EVALUATION OF SEAWEEDS AS MINERAL SOURCE IN BROILER DIETS

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ABSTRACT

An experiment was conducted at the Poultry unit of Kizimbani Agriculture Training Institute in Zanzibar to evaluate the effect of seaweed as mineral source in the growth performance of broiler chickens and carcass characteristics. Two hundred and forty (240) broiler chickens were fed four dietary treatments (T1, T2, T3 and T4), containing 0, 1, 1.5 and 2% seaweeds, from 8 - 49 days of age. Feed intake was measured daily while live weight was measured on a weekly basis. After seven weeks 2 chickens from each replicate were slaughtered to determine carcass yield and carcass characteristics. Proximate and mineral analysis of seaweed, individual feed ingredients and experimental diets were determined. The results showed that CP was highest (21.84%) in T4 and lowest (17.66%) in T2. Highest energy was observed in T3 (3019.55 kcal/kg DM) and lowest (3007.35 kcal/kg DM) in T1. TDMI per bird was lowest (4.0kg) in T1 and highest (4.6kg) in T3. Proximate analysis of seaweed showed high ash content (47.65%) low levels of CP (5.42%) and CF (3.29%). Mineral analysis in seeweed showed that it is rich in both macro and micro elements and low in amino acids. Differences for FCR between treatments were insignificant ($P > 0.05$). Body weight was significantly ($P < 0.05$) higher in T3 (2549.0g) and lower for T4 (2275.3g). Significant differences in carcass and non-carcass components were observed ($P < 0.05$). Final body weight was lower in T1 (2229.4g) and high in T3 (2481.9g). Carcass weight was highest in T3 (1961.3g) followed by T4 (1903.8g) and lowest in T1 (1673.8g) whereas dressing percentage was lowest in T1 (75%) and highest in T3 (79%). Dietary treatments had insignificant effect on overall lean, bone and fat weights. Dietary treatments had no effect on meat tenderness. Similarly, dietary treatment had no significant effect on tissue distribution apart from the bone in the drumstick. It is concluded from the current study that, seaweed inclusion at 1.5% had significant positive effects on growth rate and increased weight of broiler

chickens. In view of this, poultry farmers should be educated on the importance of using seaweed as feed ingredient or feed additive in their feed formulation.

DECLARATION

I, FAKI AME KESSI, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

__________________________ __________________

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The above declaration is confirmed;

_________________________ __________________

Prof. S. K. Mutayoba Date

(Supervisor)

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DEDICATION

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LIST OF ABBREVIATIONS AND SYMBOLS

ADF	Acid detergent fibre
ADG	Average daily gain
ANF	Anti-nutritional factor
ANOVA	Analysis of varience
BW	Body weight
Ca	Calcium
CF	Crude fibre
Cl	Chloride
Co	Cobalt
CP	Crude protein
Cu	Copper
CW	Carcass weight
DASP	Department of Animal Science and Production
DM	Dry matter
DMINT/B	Dry matter intake per bird
DP	Dressing percentage
EE	Ether Extract (fat)
FCE	Feed conversion efficiency
FCR	Feed conversion ratio
Fe	Iron
FM	Fish meal
GLM	General Linear Model
K	Pottasium

Kcal	Kilo calories
Kg	Kilogram
M	Methionine
MB	Maize bran
MC	Moisture content
ME	Metabolisable energy
Met/Cyst	Methionine/Cystine
Mg	Magnesium
MJ	Mega joule
MM	Maize meal
Mn	Manganese
Mo	Molibinum
Na	Sodium
NFE	Nitrogen Free Extract (carbohydrate)
NSP	Non-starch polysaccharides
ºC	Degree Celsius
P	Phosphorous
SAS	Statistical Analysis System
Se	Selenium
SSC	Sunflower seed cake
SWS	Seaweed (spinosum)
T1	Treatment one (Diet with 0% seaweed as mineral premix, 0.25% commercial premix)
T2	Treatment two (Diet with 1% seaweed premix, 0.125% commercial premix)

T3	Treatment three (Diet with 1.5% seaweed premix, 0.07% commercial premix)
T4	Treatment four (Diet with 2% seaweed premix, 0% commercial premix)
TDMI	Total dry matter intake
Tryp	Tryptophan
Zn	Zinc

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Poultry industry is very important in our country since it generates income, provides employment and contributes in poverty reduction. Statistics available indicate that, Tanzania has 35.5 million local and 24.5 exotic chickens (broilers and layers) (MLFD, 2012). However, the industry is faced with many challenges as far as poultry production is concerned, the crucial one being feed component. Feed is a major cost in the industry and normally accounts for about 70-80% of the entire production expenditure (Ademola and Farinu, 2006).

Different feed ingredients are used in formulating poultry diets. Studies have shown that, the inclusion levels of each feed ingredient vary with type of ingredient. Maize meal is the commonest (40%), maize bran (25%), fish meal (5%) and oil seed cakes like sunflower seed cake, and cotton seed cakes (15%) (Eekeren *et al.,* 2006; Chiba, 2009; Tahir *et al*., 2002; Sayda *et al.,* 2011; Afolayan *et al.,* 2012). The inclusion level of mineral premix in broiler diets is 0.25%, so in every 1 ton of feed the inclusion of mineral premix is about 2.5kgs (Biotech, 2014). A micronutrient is defined as a substance needed only in small amounts in the diet which enables the animal to carry out normal body functions (Woodside *et al*., 2005). Although the amount for premixes seems to be very small compared to other ingredients during feed formulation, they play a significant role as far as animal performance is concerned. Micronutrients facilitate absorption of nutrients in the system and synthesis of body enzymes. Vitamin-mineral premix is the mixture of vitamin and minerals which is added to the formulated diet to meet the requirements of vitamins and minerals that are deficient in the formulated diet

(Asaduzzaman *et al.,* 2005). Inclusion of vitamin-mineral premix in the compounded diet has become indispensable practice since feed ingredients don't contain all essential vitamins and minerals at the right amount needed by the chicken. Critical vitamins include choline, folic acid, pantothenic acid, pyridoxine, riboflavin, Vit-A, Vit-D_3 and Vit-E whereas minerals include Calcium, Phosphorus, Copper, Iodine, Iron, Manganese, Sodium and Zinc these components should be adequately supplied in the diet (Asaduzzaman *et al.,* 2005).

It is well kown that, trace elements (Co, Cu, Fe, I, Mn, Mo, Se, and Zn), among others are vital for the normal functioning of most biochemical processes in the body. They are part of several enzymes and coordinate many biological processes as such they are essential for maintaining animal health and productivity (López-Alonso, 2012). Optimal nutrition with adequate trace elements level in the diet, guarantee proper performance and functions of living organisms, among which the most important are structural, physiological, catalytic and regulatory (Suttle, 2010).

Synthetic mineral premixes are commonly used in poultry feed formulation, however, local feed formulators, tend to apply very little amount or sometimes, they don't put mineral premix in the diet, because of unreliable availability, high cost and poor quality. Consequently feed manufacturers produce substandard poultry diets (DLP, 2012). This gap can be reduced by using natural substances believed to contain high levels of macro and micro elements, vitamins, protein and essential amino-acids such as seaweed (Rimber, 2007). Seaweed is readily available in Zanzibar at village level and is cheaper when compared with commercial premixes. Seaweeds are microscopic algae which are commonly grown in the coastal areas of many countries in the world and it is commonly used as human food in some countries (Jacquine, 2014). It is a multipurpose product which is used in various industries, including fertilizer production, skin care products, cosmetics, soap making, also as an important active ingredient in some medicine and animal feeds and other food processed products (Msuya, 2013). It is estimated that, there are about 10 000 kinds of seaweeds in the world, which fall into three main groups characterized by their colour i.e. green, brown and red. The pigmentation that these groups have in their cells is the one that make big differences between them (Wei *et al.*, 2013). Green seaweeds mainly have chlorophyll a green pigment that captures sunlight for photosynthesis, while brown and red seaweeds also contain chlorophyll, but their cells also have other pigments that mask the green colour (David, 2009). Red and brown seaweeds are used in the production of various products that include hydrocolloids, alginate, gelling agent, agar and carrageenan as thickening and stabilizing food agent such as ice cream and chocolate in milk (Jaspars and Folmer, 2013).

In Zanzibar, seaweed is a famous crop which is grown along the coastal area of many villages, its production is dominated by women where it provides employment and income. In some villages dried seaweed is processed to get powder which is used for soap making, preparation of confectioneries, as well as salad making. Seaweed production in Zanzibar has been increasing annually from 9261 tons in 2003 to 11 177 tons in 2008 (Economic Survey, 2008). A large proportion of produced seaweed is sold in the local market within the islands but eventually it is exported, and only a small amount is processed. Currently, it is estimated that, approximately 1 million tones of fresh/wet seaweeds are harvested worldwide and extracted to produce about 55 000 tones of hydrocolloids, value at almost US$ 600million (McHugh, 2003). Use of seaweeds as food has strong root in Asian countries such as China, Japan and Republic of Korea, but has now also spread to North America, South America and Europe (McHugh, 2003). Seaweeds has also been used as a feed ingredient in animal diets and studies to investigate the substitution of seaweeds in broiler diets found no adverse effects on performance. Addition of 4% seaweed in the chicken's basal diet led to increased body weight gain (Ventura *et al.,* 1994; Abudabos *et al*., 2013). Additionally, Maurice *et al*. (1984) observed no adverse effect on growth, feed conversion ratio (FCR) or dressing percentage when sun dried Brazilian Elodea (Egeria densa) was added in broiler diets at 5.0%. Likewise El-Deek *et al.* (1987) found that inclusion of seaweeds in finisher broiler diets had no significant effects on growth, feed intake (FI) and feed conversion ratio (FCR). Other studies have also shown that, inclusion of 2.0% marine algae meal improved broiler performance and dressing percentage (Gu *et al.,* 1988). Despite these numerous studies there is still limited information on the use of seaweed as a mineral source in broiler diets in Zanzibar and Tanzania as a whole. Thus the objective of the current study was to evaluate the effect of using the seaweed (Spinosum) as a mineral source in broiler diets.

1.2 Problem Statement and Justification

Poultry keepers in Zanzibar are mostly faced with the problem of obtaining good feed (in terms of quality and quantity) which can meet the chicken's requirements on a daily basis. Most of the feed companies formulating and supplying feed to farmers produce feeds of poor nutritional value, leading to poor growth rate and leg problems in broilers. Following this many poultry farmers get low returns and profit from their birds sometimes failing to repay the loans or even recovering their investiment capitals. The availability of high quality poultry feed at a reasonable cost is crucial, since it can result into increase in poultry production.

In Zanzibar most of the materials that are used in poultry feed formulation are imported from Tanzania Mainland and from outside Tanzania, and only 10% comes from within. The quality of the imported materials is not known and therefore, feeds formulated by most millers are of low quality. Minerals ensure proper growth and bone development since broilers have rapid weight gain hence having strong bones can prevent legs problems. Currently most of the feed producers, use synthetic products as source of minerals in broiler diets, these include Dicalcium phosphate (DCP), bone meal, commercial broiler premix and limestone. The cost of the materials is high and availability for some of the supplements is a problem. Using alternative products as mineral sources (feed additives) in broiler diets and other livestock feeds might reduce cost of production and improve performance.

One such source is seaweed since seaweed is rich in minerals (both macro- and micro elements), vitamins, protein as well as essential amino acids. The availability of seaweeds in Zanzibar is not a problem, however, the available information shows that, there has been limited use of seaweeds in animal diets particularly for the varieties found in Tanzania (Zanzibar). In view of this the present study was undertaken to evaluate the effectiveness of seaweed as a mineral supplement in broiler diets.

1.3 General Objective

To evaluate the use of seaweeds products as a mineral supplement in broiler diets in Zanzibar.

1.4 Specific Objectives

i. To determine chemical composition of spinosum seaweed
ii. To determine the optimum level of seaweed in broiler diets
iii. To evaluate the effect of seaweed on growth performance of broiler chicken
iv. To evaluate carcass characteristics of the broiler chicken fed with seaweed (spinosum) as mineral source.

1.5 Hypothesis

There is no difference on growth performance and carcass characteristic of broiler chickens fed diets containing defferent levels of seaweed as mineral source.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Literature Overview

Poultry performance is influenced by nutrient supply in the diet amongst other factors and the demand of nutrients in poultry production vary based on their classes and physiological perspective. The nutrient demand of layer birds is quite different from that of broilers (Katule,1994; BOA,1994; Todd and Roselina, 2014). In the intensive system of poultry production where birds are mostly kept indoors, they need to receive balanced diets so as to meet their daily physiological and production demands (McDonald *et al.,* 2002). This means that each day birds need specific amount of protein, carbohydrate, fat, vitamins and minerals (James, 2008). The intake of a nutrient is an outcome of the amount of feed eaten and the level of nutrients in the feedstuffs or diets.

