

UTILIZATION OF WHOLE HATCHERY WASTE MEAL AS
ALTERNATIVE FEEDSTUFF IN BROILER DIETS

by

Nomvula Emily Radebe

Dissertation submitted in partial fulfillment of the requirements

for

the degree

MAGISTERIAL TECHNOLOGIAE

AGRICULTURE: ANIMAL PRODUCTION

in the

Faculty of Health and Environmental Science

School of Agriculture and Environmental Science

at the

Central University of Technology, Free State

Project supervisor: Prof. D.O. Umesiobi [Ph.D., MAHES (UoFS)]

Project Co-Supervisor: Prof C. vd. Westhuizen (Ph. D.,Pr.Sci.Nat)

June 2012

ACKNOWLEDGEMENT OF FINANCIAL SUPPORT

The Research Innovation Fund of the Central University of Technology, Free State, is greatly acknowledged for the financial support.

DEDICATION

This paper is dedicated to my husband, mother and sisters. The completion of this work was not possible without their support, courage and continuous help.

DECLARATION

I, Nomvula Emily Radebe, ID no 8305210522087, Student no: 205054439 declare that this dissertation titled: *Utilization of whole hatchery waste meal as alternative feedstuff in broiler diets*, submitted to Central University of Technology, Free State for the degree MAGISTER TECHNOLOGIAE: AGRICULTURE is my own independent work and that all sources used and quoted have been duly acknowledged by means of complete references; and complies with the Code of Academic Integrity, as well as other relevant policies, procedures, rules and regulations of the Central University of Technology; and has not been submitted before to any institution by myself or any other person in fulfillment (or partial fulfillment) of the requirements for the attainment of any qualification. I also disclaim this dissertation in the favour of the Central University of Technology, Free State.

Nomvula Radebe

Date

ACKNOWLEDGEMENTS

This study was conducted at ARC Poultry Section, Glen. Permission to use their facilities for this study is gratefully acknowledged.

I would like to express my deep thanks and appreciation to the following people for their valuable contributions to this project:

Dr. D.O. Umesiobi for his continuous support, guidance and encouragement

Mr. J. Nkoanyane for assisting me with the management of the birds, data collection and also for encouraging me to finish the study

Prof. S. Abiola for his valuable assistance and guidance

ARC employees, Dr. Lucky for allowing us to use ARC's facilities, **Mr. Moleko and Mr. Mfazwe** for their assistance and advices

My family and friends for their continuous interest and support

God Almighty, my Savior and Father - who gave me the strength to do the study and for completion of this study. To Him all the glory

List of Abbreviations

AFMA	Animal Feed Manufacturers Association
ANOVA	Analysis of Variance
ARC	Agricultural Research Council
CBH	Country Birds Holdings
⁰ C	Degrees Celsius
CP	Crude Protein
DoA	Department Of Agriculture
DPI	Daily Protein Intake
DUIE	Dried Un-hatched Incubator Eggs
EE	Ether Extract
EW	Eviscerated Weight
FCE	Feed Conversion Efficiency
FCR	Feed conversion Ratio
FFA	Free fatty Acids
FI	Feed Intake
FM	Fish Meal
GLPC	Glyricidia Leaf Protein Concentrate
Hb	Haemoglobin
HCT	Hematogrit
HGB	Hemoglobin
HWM	Hatchery Waste Meal
IFN	Internal Feed Identification Number
Kg	Kilogram
LM	Live Mass
MCH	Mean Corpuscular Hemoglobin
MCHC	Mean Corpuscular Hemoglobin Concentration
MCV	Mean Corpuscular Volume
ME	Metabolizable Energy
NPU	Net Protein Utilization
PCV	Packed Cell Volume
R	Rand
RBC	Red Blood Cells
SA	South Africa
SAPA	South African Poultry Association
SAS	Statistical Analysis System
SHBM	Shells Hatchery By-product Meal
TBA	Thiobarbituric Acid
UIE	Un-hatched Incubator Eggs
WBC	White Blood Cells
WG	Weight Gain
WHWM	Whole Hatchery Waste Meal

TABLE OF CONTENTS

Contents	page
Acknowledgement of Financial Support	ii.
Dedication	iii.
Declaration	iv.
Acknowledgements	v.
List of abbreviations	vi.
List of contents	vii.
List of tables	viii.
List of figures	ix.
Abstract	x.
Chapter 1: Orientation of the study	
1.1 General introduction	2
1.2 Problem statement	6
1.3 Project hypothesis	7
1.4 Project rationale	7
1.5 Objectives of the study	8
1.6 References	10
Chapter 2 Literature review	
2.1 Introduction	13
2.2 Future considerations for poultry nutrition	14
2.3 Chick management	15
2.4 Nutrition of poultry	18
2.5 Feeding program for broilers	21
2.6 Feed formulation	22
2.7 Water consumption rates for chickens	23
2.8 Hatchery waste recycling and the nutritive value of un-hatched incubator eggs	24
2.9 Processing of hatchery waste	25
2.10 Utilization of HWM in Broiler diets	27
2.11 Utilization of HWM in layer diets	31
2.12 Utilization of HWM in Cockerel diets	32

2.13 Replacement of fish meal with other protein sources	34
2.14 References	36
2.15 Published Article 1	39
2.16 Published Article 2	41
RESEARCH DESIGN AND METHODOLOGY	
Chapter 3: Effects of WHWM on the performance of broiler chickens	
3.1 Introduction	45
3.2 Effects of partial replacement of fish meal with WHWM on the performance of broiler chickens	47
3.3 Effects of partial replacement of fish meal with WHWM on feed intake	48
3.4 Effects of partial replacement of fish meal with WHWM on Weight gain	49
3.5 Effects of partial replacement of fish meal with WHWM on efficiency of feed conversion	50
3.6 Effects of partial replacement of fish meal with WHWM on protein intake	51
3.7 Materials and Methods	52
3.8 Results and discussion	59
3.9 Conclusion	61
3.10 References	62
Chapter 4: Effects of WHWM on Carcass characteristics of broiler chickens	
4.1 Introduction	65
4.2 Effects of partial replacement of fish meal with WHWM on carcass characteristics of broiler chickens	66
4.3 Effects of partial replacement of fish meal with WHWM on abdominal fat of broiler chickens	67
4.4 Effects of partial replacement of fish meal with WHWM on organ weights of broiler chickens	67
4.5 Materials and Methods	68
4.6 Results and discussion	70
4.7 Conclusion	73
4.8 References	74
Chapter 5: Effects of WHWM on Blood characteristics of broiler chickens	
5.1 Introduction	77
5.2 Effects of partial replacement of fish meal with WHWM on haematological	77

profile of broiler chickens	
5.3 Materials and Methods	78
5.4 Results and discussion	83
5.5 Conclusion	85
5.6 References	86
Chapter 6: Economic benefit of using WHWM in broiler diets	
6.1 Introduction	88
6.2 Economic benefit of using WHWM in broiler diets	88
6.3 Materials and methods	89
6.4 Results and discussion	93
6.5 Conclusion	94
6.6 References	95
Chapter 7: Effects of WHWM on meat characteristics of broiler chickens	
7.1 Introduction	97
7.2 Effects of WHWM on meat characteristics of broiler chickens	98
7.3 Materials and methods	98
7.4 Results and discussion	102
7.5 Conclusion	103
7.6 References	104
Chapter 8: General conclusion and recommendations	
8.1 Conclusion	106
8.2 Recommendations	107
Chapter 9: Overall references	108

List of Tables

Table 1	Typical daily water consumption for broilers (Liters per 1000 birds)	23
Table 2	Chemical composition (g/kg) of dried un-hatched incubator eggs	25
Table 3	Nutrient composition of FM and WHWM	53
Table 4	Composition of experimental diets	55
Table 5	Nutrient composition of experimental diets	56
Table 6	Effects of WHWM on the performance of broiler chickens	59
Table 7	Carcass characteristics of broilers fed diets in which WHWM replaced FM	71
Table 8	Nutrient composition of FM and WHWM	79
Table 9	Composition of experimental diets	80
Table 10	Nutrient composition of experimental diets	81
Table 11	Effects of WHWM on haematological profile of broiler chickens	84
Table 12	Composition of experimental diets	90
Table 13	Nutrient composition of experimental diets	91
Table 14	Nutrient composition of FM and WHWM	92
Table 15	Feed cost analysis of broilers fed diets in which WHWM replaced FM	93
Table 16	Nutrient composition of FM and WHWM	99
Table 17	Composition of experimental diets	100
Table 18	Effects of WHWM on meat characteristics of broiler chickens	102

List of Figures

Figure 1	Water provisioning in the broiler house	57
Figure 2	Weekly feed intake determination	58
Figure 3	Weighing of internal organs	70
Figure 4	Slaughtering of birds	83

Appendix

Appendix A	Data Analysis	113
-------------------	---------------	------------

UTILIZATION OF WHOLE HATCHERY WASTE MEAL AS ALTERNATIVE FEEDSTUFF IN BROILER DIETS

ABSTRACT

A 42-day feeding trial involving 180 day old broiler chicks was carried out at Glen Agric Institute ARC poultry section to study the effects of whole hatchery waste meal (WHWM) as an alternative in broiler diets. In this study whole hatchery waste meal (WHHW) replaced fish meal (FM), protein for protein, in broiler diets at 0, 10, 20, and 30% levels. One hundred and eighty broiler chickens were grouped, 45 birds per treatment which were further replicated 3 times (15 birds per replicate) in a completely randomized design. Feed and water supply were offered to birds ad libitum while standard management practices were meticulously adopted. Samples of the two test ingredients were sent to a lab for chemical analysis and the results indicated that FM had higher content of crude protein (73.18%) while that of WHWM was 42.26. The calcium phosphorus ratio was 16.6:1 for WHWM as against 1.5:1 in the FM. The results also indicated a higher content of Ash% and Ether extract for WHWM (18.12) and (23.94) respectively. The higher ash content could be due to the high content of eggshell at the time of processing. At the end of the feeding trial broiler performance, blood, carcass characteristics and the economic benefit of using WHWM in broiler diets were determined. Blood and meat samples were collected and sent to the pathology laboratory at the University of the Free State, Bloemfontein for hematological and meat characteristics analysis. Results for broiler performance

showed that broilers fed diet 2 had highest values for feed intake (118.25g/bird/day), weight gain (50.16g/bird/day) and daily protein intake (29.08g/bird/day) while those fed with diet 3 were superior in the efficiency of feed conversion (2.31). The highest value of abdominal fat 1.12% was observed in birds fed diet 2. The highest live mass was observed in birds fed diets containing no WHWM (2.83), while non significant difference were observed in live mass of birds fed diet 1, 3 and 4. Broilers fed control diet had highest mean values for eviscerated weight (2.20kg) and dressing percentage (77.86%). Blood samples were sent for analysis of White blood cells (WBC), Red blood cells (RBC) and Haemoglobin (HGB), Hematocrit (HCT), Mean corpuscular volume (MCV), Mean corpuscular haemoglobin (MCH) and Mean corpuscular haemoglobin concentration (MCHC). The results showed marginal variations in blood parameters. White blood cell counts were higher for birds fed control diet ($519.59 \times 10^3/l$) than those fed WHWM ($484.93 \times 10^3/l$). Non significant differences ($P \geq 0.05$) were observed on the HGB of all treatment groups including the control group. RBC counts of T1-T3 were not significantly different from each other but statistically significantly different from T4 (30% WHWM). The highest value of $2.67 \times 10^6/mm^3$ was observed in birds fed a higher level of WHWM. High RBC and HGB counts in the birds fed WHWM are an indicative of higher oxygen carrying capacity. The HCT and MCH results showed non-significant differences between T1, T3 and T4, except T2 which was significantly different from the other treatment groups. The MCV values for T1-T4 were 132.58, 126.47, 129.15 and 128.15 $10^{-15}L$ respectively. The highest and lowest

values were recorded on T1 and T2 respectively. The feed costs decreased with an increase in the level of WHWM in broiler diets. The lowest feed cost/kg weight gain of R8.69 recorded for broilers fed on diet three. This agrees with several studies which documented the use of hatching waste in poultry diet as means of reducing feed cost (Babiker et al 1991; Abiola, 1999; Abiola, 2000; Abiola and Onunkwor 2004). It can be concluded that 10% of FM can be replaced with WHWM in broiler diets without adverse effects on growth, hematological and carcass traits.

Key words: Broilers, WHWM, Fish Meal, General performance, carcass characteristics, hematological traits, economic values.

CHAPTER 1
INTRODUCTION

UTILIZATION OF WHOLE HATCHERY WASTE MEAL AS ALTERNATIVE FEEDSTUFF IN BROILER DIETS

CHAPTER 1

1. BACKGROUND AND OVERVIEW OF THE STUDY

1.1 GENERAL INTRODUCTION

The South African Poultry industry is the largest contributor to the Agricultural economy (Germishuis, 2006). Poultry industry especially broiler production is becoming big business in South Africa. The South African Poultry industry accounts for an estimated 16% of the total gross value of primary agriculture. Domestic demand for poultry meat is growing in the region on 7% per annum, which outstrips the performance of any other protein on the market (Esterhuizen, 2007).

The producer level turnover for the period (as recorded by the Department of Agriculture (DoA) was R 24.664 billion, made up of R 18.624 billion for poultry meat, R6.039 billion for eggs and R3.095 billion for the chick industry (included in the broiler and egg industries' gross values) and at a retail level the value was R63.893 billion (Statistics SA 2006). As producers, poultry are the largest segment in South Africa (in Rand terms) (Maree, 2008).

In a country with high unemployment rates, this industry is a very important supplier of relatively low cost protein to all sectors of the South African economy (Statistics SA, 2006). The poultry industry can still claim to feed the nation. More poultry products are being consumed annually than all other animal protein sources combined. It provides 57, 2% of animal protein consumed in South Africa (Murray, 2007).

The broiler industry is the biggest single consumer of feed stock in South Africa. Given the agricultural dominance of the poultry industry in South Africa, its influence on the closely-related feed industry is considerable. The industry is the main customer of the Animal Feed Manufacturers Association (AFMA), buying about 90% or more of their feed needs from AFMA members and consuming approximately 68% of their production.

This is responsible for approximately R11.2 billion of their industry's turnover. The industry is also the second biggest consumer of maize in South Africa. The poultry industry consumes about 20% of all maize being produced in the country (South African Poultry Association SAPA 2007)

Feed prices, as the major expenditure of poultry production, have been rising lately. This situation has increased production cost in poultry farms and is already reflected in the price of poultry products. Rising feed cost is a huge problem for the animal industries currently. Using alternative feed ingredients could be of help.

This strategy is, however, dependent on the accessibility of alternative ingredients in different parts of the world and also on regulatory limitations in animal commercial feed manufacturing. It may be needed to enhance availability of nutrients in these, in order to incorporate them in poultry diets. Feed supply is reported to be the greatest limiting factor in the improvement of animal production systems. Consequently the recycling of waste of animal origin as unconventional feed resources has long been common practice, particularly in developing countries. The high cost of imported feed ingredients, such as fish meal, methionine, lysine etc., has necessitated the use of unconventional feedstuff as replacement for conventional ones (Abiola and Onunkwor, 2004; Okereke *et al.*, 2008).

However, in most African countries, the principal constraint to commercial poultry development is usually related to feed resources and feeding aspects. Since feed cost accounts for about 60-80% of inputs of poultry production in many African countries, a number of research studies were conducted with the aim of finding a solution to the high feed costs in poultry production.

At present fish meal is the source of animal protein in practical broiler rations. The cost as well as the quality of this fish meal varies considerably throughout the year. This invites the attention of nutritionists to look for an appropriate alternative source like fish meal (either partially or completely).

Studies have been carried out on the potentials of alternative feed resources to replace dietary fish meal, due to its high cost. A high cost of fish meal derives largely from the competition between humans and livestock for fish and fish products (Agbede and Aleto, 2003).

Dietary fishmeal was substituted with hatchery waste meal (Abiola and Onunkwor, 2004), in poultry diets without adverse effects on performance.

According to Hodges (2010) intensive animal production has created new problems for society. These include ground water and air pollution, disposal of manure, animal health and welfare, zoonoses and greenhouse gas emission. Das *et al* (2002) indicated that continues growth of the poultry industry is accompanied by a need to manage large quantities of by-products such as hatchery waste. Hatchery waste contains non fertile eggs, dead chicks and broken egg shells. Although rendering plants currently use a portion of hatchery waste, large amounts are sent to landfills, which cost the poultry industry millions of rands each year. As a potential alternative to land filling, composting was investigated as a method to convert the nutrient rich waste into a stable product for beneficial use. However little has been reported on the utilization of Whole Hatchery Waste Meal (WHWM) as a feedstuff in broiler diets.

The concentration of the poultry industry has resulted in the production of large volumes of by-products including manure, farm mortalities, and hatchery and processing plant waste that require daily attention.

However, the poultry industry has responded well in objectively evaluating economically sound management principles in dealing with by-products utilization as opposed to disposal (Norton, 2000).

In South Africa, little information is available on the utilization of the locally available WHWM in broiler diets. The un-hatched incubator eggs are usually disposed off by most hatchery industries in South Africa as landfill. The option of landfill disposal of un-hatched incubator eggs is of environmental concern because of production of ammonia and carbon dioxide and the threat to controlled waters from leachate production.

1.2 PROBLEM STATEMENT

Since feed cost accounts for about 60-80% of inputs in poultry production in many African countries, a number of research studies were conducted with the aim of finding a solution to high feed costs to enhance poultry production. Studies have been carried out on the potential of alternative feed resources to replace dietary fish meal, due to its high cost.

A high cost of fish meal derives largely from the competition between man and livestock for fish and fish products (Agbede and Aletor, 2003). However, in South Africa little information is available on the utilization of the locally available WHWM in broiler diets. The un-hatched incubator eggs are usually disposed off by most hatchery industries in South Africa as landfill waste. The option of landfill disposal of un-hatched

incubator eggs is of environmental concern because of production of ammonia and carbon dioxide and the threat to controlled waters from leachate production. The real challenge for the poultry industry is to turn all the waste into economically valuable outputs using low-cost treatment systems. The huge volume of waste generated by the industry needs to be treated using bioprocesses to produce feed, fertilizer and fuels. These processes need to be applied to the organic waste streams (e.g. poultry manure, hatchery waste) and turn the cost of waste disposal into a source of income, recycle nutrients and reduce pollution (Glatz, *et al* 2011)

1.3 PROJECT HYPOTHESIS

Utilization of WHWM as partial replacement of fish meal will have no adverse effect on the performance, carcass characteristics and blood characteristics of broiler chickens. Utilization of WHWM in broiler diets will lower the feed and hatchery waste disposal costs in the production of broilers.

1.4 PROJECT RATIONALE

Poultry farmers can benefit greatly economically from utilizing WHWM as partial or complete replacement of dietary fish meal in broiler diets. Consequently, WHWM will provide alternative animal protein source and supplemental minerals such as calcium and phosphorus from egg shells. This approach will encourage waste management in poultry production.

