THE UNIVERSITY OF ZAMBIA

EVALUATION OF GLYCERIN, A BY-PRODUCT FROM THE BIOFUEL INDUSTRY, AS A FEED ADDITIVE FOR FREE RANGE CHICKENS

BY

TEMBO JOHN

A RESEARCH PROJECT SUBMITTED TO THE SCHOOL OF AGRICULTURAL SCIENCES IN THE PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF AGRICULTURAL SCIENCES.

DEPARTMENT OF ANIMAL SCIENCE

UNZA, LUSAKA

JUNE 2012

DECLARATION

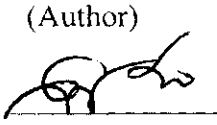
The author gives permission to the use of this thesis for consultation and to copy its parts for personal use. Any other use falls under the limitations of the copyright.

Mr. K.Walubita

(Supervisor)

Mr. Tembo John

(Author)



BSTRACT

The overall objective of this study were to evaluate glycerin, a by-product from the biofuel industry, as a feed additive for free range chickens, whereas the specific objectives were to determine the growth rates and the feed intake of free range chickens from the use of glycerin as a feed additive. Free range chickens are indigenous chicken breeds living in close contact with human communities. These chickens are often kept by rural small holder farmers and their presence yields a number of advantages for rural households. In the recent years, small holder farmers have been in an economic fight over maize which is used for the production of millions of gallons of biodiesel. Glycerin is less toxic when used in poultry and pig rations. The LD50 for toxicity in rats is 12, 600 mg/Kg and 8, 700 mg/Kg for mice. The use of glycerin as a feed additive for free range chicken rations would help large scale farmers take up the production of free range chickens rather than leaving it in the hands of small holder poultry farmers, who lack adequate resources to produce on a large scale. This study was done in an attempt to increase the performance of free range chicken in terms of growth rates using glycerin, a by-product from the biofuel industry as a feed additive. The other reason for the study was to encourage large scale farmers to take up the challenge of raising free range chickens for the benefit of fighting bacterial resistance to antibiotics in humans.

ACKNOWLEDGEMENTS

I am very grateful to my supervisor, Mr. K. Walubita who generously assisted and guided me hroughout the course of the research. I would also like to extend my sincere thanks to all rotocols of the Animal Science department for having imparted enough knowledge for me o be able to successfully run the project.

Many thanks go to my Thomro Biofuels for having helped me with the glycerin used in the tudy.

wish to thank Mr. Mbewe and the rest of the staff at farm for their invaluable cooperation nd assistance during my field work.

am also indebted to my friends Mpandamwike Mulenga, Chishiba Ashley and Mulongo bby for their encouragement even in times of hardships.

astly but not the least I sincerely thank my brother, Wilson Tembo for his unwavering pport.

EMBO

DEDICATION

This report is dedicated to my beloved parents, who would be the happiest to see me obtain the Bachelor of Agricultural Sciences degree, my brothers and sisters, for their support and encouragement throughout my stay at UNZA. Last but not the least, I would like to dedicate the report to the person I hold so dear in my life, for she has been my driving force to push forward in life, that is, my daughter, Thokozani.

ABLE OF CONTENTS

PAGE

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

APPENDICES

Appendix **Page**

PTER ONE

.0 INTRODUCTION

ree range chickens are indigenous chicken breeds living in close contact with human ɔmmunities. These chickens are often kept by rural small holder farmers and their esence yields a number of advantages for rural households, (Ngosa, 2010). However, ıe production of free range chickens among large scale farmers is generally low in ambia. The major reason for this could be the longer time taken by the indigenous ıickens to reach market weights, (Wiseman, 1994). The other reason could be ɔnsumer preference of broilers that are easy to prepare, (Londale, 1992).

ı Zambia, free range chicken production has been left solely in the hands of small scale ıdigenous poultry producers that lack adequate resources to increase the capacity of the ee range chicken enterprise, (Riise *et al.*, 2004).