2.1.1 Importance of nutritive value of feed ingredients

The value of feed (and supplement) as source of minerals depends not only on their mineral content, but also on the propotion of minerals that can be utilized by animals, a property termed ”bioavailability” (Hazell,1985). Therefore, the intention of broiler producers at any place is to produce products of good quality in order to attract the market as well as getting good economic returns. In order to achieve this, the supply of nutrients must be of acceptable propotion and low cost. Formulation of balanced rations, is a key factor in an economical poultry production enterprise and this practice is influenced by the knowledge of poultry nutrients requirements and nutritional quality of nutrient sources (NRC, 1994). Poultry diets are chiefly composed of a combination of several feedstuffs which include mineral premixes, cereals grains, oil seed meals, vitamins sources and leaf meals. These feedstuffs can be classified into, energy (carbohydrates and fat), protein/amino acids, vitamins and mineral sources. Collectively with water these feedstuffs provide all necessary nutrients that are needed for chicken's growth, health and reproduction (NRC,1994).

During feed formulation, it is important to take into consideration the factors that might hinder or reduce feed consumption and these include moisture content, palatability as well as nutrients availability (Ferket and Gernat, 2006). Furthermore, presence of anti-nutritional factors such as tannin in feed ingredients may reduce palatability and intake of the diet. Higher crude fibre content of the feedstuffs also reduce availability of nutrients to birds, since birds have no ability to digest high fibrous foods (Schaller, 1978). Therefore the feedstuffs that are selected for feed formulation (especially mineral sources) should consider bioavailability, accessibility, absorbability and retainability (Hazell, 1985).

Trace minerals and other nutrients must be provided to livestock in optimal concentrations to meet the requirements although they change with stages of growth i.e rapid growth and development of the animal and the production cycle. It is relatively difficult to justify the term "requirements" for trace minerals in the same way as it is for energy, protein, or amino acids. Requirements for minerals are hard to establish and most estimates are based on the minimum level required to overcome deficiency symptoms and not necessary to promote productivity (Close, 1998).

2.2 Nutrients Requirement of Broiler Chickens

Poultry nutrients requirement is providing birds with specific amount of nutrients so that they can grow well and finish out. Breeding poultry require correct rations to lay eggs whereas meat chicken need desired diets to reach market weight at the right time (Leeson, 2009). As humans we need correct balance of nutrients supplied by the food pyramid (meat,vegetables, dairy products and fruits). Technique of poultry feeding depends on the stage and physiological activities of the chickens requirements as the birds passes through the different stages of growth (NRC, 1994).

2.2.1 Energy requirement

Energy is the largest component in livestock diets and much of the food taken by birds is for energy requirements, in which it enables animals to reproduce, grow, and safeguarding birds against extrinsic and intrinsic factors (Beutler, 2007).

Energy contributing feedstuffs make up at least 65% of the dietary cost for broiler chickens (Dozier *et al.,* 2011). The price of maize/corn, the main source of energy in poultry diets has increased steadily due to its high demand and thus competition between animals and humans and diversified uses such as biodiesel. This consequently has led to the progressive increase of production cost of poultry (Donohue and Cunningham, 2009).

2.3 Protein Requirement

Poultry feed formulation is based on birds amino acid requirements other than Crude Protein – because these are the ones utilized by the animals (Todd, 2008). Once digested and absorbed amino acids are used as building blocks of structural protein (muscle, skin, ligament), metabolic protein, enzymes and precursors of various body components (Todd, 2008). Since body proteins are constantly synthesized and degraded an adequate supply of amino acids in the diet is critical to support growth or egg production. Feed consumption by poultry is influenced by the energy concentration in the feed, therefore, the amount of protein to be included in the feed formulation should be closely related to the energy content. A study conducted by Rostagno *et al*. (2007) indicated that a reduction of protein level in the diet might not affect performance for example body growth or breast muscle yield but it can lead to increased abdominal fat deposition. Table 1 shows the recommended levels of protein, amino acids, vitamins, minerals and energy in broiler diets.

Table 1: Recommended broiler nutrient specifications in finished feeds

Nutrient component	Starter A/H	Grower A/H	Finisher 1 A/H	Finisher 2 A/H
Energy (MJ/kg)	12.65	13.25	13.40	13.40
Protein (%)	21.5	19.5	18.0	17.0
Lysine-total (%)	1.33	1.25	1.10	1.04
Lysine-digestible (%)	1.17	1.10	0.97	0.91
Methionine-total (%)	0.56	0.53	0.48	0.44
Methionine-digestible (%)	0.50	0.48	0.43	0.40
M+C-total (%)	0.98	0.96	0.88	0.80
M+C-digestible (%)	0.86	0.84	0.77	0.70
Tryptophan (%)	0.21	0.19	0.17	0.16
Threonine (%)	0.85	0.80	0.73	0.70
Arginine (%)	1.39	1.30	1.20	1.11
Calcium (%)	0.90	0.88	0.84	0.78
Available Phosphorus (%)	0.45	0.42	0.40	0.35
Sodium (%)	0.20	0.17	0.16	0.16
Chloride (%)	0.20	0.20	0.20	0.20
Pottasium (%)	0.65	0.65	0.65	0.65
Acid base balance (meg/100g)	20	20	20	20
Linoleic Acid (%)	1.25	1.25	1.25	1.25
Feeding Programs (g/bird)	500	1400	2800	to marketing

Source: COBB Broilers Nutrition Guide (2003)

2.4 Protein Sources for Poultry

Common feed ingredient used as livestock feeds differ considerably in levels of the six basic nutrients. Protein sources in animal diets can be of animal origin (fishmeal and animal processing by products) and plants origin (legumes and oil seed meals) (Chiba, 2009).

2.5 Plant Protein Sources

World wide there is a search for alternative protein sources of poultry diets since the common protein sources which include soybean meal, cotton seed meal, fish meal and legumes are expensive (Smith, 2000). Soybean and Canola meal (i.e rapeseed) are among the largest protein based vegetables and are produced World wide (USDA, 2010). These meals have higher protein and can be used in the broiler feed to provide up to 60% of the crude protein in a typical diet (Newkirk and Classen, 2002). However, canola meal is lower in CP content (34 - 38%) in comparison with Soybean meal (44 - 49%), it is also lower in essential amino acids. Canola is considered as a protein source to those animals whose protein demand is not high.

2.6 Vegetable Mineral Source

Leafy vegetables are known as the most important group (either wild or established), that are consumed in different parts of the world (Orech *et al*., 2007). Vegetables constitute the cheapest source of macro-nutrients and micro-nutrients, especially providing some vitamins such as (A, B and C), minerals (calcium, iron, fluorine, magnesium, phosphorus, potassium, sodium and zinc), dietary fibre and protein (Johns and Kokwaro, 1991; Mwajumwa *et al*., 1991; Humphry *et al*., 1993; Nordeide *et al*., 1996; Uiso and Johns, 1996; Mathenge, 1997; Maundu *et al.,* 1999). Various vegetable species found in African countries have been used partly as condiments or spices in human diets or as supplementary feeds to livestock such as rabbits, poultry, swine and cattle (Fasuyi, 2006). The study by Lyimo *et al.* (2003) showed that, some selected indigenous vegetables in Tanzania contained reasonable amount of nutrients composition which some of them used as supplement in the normal meal by many villagers in the country, values of indigenous vegetables are presented in Table 2. Apart from nutritient contents contained such as minerals, vitamin and amino acids it has been established that green vegetable leaves are the cheapest and most abundant source of protein because of their capacity to synthesize from a broad range of virtually accessible primary materials (Aletor and Adeogun, 1995).

Table 2: Nutrient composition of selected indigenous vegetables in Tanzania (dry weight basis)

Scientific name	Vit.C mg/100 g)	Protein %	Crude Fibre %	Fat %	Calcium %	Iron%
Basella alba	98.7	5.0	1.5	0.7	250.0	4.0
Bidens schimperi	86.5	1.5	0.5	0.3	65.9	3.2
Colocacia esculenta	210.0	3.9	2.2	0.6	22.0	2.9
Amaranthus spinosus	249.0	4.6	1.6	0.6	43.2	3.8
Phaseolus vulgaris	249.6	4.7	2.3	0.6	42.1	1.9
Gynandropsis gynandra	89.6	1.5	0.8	0.3	40.5	0.8
Bidens pilosa	58.2	0.7	1.6	0.3	66.5	2.2
Solanum nigrum	234.5	1.0	0.8	0.2	66.8	2.5
Corchurus sp.	143.9	4.2	1.9	0.7	112.1	4.0
Curcubita moschata	90.6	4.3	0.6	0.7	256.0	4.0
Hibiscus esculentus	55.6	1.7	1.0	0.2	78.2	3.6
Amaranthus graecizans	46.3	4.8	1.5	0.7	246.3	3.0
Amaranthus hybridus	58.1	4.8	1.5	0.6	246.8	2.9
Commelina benglhalensis	225.3	0.6	0.6	0.2	83.6	3.3
Asystacia sp.	226.0	3.7	0.8	0.1	81.7	5.0
Celosia trigyna	101.1	2.7	1.2	0.4	154.0	4.2
Launaea cornuta	15.9	4.6	1.4	0.6	256.2	2.7
Grewia similis	121.4	0.9	0.6	0.3	126.2	2.7
Bidens sp.	79.3	1.7	0.8	0.3	80.3	2.7
Corchorus olitorius	205.4	1.8	0.9	0.3	240.3	7.7
Manihot glaziovii	53.0	4.6	1.7	0.3	266.0	2.0
Zanhoxylum paracanthum	40.8	1.5	0.7	0.2	62	3.0
Asytacia sp.	178.4	2.0	0.7	0.2	141.7	3.2
Agropyron sp.	59.0	4.4	2.1	0.6	84.0	1.2
Ceruthea sesmoidens	31.0	2.4	1.0	0.4	121.0	5.0
Sesbania sp.	65.0	4.8	1.5	0.7	230.9	4.0
Ormocarpum sp.	72.1	3.9	1.3	0.6	200.9	3.9
Monsonia angustifolia	42.0	3.2	2.2	1.0	124.0	3.0
Talinum caffrum	24.0	3.2	2.2	1.0	120.0	3.0
Galinsoga parviflora	54.0	5.0	1.5	0.7	154.0	2.8
LSD ($p \leq 0.05$)	154.4	3.1	1.1	0.5	165.9	2.6
SE ($p \leq 0.05$)	9.7	0.3	0.1	0.03	10.4	0.2

Source: Lyimo *et al.* (2003). Values are means of two independent determinations

However, the existence of intrinsic toxic factors or anti-nutritional component in plants has been one of the major hindrance in harnessing fully advantages of the nutritional values of plant foods, vegetables inclusive (Liener, 1970; Nwokolo and Bragg, 1977;

Lewis and Fenwick, 1987). Many food techniques have been established in reducing or completely eliminating the anti-nutritional levels in the plant (vegetable) food sources so as to reach levels that can be tolerated by the animals particularly in monogastrics (Fasuyi and Aletor, 2005).

2.7 Poultry Mineral Requirements

Minerals have a significant role in the general performance of poultry and their productivity (Katule, 1994). Minerals are important in metabolic activities especially those associated with nerve cells, acid base balance, osmotic pressure regulation and monosaccharide and amino acid absorption. Because of this it is necessary to provide precise and adequate levels required for optimum growth, bone development and good litter quality (Murakami *et al.*, 2001).

The "strong ions" Na^+, K^+ and Cl^- have the greatest impact on acid base balance or pH of blood and tissue. However, it is important to have proper dietary ranges and ratios of these monovalent minerals (Cations or + charges ions, and anions or – charges ions), without causing deficiency or toxicity, in order to meet the nutritional demands and obtain optimum performance (Borges *et al.*, 2003).

2.8 Seaweed Production

Seaweed refers to any large benthic algae that are multicellular, macrothallic, and this differentiates them from most algae that are macroscopic in size (Crawford, 2002). These plants form an important renewable resource in the marine environment and have been part of human civilization from time immemorial. Reports on the uses of seaweeds have been cited as early as 2500 years ago in Chinese literature (Tseng, 2004). Seaweed production is growing at a fast rate. In 2000 the production was about 10.1 million tones wet weight with an economic value of U$5.6 billion (FAO, 2002). The major producers of seaweeds are China, followed by Japan and Korea.The majority of seaweed produced is used for human consumption and for the extraction of hydrocolloids. Figure 1: Represents variation in Seaweed Production per species in Zanzibar (2001- 2008).

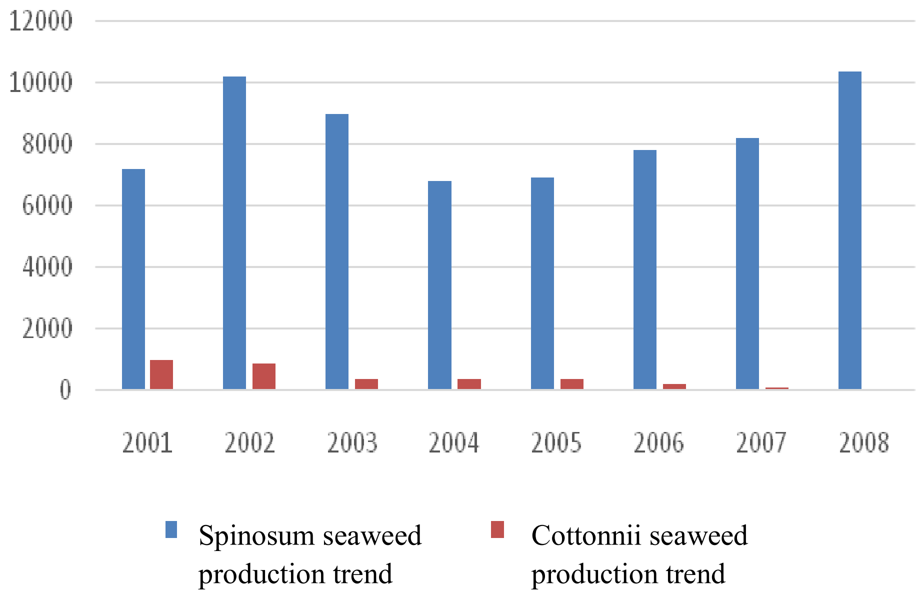

Figure 1: Variation in Seaweed Production per species in Zanzibar (2001- 2008)

Source: DFMR – Zanzibar (1990)

In Europe seaweed is relatively new development and only a small number of commercial seaweed farms are found (FAO, 2002).