Utilization of WHWM in poultry nutrition will assist the hatchery industry in the disposal problem usually associated with hatching wastes.

It can also be a solution to high feed prices resulting from the high cost of protein sources such as, fish meal. Utilization of WHWM in South Africa can also lead to more business opportunities for hatcheries to sell hatchery waste instead of disposing it off as land fill.

The utilization of WHWM as a feedstuff for poultry will economically be feasible to combat scarcity of animal protein sources as well as environmental pollution. The study was therefore conducted to achieve the objectives listed below.

1.5 OBJECTIVES OF THE STUDY

1. To determine the effect of partial replacement of fish meal with WHWM on the performance (e.g. feed intake, weight gain, efficiency of feed conversion, protein intake) of broiler chickens.
2. To determine the effect of partial replacement of fish meal with WHWM on the carcass characteristics (e. g. dressing percentage, abdominal fat, organ weights) of broiler chickens.
3. To determine the effect of partial replacement of fish meal with WHWM on blood characteristics (e.g. PCV, Hb, RBC and WBC) of broiler chickens.

4. To determine the effect of partial replacement of fish meal with WHWM on meat characteristics of broiler chickens
5. To determine the economic benefit of using WHWM in broiler diets.

REFERENCES

- Abiola, S.S. and Onunkwor, E.K., 2004. *Replacement value of hatchery waste meal for fish meal in layer diets*. Bioresource Technology 95: 103 – 106.
- Agbede, J.O. and Aletor, V.A., 2003. *Evaluation of fish meal replaced with leaf protein concentrate from glyricidia in diets for broiler – chicks: Effect on performance, muscle growth, haematology and serum metabolites*. Int. Jour. Poultry Science. 2 (4): 242 – 250.
- Das, K.C, Minkara, M.Y, Melear, N.D, and Tollner, E.W. 2002. *Effect of Poultry Litter Amendment on Hatchery Waste Composting*. J.Appl. Poult. Res.11, 282 – 290
- Esterhuizen., 2007. *Poultry and products*. USDA Foreign Agricultural Service: USA Embassy, Pretoria; South Africa
- Germishuis, 2006. South Africa, *Poultry and products*. GAIN Report, SF6033, US Embassy, Pretoria 11pp.
- Hodges. J. 2010. *Searching for sustainable intensive livestock production: Pig Progress*. Volume 26. No.6.
- Murray., 2007. *State of the poultry industry*. SAPA Industry profile

Norton, R., 2000. *Current concepts in broiler production*. Poultry Science . Auburn University.

Okereke, C.O., Ukachukwu, S.N and Umesiobi D.O. 2008. Effect of dietary inclusion of composite cassava (*Manihot esculanta*) meal on egg production characteristics of laying hens. Journal of Applied Animal Research 33: 69-72.

Glatz, Miao and Rodda. 2011. *Handling and treatment of poultry hatchery waste*. SARDI Livestock Systems; Sustainability 3, 216-237: Australia.

Statistics SA, 2006. *Labour force survey*, Statistics South Africa, Private Bag x 44, Pretoria 0001.

South African Poultry Association (SAPA). 2007. The South African Poultry Industry Profile for 2007.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Feed is the largest input in the poultry production system. The expenditure incurred on management practices is difficult to cut down. The cost of chicks is also variable and not in the hand of the poultry producers. However, feed costs can be manipulated to a great extent without affecting quality of feed and efficiency of feed utilization to render the poultry production system a viable and profitable enterprise. The typical feed formulations for different categories of poultry are quite variable in their composition depending on the availability of ingredients. The high cost and scarcity of raw materials in many occasions has been the setback of the poultry industry. Moreover, poultry birds directly compete with human beings for feed resources. Use of alternative low cost feed ingredients has been, therefore, the remedy for such crisis. Therefore there is a need that poultry producers should have a comprehensive knowledge of different feed ingredients that are used in poultry feeds. The producers need knowledge of the following

- Their nutritional merits and demerits including nutrient supply, palatability, ant-nutritional factors, bulkiness, etc.;

- Alternate feed ingredients to be selected in scarcity of conventional ingredients, their safe or effective level of inclusion in poultry feeds and compatibility with other feed ingredients that are mixed in diets.
- Moreover, the ingredients and substances that provide nutrients are classified mainly into four groups; energy feeds, Protein supplements, mineral supplements and vitamin supplements (Mandal, *et al*, 2004).

2.2 FUTURE CONSIDERATIONS FOR POULTRY NUTRITION

The future emphasis in poultry nutrition must be the development of life-cycle feeding programs for various classes of birds, rather than consideration of individual diets in isolation. Unfortunately, there is still a dearth of research information that views recommendations within the context of an overall program. With the sophistication we have today in our production systems; birds seldom fully recover from inappropriate nutrient intake at any time in their production cycle.

Because feed still represents 60-70% of the cost of production of most poultry products, there is a continual need to evaluate new or different sources of ingredients and to continually re-examine the more common ingredients. A yearly review of the published research data indicates that ingredient evaluation occupies the major portion of practical poultry nutrition research, and feed manufacturers should be aware of the potential of such new ingredients. Often so-called new ingredients are not new in the

sense of being novel to poultry feeding *per se*, rather they have not been as seriously considered in a particular geographical location (Leeson & Summers 2005)

2.3 CHICK MANAGEMENT

2.3.1 Housing

The brooding room should be heated prior to arrival of the chicks. A newly hatched chick requires supplemental heat to maintain its body temperature; therefore, an external heat source must be provided to young birds in the first few weeks. Heat lamps with infra-red bulbs are usually positioned in the centre of a brooder ring, which is used to confine chicks in a small area close to feed and water while allowing them to select an environment at their own thermal comfort level.

2.3.1.1 Brooder Rings

Brooder rings usually consist of a 30 to 45 cm wide (12 to 18 in higher sides for turkeys) strip of corrugated cardboard which has been cut to an appropriate length in order to form a ring 2.4 to 3.6 m in diameter. It is set up in the pen where the chicks are placed, and is removed once they are five to 10 days old. Size is adjusted for the number of birds to be contained, but the key is to allow room for the birds to move around so they can select their optimum temperature.

2.3.2 Temperature Control

Temperature control is important to chicks, particularly in the first three weeks of life. Brooder rings should provide adequate space for the chicks to select a comfortable temperature. If the chicks are too cold, they will become chilled and uncomfortable, and will not eat or drink. If the chicks are too hot, they will become dehydrated. Starting temperature requirements for all poultry species are similar. Initial brooding temperature, at the birds' level, should be 35 degrees Celcius ($^{\circ}\text{C}$), and reduced by approximately 3 $^{\circ}\text{C}$ per week until 21 $^{\circ}\text{C}$ is reached. If the whole room is heated and there are no heat lamps, the initial brooding temperatures should be slightly lower (30 to 33 $^{\circ}\text{C}$). After six weeks of age, temperatures between 18 and 21 $^{\circ}\text{C}$ are desirable. These brooding temperature guidelines should be adjusted according to observations of the birds. The behavior and sounds of the chicks will indicate their comfort level. Comfortable birds will be evenly spaced around the pen and will make soft "cheeping" noises. Cold birds will huddle in the warmest part of the pen and cheep loudly. If the birds are too hot, they will generally be positioned against the walls away from the heat source, and will be panting or possibly sitting with their wings outstretched and feathers fluffed out. The chicks will do a better job than a thermometer of telling you about their comfort level.

2.3.3 Floor Covering

The pens where the chicks are to be raised should be thoroughly cleaned and disinfected at least one week prior to chick placement. Any equipment to be used should also be cleaned and disinfected.

Fresh, mold-free bedding (litter) should be spread over the whole floor area, including the brooder ring. The bedding will provide insulation from the floor and will soak up moisture from the bird droppings. It will also help to prevent damage to the birds' legs due to slipping on slippery surfaces.

Types of material which can be used for bedding include straw and wood shavings. The depth of the litter should be seven to 10 cm.

During the rearing period, bedding should be removed and replaced routinely in areas which become wet. This is often necessary next to the drinkers and helps to prevent ammonia build-up in the air.

2.3.4 Ventilation

Birds require an abundance of fresh air with low contaminants such as dust and ammonia. During the first few days of brooding, little ventilation is required; however, proper ventilation is very important as the chicks are growing. In commercial barns, fans and inlets are manipulated to provide uniform air distribution. Fans draw air out of the barn and inlets let fresh air in, thereby removing dust and ammonia. Humidity can be reduced and excess heat eliminated if necessary. Drafts should be avoided with young birds.

2.3.5 Water

During the first week of brooding, deaths due to dehydration can be reduced by providing additional water sources in the brooder ring. Several shallow trays, such as

ice cube trays, can be placed throughout the ring. It is also helpful to dip the chicks' beaks into the water when initially placing them into the brooder ring.

Fresh water should be available at all times, and the water containers should be cleaned routinely. As with the feeders, the height of the water source should be regularly adjusted to be even with the back of the birds.

2.4 NUTRITION OF POULTRY

2.4.1 Feed

During the first week of brooding, in addition to the feeding troughs, small amounts of feed should be provided in shallow trays (such as box lids or egg flats) which the chicks can easily access. This helps the chicks find the feed more successfully in the first few days. It is also beneficial to place the feed and water close together during this time to ensure the chicks eat and drink. Adequate feeder space is necessary to prevent crowding at feeders and to promote uniform growth. After initial brooding, feed should be placed away from the waterers to prevent wet feed and dirty water. Feed can be provided continuously or mildly restricted. Feed should not be restricted during the first week of brooding (Brian, 2006). It is also important to know that nutrient requirements are different for each poultry classification.

2.4.2 Nutrient requirements of broilers

Feed is a major component of the total cost of broiler production. To support optimum performance, broiler rations should be formulated to give the correct balance of energy, protein and amino acids, minerals, vitamins and essential fatty acids.

Energy

Broilers require energy for growth of tissue, maintenance and activity. Carbohydrates such as corn and wheat and various fats or oils are the major sources of energy in poultry feeds (Ross broiler management manual, 2009).

Protein

Feed proteins, such as those in cereals and soybean meal, are complex compounds which are broken down by digestion into amino acids. These amino acids are absorbed and assembled into body proteins which are used in the construction of body tissue, e.g. muscles, nerves, skin and feathers (Ross broiler management manual, 2009).

Macro minerals

The provision of the correct levels of the major minerals in the appropriate balance is important for high performing broilers. The macro minerals involved are calcium, phosphorus, sodium, potassium and chloride (Ross broiler management manual, 2009).

Calcium and phosphorus

Calcium in the diet of broilers influences growth, feed efficiency, bone development, leg health, nerve function and the immune system. It is vital that calcium is supplied in adequate quantities on a consistent basis. Phosphorus, like calcium, is required in the correct form and quantity to optimise skeletal structure and growth.

Sodium, Potassium and Chloride

These minerals are needed for all metabolic functions. Shortages can affect feed intake, growth and blood pH. Excess levels of these minerals result in increased water intake and subsequent poor litter quality (Ross broiler management manual, 2009).

Trace minerals and vitamins

Trace minerals and vitamins are needed for all metabolic functions. Appropriate vitamins and trace mineral supplementation depends on the feed ingredients used, the feed manufacture and on local circumstances. Due to differences in vitamin levels of various cereals, the level of supplementation of some vitamins must be modified. Accordingly, separate recommendations are usually proposed for some vitamins, depending on the cereals upon which the diets are based

Enzymes

Enzymes are now being routinely used in poultry feeds to improve digestibility of feed ingredients. In general, feed enzymes are available that act on carbohydrates, proteins and plant-bound minerals (Ross broiler management manual, 2009).

2.5 FEEDING PROGRAM FOR BROILERS

2.5.1 Starter feeds

The objective of the brooding period (0-10 days of age) is to establish good appetite and maximum early growth in order to meet the seven-day body weight objective. It is recommended that a broiler starter feed be fed for ten days. The starter represents a small proportion of the total feed cost and decisions on starter formulation should be based primarily on performance and profitability rather than purely on diet cost. The benefit of maximising nutrient intake on early broiler growth and subsequent performance is well established. Feeding broilers the recommended nutrient density will ensure optimal growth is established during the critical period of life.

2.5.2 Grower feeds

Broiler grower feed is generally fed for 14-16 days following the starter. Starter to grower transition will involve a change of texture from crumbs/ mini-pellets to pellets. Depending on the pellet size produced, it may be necessary to feed the first delivery of grower as crumbs or mini-pellets. During this time broiler growth continues to be

dynamic. It therefore needs to be supported by adequate nutrient intake. For optimum feed intake, growth and FCR, provision of the correct diet nutrient density, especially energy and amino acids, is critical.

2.5.3 Finisher feeds

Broiler finisher feeds account for the major volume and cost of feeding a broiler. It is therefore important that feeds are designed to maximise financial return for the type of products being produced. Finisher feeds should be given from 25 days until processing. Birds slaughtered later than 42-43 days may need a second finisher feed and specification from 42 days onwards. The use of either one or more broiler finisher feeds will depend on:

- Desired slaughter weight
- Length of the production period
- Design of the feeding program (Broiler management manual, 2009).

2.6 Feed formulation

Poultry diets are commonly formulated by computer programs which match ingredient composition with diet specifications to achieve the lowest-cost feed. Diets are composed of grains, protein supplements, byproducts, minerals and vitamin supplements. Fats may be added to increase energy and reduce dustiness. The most

frequently used grains are corn, grain sorghum, wheat, oats, and barley. Soybean meal, meat meal, fish meal, feather meal and canola meal are typical protein supplements.

2.7 Water consumption rates for chickens

Water is an essential nutrient for life. Providing adequate, good quality water is critical for top broiler performance. Water consumption can be limited if the water is too hot or cold and is contaminated with excess minerals. Water and food consumption rates are interdependent and so reduced water intake can lead to reduced food intake. Typical daily water consumption for broilers is presented in Table 1.

Table 1: Typical daily water consumption for broilers (liters per 1000 birds)

Age	20 °C	32 °C
1 week	24	40
3 weeks	100	190
6 weeks	240	500
9 weeks	300	600

Water is an essential ingredient for life. Any reductions in water intake or increased water loss can have a significant effect on the lifetime performance of the chick. Water supplied to broilers should not contain excessive amounts of minerals. Water should not be contaminated with bacteria. Although water supplied as fit for human

consumption will also be suitable for broilers, water from bore holes, open water reservoirs or poor quality public supplies can cause problems. The water supply should be tested to check the level of calcium salts (water hardness), salinity and nitrates. After house cleaning and prior to chick delivery, water should be sampled for bacterial contamination at the source, the storage tank and the drinker points (Ross broiler management manual, 2009).

2.8 HATCHERY WASTE RECYCLING AND THE NUTRITIVE VALUE OF UN-HATCHED INCUBATOR EGGS

Animal protein sources are known to be superior to those of plant origin because of their higher biological value. The potentials of industrial waste of animal origin such as hatchery by-products in poultry diets have been documented (Abiola 2000). A number of studies revealed that hatchery waste meal can be utilized as a feedstuff in poultry diets because of its high nutritional value. The proximate composition and nutritive value of unhatched incubator eggs were evaluated by Abiola (1999). The chemical composition of sun-dried un-hatched incubator eggs (UIE) is presented in the Table 4.

Table 2: Chemical composition (g/kg) of dried un-hatched incubator eggs

Parameters	Composition (g/kg)
Crude protein	560
Crude fibre	18.5
Ether Extract	180.5
NFE	240
Calcium	10.4
Phosphorus	0.1
ME (kcal/g)	3.95

Source: Abiola and Onunkwor (2004)

Sohail Hassan Khan *et al* (2002) cooked raw hatchery waste with water at a 2:1 ratio for 15 minutes and then oven dried at 65 °C. HWM prepared contained 32% crude protein, 16% ether extract, 0.9% crude fibre, 40% total ash, 11.1% nitrogen free extract, 20% calcium and 0.6% available phosphorus with no *Escherichia coli* and *Salmonella*. In biological evaluation trial, non-significant differences were observed.

2.9 PROCESSING OF HATCHERY WASTE

Rasool *et al.* (1999) toasted HW without any addition of water. The toasting of waste was carried out in an open vessel without subjected to any kind of pressure at 100 °C with regular stirring. The resultant meal by the dehydration process revealed that it contained crude protein 44.25%, ether extract 30.01%, crude fibre 1.90%, ash 14.04%,

nitrogen free extract 9.80%, 4572 kcal/kg gross energy and 3600 kcal/kg metabolizable energy. HW processed in this manner may be a good source of energy, protein and has a considerable amount of fat.

Hatchery waste was amended with sawdust and yard trimmings and in one treatment with poultry litter (broiler) to determine the feasibility of composting hatchery waste. Hatchery waste co-composted with poultry litter maintained higher temperatures during the experiment resulting in higher dry matter and volatile solids and greater losses of nitrogen by the end of the composting process. The composted product containing poultry litter had higher levels of plant nutrients such as P, K, and many of the other micro nutrients than the product without poultry litter. Both treatments were effective in eliminating 99.99% of *Escherichia coli*; however, more *Salmonella* reduction was observed in the treatment containing poultry litter than the treatment without poultry litter (Das *et al.*, 2002)

All previous mentioned results of processing techniques clearly indicated that the application of appropriate processing technique not only destroys the pathogens but also enhances the keeping quality as well as palatability of waste material. Properly processed hatchery wastes have no undesirable effects on birds' health because processing techniques not only minimize the harmful pathogens but also improve the nutritional quality of waste material. Biological evaluation of processed Hatchery Waste Meal (HWM) is determined by their protein and energy qualities. Protein quality is

perhaps the most important single factor, demanding serious consideration while formulating poultry ration (Khalique & Rasool, 1998).

2.10 UTILIZATION OF HWM IN BROILER DIETS

The nutritional rich hatchery by-product meal can be incorporated in poultry and pigs diets because it has greater potential as feed for animals. Shahriar *et al* (2008) investigated the effects of different levels of Hatchery wastes (HW) in broiler chickens diets. Birds were fed HW in diets at levels of 0, 2, 4, 6 and 8%. The HW were controlled after processing (drying and eliminating the microbial load). Weight gain and feed intake were measured weekly in each replication. Results of the data showed the use of wastes until the level of 4%, non significant difference in weight gain, feed intake and Feed Conversion Ratio (FCR) between groups (in various period).

Average carcass combination included were significant in breast weight % ($P<0.05$) and abdominal fat ($P<0.01$) in between groups and organoleptic quality of the grille breast meat was significant both in males and females ($P<0.05$). The glucose value of the serum was significant in 5 and 8 weeks ($P<0.05$). Results showed the use of HW up to the 4% level (after necessary processing) in broiler diets.

