PERFORMANCE OF BROILER CHICKENS FED PEARL MILLET AS AN ENERGY SOURCE AND *ACACIA KARROO* LEAF MEAL AS AN ADDITIVE

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ABSTRACT

This study was undertaken to determine the performance and meat sensory attributes of broiler chickens fed with Pearl Millet (*Pennisetumg laucum*) as a replacement for maize, as well as the potential of tanniferous *Acacia karroo* (*A. karroo*) leaf meal as an additive on broiler leanness. The optimum level at which maize can be replaced by pearl millet was also determined. Nutritional compositions of pearl millet and *A. karroo* leaf meal were determined using the standard Association of Official Analytical Chemists protocols. One hundred and one day old chicks of the breed Cobb 500 were obtained from Namib Poultry Industries and raised on a two phase feeding regime (i.e. starter for 3 weeks and finisher for 4 weeks). During the finisher phase they were fed different treatment diets. In the first trial the treatment diets were formulated such that maize was replaced with pearl millet at levels of 25% (T2), 50% (T3), 75% (T4) and 100% (T5). A standard commercial finisher diet was used as the control (T1). Parameters studied were; voluntary feed intake, weight gain, feed conversion ratio (FCR), fat pad, breast weight, thigh weight, gizzard weight, meat sensory attributes and preference. In the second trial the standard commercial finisher diet was seeded with *A. karroo* leaf meal as an additive at levels of 0 g/kg (T1), 5 g/kg (T2), and 20 g/kg (T3), to study the effects on the feed intake, weight gain, feed conversion ratio (FCR), fat pad, breast weight, thigh weight, gizzard weight, meat sensory attributes. Feed intake was recorded daily while weight gain was recorded weekly. At the end of the feeding trials, 28 broilers were slaughtered at 42 and 49 days old and evaluated for organs

weight (thigh, breast, fat pad and gizzard) and average consumer acceptance. The results of this study have shown that the best replacement level of maize with pearl millet was at 50 %. It was however, found that the replacement of maize by pearl millet can be done up to 100% without producing significantly lower performance ($P>0.05$) compared to the optimum replacement i.e. at 50%. The study showed that feed manufacturers can use pearl millet as an energy source in place of the imported maize. Addition of 20 g/kg *A. karroo* leaf meal had a tendency to reduce fat deposition. More than 5 g/kg of *A. karroo* leaf meal may be added in order to improve fat expression. From the sensory evaluation trial, all the treatments did not affect the preferences significantly meaning the optimum levels of using pearl millet (as a substitute for maize) and *A. karroo* (as an additive) can safely be recommended without affecting the acceptability and preference of the broiler meat produced.

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List of abbreviations

A. karroo= *Acacia karroo*

ADFI= Average Daily Feed Intake

ADG= Average Daily Gain

ANOVA= Analysis of Variance

AOAC= Association of Official Analytical Chemists

CF= Crude Fiber

CP= Crude Protein

CRC = Cooperative Research Centre

CRD= Completely Randomized Design

FCR= Feed Conversion Ratio

GDP= Gross Domestic Products

HACCP= Hazard Analysis Critical Control Points

LSD= Least Significant Difference

MAWF= Ministry of Agriculture Water and Forestry

ME= Metabolizable Energy

NAB= Namibia Agronomic Board

NRC= National Research Council

NRF= National Research Foundation

P= Phosphorus

PER= Protein Efficiency Ratio

PM= Pearl Millet

PUFAs= Polyunsaturated Fatty Acids

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DEDICATION

This thesis is dedicated to my late mother Justina Hangula, (may your soul rest in eternal peace - mother I miss you) and my big brother Petrus Hangula, for their unconditional love, encouragement, support and constructive guidance during my childhood up to now. I sincerely appreciate everything they have done in my entire life.

DECLARATIONS

I, Sesilia Hafeni, hereby declare that this study is a true reflection of my own research, and that this work, or part thereof has not been submitted for a degree in any other institution of higher education.

I, Sesilia Hafeni, grant The University of Namibia the right to reproduce this thesis in whole or in part, in any manner or format, which The University of Namibia may deem fit, for any person or institution requiring it for study and research; provided that The University of Namibia shall waive this right if the whole thesis has been or is being published in a manner satisfactory to the University.

Signature... Date...
Sesilia Hafeni

CHAPTER 1

INTRODUCTION

1.1. Background

The broiler chicken industry is an important source of animal protein in Namibia, as evidenced by the increased demand (e.g. 60 000 kg per month in the northern regions of Namibia) for broiler meat by consumers (MAWF, 2008). The major advantage of broiler chicken meat is its lower iron contents (Farrell, 2010), lean meat, as well as more desirable unsaturated fatty acids (Appleby, 2010), therefore, it is perceived as healthy and nutritious as compared to beef and lamb. There are no universally accepted criteria for defining meat quality throughout the world (Monin, 2004). According to Borggaard and Andersen (2004), consumers decide on the quality of the meat which may differ according to culture.

The quality of the broiler chicken meat mainly depends on the quality of the diets fed to live birds. Nutritive value of a specific feed or diet is the function of feed intake and the efficiency of extraction of nutrients from the feed during digestion (Mandal, 1997). Feed intake of nutrients by broiler chickens is a function of the amount of feed eaten and the nutrient levels in the diet (Choct, 2012). Therefore, successful broiler production is dependent upon supplying the birds with feed of the highest achievable quality, in terms of ingredients used, processing procedures applied as well as the form in which the diet is presented to broilers (Arbor Acres, 2009).

Namibia is a Southern African country classified as semi-arid. This is because it receives very low rainfall, is generally hot and as a result water evaporates very easily. Namibian weather condition is characterized by low rainfall (mean annual rainfall of approximately 270 mm with the minimum of 20 mm) (Sweet & Burke, 2006), low soil fertility in terms of clay (5%) and nitrogen contents and high temperatures (ranging between 20^{o}C and 37^{o}C) (Sweet & Burke, 2006). Agriculture is the backbone of the Namibian economy as it provides needs for food and raw materials for many industries.

The Namibian poultry industry consists of two main sectors namely egg and meat production. Eggs are produced on commercial scale by four companies in the Erongo, Khomas and Oshikoto Regions. Until April 2012 when Namibia Poultry Industries (the biggest broiler farm in Namibia) started to fully function, broiler meat production was mainly based on subsistence farming with stocks of about 500 000 chickens (MAWF, 2008). Neither the egg nor the meat production levels realized can satisfy local demand.

As a result, Namibia is a net importer of eggs and chicken meat mainly from South Africa and Brazil. Chicken production in Namibia is limited by the scarcity and high cost of components used in manufacturing feeds as well as lack of chicken breeding skills among others. Feeds form a greater part of the variable costs of a chicken production operation amounting up to 70-80 % (Louw *et al.*, 2011). Producers with access to alternative feeds which are cheaper and locally available often tend to have economic advantage due to lower costs of production (Nader, 2006). It is therefore, advisable to identify possible ways to reduce the high costs of chicken feeds and one of them could be to replace conventional feed ingredients with cheaper, yet equally efficient, alternatives. This may be achieved by using locally available non-conventional feed stuffs as major components of chicken diets.

In broiler chicken production industry, cereal grains such as maize, sorghum, etc. and oilseeds, such as soybean and sunflower, makes up the majority of the dietary ingredients and account for a large portion of metabolizable energy, protein and amino acids (National Research Council, NRC, 1994). Maize is the most common cereal used in broiler diets as the main source of energy, in combination with soybean meal as a protein source (Panda *et al.,* 2010). This may be as a result of its high energy contents (True Metabolisable Energy (TME_n) value of 3, 448 kcal/kg) (Davis *et al.,* 2003), low fiber (22 g/kg) (Mehri *et al.,* 2010) better palatability, presence of pigments and essential fatty acids (Panda *et al,* 2010). Although maize is a major ingredient in chicken diets, as it constitutes at least 60% of all classes of chicken feed (Panda *et al.*, 2010), it is scarce (especially in semi-arid communities like those found in Namibia) and costly (Medugu *et al.,* 2010). Soyabean meal is used in chicken diets as a source of protein. Due to Namibian harsh climatic conditions very little if any is produced. Therefore, the bulk of what is used in feed manufacturing is imported from neighboring countries just like maize. When maize and soyabean meal are imported the cost of feeds usually rises beyond the reach of low resource farmers.

Pearl Millet (PM) and *Acacia karroo* (*A. karroo*) leaves are some of the local feeds which are readily available to most farmers in Namibia and can be used in chicken feeds as a source of energy and an additive respectively, to produce high quality lean meat. Pearl millet is well known for its high protein (12-14 %) and lysine (0.38-0.41 %) contents as compared to maize, corn and sorghum (Adeola and Rogler, 1994; Davis *et al.,* 2003; Singh, 2004; Garcia and Dale, 2006). Therefore, it reduces the need for high protein feed ingredients and supplemental amino acids (Singh and Perez-Maldonado, 2003), which may reduce feed costs. A study by Medugu *et al.* (2010), indicated that the cost per kg of feed and cost of feed per unit weight were lowest in pearl millet followed by high-tannin sorghum, low-tannin sorghum and maize based diets respectively. This suggests that the replacement of maize by pearl millet would be economical and also cost effective.

A. karroo leaf meal is known for its high contents of tannins and reasonable amount of protein. High contents of tannins limit the use of proteins by the body reducing the excess body fat deposition in broiler chickens hence decreasing the occurrence of cardiovascular diseases (Fisher and McNab, 1997). There was no study done in Namibia to determine the economic and performance of broiler chickens fed pearl millet and *A. karroo* leaf meal. Therefore, the aim of the present study was to investigate the growth performance, economics as well as the fat deposition of broiler chickens fed pearl millet as a replacement of maize and *A. karroo* leaf meal as an additive under Namibian environmental conditions.

1.2. Problem statement

Although Namibia has been regarded as a 100% importer of chicken meat, broiler chicken meat is the major source of protein for the Namibian consumers (Ministry of Agriculture, Water and Forestry (MAWF), 2008). Namibian broiler meat market is dominated by imports from South African producers some with capacities up to 3 million chickens per month, while the commercially feasible minimum capacity in Namibia is about 20 000 chickens per month (MAWF, 2008). On the national level, imports were valued at about N$165 million in 2006, which amount to about 9 million kg of chicken meat (MAWF, 2008). These results have clearly indicated that there is a considerable demand for broiler meat in Namibia which the local poultry industry cannot meet. One may ask why the Namibian poultry industry cannot satisfy this demand. Well, there are many factors which contribute to the failure to meet the local demand of broiler meat. One of them being the strong competition from huge producers in South Africa with regards to price, therefore, an emerging infant industry of this nature can be destroyed if the South African producers decide to deliberately lower the price of their chickens as has been experienced in the past (MAWF, 2008).

The poor broiler production capacity in Namibia is also due to costly feeds which are manufactured using imported raw materials like maize and soya bean meal. Maize and soya beans which are major ingredients of broiler diets are costly and are not readily available in Namibia. The cost of broiler feedstuffs depend on the ingredients used to formulate the feeds, therefore, cheaper yet equally efficient, alternatives to maize and soya bean meal which are readily available in Namibia are required to reduce feed costs and promote local chicken enterprises.

No studies in Namibia have been done to show the potential of both pearl millet and *A. karroo* leaf meal as the energy ingredient and as a meat fat reducing additive in poultry diets respectively. Pearl millet is a popular cereal in Namibia and has been successfully cultivated for centuries by smallholder famers. *A. karroo* trees are naturally distributed in Namibia especially in the southern areas.