ı the recent years, small holder farmers have been in an economic fight over maize hich which is used for the production of millions of gallons of biodiesel, (ARS, 2004). lycerin, a by-product from biofuels, contains energy-providing nutrients for animal roduction. Glycerin has been used as a feed ingredient for broilers and pigs, (ARS, 004). It is considered as "generally safe" when used in accordance with good ıanufacturing or feeding practices, (CFR, 2004).

lycerin is less toxic when used in poultry and pig rations. The LD50 for toxicity in rats 12, 600 mg/Kg and 8, 700 mg/Kg for mice (both non-ruminants like chickens), (ARS, 004).

pproximately 80% of the poultry worldwide are free range chickens, (Alabi *et al.*, 006). Yambayamba *et al.*, in 2006, found that approximately 90% of the chickens in the ɔur provinces they toured were free range. These percentages show the importance of ee range chicken production for rural and urban development and feeding.

he use of glycerin as a feed additive for free range chicken rations would help large cale farmers take up the production of free range chickens rather than leaving it in the ands of small holder poultry farmers, who lack adequate resources to produce on a large

scale. At both household and farm levels, free range chickens require a minimum amount of labour and financial input to maintain, making them an "ideal vehicle" for income generation, (Ngosa, 2010). Though the output of free range chickens is lower than that of intensively raised commercial chickens, it is balanced by the very low inputs required to raise free range chickens. (Sonaiya, 2004).

Thus far, very little has been done in terms of providing information on how to best rear free range chickens, (Agromisa, 2003). A limited volume of information is currently available in the form of simple field guides which provide very little useful advice on how to rear the birds from an economic point of view at large scale level.

This study was done in an attempt to increase the performance of free range chicken in terms of growth rates using glycerin, a by-product from the biofuel industry as a feed additive. The other reason for the study was to encourage large scale farmers to take up the challenge of raising free range chickens for the benefit of fighting bacterial resistance to antibiotics in humans.

1.1. PROBLEM STATEMENT

Consumption of free range chickens is generally low among Zambians because of reasons such as consumer taste. The other reason could be the longer time the free range chicken meat takes to prepare. Broilers, on the other hand, grow faster and take a shorter time to prepare but their bones, where antibiotic residues accumulate in the bone marrow, are easily crushable thereby posing a danger of bacterial resistance to antibiotics in humans. Besides many countries in Africa not excluding Zambia are unable to match free range chicken productivity to a fast growing population, given that broilers consumed on large scale pose a threat to human health in the long run (Simon *et al.*, 1999).

2. RATIONALE

In 2001, approximately 500 people in Zambia were reported to suffer from bacterial diseases that were incurable after the administration of antibiotics that previously used to

work, (WHO, 2001). This could have been a result of bacterial resistance to antibiotics in humans. Antibiotics fed to broilers as feed additives accumulate in the bone marrows of chickens and this poses a danger to human health when they consume the easily crushable bone of broilers in the long run, (Dauti, 2005).

In 2002, approximately 52% of Zambians of were estimated to suffer from bacterial related diseases resulting from bacterial resistances to antibiotics in the future, (WHO, 2002). Therefore, an increase in the production of free range chickens would help to reduce bacterial resistance to antibiotics since their bones, where antibiotic residues accumulate in the marrows, are hard to crush.

It is for this reason that finding an alternative source of feed would increase the growth rates of free range chickens, thereby, reducing cases of bacterial resistance to antibiotics in human health. Therefore, the use of glycerin as a feed additive for free range chickens was evaluated in the study in an attempt to increase chicken growth rates and feed intake.

1.3. RESEARCH OBJECTIVES

1.3.1. GENERAL OBJECTIVE

To evaluate glycerin, a by-product from the biofuel industry, as a feed additive for free range chickens.

1.3.2. SPECIFIC OBJECTIVES

- To determine the growth rates of free range chickens from the use of glycerin as a feed additive.
- To determine the feed intake of free range chickens from the use of glycerin as a feed additive.

1.4. RESEARCH HYPOTHESES

(a) H_0: Feeding glycerin will not increase growth rates in free range chickens.

H_A: Feeding glycerin will increase growth rates in free range chickens.

(b) H_0: Feeding glycerin will not increase feed intake in free range chickens.

H_A: Feeding glycerin will increase feed intake in free range chickens.

1.5. ASSUMPTION

The free range chickens that were used in the study were assumed to be meat yielding chickens and not layers.