Two species of seaweeds (Rhodophyta) *Euchema denticulatum* commercially known as “Spinosum” and *Kappaphycus alverezii* commercially known as “cottonii" have been farmed since 1989 in Zanzibar Islands and recently coastal communities in Tanzania mainland (Msuya, 2006). The two species are the only red algae reported to be exported from Tanzania (from both wild and established seaweed farms). The two types differ in the amount of carageenan contained in their cell wall and this results in differences in their prices. These species are found in abundance in East Africa marine waters and they were collected from the wild for export while unprocessed to France and Denmark (Bryceson, 2002). Over the years in Tanzania seaweed was only exported from Zanzibar Islands although recently the mainland coastal areas have also started producing significant amount of seaweed. Nonetheless there has been a decline in cottonii production over the years.

2.9 Nutritive Value of Seaweed

Seaweeds are classified based on anatomy, pigmentation, morphology and chemical composition as green (chlorophyta), brown (phenophyta) and red (rhodophyta) algae (Dawczynski *et al*., 2007). Reports on certain edible seaweed have shown that many varieties contain significant amount of protein, vitamins and minerals, essential for human nutrition (Wong and Cheung, 2000). Among the edible seaweeds of the red algae type are Porphyra, Palmaria, Gracilaria, Gelidium and Eucheuma (MacArtain *et al.,* 2007).

The institute de Phytonutrition in France (2004) carried out the study on nutrients composition of seaweeds compared to whole food; and analysed that seaweeds are high in mineral due to their marine habitat, and the diversity of the mineral they absorb is wide. Important mineral such as calcium, accumulate in seaweeds at much higher levels than in terrestrial food stuff, as presented in Table 3.

The nutrient composition of seaweed is affected by species, geographical area, season of the year, water temperature, salinity and harvesting time (Krishnaiah *et al*., 2008). These sea-vegetables are of nutritional interest since they are low caloric food, but rich in vitamins, minerals and dietary fibre (Ito and Hori, 1989). Studies on chemical composition showed that seaweeds contain on wet weight basis 6.9% total protein, 24.7%

crude fribre, 3.3% total lipids and 22.7% Ash (Tusche *et al.,* 2011). These values when compared to several local vegetables showed that the protein level in *Gracilaria. changgi* (6.9%) was much lower than that of soya bean, but slightly higher than peas and broccoli and much higher than that of most green vegetables. Seaweeds contain high amounts of minerals (8 - 48%) which include macro and the trace elements needed for human and animal nutrition (Mabeu and Fleurence, 1993). The wide range in mineral content, not found in edible land plants, is related to factors such as seaweed phylum, geographical origin, seasonal, environmental and physiological variations and processing (Mabeau and Fleurence, 1993; Nisizawa *et al.*, 1987 and Yoshie *et al.*, 1994). The mineral content of some seaweeds represent 30% of the DM and is higher than that of land plants and animal products (Madhusudan *et al.,* 2011; Ito and Hori, 1989).

In most land vegetables, ash content ranges from 5 to 10 g/100 g dry weight (USDA, 2001) e.g. potato 10.4, carrot 7.1 and tomato 7.1. Sweet corn has a lower content (2.6%); whereas, spinach has exceptionally high mineral content (20.4%) for land plants. Thus edible marine seaweeds may be an important source of minerals (Nisizawa *et al.*, 1987), since they can provide some trace elements that are lacking in land vegetables. The vitamins in seaweed meal include ascorbic acid, tocopherols and some B_1 vitamins (Madhusudan *et al.*, 2011). Due to the high levels of nutrients particularly vitamins and minerals contained in seaweeds when compared with upland vegetables (terristerial water vegetables), many researchers have recommended seaweeds to be used as food supplement to both human and animals so as to help to meet the recommended daily intake of some essential nutrients and trace elements (Rupérez, 2002; Fleurence, 1993).

Table 3: Mineral composition of seaweeds compared to whole foods

Type of food	Calcium	Pottasium	Magnesium	Sodium	Copper	Iron	Iodine	Zinc
Seaweed(mg/100g wet weight)								
Ascophyllum nodosum	575.0	765.0	225.0	1173.8	0.8	14.9	18.2	NS
Laminaria digitata	364.7	2013.2	403.5	624.6	0.3	45.6	70.0	1.6
Himanthalia elongate	30.0	1351.4	90.1	600.6	0.1	5.0	10.7	1.7
Undoria pinnatifida	112.3	62.4	78.7	448.7	0.2	3.9	3.9	0.3
Porphyra Umbilicalis	34.2	302.2	108.3	119.7	0.1	5.2	1.3	0.7
Palmaria palmata	148.8	1169.6	97.6	255.2	0.4	12.8	10.2	0.3
Chondrus crispus	373.8	827.5	573.8	1572.5	0.1	6.6	6.1	NS
Ulva spp	325.0	245.0	465.0	340.0	0.3	15.3	1.6	0.9
Enteromopha spp	104.0	351.1	455.1	52.0	0.1	22.2	97.9	1.2
Whole food(mg/100g weight)†								
Brown rice	110.0	1160.0	520.0	28.0	1.3	12.9	NA	16.2
Whole milk	115.0	140.0	11.0	55.0	Tr	0.1	15.0	0.4
Chedder cheese	7200.	77.0	25.0	670.0	0.0	0.3	39.0	2.3
Sirloin steak	9.0	260.0	16.0	49.0	0.1	1.6	6.0	3.1
Lentils green&brown	71.0	940.0	110.0	12.0	1.0	11.1	NA	3.9
Spinach	170.0	500.0	54.0	140.0	0.0	2.1	2.0	0.7
Banana	6.0	400.0	34.0	1.0	0.1	0.3	8.0	0.2
Brazil nut	170.0	660.0	410.0	3.0	1.8	2.5	20.0	4.2
Peanuts	60.0	670.0	210.0	2.0	1.0	2.5	20.0	3.5

Values for seaweeds from the Institut de Phytonutrition (2004)
† Values for whole foods from Mc Cancer *et al* (1993)
Abbreviations: NA, no data available; Tr, trace

2.10 Proximate Composition of Different Seaweeds

Knowledge of the nutrient composition of marine macroalgae is both important for the animals feeds (Hawkins and Hartnoll, 1983), as well as human food (Abbott, 1988) and for the evaluation of potential sources of carbohydrates, protein and lipids for industrial use (Chapman and Chapman, 1980). Seaweeds are nutritionally valuable either as fresh or dried vegetables, or as ingredients in a wide range of prepared food (Robledo and Pelegrin, 1997). Other species of edible seaweeds contain significant quantities of protein, lipids, minerals and vitamins but the nutrient content may vary with species, geographical location, season and temperature (Norziah and Ching 2002; Wong and Cheunge, 2000; Kaehler and Kennish, 1996 and Dawes *et al*., 1993).

Table 4: Mean (±SE) contents of carbohydrate from selected Mandapam coastal region (Gulf of Mannar) southeast coast of Tamilnadu during August 2011

S/N	Name of the species	Lipid%	Carbohydrate%	Crude Protein%
1	*Gracillaria corticata*	5.2±0.94	43.33±2.61	6.33±0.43
2	*Sargassum longifolium*	8.2±1.57	16.8±0.7	18.65±1.21
3	*Turbinaria conoides*	3±0.56	14.9±1.08	15.9±1.22

Source: Narasimman, (2012)

Nutritional properties of feed ingredients are mostly estimated from their chemical composition alone (Darcy-Villion,1993; Mabeau and Fleurence, 1993). In comparison with land plants (vegetables) the chemical composition of seaweeds has been poorly investigated and most of the available information is mainly for the traditional Japanese seaweeds (Fujiwara-Arasaki *et al*., 1984; Watanabe and Nisizawa, 1984). Table 4 above shows Proximate composition of some seaweeds and Table 5 shows mineral composition of Spinosum seaweed.

Table 5: Mineral composition of spinosum seaweed

Mineral composition	Ca	Mg	K	P	Na	Cu	Zn	Fe
Macro-elements (%)	0.59	0.76	11.91	0.04	4.79	-	-	-
Micro-elements (ppm)	-	-	-	-	-	7.50	13.00	66.00

Source: Ruperez, (2002)

2.11 Potential of Seaweeds on Livestock Production

Several studies have been conducted to assess the possibility of using seaweeds as feeds or feed additives or supplement in animal diets. The literature has shown that, seaweeds are a good source of minerals, carbohydrates, vitamins and some essential amino acids like arginine, tryptophane and phenylalanine (Marín *et al.*, 2009). Additionally, no antinutritinal elements have been detected in seaweeds (Carrillo *et al.,* 2002 and Casas – Valdez *et al.,* 2006). Seaweeds or seaweeds extracts can potentially be used as feed additives (Gardiner *et al.*, 2008) for both performance improvement and pathogenic reduction (Allen *et al.*, 2001).

The study by Gahan *et al.* (2009), showed that, seaweeds can replace lactose in piglets diets. The study also revealed that lactose-seaweeds interaction at certain combinations, increased average daily gain (ADG), average daily feed intake (ADFI) and Feed Conversion ratio (FCR). Another study by Hansen *et al.* (2003) and Al-Shorepy *et al.* (2001), showed that seaweeds under certain circumstances could be used as an alternative energy feed source for ruminants.

2.12 Potential of Seaweed on Poultry Feeding (layers/broilers)

Modern intensive animal production require the application of different types of feed additives to ensure good growth rate and efficiency production (Michalak and Chojnacka, 2009). Increased growth rate and milk/meat/eggs production greately increases nutrients requirement particularly minerals (Michalak and Chojnacka, 2009). In the present research, a new biological form of minerals feed additive is proposed (Chojnacka, 2007). The marine microalgae Ulva prolifera, enriched with micro-elements in the biosorption process, is a unique combination of biological and condensed form of micro-elements (Saeid *et al.*, 2013). Some reports have shown that the color of the skin of broiler chicks and legs as well as egg yolks, are the important qualities that can be improved by feeding algae (Leng *et al*., 2014).

It is important to underline that, the form of feed additive selected for use in animal feeding should be locally available, with high biological value, low cost, stable and have positive effect in the diet (Glencross *et al.,* 2007). After considering these requirements, micro-algae could be an essential mineral supplement in poultry feeds.

Studies have shown that, marine macroalgae are permanently covered in nutrient rich seawater, as a result they absorb high levels of minerals thus become an important source of food, feed, fertilizer and chemical (Dhargalka and Pereira, 2005). Macroalgaes proteins are characterized by high digestibility about 98% (in comparison with reference casein) (Aguilera-Morales *at el*., 2005; Wahbeh, 1997). Some seaweeds like Ulva contains a full range of essential amino acids (g/100 g of protein). Table 6 shows Essential Amino acid content found in some species of Ulva seaweed.

The microalgae amino acid content is well balanced and contains most of the essential amino acids needed for life and health (Aguilera-Morales *et al.*, 2005; Wahbeh, 1997).

Additionaly, macroalgae are very good source of Vitamin A, B_1, B_{12}, C, D, E, Ribloflavin, niacin, panthothenic acid and folic acid (Dhargalka and Pereira, 2005). Furthermore, seaweeds are also known to be rich in minerals, hence to some extent seaweed can be used as mineral source of livestock and plant agriculture (Michalak and Chojnacka, 2009).

Table 6: Essential amino acid content found in some species of Ulva seaweed

Seaweed species	Types of Amino acid contents (in g/100g of protein)									
	Histidine	Arginine	Lysine	Isolysine	Leucine	Phenelalamine	Tryptophan	Threonine	Valine	Methionine
Ulva prolifera	3.4	3.1	2.9	2.9	4.3	3.7	2.9	3.7	4.0	4.0
Ulva lactuca	8.5	3.0	4.4	3.3	4.6	11.0	5.7	2.7	5.3	5.3
Ulva angusta	1.6	4.5	4.6	5.0	7.5	3.3	2.2	6.5	7.8	7.8

Source: Aguilera-Morales, (2005)

The mineral composition of some seaweeds (such as Ulva) is higher than that of grains, which are frequently used as the main component of fodder. The content of ash in grains varies from 1.4% in maize to 2.73% in Oats (Jozefiak *et al.*, 2007). This is much lower than ash content in microalgae although it is dependent on species and the area of occurrence but it ranges from 18.8 to 31.6% (Szefer and Skwarzec, 1988).

Study by Michalak *et al*. (2011) showed that, diets fed to laying hens supplemented with two marine macroalgae Enteromopha prolifera and Cladophora spp enriched with microalgae [Cu(II), Zn(II), Co(II), Mn(II), Cr(III)] as mineral source instead of inorganic minerals resulted into higher microelements transfer to the eggs and enhanced the colour of yolk. It was further observed that diets containing macroalgae led to increased egg weight, egg shell thickness as well as body weight of hens.