1.3. Significance of the study

This study was carried out in order to provide an understanding on how pearl millet can be successfully incorporated into broiler diets as a replacement of maize and *A. karroo* leaf meal as an additive, without reducing the broiler performance but rather increase and improve the quality of the broiler meat. The study was aimed at reducing the cost of broiler diets, which would promote the broiler meat production in Namibia. The results of this study will therefore, add knowledge on how much of pearl millet and *A. karroo* leaf meal can be incorporated into the diet in order to maximize the production while at the same time minimizing the cost, given the Namibian environmental conditions. Local poultry feed manufacturers tend to benefit as they are likely to start using local ingredients. Local pearl millet Producers are likely to gain better value for their crop if it becomes an input in the local feed industry. The study is aimed at demonstrating the potential of substituting maize and adding an additive in broiler finisher rations.

1.4. Objectives

1.4.1. General Objective

The general objective of this study was to study the performance of broiler chickens fed pearl millet as a replacement of maize as well as the effect of *A. karroo* leaf meal level as an additive to lower fat deposition in the carcasses.

1.4.2. Specific Objectives

The specific objectives of the study were to:

I) Determine the growth performance and carcass quality of broiler chickens when maize is replaced with pearl millet under Namibian weather conditions and determine the optimum replacement levels of maize with pearl millet in broiler diets.

II) Determine the effects of feeding maize-soybean meal based diets with a tanniferous additive (*A. karroo* leaf meal) on the fat deposition of broiler chickens and determine the optimum levels of *A. karoo* as an additive.

III) Determine the economics of production of broiler chickens when maize is replaced with pearl millet under Namibian environmental conditions.

1.5. Hypotheses

The null hypotheses of the study were:

I) Pearl millet has no potential in replacing maize as an energy source in broiler diets under Namibian weather conditions.

II) *A. karroo* leaf meal additive in maize-soybean meal based diets has no effects on the fat deposition of broiler chickens.

III) Pearl millet has no potential to make broiler diets cheaper given the Namibian harsh environmental conditions.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

Cereal grains particularly maize are used in livestock diets worldwide (Thompson and Weber, 1981). Maize is the most common cereal used in broiler diets as the main source of energy (Panda *et al.,* 2010), and constitutes about 50-60% in most poultry diets (Ibitoye, 2012). Although maize is produced worldwide, there is a huge competition for it among humans, livestock and industries. This may be a result of its high energy contents (TME_n value of 3, 448 kcal/kg) (Davis *et al.*, 2003), low fiber (22 g/kg) (Mehri *et al.,* 2010), better palatability, presence of pigments and essential fatty acids (Panda *et al.,* 2010). The fat content of maize grains is said to be about 4% which is an excellent source of linoleic essential fatty acid (about 50%) (Ibitoye, 2012). Research by Olomu (1995) has indicated that maize contains about 3510 kcal/kg of Metabolizable Energy (ME) and 8.80% of Crude protein (CP).

Currently researchers are faced with a challenge to critically evaluate grains such as pearl millet, sorghum, wheat, etc. (Ibitoye, 2012), which could be used as alternative energy source in poultry industry as a result of high costs, the ever increasing competition between man and animals for maize (Tegbe *et al*., 1984; Egbunike *et al.*, 2002) and the inadequate production of farm crop to meet the needs of man and livestock (Babatunde *et al.*, 1990).

Studies have shown that pearl millet could potentially be successfully incorporated into poultry diets (Adeola and Rogler, 1994). Although variable at times, pearl millet is said to have high protein content than maize (Burton *et al.*, 1972; Sullivian *et al.,* 1990; Adeola and Rogler, 1994; Amato & Forrester, 1995). Some studies have shown that pearl millet has essential amino acid profile which is more balanced than that of maize (Sullivian *et al.,* 1990; Adeola and Rogler, 1994; Amato & Forrester, 1995). More studies have indicated that PM has higher oil content than other common cereal grains (Rooney, 1978; Sullivian *et al.,* 1990; Hill and Hanna, 1990; Adeola and Rogler, 1994) and it is said to be a better source of linolenic acid (Rooney, 1978). Research has indicated that pearl millet is superior to maize and sorghum in protein content and quality, as well as protein efficiency ratio (PER) values (Ibitoye, 2012). Pearl millet is also said to have lower Metabolizable Energy (2555 kcal/kg), however it has higher percent crude fiber (4.30), ash (3.00) and crude protein (12.0) (Olomu, 1995). PM is native to the western edges of the Sahara Desert which does not contain any condensed polyphenols such as the tannins which are found in sorghum that can interfere with or slow down digestibility (Ibitoye, 2012).

Sorghum is a cereal grain which is said to successfully grow on poorer soils and in drier conditions as compared to maize. According to Olomu (1995), sorghum is estimated to have about 3270 kcal/kg contents of Metabolizable Energy, 9.5% of crude protein, 1.20% of ash and 2.70%of fibre.

Cereal grains like pearl millet and sorghum seem to be relatively cheaper and easy to cultivate in harsh environments as compared to maize which requires more moisture. In order to identify the ideal alternative for maize, one has to first think of the environment as well as to acquire an in-depth understanding of the chemical characteristics alternative feeds available locally including their consequent effects on performance of broiler chickens. This may result in a more sensible utilization of these ingredients which may reduce the demand of maize and eventually lower the prices of poultry feed ingredients.

2.2. An Overview of Namibia and Agricultural Potential

Namibia is located on the south-western coast of Africa between latitudes 17.5° and 29° south and longitudes 11.5° and 25.5° east. It borders Angola to the north, Zambia and Zimbabwe to the north-east, Botswana to the east, South Africa to the south and the Atlantic Ocean to the west. The Kunene, Okavango, Zambezi, Kwando-Chobe and Orange Rivers form part of the borders and are the only perennial rivers in Namibia. The cold Benguella current along the west coast of the country contributes to the fact that Namibia is the most arid country in Africa south of the Sahara.

Namibian weather condition is characterized by low rainfall (mean annual rainfall of approximately 270 mm with the minimum of 50 mm) (Sweet and Burke, 2006), low soil fertility in terms of clay (5%) and nitrogen contents, and high temperatures (ranging between 20^{o}C and 37^{o}C) (Sweet and Burke, 2006). Rainfall in Namibia occurs mainly during the summer months of December to March. Only the extreme south-western corner may receive rain during the entire year, and this has a significant influence on the natural vegetation of that area.

Before independence, white dominated towns and commercial farming areas received mostly the development and provision of basic services and infrastructure. Hence, opportunities for employment for the indigenous people were confined to lower ranking civil service jobs, without the facilities necessary for entrepreneurial development. As a result, production and manufacturing of finished products as well as the provision of services were left to the South African commercial and industrial sector resulting in inexperienced labor (either employed or self-employed) pool of any significance built up in Namibia. Namibia was therefore left with not only a shortage of skills and expertise but also with the basic experience necessary to build upon and develop its livelihood and indigenous people.

The denial of the means to advance over many years has induced a unique blend of sociological weariness and remarkable human coping mechanisms in the communal farmers of the northern areas in addition to harsh uncompromising natural environment, massive distances, incipient drought, and progressive natural degradation. However, the Government of Namibia has done quite a lot to improve on the infrastructures e.g. roads, information dissemination through different means such as education, which provided Namibians opportunities for redressing the legacy of the past. Accordingly, the Namibian Agricultural industry is still in its infancy, however at the current stage, Namibia is in a good position to expand its livestock industry which includes chicken production.

The total surface area of Namibia is 824 295 km^2 (van der Merwe, 1983; Moorsom, 1984). Of the 82.4 million ha surface area, 15% is not suitable for farming; 15% of the surface area, mainly in the agriculturally unsuitable areas, is state owned (nature reserves, Diamond Area); 44% of the total area is farmed commercially and 41% is communal land. Only 34% of the available land is suitable for crop farming, but only 1.4% of this is actually utilized (Talbot, 1970; Rao *et al.*, 1991).

Agriculture plays a major role in the economy of Namibia. Agriculture in Namibia is based mainly on livestock farming. Since the natural vegetation serves as grazing, the type of livestock farmed differs between different parts of the country. In the south mainly sheep and goats are farmed by both commercial and communal sectors. Broiler production industry and agronomy plays a minor part in the Namibian agricultural sector in terms of contribution to Gross Domestic Product (GDP) but a larger proportion of the population (which is in the rural areas) is involved in chicken and crop farming than in livestock farming (Rao *et al.*, 1991).

The most recent population census figures available (2011) set the population at 2 104 900. The previous census figures (2001) indicated that the largest portion of the population is in the rural areas, whereby the population density was highest in the northern central regions of Omusati, Oshana, Oshikoto and Ohangwena and the north-eastern regions of Okavango and Caprivi. According to the current census figures, about 58 % (1 219 400) of the population live in rural areas while 42 % (885 500) live in urban areas, as compared to 67 % of the population living in rural areas and 33 in urban areas in 2001 census. This shows the rate of urbanization in Namibia is increasing. Urbanization involves the movement of young people from rural areas to urban areas in search for jobs to better their lives and families. This actually increases the lack of man power to work in pearl millet and maize fields, which may result in reduced yields. The carrying capacity in the northern communal regions of Namibia is estimated to be 0.1 to 0.5 persons per cultivated ha (Rao *et al.,* 1991). The main crops in Namibia are pearl millet, sorghum, maize, wheat, beans, alfalfa and some fruit and vegetables (melons, grapes, tomatoes). Field size varies from 0.2 to 100 ha, but farmers typically cultivate about 2 - 4 ha (Lechner, 1992; Yaron *et al*., 1992), mainly with pearl millet, sorghum or maize (or a mixture of these grains) and often some minor but very important crops like Bambara nut, groundnut, cowpea and melons. Yields for subsistence farmers of pearl millet vary from 100 kg /ha to 900 kg/ha whereas the potential yield in the area, under good management, using improved varieties and fertilizer, is 1,200 kg/ha (Lechner, 1992). A few commercial farmers produce crops in areas such as the "Maize Triangle" (Otavi - Grootfontein - Tsumeb), Hardap Irrigation Scheme, Stampriet area and the Noordoewer Irrigation Scheme. The land cultivated by these farmers varies greatly from about 4 to 5,000 ha (Rao *et al.,* 1991). In the Maize Triangle lands are almost exclusively under maize production with some sunflower, cotton and dry beans (Namibia Agronomic Board, (NAB), 2011).

2.3. Maize and PM production and marketing in Namibia

Namibia has a land surface area of 824 290 square kilometers and a human population estimated at 2.1 million with about 70% living in rural areas (Bamhare, 2009). Namibia is rated to have the driest climate in sub-Saharan Africa with a mean annual rainfall of approximately 270 mm (Sweet and Burke, 2006). There is a wide regional variation in rainfall, from less than 20 mm in the western Namib and coastal zones to more than 700 mm at the eastern end of the Caprivi strip (Katima Mulilo), but only 5% of the country receives more than 500 mm (Sweet and Burke, 2006).

Due to harsh conditions, maize production is mainly practiced successfully under irrigation schemes on the dry regions of the country, it is therefore, regarded as a principal commercial crop. This usually comes with high costs of production which does not correspond with commodity prices (NAB, 2011). Among others, high electricity cost is the most costly input of maize production under irrigation (NAB, 2011), which lead to high prices of maize in Namibia as compared to the neighboring countries such as South Africa and Zambia. This influences the import of maize grains by the chicken feed manufacturing industry in order to reduce their costs of production. Among communal farmers, maize can only be grown in the Caprivi regions while the rest of the northern west parts of the country grow pearl millet. It would make economic and developmental sense to promote pearl millet as the energy source in broiler diets because it is grown by the majority of the communal farmers in the rural areas. Farmers in Caprivi region would be encouraged to produce excess maize and those in the north west regions would produce excess pearl millet to enable them to farm with broiler chickens on commercial level thus improving the economy, reduce the unemployment and reduce poverty in Namibia.