CHAPTER TWO

2.0 REVIEW OF LITERATURE

In 2006, Dozier and Bregendahl investigated the use of glycerin as a feed ingredient in broiler rations. In his experiment, he reared broilers up to 42 days of age. He used glycerin in inclusions of 0, 5, 10 and 15% as treatments for broiler rations. At 42 days of age, the use of glycerin at 5% inclusion rate showed insignificant results on broiler growth rates whereas 10% glycerin inclusion rates showed significantly high growth rates, (Dozier, 2006). The inclusion of 15% glycerin showed poor growth rates for broilers and the flowability of the feed from the automatic feeders was very poor. This could have been attributed to the poor pelleting quality that was observed on the rations containing the 15% glycerin inclusion, (Dozier *et al.*, 2006).

Glycerin can be used in small portions as a partial replacement for other energy providing food sources that are costly compared to it, (ARS, 2004). Glycerin provides a cheaper source of energy in broiler and pig rations, (Cryer and Bartley, 1973). The United States of America spends approximately US $2 billion on maize for the production of biodiesel. It is for this reason that the use of glycerin as a partial replacement for maize in poultry and pig diets would save huge sums of capital since glycerin is a cheaper source of energy than maize, (Lessard, 2000).

According to the Poultry Science report for 2008, the use of glycerin as a feed ingredient for broilers is one of the alternatives for minimizing the cost of production of poultry and livestock feeds.

The American Research Service report for 2005 revealed that glycerin inclusions in broiler diets had no effect on the carcass quality of the chickens and meat quality was not affected by the use of glycerin in the broiler rations, (ARS, 2005).

Many studies have shown the beneficial effects of glycerol on amino acid or nitrogen retention in rats (Chan *et al.*, 1981) and humans (Brennan *et al.*, 1975). This is because glycerol may spare the gluconeogenic amino acids via the inhibition of phosphoenol-pyruvate carboxikinase (Cryer and Bartley, 1973; Young *et al.*, 1964) or glutamate

dehydrogenase activity (Steele *et al.*, 1971). However, in a subsequent study, Simon *et al.*, (1997) observed no positive effect of glycerol on nitrogen retention in a diet low in protein (18%) or high in carbohydrates. Conversely, Lessard *et al.*, (2000) reported that a 5% glycerin diet had no effect on broiler carcass fat, except abdominal fat pad weight.

Glycerin may increase the protein deposition due to the reduction of gluconeogenic amino acids via the inhibition of phosphoenol-pyruvate carboxykinase (Cryer and Bartley, 1973; Young *et al.*, 1964). Even though glycerol was proven to improve protein deposition in broilers (Simon *et al.*, 1996), rats (Chan *et al.*, 1981) and humans (Brennan *et al.*, 1975), glycerin can only be used at certain rates in different livestock rations. According to the Sustainable Agricultural Research Development report for 2004, the deposition of protein caused by glycerin intake in broiler bodies is a cheaper and good source of protein for the growing human populations, (SARD, 2004).

CHAPTER THREE

3.0 METHODOLOGY

3.1. MATERIALS

The following materials were used in the study:

3.1.1. Location

The study was done in Mulimbu Village, Petauke district, located 400Km from the capital city, Lusaka.

3.1.2. Chicks

A total of 80 chickens were used. The 60 chickens were randomly apportioned rations containing glycerin inclusions whereas the 20 remaining chickens were fed rations without glycerin inclusions, and these were used as controls.

3.2. METHOD

3.2.1. Data Collection

Diets were formulated for the 14 days old chicks. The average weights were taken at the start of the study to check for the initial average weights before the inclusion of glycerin to the rations. Average weights were also taken at the ages of 28, 49 and 70 days of age. The actual diet included maize, to provide energy, and soybeans, to provide the protein portion of the diet. Glycerin was added at the rates of 0%, 5%, 10% and 15%. As the level of glycerin in the ration increased, the amount of maize and soybeans decreased.

In the study, glycerin was used as a feed additive for free range chickens. The influence of glycerin supplementation on weight gain and feed intake were investigated. The 80 chickens were fed ad lib in 16 groups with isoenergetic diets based on maize and soybeans meal and treatments 0%, 5%, 10% and 15% pure

glycerin were inclusions in the dry matter. There were 5 chicks per treatment. Sixty chicks were randomly assigned to each of the 12 pens located in the poultry houses of local design. Each pen was equipped with a locally made feeder (a 5L container cut on one side) and a water font (a 5L container cut into half). Temperature and airflow were controlled through natural ventilation from the large windows and side wall curtains of the poultry houses. Care and management of the chickens followed the recommended guidelines, (Ngosa, 2010).