Broiler chicks were fed diets incorporating hatchery waste for 42 days. Hatchery waste was a substitute for fish meal. The diets were D1 (8%FM+0%HW), D2 (4%FM+4%HW), and D3 (0%FM+8%HW). Performance and meat yield were studied. The growth rate, feed conversion, performance index, meat yield and profitability increased with the inclusion of dietary HW in increased amounts. Feed consumption showed no significant difference due to the replacement of fish meal (FM) by HW. It was further suggested that 8% HW be used in the diets to completely replace Fish

meal to help in the formulation of a well balanced and economical diet to achieve maximum growth and meat yield (Rahman *et al*, 2003).

Saima *et al* (2001) cooked raw hatchery waste with water under pressure; dried and chemically analyzed it. Broiler chicks were fed diets containing 0, 2, 4, and 6 % cooked hatchery waste meal (HWM), adlibitum to determine its effectiveness and acceptability as a nutrient source from hatch to 6 week of age. Diets were formulated to be isocaloric and equivalent in as many nutrients as possible. The addition of cooked HWM at 4% level had no effect on body weight compared with control diet. Feed intake was found to be similar at all levels of HWM but it was found to be significantly less in control diet in starter phase. Contrasting results were obtained with feed efficiency with control birds being most efficient in starter phase but generally similar to birds fed 2% and 4% cooked HWM. Processed HWM was acceptable and highly utilizable as a protein source and nutrient substitute in the diets of the commercial broiler.

A study focused on hatchery waste as a protein source based on its nutritional value was conducted. The major theme of the experiment was subjection of HWM to different processing techniques to establish its most appropriate level for usage in broiler ration in commercial poultry production sector. Hatchery waste was subjected to processing techniques like cooking, toasting, and formalin treatment. The dried raw and processed hatchery waste meals were micro-biologically analyzed. The chemical composition of raw and processed HWM showed non-significant differences in various proximate

fractions because the samples for each processing technique were collected on the similar day. Similarly the amino acid and profile showed non-significant differences.

Microbial analysis of raw hatchery waste revealed that total viable counts in raw material were significantly ($P < 0.05$) higher (2.6×10^{14} per gram of material) which were brought to a safe level by processing techniques. The total viable counts in cooked and toasted hatchery waste meals were significantly less as compared to formalin treated meals. Free fatty acids (FFA) for cooked and toasted HWM's were 7.293 and 6.732 respectively while thiobarbituric acid (TBA) values for cooked and toasted meals were 4.782 and 4.823 mg/kg meal on first day of storage. The FFA contents and TBA values of cooked and toasted HWMs with 0.5 and 1.0% BHT showed significant differences ($P < 0.01$) after every 10 day interval during storage period of 40 days. Maximum FFA (11.50) was noted in toasted HWM with 0.5 % antioxidant, while minimum (9.21) were noted in cooked HWM with 1.0 % antioxidant (9.21).

There were non-significant differences in FFA up to 30 days. TBA values were highest (10.29 mg) in toasted HWM with 0.5% antioxidant while lowest value (6.77 mg) for TBA was recorded in cooked HWM with 1 % antioxidant. In 3rd phase, protein quality and gross energy contents of cooked and toasted HWMs were determined. There were significant differences ($P < 0.01$) in weight gain, net protein utilization (NPU) and PER of standard diet, cooked and toasted meals. Maximum weight gain was observed in standard diet (82 grams). Net protein utilization was also significantly higher ($P < 0.05$) in this group (48g). Non significant differences were observed in NPU of cooked and toasted HWM. Maximum feed consumption (227.75 gm) was recorded in birds fed on toasted HWM while lowest feed consumption (189.0 gm) was noted in birds reared on protein free diet. Maximum protein intake was noted in birds consuming toasted HWM (52.34 gm).

The PER was also found to be higher (1.60) in group fed standard diet. But cooked and toasted hatchery waste meals differed non-significantly in PER. Gross energy contents analyzed in cooked hatchery waste meal were 4462.72 kcal/kg of dried material whereas toasted meal was found to contain 4477.11 kcal/kg gross energy. In phase 4, the effect of control diets and diets containing 2, 4 and 6% levels of either cooked or toasted HWM on the broiler performance was observed. Significant ($P < 0.01$) differences were recorded in weight gain and FCR of birds fed on various experimental diets during starter phase. Feed consumption was significantly ($P < 0.05$) low in birds fed on control diet while the differences among the diets containing various levels of cooked- and toasted HWM were non-significant. Maximum weight gain was observed in birds fed on diets with 4 % toasted HWM (917.32 g).

While maximum value for FCR was recorded for control group in starter phase (1.41). The results showed non-significant differences in weight gain of birds and significant differences ($P < 0.01$) in feed consumption and FCR. Birds fed on control diet gained minimum weight (3076.21gms). Maximum weight gain was recorded in birds consuming diets with 6 % cooked HWM (3224.02 gm). Birds fed on control diet showed best value for FCR (2.01) while birds consuming diet containing 6% cooked HWM showed the worst value. Maximum liver weight per 100g body weight was recorded in birds kept on diets having 6% cooked HWM (Saima, 2001)

Hatchery waste including infertile eggs, dead embryos in shell, dead or low grade chicks was cooked at 100 degrees C for 15 minutes and the oven dried and ground. HWM thus prepared contained 44.25% protein, gross energy 4573 kcal/kg, ME 3600 kcal/kg, 30% ether extract, 1.9% fibre, 14% ash, 9.8% nitrogen-free extract, 7.26% Ca, 0.84% P, 1.86% lysine and 0.66% methionine with no salmonella and *Escherichia coli* in a trial, significantly higher weight gain was observed with the diet containing 12% HWM compared to that containing a similar amount of fish meal. Protein efficiency ratio for the two diets was 3.96 vs. 2.85; protein digestibility, 86.02 vs 71.9%; net protein

utilization, 64.9 vs. 42.37% and biological value 75.37 vs. 58.84%, respectively, indicating a better balance of amino acids in HWM than fish meal. A performance trial on broiler chickens also revealed better weight gain and feed efficiency on the diet containing 12% HWM than that containing a similar level of fish meal (Rasool *et al*, 1999)

2.11 UTILIZATION OF HWM IN LAYER DIETS

Abiola and Onunkwor (2004) replaced fish meal with hatchery waste meal (protein for protein) in layer diets at 0%, 33%, 66% and 100% levels. Both feed and protein intake were superior on HWM diets. The highest hen-day production of 73.97% was obtained on diet 2 in which 33% of fish meal was replaced with HWM. Egg weight and egg length were also superior on HWM diets. All birds fed on HWM diets had thicker egg shells (0.33 mm) than those fed on the control diet (0.32 mm). Results obtained for yolk weight were significantly different ($P < 0.05$). Highest values for yolk weight (16.91g) and albumen weight (40.93g) were recorded for birds fed with diet 4 in which 100% fish meal was replaced with HWM. HWM can replace fish meal completely in layer diets without adverse effect on egg quality characteristics

Dried and powdered egg shells as waste from hatchery was fed as a source of calcium to white Leghorn laying birds of 52 weeks of age. Four test diets were prepared by replacing calcium sources with limestone and oyster shell waste in T1 to T4 diets and di-calcium phosphate at 50 and 100% level respectively in T3 and T4 diets. The equivalent amount of phosphorus content of di-calcium phosphate was supplied

through potassium dehydrogen phosphate. The egg production, egg weight, egg mass, feed intake, feed conversion ratio, external and internal qualities of eggs were studied during the experimental period of 63 days. HESW contains 1.2% crude protein and 34% calcium. Results showed that egg production increased significantly ($P < 0.05$) in the T2 & T3 groups. FCR and egg weight was comparable among different dietary treatments. Egg shell thickness differ significantly due to Ca and P sources instead of limestone or oyster shell could maintain the egg production and egg quality traits in laying birds (Toppo, *et al*, 2003)

2.12 UTILIZATION OF HWM IN COCKEREL DIETS

Abiola (2000) investigated the effect of feeding HWM diets on haematological indices and serum metabolites of cockerels. Haematological values were generally higher in birds fed HWM diets than those fed control diet. PCV and Hb concentrations which tended to decrease with an increase in the level of HWM in the diets gave the values that ranged between 23.50 – 27.50% for PCV and 7.85g/100ml – 9.20g/100ml for Hb. Lowest WBC count of 5.40 ($\times 10^3/\text{mm}^3$) was recorded for birds fed control diet. Cholesterol concentration appeared to increase with increase in level of HWM in the diets. Highest values of 144.50mg/100ml cholesterol were recorded on 15% HWM diet. Dietary treatments had significant effects ($P < 0.05$) on total protein, Creatinine and urea concentrations. There were no abnormal blood characteristics in the birds fed

HWM diets. Cockerels will tolerate 15% HWM diet in the starter phase without adverse effect on performance.

Un-hatched incubator eggs (UIE) is a potential protein supplement in poultry diets as replaced for expensive protein sources such as soybean. The feeding trial revealed that bird fed dried un-hatched incubator eggs (DUIE) diets were superior in body weight gain and feed intake than those fed soybean diet. Results of feed conversion ratio were statistically significant ($P < 0.05$). Best ratio of 2.92 was recorded on the diet containing 5% (DUIE). Efficiency of protein utilization was also superior on the diets containing DUIE where the best ratio of 1.68 was recorded on 10% replacement level. DUIE can be incorporated into starter diets of cockerels without adverse effect on performance.

It was also indicated that this will minimize the disposal problem of hatchery waste and provide another protein source for the poultry industry (Abiola, 1999).

Abiola (2001) substituted groundnut cake for hatchery waste meal in the finisher diets of cockerels. Cockerels were fed four experimental diets in which groundnut cake (GNC) was replaced with hatchery waste meal (HWM) at 0, 10, 15 and 20% levels. Dietary treatments had significant effects ($P < 0.05$) on growth rate of cockerels and increased with rise in the level of HWM in the diet. Daily weigh gain was highest on 20% HWM diet with a value of 22.10g/bird/day. The high energy content of HWM diets depressed feed intake, improved feed utilization and increased abdominal fat

deposition. Weight of gizzards, lungs and heart did not show any particular trend. Cholesterol concentration was higher on HWM diets than control diet. The highest value of 131.67mg/100ml cholesterol level was obtained on 15% HWM diet. Both creatinine and urea concentrations decreased with increase in the level of HWM in the diets. The concluded that up to 20% HWM is recommended in the finisher diet of cockerels. This will assist in solving the disposal problem of hatchery waste and provide new animal protein source for feed industry.

2.13 REPLACEMENT OF FISH MEAL WITH OTHER PROTEIN SOURCES

Many attempts were made to replace fish meal with other protein resources with the view to reducing feed costs. Attempt to overcome this is to include relatively inexpensive feed ingredients. For example fish meal was replaced with maggot in broiler diets and there was no significant effect on the performance of broilers (Awoniyi *et al*, 2003). Agbede & Aletor (2003) indicated that fish meal protein in the diet of broiler could be replaced by 25% Glyricidia leaf protein concentrate (GLPC) without adverse effect on performance, carcass characteristics, and muscle development or haematological variables in broiler chicks.

The effect of supplementation of palm kernel oil in periwinkle flesh and palm kernel cake-based diets on carcass characteristics and meat quality of broilers was evaluated. Birds were assigned to five dietary treatments in a completely randomized design. Carcass measures and cuts were significantly influenced ($P < 0.05$) by dietary

treatments. Diets 2, 3 and 5 gave significantly higher plucked dressed weights, total edible meat and total bone weights, respectively. Also carcass cuts were significantly increased ($P < 0.05$) in birds on periwinkle and palm kernel oil diets, with abdominal fat being highest in diet 5 having 40mg kg⁻¹palm kernel oil. However, proximate composition, physical and sensory properties were not significantly ($P > 0.05$) influenced by dietary treatment. Results showed that carcass characteristics improved as compared to the control group (Okon & Ayuk, 2003).

Research studies discussed above clearly indicates that fish meal can be replaced with whole hatchery waste meal without any effect on the hematological profile, carcass characteristics and general performance of broilers chicks. Most studies also revealed that hatchery waste meal when properly treated and processed, it is an important source of protein and it can therefore replace fish meal to some extent.

REFERENCES

- Abiola, S.S., 1999. *Yield of unhatched incubator eggs and its replacement value in soybean meal diets fed to cockerels*. Trop Jour. Anim. Sci. 1 (2): 79 – 85.
- Abiola, S.S. and Onunkwor, E.K., 2004. *Replacement value of hatchery waste meal for fish meal in layer diets*. Bioresource Technology 95: 103 – 106.
- Abiola, S.S., 2000. *Haematological indices and serum metabolites of cockerels fed hatchery waste meal diets*. Trop.Vet. 18, 79 – 84.
- Abiola, S.S., 2001. *Substitution of groundnut cake for hatchery waste meal in the finisher diets of cockerels*. J. Pure and Appl. Sci. Vol 4 (1), 48-53
- Agbede, J.O. and Aletor, V.A., 2003. *Evaluation of fish meal replaced with leaf protein concentrate from glyricidia in diets for broiler – chicks: Effect on performance, muscle growth, haematology and serum metabolites*. Int. Jour. Poultry Science. 2 (4): 242 – 250.
- Awoniyi, T.A.M., Aletor, V.A. and Aina, J.M., 2003. *Performance of broiler – chickens fed on maggot meal in place of fish meal*. Inter. Jour. Poultry Science. 2 (4): 271 – 274.
- Brian, D. 2006. *Environmental factors to control when brooding chicks*. Fairchild, Extension Poultry Scientist. The University of Georgia

- Das, K.C, Minkara, M.Y, Melear, N. D., and Tollner, E.W. 2002. *Effect of Poultry Litter Amendment on Hatchery Waste Composting*. J.Appl. Poult. Res.11, 282 - 290
- Khalique. A. and Rasool. S. 1998. Competitive biological evaluation of some animal & vegetable protein feed stuffs through chicks and rat assay: Pakistan J. Livest. and Poult. 4 (2) Leeson, S. & Summers, J. D. 2005. *Commercial poultry nutrition*. 3rd edition: Nottingham University Press. England.
- Mandal, A. B., Yadav. A.S., Johri.T.S., and Pathak. N.N. 2004. *Nutrition and disease management of poultry*: International Book Distributing Co. India.
- Okon, B.I. and Ayuk, A.A., 2003.*Carcass characteristics and meat quality of broilers fed periwinkle flesh, palm kernel cake and oil – based rations*. Dept Animal Science, Faculty of Animal Science. University of Calabar: Nigeria.
- Rahman,M., Akter, M., and Howlider,M.A.R.2003. *Replacement of fish meal by hatchery waste in broiler diets*. Bangladesh Veterinarian, Vol 20.No 1.29-35
- Rasool, S.; Rehan, M.; Haq, A.; Alam, M.Z. 1999. *Preparation and nutritional evaluation of hatchery waste meal for broilers*. Asian Australasian Journal of Animal Sciences. Thailand, Vol 4. p. 554-557.
- Ross, Broiler Management Manual. 2009. *Chick management, provision of feed and water*. p 11- 38.

- Saima, 2001. *Feeding value of processed hatchery wastes as a source of protein in broiler rations*. Phd Thesis. University of Agriculture. Faisalabad.
- Shahriar, H.A., Nazer-Adl. K., Doolgarisharaf. J. and Monirifar. H., 2008. *Effects of dietary different levels of Hatchery Waste in broiler*. Journal of Animal and veterinary Advances. Vol 7 No1. p100-105.
- Sohail Hassan Khan., and Bashir Mahmood Bhatti. 2002. *Effects of feeding cooked hatchery waste on the performance of broilers*. Pakistan Veterinary Journal: Vol 22 No1. P 27-30
- Toppo, S., Shrivastava. H. P., DeoC.,NarayanR.,MajumdarS. 2003. *Feeding of hatchery egg sell waste as a calcium source to laying chickens*. Indian Journal of Poultry Science. Volume 38, No2.

Whole hatchery waste meal as alternative protein and calcium sources in broiler diets

SS Abiola¹, NE Radebe², C van der Westhuizen³ & DO Umesiobi³

¹Department of animal Production and Health, University of Agriculture, Abeokuta, Ogun State, Nigeria. ² Glen College of Agriculture, Glen, South Africa. ³ School of Agriculture and Environmental Science, Central University of Technology, Free State, Bloemfontein, South Africa. Corresponding author: abiolass@yahoo.com

A Study was conducted in which processed whole hatchery waste meal (WHWM) replaced fish meal (FM), protein for protein, in broiler diets at 0, 10, 20 and 30% levels. There were 45 birds per treatment and 15 birds per replicate. The feeding trial which lasted for 42 days was carried out at the poultry unit, Agricultural Research Council, Glen, South Africa. Chemical analysis of the two test ingredients indicated that WHWM had higher contents of ash (18, 12%) and ether extract (23, 94%). However, crude protein content of FM was 73, 18% while that of WHWM was 42, 26%. Calcium-phosphorus ratio was 16.6:1 for WHWM as against 1.5:1 in the FM. Broilers fed with diet 2 had highest values for feed intake(118.25g/bird/day) and weight gain(50.16g/bird/day) while those fed with diet 3 were superior in efficiency of feed utilization(2.31). Results obtained for carcass traits decreased with increase in the levels of WHWM in the diets. Broilers fed with control diet had highest mean values for eviscerated weight (2.20kg) and dressing percentage (77.86%). Values recorded for

abdominal fat and internal organs (liver, lungs, heart and gizzard) did not show any particular trend. Similarly there were slight variations in the results obtained for blood parameters. Cost of feed intake/bird decreased with increase in the levels of WHWM in the diets. It can be concluded from the results of this study that 10% of FM can be replaced with WHWM in broiler diets without adverse effects on growth and carcass traits. This approach of turning waste into a valuable product will provide alternative protein and calcium sources in broiler diets and solve the problem of hatching waste disposal in the hatchery industry.

Published Proceedings of the 44th Congress of the South African Society of Animal Science. 11-14 July 2011, University of Stellenbosch, Western Cape: South Africa. p. 61.

Partial replacement of fish meal with whole hatchery waste meal and their effects on the performance and carcass characteristics of broiler.

NE Radebe, DO Umesiobi, SS Abiola School of Agriculture and Environmental Sciences, Central University of Technology, Free State, Private Bag X20539, Bloemfontein 9300, South Africa.

Background

Performance and carcass characteristics of broilers may be improved with the partial replacement of fish meal (FM) with whole hatchery waste meal (WHWM) in broiler diets.

Objective

To determine whether 0, 10, 20 or 30% replacement of FM with WHWM in broiler diet may improve the general performance and carcass characteristics of broilers.

Design

A total of 180 day-old broilers were recruited and redistributed into four treatment groups consisting of 45 birds per treatment. In this study, processed WHWM replaced FM, protein for protein in broiler diets at 0, 10, 20 or 30% replacement levels. The experimental protocols lasted for 6 weeks and data were subjected to analysis of variance in a randomized complete block design to compare the effects of the four

treatment diets on feed intake, weight gain, efficiency of feed utilization, carcass weight, dressing percentage abdominal fat and internal organ.