Pearl millet is vital to the food security of most rural households in the northern part of the country. It was gazetted in May 2008 as a controlled crop under the Agronomic Industry, Act 20 of 1992 which accorded pearl millet the same status as maize and wheat (NAB), 2011). There is not much data available of pearl millet production since it was only produced for home consumption. In Namibia, low yield of pearl millet seems to be a result of communal farmers' reluctance to the adoption of improved varieties. Communal farmers rather opt for the traditional variety which is regarded as a wealth of indigenous crop landraces, in the northern farming areas. This is because these pearl millet varieties are particularly well adapted to the relatively dry conditions. Information on the use of the pearl millet landraces in Namibia is not well documented, but it is well known from experience that farmers still like to grow traditional varieties of pearl millet, mainly because it still yield sufficiently during normal years, confer stability (Appa Rao *et al.*, 1991) and farmers prefer some of their qualities, like taste, storability or stalk length and strength. Adoption of new pearl millet varieties may increase the output per year.

As one of the controlled crops pearl millet production in Namibia is being supported by MAWF and NAB who teamed up to develop a sustainable pearl millet Marketing System in Namibia (NAB, 2011). This will encourage farmers to produce surplus pearl millet for sale and earn smallholder farmers some money to pay for school fees for kids and for other every day basic needs. Refer to table 2.1 for some estimates of prices and production levels of pearl millet in Namibia.

Table 2.1. Pearl millet production and prices

Crop	**Planting period: Dec-Jan**	**Marketing period: May-Sep**	**Planted area (ha)**	**Harvested crop (t)**	**Quantity marketing (t)**	**Price (N$/t)**
Commercial	2005/6	2006	307	327	112	1,780
Communal	2005/6	2006	Estimated	Estimated	estimated	
Caprivi			1,400	532	184	1,760
Kavango			12,000	4,560	317	1,760
North-Central Regions			153,600	53,000	474	1,760
Total			**167,600**	**58,852**	**1,087**	

Source: NAB, 2011

2.4. Management, Nutrition and diets of broiler chickens

Broiler chickens are mainly bred for fast growth and slaughtered when they weigh about 1.8 to 2.2 kg live mass, usually between 6 and 8 weeks of age (Musa *et al.*, 2006). The overall objective for broiler chicken producers is to produce meat with leaner tissue and acceptable lipid content in order to meet modern consumer demands as per the Hazard Analysis and Critical Control Points (HACCP) approach (Weltzien, 2009). Since feed expenditures frequently comprise 80% of broiler chicken production cost (Louw *et al.*, 2011), decisions regarding ration composition have a significant impact upon profitability of any broiler production enterprise. However, ration composition is just one of the many interactive components that must be met for efficient production (Teer and Wiernusz, 2003). Therefore, to ensure fast growth rate and efficient feed conversion in broiler chickens, good management practices which involves effective disease prevention and control, flock maintenance under continuous illumination as well as provision of high quality feeds and water (fed *ad libitum*) are all necessary (Amakari and Owen, 2011).

Broiler diets are formulated to provide the energy and nutrients essential for health and efficient broiler production (Arbor Acres, 2009). Amino acids, energy, water, vitamins and minerals are the basic nutrients required by broiler chickens to ensure correct skeletal growth and muscle deposition (Appleby, 2010). Chicken meat is categorized as a white meat and it is distinguished from other meats such as beef and lamb by its lower iron contents which amount at 0.7 mg/100 g as compared to 2 mg/100 g in beef and lamb (Farrell, 2010). About half of the fat from chicken meat is made up of the desirable monounsaturated fats, and only one-third of the less healthy saturated fats (Farrell, 2010). Poultry meat is an important provider of the essential polyunsaturated fatty acids (PUFAs), especially the omega (n)-3 fatty acids (Ravindran, 2010). Omega-3 fatty acids are said to be of benefit to human health due to the fact that they reduce the risk of cardiovascular diseases (Wahrburg, 2004). The amounts of these important fatty acids can be increased more easily in chicken meat than in other livestock meats; so too can some trace minerals and vitamins (Farrell, 2010). A study by Yu *et al.*(2008) showed that adding 0.24 mg of selenium (as organic selenium) per kilogram of feed, the selenium content of breast meat can be increased from 8.6 μg to 41 μg/100g, which is more than 65 percent of the Recommended Dietary Intake (RDI).

An economical decision on dietary nutrient levels especially for dietary protein and amino acids is required when formulating boiler diets in order to command high levels of performance (Amakari and Owen, 2011). Energy levels which will give the best economic return are mostly determined by the local conditions under which the broiler chickens are raised (Choct, 2012). However, the quality of protein in feeds is based on the presence and balance of essential amino acids in the feed ingredients but not on the dietary crude protein levels (Appleby, 2010). It is therefore, the availability of these essential amino acids that are considered when formulating broiler diets.

The actual protein levels as well as macro minerals such as calcium, phosphorus, magnesium, sodium, potassium and chloride to be used in broiler diets will vary according to the feed ingredients and will be driven by the first limiting essential amino acid not available in synthetic form (Teer and Wiernusz, 2003). An Ideal Amino Acid Profile can be used to ensure that the appropriate balance of digestible amino acids is supplied (Appleby, 2010). High quality protein sources are required especially during hot weather conditions (West, 1999). Calcium in the broiler diets influences growth, feed efficiency, bone development, led health, nerve function and the immune system therefore, it is vital that calcium is in adequate quantities and on a consistent basis to achieve optimum performance (Weltzien, 2009). Just like calcium, phosphorus is required in the correct form and quantity to optimize broiler performance therefore, Ca: Av P ratio (Calcium: Available Phosphorus) of 2:1 is appropriate for broiler diets (Choct, 2012).

2.5. Broiler chicken diet ingredients

Nutritive value of a specific feed or diet is the function of feed intake and the efficiency of extraction of nutrients from the feed during digestion (Mandal, 1997). The feed intake of nutrients by broiler chickens is a function of the amount of feed eaten and the nutrient levels in the diet (Choct, 2012). Therefore, a successful broiler production is dependent upon supplying the birds with feed of the highest achievable quality, in terms of ingredients used, processing procedures applied as well as the form in which the diet is presented to broilers (Arbor Acres, 2009). Feed can easily represent 80% of the variable costs of broiler production (Louw *et al.,* 2011) with protein and energy accounting for 85-90 % of feed costs (Schwartz, 2008). A typical feed consumption and body weight of modern broiler chickens in relation to age and sex is shown in Table 2.2 below.

Table 2.2 Bodyweight and cumulative feed consumption for male and female broilers (g)

Age (weeks)	Male Body weight	Male Cumulative Feed Intake	Female Body weight	Female Cumulative Feed Intake
0	40	0	40	0
1	170	150	165	145
2	450	480	420	460
3	865	1120	780	1030
4	1410	2020	1250	1825
5	2250	3200	1750	2830
6	2700	4500	2300	4020
7	3350	6000	2800	5400
8	3900	7400	3300	6800
9	4400	8800	3700	8200

Source: Poultry CRC, 2009

Nutrient intake of fast growing broilers needs to be carefully controlled to prevent metabolic diseases such as ascites and leg weakness (Choct, 2012). Table 2.3 presents some typical levels of selected nutrients for broiler diets.

Table 2.3. Examples of broiler diets

Nutrients	Starter	Grower	Finisher
Age fed (days)	0-10	11-24	25-slaughter
Crude protein (%)	22-25	21-23	19-21
ME (MJ/kg)	12.60	13.30	13.50
ME (kcal/kg)	3010	3175	3225
Total Arginine (%)	1.48	131	1.11
Digestible Arginine (%)	1.33	1.18	1.00
Total Lysine (%)	1.44	1.25	1.05
Digestible Lysine (%)	1.27	1.10	0.92
Total Methionine (%)	0.51	0.45	0.39
Digestible Methionine (%)	0.47	0.42	0.36
Total Methionine +Cystine (%)	1.09	0.97	0.83
Digestible Methionine +Cystine (%)	0.94	0.84	0.72
Total Threonine (%)	0.93	0.82	0.71
Digestible Threonine (%)	0.80	0.70	0.61
Total Trypophan (%)	0.25	0.22	0.19
Digestible Tryptophan (%)	0.22	0.19	0.17
Total Valine (%)	1.09	0.96	0.81
Digestible Valine (%)	0.94	0.83	0.70
Calcium (%)	1.0	0.90	0.85
Available phosphorous (%)	0.50	0.45	0.42
Sodium (%)	0.16	0.16	0.16

Source: Poultry CRC, 2009

Cereal grains are used in broiler chicken diets as the main source of energy and oilseeds such as sunflower meal and soya bean meal primarily contribute to the dietary protein (Choct, 2012). Maize is the common cereal used in combination with soya bean meal or sunflower seeds, to formulate compounded broiler diet. Due to its high contents of energy, low fiber, better palatability, presence of pigments and essential fatty acids, maize is widely used as an energy source in broiler diets (Panda *et al*., 2010). However, the protein content of maize is low compared to the other cereals (Dale, 1994).

Although maize is being used primarily as an energy source it contributes about 25-30% of dietary protein in broiler chicken diets (Panda *et al*., 2010).

Pearl millet is a drought resistant cereal crop (Lee and Hanna, 2002; Mehri *et al*., 2009), which grows well in infertile sandy soils and therefore, grows well in dry countries such as Namibia, India and other Southern African countries. Studies have shown that pearl millet is higher in crude protein and amino acid lysine contents than maize (Adeola and Rogler 1994; Singh, 2004). Substitution of maize with pearl millet reduces the need for high protein feed ingredients and supplemental amino acids (Singh and Perez-Maldonado, 2003). Research has indicated that performance of broiler chickens fed pearl millet diets which are formulated with correct estimates of protein and energy is equivalent to that of maize diets (Sullivan et al., 1990; Amato and Forrester, 1995). Research has also indicated that pearl millet is equal to or better than typical maize-soybean poultry diets for broiler production and can be fed at up to 10% of the ration without grinding (Davis *et al*., 2003; Hidalgo *et al*., 2004), which may result in reduced feed processing costs. A study by Lloyd (1964) has shown that broiler chickens fed on pearl millet diets were heavier and had better feed conversion rate than those fed on maize.

Although it is well documented, as indicated earlier, that pearl millet can be successfully incorporated into broiler diets, little information is available on grinding and pelleting responses of pearl millet based diets. A study by Dozier (2005), revealed that decreasing the grind size of pearl millet improved pellet durability index and percentage of fines, therefore, pearl millet-based diets have acceptable grinding and pelleting performance compared with a typical corn-soybean meal diet. However, studies have shown that starch digestibility can be improved by means of feeding broilers with whole grains (Svihus and Hetland, 2001; Hetland *et al*., 2002) without detrimental effects to feed utilization (Kiiskinen 1996; Svihus *et al*., 1997; Jones and Taylor, 2001; Hetland *et al*., 2002). A study by Hidalgo *et al*. (2004) has shown that whole pearl millet grains can be readily broken down by young broilers, therefore, it can be incorporated into their diets. Several studies have revealed that broiler chicken fed whole pearl millet (Hidalgo *et al*., 2004), wheat, triticale, and barley (Kiiskinen, 1996; Svihus *et al*., 1997; Jones and Taylor, 2001) grains has shown a significant increase in gizzards size which was related to muscular adaptation to increased grinding activity.