The chickens were weighed at 28, 49 and 70 days of age. No mortalities were recorded during the period of the study. The 4X4 Latin Square Design was used in the study. Data was collected and it was subjected to an analysis of variance using GenStat 14th edition. Significant differences among or between means were separated also by using the 14th edition of GenStat.

The 4X4 Latin Square Design had treatments A, B, C and D, representing 0%, 5%, 10% and 15% glycerin inclusions respectively. The tables below show the average weights for the chickens at 14, 28, 49 and 70 days of age.

ble 3.1 Average weights (in Kg) for chickens at 14 days of age.

B 0.23	**A 0.25**	**D 0.28**	**C 0.21**
A 0.22	**B 0.31**	**C 0.26**	**D 0.23**
D 0.22	**C 0.22**	**B 0.24**	**A 0.26**
C 0.29	**D 0.19**	**A 0.22**	**B 0.23**

e 3.2 Average weights (in Kg) for chickens at 28 days of age.

B 0.47	**A 0.39**	**D 0.42**	**C 0.37**
A 0.45	**B 0.49**	**C 0.40**	**D 0.41**
D 0.38	**C 0.43**	**B 0.56**	**A 0.42**
C 0.43	**D 0.39**	**A 0.44**	**B 0.57**

ɔle 3.3 Average weights (in Kg) for chickens at 49 days of age.

B 0.64	**A 0.48**	**D 0.43**	**C 0.45**
A 0.51	**B 0.69**	**C 0.57**	**D 0.49**
D 0.44	**C 0.60**	**B 0.66**	**A 0.53**
C 0.58	**D 0.47**	**A 0.48**	**B 0.61**

le 3.4 Average weights (in Kg) for chickens at 70 days of age.

B 0.92	**A 0.80**	**D 0.78**	**C 0.87**
A 0.82	**B 0.97**	**C 0.97**	**D 0.83**
D 0.81	**C 0.93**	**B 0.96**	**A 0.77**
C 0.91	**D 0.83**	**A 0.85**	**B 1.01**

.3. PARAMETERS MEASURED

'he average body weight was the only Variate in the study. The average weights were ıken per pen and the weights were rounded off to the nearest two decimal places.

CHAPTER FOUR

4.0 RESULTS

Glycerin, a by-product from the biofuel industry was evaluated as a feed additive for the free range chicken rations and the results were obtained as explained below:

4.1. Live weight performance:

The chickens were of the same age and similar weights at 14 days of age. The 2 weeks old chickens were used to evade possibilities of mortalities during the study.

The study revealed that inclusion of 5% glycerin to the rations had a highly significant effect on the body weight compared to the chickens on the control diet with no glycerin added to the ration. Moreover, the addition of 10% glycerin to the rations resulted in body weights similar to chickens on the rations containing 5% glycerin at 49 and 70 days of age. On the contrary, chicken fed on a diet containing 15% glycerin were significantly lower than chicken on the control diet and diets containing 5% and 10% glycerin inclusions. The reduction in weight could be related to lower feed intake. During the first 7 days of the study, the chickens fed on rations containing 15% glycerin showed lower feed intake compared to the rest of the chickens, and over the second week of the study, chickens fed on rations containing 5% glycerin had a significantly higher feed intake as compared to the chickens on the control diet or the rations containing 10% and 15% glycerin. However, feed consumption for the chickens fed on rations containing 15% glycerin declined during the study period compared to chickens on the control diet and those fed on rations containing 5% and 10% glycerin.

The diets containing 5% glycerin had visibly higher pellet quality compared to the rest of he rations. Feed intake was significantly higher for the chickens fed diets containing 5% nd 10% glycerin. Hence, the increase in the average body weight gain associated with iese diets.

he inclusion of glycerin produced positive growth results on the free range chickens at % and 10% inclusion rates. The inclusion of 15% glycerin showed poor growth rates

compared to the growth rates of chickens on the control diet. In addition, the 5% and 10% inclusion rates resulted in increased feed intake. The 15% glycerin inclusion rate showed poor feed intake by free range chickens.

The analyses of variance showed that inclusion of glycerin in the free range chicken rations showed significant differences at 49 and 70 days of age whereas at 28 days of age, the results were insignificant.