Outcomes

Proximate analyses of the two test ingredients showed that WHWM had higher ash content and ether extract than FM. However, crude protein content of FM was higher than those of WHWM. Calcium-phosphorus ratio was 16:6.1 for WHWM in comparison with 1.5:1 in the FM. Broiler fed 10% WHWM diet had highest significant values ($P < 0.05$) in feed intake and weight gain, carcass weight, dressing percentage, internal organs (liver, lungs, heart and gizzard) and blood parameters. While as, feed conversion efficiency and abdominal fat were highest ($P < 0.05$) at 30% WHWM replacement level compared to other treatment groups. Cost of feed consumption/bird decreased significantly ($P < 0.01$) with increase in the levels of WHWM replacement in the diets.

Conclusion

Replacing fish meal with whole hatchery waste meal in broiler diet appears to be most beneficial in improving general performance and carcass traits of broilers.

Source of Funding

Supported by Research Innovation Fund of the Central University of Technology, Free State, South Africa.

*Published Proceedings of the Nutrition Society of Australia, 29 November–02
December 2011. pp. 84.*

CHAPTER 3

EFFECTS OF WHWM ON THE PERFORMANCE OF BROILER CHICKENS

CHAPTER 3: EFFECTS OF WHWM ON THE PERFORMANCE OF BROILER

CHICKENS

3.1 INTRODUCTION

The improvement of poultry production highly depends on synergy between science and practice. By use of modern technology, genetics, microbiology, informatics and nutrition knowledge, production of fattening chicken highly increased in the whole world in last 30 years with significant changes on quantity of food needed for 1kg of weight gain and necessary time for achieving desired body mass. Poultry feeding is, by biology and ecology means, very important factor in poultry production. The heart of the matter of feeding is to satisfy vital and productive needs of an animal by giving all nutritive and biology worth substances and putting them in organism. Determination of the required amount of energy and protein in feedstuff is probably the most important decision to be made when it comes to feed formulation for broiler breeders. Energy itself comprises 70% of the total cost of feed. The right relation between nutrients in fodder mixture requests good knowledge of needed concentrations of energy and proteins, amino acids, minerals and vitamins. In chicken production, it is very important to evaluate the ratio between raw protein level and metabolic energy level in fodder mixtures. Today's trend is to reduce protein and energy in feedstuff and on the other side to maintain an appropriate level of amino acids in order to optimize the

performance. When it comes to a rational use of protein from feed it is good to know that animal organisms do not use protein but amino acids.

In South Africa, about 17.7 million broilers are slaughtered each week. Including imports, spent hens and breeders, the per capita consumption of slaughtered poultry in the country is roughly 30kg, which is substantial growth since the 21.7 kg of 1997 (SAPA 2010). Continuous growth of the poultry industry is accompanied by a need to manage large quantities of by-products such as hatchery wastes. Hatchery wastes contain non fertile eggs, dead chicks, and broken egg shells. Although rendering plants currently use a portion of hatchery waste, large amounts are sent to landfills, which cost the poultry industry millions of rands each year. As a potential alternative to land-filling, composting was investigated as a method to convert the nutrient rich waste into a stable product for beneficial use.

However in South Africa there is dearth of information on the utilization of WHWM as a feedstuff in broiler diets. Hence, this study was aimed at evaluating the effects of WHWM on broiler performance (Feed intake, weight gain, feed conversion efficiency and protein intake).

3.2 EFFECTS OF PARTIAL REPLACEMENT OF FISH MEAL WITH WHWM ON THE PERFORMANCE OF BROILER CHICKENS

There are several measures that can be used to evaluate broiler performance – growth rate, days to market, mortality and feed efficiency. Feed is typically the most costly expense in broiler production. As a result feed efficiency is typically the primary tool by which a flock is evaluated. Today we have many factors affecting both growth rate and feed intake, because we have moved from standardized growing programs to one tailored to meet specific local goals and economic conditions. Feed efficiency of broilers is affected by bird age, sex, health and environmental temperature. Above mentioned factors also have an influence on the overall performance of broilers (Leeson, 2000).

Rahman, *et al* (2003) fed broiler chicks on 3 isonitrogenous and isoenergetic diets incorporating hatchery waste (HW) as a substitute to fish meal (FM). The diets were; D₁ (8% FM + 0%HW), D₂ (4%FM+4%HW), and D₃ (0% FM+8%HW). The performance and meat yield characteristics were studied. Performance index, growth rate, feed conversion, meat yield and profitability increased with the inclusion of dietary hatchery waste in increased amounts. It was suggested that 8% HW be used in the diet to completely replace FM to help in the formulation of a well balanced and economical diet to achieve maximum growth and meat yield.

In biological evaluation trial, non significant differences were observed among rations in which HWM replaced the fish meal at 0(A), 25(B), 50(C) and 75(D) levels in broiler rations. In 6 weeks performance trial, the body weight gains were 1807.69, 1916.39, 1788.39 and 1635.66 gm in A, B, C and D rations, respectively. This shows no significant difference among all rations (Sohail, *et al.*2002).

Abiola, *et al* (2009) investigated the replacement of fish meal with whole and shells hatchery by-product meal on performance and carcass characteristics of broilers. Values obtained for all performance indices (body weight gain, feed intake, feed conversion ratio, protein intake and protein efficiency ratio) for bird fed shells hatchery by-product meal (SHBM) diet were comparable to those fed with the control, suggesting that SHBM can replace fish meal completely in broiler ration.

3.3 EFFECTS OF PARTIAL REPLACEMENT OF FISH MEAL WITH WHWM ON FEED INTAKE

Feed intake is the single most important factor regulating performance of agricultural animals. Feed intake controls the rate of output of all animal products and is the common denominator of efficiency, regardless if the output is meat, eggs, or reproduction. While numerous factors influence feed intake, growers control their own destiny when it comes to on-farm management practices. Access to feed and water must be provided at all times. Feeder and drinker must be adjusted and maintained at the proper level during the entire flock. Temperature, humidity, ventilation, and

ammonia must be kept within acceptable ranges; otherwise feed intake and flock performance will suffer (Tabler, 2008).

Rahman (2003) in his study the replacement of fish meal by hatchery waste in broiler diets, where the performance and meat yield characteristics were studied, he reported that feed consumption showed no significant difference due to replacement of fish meal by hatchery waste. The effects of dietary different levels of hatchery wastes in broiler diets were investigated. Weight gain and feed intake were measured weekly. The results of the data showed the use of waste until the level of 4%, non significant difference in weight gain, feed intake and feed conversion ratio between groups.

3.4 EFFECTS OF PARTIAL REPLACEMENT OF FISH MEAL WITH WHWM ON WEIGHT GAIN

Energy and protein are two main nutrients that can affect all production parameters in broiler chickens (Collin *et al.*, 2003; Kamran *et al.*, 2008). These nutrients are the major factors that influence the cost of chicken ration. Lowering percentage of dietary protein may decrease the charge of ration. Increasing dietary ME significantly increased the body weight gain (Zaman *et al.*, 2008). In a study conducted by (Steiner *et al.*, 2008) to evaluate the effect of crude protein level and low energy supply on broiler production parameters, a better weight and mass gain were achieved in the groups fed the feed with a higher content of crude protein and energy.

When processed whole hatchery by-product meal (WHBM) and shells hatchery by-product meal (SHBM) replaced fish meal protein for protein in broiler diet, Values obtained for performance indices (weight gain, feed intake, feed conversion ratio, protein intake and protein efficiency ratio) for birds fed with control and SHBM diets were comparable with one another. Birds fed with control diet had highest dressing yield of 75.50% while lowest value of 67.71% was obtained on WHBM diet. Results obtained for the thigh and wings were comparable for all dietary treatments. WHBM and SHBM can replace fish meal in broiler diets without adverse effects on performance and carcass characteristics (Abiola, *et al* 2009).

3.5 EFFECTS OF PARTIAL REPLACEMENT OF FISH MEAL WITH WHWM ON EFFICIENCY OF FEED CONVERSION

By definition, feed conversion ratio (FCR) is a composite trait affected by starting body weight, feed intake on test, and growth rate while being tested. Genetic selection can be used to improve feed efficiency in a limited number of ways. First, feed intake can be reduced. Second, more body weight could be gained on the same amount of feed. The third alternative is the combination of the two. It is generally agreed that reducing feed intake may have negative consequences on other traits including growth (Skinner, *et al*.2003).

In a study conducted by (Shariar, *et al* 2008) where hatchery waste was included in broiler chickens diets, results showed in feed conversion ratio (FCR) significant

difference between experimental and control groups during 2-3 weeks ($p>0.05$) and 6-8 weeks ($p<0.01$) and no effect ($p>0.05$) in 3-6 week period of hatchery waste were found.

Sohail, 2002 evaluated the effect of feeding cooked hatchery waste on the performance of broilers. Non significant differences were observed among rations in which HWM replaced the fish meal at 0(A), 25(B), 50(C) and 75(D) levels in broiler rations. These rations showed that feed conversion ratio values were 2.59, 2.32, 2.43 and 2.63 in the corresponding groups, which shows no significant difference among all rations.

3.6 EFFECTS OF PARTIAL REPLACEMENT OF FISH MEAL WITH WHWM ON PROTEIN INTAKE

The search for alternative protein sources of feed ingredients as a partial or complete substitute to fish meal, a conventional costly ingredient in poultry rations has been long and tortuous. Demand for feed grade fish and fish meal significantly exceeds availability. Also due to the hazards of pathogenic salmonella contamination of late, most poultry feeds, especially breeder rations are being formulated without supplementation of fish ingredients (Ojewola, *et al.* 2005).

in a study conducted to compare the effects of diets with various energy constant ME:CP ratio on performance nutrients efficiency and carcass characteristics of broiler

chickens, it was concluded that the higher concentration of energy and protein in diets especially $>3000 \text{ kcal ME kg}^{-1}$ may improve the performance parameters and carcass characteristic of broiler diets with $<3000 \text{ kcal ME kg}^{-1}$ has produced lower growth performance parameters (Hosseini-Vashan *et al* 2010).

Saima (2001) in his study focused on hatchery waste as a protein source based on its nutritional value, he determined the protein intake of cooked and toasted HW meals. The data on feed intake and protein intake of birds fed experimental diets revealed non-significant difference. The protein efficiency ratios of hatchery waste meal were less than that of standard diet.

3.7 MATERIALS AND METHODS

3.7.1 Collection and processing of Whole Hatchery Waste Meal

The Un-hatched incubator eggs (hatching waste) used for this experiment were collected from the Hatchery unit, Agricultural Research Council, Glen Agricultural Institute. The wastes were boiled in water for 20 minutes and then allowed to cool down for 2 to 3 hours. The boiled samples were broken into pieces and oven dried at 70°C for one hour. The dried waste was milled using milling machine in order to produce Whole Hatchery Waste Meal (WHWM).

3.7. 2 Nutrient composition of Whole Hatchery Waste Meal and Fish Meal

Samples of whole hatchery waste meal and fish meal were sent to the University of the Free State for analysis; the two were compared and composition is presented in Table 3

Table 3: Nutrient composition of FM and WHWM

Nutrients	FM	WHWM
Moisture (%)	8.17	4.85
Ash (%)	12.73	18.12
Ether extract (%)	10.70	23.94
Crude protein (%)	73.18	42.26
Gross Energy	23.20	20.24
Calcium (%)	3.14	10.97
Phosphorus (%)	2.09	0.66
Ca:P	1.5:1	16.6:1

Values are means of two determinations

3.7.3 Preparation of experimental diets

Feed ingredients required to formulate a complete broiler diet were purchased. Feed was prepared manually by mixing all the ingredients on a clean cement floor using spades. Four broiler diets were prepared in which WHWM replaced fish meal (protein for protein) at 0, 10, 20 and 30% levels. The composition of the four experimental diets is presented in Table 4 and the nutrient composition of experimental diets in Table 5.

Table 4: Composition of experimental diets

Replacement levels of WHWM				
Ingredients	0%	10%	20%	30%
Maize	53.00	53.00	53.00	53.00
Soybean meal	28.40	28.40	28.40	28.40
Fish meal	4.00	3.60	3.20	2.80
WHWM	0.00	0.70	1.40	2.10
Wheat Bran	10.00	9.70	9.40	9.10
Limestone	1.20	1.20	1.20	1.20
Mono-calcium phosphate	1.50	1.50	1.50	1.50
Oyster shell	1.00	1.00	1.00	1.00
Premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20
Lysine	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00

Table 5: Nutrient composition of experimental diets

Nutrients	Diets			
	1	2	3	4
Moisture (%)	5.93	5.81	5.20	5.15
Ash (%)	5.96	7.04	6.92	6.40
Ether extract (%)	2.28	2.22	2.58	3.06
Crude protein (%)	25.23	24.59	25.16	25.09
Gross energy	18.29	17.82	18.12	18.14
Ca (g/100g)	1.35	1.46	1.68	1.53
Ph (g/100g)	0.47	0.43	0.47	0.45
Ca: Ph	2.9:1	3.4:1	3.6:1	3.4:1

3.7.4 Management of the birds

A total of 180 day-old broiler chicks purchased from Country Birds Holding (CBH) Ltd, Botshabelo road, Bloemfontein were used for the study. There were four treatments with 45 birds per treatment and 15 birds per replicate. Feed and water were provided *ad libitum* for 42 days. Necessary vaccinations and medications were carried out as at when due.



Figure 1: Water provisioning in the broiler house

3.7.5 Experimental site

The study was carried out on a deep litter system in the poultry unit, Agricultural Research Council, Glen Agric Institute.

3.7.6 Data collection

Data were collected on growth (feed intake, weight gain, feed conversion, and daily protein intake). Initial body weight of the birds was taken and recorded on the first day of the experiment. Growth response was determined on a weekly until the last day of the experiment. Final body weight, Feed intake, feed conversion efficiency and protein intake of the experimental birds were determined on the last day of the experiment.



Figure 2: Weekly feed intake determination

3.7.7 Laboratory analysis

Chemical analysis of experimental diets, FM and WHWM were determined in the Department of Animal Science, University of the Free State and University of Pretoria Nutrilab.

3.7.8 Statistical analysis

Data obtained were subjected to analysis of variance (ANOVA) in a Complete Randomized Design (SAS, 1999). Differences between the treatment means were separated following the procedures of McDonald (2008).

3.8 RESULTS AND DISCUSSION

Table 6: Effects of WHWM on the performance of broiler chickens

Parameters	0%	10%	20%	30%
Feed intake (g/bird/day)	113.78 ^a ± 4.94	118.25 ^b ± 4.50	108.17 ^{ab} ± 15.11	103.97 ^c ± 0.96
Weight gain (g/bird/day)	48.18 ^a ± 3.37	50.16 ^b ± 3.95	46.67 ^c ± 3.83	41.27 ^d ± 3.34
Feed conversion	2.36 ^a ± 0.12	2.37 ^a ± 0.18	2.31 ^a ± 0.17	2.53 ^b ± 0.20
Daily protein intake (g/bird/day)	28.70 ^a ± 1.25	29.08 ^b ± 1.10	27.22 ^{ab} ± 3.80	26.80 ^c ± 0.24

^{abcd} Means within row with different superscript differ significantly at (P < 0.05)

Feed intake, weight gain, Feed conversion efficiency and Daily protein intake for treatment 1 to treatment 4 are shown in table 8. Feed intake of birds fed control diets and diets containing 10, 20 and 30 % level of WHWM were 113.78, 118.25, 108.17 and 103.97g/bird/day respectively (Table 8). Maximum feed intake was recorded in birds fed 10% WHWM (118.25). Minimum feed intake was observed in birds fed WHWM at 30% level (103.97). Birds fed WHWM at 10% level are significantly heavier than the control group, 20% and 30% levels of WHWM inclusion. Feed conversion results show higher conversion efficiency at 30% level of WHWM inclusions. Non significant differences ($P > 0.05$) on FCE of T1, T2 & T3. Values of (2.36, 2.37 & 2.31) were obtained, respectively. Non significant difference was observed on the Daily protein intake of birds fed WHWM at 0% and 20% levels. The highest value of (29.08) Daily protein intake was obtained at 10% level of WHWM inclusion. The lowest value of (26.80) DPI was observed at 30% level of WHWM inclusion.

The results observed indicate high FI, WG & DPI at 10% level of WHWM inclusion. Feed conversion efficiency is high at 30% level of WHWM. The maximum replacement of fish meal with WHWM (30% level) result in low FI, WG & DPI, but increases Feed conversion efficiency. The results suggest low weight gain because of low feed intake at 30% level of WHWM inclusion.

3.9 CONCLUSION

In conclusion, this study demonstrated that hatchery wastes had no adverse effects on broiler performance. The performance of broiler chickens was higher when Whole Hatchery waste meal replaced fish meal at 10% level. High feed intake, weight gain and daily protein intake were obtained at 10% level. Feed conversion results show higher conversion efficiency at 30% level of WHWM inclusions. Therefore WHWM can replace fish meal at 10% levels without adverse effects on performance. The results of this study were in agreement with the results of Shahriar *et al* (2008), they also observed no significant difference in weight gain in broilers fed different levels of hatchery wastes. Since the replacement of fish meal with WHWM did not hamper broiler performance in terms of feed intake, weight gain, Feed conversion efficiency and daily protein intake, its utilization in poultry diets could be encouraged. This approach will not only provide alternative feedstuff (protein and calcium sources) in broiler diets but it will also reduce competition between man and animals for fish and feed ingredients with a consequent reduction in the market price of fish.

REFERENCES

- Abiola, S. S., Adelaja, A. A., Akanmu, A. M., Sogunle, O. M. and Egbeyale, L. T. 2009. Replacement of Fish Meal with Whole and Shelles Hatchery By-Product Meal on Performance and Carcass Characteristics of Broilers. Proceedings of Annual Conference of ASAN 2009.
- Collin. A., Malheiro, R.D., Moraes, V.M.B, Pieter Van As, P., Darras, V.M., Taouis, M, Eddy Decuyper, E. and Buyse, J.. 2003. *Effects of dietary macronutrient content on energy metabolism and uncoupling protein mRNA expression in broiler chickens*. Br. J. Nutr., 90: 261-269.
- Hosseini-Vashan. A.R., Golian. A., Motaghinia. Gh. Namvari.M., and Hamed. M. 2010. *Comparison of growth performance and carcass characteristics of broiler chickens fed diets with various energy and constant energy to protein ratio*. Journal of Animal and Veterinary Advances. Vol 9. (20). P 2565 - 2570
- Kamran. Z., Sarwar. M., Nisa. M., Nadeem. M. A., Mahmood. S., Babar. M.E., and Ahmed. S. 2008. *Effects of low-protein diets having constant energy –to- protein ratio on performance and carcass characteristics of broiler chickens from one to thirty five days of age*. Poult. Sci., 87: 468 - 474
- Leeson, S. 2000. *Poultry: Is feed efficiency still a useful measure of broiler performance?* Department of Animal and Poultry Science/ University of Guelph.