Several authors hypothesized that the health as well as the gizzard size and function, for the broiler chickens could be improved by feeding whole grains (such as wheat, sorghum, barley, and oats) or larger particle sizes (Gabriel *et al*., 2006; Amerah *et al*., 2007; 2008). Studies have shown that broiler chicks which were exposed to larger particle sizes, or whole grains tend to have higher possibilities of increased gizzard sizes and its activity levels, as well as improved effects on internal health (Nir *et al*., 1994a; Jacobs *et al*., 2009). When nutrient digestion of broilers is improved at first weeks of production, their gain weight potential is said to improve to market weight, this is because of the nutrient digestion of chicks which is suboptimal until about 14 days of age (Noy and Skylan, 1999; Batal and Parsons, 2002). According to Nir *et al*. (1995), since the gizzard is a major intestinal motility and enzymatic secretion regulator, feeding broilers with larger particles or whole grains to stimulate gizzard size and peristalsis may be appropriate to the intestinal tract. Feeding larger particles or whole grains reduces feed passage as a result of slow digestion which may improve energy and nutrient utilization because of more reflux of intestinal contents and increased exposure time of nutrients to digestive enzymes (Nir *et al*., 1995). Several studies have indicated that the gizzard can be regarded as a barrier in preventing pathogenic bacteria from entering the distal intestinal tract (Ferket, 2000; Naughton and Jensen, 2001; Engberg *et al*., 2002; Engberg *et al*., 2004).

In Namibia, pearl millet is not yet used in commercial feed industry firstly, because its production is barely sufficient to satisfy food requirements, little surplus is left for animal feed. Secondly, pearl millet production fluctuates widely from year to year because of rainfall variability and drought in the main production areas. However, farmers can be encouraged to produce more during the years of good rainfall so that there is enough feed to support a small/medium broiler operation.

2.6. The use of tannins browses in broiler diets

Efforts made to maximize profit in meat-type poultry industry has resulted in much more progress in genetics and a better knowledge of nutritional requirements of broiler chickens which allowed the improvement of growth performance and increase in muscle weights (Weltzien, 2009). In the process of profit maximization, the deposition of subcutaneous or abdominal adipose tissue has increased as well. Since broiler chickens were mainly selected for rapid growth, their abdominal and subcutaneous fat deposition is said to be associated with changing concentrations of hormones and neural control mechanisms that regulate feed intake (Musa *et al*., 2006). As a result modern broiler chickens tend to eat more feed than is required for the growth and maintenance of their muscles (Smith and Pesti, 1998), which leads to excessive deposition of body fat, low meat yield and poor feed efficiency (Musa *et al*., 2006).

Due to the incidence of some chronic diseases in humans which is associated with the amount and type of fat consumed (Vasta *et al*., 2009), the amount of fat in broiler chicken meat is becoming a concern among consumers (Evans *et al*., 2002). To respond to the demand of low fat and low cholesterol chicken meat by consumers, nutritionists are faced with a challenge of identifying feeding strategies which can be used to manipulate nutrition of broiler chickens. Research has shown that fatty acid composition can be manipulated by feeding strategies (Najbjerg, 2011).

Horvath (1981) has defined tannins as "Any phenolic compound of sufficiently high molecular weight containing sufficient hydroxyls and other suitable groups (i.e. carboxyls) to form effectively strong complexes with protein and other macromolecules under the particular environmental conditions being studied". Tannins are a very complex group of plant secondary metabolites, which are soluble in polar solution and are distinguished from other polyphenolic compounds by their ability to precipitate proteins (Silanikove *et al*., 2001).

Tannins are found in approximately 80% of woody and 15% of herbaceous dicotyledonous species. They can occur at high levels in some forages and feeds (Bryant *et al*., 1992). Tannins have a negative effect on protein metabolism and decrease palatability of feeds at high levels (Barry and Manley, 1986) but at very low levels most are beneficial (Foo *et al*., 1996). The presence of condensed tannin has been associated with reduced carcass fat content in lambs grazing *L. pedunculutas* (Purchas and Keogh, 1984) and *H. coronarium* (Terrill *et al*., 1992). However, in lambs grazing *L. corniculatus*, Wang *et al*. (1996) found no difference in carcass fatness. Low tannin sorghums have the feeding values for monogastric animals similar to those of maize (Brand *et al.*, 1992; Douglas *et al*., 1993). Leeson and Summers (1991) stated that low tannin feeds offer an excellent alternative in diets for the production of non-pigmented poultry products. Feeds high in tannins also have a potential to greatly reduce the speed of meat spoilage (Carpenter *et al*., 2007; Vista *et al*., 2007). The production of bird proof (high tannin) sorghum, however, possess nutritional problems when the grain is subsequently incorporated into monogastric feeds (NRC, 1994).

During the finisher phase higher levels of maize are used and this has a tendency of producing fatty carcasses. Permitted additives of an organic matter seem to be the answer. Acacia trees generally have high levels of tannins and have a potential to be used as additives in small ruminants (Purchas and Keogh, 1984; Terrill *et al*., 1992) and poultry (Brand *et al.*, 1992; Douglas *et al*., 1993; Ngambi *et al*., 2009) diets. *A. karroo* is said to be widespread, abundantly available during the dry season (Mokoboki *et al*., 2005) and has about 4.52 % DM levels of condensed tannins (Mashamaite, 2004; Ngambi *et al*., 2009). Farmers can therefore, utilize the *A. karroo* leaves for example when they de-bush to control bush encroachment, harvest the leaves and prepare *A. karroo* leaf meal which can be fed to animals so that they produce leaner but healthier meat.

CHAPTER 3

MATERIALS AND METHODS

3.1. Location of the study and research materials

This study was conducted at the poultry units at Neudamm Agricultural Campus of the University of Namibia. Neudamm Agricultural Campus is situated between 22°30.105‟S and 017°20.824‟E in the Khomas Region, located about 34 km east of Windhoek, the capital city of Namibia. Soya bean meal and vitamin-minerals premixes were bought from Feedmaster Ltd. *A. karroo* leaves were collected around Neudamm farm. A bush cutter was used to harvest *A. karroo* leaves, and the leaves were left to dry in the field placed on top of plastic sheets on the ground. Maize grains were purchased from Shadikongoro Irrigation Project in Ndoga Linena in Okavango region and pearl millet from a communal farm in Omusati region in the northern part of Namibia. Unpolished pearl millet grains ground with a 2 mm sieve were incorporated into the diets (a starter and a finisher). The saw dust was obtained from a local company and used as bedding throughout the experiment. Other feed ingredients and equipment such as drinking troughs, feed pens, incandescent lamp heaters, salt, vegetable oil, detergents, disinfectants, medication, stress pack etc., were procured from local shops. Experimental diets were formulated on a computer and mixed manually as a mash. All of the ingredients used to formulate experimental diets were analyzed for dry matter, crude protein, energy, crude fiber, ether extract, calcium and phosphorus according to official Methods of Analysis (AOAC, 1995). One hundred and one (101) day-old broiler (mixed sex) Cobb500 chicks were supplied by the Namib Poultry Industries (the only commercial broiler farm in Namibia) and were used for the study which lasted for 7 weeks. A two phase feeding regime was used comprising three weeks starter phase and 4 weeks finishers phase.

3.2. Husbandry and Sampling Procedure

On arrival the chicks (101 day-old chicks) were given fresh water with a stress pack as a supplement as well as a starter diet. The chicks were kept in the same brooder house and fed with the same starter diet for the first 3 weeks (see Table 3.1). The chicks were vaccinated against New Castle Disease.

Table 3.1 Composition (%) of experimental broiler starter diet (0-3 weeks)

Feedstuff	**Starter Diet**
Maize (Unpolished) % (kg/100kg)	66
PM (Unpolished % (kg/100Kg)	0
Soya bean meal (44%CP)	33
Salt (% (kg/100kg)	0.5
Vit Min Premix (% (kg/100kg)	0.5
Vegetable Oil (% ml/kg)	0.
Nutritional Information	
Crude Protein %	20
Energy ME/MJ/Kg	12
Crude Fiber %	3.33

All of the 101 chickens were exposed to uniform standard husbandry conditions throughout the experiment. All the chickens were housed in one poultry house with sufficient mature bird space of at least $1m^2$ per 10 birds.

The broiler chickens used in this study were from parent stock of 34 weeks old, which are known to lay eggs with uniform sizes. Therefore, blocking on initial weights was not necessary because the chicks supplied had uniform day old weights of between 500-650 g. Humidity and ambient temperature within the poultry house was uniform. Temperature was monitored throughout the experimental period using a mercury thermometer. Furthermore, stress pack was administered throughout the experiment on weekly bases as a means of reducing stress arising from temperature variations.

Due to the fact that maize was replaced with pearl millet up to 100% a two phase feeding regime was adopted comprising 3 (three) weeks starter phase and 4 (four) weeks finisher phase. Normally on a commercial farm that does everything right, a two phase feeding is 3 weeks starter phase and 3 weeks finisher phase but in this study the finisher phase was extended to 4 weeks to give more opportunities of studying what happens beyond the recommended 6 weeks post hatching. The actual experimental treatments started from the beginning of week 4 and the chickens were randomly allocated to the different experimental treatments. The birds were subjected to the treatment diets during the finisher phase simply because there was no guarantee that day old chickens would survive some of the treatments so it was found prudent to start the trials with grown up chickens.

The actual experimental treatments started from the beginning of week 4 and the chickens were randomly distributed in two different experiments as described in section 3.2.1 and 3.2.2. Fresh water was always provided and given *ad libitum* throughout the experiment.

3.2.1. Experiment 1. Replacement of maize with PM

The experimental design used in this trial was a Completely Randomized Design (CRD). The initial weight range at the beginning of the finisher was from 500 g to 650 g, therefore, the weight range was too narrow to warrantee blocking. The population of the chickens was 99 (after two died in the first week). For this trial the sample size was 70. The chickens were randomly allocated to five (5) different dietary treatments with two (2) replicates of 7 birds each. In other words the chickens were group fed as 7 chickens in each replicate. Standard maize-soya bean meal based broiler finisher diet was formulated as per BIS (1992) and used as the control. Maize was replaced with pearl millet quantitatively at the level of 0 % (T1 = control); 25 % (T2), 50 % (T3), 70 % (T4) and 100 % (T5) as shown in Table 3.2 below.

Table 3.2 Composition (%) of experimental broiler finisher diet (3-6 weeks)

Feedstuff	Substitution of maize with PM (%)				
	Control Treatment 1 (T1)	**25% PM (25% of maize substituted) (T2)**	**50% PM (50% of maize substituted) (T3)**	**75% PM (75% of maize substituted) (T4)**	**100% PM (100% of maize substituted)(T5)**
Maize (Unpolished) %	78	58.5	39	19.5	0
PM (Unpolished %)	0	19.5	39	58.5	78
Soybean meal (44%CP) %	21	20.5	20.5	19.5	19.5
Salt %	0.5	0.5	0.5	0.5	0.5
Vit Min Premix %	0.5	0.5	0.5	0.5	0.5
Vegetable Oil %	0	0.5	0.5	1.5	1.5
Nutritional Information					
Crude Protein %	16.26	16.18	16.31	16.02	16.06
Energy ME/MJ/Kg	12	12.05	12	11.9	11.8
Crude Fiber %	3.33	3.68	4	4.02	4

Each of the five experimental diets was offered *ad libitum* in mash form. Diets were formulated to be similar in nutrient content and to meet the nutritional requirements listed by the NRC (1994). The diets were iso-caloric (iso-energetic) and iso-nitrogenous.

3.2.2. Experiment 2: Supplementation of maize based diet with A. Karroo leaf meal

The experimental design used in this trial was a Completely Randomized Design (CRD). Again as for experiment 1, the initial weight range at the beginning of the finisher was from 600 g to 650 g, therefore, the weight range was too narrow to warrantee blocking. The original population of the chickens was 101 (two died in the first week of natural causes). For this trial the sample size was 42. The chickens were randomly allocated to three (3) different dietary treatments with two (2) replicates of 7 birds each. Fresh water and feed was always given *ad libitum* between 8 and 9 AM every day. Standard maize-soya bean meal based broiler finisher diet (T0) was formulated as the control as per BIS (1992). This maize-soya bean meal based broiler finisher diet was seeded with the additive *A. karroo* quantitatively at the level of 5 (T1) and 20 (T2) g/kg (Table 3.3) in the control diet. Each of the three experimental diets was offered *ad libitum* as mash and the rest of the activities were carried out exactly like in experiment 1.