2.13 Use of Seaweed in Broiler Diets and Its Effect on Broiler Performance

Studies to assess the potential of seaweed in broiler diets, showed insignificant effect on final body weight, carcass weight, and dressing percentage (Pantjawidjaja, 2011). However, a study by Abudabos *et al*. (2013), showed that, diets containing 4.5% seaweed gave better broiler growth rate, than those containing 0 % and 0.5 %. It was also found that, seaweed led to higher dressing percentage and lower abdominal fat compared to control diet. In other studies it was noted that the use of seaweed in poultry diets as an alternative ingredient to corn showed no differences in Feed intake (FI), body weight gain (BWG) and feed conversion ratio at inclusion levels of 0, 1.0 and 3.0%. The effects of Seaweeds on broiler performances are inconsistent EL-Deek *et al.* (2011) observed high body weight and body weight gain when broilers were fed on 0.2, 4 and 6%. However, increases in blood plasma concentration only occurred at 2% level. Insignificant differences were also observed on feed intake and feed conversion ratio, when seaweed was provided at 0, 4, 8 and 12% in broiler starter diet (EL-Deek and Brikaa, 2009). In the same study insignificant effects were also reported for growth, dressing percentage, gizzard weight as well as muscles (thigh and breast).

2.14 Limitation of Seaweed on Broilers Production

Extensive published literature on the suitability of different algae strains which can be used as animal feeds, has shown that, there are no adverse effects for seaweeds use in poultry diets at the levels of 5% to 10% (E-L Deek *et al.,* 2011). However, the use of algae at high concentrations has negative effects (Zaki *et al.,* 1994). Diets containing seaweeds exceeding 10% were found to affect growth performance, carcass composition and feed utilization of the common carp (cyprinus carpio L) fingerlings. It is believed that, reduced efficiency of feed ulitization associated with the diet containing higher levels of seaweeds, is due the presence of antinutritional factors known to influence the digestion and utilization of many nutrients (Zaki *et al.,* 1994). Algae carbohydrates, are in the form of starch, glucose and polysaccharides and have high digestibility and poses no limitation on the use of algae in dried food and feed (Backer, 2004). Algae fats consist of glycerol and bases which esterifies to saturated and unsaturated fatty acids, some of which are of particular importance in the animals body (Tzovenis *et al.*, 2003). A study by Moh'd and Ching, (2000), showed that, seaweeds such as Glacilaria changgi contained a higher composition of unsaturated fatty acids (74%), mainly omega fatty acids and 26% of saturated fatty acids (mainly palmitic acid).

The chemical composition of seaweeds is not affected by primary processing such as washing. Tannin as anti-nutritional factor in seaweed is only detected at low levels (EL-Deek and Brikaa, 2009). Some seaweeds such as Macrocystis pyrifera have been found to have higher in vivo and vitro dry matter (DM) digestibility being 90.34 and 83.24% respectively (EL-Deek and Brikaa, 2009). The study by Lahaye *et al.* (1994) reported that, seaweeds had the total dietary fiber content ranged between 32.7 and 74.6 % (on dry matter weight basis) of which 57.6 to 85.0 % were water soluble.

2.15 Literature Conclusion

The literature reviewed shows that, seaweeds can be used as an alternative feed ingredient in livestock diets (ruminant and monogastric). This is because seaweeds contain all necessary nutrients (both macro and micro elements) needed for the growth and performance of the animals.

However, only a few studies on use of seaweeds as source of minerals preximes have been carried out. Most of the studies done emphasize the use of seaweed as foodstuffs, although it could be worthwhile to use seaweeds products as source of minerals premix in the broiler diet. In seaweeds producing areas like Zanzibar; the approach could minimize poultry production cost interms of mineral supplementation and ultimately broiler farmers would save this cost. Seaweeds meal is very rich in many nutrients needed for normal growth and general performance of the animals. In viewing the literature, there was lack of information on the use of solely seaweed as a mineral premix.

Additionally, the available information as regards to the use of seaweeds is still contradictory and appears to have unpredictable effects on broiler performances. In the same cases it depressed performance while in others it seemed to improve performance. In view of these, it is therefore important to carry out a study so as to determine the optimal level of seaweeds to be used as mineral premix in the broiler diets and its effect on broiler performance under the Tanzanian conditions.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Area of Experiment Study

The study was conducted at Kizimbani Agriculture Training Institute in Zanzibar (KATI) about 5 kilometers from Zanzibar Town. The Institute is situated at latitude 6^0 South, longitude 39^0 East and 20 m above sea level. The area receives an average rainfall of 1564 mm/annum and annual average temperature of 25.7^0C.

3.2 Experimental Diets and Preparations

Dried Seaweed was obtained at the selling point i.e Zanzibar East Africa Company (ZANEA), from Unguja Island. The obtained seaweed was sun dried one day before grinding afterwhich it was well packed in polythene bags and stored at room temperature. Other feed ingredients including maize bran, sunflower meal, fish meal, maize meal, broiler premix, DL- Methionine, salt, limestone and other were purchased from Agrovet shops and were then stored at room temperature.

The chemical composition of both seaweed meal and other feed ingredients were determined at the DASP Laboratory for Proximate analyisis and at Soil Science Laboratory for minerals analysis before the diets were compounded. Four dietary treatments (T1, T2, T3 and T4) were locally compounded and their chemical and minerals compositions were determined, using AOAC (1995). The dietary treatments contained different levels of seaweed as mineral premix, Treatment one (T1) no seaweed (0% seaweed) it contained (0.25% commercial premix as control), Treatment two (T2) had 0.9% seaweed, Treatment three (T3) 1.5% seaweed and Treatment four (T4) contained 2% seaweed. All experimental diets were thoroughly mixed, well packed in 50kg bag, and marked accordingly for easy identification i.e T1, T2, T3 and T4, and were then stored at room temperature ready for feeding.

The estimated Crude Protein (CP) and Metabolisable Energy (ME) of each ingredient in the diet was calculated by taking the estimated values of Crude Protein and Metabolisable Energy of the ingredients multiplied by the inclusion level in the diet. Calculated CP and ME of each experimental diet was obtained by adding calculated CP and energy of all ingredients present in the diet. Table 7 shows physical composition of the experimental diets and their calculated CP and energy.

Table 7: Physical composition of the experimental diets (%)

	Levels of seaweed meal			
Ingredient	T1	T2	T3	T4
Seaweed meal	0	0.875	1.5	2
Maize meal	68	68	68	68
Maize bran	10	9.25	7.68	7.25
Fish meal	16	16	16	16
Sunflower meal	5	5	5	5
DL-Methionine	0.25	0.25	0.25	0.25
Broiler premix	0.25	0.125	0.07	0
Limestone	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Total	100	100	100	100
Calculated CP%	19	19	19.30	19.25
Calculated Energy ME kcal/kg	3047.35	3028.00	3016.39	3005.55

T1 = 0% seaweed; T2 = 0.9% Seaweed; T3 = 1.5%; T4 = 2% Seaweed

3.3 Experimental Design and Birds' Management

The experiment involved the evaluation of the effect of seaweed on growth performance and carcass quality of broilers birds. A total of two hundred and forty (240), day old broiler chicks were purchased from “Thuirachicks and Company” in Zanzibar and were brooded together for one week at Kizimbani poultry unit. Before placing chicks in the brooder room the initial weight of each chick was taken and recorded, and chicks were provided with “Vitalyte” (feed additive containing some minerals, electrolyte and essential amino-acids) during the first 5 days. During the preliminary period i.e. first week of age brooding period all chicks were offered a commercial diet *ad libitum* purchased from one Agrovet shop in Zanzibar. At the same time the brooder was provided with drinkers to meet the requirement of chicks as far as water was concerned. The inside temperature was maintained at $35^{\circ}C$, the electric bulbs were well placed in the brooder to ensure the constant supply of the required heat.

After one week, the chicks were assigned to their respective treatments and each treatment was replicated four times with fifteen (15) chicks in each replicate making total of (240 chicks). The rearing rooms floor were covered with wood shavings and feeding and drinking equipments were put in place. During the growing period day light was used as source of light during day time whereas electrical bulbs were used at night. All chicks were vaccinated against Newcastle disease on day seven, and on day twelve they were vaccinated against Infectious Bursa disease and it was repeated at day 19. At four weeks of age all chicks were provided with amprolium (ant-coccidiosis) as prophylaxis for 3 days.

3.4 Experimental Procedure and Data Collection

The broiler chicks’s performance was evaluated by using change in body weight (growth rate), feed intake and feed conversion ratio.

3.4.1 Growth rate

As mentioned before, all chicks were initially weighed on individual basis and their weights were recorded before being introduced in the brooding room. During this time chicks were wing tagged for easy identification. Weighing of chicks was done on a weekly basis to get weekly weight of each bird. Weight difference between t_1 and t_2 was used to calculate weight gain as shown in formula 1.

The Growth rate was calculated as follows:-

$$W = \frac{Wt_2 - Wt_1}{t_2 - t_1} \quad \text{...(1)}$$

Where by:

W = average daily weight gain g/d (growth rate)

Wt_1 = Initial live weight

Wt_2 = Final live weight

T_1 = Time 1 (day zero)

T_2 =Number of days at disposal

3.4.2 Feed intake and feed conversion ratio

Feed intake was determined by weighing the amount of feed offered and feed refusal in each pen (replicate) on a daily basis. Feed intake per pen was obtained by calculating the difference between the total weight of feed given and weight of the refusal feed (left over feed). However, Feed conversion ratio (FCR) was obtained by dividing the total feed intake with total weight gain of all birds in each pen as shown in formula 3.

Feed intake was obtained by using formula 2.

Feed intake (FI) = Feed offered – Feed refusal…………………………………………...(2)

$$\text{Feed Conversion ratio (FCR)} = \frac{\text{Feed intake}}{\text{Average daily gain}} \quad \text{...(3)}$$

3.5 Carcass Characteristics

After seven weeks, two broiler chicks were randomly selected from each replicate for slaughter, (making a total of 32 broiler chicks for the whole study). Slaughtering was done by cutting off the head, at the head neck using a sharp knife. After slaughter each bird was soaked in hot water at (70°C) for 2 minutes followed by removal of feathers. The feet were carefully cut off at the tibia femur joint afterwhich the abdomen was incised at the mid ventral using a sharp knife and then whole gastro intestinal tract was removed. Edible organs (Gizzard, liver, spleen and heart) were separated from the gut, each internal organ was separately weighed. The percentage of the component was calculated as weight of the component over the live weight as shown in the formular 4.

$$\%\ \text{weight of component} = \frac{\text{Weight of component}}{\text{Live weight}} \times 100 \quad \ldots\ldots(4)$$

The gizzard was longitudinally opened so as to remove the contents and the inner membrane before weighing. After removal of all internal organs the carcass weight of each chicken was measured and then halved along the spine. Tissue from the breast, thigh and drumstick were separated and tissue distribution i.e fat, muscles and bone were also determined and expressed as percentage by using formular 5.

$$\%\ \text{tissue} = \frac{\text{Weight of tissue}}{\text{Weight of component}} \times 100 \quad \ldots\ldots(5)$$

Where by weight of component could be breast, thigh and drumstick weight.

Dressing out percentage was calculated as shown in the formula 6.

$$\text{dressing}\ \% = \frac{CW}{LW} \times 100 \quad \ldots\ldots(6)$$

Where by:

CW = carcass weight; LW = live weight.

Meat samples from the breast, thigh and drumstick muscles were taken from each bird for tenderness assessment.

3.5.1 Chemical analysis of individual feedstuff and dietary treatments

Samples of individual feed ingredient and experimental diets were analysed for their content of DM, CP, CF, EE, ME, AA, ASH, MC, Ca, P, Fe, Mn, etc; according to AOAC (2005) and Atomic Absorption Spectrophotometer (for macro and micro elements analysis).

3.5.2 Tenderness determination

The meat samples (muscles) from the breast, thigh and drumstick used for the determination of tenderness were preserved in a deep freezer at -20°C for about 48 hours then weighed and refregirated overnight at 4ºC. After refrigeration the meat samples were mopped (minced) and re-weighed, ready for vaccum packing procedure. After packing the meat was cooked in a water bath set at 70ºC for 1hr, then the samples were removed from water bath and were put in cold water and then refrigerated for 24 hours.

After refrigeration the samples were removed from the polythene packs and water was drained, then weighed again, thereafter the cooking loss was determined by calculating defferent between two weights (weight of meat samples before cooking and weight of meat samples after cooking). The meat samples were sliced into one centimeter cubes (cm^3) thickness and were subjected to the Warner Bratzler Shear Force (WBSF) machine (Zwick/Roell Z2.5. Germany) for tenderness determination (Available at DASP- SUA). The shaped rectangular meat blocks were cut (length 2.5 x width 1.0 x height x 1.0 cm^3) and each block was sheared perpendicular to the muscle fibre direction, then Zwick was set with 30KN load cell, with a crosshead speed of 100mm/min. The values for meat tenderness of the samples were displayed in N/cm^3 and were recorded in excell sheet then statistically analysed (SAS, 2000).

3.6 Data Processing

Collected data from each treatment were entered into the computer data base (excel sheet) ready for statistical analysis (SAS, 2000).