- McDonald, J.H.; *Handbook of Biological Statistics*; Baltimore, Maryland: Sparky House.Publishing; pages 1-28; 2008.
- Ojewola, G.S. Okoye, F.C & Ukoha, O.A. 2005. *Comparative utilization of three animal protein sources by broiler chickens*. International Journal of Poultry Science 4 (7): 462-467.
- Rahman, M., Akter, M., & Howlider,M.A.R.2003. *Replacement of fish meal by hatchery waste in broiler diets*. Bangladesh Veterinarian, Vol 20.No 1.29-35
- Saima, 2001. *Feeding value of processed hatchery wastes as a source of protein in broiler rations*. Phd Thesis. University of Agriculture. Faisalabad.
- South African Poultry Association (SAPA). 2010.The South African Poultry Industry Profile for 2010
- Shahriar, H.A., Nazer-Adl. K., Doolgarisharaf. J. and Monirifar. H., 2008. *Effects of dietary different levels of Hatchery Waste in broiler*. Journal of Animal and veterinary Advances. Vol 7 No1. p100-105.
- Skinner-Noble, D.O. and Teeter, R.G. 2003. Components of Feed Efficiency in Broiler Breeding Stock: Energetics, Performance, Carcass Composition, Metabolism, and Body Temperature

Sohail Hassan Khan., and Bashir Mahmood Bhatti. 2002. *Effects of feeding cooked hatchery waste on the performance of broilers*. Pakistan Veterinary Journal: Vol 22 No1. P 27-30

Tabler, G.T. 2008. *Early feed intake and bird performance*. Center of Excellence for Poultry Science-Avian Advice (Vol. 5, No. 1), University of Arkansas.

Zaman. Q.U. Mushtaq. T., Nawaz. H., Mirza. M.A. and Mahmood. S. 2008. *Effects of varying dietary and protein on broiler performance in hot climate*. Anim Feed Sci. Technol., 146: 302 -312.

CHAPTER 4

EFFECTS OF WHWM ON CARCASS CHARACTERISTICS OF BROILER CHICKENS.

CHAPTER 4: EFFECTS OF WHWM ON CARCASS

CHARACTERISTICS OF BROILER CHICKENS.

4.1 INTRODUCTION

Poultry is the most consumed meat per capita in the United States, and is one of the most consumed meats in the world. In 2002, chicken consumption has increased significantly from the early 1990's. One of the main reasons poultry meat consumption has increased in the last decade is the nutritional value of the meat. The fat in poultry meat is located in the skin and is therefore easily removable compared to other meats, enabling consumers to adopt a more low-fat type of meat in their diets. Along with this low-fat aspect, the fat in poultry meat is lower in saturated fatty acids and higher in unsaturated fatty acids. This fat deposition can vary among species and is diet dependent. Therefore, poultry meat can easily be incorporated into a well balanced diet to improve health (Alvarado, *et al.* 2004).

Kamran *et al* (2008) indicated that carcass yield, breast meat yield, thigh yield, liver and heart and abdominal fat were not influenced by concentration of dietary energy and protein. The abdominal fat and liver weights and protein and fat contents of the carcass were significantly increased by increasing dietary ME (Zaman 2008). According to Hosseini-Vashan *et al* (2010) the gender also affect breast, thigh and heart weight of broiler chickens fed diets with different nutrients density.

4.2 EFFECT OF PARTIAL REPLACEMENT OF FISH MEAL WITH WHWM ON CARCASS CHARACTERISTICS OF BROILER CHICKENS.

Sohail (2002) calculated the dressing percentage of birds fed on cooked and toasted hatchery waste meal. Highest dressing percentage was noted in birds fed diets with 2% toasted HWM (56.06%) while the lowest dressing percentage was observed in birds fed diets having 4% toasted hatchery waste meal (51.82%). Data regarding the dressing percentage of birds on various experimental rations revealed non significant differences. The dressing percentage of birds fed 2, 4 and 6% of either toasted or cooked HWM's did not vary significantly from each other as well as from control diet. Thus the rations were equally found efficient with respect to their effect on dressing percentage.

4.3 EFFECT OF PARTIAL REPLACEMENT OF FISH MEAL WITH WHWM ON ABDOMINAL FAT OF BROILER CHICKENS.

The effects of dietary different levels of hatchery wastes in broiler were investigated by Shahriar (2008). In that study, with the increase of levels of hatchery waste in diet abdominal fat ($P>0.01$) increased. The results showed that in chicks, diets rich hatchery waste cause increased abdominal fat deposition. Abdominal fat deposition showed significant effects were with fed waste, corresponding with the results of Ferrier, *et al.* (2001).

4.4 EFFECT OF PARTIAL REPLACEMENT OF FISH MEAL WITH WHWM ON ORGAN WEIGHTS OF BROILER CHICKENS.

Breast ($P>0.05$) and wing weight ($P>0.01$) decreased, but thigh weight was not affected with the increase of levels wastes in diet that due can be high fat and their deposit in body of chick and low feed intake by hatchery waste groups. It showed the best breast weight in the wastes with 2% and a control groups. Average carcass combination included were significant in breast weight % ($p<0.05$) in between groups and organoliptic quality of the grille breast meat was significant both in males and females ($p<0.05$). The glucose value of the serum was significant in 5 and 8 weeks ($p<0.05$). Results showed, we could use from the HW to 4% level after necessary processing in broiler diets (Shahriar, 2008).

MATERIALS AND METHODS

4.5.1 Collection and processing of hatching wastes

The Un-hatched incubator eggs collected from the Agricultural Research Council Hatchery Unit at Glen Agricultural Institute were used for this study. The eggs were boiled in water for 30 minutes and then allowed to cool down. Cooked eggs with the shell were broken into pieces and oven dried at 110°C for 1-2 hours. After drying, the eggs were milled into powder in order to form Whole Hatchery Waste Meal (WHWM). Four broiler diets were prepared in which WHWM replaced FM (protein for protein) at

0%, 10%, 20% and 30% levels. Processing of WHWM took place at Glen Agricultural Institute.

4.5.2 Management of experimental birds

The experiment was conducted with day old broiler chickens obtained from Country Birds Holding 200 day old broiler chicks were brooded and reared as a single group from day old to two weeks in a brooder house. After 2 weeks (14 days),180 birds were subsequently randomly divided into four treatment groups viz: Group A, 0% level, Group B, 10% level, Group C, 20% level, and Group D – 30% level, of 45 birds per treatment and 15 birds per replicate. The birds had free access to feed and water at all times.

During the first two weeks (brooding period) heat was provided day and night using infra red lamps. After two weeks (brooding period) lights were turned off during the day, except on dark and rainy days and switched on at night. Day old birds were vaccinated for New Castle Disease and Mareks Disease. At two weeks of age, birds were vaccinated for Gumboro (Infectious bursal disease). Coccidiostat (for coccidiosis) was administered at the age of 4 weeks. Birds were vaccinated for New Castle diseases at 6 weeks of age, while the birds were de-wormed at the age of 6 weeks.

The birds were housed in a commercial broiler house for the entire experimental period. Bedding (litter material) was provided by using wood shavings. Birds were kept

on the same litter material for the last six weeks of the experiment. Litter was turned, wet litter was removed frequently and dry wood shavings were added when necessary. Litter was kept dry at all times to avoid coccidiosis and other diseases and conditions.

At the end of the feeding trial, six birds per treatment (2 birds per replicate) were selected at random and slaughtered for carcass and blood analysis. From the slaughtered birds, dressing % was determined. Abdominal fat and internal organs (e.g. liver, heart, lungs, and gizzard) were removed, weighed and expressed as percentage of live weight.



Figure 3: weighing of internal organs

RESULTS AND DISCUSSION

Table 7: Carcass characteristics of broilers fed diets in which WHWM replaced

FM

Parameters	0%	10%	20%	30%
Live mass (kg)	2.83 ^a ± 0.26	2.76 ^a ± 0.22	2.54 ^a ± 0.42	2.54 ^b ± 0.21
Eviscerated weight (kg)	2.20 ^a ± 0.14	2.10 ^b ± 0.16	1.90 ^{ab} ± 0.33	1.88 ^c ± 0.18
Dressing %	77.86 ^a ± 2.92	76.20 ^a ± 0.86	74.72 ^b ± 1.70	74.05 ^{bc} ± 1.16
Abdominal fat %	0.79 ^a ± 0.45	1.12 ^b ± 0.05	0.78 ^a ± 0.07	0.96 ^a ± 0.28
Liver %	2.19 ^a ± 0.15	2.32 ^a ± 0.22	2.41 ^b ± 0.16	2.65 ^c ± 0.21
Lungs %	0.67 ^a ± 0.04	0.70 ^b ± 0.04	0.80 ^c ± 0.04	0.61 ^a ± 0.11
Heart %	0.54 ^a ± 0.06	0.49 ^b ± 0.04	0.54 ^a ± 0.08	0.55 ^a ± 0.03
Gizzard %	1.68 ^a ± 0.33	1.31 ^a ± 0.10	1.2 ^b 4 ± 0.20	1.52 ^a ± 0.19

^{abcd} Means within row with different superscript differ significantly at (P <0.05)

The effects of feeding WHWM on broiler Live mass (LM), Eviscerated weight (EW), Abdominal Fat % (AF) Liver %, lung %, heart %, and gizzard % are presented in table 9. The highest live mass was observed in birds fed diets containing 0% WHWM (2.83), while the lowest in those fed diets with 20% and 30% levels of WHWM. The results showed non significant difference in live mass of birds fed WHWM at 0%, 10% and

20% level. EW of birds fed WHWM at 0%, 10%, 20% and 30% levels were 2.20, 2.10, 1.90, and 1.88kg respectively. The results show that EW decreased with an increase in WHWM in the diets. The highest value of 2.20kg was obtained for control diet, while the lowest value of 1, 88kg was observed in the diet containing 30% WHWM. The highest dressing % was noted in birds fed control diet (T1) (77.86%), while the lowest dressing % was observed in birds fed diets WHWM at 30% level (74.05). The dressing % of T3 and T4 were comparable. Non significant differences were observed on the abdominal fat % of birds fed a control diet, 20% and 30% levels of WHWM. The highest value of 1.12 abdominal fat % was observed in birds fed 10% level of WHWM.

Liver % for control diet, T2, T3, & T4 were 2.19, 2.32, 2.41, and 2.65 respectively. Maximum liver % was recorded in birds 30% WHWM level (2.65), while the minimum value was noted in a group fed control diet. Results indicate that liver % increased with an increase in the inclusion of WHWM in broiler diets. Statistically non significant differences were observed on the lung% of birds fed the control diet and 30% (maximum) inclusion of WHWM. Lung % of T2 and T3 were significantly different from each other.

Heart % of the control diet, 20% and 30% levels of WHWM were comparable and significantly not different from each other. The lowest value of heart % was recorded at 10% level of WHWM and was statistically significantly different from other diets. Gizzard % of broilers fed 20% level of WHWM inclusion were statistically

significantly different ($P < 0.05$) from those of broilers fed the control diet and WHWM at 10% and 30% levels.

4.7 CONCLUSION

It is evident in this study that higher Live mass, eviscerated weight, dressing percentage and gizzard percentage were noted on the control diet, indicating that increased levels of WHWM in broiler diets resulted in a decrease in the live mass, eviscerated weight, Dressing% and Gizzard%. These results agree with those of Shariar *et al* 2008 that the increase of HW levels results in a decrease in breast and wing weights. The highest level of WHWM (30%) resulted in increased liver and heart%, while the lower level (10%) only increased abdominal fat of broiler chickens. However, for all parameters at all levels no negative impact (abnormalities) of WHWM was noted on the organs, e.g. enlargement of the liver, etc. In this connection (Ismail *et al*. 2011) reported that carcass characteristics were not significantly influenced by the dietary treatments of HWM and that there were no significant differences in any of the carcass characteristics. In addition they also demonstrated that hatchery waste has no unfavorable effect on carcass characteristics.

REFERENCES

- Alvarado, C.Z. and Thompson, L.D., 2004. *Poultry meat: Carcass Composition and Characteristics*. Encyclopedia of Animal Science.
- Hosseini-Vashan. A.R., Golian. A., Motaghinia. Gh. Namvari.M., and Hamed. M. 2010. *Comparison of growth performance and carcass characteristics of broiler chickens fed diets with various energy and constant energy to protein ratio*. Journal of Animal and Veterinary Advances. Vol 9. (20). P 2565 - 2570
- Ismail. Z. S. H. and Ali. A. H. H. 2011. *Effects of dietary hatchery waste on some reproductive and physiological characteristics of Broiler chicks*. Animal production Department, Faculty of Agriculture, South Valley University: Egypt.
- Kamran. Z., Sarwar. M., Nisa. M., Nadeem. M. A., Mahmood. S., Babar. M.E., and Ahmed. S. 2008. *Effects of low-protein diets having constant energy –to- protein ratio on performance and carcass characteristics of broiler chickens from one to thirty five days of age*. Poult. Sci., 87: 468 - 474
- Shahriar, H.A., Nazer-Adl. K., Doolgarisharaf. J. and Monirifar. H., 2008. *Effects of dietary different levels of Hatchery Waste in broiler*. Journal of Animal and veterinary Advances. Vol 7 No1. p100-105.

Sohail Hassan Khan., and Bashir Mahmood Bhatti. 2002. *Effects of feeding cooked hatchery waste on the performance of broilers*. Pakistan Veterinary Journal: Vol 22 No1. P 27-30.

Zaman. Q.U. Mushtaq. T., Nawaz. H., Mirza. M.A. and Mahmood. S. 2008. *Effects of varying dietary and protein on broiler performance in hot climate*. Anim Feed Sci. Technol., 146: 302 -312.

CHAPTER 5

EFFECTS OF WHWM ON THE BLOOD CHARACTERISTICS OF BROILER CHICKENS

CHAPTER 5: EFFECTS OF WHWM ON THE BLOOD

CHARACTERISTICS OF BROILER CHICKENS.

5.1 INTRODUCTION

The aim is to investigate as to whether the inclusion of whole hatchery waste meal in broiler diets will have any effects on the blood characteristics of broiler chickens. Esonu, *et al* 2001 stated that hematological constituents reflect the physical responsiveness of the animal to its internal and external environments which include feed and feeding. Some scientists have found the effects of various feeds on the hematology and serum biochemistry of livestock and concluded that feed ingredients including unconventional sources affect animal physiology, which makes this study imperative.

5.2 THE EFFECTS OF PARTIAL REPLACEMENT OF FISH MEAL WITH WHWM ON HAEMATOLOGICAL PROFILE OF BROILER CHICKENS

Most studies conducted in the past on the replacement of fish meal with whole hatchery waste meal investigated a lot on the performance, carcass characteristics and egg quality but little has been reported on haematological profile of broiler chickens fed on hatchery waste. Abiola, 2000 investigated haematological indices and serum metabolites of cockerels fed hatchery waste meal diets. Haematological values were

generally higher in birds fed HWM diets than those fed control diet. Packed cell volume (PCV) and hemoglobin (Hb) concentrations which tended to decrease with increase in the level of HWM in the diets gave the values that ranged between 23.50% - 27.50% for PCV and 7.85g/100ml – 9.20g/ml for Hb. Lowest white blood cell (WBC) count of 5.40 ($\times 10^3/\text{mm}^3$) was recorded for birds fed control diet. Cholesterol concentration appeared to increase with increase in level of HWM in the diets. Dietary treatments had significant effects ($p < 0.05$) on total protein, creatinine and urea concentrations. There was no abnormal blood characteristics in the birds fed HWM diets.

5.3 MATERIALS AND METHODS

5.3.1 Processing of Whole Hatchery Waste Meal.

The Un-hatched incubator eggs used for this experiment were collected from the Agricultural Research Council Hatchery Unit at Glen Agricultural Institute. The eggs were boiled in water for 30 minutes and then allowed to cool down. Cooked eggs with the shell were broken into pieces and oven dried at 110°C for 1-2 hours. After drying, the eggs were milled into powder using milling machine in order to produce Whole Hatchery Waste Meal (WHWM). Processing of WHWM took place at Glen Agricultural Institute.

5.3.2 Nutrient composition of Whole Hatchery Waste Meal and Fish Meal

Samples of whole hatchery waste meal and fish meal were sent to the University of the Free State for analysis; the two were compared and composition is presented in Table 8

Table 8: Nutrient composition of FM and WHWM

Nutrients	FM	WHWM
Moisture (%)	8.17	4.85
Ash (%)	12.73	18.12
Ether extract (%)	10.70	23.94
Crude protein (%)	73.18	42.26
Gross Energy	23.20	20.24
Calcium (%)	3.14	10.97
Phosphorus (%)	2.09	0.66
Ca:P	1.5:1	16.6:1

Values are means of two determinations

5.3.3 Preparation of experimental diets

Feed ingredients required to formulate a complete broiler diet were purchased. Feed was prepared manually by mixing all the ingredients on a clean cement floor using

spades. Four experimental diets were prepared in which WHWM replaced fish meal (protein for protein) at 0%, 10%, 20% and 30% levels. The composition of the four experimental diets is presented in Table 9.

Table 9: Composition of experimental diets

Replacement levels of WHWM				
Ingredients	0%	10%	20%	30%
Maize	53.00	53.00	53.00	53.00
Soybean meal	28.40	28.40	28.40	28.40
Fish meal	4.00	3.60	3.20	2.80
WHWM	0.00	0.70	1.40	2.10
Wheat Bran	10.00	9.70	9.40	9.10
Limestone	1.20	1.20	1.20	1.20
Mono-calcium phosphate	1.50	1.50	1.50	1.50
Oyster shell	1.00	1.00	1.00	1.00
Premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20
Lysine	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00

Table 10: Nutrient composition of experimental diets

Nutrients	Diets			
	1	2	3	4
Moisture (%)	5.93	5.81	5.20	5.15
Ash (%)	5.96	7.04	6.92	6.40
Ether extract (%)	2.28	2.22	2.58	3.06
Crude protein (%)	25.23	24.59	25.16	25.09
Gross energy	18.29	17.82	18.12	18.14
Ca (g/100g)	1.35	1.46	1.68	1.53
Ph (g/100g)	0.47	0.43	0.47	0.45
Ca: Ph	2.9:1	3.4:1	3.6:1	3.4:1

5.3.4 Birds and Management

The experiment was conducted with day old broiler chickens obtained from Country Birds Holding Ltd, situated between Botshabelo and Bloemfontein, N8 Road.

Broiler chicks (200 day old) were reared as a single group from day old to two weeks in a brooder house. After 2 weeks (14 days), the birds (180) were subsequently randomly divided into four treatment groups viz: Group A, 0% level, Group B, 10%

level, Group C, 20% level, and Group D – 30% level, of 45 birds per treatment and 15 birds per replicate. The birds had free access to feed and water at all times.

During the first two weeks (brooding period) heat was provided day and night using infra red lamps. After two weeks (brooding period) lights were turned off during the day, except on dark and rainy days and switched on at night. Day old birds were vaccinated for New Castle Disease and Mareks Disease. At two weeks of age, birds were vaccinated for Gumboro (Infectious bursal disease). Coccidiostat (for coccidiosis) was administered at the age of 4 weeks. Birds were vaccinated for New Castle diseases at 6 weeks of age, while the birds were de-wormed at the age of 6 weeks.