Table 3.3 Composition (%) of experimental broiler finisher diet (3-6 weeks)

Feedstuff	*A. karroo* leaf meal additive		
	Control 0	**5** (g/kg)	**20** (g/kg)
Maize (Unpolished) %	78	78	78
Soybean meal (44%CP) %	21	21	21
Salt %	0.5	0.5	0.5
Vit Min Premix %)	0.5	0.5	0.5
Acacia Karroo leaf meal g/kg	0	5	20

3.3. Data Collection

The birds were individually identifiable by color-coded marks on the feathers and toes, and the body weight of individual chickens, and feed conversion ratio were recorded per replicate at weekly intervals while feed intake measurements were taken daily by recording weights of feed given and weight of left-overs (refusals). The efficiency of feed conversion as a ratio was calculated as feed intake per unit body weight gain. At the end of the feeding trial, birds were randomly chosen for slaughter from both experiments at six (6) weeks of age and seven (7) weeks of age. In each case, 4 chickens were randomly selected from each of the treatment diets. The birds were starved of feed over night, but water was available to them. Birds were slaughtered by cervical dislocation and bled. The carcasses were quickly immersed in cold, and then boiled water and cold water again followed by de-feathering. The carcasses were eviscerated, abdominal fat pad, thigh and breast meat was removed, weighed and stored in the freezer for sensory evaluation in Experiment 3 (Chapter 6). Fat surrounding the gizzard and intestines extending to the bursa were considered as abdominal fat (Mendonca and Jensen, 1989).

3.4. Consumer Scores of Broiler Chicken Meat

3.4.1 Meat Sample Preparation

Sensory analysis was carried out on broiler meat from chickens fed on pearl millet based diets and maize based diets with *A. karroo* leaf meal additives versus the control chickens in each case. Thighs and breasts were sampled for the sensory evaluation. The samples were defrosted at around 4 ^{o}C for 24hrs. Samples from different diets were roasted separately. The meat samples were roasted wrapped into an aluminum foil and coded. Both thighs and breast samples were thermally treated by roasting in an oven preheated at 160 ^{o}C for an average of 38 minutes. After a few minutes (about 4-5 minutes) of cooling at room temperature, samples were cut into cubes and individually wrapped each in a small 2±1 cm piece of an aluminum foil paper.

3.4.2. Broiler Meat Sensory Evaluation

Overall consumer acceptability/liking of the meat was studied through a mini sensory evaluation with 32 panelists of whom the majority were between the age of 18 and 26 years. Meat sensory evaluation was done on roasted meat samples from pearl millet replacements of maize based chickens, as well as *A. karroo* leaf meal added. Samples were warmed prior to serving. Each assessor was served with samples of breast and a thigh from all eight diets, a glass of purified water, slices of apple and an evaluation form. To account for sampling order bias, samples coded with random three-digit numbers were presented to each assessor to evaluate for different attributes of meat quality. At the beginning, assessors were informed on how to evaluate the meat samples and complete the forms provided to them. Assessors were requested to rinse their mouth and take a bite on the piece of an apple provided after each taste in order to limit crossover effects of the treatments. A meat sensory attributes evaluation form with a nine-point hedonic scale (1= dislike extremely, 2 =dislike very much, 3 = dislike moderately, 4= dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7= like moderately, 8= like very much, 9= like extremely) was used. Assessors were requested to assess the aroma intensity for all of the samples immediately after unfolding the foil off the sample, whereas the juiciness, tenderness and flavor intensity was by tasting. Refer to the sensory evaluation form in appendix D for a clear outline.

3.5. Statistical Analysis

Statistical analyses for both experiment 1 and 2 were performed using the General Linear Model (GLM) procedure of IBM SPSS Statistics 20 (2011) package. Before comparing the experimental means using analysis of variance (ANOVA), homogeneity of variance was assessed based on the Levene Test. ANOVA was then used to determine the effect of different dietary levels of pearl millet as a replacement of maize as well as *A. karroo* as an additive in maize based diets on feed intake, growth performance, feed conversion ratio, fat pad and gizzard yield. Least significant difference (LSD) Test was used to determine the significance of differences among the means. Correlation analysis was used to relate dietary levels of pearl millet as a replacement of maize to animal performance indices (the fat pad). The level of significance used in all results was $P<0.05$.

Statistical analyses for meat sensory evaluation were performed using the Friedman's Test procedure of IBM SPSS Statistics 20 (2011) package. Wilcoxon Signed-Rank Tests of IBM SPSS Statistics 20 (2011) package was used to determine the effect of different dietary levels of pearl millet as a replacement of maize and addition levels of *A. karroo* in maize based diets on sensory characteristics. The effects of age, gender and session on meat sensory characteristics of Cobb 500 broilers chickens was also determined. The level of significance used in all results was $p < 0.05$. Since multiple comparisons were carried out when performing the Wilcoxon tests, it is more likely that results could be declared significant while they are not. This is known as the Type I error, and to avoid this Bonferroni adjustment (that is, the significance level, e.g. $p < 0.05$, divided by the number of test used) was carried out. In this case $p < 0.05$ was used and 20 tests were ran (paired comparisons). Therefore in this study, if the *p* value is greater than 0.0025 then there is no statistic difference.

CHAPTER 4

RESULTS

4.1. Growth and carcass performance of broiler chickens when maize is replaced with PM under Namibian weather conditions.

The proximate analysis for pearl millet (PM) is presented in Table 4.1. On dry matter bases, pearl millet contained 120 g crude protein (CP) per kg, 2.1 g crude fiber (CF) per kg and 1.3 g of ash per 100 g.

Table 4.1. Composition of determined and proximate analysis of PM

Feed	CP (g/kg)	CF (g/kg)	Ash (g/100g)	Ca (mg/100g)	P (mg/100g)	Fat (g/kg)
PM	120	21	1.3	16	373	4.0

PM = Pearl Millet,

4.1.1. Nutrient composition of treatment diets

Nutrient composition of experimental broiler finisher diets fed to Cobb 500 broiler chickens from week 3 to week 7 are shown in Table 4.2.

Table 4.2. Nutrient composition of experimental broiler finisher diet (3-7 weeks)

Nutrient	Experimental Diets				
	T_1	T_2	T_3	T_4	T_5
Crude Protein %	16.3	16.2	16.3	16.0	16.1
Crude Fibre %	3.33	3.68	4.00	4.02	4.00
Energy ME/MJ/Kg	12.00	12.1	12.00	11.9	11.8

T1= Control diet; T2 = 25% of Maize replaced with pearl millet; T3 = 50% of Maize replaced with pearl millet; T4 = 75 % Maize-based replaced with pearl millet; T5 = 100 % Maize replaced with pearl millet

The results of the effects of replacing maize with pearl millet on feed intake (g/bird/day), weight gain (g/bird/day) and feed conversion ratio (FCR) (g feed/g live weight gain) of Cobb 500 broiler chickens from 21 to 42 and 49 days of age are presented in the tables 4.3 and 4.4 below.

Table 4.3. Effects of replacing maize with pearl millet on feed intake (g/bird/day), weight gain (g/bird/day) and feed conversion ratio (FCR) (g feed/g live weight gain) of Cobb 500 broiler chickens from 21 to 42 days of age

Treatment	ADFI	ADG	FCR
T1	62.3±2.62^{a}	49.6±2.37^{a}	1.3^{a}
T2	69.1±4.85^{a-b}	57.2±1.78^{b}	1.2^{a-b}
T3	75.4±2.73^{b}	60.3±2.34^{b}	1.3^{a}
T4	69.2±4.45^{a-b}	60.9±2.85^{b}	1.1^{b}
T5	70.7±2.55^{a-b}	59.9±3.26^{b}	1.2^{a-b}

$^{a-b}$Means within a column without a common superscript differ significantly ($P < 0.05$).

ADFI = Average daily feed intake; ADG= Average daily gain.

T1= Control diet; T2 = 25% of Maize replaced with PM; T3 = 50% Maize replaced with 50% of pearl millet; T4 = 75 % Maize-based replaced with pearl millet; T5 = 100 % Maize replaced with of pearl millet

Table 4.4. Effects of replacing maize with pearl millet on feed intake (g/bird/day), weight gain (g/bird/day) and feed conversion ratio (FCR) (g feed/g live weight gain) of Cobb 500 broiler chickens from 21 to 49 days of age

Treatment	ADFI	ADG	FCR
T1	64.0 ± 2.56^{a}	53.9 ± 1.83^{a}	1.2^{a}
T2	$68.0 \pm 4.65^{a-b}$	60.1 ± 0.88^{b}	1.1^{b}
T3	74.7 ± 2.72^{b}	63.0 ± 1.75^{b}	1.2^{a}
T4	$67.6 \pm 4.34^{a-b}$	62.7 ± 2.62^{b}	1.1^{b}
T5	$68.7 \pm 2.74^{a-b}$	61.3 ± 2.30^{b}	1.1^{b}

$^{a-b}$Means within a column without a common superscript differ significantly ($P < 0.05$). ADFI = Average daily feed intake; ADG= Average daily gain. T1= Control diet; T2 = 25% of Maize replaced with pearl millet; T3 = 50% Maize replaced with 50% of pearl millet; T4 = 75 % Maize-based replaced with PM; T5 = 100 % Maize replaced with of PM

4.1.2. Weight gains

Since the Levene table statistics indicates that 0.712 was < 2.340 and 2.25 (from the F-table) (p value = 0.581 > the null hypothesis which states that the mean variances are equal could not be rejected. Hence, it was assumed that the variances of the mean weight gain of different diets were equal. Therefore, an analysis of variance was performed to evaluate the equality of the mean weight gains for the experimental diets.

Results from the analysis of variance have shown that there was a significant difference ($P< 0.05$) between weight gains for the experimental diets. Therefore, it can be concluded that replacing maize with pearl millet has significant effects ($P < 0.05$) on weight gain (g/bird/day). The least significant difference (LSD) was then performed in order to assess the difference between pairs of mean weight gains for different experimental diets. Results in Tables 4.3 and 4.4 shows that replacing maize with pearl millet at 25 %, 50 %, 75 % and 100% had a significant effect on the weight gains of the broiler chickens, whereby the pearl millet 50 % replacement diet produced broilers with heavier weight gains followed by pearl millet 75 %, 100 % and 25 % as compared to the pearl millet 0 % (control diet). At both 42 and 49 days of age, the use of maize with pearl millet at 50 % and 75 % had a highly significant effect ($P < 0.05$) on the weight gains of the broiler chickens, whereby the pearl millet 50 % and 75 % replacement diet produced birds with heavier weight gains than maize based diet. Replacing maize with pearl millet at 25 % and 100 % had a significant effect ($P < 0.05$) on the weight gains of the broiler chickens.

4.1.3. Feed intake and FCR

Table 4.3 and 4.4 present results on the daily feed intakes and FCR of the broiler chickens fed different diets. Analysis of variance revealed that there was a significant difference ($P = 0.016$ at 42 days of age and 0.022 at 49 days of age) ($P < 0.05$) in the amount of feed consumed and FCR for the birds fed different diets on daily basis, therefore the null hypothesis stating that the broilers consumed the same quantity of different diets was rejected. The least significant difference (LSD) was then performed in order to assess the difference between pairs of the mean feed intake for different experimental diets. Results from LSD revealed that there was no significant effect in the amount of feed consumed for the birds fed pearl millet 25 %, 75 % and 100 % diets as compared to the maize based diet on daily basis. However, birds fed pearl millet 50 % consumed more ($P = 0.013$, at 42 days of age and $P = 0.037$ at 49 days of age) feed than the maize based diet.