During the course of the study, it was observed that the litter pens where the chickens fed on rations containing 15% glycerin was much wetter than that of litter pens where chickens were fed on control rations and rations containing 5% and 10% glycerin inclusions. Further, the wet litter could have been as a result of higher feed passage resulting in wet stools.

pendix I: Table A1 showing average weights (in Kg) at 28 days of age.

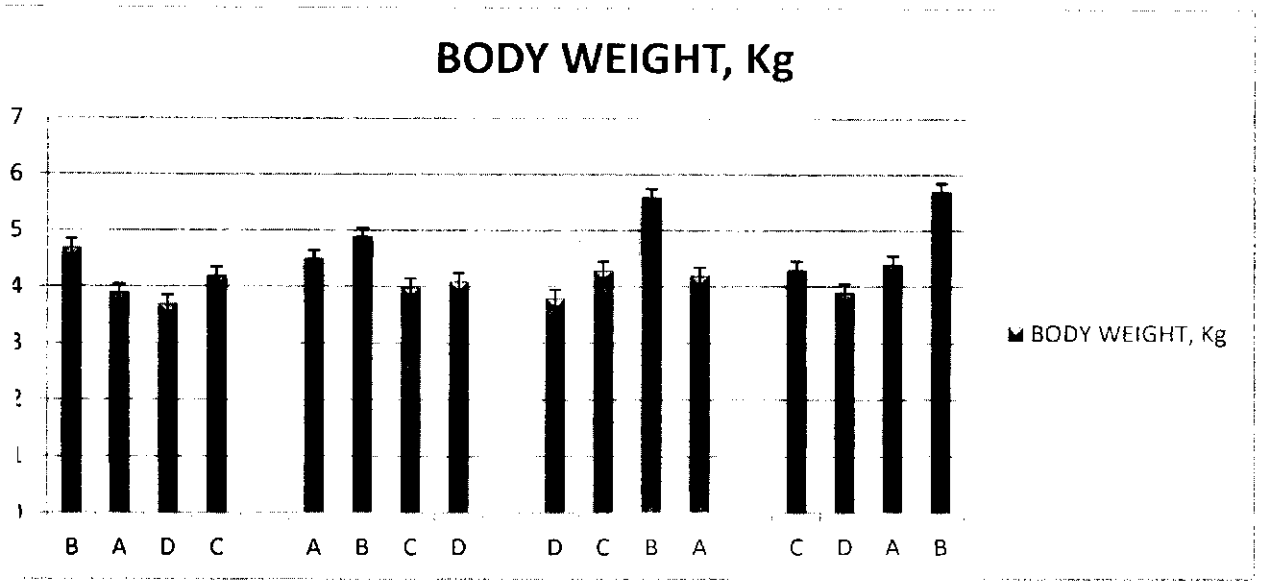
HOUSE	ORDER	GLYCERIN %	BODY WEIGHT, Kg
1	A	B	0.47
2	A	A	0.39
3	A	D	0.37
4	A	C	0.42
1	B	A	0.45
2	B	B	0.49
3	B	C	0.4
4	B	D	0.41
1	C	D	0.38
2	C	C	0.43
3	C	B	0.56
4	C	A	0.42
1	D	C	0.43
2	D	D	0.39
3	D	A	0.44
4	D	B	0.57

endix II: Table A2 showing average weights (in Kg) at 49 days of age.

