sources of protein feeds like soya beans production should be encouraged in places where the crop can be grown.

## 5.4 Limitations of the study and suggestion for further studies

1. One of the most important limitations of this study was that, the experiment was not designed with the knowledge of any economic studies in mind. This has made it difficult for the researcher to obtain accurate values on the aspect of the costs outside the feed components.
2. All the twelve experimental rations were fed to only one breed of birds. Since breed types influence the accuracy of prediction in egg production (McDonald, 1978), a study on a single breed cannot bring about favourable comparisons. It is therefore appropriate to carry out a similar study on other breeds.
3. Caution should be taken with respect to the problem of emphasis on the important distribution between the animal itself as a product as in the case of meat production, and the situation where the product is a flow over time from the animal as in the case of milk, eggs, wool and power production. For any meaningful economic study therefore, the consideration of all areas related to the outcome of the production is very neccessary.
4. This study concentrated only on the feed aspect of the experimental rations. There is a need for further study of this kind that will take other cost aspects of production into consideration. When this is done, it will provide a valuable information to both researchers and poultry producers in general.

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# APPENDIX A

## REGRESSION COEFFICIENTS FOR RATIONS 2 TO 12

$A_1$: Ration 2

| Variables | Regression coefficients | t value | $R^2$ value | F value |
|---|---|---|---|---|
| $X_1$ | 2.306 (1.948) | 1.432 | | |
| $X_2$ | - 0.291 (3.293) | - 0.883 | 0.110 | 1.478 |
| $X_3$ | - 1.387 (2.948) | - 0.471 | | |
| Constant | 2.443 (1.065) | 2.296[x] | | |
| n = 40 | | | | |

$A_2$: Ration 3

| Variables | Regression coefficients | t value | $R^2$ value | F value |
|---|---|---|---|---|
| $X_1$ | 0.347 (0.386) | 0.898 | | |
| $X_2$ | - 1.746 (0.392) | - 4.451[x] | 0.373 | 7.126 |
| $X_3$ | 0.204 (0.169) | 1.209 | | |
| Constant | 3.197 (0.545) | 5.866[x] | | |
| n = 40 | | | | |

x - significant at 5% level.

$A_3$: Ration 4

| Variables | Regression coefficients | t value | $R^2$ value | F value |
|---|---|---|---|---|
| $X_1$ | - 4.441<br>( 9.756) | - 0.455 | | |
| $X_2$ | 3.717<br>(22.966) | 0.162 | 0.033 | 0.411 |
| $X_3$ | 0.228<br>(23.503) | 0.972 | | |
| Constant | - 0.271<br>( 7.245) | - 0.374 | | |
| n = 40 | | | | |

$A_4$: Ration 5

| Variables | Regression coefficients | t value | $R^2$ value | F value |
|---|---|---|---|---|
| $X_1$ | - 4.234<br>(54.013) | - 0.784 | | |
| $X_2$ | 1.455<br>(54.448) | 0.267 | 0.087 | 1.146 |
| $X_3$ | 2.440<br>( 2.034) | 1.200 | | |
| Constant | 1.280<br>(25.786) | 0.496 | | |
| n = 40 | | | | |

$A_5$: Ration 6

| Variables | Regression coefficients | t value | $R^2$ value | F value |
|---|---|---|---|---|
| $X_1$ | - 127.138 (2566.379) | - 0.496 | | |
| $X_2$ | - 2437.910 (4945.906) | - 0.493 | 0.035 | 0.436 |
| $X_3$ | 2565.703 (5359.374) | 0.479 | | |
| Constant | 139.323 (659.414) | 0.211 | | |
| n = 40 | | | | |

$A_6$: Ration 7

| Vriables | Regression coefficients | t value | $R^2$ value | F value |
|---|---|---|---|---|
| $X_1$ | - 31.206 (15.758) | - 1.980 | | |
| $X_2$ | 32.825 (15.757) | 2.083[x] | 0.157 | 2.235 |
| $X_3$ | - 1.344 (0.874) | - 1.537 | | |
| Constant | -21.684 (11.826) | - 1.834 | | |
| n = 40 | | | | |

x - significant at 5% level.