The birds were housed in a commercial broiler house for the entire experimental period. Bedding (litter material) was provided by using wood shavings. Birds were kept on the same litter for the last six weeks of the experiment. Litter was turned, wet litter was removed frequently and dry wood shavings were added when necessary. Litter was kept dry at all times to avoid coccidiosis and other diseases and conditions.

At the end of the trials blood samples were collected and sent to the Pathology Laboratory, at the University of Free State for analysis of White blood cells (WBC), Red blood cells (RBC), and Hemoglobin (HGB), Hematogrit (HCT), Mean corpuscular volume (MCV), Mean corpuscular hemoglobin (MCH) and Mean corpuscular hemoglobin concentration (MCHC).



Figure 4: Slaughtering of birds

5.4 RESULTS AND DISCUSSION

Table 11: The effects of WHWM on hematological profile of broiler chickens

Parameters	0% level	10% Level	20% Level	30% level
WBC ($\times 10^3/l$)	519.59 ^a $\pm$ 68.79	426.05 ^b $\pm$ 49.11	474.64 ^c $\pm$ 73.98	484.93 ^d $\pm$ 71.83
RBC ($10^6/mm^3$)	2.49 ^a $\pm$ 0.11	2.41 ^a $\pm$ 0.28	2.35 ^a $\pm$ 0.35	2.67 ^b $\pm$ 0.15
HGB (g/dL)	8.70 ^a $\pm$ 0.33	8.17 ^a $\pm$ 0.71	8.23 ^a $\pm$ 1.35	8.77 ^a $\pm$ 0.54
HCT (%)	33.03 ^a $\pm$ 2.34	30.37 ^b $\pm$ 2.61	30.35 ^{a b} $\pm$ 4.46	33.92 ^a $\pm$ 1.72
MCV ($10^{-15}L$)	132.58 ^a $\pm$ 4.78	126.47 ^b $\pm$ 4.06	129.15 ^c $\pm$ 3.43	128.15 ^a $\pm$ 7.49
MCH (pg)	34.93 ^a $\pm$ 1.03	34.02 ^b $\pm$ 1.37	34.95 ^{a b} $\pm$ 0.87	32.97 ^a $\pm$ 3.15
MCHC (g/dL)	26.42 ^a $\pm$ 1.09	26.92 ^a $\pm$ 0.45	27.07 ^b $\pm$ 0.83	25.72 ^c $\pm$ 1.05

^{abcd} Means within row with different superscript differ significantly at (P < 0.05)

WBC, RBC, HGB, HCT, MCV, MCH and MCHC results are presented in Table 11. WBC counts for all treatment groups were significantly different from each other. High WBC count was observed on birds fed control diet ($51959 \times 10^3/l$) and lower count on birds fed WHWM ($484.93 \times 10^3/l$) Statistically non significant differences ($P \geq 0.05$) were observed on the HGB of all treatment groups including the control group. RBC counts of T1 – T3 were not significantly different from each other but statistically significantly different from T4 (30% WHWM). The highest value of ($2.67 \times 10^6/mm^3$) was observed in birds fed higher level of WHWM. The HCT and MCH results showed non

significant differences between T1, T3 and T4, except T2 which was significantly different from other treatment groups. The MCV values for T1 –T4 were 132.58, 126.47, 129.15 and (128.1510⁻¹⁵L) respectively. The highest and the lowest values were recorded on T1 and T2 respectively. T1 and T2 MCHC results are comparable and significantly not different from each other but significantly different from T3 and T4, which are statistically significantly different from each other

5.5 CONCLUSION

White blood cell counts were higher for birds fed control diet than those fed WHWM. This may suggest that there was no need for birds fed WHWM to react and produce antibodies necessary to fight any infection in their WHWM included diets. Further suggest that there was little or no contamination of unhatched incubator eggs after incubation. The primary function of RBC is to transport oxygen to all the tissues from the lungs. High RBC and HGB counts on the birds fed.WHWM are an indicative of higher oxygen carrying capacity. Birds with high oxygen carrying capacity do not succumb to any form of respiratory disease (Mmereole, 1996). It can be concluded that 10% of FM can be replaced with WHWM in broiler diets without noticeable adverse effects on haematological characteristics.

REFERENCES

- Abiola, S.S., 2000. *Haematological indices and serum metabolites of cockerels fed hatchery waste meal diets*. Trop.Vet. 18, 79 – 84.
- Esonu, B. O., Emenalom, O. O., Udedibie, A.B.I., Herbert, U., Ekpok, C.F., Okoli, I.C., and Iheukwumere, F.C. 2001. Performance and blood chemistry of weaner pigs fed raw mucuna (velvet bean). Tropical Animal Production Investigations, 4: 49 – 54.
- Esonu, B.O., F.C. Iheukwumere, O.O. Emanolom, M.C, M.C. Uchegbu and E.B.Etuk. 2002. *Performance, nutrient utilization and organ characteristics of broilers of broilers fed microdesmis puberula leaf meal*. Livestock production for Rural Development. 14:6.
- Mmereole, F. U. C., 1996. The study haematological parameters in the Nigerian Local Chicken. Nig. J. Anim. Prod., 1: 94-97

CHAPTER 6

ECONOMIC BENEFITS FROM USING WHWM IN BROILER DIETS

CHAPTER 6: ECONOMIC BENEFIT FROM USING WHWM IN BROILER DIETS

6.1 INTRODUCTION

The cost of feed accounts about 65% of broiler and 75% of layer production. The feeding cost being the mayor constraint in poultry enterprise, every effort is directed to maintain feed quality, contain feed cost and utilize every bit of the feed to convert into food for mankind. The cost, easy availability and nutritional quality of feed coupled with genetically potent feed efficient stocks are the need of time. The ways to curtail feeding cost and wastage of nutrients, and to reduce soil pollution due to loss of the nutrients through excreta, are established of optimum requirements, for various nutrient updating nutritional requirements updating nutritional requirements to keep up with genetic improvements, efficient utilization of raw materials and ensuring efficient utilization of nutrients through feed processing and use of additives (*et al*, 2004)._

6. 2 ECONOMIC BENEFITS FROM USING WHWM IN BROILER DIETS

In recent years, poultry industries are rapidly growing than other livestock market. In other hand, shortage of feed ingredient and its increasing price could not meet the demand of poultry feed. Even increasing of poultry industries wastes has also increased. Disposal of these wastes is another problem to growing industries, as concerning with environmental pollution (Dilip, *et al*.2010). Thus the key objective of

this work is to utilize hatchery waste as a feedstuff in broiler diets to lower feed prices and to solve the problem of disposal of such by products.

The effects of feeding cooked hatchery waste on the performance of broilers was studied and the results showed that the cost per chick to market age was lowest in ration containing high level of HWM (7.5%) and highest in ration containing high level of fish meal (10%) indicating maximum replacement of fish meal by hatchery waste meal in broiler ration is economical (Sohail, 2002)

6.3 MATERIALS AND METHODS

A total of 180 two-week old broiler chicks were used in a 6 week feeding trial in a completely randomized design to assess the economic benefit of using WHWM in broiler diets. Broiler chicks were subsequently randomly divided into four treatment groups viz: Group A, 0% level, Group B, 10% level, Group C, 20% level, and Group D – 30% level, of 45 birds per treatment and 15 birds per replicate. The four dietary treatments were further replicated 3 times with 15 birds per replicate. Feeding and water supply to the birds were *ad libitum* while other standard management practices were adopted.

Feed ingredients required to formulate a complete broiler diet were purchased. Feed was prepared manually by mixing all the ingredients on a clean cement floor using spades. Four experimental diets were prepared in which WHWM replaced fish meal

(protein for protein) at 0%, 10%, 20% and 30% levels. The composition of the four experimental diets is presented in Table 12.

Table 12: Composition of experimental diets

Ingredients	Replacement levels of WHWM			
	0%	10%	20%	30%
Maize	53.00	53.00	53.00	53.00
Soybean meal	28.40	28.40	28.40	28.40
Fish meal	4.00	3.60	3.20	2.80
WHWM	0.00	0.70	1.40	2.10
Wheat Bran	10.00	9.70	9.40	9.10
Limestone	1.20	1.20	1.20	1.20
Mono-calcium phosphate	1.50	1.50	1.50	1.50
Oyster shell	1.00	1.00	1.00	1.00
Premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20
Lysine	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00

Table 13: Nutrient composition of experimental diets

Nutrients	Diets			
	1	2	3	4
Moisture (%)	5.93	5.81	5.20	5.15
Ash (%)	5.96	7.04	6.92	6.40
Ether extract (%)	2.28	2.22	2.58	3.06
Crude protein (%)	25.23	24.59	25.16	25.09
Gross energy	18.29	17.82	18.12	18.14
Ca (g/100g)	1.35	1.46	1.68	1.53
Ph (g/100g)	0.47	0.43	0.47	0.45
Ca: Ph	2.9:1	3.4:1	3.6:1	3.4:1

The Un-hatched incubator eggs used for this experiment were collected from the Agricultural Research Council Hatchery Unit at Glen Agricultural Institute. The eggs were boiled in water for 30 minutes and then allowed to cool down. Cooked eggs with the shell were broken into pieces and oven dried at 110⁰C for 1-2 hours. After drying, the eggs were milled into powder using milling machine in order to produce Whole Hatchery Waste Meal (WHWM). Processing of WHWM took place at Glen Agricultural Institute.

Nutrient composition of whole hatchery waste meal and fish meal was determined. Samples of whole hatchery waste meal and fish meal were sent to the University of the

Free State for analysis; the two were compared and composition is presented in Table 14.

Table 14: Nutrient composition of FM and WHWM

Nutrients	FM	WHWM
Moisture (%)	8.17	4.85
Ash (%)	12.73	18.12
Ether extract (%)	10.70	23.94
Crude protein (%)	73.18	42.26
Gross Energy	23.20	20.24
Calcium (%)	3.14	10.97
Phosphorus (%)	2.09	0.66
Ca:P	1.5:1	16.6:1

Initial body weight of the birds was taken and recorded on the first day of the experiment (day 15). The birds were further weighed weekly. Feed intake of the birds was calculated on a weekly basis from the third week until the last day of the experiment. Final body weight, Feed intake, feed conversion efficiency and protein intake of the experimental animals were determined on the last day of the experiment. The cost of feed, total feed cost for feed intake per bird, and total cost per weight gained were determined. The data were subjected to analysis of variance.

6.4 RESULTS AND DISCUSSION

Table 15: Feed cost analysis of broilers fed diets in which WHWM replaced FM

Parameters	0%	10%	20%	30%
Cost of feed(R/kg)	3.83 ^a ± 0.00	3.79 ^b ± 0.00	3.76 ^c ± 0.00	3.73 ^d ± 0.00
Cost total FI bird(R/bird)	18.37 ^a ± 0.91	18.82 ^b ± 0.17	17.08 ^a ± 2.39	16.28 ^c ± 0.15
Cost weight gain(R/kg)	9.10 ^a ± 0.45	8.97 ^a ± 0.67	8.69 ^b ± 0.65	9.40 ^b ± 0.72

^{abcd} Means within row with different superscript differ significantly at (P <0.05)

The effects of WHWM on feed costs, feed intake per bird total cost and weight gain cost are illustrated on Table 11. The cost of feed for T1 (0%), T2 (10%), T3 (20%) and T4 (30%) were R3.83, R3.79, R3.76 and R 3.73 respectively. Statistically significant differences were observed for all the treatments. The costs of feed were higher for the control diet and lower at 30% level of WHWM inclusion. The feed costs decreased with an increase of WHWM in broiler diets. Total cost FI per bird were high at 10% level of WHWM and low at 30% level, 18.82 and 16.28 respectively. Costs per weigh gain were comparable for T1 and T2, non significant differences were observed. T3 and T4 were comparable and also non significant differences were observed.

6.5 CONCLUSION

The utilization of WHWM in broiler diets resulted in lower feed cost. This is because un-hatched incubator eggs were provided by ARC free of charge, while fish meal was purchased. Total cost for feed intake per bird decreased with increased level of WHWM; therefore it is economical to use WHWM as in broiler diets. Weight gain per bird were comparable for all the treatments, therefore WHWM has a potential as an alternative /ingredient in broiler diets. (Shahriar *et al.* 2008) reported that the utilization of HW after proper processing has two advantages. First it is a useful and economical source of nutrients for poultry. Second, it reduces the pollution.

REFERENCES

- Dilip, S. and Dambar, B. K. 2010. *Utilization of Hatchery by-products as Feed ingredients in Broiler Chicken Feed*. Journal of Solid Waste Technology & Management.
- Mandal, A. B., Yadav. A.S., Johri.T.S., and Pathak. N.N. 2004. *Nutrition and disease management of poultry*: International Book Distributing Co. India.
- Shahriar, H.A., Nazer-Adl. K., Doolgarisharaf. J. and Monirifar. H., 2008. *Effects of dietary different levels of Hatchery Waste in broiler*. Journal of Animal and veterinary Advances. Vol 7 No1. p100-105.
- Sohail Hassan Khan., and Bashir Mahmood Bhatti. 2002. *Effects of feeding cooked hatchery waste on the performance of broilers*. Pakistan Veterinary Journal: Vol 22 No1. P 27-30.

CHAPTER 7

EFFECTS OF WHWM ON MEAT CHARACTERISTICS OF BROILER CHICKENS

CHAPTER 7: EFFECTS OF WHWM ON MEAT

CHARACTERISTICS OF BROILER CHICKENS

7.1 INTRODUCTION

The consumption of chicken and turkey meat has increased over the last several decades compared to other meats. This increase in consumption can be attributed to the versatility, variety and the incorporation of poultry meat into a low-fat diet. Several factors allow poultry meat to be a leaner choice in meats, including easy removal of the skin, lack of marbling and a higher ratio of unsaturated fats to saturated fats. For example, a 100-g serving of roasted light chicken meat with skin is a an excellent protein source, providing about 58% of the daily reference value of protein, is low in fat, and is an excellent source of several minerals and vitamins. However nutrient composition of poultry meat can be different depending upon meat type (light vs. dark) and cooking method (Alvarado, *et al*, 2010)

Given the above characteristics of chicken meat and the high consumption rate of chicken meat it is therefore imperative that the effects of WHWM on the meat characteristics of broiler chickens be established, if WHWM is to be utilized as feedstuff in broiler diets.

7. 2 EFFECTS OF WHWM ON MEAT CHARACTERISTICS OF BROILER CHICKENS

According to Rahman, *et al* (2003) meat yield and profitability increased with the inclusion of dietary hatchery waste in increased amounts. He further suggested that 8% HW be used in the diet to completely replace dietary FM to help in the formulation of a well balanced and economical diet to achieve maximum growth and meat yield.

7.3 MATERIALS AND METHODS

The Un-hatched incubator eggs used for this experiment were collected from the Agricultural Research Council Hatchery Unit at Glen Agricultural Institute. The eggs were boiled in water for 30 minutes and then allowed to cool down. Cooked eggs with the shell were broken into pieces and oven dried at 110⁰C for 1-2 hours. After drying, the eggs were milled into powder using milling machine in order to produce Whole Hatchery Waste Meal (WHWM). Processing of WHWM took place at Glen Agricultural Institute.

Samples of whole hatchery waste meal and fish meal were sent to the University of the Free State for analysis; the two were compared and the nutrient composition is presented in Table 16

Table 16: Nutrient composition of FM and WHWM

Nutrients	FM	WHWM
Moisture (%)	8.17	4.85
Ash (%)	12.73	18.12
Ether extract (%)	10.70	23.94
Crude protein (%)	73.18	42.26
Gross Energy	23.20	20.24
Calcium (%)	3.14	10.97
Phosphorus (%)	2.09	0.66
Ca:P	1.5:1	16.6:1

Feed ingredients required to formulate a complete broiler diet were purchased. Feed was prepared manually by mixing all the ingredients on a clean cement floor using spades. Four experimental diets were prepared in which WHWM replaced fish meal (protein for protein) at 0%, 10%, 20% and 30% levels. The composition of the four experimental diets is presented in Table 17.

Table 17: Composition of experimental diets

Ingredients	Replacement levels of WHWM			
	0%	10%	20%	30%
Maize	53.00	53.00	53.00	53.00
Soybean meal	28.40	28.40	28.40	28.40
Fish meal	4.00	3.60	3.20	2.80
WHWM	0.00	0.70	1.40	2.10
Wheat Bran	10.00	9.70	9.40	9.10
Limestone	1.20	1.20	1.20	1.20
Mono-calcium phosphate	1.50	1.50	1.50	1.50
Oyster shell	1.00	1.00	1.00	1.00
Premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20
Lysine	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00

The experiment was conducted with 200 day old broiler chicks. The chicks were reared as a single group under the same conditions from day old to two weeks in a brooder house. After 2 weeks (14 days), the birds (180) were subsequently randomly divided into four treatment groups viz: Group A, 0% level, Group B, 10% level, Group C, 20%

level, and Group D – 30% level, of 45 birds per treatment and 3 replicates of 15 birds per replicate. The birds had free access to feed and water at all times.

During the first two weeks (brooding period) heat was provided 24 hours using infra red lamps. Lights were provided 24 hours during the brooding period. From the first day of the trial lights were on at night and turned off during the day, except on dark and rainy days. Day old birds were vaccinated for New Castle Disease and Mareks Disease. At two weeks of age, birds were vaccinated for Gumboro (Infectious bursal disease). Coccidiostat (for coccidiosis) was administered at the age of 4 weeks. Birds were vaccinated for New Castle diseases at 6 weeks of age, while the birds were dewormed at the age of 6 weeks.

The birds were housed in a commercial broiler house for the entire experimental period. Bedding (litter material) was provided by using wood shavings. Birds were kept on the same litter for the last six weeks of the experiment. Litter was turned regularly, wet litter removed frequently and dry wood shavings were added when necessary. Litter was kept dry at all times to avoid the build up of infections.

At the end of the trials 2 birds per replicate, making a total of 6 birds per treatment group were slaughtered. Meat samples were taken and send to the laboratory for analysis. The data was subjected to Analysis of Variance and the results are presented below.