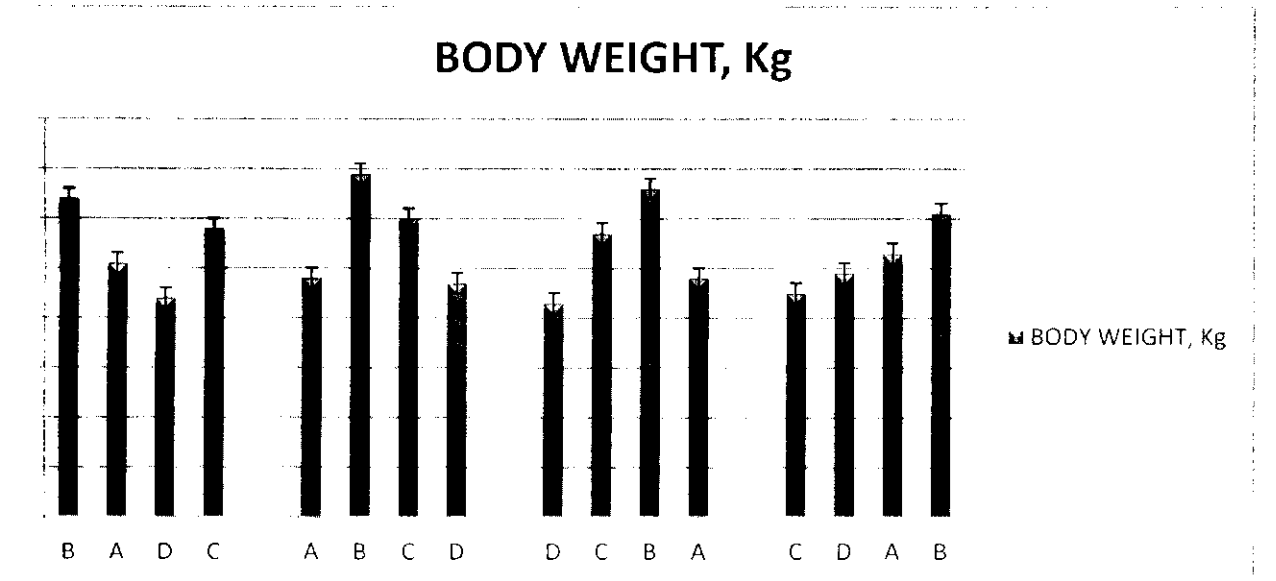
HOUSE	ORDER	GLYCERIN %	BODY WEIGHT, Kg
1	A	B	0.64
2	A	A	0.51
3	A	D	0.44
4	A	C	0.58
1	B	A	0.48
2	B	B	0.69
3	B	C	0.6
4	B	D	0.47
1	C	D	0.43
2	C	C	0.57
3	C	B	0.66
4	C	A	0.48
1	D	C	0.45
2	D	D	0.49
3	D	A	0.53
4	D	B	0.61

ndix III: Table A3 showing average weights (in Kg) at 70 days of age.

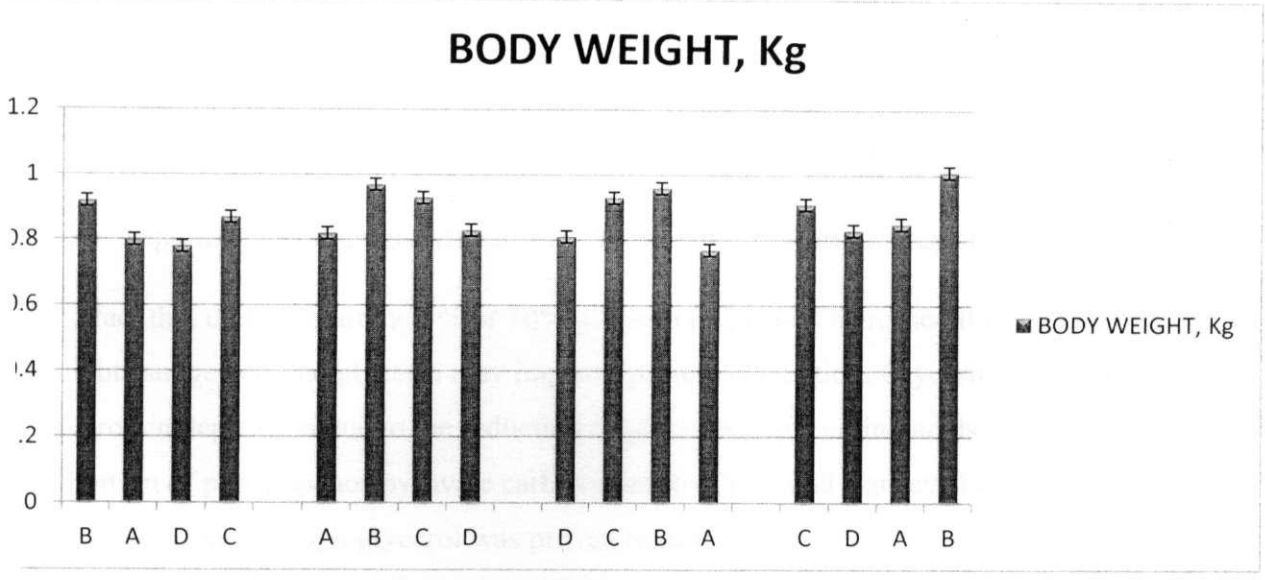
SE	ORDER	GLYCERIN %	BODY WEIGHT, Kg
1	A	B	0.92
2	A	A	0.8
3	A	D	0.78
4	A	C	0.87
1	B	A	0.82
2	B	B	0.97
3	B	C	0.93
4	B	D	0.83
1	C	D	0.81
2	C	C	0.93
3	C	B	0.96
4	C	A	0.77
1	D	C	0.91
2	D	D	0.83
3	D	A	0.85
4	D	B	1.01



re 4.1 Average weights (in Kg) for chickens at 28 days of age.