$A_7$: Ration 8

| Variables | Regression coefficients | t value | $R^2$ value | F value |
|---|---|---|---|---|
| $X_1$ | - 140.522 (218.326) | - 0.644 | | |
| $X_2$ | - 1.131 (0.600) | - 1.884 | 0.179 | 2.612 |
| $X_3$ | 140.553 (218.378) | 0.644 | | |
| Constant | - 25.605 (46.644) | 0.549 | | |
| n = 40 | | | | |

$A_8$: Ration

| Variables | Regression coefficients | t value | $R^2$ value | F value |
|---|---|---|---|---|
| $X_1$ | - 426.077 (2151.584) | - 0.198 | | |
| $X_2$ | - 29.105 (40.717) | - 0.715 | 0.036 | 0.453 |
| $X_3$ | 454.768 (2150.689) | 0.212 | | |
| Constant | 2.459 (49.180) | 0.500 | | |
| n = 40 | | | | |

$A_9$: Ration 10

| Variables | Regression coefficients | t value | $R^2$ value | F value |
|---|---|---|---|---|
| $X_1$ | - 33.620 (13.128) | - 2.561[x] | | |
| $X_2$ | 36.032 (58.378) | 0.617 | 0.182 | 2.669 |
| $X_3$ | - 1.921 (59.710) | - 0.322 | | |
| Constant | - 24.029 (30.492) | - 0.788 | | |
| n = 40 | | | | |

$A_{10}$: Ration 11

| Variables | Regression coefficients | t value | $R^2$ value | F value |
|---|---|---|---|---|
| $X_1$ | - 0.735 (16.023) | - 0.459 | | |
| $X_2$ | - 4.878 (15.480) | - 0.315 | 0.035 | 0.429 |
| $X_3$ | 4.085 (3.787) | 1.079 | | |
| Constant | 5.305 (8.062) | 0.658 | | |
| n = 40 | | | | |

x - significant at 5% level.

$A_{11}$: Ration 12

| Variables | Regression coefficients | t value | $R^2$ value | F value |
|---|---|---|---|---|
| $X_1$ | 0.770<br>(0.963) | 0.799 | | |
| $X_2$ | 840.839<br>(2268.911) | 0.374 | 0.052 | 0.661 |
| $X_3$ | - 849.205<br>(2268.510) | - 0.374 | | |
| Constant | - 510.882<br>(1370.755) | - 0.373 | | |
| n = 40 | | | | |

## APPENDIX B

### EQUATIONS USED TO SOLVE THE COBB-DOUGLAS FUNCTIONS[1]

$$PAX_1^{b1}X_2^{b2}X_3^{b3} - r_1X_1 - r_2X_2 - r_3X_3$$

$B_1$: For two variable equations, $X_1$, $X_2$;

$$X_1 = \left(\frac{b1}{r1}\right)^{\frac{1-b2}{1-b1-b2}}\left(\frac{b2}{r2}\right)^{\frac{b2}{1-b1-b2}}(AP)^{\frac{1}{1-b1-b2}}$$

$$X_2 = \left(\frac{b1}{r1}\right)^{\frac{b1}{1-b1-b2}}\left(\frac{b2}{r2}\right)^{\frac{1-b1}{1-b1-b2}}(AP)^{\frac{1}{1-b1-b2}}$$