3.7 Statistical Analysis

The obtained data were analysed using 2 models. Dietary treatments were regarded as independent variables while weight gain, feed intake, feed conversion ratio (FCR) and carcass characteristics were dependent variables. The data were analysed by using the General Linear Model (LGM) procedure of (SAS, 2000). The statistical models used are shown in section 3.7.1 and 3.7.2.

3.7.1 Analysis on weight gains and carcass characteristic

$Yijk = \mu + Tij + (X_2 - X_1) + eijk$ ....(7)

Where; $Yijk$ = Effect of the i^{th} dietary treatments on the j^{th} bird in k^{th} period

μ =General mean effect

Tij = Effect of i^{th} dietary treatment on j^{th} birds

X_2 = Final group mean weight after k^{th} period

X_1 = Initial group mean

$Eijk$ = Random error.

3.7.2 Analysis of feed intake

$Yij = \mu + Ti + ßj + eij$ ....(8)

Where; Yij = expected observation in each experimental unit

μ = General mean for all observation

Ti = effect of i^{th} treatment in the j^{th} replication

$ßij$ = effect of j^{th} replication within treatment i^{th}

eij = experimental random error.

CHAPTER FOUR

4.0 RESULTS

4.1 General Condition of the Birds

The results were gathered based on real situation which took place at the experimental site, Kizimbani Agriculture Training Institute. Generally all chicks were in good health and there was no death throughout the experimental period. This showed that, the survival of the birds and health status were not affected by the addition of the seaweeds in the diets of broilers.

4.2 Chemical Composition of Feed Ingredients used in Compounding Experimental Diets

The chemical composition of feedstuffs used in the preparation of the experimental diets are summarized in Table 8, CP content was highest in fish meal (47.55%) and lowest in seaweed (5.42%). Highest CF (26.33%) was noted in sunflower meal whereas it was lowest in fish meal (0.93%). EE was higher in maize bran (14.73%) and lower in seaweed (0.3%) where as DM was almost similar in most ingredients but was high (97.68%) in fish meal and lower (94.59%) in the seaweed. lysine was highest (4.53%) for fish meal and lowest in seaweed (0.69%). tryptophan was highest (0.7%) in maize bran and lowest (0.03) in maize meal. No methionine/cystine was detected in seaweed, however the highest was 2.13% in fish meal and lowest was 0.12% in maize meal. Ash content was higher in seaweed 47.65% and lowest 1.35% in maize meal.

Table 8: Proximate composition of individual feed ingredients

Sample names	%CP	%CF	%EE	%DM	%Lysine	%Tryp	%Met/ Cyst	%Ash	Kcal/kgDM ME
Maize meal	9.29	2.59	3.53	95.08	0	0.03	0.12	1.35	2889.9
Seaweed (Spinosum)	5.42	3.29	0.3	94.59	0.69	0.14	0.00	47.65	873.1
Sunflower cake	23.74	26.33	4.65	97.44	1.07	0.23	0.84	7.44	1821.1
Maize bran	16.91	10.15	14.73	96.57	0.00	0.7	0.25	5.67	2827.8
Fishmeal (Ocean fish meal)	47.55	0.93	2.68	97.68	4.53	0.55	2.13	46.16	2701.5

KEY: CP = Crude Protein; CF = Crude Fibre; EE = Ether Extract; DM = Dry Matter; Tryp = Tryptophan; Met/Cyst = Methionine/cystine; ME = Metabolisable Energy

4.3 Chemical Composition of the Feed Ingredient (Seaweed Spinosum)

The results for chemical composition (mineral composition) of the tested feed ingredient (seaweed) as mineral premix is presented in Table 9.

Table 9: Proximate, mineral and amino acid composition of seaweed

Proximate	Macro mineral (%)	Micro mineral (ppm)	Amino acid (%)
DM (%) 94.59	Ca 0.59	Cu 11.09	Lysine 0.69
CP (%) 5.42	Mg 1.54	Zn 18.99	Trypto 0.14
CF (%) 3.29	K 13.48	Mn 22.95	Meth/Cyst 0
NFE (%)56.66	Na 6.71	Fe 523.22	
Ash (%) 47.65	P 0.03		
ME kcal/kg 873.1			

KEY: Macro-elements: Ca = Calcium: Mg = Magnesium: K = Pottasium: Na = Sodium: P = Phosphorus: and for the Micro-elements: Cu = Copper: Zn = Zinc: Mn = Manganase: Fe = Iron: Amino acid: Lysine, Trypto = Tryptophan, Met/Cyst= Methionine/Cystine: CP = Crude protein: CF= Crude fiber: EE = Ether extract: NFE: Nitrogen free extract: DM= Drymatter: MC= Moisture content: ASH= Mineral: kcal/kgDM ME = Kilocalories per kilogramdrymatter metabolisable energy

4.4 Chemical Composition of the Treatments Compounded diet for Broilers

The chemical composition of compounded diets is shown in Table 10. There was no significant difference for Dry matter (DM) content observed between the experimental diets. Crude protein was similar for T_1 and T_4, and was slightly lower for T_2 and T_3. The level of Ether Extract (EE), was similar for T_1, T_2 and T_4 treatments but slightly lower for T_3. Additionally, T_2 and T_4 had higher crude fibre (CF) compared to T_1 and T_3. An increase in moisture content with increasing seaweed inclusion was noted.

Table 10: Chemical composition of the experimental diets

Nutrients	T_1	T_2	T_3	T_4
DM (%)	90.73	90.05	89.95	89.73
CP (%)	21.13	17.66	18.16	21.84
EE (%)	5.1	5.23	4.73	5.09
CF (%)	1.74	2.99	1.81	2.86
ASH (%)	6.01	6.28	7.45	5.84
MC (%)	9.27	9.99	10.06	10.27
NFE (%)	43.25	42.15	42.21	45.9
Lysine (%)	1.4	1.48	1.62	1.63
Tryptophan (%)	0.38	0.42	0.84	0.84
Met/Cyst (%)	0.84	0.84	0.83	0.83
K (%)	0.43	0.40	0.45	0.58
Ca (%)	0.59	0.74	0.56	0.69
P (%)	0.49	0.52	0.58	0.45
Ca:P ratio	1.18	1.14	0.97	1.53
Mg (%)	0.15	0.16	0.15	0.17
Na (%)	0.18	0.18	0.26	0.33
Cu (ppm)	4.33	3.27	3.27	2.20
Zn (ppm)	41.55	41.07	36.78	38.21
Fe (ppm)	212.77	181.34	181.34	263.85
Mn (ppm)	16.729	15.052	13.375	12.536
ME kcal/kgDM	3007.35	3008.00	3019.55	3013.39

KEY: DM = Dry Matter; CP = Crude Protein; EE = Ether Extract; CF = Crude Fibre; ASH =ASH; MC = Moisture Content; K= Pottasium; Ca = Calcium; Mg = Magnesium; P = Phosphorus; Na = Sodium; Cu = Copper; Zn = Zinc; Fe = Iron; Mn = Manganase; ME = Metabolisable Energy; kcal = kilocalories; kg = kilogram; T_1 = 0% seaweed; T_2 = 1% Seaweed; T_3 = 1.5% Seaweed; T_4 = 2% Seaweed

4.5 Effect of Dietary Treatments on Growth Performance

4.5.1 Body weight

Table 11 shows the least square means for body weight and Appendix 2 shows the ANOVA Table of broiler chicken fed the experimental diets. Significant differences ($P < 0.05$) in growth performance of broiler chicken between the dietary treatments were noted. Body weight was higher for T3 and T4, lower for T1 throughout the experiemental period. The inclusion of seaweed resulted in increased body weight. However, minor differences in weight gain between T3 and T4 were also noted.

Table 11: Least square means (± SE) for body weight at different ages in birds fed different dietary treatments

	Dietary treatments				
Age (Weeks)	T1	T2	T3	T4	P- value
Day 0	40.7±0.46	39.8±0.4	39.0±0.4	40.2±0.4	0.0612
2	352.0±6.9[b]	367.9±7.5[a]	385.8±7.5[a]	382.7±7.5[a]	0.0037
3	604.8±14.4[c]	614.9±15.7[bc]	673.9±15.7[a]	651.4±15.6[ab]	0.0003
4	926.7±22.3[b]	964.9±24.4b[ab]	1018.6±24.4[a]	1034.8±24.3[a]	<0.0001
5	1346.6±30.5[c]	1416.7±33.3[b]	1567.3±33.4[a]	1476.6±33.1[b]	<0.0001
6	1743.6±39.7[c]	1815.7±43.4[b]	2013.3±43.5[a]	1894.4±43.2[b]	<0.0001
7	2275.3±42.7[c]	2293.6±46.7[bc]	2549.0±46.9[a]	2415.2±46.5[b]	<0.0001

[a,b,c] Least square means with the different letter script within the same row are significantly different ($p < 0.05$)
KEY: T1 = 0% Seaweed; T2 = 1% Seaweed; T3 = 1.5% Seaweed; T4 = 2% Seaweed

4.5.2 Effect of dietary treatments on growth rate of broilers

The effect of dietary treatments on weight gain in broilers chickens is shown in Table 12 and its ANOVA Table is presented in Appendix 3. The results showed progressive increase in weight from week 2 to week 7. Weight in T3 and T4 at the second week of age (2wk) was the effect of experimental diets, since chickens were subjected to the experimental diets from day 7 of age. Significant differences in live weight gain throughout the experimental period between the dietary treatments were noted. T1 (control) had higher weight gain at week 7 compared to the other experimental treatments ($P < 0.5$). However, T1 compared to T3 and T4 had insignificant weight gain ($P > 0.05$).

Table 12: Least square means (± SE) of weight gains of experimental broilers chicken from to 2 to7 weeks of age

	Dietary treatments				
	T1	T2	T3	T4	P - value
(Weeks)			Weightgain(gms)		
2	184.7±5.4^{b}	193.9±5.9^{b}	212.0±5.8^{a}	212.8±5.9^{a}	0.0005
3	251.1±9.0^{b}	244.3±9.9^{b}	289.0±9.8^{a}	269.9±9.8^{ab}	0.0019
4	322.4±10.3^{a}	350.4±11.3^{b}	346.9±11.1^{b}	385.9±11.1^{c}	<0.0001
5	416.2±12.1^{a}	452.2±13.3^{b}	549.9±13.0^{c}	442.6±13.0^{b}	<0.0001
6	399.6±19.3^{a}	406.2±21.2^{a}	451.4±20.9^{a}	428.0±20.9^{a}	0.0708
7	541.2±21.9^{b}	472.3±24.0^{a}	534.5±23.7^{b}	519.8±23.6^{b}	0.0007

a,b,c Least square means with the different letters script within the same row are significant different ($p < 0.05$)
KEY: T1 = 0% Seaweed; T2 = 1% Seaweed; T3 = 1.5% Seaweed; T4 = 2% Seaweed

4.6 Effect of Dietary Treatment on Drymatter Intake

The least square means on DM intake are presented in Table 13 and the ANOVA Table is available in Appendix 4. An increase in Drymatter (DM) intake with age of chickens was noted in the dietary treatments. Throughout the experimental period intake was highest for T3 but inconsistent variations were observed between the other dietary treatments.

Table 13: Least square means (± SE) on dry matter intake of broilers from 2 to 7 weeks of age

	Dietarary treatments				
	T1	T2	T3	T4	P - Value
Age (Weeks)					
2	304.7±9.3	310.2±9.3	321.6±9.3	311.3±9.3	0.7823
3	461.4±13.8	445.1±13.8	499.3±13.8	479.9±13.8	0.1764
4	655.6±10.5^{a}	737.2±10.5^{c}	764.6±10.5^{c}	731.1±10.5^{b}	0.0013
5	810.5±17.8^{a}	846.5±17.8^{a}	979.3±17.8^{b}	900.3±17.8^{a}	0.0023
6	940.9±29.9	949.0±29.9	1099.7±29.9	1030.2±29.9	0.0544
7	928.1±50.9	849.1±50.9	1022.4±50.9	910.9±50.9	0.3738
TDMINT(gms)	4101.3±85.3^{a}	4137.1±85.3^{b}	4686.9±85.3^{d}	4363.7±85.3^{c}	0.0129

a,b,c Least square means with the different letters script within the same row are significant different ($p < 0.05$)
KEY: TDMINT = Total dry matter intake; T1 = 0% Seaweed; T2 = 1% Seaweed; T3 = 1.5% Seaweed; T4 = 2% Seaweed

4.7 Effect of Dietary Treatment on Average Daily Gain, Dry Matter Intake per Bird and Feed Conversion Ratio

The least square means on average daily gain (ADG), dry matter intake per bird (DMINT/B) and feed conversion ratio (FCR) are presented in Table 14 and Appendix 5 shows the ANOVA Table. The effect of dietary treatments on average daily gain was insignificant (P > 0.05) although minor differences were noted whereby T3 was a higher, followed by T4 and T2 and the lowest was T1. A similar trend was noted for drymatter intake per bird. No significant difference between dietary treatments was observed for overall feed conversion ratio.