4.1.4. Carcass parts weights

Table 4.5 and 4.6 present results on the effects of PM (T1, T2, T3, T4 and T5) diets on thigh, fat pad, breast and gizzard weights/yield (g) of Cobb 500 broiler chickens at 42 and 49 days of age respectively. Results from the analysis of variance (ANOVA) have shown that, replacing maize with PM had no significant effects ($P>0.05$) on the thigh, breast and fat pad yield at both slaughter dates as well as gizzards yield at 49 slaughter age. However, pearl millet replacement had significant effects ($P<0.05$) on the gizzard weights 42 days of age. The least significant difference (LSD) was then performed and revealed that the control broiler diet, produced chickens with significant lighter gizzards as compared to the gizzards from the chickens fed PM 50 % ($P = 0.042$) and PM 25 % ($P = 0.020$).

Table 4.5. Effects of pearl millet on carcass parts weight (g) of Cobb 500 broiler chickens at 42 days of age

Treatment	Thigh	Fat pad	Breast	Gizzard
T1	184.0±6.15	28.8±5.91	410.0±31	37.5±1.44^{a}
T2	190.8±13.8	25.0±2.04	373.8±39.6	46.3±1.25^{b}
T3	188.5±9.19	27.5±3.23	411.3±33.0	45.0±2.04^{b}
T4	189.8±3.25	28.8±1.25	447.5±15.1	41.3±2.40^{a-b}
T5	205.0±11.9	37.5±4.30	456.3±26.6	42.5±4.33^{a-b}

$^{a-b}$Means within a column without a common superscript differ significantly ($P < 0.05$). T1= Control diet; T2 = 25% of Maize replaced with pearl millet; T3 = 50% Maize replaced with 50% of PM; T4 = 75 % Maize-based replaced with PM; T5 = 100 % Maize replaced with of PM

Table 4.6. Effects of pearl millet replacement on organs weight (g) of Cobb 500 broiler chickens at 49 days of age

Treatment	Thigh	Fat pad	Breast	Gizzard
T1	252±4.71	45.0±2.04	459±14.8	41.3±1.25
T2	232±13.5	35.0±2.04	426±28.4	48.8±3.75
T3	240±30.6	40.0±2.89	510±41.6	48.3±4.41
T4	246±4.93	45.0±2.89	537±16.4	46.7±1.67
T5	216±10.2	38.3±4.41	531±26.0	48.3±1.67

T1= Control diet; T2 = 25% of Maize replaced with pearl millet; T3 = 50% Maize replaced with 50% of pearl millet; T4 = 75 % Maize-based replaced with pearl millet; T5 = 100 % Maize replaced with pearl millet

4.1.1. The economics of replacing maize with pearl millet in broiler diets

Table 4.7 indicates that, on average, to raise one bird of +1.0416 kg on maize based finisher diet, N$3.925 is required (for feeds only) in the first 3 weeks of the finisher phase, while N$5.376 is required to finish off a broiler chicken of the weight +1.5092. About N$5.20 is required to raise one bird of +1.2579 kg on average with a pearl millet 100 % finisher diet, while N$6.7326 is required (for feeds only) is required to finish off a broiler chicken of the weight +1.7164.

Table 4.7. Shows feed consumed by broiler chickens per day fed different diets and costs

Diet	Feed Intake/ Day (kg)	No. of days	Unit Cost (N$)/kg	Total Cost (N$)
42 days of age				
Maize based	0.0623	21	3.87	5.06
PM 25 %	0.0691	21	4.04	5.86
PM 50 %	0.0754	21	4.14	6.56
PM 75 %	0.0692	21	4.17	6.06
PM 100 %	0.0707	21	4.27	6.34
49 days of age				
Maize based	0.064	28	3.87	6.94
PM 25 %	0.068	28	4.04	7.69
PM 50 %	0.0747	28	4.14	8.66
PM 75 %	0.0676	28	4.17	8.02
PM 100 %	0.0687	28	4.27	8.21

Table 4.8. Shows costs, weight gained and feeds consumed by chickens fed on different diets for 28 days (from day 21 to day 49)

Diet	Total consumed (kg)	Total gained (kg)	Unit Cost (N$)	Total Cost (N$)
42 days of age				
Maize based	1.3083	1.0416	3.94	5.15
PM 25 %	1.4511	1.2012	4.04	5.86
PM 50 %	1.5834	1.2663	4.14	6.56
PM 75 %	1.4532	1.2789	4.17	6.06
PM 100 %	1.4847	1.2579	4.27	6.34
49 days of age				
Maize based	1.792	1.5092	3.87	6.94
PM 25 %	1.904	1.6828	4.04	7.69
PM 50 %	2.0916	1.764	4.14	8.66
PM 75 %	1.8928	1.7556	4.17	7.89
PM 100 %	1.9236	1.7164	4.27	8.21

Table 4.9. Shows the total variable costs for the whole experiment

Expenditure on the project				
Inputs	**Unit**	**No. of Units**	**Unit Cost (N$)**	**Total Cost (N$)**
Premix	1.5 kg	2	86.25	172.50
SBM	50 kg	3	306.02	918.05
Maize (bag)	50 kg	1	150	150.00
Mahangu (bag)	20 kg	7	70	490.00
Stress park	100 g	4	135	540.00
waters & Feeders	14 each	28		1 980.00
Lamp Holders type1		2	11.95	23.90
Lamp Holders type2		2	30.95	61.90
Light Kit		3	59.99	179.97
GumburoVacc.		1	92.56	92.56
Newcastle Vacc.		1	55.42	55.42
Disinf.		1	190.87	190.87
Chick. Grower	50 kg	6	248	1,488.00
Chick. Grower	5 kg	6	38.7	232.20
Ripcord (electric wire)	0.75mm	16	3.75	60.00
Bulbs	150w	14	52.6	736.40
wire mash	Meters	25 M	13.74	343.55
Bush cutter		2	236.5	473.00
Gloves		1	82.81	82.81
Total Cost				6, 291.13

4.2. Effects of feeding maize-soybean meal based diets with a tanniferous additive (*A. karroo* leaf meal) to broiler chickens

Results of the composition of determined proximate analysis for *A. karroo* are presented in Table 4.10. On a dry matter basis, *A. karroo* leaf meal contained 130 g crude protein (CP) per kg, 150 g crude fiber (CF) per kg, 2 mg of calcium (Ca) per 100 g, 0.1 mg of phosphorus (P) per 100 g, 4 g of fat per kg as well as 67 g of Ash per 100 g.

Table 4.10. Chemical Composition of *A. karroo*

Feed	CP (g/kg)	CF (g/kg)	Ash (g/100g)	Ca (mg/100g)	P (mg/100g)	Fat (g/kg)
AKLM	130	150	6.7	2.0	0.1	18

AKLM = *Acacia karroo* leaf meal

4.2.1. Nutrient composition of treatment diets

Nutrient composition of experimental broiler finisher diets fed to Cobb 500 broiler chickens from week 3 to week 7 are shown in Table 4.11. Both experimental finisher diets used in *A. karroo* additive, namely; T1 (maize-based diet = control); T2 (5 g/kg additive) and T3 (20 g/kg additive), contained approximately 16.3 %, 16.2 %, 16.3 %, 16.0 % and 16.1 % of CP, 3.33 %, 3.68 %, 4.00 %, 4.02 %, and 4.00 % of CF as well as 12.0 ME/MJ/Kg, 12.1 ME/MJ/Kg, 12.00 ME/MJ/Kg, 11.9 ME/MJ/Kg and 11.8 ME/MJ/Kg of energy respectively

Table 4.11. Nutrient composition of experimental broiler finisher diet (3-7 weeks)

Nutrient	Experimental Diets				
	T1	T2	T3	T4	T5
Crude Protein %	16.3	16.2	16.3	16.0	16.1
Crude Fiber %	3.33	3.68	4.00	4.02	4.00
Energy ME/MJ/Kg	12.00	12.1	12.00	11.9	11.8

T1= Control; T2 = Maize-based diet replaced with 25% of pearl millet; T3 = Maize-based diet replaced with 50% of pearl millet; T4 = Maize-based diet replaced with 75% of pearl millet; T5 = Maize-based diet replaced with 100% of pearl millet

Table 4.12 and 4.13 presents the results of effects of *A. karroo* leaf meal level of addition on maize based diets on feed intake (g/bird/day), weight gain (g/bird/day) and feed conversion ratio (FCR) (g feed/g live weight gain) of Cobb 500 broiler chickens from 21 to 42 and 49 days of age, respectively.

4.2.2. Weight gains

Analysis of variance revealed that there was no significant difference in the amount of weight gain for the birds fed different diets on daily basis, therefore the null hypothesis stating that the broilers fed different diets gained the same amount of weights could not be rejected. In other words, the average mean weight gain (daily gain) by the broilers fed different *A. karroo* leaf meal levels of addition on maize based diets as well as those fed maize based diets (control diet), are not significantly different (P < 0.05). Hence the least significant difference (LSD) was not performed to compare the average mean intakes considering the pairs of diets.

Table 4.12. Effects of *A. karroo* leaf meal level of addition on maize based diets on feed intake (g/bird/day), weight gain (g/bird/day) and feed conversion ratio (FCR) (g feed/g live weight gain) of Cobb 500 broiler chickens from 21 to 42 days of age

Treatment	ADFI	ADG	FCR
T1	62.3 ± 2.62^{a}	49.6 ± 2.37	1.30
T2	75.5 ± 2.94^{b}	51.7 ± 1.18	1.46
T3	59.3 ± 3.55^{a}	51.5 ± 1.64	1.15

$^{a\text{-}b}$Means within a column without a common superscript differ significantly (P < 0.05). T1= Control (no *A. karroo* leaf meal added); T2 = Maize-based diet with 5 g/kg supplementation level of *A. karroo* leaf meal; T3 =. Maize-based diet with 20 g/kg supplementation level of *A. karroo* leaf meal. ADFI = Average daily feed intake; ADG= Average daily gain.

Table 4.13. Effects of *A. karroo* leaf meal level of addition on maize based diets on feed intake (g/bird/day), weight gain (g/bird/day) and feed conversion ratio (FCR) (g feed/g live weight gain) of Cobb 500 broiler chickens from 21 to 49 days of age

Treatment	ADFI	ADG	FCR
T1	64.0±2.56	53.9±1.83	1.19^{b}
T2	77.7±2.83	56.5±1.08	1.38^{a}
T3	60.6±3.47	54.4±1.25	1.11^{b}

$^{a-b}$Means within a column without a common superscript differ significantly (P < 0.05). T1= Control (no *A. karroo* leaf meal added); T2 = Maize-based diet with 5 g/kg supplementation level of *A. karroo* leaf meal; T3 = Maize-based diet with 20 g/kg supplementation level of *A. karroo* leaf meal. ADFI = Average daily feed intake; ADG= Average daily gain.

4.2.3. Feed intake

Table 4.13 also present results on the daily feed intakes of the broiler chickens fed different diets. Analysis of variance revealed that there is a significant difference in the amount of feed consumed by the birds fed different levels of *A. karoo* meal on daily basis, therefore the null hypothesis stating that the broilers consumed the same quantity of different diets was rejected. In other words, the average mean consumptions (daily intake) by the broilers fed different dietary levels maize based diets with *A. karroo* additive at different levels as well as those fed control diet, are significantly different (P = 0.022). Hence, the least significant difference (LSD) was performed to compare the average mean intakes considering the pairs of diets. Results from the LSD have shown that addition of 5g/kg of *A. karroo* leaf meal to maize based diets had highly significant effect ($P = 0.009$) on the feed intake of the Cobb 500 broiler chickens as compared to those without *A. karroo* leaf meal, while birds fed on 20 g/kg *A. karroo* supplemented diet ($P = 0.535$) had similar feed intake as those without *A. karroo* leaf meal (control diet). Furthermore, maize based diets with 20 g/kg of *A. karroo* leaf meal additive resulted in significant ($P = 0.002$) feed intake as compared to the birds fed 5 g/kg additive diet. It is therefore, clear from these results that broilers fed maize based diet (control diet) and 20 g/kg *A. karroo* leaf meal additive consumed similar quantities of feed and less feed than the birds fed 5 g/kg additive diet.