$B_2$: For three variable equations, $X_1$, $X_2$, $X_3$;

$$X_1 = \left(\frac{b1}{r1}\right)^{\frac{1-b2-b3}{1-b1-b2-b3}}\left(\frac{b2}{r2}\right)^{\frac{b2}{1-b1-b2-b3}}\left(\frac{b3}{r3}\right)^{\frac{b3}{1-b1-b2-b3}}(AP)^{\frac{1}{1-b1-b2-b3}}$$

$$X_2 = \left(\frac{b1}{r1}\right)^{\frac{b1}{1-b1-b2-b3}}\left(\frac{b2}{r2}\right)^{\frac{1-b1-b3}{1-b1-b2-b3}}\left(\frac{b3}{r3}\right)^{\frac{b3}{1-b1-b2-b3}}(AP)^{\frac{1}{1-b1-b2-b3}}$$

$$X_3 = \left(\frac{b1}{r1}\right)^{\frac{b1}{1-b1-b2-b3}}\left(\frac{b2}{r2}\right)^{\frac{b2}{1-b1-b2-b3}}\left(\frac{b3}{r3}\right)^{\frac{1-b3}{1-b1-b2-b3}}(AP)^{\frac{1}{1-b1-b2-b3}}$$

Where $b_i$s are the transformation coefficients.

$r_i$s are the prices of the variable inputs.

A is a constant.

P is the price of the output.

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[1] Derived from Henderson, J.M. and Quandt, R.E. (1971), Microeconomic theory. A mathematical approach. Second edition. McGraw-Hill Company. p. 69.

APPENDIX C

FEED CONSUMPTION/BIRD/DAY IN KG.

| No. of cases | Rations | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1. | 114.88 | 115.92 | 111.90 | 111.98 | 112.05 | 109.23 |
| 2. | 128.20 | 120.83 | 113.54 | 116.29 | 119.20 | 114.95 |
| 3. | 143.71 | 145.45 | 135.11 | 134.67 | 136.11 | 127.76 |
| 4. | 143.71 | 146.57 | 146.51 | 133.78 | 134.50 | 144.16 |
| 5. | 136.61 | 146.88 | 142.71 | 136.90 | 147.73 | 139.12 |
| 6. | 139.13 | 144.94 | 142.24 | 135.27 | 143.34 | 129.22 |
| 7. | 116.19 | 133.12 | 125.00 | 129.35 | 132.31 | 132.14 |
| 8. | 117.31 | 113.35 | 119.88 | 120.88 | 131.12 | 105.26 |
| 9. | 137.88 | 137.00 | 134.16 | 137.58 | 145.75 | 136.11 |
| 10. | 125.31 | 134.09 | 142.70 | 127.64 | 138.95 | 130.16 |
| 11. | 119.49 | 111.90 | 118.23 | 116.89 | 111.01 | 109.08 |
| 12. | 134.97 | 116.37 | 118.75 | 118.82 | 119.79 | 113.10 |