Table 14: Least square means (± SE) for broiler performances on average daily gain, drymatter intake per bird and feed conversion ratio for broiler chickens

	Dietary treatments				
	T1	T2	T3	T4	P – Value
Variables					
ADG	$45.8{\pm}0.1^{b}$	$47.3{\pm}1.0^{b}$	$50.9{\pm}1.0^{a}$	$48.8{\pm}1.0^{ab}$	0.1179
DMINT/B	$83.7{\pm}1.7^{b}$	$84.4{\pm}1.7^{b}$	$95.7{\pm}1.7^{a}$	$89.1{\pm}1.7^{b}$	0.0129
FCR	$1.8{\pm}0.0^{ab}$	$1.8{\pm}0.0^{b}$	$1.9{\pm}0.0^{a}$	$1.8{\pm}0.0^{ab}$	0.1988

a,b,c Least square means within the same row with at least one common letter script do not differ significantly (p > 0.05)
KEY: ADG = Average daily gain; DMINT/B = Drymatter intake per bird; FCR = Feed conversion ratio; T1 = 0% Seaweed; T2 = 1% Seaweed; T3 = 1.5% Seaweed; T4 = 2% Seaweed

4.8 Effect of Dietary Treatments on Final weight gain, Carcass and Non-carcass Component on Broiler Chicken

Table 15 shows the least square means for carcass and non-carcass components of broiler chicken fed diets containing different levels of Seaweed (Spinosum) and the ANOVA Table is presented on Appendix 1. Inclusion of Seaweed affected some parameters of carcass and non-carcass components. Final body weight was affected by inclusion of seaweed in the diet whereby a higher weight was noted for T_3 and T_4 and was slightly lower for T_1 and T_2. Carcass weight was highest for T_3 and lowest for T_1 and the differences between the treatments were significant. The trend for dressing percentage, was similar to that of carcass weight and whereby highest dressing percentage was in T_3 followed by T_4, T_2 and lowest in T_1. No significant differences were observed for breast, thigh, drumstick and head percentages between dietary treatments. Statistical differences between treatments were observed for legs but there was no significant difference for GIT %, GIT Length, Liver % and Heart % between all dietary treatments. On the other hand, gizzard % was lowest for T_3.

Table 15: Effect of dietary treatments on carcass and non-carcass components at 7 weeks of age

	T1	T2	T3	T4	P – Value
Variables					
Final body wt(gms)	2229.4 ± 100.5^{a}	2271.9 ± 100.5^{b}	2481.9 ± 100.5^{a}	2465.0 ± 100.5^{a}	0.0056
Carcass wt(gms)	1673.8 ± 83.0^{b}	1730.6 ± 83.0^{ab}	1961.3 ± 83.0^{a}	1903.8 ± 83.0^{ab}	0.0035
Dressing %	75.0 ± 0.7^{c}	76.0 ± 0.7^{bc}	79.0 ± 0.7^{a}	77.2 ± 0.7^{ab}	0.0039
Breast %	7.5±0.3	7.4±0.3	8.3±0.3	7.8±0.3	0.2257
Thigh %	5.9±0.4	6.8±0.4	6.0±0.4	6.2±0.4	0.5389
Drumstic %	4.8±0.2	4.9±0.2	4.8±0.2	4.8±0.2	0.8435
Head %	2.3±0.1	2.3±0.1	2.3±0.1	2.1±0.1	0.3903
Legs %	3.7 ± 0.2^{ab}	4.0 ± 0.2^{a}	3.4 ± 0.7^{b}	3.7 ± 0.7^{ab}	0.0031
GIT %	4.7±0.3	4.9±0.3	4.3±0.3	4.6±0.3	0.7682
GIT Leng %	7.6±0.4	8.1±0.4	7.6±0.4	7.6±0.4	0.9675
Gizzard %	2.6 ± 0.2^{a}	2.4 ± 0.2^{ab}	1.8 ± 0.2^{b}	2.0 ± 0.2^{b}	0.0334
Liver %	2.0±0.2	2.0±0.2	2.1±0.2	2.1±0.2	0.7665
Heart %	0.5 ± 0.1^{a}	0.5 ± 0.1^{a}	0.5 ± 0.1^{a}	0.5 ± 0.1^{a}	0.0334
Spleen %	0.1 ± 0.0^{a}	0.2 ± 0.0^{b}	0.1 ± 0.0^{a}	0.1 ± 0.0^{a}	>0.0001

[a, b, c] Least square mean within the same row with at least one common letter script do not differ significantly ($p > 0.05$)

NOTE: Values are expressed as percentage of live weight

4.9 Effect of Dietary Treatment on Lean, Bone and Fat

The least square means on lean, bone and fat are shown in Table 16 and its ANOVA Table is available on Appendix 6. The effect of dietary treatments on lean, bone and fat showed no significant difference between treatments. The effect of seaweed as mineral premix for bone was insignificant but values in T1 and T2 were slightly higher than T3 and T4. Proportion of fat was slightly affected by treatment whereby an increase with increasing levels of seaweed was noted.

Table 16: Least square means (± SE) for broiler performances on lean, bone and fat

	Dietary treatments (%)				
	T1	T2	T3	T4	P - Value
Variables					
Lean	56.4±1.5	56.5±1.5	59.6±1.5	59.5±1.5	0.3179
Bone	18.9±0.8	18.6±0.8	17.5±0.8	17.8±0.8	0.7550
Fat	9.2±10.9	9.9±10.9	24.7±10.9	25.4±10.9	0.3565

KEY: T1 = 0% Seaweed; T2 = 1% Seaweed; T3 = 1.5% Seaweed T4 = 2% Seaweed

4.10 Effect of Dietary Treatments on Tissue Distribution

The effect of dietary treatments on tissue distribution of breast, thigh and drumstick are presented in Table 17 and the ANOVA Table on Appendix 8. The present study observed insignificant differences ($P > 0.05$) between the dietary treatments as far as muscles were concerned for each tissues (breast, thigh and drumstick). However the breast muscles were a bit heavier in T_3, followed by T_1, T_2 and T_4 was the last. Chickens from T_1 had heaviest thigh muscles whereas the lowest were from T_2.

For drumstick muscle chickens from T4 were a bit heavier, followed by T3, then T1 and T2 had lighter muscles. The difference in weight of bone for breast and thigh was insignificant ($p > 0.05$). But variations were noted in breast bone, T2 was slightly heavier, followed by T1, then T3 and T4. For Thigh bone, heavy weight was noted in T4, then followed by T3, T1 and T2. However, highly significant differences ($P < 0.05$) were noted for the bone of drumstick. The weight of drumstick bone from chicken in T4 was heavier, then T3, T2 and T1 was the lowest.

Differences in fat weight, were insignificant ($P > 0.05$) between all tissues (breast, thigh and drumstick) in their respective dietary treatments. Heaviest breast fat was noted in T4, followed by T2, then T1 and last one T3. Thigh fat was highest in T2, then T3, followed by T4 and lastly T1. drumstick's fat, was similar across all treatment diets.

Table 17: Least square means (± SE) on tissue distribution of breast, thigh and drumstick of broiler chickens

	Dietary treatments				
Variables	T1	T2	T3	T4	P- Value
Breast Muscle	97.6±1.0	97.0±1.0	97.8±1.0	96.8±1.0	0.8708
Bone	1.0±0.4	1.1±0.4	0.9±0.4	0.8±0.4	0.9741
Fat	1.3±0.8	1.8±0.8	1.2±0.8	2.3±0.8	0.7153
Thigh Muscle	79.6±3.5	69.9±3.5	78.9±3.5	77.9±3.5	0.2411
Bone	12.5±0.9	11.9±0.9	12.6±0.9	13.8±0.9	0.5130
Fat	7.9±1.7	10.4±1.7	8.4±1.7	8.3±1.7	0.7451
DrumstickMuscle	70.5±1.5^{ab}	66.9±1.5^{b}	70.7±1.5^{ab}	73.0±1.5^{a}	0.0819
Bone	1.0±0.0^{d}	2.0±0.0^{c}	3.0±0.0^{b}	4.0±0.0^{a}	<0001
Fat	2.5±0.6	2.5±0.6	2.5±0.6	2.5±0.6	1.000

KEY: T1 = 0% Seaweed; T2 = 1% Seaweed; T3 = 1.5% Seaweed; T4 = 2% Seaweed

4.11 Effect of Dietary Treatments on Tenderness of Broiler Meat

The effect of seaweed inclusion in the diet as mineral premix on tenderness of different parts of broiler meat chicken is presented in Table 18 and ANOVA Table on Appendix 7. The results in this study showed that, difference in tenderness for breast, drumstick and thigh muscles between the treatments were insignificant ($P > 0.05$), although shear force values were lowest for T1 and higher in T2, T4 and T3. However, significant differences ($P < 0.05$) tenderness for drumstick muscles between the dietary treatments were noted. The highest tenderness was for T3 and the lowest was in T4.

Table 18: Least square means (± SE) on tenderness of different parts in broiler chicken fed on diet supplemented with different level of seaweed as minerals source

	Dietary treatments				
	T1	T2	T3	T4	P - Value
Variables					
Breast	19.4±1.7	20.1±1.7	21.3±1.7	20.5±1.7	0.8320
Thigh	15.8±1.2	16.7±1.2	16.2±1.2	19.9±1.2	0.1334
Drumstick	16.0±1.2	16.2±1.2	15.1±1.2	20.1±1.2	0.0343

KEY: T1 = 0% Seaweed; T2 = 1% Seaweed; T3 = 1.5% Seaweed; T4 = 2% Seaweed

CHAPTER FIVE

5.0 DISCUSSION

5.1 Chemical Composition of Feed Ingredients used in the Experimental Diet

With the exception of seaweed as one of the feed ingredients used in the preparation of diet, which has already been explained above, other chemical compositions of feed ingredients used, i.e. Maize meal, Maize bran, Sunflower Cake, Fish meal, some of the compositions were within the range as reported in other studies (Mlay *et al.,* 2005; Olugbemi *et al.,* 2010; Kakengi *et al.,* 2007).

The CF content of 26.33 % and 10.15 % for sunflower and maize bran respectively obtained in the present were significantly different from values of 59.1% sunflower and 31.9% maize bran obtained by Mlay *et al.* (2005). These differences could be due to processing methods such as decortication/dehulling before extracting oil from sunflower. Likewise chemical compositions of fish meal reported by Kakengi *et al.* (2007) was different from the one obtained in present study.

The present study obtained the chemical compositions of fish meal, as 47.55% CP; 0.925% CF; 2.68% EE; 97.68% DM; 46.16% ASH, while reported by Kakengi *et al.* (2007) were 56.6% CP; 1.4% CF; 9.95% EE; 87.9% DM; 30.3% ASH. The variations in chemical composition of fish meal, could be due to the size and origin of the fish, (i.e sea or fresh water) since salinity of the water plays a significant role in mineral composition of fish, the issue of quality parameters such as muscle composition, fat deposition, muscle fat acid composition, type of fish, either cultured or wild can also affect content (Grigorakis *et al.*, 2002).

5.2 Chemical Composition Spinosum Seaweed

The chemical compositions particularly minerals of the seaweed (spinosum) obtained in the present study were within the range reported in other studies (Norziah and Cheng, 1999; Rupérez, 2002). However, variations for trace elements from the same studies were noted. The variations in the nutrient composition of the seaweed in the present study compared to findings reported in other studies might be due to differences in varieties, growing condition, sea salinity, geographical area and method used for harvesting and processing (Marinho-Soriano *et al.,* 2006; Chan *et al.*, 1997).

The level of 0.69% for lysine obtained in the present study was significantly lower than values reported elsewhere ranging from 1.13 to 7.0mg/100g. The reasons for these differences could be due to factors such as protein content of the seaweed species, time of harvesting as it is believed that during spring protein content of the seaweed is higher than in the summer and autum (Khairy and El-Shafay, 2013). On the other hand the presence of tryptophan and lack of methionine/cystine observed in current study was contrary to the findings of other studies whereby substantial levels of methionine/cystine were detected ranging from 0.39% to 5.85 mg/100 g (E-L Deek and Brika, 2009; Ito and Hori,1989). The underlying cause for these differences is unclear although it could be varietal differences and analytical errors.

Most of the analysed chemical components in the present study were within the range Manivannan *et al.* (2009); Narasimman (2012); Manivannan *et al.* (2008) and Murugaiyan *et al.* (2012). However, for crude protein (CP %) wide variations have been noted ranging from 9.65 to 31.07% CP, this could be a reflection of differences in seaweed varieties. Carbohydrate (NFE) level of 56.66% obtained in the present study was higher than 43.33% reported by the above researchers. The variations in chemical composition in seaweed might be due to various factors that include species, time of harvesting, geographical area where seaweed is cultivated, salinity of the sea (Marinho-Soriano *et al.,* 2006). Additionally, it is also believed that the drying methods can be among the factors contributing in minerals leakage, such as sun-drying which might cause leaching due to long exposure time to the sun (Chan *et al.,* 1997).

5.3 Chemical Composition of the Broiler Dietary Treatments

The chemical compositions of the compounded dietary treatments was mostly a reflection of individual feed ingredients used. The experimental diets were initially planned to contain 19% CP for all the dietary treatments with the exception of minor differences at T3 and T4 where it was 19.30% CP (T3) and 19.25% CP (T4). However the analysed results of the compounded diet showed that CP % content was higher and lower in some dietary treatments from the original plan. The variation in CP content of the experimental diets was unexpected and reasons for this are unclear, although it could be due to mixing procedure of the dietary feeds, since it was done manually. On the other hand, the energy of the compounded diets was comparable to the calculated content and was within the range (Pantjawidjaja, 2011).