7.4 RESULTS AND DISCUSSION

Table 18: EFFECTS OF WHWM ON MEAT CHARACTERISTICS OF BROILER CHICKENS

Parameters	0%	10%	20%	30%
Crude protein %	19.48 ^a ± 0.13	20.08 ^a ± 1.38	21.48 ^b ± 0.61	19.98 ^a ± 0.97
Fat %	3.40 ^a ± 0.61	3.59 ^a ± 1.27	3.39 ^a ± 0.97	4.84 ^a ± 2.23
Ash%	3.02 ^a ± 0.55	2.97 ^a ± 0.93	3.68 ^b ± 0.42	3.27 ^c ± 0.09
Moisture %	74.50 ^a ± 0.37	72.47 ^a ± 2.52	74.09 ^a ± 0.86	71.88 ^b ± 0.17
Gross energy	28.25 ^a ± 1.97	27.48 ^b ± 1.82	26.47 ^c ± 2.24	25.79 ^a ± 0.62

^{abcd} Means within row with different superscript differ significantly at (P <0.05)

Crude protein % of T1, T2, T3 and T4, were 19.48, 20.08, 21.48 and 19.98% respectively. Crude protein % of the control diet (T1) was comparable to that of T2 and T4. Statistically non significant differences were observed between them (P ≥ 0.05). Non significant differences were observed on the Fat % of birds fed control diet and of birds fed WHWM at all levels. Results of ash percentage in this experiment showed that ash % of control diet and 10% WHWM is significantly not different from each other but statistically significantly different from that of treatment 3 and treatment 4. Moisture % decreased with an increase in the level of WHWM. A high moisture percentage was

obtained for the control diet (74.50) and a low % of (71.88) for treatment 4. Gross energy results revealed that birds fed control diet possessed high gross energy percentage than birds in all other treatment groups. Lower gross energy % was observed on birds fed the highest level of WHWM (30% level).

7.5 CONCLUSION

The results in this experiment revealed that the addition of WHWM to the broiler diets led to a significantly higher ($P < 0.05$) crude protein %, and fat % than the control diet. High ash percentage on birds fed WHWM can be linked unforeseen aspects involved in the processing of Hatchery waste e.g. the method used and period of drying waste. Expectedly moisture % of WHWM fed birds would be low due to high ash percentage. Gross energy results of the control diet are comparable to the WHWM diets WHWM could be considered as potential feedstuff in broiler diets because WHWM results are comparable to the control group. However further and detailed evaluations are required to establish the effect of oven drying hatchery waste on the quality of the end product.

REFERENCES

- Alvarado, C.Z. and Thompson, L.D., 2004. *Poultry meat: Carcass Composition and Characteristics*. Encyclopedia of Animal Science. Second Edition.
- Rahman, M., Akter, M., and Howlider, M.A.R.2003. *Replacement of fish meal by hatchery waste in broiler diets*. Bangladesh Veterinarian, Vol 20.No 1.29-35

CHAPTER 8

GENERAL CONCLUSION AND RECOMMENDATIONS

CHAPTER 8: GENERAL CONCLUSION AND RECOMMENDATIONS

8.1 CONCLUSION

In conclusion, this study has shown that WHWM has a potential as an alternative feedstuff in broiler diets. Results of the chemical analysis of the two ingredients FM and WHWM indicated that WHWM had higher contents of ash ether extract. The higher ash content could be due to high content of eggshell at the time of processing. The higher ether extract content of WHWM could be associated with higher egg yolk content of infertile eggs in the processed samples. However crude protein content of WHWM was lower than that of FM. Results of growth traits indicated that feed intake and weight gain decreased as the levels of fish meal decreased in the diets. Results also indicate the superiority of FM over WHWM. Results obtained for carcass traits decreased with increase in the levels of WHWM in the diets. This could be an indication of poor utilization of nutrients in the WHWM diets. When analysis of White blood cells (WBC), Red blood cells (RBC), and Haemoglobin (HGB), Hematocrit (HCT), Mean corpuscular volume (MCV), Mean corpuscular haemoglobin (MCH) and Mean corpuscular haemoglobin concentration (MCHC) were done results showed marginal variations in blood parameters. It can therefore, be concluded that 10% of FM can be replaced with WHWM in broiler diets without noticeable adverse effects on haematological characteristics. The costs of feed were higher for the control diet and lower at 30% level of WHWM inclusion. The feed costs decreased with an increase of

WHWM in broiler diets; therefore it is economical to use WHWM as a feedstuff in broiler diets.

Results of this study indicated that 10% of fish meal (FM) can be replaced with whole hatchery waste meal (WHWM) in broiler diets without adverse effects on growth, carcass traits and blood characteristics, meat characteristics and total feed costs. This approach will provide alternative protein and calcium sources in broiler diets and minimize problem of hatching waste disposal from hatchery industry. As a related matter the utilization of WHWM as a feedstuff in broiler diets will reduce poultry feed costs associated with the high costs of fish meal.

8.2 RECOMMENDATIONS

It is recommended that FM be replaced by WHWM at 10% level as it is evident from the results of this study that the utilization of WHWM at this level outperformed all other treatment groups in most parameters measured. This observation is very positive especially now that people are conscious of reducing feed cost in the poultry industry. Further research should direct attention to inclusion of WHWM in commercial broiler diets and investigate the pros and cons of manual mixing own feed with WHWM as opposed to mixing mechanically. Further and detailed evaluations are also required to establish the effect of oven drying hatchery waste on the quality of the end product.

REFERENCES

- Abiola, S.S., 1999. *Yield of unhatched incubator eggs and its replacement value in soybean meal diets fed to cockerels*. Trop Jour. Anim. Sci. 1 (2): 79 – 85.
- Abiola, S.S. and Onunkwor, E.K., 2004. *Replacement value of hatchery waste meal for fish meal in layer diets*. Bioresource Technology 95: 103 – 106.
- Abiola, S.S., 2000. *Haematological indices and serum metabolites of cockerels fed hatchery waste meal diets*. Trop.Vet. 18, 79 – 84.
- Abiola, S.S., 2001. *Substitution of groundnut cake for hatchery waste meal in the finisher diets of cockerels*. J. Pure and Appl. Sci. Vol 4 (1), 48-53
- Abiola, S. S., Adelaja, A. A., Akanmu, A. M., Sogunle, O. M. and Egbeyale, L. T. 2009. *Replacement of Fish Meal with Whole and Shelles Hatchery By-Product Meal on Performance and Carcass Characteristics of Broilers*. Proceedings of Annual Conference of ASAN 2009.
- Agbede, J.O. and Aletor, V.A., 2003. *Evaluation of fish meal replaced with leaf protein concentrate from glyricidia in diets for broiler – chicks: Effect on performance, muscle growth, haematology and serum metabolites*. Int. Jour. Poultry Science. 2 (4): 242 – 250.

- Alvarado, C.Z. and Thompson, L.D., 2004. *Poultry meat: Carcass Composition and Characteristics*. Encyclopedia of Animal Science. Second Edition.
- Awoniyi, T.A.M., Aletor, V.A. and Aina, J.M., 2003. *Performance of broiler – chickens fed on maggot meal in place of fish meal*. Inter. Jour. Poultry Science. 2 (4): 271 – 274.
- Das, K.C, Minkara, M.Y, Melear, N.D, and Tollner, E.W. 2002. *Effect of Poultry Litter Amendment on Hatchery Waste Composting*. J.Appl. Poult. Res.11, 282 - 290
- Dilip, S. and Dambar, B. K. 2010. *Utilization of Hatchery by-products as Feed ingredients in Broiler Chicken Feed*. Journal of Solid Waste Technology & Management.
- Esonu, B.O., F.C. Iheukwumere, O.O. Emanolom, M.C, M.C. Uchegbu and E.B. Etuk, 2002. *Performance, nutrient utilization and organ characteristics of broilers of broilers fed microdesmis puberula leaf meal*. Livestock production for Rural Development,14:6.
- Esterhuizen., 2007. *Poultry and products*. USDA Foreign Agricultural Service: USA Embassy, Pretoria; South Africa
- Germishuis, 2006. South Africa, *Poultry and products*. GAIN Report, SF6033, US Embassy, Pretoria 11pp.

- Glatz, Miao and Rodda. 2011. *Handling and treatment of poultry hatchery waste*. SARDI Livestock Systems; Sustainability 3, 216-237: Australia.
- Hodges. J. 2010. *Searching for sustainable intensive livestock production: Pig Progress*. Volume 26. No.6.
- Hosseini-Vashan. A.R., Golian. A., Motaghinia. Gh. Namvari.M., and Hamed. M. 2010. *Comparison of growth performance and carcass characteristics of broiler chickens fed diets with various energy and constant energy to protein ratio*. Journal of Animal and Veterinary Advances. Vol 9. (20). P 2565 – 2570.
- Ismail. Z. S. H. and Ali. A. H. H. 2011. *Effects of dietary hatchery waste on some reproductive and physiological characteristics of Broiler chicks*. Animal production Department, Faculty of Agriculture, South Valley University: Egypt.
- Kamran. Z., Sarwar. M., Nisa. M., Nadeem. M. A., Mahmood. S., Babar. M.E., and Ahmed. S. 2008. *Effects of low-protein diets having constant energy –to- protein ratio on performance and carcass characteristics of broiler chickens from one to thirty five days of age*. Poult. Sci., 87: 468 - 474
- Leeson, S. 2000. *Poultry: Is feed efficiency still a useful measure of broiler performance?* Department of Animal and Poultry Science/ University of Guelph.

- Leeson, S. & Summers, J. D. 2005. *Commercial poultry nutrition*. 3rd edition: Nottingham University Press. England.
- Mandal, A. B., Yadav. A.S., Johri.T.S., and Pathak. N.N. 2004. *Nutrition and disease management of poultry*: International Book Distributing Co. India.
- Mmereole, F. U. C., 1996. The study haematological parameters in the Nigerian Local Chicken. Nig. J. Anim. Prod., 1: 94-97
- Murray., 2007. *State of the poultry industry. SAPA Industry profile*
- Norton, R., 2000. *Current concepts in broiler production*. Poultry Science .Auburn University.
- Ojewola, G.S. Okoye, F.C and Ukoha, O.A. 2005. *Comparative utilization of three animal protein sources by broiler chickens*. International Journal of Poultry Science 4 (7): 462-467.
- Okereke, C.O., Ukachukwu, S.N and Umesiobi D.O. 2008. Effect of dietary inclusion of composite cassava (*Manihot esculanta*) meal on egg production characteristics of laying hens. Journal of Applied Animal Research 33: 69-72.

- Okon, B.I. and Ayuk, A.A., 2003. *Carcass characteristics and meat quality of broilers fed periwinkle flesh, palm kernel cake and oil – based rations*. Dept Animal Science, Faculty of Animal Science. University of Calabar: Nigeria.
- Rahman, M., Akter, M., and Howlider, M.A.R. 2003. *Replacement of fish meal by hatchery waste in broiler diets*. Bangladesh Veterinarian, Vol 20. No 1. 29-35
- Rasool, S.; Rehan, M.; Haq, A.; Alam, M.Z. 1999. *Preparation and nutritional evaluation of hatchery waste meal for broilers*. Asian Australasian Journal of Animal Sciences. Thailand, Vol 4. p. 554-557.
- Saima, 2001. *Feeding value of processed hatchery wastes as a source of protein in broiler rations*. Phd Thesis. University of Agriculture. Faisalabad.
- Shahriar, H.A., Nazer-Adl. K., Doolgarisharaf. J. and Monirifar. H., 2008. *Effects of dietary different levels of Hatchery Waste in broiler*. Journal of Animal and veterinary Advances. Vol 7 No1. p100-105.
- Skinner-Noble, D.O. and Teeter, R.G. 2003. *Components of Feed Efficiency in Broiler Breeding Stock: Energetics, Performance, Carcass Composition, Metabolism, and Body Temperature*.

- Sohail Hassan Khan, and Bashir Mahmood Bhatti. 2002. *Effects of feeding cooked hatchery waste on the performance of broilers*. Pakistan Veterinary Journal: Vol 22 No1. P 27-30
- South African Poultry Association (SAPA). 2007. The South African Poultry Industry Profile for 2007.
- South African Poultry Association (SAPA). 2010. The South African Poultry Industry Profile for 2010.
- Statistics SA, 2006. *Labour force survey*, Statistics South Africa, Private Bag x 44, Pretoria 0001.
- Tabler, G.T. 2008. *Early feed intake and bird performance*. Center of Excellence for Poultry Science-Avian Advice (Vol. 5, No. 1), University of Arkansas.
- Toppo, S., Shrivastava H. P., Deo C., Narayan R., Majumdar S. 2003. *Feeding of hatchery egg shell waste as a calcium source to laying chickens*. Indian Journal of Poultry Science. Volume 38, no2.
- Zaman. Q.U. Mushtaq. T., Nawaz. H., Mirza. M.A. and Mahmood. S. 2008. *Effects of varying dietary and protein on broiler performance in hot climate*. Anim Feed Sci. Technol., 146: 302 -312.

RESULTS ANALYSIS

Performance Characteristics

Rep No.	FI (g/b/day)	Wt gain(g/b/day)	Feed conversion	Daily Protein Intake
1A	119.19	50	2.38	30.07
1B	112.62	50.24	2.24	28.41
1C	109.52	44.29	2.47	27.63
2A	119.29	46.43	2.57	29.33
2B	122.14	54.29	2.25	30.03
2C	113.33	49.76	2.28	27.87
3A	122.14	50.95	2.4	30.73
3B	92.14	43.57	2.11	23.18
3C	110.24	45.48	2.42	27.74
4A	104.52	45	2.32	26.22
4B	104.52	38.57	2.71	26.22
4C	102.86	40.24	2.56	25.81

Carcass characteristics

Rep No.	Live Mass (kg)	Eviscerated weight (kg)	Dressing %	Abdominal fat %	Liver %	Lungs %	Heart %	Gizzard %
1A	3.13	2.35	75.08	0.56	2.34	0.64	0.61	1.7
1B	2.68	2.08	77.61	1.31	2.05	0.71	0.49	1.34
1C	2.67	2.16	80.9	0.49	2.17	0.67	0.52	1.99
2A	2.52	1.94	76.98	1.11	2.1	0.67	0.52	1.43
2B	2.79	2.1	75.27	1.18	2.33	0.75	0.44	1.25
2C	2.96	2.26	76.35	1.08	2.53	0.68	0.51	1.25
3A	3.02	2.28	75.5	0.79	2.22	0.83	0.53	1.06
3B	2.24	1.7	75.89	0.71	2.5	0.76	0.63	1.21
3C	2.35	1.71	72.77	0.85	2.51	0.8	0.47	1.45
4A	2.71	2.03	74.91	0.96	2.44	0.59	0.55	1.73
4B	2.59	1.93	74.52	1.24	2.66	0.73	0.58	1.35
4C	2.31	1.68	72.73	0.69	2.86	0.52	0.52	1.47

Hematological Characteristics

No.	WBC	RBC	HGB	HCT	MCV	MCH	MCHC
1A1	566.25	2.63	8.9	35.9	136.5	33.8	24.8
A2	543.41	2.62	9.2	36.1	137.8	35.1	25.5
1B1	507.25	2.49	8.6	31.2	125.3	34.5	27.6
B2	385.96	2.41	8.2	31	128.6	34	26.5
1C1	562.57	2.4	8.6	32.2	134.2	35.8	26.7
C2	552.09	2.39	8.7	31.8	133.1	36.4	27.4
2A1	417.84	2.63	9.1	33	125.5	34.6	27.6
2A2	422.66	2.02	7.2	26.7	132.2	35.6	27
2B1	490.95	2.66	8.5	32.5	122.2	32	26.2
2B2	474.9	2.66	8.7	32.4	121.8	32.7	26.9
2C1	365.87	2.25	7.8	28.9	128.4	34.7	27
2C2	384.1	2.23	7.7	28.7	128.7	34.5	26.8
3A1	403.37	2.2	7.5	28.6	130	34.1	26.2
3A2	410.58	2.24	7.6	29	129.5	33.9	26.2
3B1	530.52	2.66	9.3	32.7	122.9	35	28.4
3B2	583.49	2.9	10.5	38.3	132.1	36.2	27.4
3C1	497.22	2.09	7.3	26.8	128.2	34.9	27.2
3C2	422.66	2.02	7.2	26.7	132.2	35.6	27
4A1	552.02	2.76	9.2	35.8	129.7	33.3	25.7
4A2	548.99	2.76	9.2	36.2	131.2	33.3	25.7
4B1	423.16	2.48	8.9	33.7	135.9	35.9	26.4
4B2	424.86	2.48	9.1	33.3	134.3	36.7	27.3
4C1	550.01	2.81	8.3	32.4	118.9	29.3	24.6
4C2	410.56	2.7	7.9	32.1	118.9	29.3	24.6

FEED COST ANALYSIS

Rep No.	Cost of feed/kg	Cost of total FI/bird	Feed cost/kg/wt gain
1A	R 3.83	R 19.38	R 9.23
1B	R 3.83	R 18.12	R 8.59
1C	R 3.83	R 17.62	R 9.47
2A	R 3.79	R 18.99	R 9.74
2B	R 3.79	R 19.44	R 8.53
2C	R 3.79	R 18.04	R 8.63
3A	R 3.76	R 19.29	R 9.01
3B	R 3.76	R 14.55	R 7.95
3C	R 3.76	R 17.41	R 9.12
4A	R 3.73	R 16.37	R 8.66
4B	R 3.73	R 16.37	R 10.10
4C	R 3.73	R 16.11	R 9.43

MEAT CHARACTERISTICS

	CP %	Fat %	Ash %	Moisture %	Gross Energy Mj/kg
1A	19.3395	2.79	3.6	74.89	26.507
1B	19.5895	4	2.94	74.16	27.854
1C	19.51	3.42	2.51	74.46	30.393
2A	19.285	4.47	2.48	71.79	28.363
2B	19.2845	4.16	2.39	70.35	28.7
2C	21.677	2.13	4.05	75.26	25.388
3A	20.7775	2.87	3.94	73.77	28.29
3B	21.8255	4.51	3.9	75.06	27.156
3C	21.8255	2.78	3.2	73.44	23.969
4A	18.8545	7.31	3.34	72.08	26.49
4B	20.475	2.97	3.29	71.786	25.284
4C	20.6025	4.23	3.17	71.78	25.605

The MEANS Procedure

Batch=One

Variable	N	Lower Quartile	Median	Upper Quartile	Mean	Std Dev	Minimum	Maximum
FI	3	109.52	112.62	119.19	113.78	4.94	109.52	119.19
Wt_gain	3	44.29	50.00	50.24	48.18	3.37	44.29	50.24
Feed_conversion	3	2.24	2.38	2.47	2.36	0.12	2.24	2.47
Daily_Protein_Intake	3	27.63	28.41	30.07	28.70	1.25	27.63	30.07
Live_Mass	3	2.67	2.68	3.13	2.83	0.26	2.67	3.13
Evis_weight	3	2.08	2.16	2.35	2.20	0.14	2.08	2.35
Dressing_Perc	3	75.08	77.61	80.90	77.86	2.92	75.08	80.90
Abdominal_Fat_Perc	3	0.49	0.56	1.31	0.79	0.45	0.49	1.31
Liver_Perc	3	2.05	2.17	2.34	2.19	0.15	2.05	2.34
Lungs_Perc	3	0.64	0.67	0.71	0.67	0.04	0.64	0.71
Heart_Perc	3	0.49	0.52	0.61	0.54	0.06	0.49	0.61
Gizzard_Perc	3	1.34	1.70	1.99	1.68	0.33	1.34	1.99
Cost_of_feed	3	3.83	3.83	3.83	3.83	0.00	3.83	3.83
Cost_total_FI_bird	3	17.62	18.12	19.38	18.37	0.91	17.62	19.38
Cost_per_wt_gain	3	8.59	9.23	9.47	9.10	0.45	8.59	9.47
CP_Perc	3	19.34	19.51	19.59	19.48	0.13	19.34	19.59
Fat_Perc	3	2.79	3.42	4.00	3.40	0.61	2.79	4.00
Ash_Perc	3	2.51	2.94	3.60	3.02	0.55	2.51	3.60
Moisture_Perc	3	74.16	74.46	74.89	74.50	0.37	74.16	74.89
Gross_Energy	3	26.51	27.85	30.39	28.25	1.97	26.51	30.39