| 13. | 147.02 | 145.03 | 142.63 | 149.07 | 137.89 | 132.30 |
| 14. | 144.05 | 142.16 | 144.20 | 139.29 | 131.52 | 136.02 |
| 15. | 151.64 | 147.36 | 148.81 | 150.16 | 163.04 | 141.46 |
| 16. | 151.04 | 151.14 | 150.30 | 138.74 | 147.67 | 146.43 |
| 17. | 145.03 | 124.15 | 136.31 | 140.92 | 138.20 | 122.36 |
| 18. | 125.62 | 108.84 | 127.31 | 127.02 | 133.54 | 127.25 |
| 19. | 144.72 | 131.46 | 134.52 | 137.11 | 131.52 | 107.92 |
| 20. | 149.22 | 128.40 | 133.93 | 138.82 | 136.64 | 131.06 |
| 21. | 112.43 | 116.67 | 116.27 | 116.37 | 117.49 | 116.74 |
| 22. | 125.74 | 122.92 | 125.74 | 125.74 | 124.77 | 128.79 |
| 23. | 145.54 | 139.73 | 147.43 | 135.42 | 154.81 | 133.71 |
| 24. | 141.82 | 141.67 | 144.43 | 130.86 | 134.08 | 142.55 |
| 25. | 143.45 | 147.72 | 157.79 | 152.16 | 161.72 | 161.02 |
| 26. | 144.57 | 144.72 | 158.28 | 156.40 | 168.63 | 153.57 |
| 27. | 140.31 | 133.84 | 148.30 | 146.90 | 152.64 | 153.90 |
| 28. | 134.52 | 125.00 | 131.97 | 124.22 | 133.85 | 131.74 |
| 29. | 144.55 | 144.93 | 151.70 | 133.12 | 157.61 | 153.06 |
| 30. | 148.80 | 138.35 | 150.17 | 134.29 | 139.28 | 140.00 |
| 31. | 118.68 | 128.88 | 121.35 | 112.50 | 117.81 | 119.42 |
| 32. | 118.36 | 126.56 | 133.56 | 116.22 | 127.53 | 125.52 |
| 33. | 145.09 | 147.47 | 135.71 | 147.83 | 158.83 | 142.56 |
| 34. | 140.18 | 158.93 | 154.50 | 135.79 | 132.76 | 136.01 |
| 35. | 145.98 | 157.38 | 155.12 | 151.30 | 164.60 | 156.25 |
| 36. | 148.81 | 167.78 | 157.22 | 151.09 | 159.47 | 151.64 |
| 37. | 129.46 | 143.88 | 146.85 | 145.24 | 158.07 | 131.40 |
| 38. | 122.90 | 131.34 | 137.34 | 130.89 | 136.49 | 123.06 |
| 39. | 164.29 | 161.28 | 148.64 | 148.75 | 147.84 | 133.93 |
| 40. | 143.17 | 165.87 | 159.21 | 161.79 | 141.16 | 133.18 |
| Average | 136.86 | 137.27 | 138.76 | 134.95 | 139.38 | 132.58 |