The variations between calculated and actual composition of the diets might be due to existing variation in feed composition, improper sampling for laboratory analysis or improper mixing since this was done manually. The differences in nutritive value of feed ingredients between published and actual are mostly caused by several factors that include plant variety, stage of maturity at harvesting, processing and storage condition (Tiwari *et al.,* 2006; Laswai *et al.,* 2002; Gerasimenko *et al.,* 2010). This feature shows the importance of analyzing feed components before feed formulation is done. The prolonged exposure to high temperature of tropical feedstuffs also has a negative effect on the nutritive value and therefore affecting the chemical composition of compounded diets. It has also been noted that most of the commercial broiler diets in tropical countries contain low CP (16 - 18%) probably due to the nature of the feed ingredients that are used. (Widyaratne and Drew, 2011). However, studies have shown that these levels of CP to some extent support optimal broiler growth, Azarnik *et al.* (2010) and Rostagno *et al.* (2007) reported that this could be due to high environmental temperature condition.

5.4 Effect of Dietary Treatments on Growth Performance

5.4.1 Effect of dietary treatments on growth rate of broilers

The mean weight gain of birds across the dietary treatments from the second to seventh week presented in Table 12, showed no significant difference between dietary treatments. The increased weight gain observed in the present study was an indication that, the quality and intake of drymatter for the dietary treatments was good. The weight gains obtained in present study were within the range reported by Hernández *et al.* (2013). The observed trend for increased weight gain especially in the second week and fourth week of age was associated with increased dry matter intake. On other hand the observed decline in live weight gain during week 6 could be a reflection of normal growth pattern of animal. The rate of growth of animal accelerate during the early stages of growth and thereafter decline as mature weight is approached (McDonald *et al.*, 2010).

5.5 Effect of Dietary Treatment on Drymatter Intake

The present study showed that, feed intake of the broiler chicken at six weeks of age was between 3.2 to 3.7 kg. This value was similar to the values reported by Sundu and Dingle (2008) for the same age of broilers which ranged between 3.1 to 3.7 kg of feed per bird. The reason of this might be due to low CF and EE of the experimental diets which accelerated feed intake and digestion of the feed ingredient. The total feed intake on dry matter basis for the four dietary treatments ranging between 4.1 to 4.7 kg per bird for the whole experimental period and was within acceptable levels reported elsewhere (Yu *et al.,* 1990).

The results of the present study showed increases in feed intake during the fourth, fifth and sixth weeks, in comparison with the second and third week. This was probably due to the acclimitization of the broiler chicks to the experimental diets containing seaweed. The lowest feed intake for T1 on dry matter basis in relation with other dietary treatment (T2, T3 and T4), as shown in Table 13 from the second up to seventh week of age was an indication of nutrient adequacy but this also showed that diets supplemented with seaweed (as premix) stimulated appetite of broiler chickens. However, high overall drymatter intake including the control diet, was a reflection of good energy balance. since it is understood that, amongst dietary factors affecting feed intake is the concentration of energy in the diet (Eekeren *et al.,* 2006).

5.6 Effect of Dietary Treatments on Average Daily Weight Gain, Dry Matter Intake per bird and Feed Conversion Ratio

The gradual increase of average weight gains of birds with increasing seaweed in the diet compared to those fed the control diet was an evidence that, seaweed inclusion did not affect feed intake and general performance. It was also speculated that seaweed might have a stimulatory effect for feed intake due to the presence of appreciable levels of sodium chloride. This further illustrated that the dietary treatments with seaweed inclusion (as mineral source), were better than the control diet. However, the difference observed between T3 and T4 indicated that the inclusion of 1.5% (seaweed spinosum) in combination with some low levels of commercial premix gave best results. However, in order to reach a valid conclusion further research is needed.

Overall feed conversion ratio of the present study, showed that there was no significant difference in all dietary treatments. Values for FCR mainly depend on two factors, the growth rate and feed intake and both are mostly affected by the quality of the diet. High FCR is obtained when feed intake is high and growth rate is low as would happen with an unbalanced diet (Simol *et al*., 2012). The study of Magala *et al.* (2012) observed that higher dietary energy with low protein resulted into slow growth of the chicken and hence decreased weight gain. This was probably due to a decrease in intake of other nutrients such as amino acids which are essential for growth in broiler chickens. Feed conversion ratio obtained from the current study agree within the normal range and the results agree with FAO (2010) which reports that normal FCR for broiler is 2, however this value depends on the number of factors such as feed quality, age of birds and duration where birds exposed to light. Therefore the FCR obtained in this study is within the expected range.

5.7 Effect of Dietary Treatment on Final weight gain, Carcass and Non-carcass Component of Broiler Chickens

The final means of live weight of broiler birds across the experimental diets at seven week of age ranged from 2.2 in T1 and 2.5kg in T4. The higher final weight observed in seaweed based diets (T3 and T4) in the present study was probably due to physical properties of seaweed such as high solubility, high nitrogen free extract and low antinutritional factors (Rioux *et al*., 2007; AL- Harthi and EL-Deek, 2012). Another reason could be that the level of seaweed in the diets of the present study was within the acceptable limit, since it is believed that seaweed promote growth rate up to 5%, when the level is beyond 5% decline in growth rate is noted, possibly due to increased level of antinutritional factors contained in some seaweed species (Zaki, 1994).

The results of the current study concor with the findings by El-Deek and Brikaa, (2009), who reported weight of 2.3kg of broiler birds during disposal. The minor differences in final body weight between findings of the present study and other studies was probably due to individual variation such observe since male animal have higher live weight gain and carcass weight compared to female (Broadbent *et al.,* 1981). Similar results of increasing body weight and other carcass components were also reported by El-Deek and Brikaa (2009) when inclusion of seaweed in pelleted diets resulted into better feed efficiency.

The carcass components such as breast, thigh and drumstick were not significantly affected by dietary treatment probably due to similarity of amino acids availability in the dietary treatments. The cause for the observed increase in spleen % noted in T2 in comparison with other dietary treatments is not clear. However, studies by Wong and Cheung, (1991) and El- Deek *et al.* (2011) showed that some wild species of seaweed *Colpomenia sinuosa* led to increased weight of internal organs such as the kidney. This feature could be probably due to the presence of Antinutritional factor (ANF) whereby the detoxification processes tend to sometimes increase organ weight.

The lighter gizzard weight for T_3 was probably due to the nature of the feed. The presence of acqueous milleu might have softened the feed, thereby increasing passage rate and solubility. This in turn led to less grinding/mechanical action by the gizzard. Similar results were reported by Promthong *et al.* (2007), whereby broilers fed cassava pellet diet showed lower gizzard weight than those fed corn or cassava chips diets. The insignificant differences for liver % amongst all dietary treatments was probably due to equal supply of glucose for hepatic regulation of blood glucose and its accumulation in the form of glycogen. Whether the increase of liver weight is caused by such proposed mechanism is not very clear. The cause for the slightly higher liver weight value obtained in the present study compared with the one reported by EL-Deek and Brikaa, (2009) is not clear although it might be associated with type and species of the seaweed used. The increase in absolute weight for legs observed in the present study for T2 and T4 conformed to the findings reported by Hamdi *et al.* (2015), who found that Tibia weight and bone mineralization were influenced by level of Calcium whereby low-Calcium diet resulted into lower bone weight and ash content. Also these results agree with the findings obtained by Onyango *et al.* (2003) who stated that, bone – mineral content, bone mineral density and ash percentage increased linearly as the level of dietary calcium increased from 0.45 to 0.91%. The observed low Ca level in T3 despite high seaweed (1.5%) compared to 1% in T2 and subsequent low leg % was unexpected (Table 10 and Table 15). Probably the unexpected results obtained in the present study might be due to uneven distribution of the individual feed ingredients during feed mixing (hand mixing). The insignificant differences observed for the other non- carcass components in the current study might be due to equal proportion of most of the required nutrients.

5.8 Effect of Dietary Treatments on Lean, Bone and Fat

The least square means on Lean, Bone and Fat are presented in Table 16, the effect of dietrary treatments on Lean percentage showed that,there was no significant difference between the treatments, however, minor variation were observed between them. In T1 and T2 had similar results (56.6 percentage) and the same situation with T3 and T4 (59.6 percentage). Based on the variations observed between treatments, we can still say that, the dietary treatments which had seaweed inclusion performed better than those receiving either small amount of seaweed or completelty no seaweed. The report by Castellini *et al.* (2002) mentioned that, chicken with access to grass had higher percentage breast and drumstick and lower abdominal fat, however, it also stated that organic production system seems to be a good alternative production method due to better welfare conditions and good quality of the carcass meat. However, the values of the present study to some extent resemble those reported by Pantjawidjaja (2011), the similarity could be due to type of seaweed used i.e *Euchema cottonii* and *Gracillaria verucosa*.

Dietary treatments had no significant effect on bone percentage, although minor variations were observed between the treatments. These results indicate that seaweed as a premix in the diet tended to have a positive effect on body bone development. The present findings were similar to that of Mutuş *et al.* (2006) who observed the effect of dietary supplemental probiotic on morphometric parameter and yield stress of the bones (tibia, tibiotarsal index). The similarity might be due to the minerals content available in the tested feed ingredient (seaweeds).

Dietary treatments of the present study showed no significant difference between the treatments as far as fat percentages was concerned, Yet differences in absolute weight within the treatments were noted whereby T1 and T2 had lighter weight of fat while T3 and T4 had the heaviest fat content. Heavy weight of fat in T3 and T4 could be due to the fact that, the dry matter feed intake of these two treatments were higher compared to T1 and T2. In that context, the broiler chickens under T3 and T4 consumed more calories, put on more weight, and had excess fat content compared to chickens in the other dietary treatments. Other studies showed that, naturally young animals including chickens need high concentration of nutrients in the diet during the early stages of growth in order to support multiplication of tissues and maintenance. The demand of nutrients decline towards attainment of maximum growth (Goliomytis *et al.,* 2003). For that reason, when the maximum growth of broiler is achieved the feed or nutrients are mainly used for maintenance only or fat deposition. However, the values obtained in the present study was different from that reported by AL-Deek and Brikaa (2009). The reason for the variations could be due to type of fat analysed such as (abnorminal and body fat), fat content of the diet, chemical compostion of the feed ingredients and mode of the diet preparation such as pellet or mash form.

5.9 Effect of the Dietary Treatments on Tissue Distribution

The least square means of dietary treatments on tissues distribution are presented in Table 17. The effect of seaweed inclusion (as mineral premix) was insignificant through out tissue distribution. The only significant difference was for the drum stick tissues (bone tissue) and there were high significant differences ($P < 0.05$) between the T3 and T4. The heaviest drumstick bones of broilers in T4 then T3 compared to those in T2 and T1 treatments could be an indication that, T3 and T4 containing higher percentage of seaweed (1.5 and 2 %) and that probably had higher mineral content thus influencing bone development. The increase in absolute weight for legs observed in the present study for T3and T4 conformed to the findings reported by Hamdi *et al.* (2015), who found that Tibia weight and bone mineralization were influenced by level of Calcium whereby low-Calcium diet resulted into lower bone weight and ash content. Also these results agree with the findings obtained by Onyango *et al.* (2013) who stated that, bone – mineral content, bone mineral density and ash percentage increased linearly as the level of dietary calcium increased from 0.45 to 0.91 %.

The non significant differences for tissue distributions such as lean especially breast muscle and fat tissues was an indication that, all dietary treatments had almost similar Crude Protein level in the diet. Bartov and Plavnik (1998) and Rostagno *et al.* (2007) reported that, inbalance level of CP in the broiler diet can lead to linear increases of fat deposition.

5.10 Effect of Dietary Treatments on Tenderness of Broiler Meat

The effect of experimental diets on tenderness of different parts of the broiler meat chicken is presented inTable 18 and showed that dietary treatments had no significant effect on tenderness. On other hand, the overall outcome showed that the meat in all dietary treatments were very tender since the maximum shear force values did not exceed 30 Newton. The tenderness of the meat is influenced by factors such as age, type and level of fatty acids in the diet. Normally a diet with low concentration of polyunsaturated fatty acids produces tender meat (Schilling *et al.,* 2010). In the present study the level and type of fatty acids available in the diet were not determined. However, the values for fat obtained in the present study were different from those reported by EL-Deek and Brikaa, (2009). The reasons for the differences might be age, type of chicks and level of fatty acid in the diet, could also be due to individual variation exist among the hybrid.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

i. The increase of seaweed level in the broiler diet moderately increased overall live body weight, feed intake and feed conversion ratio.

ii. Seaweed inclusion in the diet had effect on cumulative weight gain, average daily gain, weekly weight gain and drymatter intake per bird.

iii. Inclusion level of seaweed as mineral premix had effect on carcass yield and dressing percentage. However, no other effect was observed for breast, thigh and drumstick.

iv. The seaweed inclusion in the diet had no effect on non-carcass components as percentage, the only effect was noted in some component whereby reduction in spleen percentage was noted.

v. Inclusion level of seaweed had effect on overall body fat content whereby increase of body fat was observed in T3 and T4.

vi. The inclusion level of seaweed in the broiler diet had an effect on tissue distribution especially for bone tissues. There was increased weight of thigh and drumstick's bone in T3 and T4.

vii. Seaweed inclusion at 1.5 % (T3) had overall positive effect on all dependent variables i.e dietary treatments which contained 1.5 % can be considered as optimum in broiler diets.