4.2.4. Carcass parts weights

Table 4.14 and 4.15 present results on the effects of *A. karroo* leaf meal additive on thigh, fat pad, breast and gizzard weights/yield (g) of Cobb 500 broiler chickens at 42 and 49 days of age. Results from the analysis of variance (ANOVA) have revealed that broiler chickens fed maize-based diets with 5 g/kg and 20 g/kg *A. karroo* leaf meal additives had no significant effects ($P<0.05$) on the thigh, fat pad and gizzard weights. Broiler chickens fed maize-based diets with 5 g/kg *A. karroo* leaf meal additives had no significant effects ($P<0.05$) breast weights as well. However, the 20g/kg treatment affected the breast weights of the broiler chickens significantly ($P = 0.006$).

Table 4.14. Effects of maize-based diet and *A. karroo* leaf meal level of addition on carcass parts weight (g) of Cobb 500 broiler chickens at 42 days of age.

Treatment	Thigh	Fat pad	Breast	Gizzard
T1	184.0±6.15	28.8±5.91	410.0±31.2[a]	37.5±1.44
T2	198.3±14.1	33.8±3.75	398.8±27.3[a]	35.0±2.04
T3	174.5±2.10	30.0±2.04	280.0±30.1[b]	38.8±2.40

[a-b]Means within a column without a common superscript differ significantly (P < 0.05). T1= Control (no *A. karroo* leaf meal added); T2 = Maize-based diet with 5 g/kg supplementation level of *A. karroo* leaf meal; T3 =. Maize-based diet with 20 g/kg supplementation level of *A. karroo* leaf meal.

Table 4.15. Effects of maize-based diet and *A. karroo* leaf meal level of addition on organs weight (g) of Cobb 500 broiler chickens at 49 days of age

Treatment	Thigh	Fat pad	Breast	Gizzard
T1	252±4.71	45.0±2.04	459±14.8	41.3±1.25
T2	256±5.31	42.5±1.44	434±24.8	43.±1.25
T3	233±16.0	42.5±1.44	450±35.2	45.0±0.00

[a-b]Means within a column without a common superscript differ significantly (P < 0.05). T1= Control (no *A. karroo* leaf meal added); T2 = Maize-based diet with 5 g/kg supplementation level of *A. karroo* leaf meal; T3 =. Maize-based diet with 20 g/kg supplementation level of *A. karroo* leaf meal.

4.3. Consumer Sensory Evaluation

Table 6.1.shows effects of pearl millet (T1, T2, T3 and T4), maize-based diet and additive level of *A. karroo* leaf meal on the sensory characteristics and preference of meat from Cobb 500 broiler chickens in terms of the median scores. Results from the Friedman's Test have shown that, replacing maize with pearl millet, and addition of *A. karroo* leaf meal to maize – based diets at different levels did not significantly ($P<0.05$) affect consumer's scores/linking for the taste, juiciness, tenderness and preference of the broiler meat. However, based on Friedman's Test, pearl millet diets, maize-based diets and *A. karroo* leaf meal level of supplementation had significant effect ($P < 0.007$) on the aroma of the broiler meat based on the scores of the assessors.

Table 4.16. Effects of pearl millet (T1, T2, T3 and T4), maize-based diet and *A. karroo* leaf meal level of supplementation on the sensory characteristics and preference of meat from Cobb 500 broiler chickens

Treatment	AR	TA	JU	TE	PR
MB_{T0}	7	6	7	7	4
MB_{T1}	7	6	6	7	4
MB_{T2}	7	6.5	7	6	4
PM_{T1}	5	6	7	7	4
PM_{T2}	6.5	7	6	6.5	4
PM_{T3}	6	6.5	6	6	4
PM_{T4}	7	6	6	7	3.5

$^{a\text{-}b}$Means within a column without a common superscript differ significantly ($P < 0.05$). AR = Aroma, TA = Taste, JU = Juiciness, TE = Tenderness, PR = Preference

The Wilcoxon Signed-Rank Tests was performed and revealed that broiler chickens fed maize-based diets with 5 g/kg additive received significantly higher ($P = 0.001$) consumer scores than pearl millet 25 % and pearl millet 50 % respectively. Broiler chickens fed maize-based diets supplemented with 20 g/kg received significantly higher ($P = 0.005$) consumer scores than pearl millet 25%. However, these results could be affected by the Type I error, hence the Bonferroni adjustment was performed which indicated that broiler chickens fed maize-based diets supplemented with 5 g/kg received significantly higher ($P = 0.001$) consumer scores than pearl millet inclusion at 25 % but not at 50 %.

CHAPTER 5

DISCUSIONS

5.1. Growth and carcass performance of broiler chickens when maize is replaced with PM under Namibian weather conditions

5.1.1. Feed analysis results

From the nutritional point of view, pearl millet is said to be equivalent or better than maize-based diets, as shown in the study of Stringhini and Franca (1999), as cited in Davis *et al*.(2003) and by Gulia *et al*., (2007).The pearl millet grains used in this study contained 120 g of crude protein per kg, 21 g of crude fiber per kg, 16 mg of calcium per 100 g, 4 g of fat per kg, 373 mg of phosphorus per 100 g and 1.3 g of ash per 100g. Crude protein, fat and crude fiber contents of pearl millet observed in the present study are in the agreement with previous studies (Davis *et al*., 2003; Hidalgo *et al*., 2004) and quite different from those reported by Mehri *et al*. (2010). The amount of soybean meal required to formulate experimental diets was reduced by 1.5% at 100% inclusion of pearl millet (19.5% of soybean was used) as compared to that of the 0% inclusion of pearl millet (maize-soybean based, which is the experimental control diet) where 21% was required. Since protein is the most expensive nutrient in feeds, the use of pearl millet reduces feed costs.

Experimental finisher diets (T1 – T5) used to study the effects of replacing maize with pearl millet contained 12.0, 12.1, 12.0, 11.9 and 11.8 ME/MJ/Kg energy contents and 16.3, 16.2, 16.3, 16.0 and 16.1 % protein contents respectively. These diets were formulated, considering the costs of broiler chicken diets as well as Namibia's harsh environmental conditions. Therefore, approximately 16 % of crude protein was used in the finisher diets.

5.1.2. Effects of pearl millet on production performance of broiler chicken

Research findings of the present study have revealed that replacing maize with pearl millet in broiler diets had no adverse effect on production responses of broiler chickens. Similar findings were reported by Davis *et al*. (2003); Tornekar *et al*. (2009) and Baurhoo *et al*. (2011). Broiler chickens fed pearl millet (PM) diets (PM 25%, PM 75 %, PM 100 %), especially those fed 50 % PM, gained significantly more weight than the control – based diets. It is not clear why the chickens fed PM 50 % diets resulted in significantly heavier birds than the ones fed PM 25 %, PM 75 % and PM 100 %. Perhaps it could be a result of a longer adaptation period required for the gizzards to adapt to a new diet, which should be obviously longer in broilers fed PM 100 % and PM 75 % since they were introduced to totally different diets. However, no studies were accessed to back up this statement.

5.1.3. Effects of pearl millet on FCR

The present study observed that replacement of maize with pearl millet had no significant (P > 0.05) effect on feed intake and FCR (g feed/g live weight gain) of broiler chickens from 21 to 49 days of age. However, from visual observations for the feed intakes, birds fed dietary levels of pearl millet as a replacement of maize had higher feed intake as compared to those which were fed maize-based diet. This observation is in agreement with the field observations on more feed wastage in maize-based diets as compared to the pearl millet-based diets, and the same observations were reported by Baurhoo *et al*. (2011). FCR values obtained in this experiment ranged between 1.14 to 1.25 (pearl millet based diets) and 1.30 (control diet) at 42 days of age and between 1.08 to 1.19 for pearl millet based diets and 1.19 for the control diet at 49 days of age. These figures are in the same range as the ones reported by Atil (2007).

Based on some research findings (Sott *et al*., 1982), broiler chickens consume enough feed to satisfy their energy requirements. Therefore, similar feed intakes were expected, because all of the experimental finisher diets used for the study contained more or less similar energy levels. Although not significant, differences in feed intake reported in the current study may be associated with more wastage in control diet as compared to pearl millet - based diets, creating a need for further studies. As a result, the findings of this study may be said to be similar to the ones reported by Davis *et al*. (2003) and Mehri *et al*. (2010), which revealed similar FCR in pearl millet– based and maize – based diets.

5.1.4. Effects of pearl millet on gizzard weight

Results of the present study have shown that, the relative gizzard weights were significantly higher in birds fed PM 25 % (46.3 g) and PM 50 % (45.0 g) than those from birds fed the control diet (37.5g) at 42 days of age. Studies have shown that, moderate amounts of fiber in the broiler chicken diets improve the development of the gizzard (Gonzales-Alvarado *et al*., 2007; Hetland and Svihus, 2007). Birds fed PM diets had significant increased gizzard weights, which might be associated with moderate amount of fiber from pearl millet grains.

5.1.5. Effect of pearl millet on abdominal fat

Regardless of the age at slaughter, there was no significant difference ($P > 0.05$) in the abdominal fat deposition, breast and weight (g) of thighs for the broilers fed maize-based diet (control diet) and those which were fed pearl millet diets.

5.1.6. Economics of production of broiler chickens when maize is replaced with pearl millet

Although pearl millet grains are more expensive, diets formulated with pearl millet produces birds with heavier weights than those of maize based diets. If pearl millet makes its way into the feed manufacturing value chain, this may stimulate more production which will eventually lower the prices. Local farmers will benefit from increased farm incomes.

5.2. Effects of feeding maize-soybean meal based diets with a tanniferous additive (*A. karroo* leaf meal) to broiler chickens.

5.2.1. Feed analysis results

The determined crude protein content of *A. karroo* leaf meal was 130g per kg, which is slightly higher than 120 g per kg reported by Ngambi et al. (2009). Kahiya *et al*. (2004) reported similar results. Although, *A. karroo* leaves contains high concentrations of tannins, predominantly condensed tannins, its high protein contents are best for supplementation in animal feeds, as shown in the study by Makkar (2003), cited in Ngambi *et al*. (2009).

Experimental finisher diets (T0, T1, T2 and T3) used to study the effects of adding *A. karroo* leaf meal at different levels on maize based diets on contained 12.0, 12.1, 12.0, 11.9 and 11.8 ME/MJ/Kg energy contents and 16.3, 16.2, 16.3, 16.0 and 16.1 % protein contents, respectively. These diets were formulated, considering the costs of broiler chicken diets as well as Namibia's harsh environmental conditions. Therefore approximately 16 % of crude protein was used in the finisher diets.