4.2 Average weights (in Kg) for chickens at 49 days of age.



ure 4.3 Average weights (in Kg) for chickens at 70 days of age

4.2. ANALYSIS OF RESULTS

The data collected was subjected to an analysis of variance (ANOVA) using GenStat 14th edition. Significant differences on treatments were observed and treatments separated using treatment means and the standard errors of differences of means, (s.e.d).

4.3. DISCUSSION

Chickens fed on rations containing 15% glycerin had almost similar weights and feed ntake as chickens on the control ration during the experiments conducted from 28, 49 nd 70 days of age. The 5% inclusion rate of glycerin in the diet of free range chickens ncreased growth rates significantly.

Many studies have shown the beneficial effects of glycerol on amino acid or nitrogen etention in rats (Chan *et al.*, 1981) and humans (Brennan *et al.*, 1975). This is because lycerol may spare the gluconeogenic amino acids via the inhibition of phosphoenol-yruvate carboxikinase (Cryer and Bartley, 1973; Young *et al.*, 1964) or glutamate ehydrogenase activity (Steele *et al.*, 1971).

However, in a subsequent study, Simon *et al.*, (1997) observed no positive effect of glycerol on nitrogen retention in a diet low in protein (18%) or high in carbohydrates. Conversely, Lessard *et al.*, (2000) reported that a 5% glycerin diet had no effect on broiler carcass fat, except abdominal fat pad weight. In this study, free range chickens showed significantly high growth rates at 5% and 10% glycerin inclusions.

The fact that diets containing 5% or 10% glycerin inclusions increased the chicken body weights suggested that glycerin may improve protein deposition. Glycerin may increase the protein deposition due to the reduction of gluconeogenic amino acids via the inhibition of phosphoenol-pyruvate carboxykinase (Cryer and Bartley, 1973; Young *et al.*, 1964). Even though glycerol was proven to improve protein deposition in broilers (Simon *et al.*, 1996), rats (Chan *et al.*, 1981) and humans (Brennan *et al.*, 1975), glycerin added to free range chicken rations at inclusions higher than 10% showed tremendously poor growth results. On the other hand, the minor variability in the average weights could be attributed to the fact that the sample used was a combination of layers and meat yielding chickens. The inclusion of 15% glycerin had the similar results on growth as compared to chickens on the control ration.

The fact that rations containing 15% glycerin resulted in decreased growth rates may be due to the lower feed intake as compared to feed intakes of the control ration and the rest of the glycerin inclusions. In situations of suboptimal feed intake or carbohydrate intake glycerol may form glucose-sparing gluconeogenic amino acids consequently increasing the protein deposition.

CHAPTER FIVE

5.0 CONCLUSION

In conclusion, based on the results of the study, glycerin, a by-product from biofuels can be an acceptable source of energy for free range chickens at 5% and 10% glycerin inclusion rates. The use of glycerin at 15% inclusion rates results in reduced live weight performance and is highly related to problems with pellet quality. Glycerin also plays a critical role in body metabolism. Glycerin can partially replace conventional energy sources like maize, fats and oils as an energy source in rations fed to the free range chickens.

5.1. RECOMMENDATION

The influence of glycerin levels on pellet quality need to be evaluated further.