Appendix C cont.

| No. of cases | Rations | | | | | |
|---|---|---|---|---|---|---|
| | 7 | 8 | 9 | 10 | 11 | 12 |
| 1. | 103.50 | 109.30 | 103.42 | 106.10 | 108.93 | 105.58 |
| 2. | 110.80 | 108.11 | 112.50 | 108.63 | 111.90 | 108.71 |
| 3. | 135.20 | 134.38 | 133.93 | 137.30 | 135.49 | 126.34 |
| 4. | 151.78 | 130.28 | 139.28 | 147.32 | 125.97 | 131.99 |
| 5. | 144.47 | 134.39 | 138.99 | 139.14 | 141.74 | 134.08 |
| 6. | 149.11 | 138.43 | 137.35 | 145.78 | 161.68 | 141.07 |
| 7. | 126.13 | 115.16 | 130.03 | 125.32 | 132.47 | 123.40 |
| 8. | 114.10 | 117.37 | 113.24 | 123.05 | 108.44 | 113.49 |
| 9. | 113.46 | 129.62 | 135.07 | 133.25 | 133.98 | 129.80 |
| 10. | 130.45 | 125.73 | 134.42 | 125.45 | 124.80 | 130.57 |
| 11. | 103.12 | 104.02 | 103.89 | 107.29 | 111.61 | 105.13 |
| 12. | 107.14 | 113.54 | 103.20 | 118.60 | 111.61 | 104.39 |
| 13. | 131.99 | 124.47 | 128.18 | 136.16 | 131.89 | 121.06 |
| 14. | 138.62 | 134.17 | 135.06 | 135.25 | 131.99 | 157.84 |
| 15. | 145.91 | 145.21 | 140.58 | 138.04 | 137.77 | 130.95 |
| 16. | 152.86 | 135.56 | 144.90 | 139.60 | 127.94 | 146.94 |
| 17. | 139.62 | 139.47 | 131.12 | 140.89 | 124.74 | 137.18 |
| 18. | 114.12 | 135.27 | 120.41 | 120.24 | 114.28 | 110.31 |
| 19. | 133.19 | 142.02 | 143.11 | 151.25 | 144.64 | 127.47 |
| 20. | 134.55 | 135.08 | 127.64 | 133.57 | 133.57 | 110.96 |
| 21. | 114.81 | 113.10 | 112.05 | 110.19 | 106.47 | 106.55 |
| 22. | 119.04 | 118.08 | 118.82 | 117.40 | 113.30 | 112.43 |
| 23. | 113.71 | 134.88 | 144.19 | 145.50 | 138.90 | 137.20 |
| 24. | 138.39 | 133.38 | 140.75 | 142.08 | 138.17 | 118.30 |
| 25. | 147.77 | 158.60 | 150.97 | 158.41 | 150.73 | 148.29 |
| 26. | 142.78 | 149.84 | 172.45 | 160.80 | 157.63 | 162.58 |
| 27. | 145.80 | 135.54 | 148.04 | 161.00 | 126.70 | 140.22 |
| 28. | 131.07 | 128.93 | 127.68 | 128.83 | 119.64 | 109.78 |
| 29. | 161.90 | 148.30 | 145.54 | 123.81 | 142.01 | 139.75 |
| 30. | 129.96 | 140.09 | 137.32 | 121.09 | 135.03 | 123.60 |
| 31. | 115.85 | 115.48 | 108.78 | 107.96 | 108.11 | 110.86 |
| 32. | 123.14 | 120.68 | 108.43 | 119.18 | 113.69 | 110.86 |
| 33. | 149.40 | 140.33 | 132.04 | 139.98 | 141.07 | 134.63 |
| 34. | 138.76 | 121.20 | 130.95 | 136.41 | 131.75 | 145.96 |
| 35. | 147.03 | 150.74 | 144.05 | 152.80 | 153.65 | 147.98 |
| 36. | 141.14 | 136.90 | 137.05 | 135.25 | 147.83 | 149.59 |
| 37. | 128.65 | 120.81 | 121.13 | 127.92 | 124.53 | 123.62 |
| 38. | 118.16 | 120.13 | 119.60 | 110.03 | 120.37 | 112.50 |
| 39. | 138.04 | 139.77 | 138.51 | 130.87 | 135.71 | 132.63 |
| 40. | 129.35 | 132.50 | 134.42 | 123.04 | 114.83 | 132.32 |
| Average | 132.37 | 130.27 | 130.74 | 131.67 | 129.38 | 127.65 |

## APPENDIX E

### PRICE LIST USED IN THE WRITE UP OF THE STUDY

| Feedstuff | ₦/ton | ₦/Kg |
|---|---|---|
| Groundnut meal | 290.00 | 0.29 |
| Yellow maize | 310.00 | 0.31 |
| Wheat offal | 120.00 | 0.12 |
| Fish meal | 800.00 | 0.80 |
| Bone meal | 80.00 | 0.08 |
| Periwinkle shell | 200.00 | 0.20 |
| Common salt | 440.00 | 0.44 |
| Premix | 6000.00 | 6.00 |
| Chick mash in Samaru | 356.00 | 0.36 |
| Growers ration in Samaru | 312.00 | 0.31 |
| Day old chicks each at | | 0.85 |
| Spent birds each at | | 4.00 |
| Eggs of all grades per dozen | | 1.60 |

From 0 - 8 weeks, each chick consumes 1.9 to 2.1 Kg of chick mash.

From 9 - 20 weeks, each bird consumes 6.5 to 7.0 Kg of growers ration.

One man can manage 2,500 birds or layers putting in 7 to 8 man-hours daily[1]

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[1] Ogundipe, S.O. (1982), Towards More Meat and Eggs for Green Revolution. Poultry Production Standards for Nigeria. AERLS Newsletter, Vol. 8, No. 2. December, 1982. pp. 1 - 13.