6.2 Recommendations

As far as the present study is concerned, the seaweed inclusion level at 1.5 % (as source of premix) was the best, since good performance was observed for this dietary treatment. However, it can also be recommended that, broiler chickens supplemented with seaweed as premix, should be slaughtered at the age of six week, so carcass (subcutaneous /abdominal) fat content may be reduced, because it seems that, the diet with seaweed content increased apetite and thus more calories are taken by bird.

It is recommended that, further studies need to be done on the effects of seaweed in broiler chickens, layers and other class of poultry and livestock in general in mineral supplementation. Based on the potential of seaweed production in Tanzania the need of doing further research of various seaweed grown in the country is there, so as to understand their effect on animal performance.

Also due to variation of chemical composition of different seaweeds, studies are required to elucidate the potential of each.

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APPENDICES

Appendix 1: ANOVA Table: Effect of dietary treatment (with seaweed as premix) on carcass and non-carcass components

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The GLM Procedure

R-Square	Coeff Var	Root MSE	SBWT Mean		
0.407366	12.03142	284.1860	2362.031		
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Treat	3	405527.344	135175.781	1.67	0.1961

R-Square	Coeff Var	Root MSE	CWT Mean		
0.429490	12.91057	234.6295	1817.344		
Source	**DF**	**Type III SS**	**Mean Square**	**FValue**	**Pr > F**
Treat	3	450514.8437	150171.6146	2.73	0.0636

R-Square	Coeff Var	Root MSE	Dressing Mean		
0.423781	2.450241	1.882175	76.81594		
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Treat	3	69.89693438	23.29897812	6.58	0.0018

R-Square	Coeff Var	Root MSE	Breast Mean		
0.183341	12.22876	0.947534	7.748409		
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Treat	3	4.20143204	1.40047735	1.56	0.2220

R-Square	Coeff Var	Root MSE	Thigh Mean		
0.105359	17.87564	1.110694	6.213450		
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Treat	3	3.83698188	1.27899396	1.04	0.3921

R-Square	Coeff Var	Root MSE	Dstick Mean		
0.048952	11.24295	0.546692	4.862536		
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr >F**
Treat	3	0.06699389	0.02233130	0.07	0.9731

R-Square	Coeff Var	Root MSE	Head Mean		
0.136886	9.703152	0.219261	2.259688		
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Treat	3	0.16010937	0.05336979	1.11	0.3622

R-Square	Coeff Var	Root MSE	Leg Mean
0.434734	12.95641	0.478780	3.695313

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	1.34740938	0.44913646	1.96	0.1439

R-Square	Coeff Var	Root MSE	GIT Mean
0.063095	18.50400	0.851068	4.599375

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	1.18441250	0.39480417	0.55	0.6557

R-Square	Coeff Var	Root MSE	Liver Mean
0.063413	28.47526	0.576624	2.025000

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	0.14702500	0.04900833	0.15	0.9305

R-Square	Coeff Var	Root MSE	Spleen Mean
0.630970	22.68203	0.024312	0.107188

Source	DF	Type III SS	Mean Square	F Value	P >F
Treat	3	0.02713438	0.00904479	15.30	<.0001

R-Square	Coeff Var	Root MSE	Gizzard Mean
0.312140	26.12429	0.578816	2.215625

Source	DF	Type III SS	Mean Square	F Value	P >F
Treat	3	3.08951250	1.02983750	3.07	0.0445

R-Square	Coeff Var	Root MSE	Heart Mean
0.019794	40.75175	0.194080	0.476250

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	0.02042500	0.00680833	0.18	0.9085

R-Square	Coeff Var	Root MSE	GITLen Mean
0.191770	14.35138	1.112546	7.752188

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	1.61935938	0.53978646	0.44	0.7289

Appendix 2: ANOVA Table: Effect of Seaweed premix on Body weight (g/bird)

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The GLM Procedure

R-Square	Coeff Var	Root MSE	WTWK1 Mean
0.066914	13.75653	23.94152	174.0375

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	3	2325.192836	775.064279	1.35	0.2584
INTWT0	14	6840.301956	488.592997	0.85	0.6115

R-Square	Coeff Var	Root MSE	WTWK2 Mean
0.153711	12.12242	45.54898	375.7417

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	3	38869.02018	12956.34006	6.24	0.0004

INTWT0	14	21968.33277	1569.16663	0.76	0.7155

R-Square	Coeff Var	Root MSE	WTWK3 Mean
0.183791	14.71574	94.60505	642.8833

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	3	162162.8227	54054.2742	6.04	0.0006
INTWT0	14	124137.4763	8866.9626	0.99	0.4637

R-Square	Coeff Var	Root MSE	WTWK4 Mean
0.199354	14.72945	146.9508	997.6667

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	3	402124.1781	134041.3927	6.21	0.0005
INTWT0	14	207724.1328	14837.4381	0.69	0.7860

R-Square	Coeff Var	Root MSE	WTWK5 Mean
0.297650	13.71528	200.6832	1463.208

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	3	1382123.080	460707.693	11.44	<.0001
INTWT0	14	352814.256	25201.018	0.63	0.8423

R-Square	Coeff Var	Root MSE	WTWK6 Mean
0.285172	13.80934	261.7307	1895.317

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	3	2098341.907	699447.302	10.21	<.0001
INTWT0	14	639499.670	45678.548	0.67	0.8053

R-Square	Coeff Var	Root MSE	WTWK7 Mean
0.363518	11.72468	281.6044	2401.808

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	3	2500124.208	833374.736	10.51	<.0001
INTWT0	14	987836.924	70559.780	0.89	0.5707

Appendix 3: ANOVA Table: Effect of seaweed premix on weekly live weight gain

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The GLM Procedure

R-Square	Coeff Var	Root MSE	WTG2 Mean
0.175652	17.76736	35.80863	201.5417

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	3	32069.47379	10689.82460	8.34	<.0001
INTWT0	14	10328.05200	737.71800	0.58	0.8828

R-Square	Coeff Var	Root MSE	WTG3 Mean
0.161220	22.38026	59.78608	267.1375

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	3	68475.41580	22825.13860	6.39	0.0004
INTWT0	14	35728.74674	2552.05334	0.71	0.7593

R-Square	Coeff Var	Root MSE	WTG4 Mean
0.235152	19.11897	67.83092	354.7833

Source	DF	Type III SS	Mean Square	F Value	Pr > F

TREAT	3	112883.3773	37627.7924	8.18	<.0001
INTWT0	14	59540.4912	4252.8922	0.92	0.5333

R-Square	Coeff Var	Root MSE	WTG5 Mean		
0.431600	17.12652	79.73107	465.5417		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	3	586984.8752	195661.6251	30.78	<.0001
INTWT0	14	100839.9845	7202.8560	1.13	0.3301

R-Square	Coeff Var	Root MSE	WTG6 Mean		
0.113052	29.35670	127.4105	434.0083		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	3	93210.0688	31070.0229	1.91	0.1282
INTWT0	14	223328.5257	15952.0375	0.98	0.4720

R-Square	Coeff Var	Root MSE	WTG7 Mean		
0.172093	28.44033	144.0479	506.4917		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	3	157690.9698	52563.6566	2.53	0.0578
INTWT0	14	274376.8042	19598.3432	0.94	0.5118

Appendix 4: ANOVA Table: Effect of seaweed premix on drymatter intake (DMINT)

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The GLM Procedure

R-Square	Coeff Var	Root MSE	DMINT2 Mean		
0.256415	5.984239	18.66837	311.9589		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	598.6417500	199.5472500	0.57	0.6471
Replc	3	482.9621274	160.9873758	0.46	0.7157

R-Square	Coeff Var	Root MSE	DMINT3 Mean		
0.565399	5.858705	27.61987	471.4331		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	6579.739182	2193.246394	2.88	0.0957
Replc	3	2352.303713	784.101238	1.03	0.4253

R-Square	Coeff Var	Root MSE	DMINT4 Mean		
0.872613	2.898191	20.92855	722.1246		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	26142.92671	8714.30890	19.90	0.0003
Replc	3	860.39418	286.79806	0.65	0.5999

R-Square	Coeff Var	Root MSE	DMINT5 Mean		
0.855464	4.015773	35.50525	884.1449		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	64594.61342	21531.53781	17.08	0.0005
Replc	3	2556.71282	852.23761	0.68	0.5882

R-Square	Coeff Var	Root MSE	DMINT6 Mean		
0.685394	5.950824	59.80461	1004.980		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	67341.21030	22447.07010	6.28	0.0138
Replc	3	2785.78273	928.59424	0.26	0.8527

R-Square	Coeff Var	Root MSE	DMINT7 Mean		
0.450749	10.99076	101.9522	927.6171		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	61694.77640	20564.92547	1.98	0.1878
Replc	3	15076.61930	5025.53977	0.48	0.7019

Appendix 5: ANOVA Table: Effect of seaweed premix on Average Daily Gain, Dry Matter Intake per Bird and Feed conversion ratio

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The GLM Procedure

R-Square	Coeff Var	Root MSE	ADG Mean		
0.612469	4.204642	2.026361	48.19343		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	57.27151142	19.09050381	4.65	0.0316
Replic	3	1.13390161	0.37796720	0.09	0.9626

R-Square	Coeff Var	Root MSE	DMINTB Mean		
0.781182	3.945266	3.480094	88.20937		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	362.8352985	120.9450995	9.99	0.0032
Replic	3	26.2931609	8.7643870	0.72	0.5629

R-Square	Coeff Var	Root MSE	FCR Mean		
0.549869	2.783626	0.050932	1.829689		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	0.01783642	0.00594547	2.29	0.1469
Replic	3	0.01068293	0.00356098	1.37	0.3124

R-Square	Coeff Var	Root MSE	FER Mean		
0.541921	2.835454	0.015512	0.547076		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	0.00157625	0.00052542	2.18	0.1597
Replic	3	0.00098574	0.00032858	1.37	0.3144

Appendix 6: ANOVA Table: Effect of seaweed premix on Lean, Bone and Fat

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The GLM Procedure

R-Square	Coeff Var	Root MSE	LEAN Mean		
0.155120	7.357267	4.267695	58.00652		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	78.16849013	26.05616338	1.43	0.2556

R-Square	Coeff Var	Root MSE	BONE Mean		
0.065498	13.11957	2.383445	18.16710		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	10.73878249	3.57959416	0.63	0.6019

R-Square	Coeff Var	Root MSE	FAT Mean		
0.145083	178.8484	30.93313	17.29573		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	1927.374686	642.458229	0.67	0.5770

Appendix 7: ANOVA Table: Effect of seaweed premix on Tenderness

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The GLM Procedure

R-Square	Coeff Var	Root MSE	SFBR Mean		
0.051168	24.22354	4.928581	20.34625		
Source	DF	Type III SS	Mean Square	F Value	Pr> F
Treat	3	15.81859840	5.27286613	0.22	0.8837

R-Square	Coeff Var	Root MSE	SFTH Mean		
0.222816	19.89150	3.413143	17.15881		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	84.33027404	28.11009135	2.41	0.0886

R-Square	Coeff Var	Root MSE	SFDR Mean		
0.310493	20.42088	3.435227	16.82213		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	120.1412157	40.0470719	3.39	0.0322

Appendix 8: ANOVA Table: Effect of seaweed as mineral premix on Tissue Distribution

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The GLM Procedure

R-Square	Coeff Var	Root MSE	BRMUSC Mean		
0.055317	2.099063	2.042832	97.32114		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	2.93238971	0.97746324	0.23	0.8708

R-Square	Coeff Var	Root MSE	BRBN Mean		
0.017570	79.56976	0.797552	1.002331		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	0.13651266	0.04550422	0.07	0.9741

R-Square	Coeff Var	Root MSE	BRFAT Mean		
0.103154	91.15617	1.528263	1.676532		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	3.22361558	1.07453853	0.46	0.7153

R-Square	Coeff Var	Root MSE	THMUSC Mean		
0.285702	9.261174	7.096112	76.62216		
Source	DF	Type III SS	Mean Square	F Value	Pr >F
Treat	3	241.6887071	80.5629024	1.60	0.2411

R-Square	Coeff Var	Root MSE	THBN Mean		
0.168186	13.49013	1.713060	12.69861		
Source	DF	Type III SS	Mean Square	F Value	Pr >F
Treat	3	7.12015506	2.37338502	0.81	0.5130

R-Square	Coeff Var	Root MSE	THFAT Mean		
0.094074	38.70704	3.384555	8.744029		
Source	DF	Type III SS	Mean Square	F Value	Pr >F
Treat	3	14.27457380	4.75819127	0.42	0.7451

R-Square	Coeff Var	Root MSE	DMUSC Mean		
0.416100	4.299820	3.021643	70.27370		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	78.07766681	26.02588894	2.85	0.0819

R-Square	Coeff Var	Root MSE	DBN Mean		
1.000000	0	0	2.500000		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	20.00000000	6.66666667	Infty	<.0001

R-Square	Coeff Var	Root MSE	DFAT Mean		
0.000000	51.63978	1.290994	2.500000		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treat	3	0	0	0.00	1.0000