EFERENCES

1. Agromisa, (2003), **Chicken farming in the tropics: basics.** Educational material no.32. ISBN 90-5285-006-2, p 180.
2. Alexandratos, N. (ed.), 1995. World Agriculture: towards 2010. An FAO study. FAO, Rome, and
   John Wiley, Chichester, UK.
3. American Research Service (ARS) report, 2004.
4. Code of Federal Regulations (CFR) report 2004.
5. Dozier *et al.*, 2004. **Evaluation of glycerin as feed ingredient for broilers.** Chalington Publishers, Olso.
6. Gueye, E.F., 1992. **Ethnoveterinary medicine against poultry diseases in Africa villages.** World Poultry Science Journal 55:187-198.
7. Londale, C, 1992. **Raw materials for animal feed compouders and farmers.** Chalcombe publications, Marlow, UK.
8. Lessard *et al.*, 2000. **The Collection, Analysis and Monitoring and Evaluation of glycerin in Poultry and pig rations.** Baltimore/London: Johns Hopkins University Press, for the World Bank., 174pp. Bhuktan, J.P., Basilio, C.S., Killough, S.A., De los Reyes, M.F.L.,

9. Ngosa, M, 2010. **Village Chicken Management manual.** Poultry Association of Zambia.
10. Riise, J.C., Permin, A., C.V and Frederiksen, L., 2004. **Keeping village poultry. A technical manual on small scale poultry production.**
11. Sonaiya, E.B and Swan, S.E.J., 2004. **Manual-Technical guide on Small Scale Poultry Production.** FAO Animal Production and Health no. ISBN 92-5-105082-1.
12. Wiseman, J. 1994. (ed) **Nutrition and Feeding of Poultry.** Nottingham University Press. ISBN 1-897676-52-2, P 305.
13. World Health Organization (WHO) report, 2001.
14. World Health Organization (WHO) report, 2002.

15. Simon *et al.*. 1997. FESLM: An international framework for evaluating glycerin in poultry management. *World Livestock Resources Report* **73**. FAO, Rome. 74 p.

16. Simon *et al.*, 1997. *Pig and Poultry Management: An Impact Study*. Abstract ofpaper in New Horizons Workshop, Bangalore, India, 28 Nov.-2 Dec., 1994. (forthcoming: eds. Pretty *et al.*). London: International Institute for Environment and Development.

APPENDICES

Appendix IV: ANOVA for average weights of chickens at 28 days of age.

Source Of Variation	Degree(S) Of Freedom	Sum Of Squares	Mean Squares	V.R	F Prob
ROW	3	0.007969	0.002656	0.63	0.048
COLUMN	3	0.002869	0.000956	0.23	
TREATMENT	3	0.061069	0.020356	4.86	
ERROR	6	0.025137	0.004190		
TOTAL	15	0.097044			

Appendix V: Table of Means

Treatment	A	B	C	D
Means	0.500	0.650	0.545	0.497
Grand Mean	0.548			

Appendix VI: Standard errors of differences of means.

Table	Glycerin %
Rep	4
D.F	6
S.E.D	0.0324

Appendix VII: ANOVA for average weights of chickens at 49 days of age.

Source of Variation	*Degree(S)* Of Freedom	*Sum Of* Squares	*Mean* Squares	*V.R*	*F Prob*
ROW	3	0.0020250	0.0006750	0.89	0.002
COLUMN	3	0.0044750	0.0014917	1.97	
TREATMENT	3	0/0407250	0.0135750	17.90	
ERROR	6	0.0045500	0.0007583		
TOTAL	15	0.0517750			

Appendix VIII: Table of Means

Treatment	A	B	C	D
Means	0.4250	0.5225	0.4200	0.3875
Grand Mean	0.4387			

Appendix IX: Standard errors of differences of means.

Table	Glycerin %
Rep	4
D.F	6
S.E.D	0.01947

Appendix X: ANOVA for average weights of chickens at 70 days of age.

SOURCE OF VARIATION	DEGREE(S) OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	V.R	F PROB
ROW	3	0.0008187	0.0002729	0.51	< 0.001
COLUMN	3	0.0075687	0.0025229	4.75	
TREATMENT	3	0.0698188	0.0232729	43.81	
ERROR	6	0.0031875	0.0005313		
TOTAL	15	0.0813938			

Appendix XI: Table of Means

Treatment	A	B	C	D
Means	0.8100	0.9650	0.9100	0.8125
Grand Mean	0.8744			

Appendix XII: Standard errors of differences of means.

Table	Glycerin %
Rep	4
D.F	6
S.E.D	0.01630

Appendix XIII: Characterization of Glycerin.

Specification	**Value**
Total glycerol, %	86.95
Methanol,%	0.028
pH	5.33
Moisture, %	9.63
Total fatty acid, %	0.29
CP,%	0.41
Na,%	1.26
Cl,%	1.86
K,%	0.005
Gross energy, Kcal/lb	1,644