Batch=Two

Variable	N	Lower Quartile	Median	Upper Quartile	Mean	Std Dev	Minimum	Maximum
FI	3	113.33	119.29	122.14	118.25	4.50	113.33	122.14
Wt_gain	3	46.43	49.76	54.29	50.16	3.95	46.43	54.29
Feed_conversion	3	2.25	2.28	2.57	2.37	0.18	2.25	2.57
Daily_Protein_Intake	3	27.87	29.33	30.03	29.08	1.10	27.87	30.03
Live_Mass	3	2.52	2.79	2.96	2.76	0.22	2.52	2.96
Evis_weight	3	1.94	2.10	2.26	2.10	0.16	1.94	2.26
Dressing_Perc	3	75.27	76.35	76.98	76.20	0.86	75.27	76.98
Abdominal_Fat_Perc	3	1.08	1.11	1.18	1.12	0.05	1.08	1.18
Liver_Perc	3	2.10	2.33	2.53	2.32	0.22	2.10	2.53
Lungs_Perc	3	0.67	0.68	0.75	0.70	0.04	0.67	0.75
Heart_Perc	3	0.44	0.51	0.52	0.49	0.04	0.44	0.52
Gizzard_Perc	3	1.25	1.25	1.43	1.31	0.10	1.25	1.43
Cost_of_feed	3	3.79	3.79	3.79	3.79	0.00	3.79	3.79
Cost_total_FI_bird	3	18.04	18.99	19.44	18.82	0.71	18.04	19.44
Cost_per_wt_gain	3	8.53	8.63	9.74	8.97	0.67	8.53	9.74
CP_Perc	3	19.28	19.29	21.68	20.08	1.38	19.28	21.68
Fat_Perc	3	2.13	4.16	4.47	3.59	1.27	2.13	4.47
Ash_Perc	3	2.39	2.48	4.05	2.97	0.93	2.39	4.05
Moisture_Perc	3	70.35	71.79	75.26	72.47	2.52	70.35	75.26
Gross_Energy	3	25.39	28.36	28.70	27.48	1.82	25.39	28.70

Batch=Three

Variable	N	Lower Quartile	Median	Upper Quartile	Mean	Std Dev	Minimum	Maximum
FI	3	92.14	110.24	122.14	108.17	15.11	92.14	122.14
Wt_gain	3	43.57	45.48	50.95	46.67	3.83	43.57	50.95
Feed_conversion	3	2.11	2.40	2.42	2.31	0.17	2.11	2.42
Daily_Protein_Intake	3	23.18	27.74	30.73	27.22	3.80	23.18	30.73
Live_Mass	3	2.24	2.35	3.02	2.54	0.42	2.24	3.02
Evis_weight	3	1.70	1.71	2.28	1.90	0.33	1.70	2.28
Dressing_Perc	3	72.77	75.50	75.89	74.72	1.70	72.77	75.89
Abdominal_Fat_Perc	3	0.71	0.79	0.85	0.78	0.07	0.71	0.85
Liver_Perc	3	2.22	2.50	2.51	2.41	0.16	2.22	2.51
Lungs_Perc	3	0.76	0.80	0.83	0.80	0.04	0.76	0.83
Heart_Perc	3	0.47	0.53	0.63	0.54	0.08	0.47	0.63
Gizzard_Perc	3	1.06	1.21	1.45	1.24	0.20	1.06	1.45
Cost_of_feed	3	3.76	3.76	3.76	3.76	0.00	3.76	3.76
Cost_total_FI_bird	3	14.55	17.41	19.29	17.08	2.39	14.55	19.29
Cost_per_wt_gain	3	7.95	9.01	9.12	8.69	0.65	7.95	9.12
CP_Perc	3	20.78	21.83	21.83	21.48	0.61	20.78	21.83
Fat_Perc	3	2.78	2.87	4.51	3.39	0.97	2.78	4.51
Ash_Perc	3	3.20	3.90	3.94	3.68	0.42	3.20	3.94
Moisture_Perc	3	73.44	73.77	75.06	74.09	0.86	73.44	75.06
Gross_Energy	3	23.97	27.16	28.29	26.47	2.24	23.97	28.29

Batch=Four

Variable	N	Lower Quartile	Median	Upper Quartile	Mean	Std Dev	Minimum	Maximum
FI	3	102.86	104.52	104.52	103.97	0.96	102.86	104.52
Wt_gain	3	38.57	40.24	45.00	41.27	3.34	38.57	45.00
Feed_conversion	3	2.32	2.56	2.71	2.53	0.20	2.32	2.71
Daily_Protein_Intake	3	25.81	26.22	26.22	26.08	0.24	25.81	26.22
Live_Mass	3	2.31	2.59	2.71	2.54	0.21	2.31	2.71
Evis_weight	3	1.68	1.93	2.03	1.88	0.18	1.68	2.03
Dressing_Perc	3	72.73	74.52	74.91	74.05	1.16	72.73	74.91
Abdominal_Fat_Perc	3	0.69	0.96	1.24	0.96	0.28	0.69	1.24
Liver_Perc	3	2.44	2.66	2.86	2.65	0.21	2.44	2.86
Lungs_Perc	3	0.52	0.59	0.73	0.61	0.11	0.52	0.73
Heart_Perc	3	0.52	0.55	0.58	0.55	0.03	0.52	0.58
Gizzard_Perc	3	1.35	1.47	1.73	1.52	0.19	1.35	1.73
Cost_of_feed	3	3.73	3.73	3.73	3.73	0.00	3.73	3.73
Cost_total_FI_bird	3	16.11	16.37	16.37	16.28	0.15	16.11	16.37
Cost_per_wt_gain	3	8.66	9.43	10.10	9.40	0.72	8.66	10.10
CP_Perc	3	18.85	20.48	20.60	19.98	0.97	18.85	20.60
Fat_Perc	3	2.97	4.23	7.31	4.84	2.23	2.97	7.31
Ash_Perc	3	3.17	3.29	3.34	3.27	0.09	3.17	3.34
Moisture_Perc	3	71.78	71.79	72.08	71.88	0.17	71.78	72.08
Gross_Energy	3	25.28	25.61	26.49	25.79	0.62	25.28	26.49

The NPARIWAY Procedure

Analysis of Variance for Variable FI Classified by Variable Batch		
Batch	N	Mean
Four	3	103.966667
One	3	113.776667
Three	3	108.173333
Two	3	118.253333

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	353.313958	117.771319	1.7211	0.2396
Within	8	547.425067	68.428133		
Average scores were used for ties.					

The NPARIWAY Procedure

Analysis of Variance for Variable Wt_gain Classified by Variable Batch		
Batch	N	Mean
Four	3	41.270000
One	3	48.176667
Three	3	46.666667
Two	3	50.160000

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	130.706433	43.568811	3.3061	0.0783
Within	8	105.426133	13.178267		

The NPARIWAY Procedure

Analysis of Variance for Variable Feed_conversion Classified by Variable Batch		
Batch	N	Mean
Four	3	2.530000
One	3	2.363333
Three	3	2.310000
Two	3	2.366667

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	0.081692	0.027231	0.9599	0.4571
Within	8	0.226933	0.028367		

The NPARIWAY Procedure

Analysis of Variance for Variable Daily_Protein_Intake Classified by Variable Batch		
Batch	N	Mean
Four	3	26.083333
One	3	28.703333
Three	3	27.216667
Two	3	29.076667

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	17.188533	5.729511	1.3263	0.3320
Within	8	34.559067	4.319883		
Average scores were used for ties.					

The NPARIWAY Procedure

Analysis of Variance for Variable Live_Mass Classified by Variable Batch		
Batch	N	Mean
Four	3	2.536667
One	3	2.826667
Three	3	2.536667
Two	3	2.756667

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	0.202425	0.067475	0.7970	0.5293
Within	8	0.677267	0.084658		

The NPARIWAY Procedure

Analysis of Variance for Variable Evis_weight Classified by Variable Batch		
Batch	N	Mean
Four	3	1.880000
One	3	2.196667
Three	3	1.896667
Two	3	2.100000

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	0.217233	0.072411	1.5442	0.2766
Within	8	0.375133	0.046892		

The NPARIWAY Procedure

Analysis of Variance for Variable Dressing_Perc Classified by Variable Batch		
Batch	N	Mean
Four	3	74.053333
One	3	77.863333
Three	3	74.720000
Two	3	76.200000

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	25.804758	8.601586	2.5476	0.1291
Within	8	27.010933	3.376367		

The NPARIWAY Procedure

Analysis of Variance for Variable Abdominal_Fat_Perc Classified by Variable Batch		
Batch	N	Mean
Four	3	0.963333
One	3	0.786667
Three	3	0.783333
Two	3	1.123333

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	0.238625	0.079542	1.0978	0.4046
Within	8	0.579667	0.072458		

The NPARIWAY Procedure

Analysis of Variance for Variable Liver_Perc Classified by Variable Batch		
Batch	N	Mean
Four	3	2.653333
One	3	2.186667
Three	3	2.410000
Two	3	2.320000

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	0.347892	0.115964	3.3427	0.0765
Within	8	0.277533	0.034692		

The NPARIWAY Procedure

Analysis of Variance for Variable Lungs_Perc Classified by Variable Batch		
Batch	N	Mean
Four	3	0.613333
One	3	0.673333
Three	3	0.796667
Two	3	0.700000

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	0.052492	0.017497	4.4297	0.0410
Within	8	0.031600	0.003950		
Average scores were used for ties.					

The NPARIWAY Procedure

Analysis of Variance for Variable Heart_Perc Classified by Variable Batch		
Batch	N	Mean
Four	3	0.550000
One	3	0.540000
Three	3	0.543333
Two	3	0.490000

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	0.006825	0.002275	0.6877	0.5845
Within	8	0.026467	0.003308		
Average scores were used for ties.					

The NPARIWAY Procedure

Analysis of Variance for Variable Gizzard_Perc Classified by Variable Batch		
Batch	N	Mean
Four	3	1.516667
One	3	1.676667
Three	3	1.240000
Two	3	1.310000

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	0.356158	0.118719	2.4571	0.1376
Within	8	0.386533	0.048317		
Average scores were used for ties.					

The NPARIWAY Procedure

**Analysis of Variance for Variable Cost_of_feed
Classified by Variable Batch**

Batch	N	Mean
Four	3	3.730
One	3	3.830
Three	3	3.760
Two	3	3.790

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	0.016425	0.005475	Infty	<.0001
Within	8	-0.000000	-0.000000		
Average scores were used for ties.					

The NPARIWAY Procedure

**Analysis of Variance for Variable Cost_total_FI_bird
Classified by Variable Batch**

Batch	N	Mean
Four	3	16.283333
One	3	18.373333
Three	3	17.083333
Two	3	18.823333

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	12.265425	4.088475	2.3188	0.1519
Within	8	14.105667	1.763208		
Average scores were used for ties.					

The NPARIWAY Procedure

Analysis of Variance for Variable Cost_per_wt_gain Classified by Variable Batch		
Batch	N	Mean
Four	3	9.396667
One	3	9.096667
Three	3	8.693333
Two	3	8.966667

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	0.767900	0.255967	0.6421	0.6092
Within	8	3.189267	0.398658		

The NPARIWAY Procedure

Analysis of Variance for Variable CP_Perc Classified by Variable Batch		
Batch	N	Mean
Four	3	19.977333
One	3	19.479667
Three	3	21.476167
Two	3	20.082167

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	6.598063	2.199354	2.7155	0.1150
Within	8	6.479333	0.809917		
Average scores were used for ties.					

The NPARIWAY Procedure

Analysis of Variance for Variable Fat_Perc Classified by Variable Batch		
Batch	N	Mean
Four	3	4.836667
One	3	3.403333
Three	3	3.386667
Two	3	3.586667

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	4.345000	1.448333	0.7319	0.5614
Within	8	15.830067	1.978758		

The NPARIWAY Procedure

Analysis of Variance for Variable Ash_Perc Classified by Variable Batch		
Batch	N	Mean
Four	3	3.266667
One	3	3.016667
Three	3	3.680000
Two	3	2.973333

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	0.945492	0.315164	0.9313	0.4690
Within	8	2.707400	0.338425		

The NPARIWAY Procedure

Analysis of Variance for Variable Moisture_Perc Classified by Variable Batch		
Batch	N	Mean
Four	3	71.882000
One	3	74.503333
Three	3	74.090000
Two	3	72.466667

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	14.281916	4.760639	2.6203	0.1227
Within	8	14.534757	1.816845		

The NPARIWAY Procedure

Analysis of Variance for Variable Gross_Energy Classified by Variable Batch		
Batch	N	Mean
Four	3	25.793000
One	3	28.251333
Three	3	26.471667
Two	3	27.483667

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	10.607261	3.535754	1.1202	0.3967
Within	8	25.250044	3.156255		

RADEBE - NOV 2010

The MEANS Procedure
Batch=1

Variable	Label	N	Lower Quartile	Median	Upper Quartile	Mean	Std Dev	Minimum	Maximum
WBC	WBC	6	507.25	547.75	562.57	519.59	68.79	385.96	566.25
RBC	RBC	6	2.40	2.45	2.62	2.49	0.11	2.39	2.63
HGB	HGB	6	8.60	8.65	8.90	8.70	0.33	8.20	9.20
HCT	HCT	6	31.20	32.00	35.90	33.03	2.34	31.00	36.10
MCV	MCV	6	128.60	133.65	136.50	132.58	4.78	125.30	137.80
MCH	MCH	6	34.00	34.80	35.80	34.93	1.03	33.80	36.40
MCHC	MCHC	6	25.50	26.60	27.40	26.42	1.09	24.80	27.60

Batch=2

Variable	Label	N	Lower Quartile	Median	Upper Quartile	Mean	Std Dev	Minimum	Maximum
WBC	WBC	6	384.10	420.25	474.90	426.05	49.11	365.87	490.95
RBC	RBC	6	2.23	2.44	2.66	2.41	0.28	2.02	2.66
HGB	HGB	6	7.70	8.15	8.70	8.17	0.71	7.20	9.10
HCT	HCT	6	28.70	30.65	32.50	30.37	2.61	26.70	33.00
MCV	MCV	6	122.20	126.95	128.70	126.47	4.06	121.80	132.20
MCH	MCH	6	32.70	34.55	34.70	34.02	1.37	32.00	35.60
MCHC	MCHC	6	26.80	26.95	27.00	26.92	0.45	26.20	27.60

Batch=3

Variable	Label	N	Lower Quartile	Median	Upper Quartile	Mean	Std Dev	Minimum	Maximum
WBC	WBC	6	410.58	459.94	530.52	474.64	73.98	403.37	583.49
RBC	RBC	6	2.09	2.22	2.66	2.35	0.35	2.02	2.90
HGB	HGB	6	7.30	7.55	9.30	8.23	1.35	7.20	10.50
HCT	HCT	6	26.80	28.80	32.70	30.35	4.46	26.70	38.30
MCV	MCV	6	128.20	129.75	132.10	129.15	3.43	122.90	132.20
MCH	MCH	6	34.10	34.95	35.60	34.95	0.87	33.90	36.20
MCHC	MCHC	6	26.20	27.10	27.40	27.07	0.83	26.20	28.40

Batch=4

Variable	Label	N	Lower Quartile	Median	Upper Quartile	Mean	Std Dev	Minimum	Maximum
WBC	WBC	6	423.16	486.93	550.01	484.93	71.83	410.56	552.02
RBC	RBC	6	2.48	2.73	2.76	2.67	0.15	2.48	2.81
HGB	HGB	6	8.30	9.00	9.20	8.77	0.54	7.90	9.20
HCT	HCT	6	32.40	33.50	35.80	33.92	1.72	32.10	36.20
MCV	MCV	6	118.90	130.45	134.30	128.15	7.49	118.90	135.90
MCH	MCH	6	29.30	33.30	35.90	32.97	3.15	29.30	36.70
MCHC	MCHC	6	24.60	25.70	26.40	25.72	1.05	24.60	27.30

The NPARIWAY Procedure

**Analysis of Variance for Variable WBC
Classified by Variable Batch**

Batch	N	Mean
1	6	519.588333
2	6	426.053333
3	6	474.640000
4	6	484.933333

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	26855.383813	8951.794604	2.0144	0.1443
Within	20	88876.757350	4443.837867		
Average scores were used for ties.					

The NPARIWAY Procedure

**Analysis of Variance for Variable RBC
Classified by Variable Batch**

Batch	N	Mean
1	6	2.490000
2	6	2.408333
3	6	2.351667
4	6	2.665000

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	0.335546	0.111849	1.9236	0.1583
Within	20	1.162917	0.058146		
Average scores were used for ties.					

The NPARIWAY Procedure

**Analysis of Variance for Variable HGB
Classified by Variable Batch**

Batch	N	Mean
1	6	8.700000
2	6	8.166667
3	6	8.233333
4	6	8.766667

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	1.733333	0.577778	0.8410	0.4874
Within	20	13.740000	0.687000		
Average scores were used for ties.					

The NPARIWAY Procedure

**Analysis of Variance for Variable HCT
Classified by Variable Batch**

Batch	N	Mean
1	6	33.033333
2	6	30.366667
3	6	30.350000
4	6	33.916667

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	60.623333	20.207778	2.3009	0.1082
Within	20	175.650000	8.782500		
Average scores were used for ties.					

The NPARIWAY Procedure

Analysis of Variance for Variable MCV Classified by Variable Batch		
Batch	N	Mean
1	6	132.583333
2	6	126.466667
3	6	129.150000
4	6	128.150000

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	119.834583	39.944861	1.4894	0.2478
Within	20	536.391667	26.819583		
Average scores were used for ties.					

The NPARIWAY Procedure

Analysis of Variance for Variable MCH Classified by Variable Batch		
Batch	N	Mean
1	6	34.933333
2	6	34.016667
3	6	34.950000
4	6	32.966667

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	15.923333	5.307778	1.5590	0.2305
Within	20	68.090000	3.404500		
Average scores were used for ties.					

The NPARIWAY Procedure

Analysis of Variance for Variable MCHC Classified by Variable Batch		
Batch	N	Mean
1	6	26.416667
2	6	26.916667
3	6	27.066667
4	6	25.716667

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	3	6.671250	2.223750	2.8152	0.0654
Within	20	15.798333	0.789917		
Average scores were used for ties.					