5.2.2. Effects of *A. karroo* leaf meal on weight gain and FCR

The present study observed that different *A. karroo* leaf meal levels added to maize based diets had no significant ($P > 0.05$) effect on weight gain and feed conversion ratio (FCR) (g feed/g live weight gain) of broiler chickens from 21 to 49 days of age. Similar results were reported by Ngambi *et al.*, (2009). Although findings of the present study have shown that adding 5 g/kg of *A. karroo* leaf meal to the broiler chicken diets significantly affected (P = 0.009) the feed intake, field observations relates these findings to the wastage of feed other than the actual feed intake by the birds. Therefore, it can be concluded that adding 5 g/kg and 20 g/kg levels of *A. karroo* leaf meal to broiler chicken diets had no effects on the feed intakes of the chickens. A study on broilers fed sorghum cultivars, some of which were low and some high in tannins levels indicated that high levels of tannins reduced growth rates, feed intake, metabolisable energy, protein digestibility and resulted in leg abnormality in chicks (Armstrong *et al*., 1974). Studies have shown that *A. karroo* contains condensed tannins that tend to bind with dietary protein and other nutrients, which reduces feed intake and digestibility in animals (Dube, 1993; Makkar, 2003).

5.2.3. Effects of *A. karroo* leaf meal on fat deposition, weight of thighs and gizzards

Regardless of the age at slaughter, there was no significant difference (P > 0.05) in the abdominal fat deposition, weight of thighs and gizzards for the broilers fed maize-based diet (control diet) and the ones with *A. karroo* leaf meal additive. However, chickens fed maize based diets with 20 g/kg of *A. karroo* leaf meal had significantly (P = 0.006) lower breast. This may be due to the fact that addition of 20 g/kg of *A. karroo* leaf meal to broiler diets tends to reduce body weights of chickens. Although there was no significant difference (P > 0.05) in the abdominal fat deposition for the broilers fed maize-based diet (control diet) with an addition of 20 g/kg of *A. karroo* leaf meal, it can be concluded that adding 20 g/kg of *A. karroo* to broiler diets reduces growth rates with a tendency to significantly reduce (P = 0.058) the fat deposition (considered at P<0.05 level of significance). It could also be concluded that more than 5 g/kg of *A. karroo* leaf meal should be added in order to achieve a significant reduction of fat deposition in Cobb 500 broiler chickens. A study by Ngambi *et al*. (2009) observed that supplementing diets with 9 g/kg and 12 g/kg levels of *A. karroo* leaf meal reduced fat pad weights by 26 and 29 % in female and male Ross 308 broiler chickens. Results of a study by Ristic (2005) as cited in Nikolova *et al.* (2007) revealed that Cobb 500 genotype had significantly less abdominal fat by 0.4 % as compared to Ross 308 genotype. Therefore, more quantities of tannins contents may be required for a significant reduction in abdominal fat of Cobb 500 as compared to the Ross 308.

5.3. Consumer Sensory Evaluation

In the current study, replacing maize with pearl millet as well as using *A. karroo* leaf meal as an additive to maize-based diets had no effect (P > 0.05) on the taste, juiciness, tenderness and preference of meat from Cobb 500 broiler chickens. According to Mapiye *et al*. (2009) supplementation of ruminant animal diets with *A. karroo* plant leaves results in improved meat sensory characteristics. Intramuscular fat content of the meat influences the juiciness of the meat directly (Webb *et al.,* 2005). In the current study, juiciness which is said to be mainly affected by the animal species (Muchenje *et al*., 2008) was not affected by addition of 5 g/kg and 20 g/kg *of A. karroo* leaf meal to maize-soybean based broiler diets. A study by Ngambu (2011) revealed that the meat juiciness scores from the *A. karroo* supplemented goats were significantly higher (P< 0.05) than the meat juiciness scores of meat from the non-supplemented goats. Therefore, the same study concluded that, the improvement in meat juiciness scores from the *A. karroo* supplemented goats could be attributed to the effect of *A. karroo* supplementation since it is known to improve the resilience of meat producing animals (Arsenos *et al*., 2009) and is a source of proteins (Mokoboki *et al*., 2005).

In the present study, addition of *A. karroo* leaf meal to broiler diets did not affect the flavor of the meat. Similar findings were reported in previous studies (French *et al*., 2001; Ngambu, 2011) who have reported that diet has no significant effect on the flavor of the meat. These results however are contrary to the findings of Melton (1983) and Berry *et al.* (1988) which revealed that diet has a significant effect on the meat flavor. The difference in results obtained by different authors may be as a result of feed ingredients as well as animal species and breed used, i.e. silage and pastures (Melton, 1983), corn diets to corn silage diets (Berry *et al*., 1988), grass, grain-fed (French *et al*., 2001) both in small ruminants and the present study maize based diets in broilers.

Results of the present study have also shown that age and gender had no significant effect (P > 0.05) on the assessors' responses on the attributes of the chicken meat from broiler chickens which were fed different diets. Since the sensory analysis was carried out at Neudamm campus of the University of Namibia, the age group of the assessors ranged between 18 and 26 which may have an effect on the final results. However, these results are different from the previous studies who have reported a significant effect of consumer gender on sensory characteristics with the highest scores recorded by female consumers (Simela, 2005; Dyubele, *et al*., 2010; Xazela *et al.* 2011; Ngambu, 2011) who all, where females reported higher scores of meat juiciness than males consumers. There are few studies on the effects of PM on meat characteristics and consumer acceptability.

5.4. General Discussion

From the nutritional point of view, pearl millet is said to be equivalent or better than maize-based diets, as reported by Stringhini and Franca (1999), and Davis *et al*. (2003). The pearl millet grains used in this study contained 120 g of crude protein per kg, 21 g of crude fiber per kg, 16 mg of calcium per 100 g, 4 g of fat per kg, 373 mg of phosphorus per 100 g and 1.3 g of ash per 100g. As a result of the higher protein content the amount of soybean meal required to formulate experimental diets was reduced by 1.5% at 100% inclusion of pearl millet creating opportunities for cost saving from the angle of using less protein source as a result of using pearl millet instead of maize in finisher diets of broiler chickens.

Crude protein, fat and crude fiber contents of PM observed in the present study are in the agreement with previous studies (Davis *et al*., 2003; Hidalgo *et al*., 2004) and quite different from those reported by Mehri *et al*. (2010).

Experimental finisher diets (T0, T1, T2, T3 and T4) used to study the effects of replacing maize with pearl millet contained 12.0, 12.1, 12.0, 11.9 and 11.8 ME/MJ/Kg energy contents and 16.3, 16.2, 16.3, 16.0 and 16.1 % protein contents respectively. The diets therefore, supplied enough energy according to NRC or ARC nutrient requirements for energy by broilers. Since birds eat to satisfy their energy requirements, energy content did not negatively affect the results of the study.

The determined crude protein content of *A. karroo* leaf meal was 130g per kg, which is slightly higher than 120 g per kg reported by Ngambi *et al*. (2009). Although, *A. karroo* leaves contains high concentrations of tannins, predominantly condensed tannins, its high protein content has opportunities for protein supplementation especially in ruminant fattening feeds, as shown in the study of Makkar (2003). In birds *A. karroo* is used in smaller quantities; that is as an additive and not a protein supplement since it contains less that 20 % crude protein.

Findings of the present study have shown that addition of 5 g/kg and 20 g/kg of *A. karroo* leaf meal had no significant effects ($P > 0.05$) on the feed intake, weight gain as well as FCR. Also 5g/kg *A. karroo* meal has no effect in producing lean meat with higher level of 20 g/kg tending to have effects on fat deposition thus producing leaner carcasses. High levels of tannins in *A. karroo* leaf meal tend to reduce body weights of animals if large quantities are consumed. A study on broilers fed sorghum cultivars, some of which are low and some are high in tannins levels have indicated that high levels of tannins reduces growth rates, feed intake, metabolisable energy, protein digestibility and may result in leg abnormality in chicks (Armstrong *et al*., 1974). From the results of this study, it can be concluded that more than 5 g/kg of *A. karroo* leaf meal should be supplemented in order to achieve a significant reduction of fat deposition in Cobb 500 broiler chickens. It shows then that more quantities of tannins contents (than in the 5g/kg) may be required for a significant reduction in abdominal fat of Cobb 500.

Replacement of maize with pearl millet had significant ($P < 0.05$) effect on feed intake (g/bird/day) of broiler chickens from 21 to 42 days of age. Based on some research findings (Sott *et al*., 1982), broiler chickens consume enough feed to satisfy their energy requirements. Therefore, similar feed intakes were expected, because all of the experimental finisher diets used for the study contained more or less similar energy levels. Differences in feed intake reported in the current study may be associated with more wastage in maize - based diets as compared to pearl millet - based diets, raising room for further studies.

Research findings of the present study have revealed that replacing maize with pearl millet in broiler diets had no adversely effects on production responses of broiler chickens even up to 100% substitution. Similar findings were reported by Davis *et al*. (2003); Tornekar *et al*. (2009) and Baurhoo *et al*. (2011).

Results of the present study have shown that, the relative gizzard weights were significantly higher in birds fed pearl millet (PM) 25 %, PM 50 % and PM 100 % than those from birds fed the control. Studies have shown that, moderate amounts of fiber in the broiler chicken diets improve the development of the gizzard (Gonzales-Alvarado *et al*., 2007; Hetland and Svihus, 2007). Birds fed pearl millet diets had significant increased gizzard weights, which might be associated with moderate amount of fiber from pearl millet grains. Care needs to be taken if this feeding trial is to be started at day old chicks' age level.

Replacing maize with pearl millet as well as addition of *A. karroo* leaf meal to maize-based diets had no effect ($P > 0.05$) on the sensory characteristics and preference of meat from Cobb 500 broiler chickens.

Some consumers reported sliminess in chicken meat with the high *A. karroo* treatment. An optimum level seems to be between the 5g/kg and the 20 g/kg levels. It would make an economic sense if communal farmers can use pearl millet in broiler diets.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

The research findings of the present study have revealed that replacing maize with pearl millet (PM) in broiler diets had no adverse effects on overall production responses of broiler chickens. Broiler chickens fed PM 50 % diets resulted in significantly heavier birds. In situations where there is no maize, pearl millet can be used as the sole energy source albeit with some slight reduction in performance. Addition of 5 g/kg and 20 g/kg *A. karroo* leaf meal to broiler diets had no effects on the feed intakes, growth rate and feed conversion ration of the broiler chickens. However, addition of 20 g/kg of *A. karroo* leaf meal to broiler diets has shown a marginal reduction ($P = 0.058$) in fat deposition. More than 5 g/kg of *A. karroo* leaf meal may be added in order to achieve a significant reduction of fat deposition in Cobb 500 broiler chickens. Replacing maize with pearl millet and maize-based diets with *A. karroo* leaf meal additive had no effect ($P > 0.05$) on the taste, juiciness, tenderness and preference of broiler chicken meat.

6.2. Recommendations

In this study, treatments were imposed on the finisher stage of maturity. Therefore, research is recommended to test the treatment from day old chickens. Repeated feeding trials on a larger scale is recommended before pearl millet and *A. karroo* can be safely used by feed manufacturers. The same research should be done with different broiler breeds (indigenous chickens).

CHAPTER 7

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Appendixes

Appendix A

Weight Gain per bird per day at 42 days of age

Descriptives

MeanDailyup42daysgains

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Control	7	49.5714	6.27079	2.37013	43.7719	55.3709
A. karroo 5g	9	51.7407	3.54643	1.18214	49.0147	54.4668
A. karroo 20g	5	51.5333	3.66364	1.63843	46.9843	56.0823
PM 25%	4	57.1667	3.55382	1.77691	51.5117	62.8216
PM 50%	7	60.2857	6.18968	2.33948	54.5612	66.0102
PM 75%	5	60.9333	6.37007	2.84878	53.0238	68.8428
PM 100%	5	59.9333	7.29688	3.26326	50.8731	68.9936
Total	42	55.3651	6.81056	1.05089	53.2428	57.4874

Test of Homogeneity of Variances

MeanDailyup42daysgains

Levene Statistic	df1	df2	Sig.
1.156	6	35	.352

ANOVA

MeanDailyup42daysgains

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	868.442	6	144.740	4.903	.001
Within Groups	1033.293	35	29.523		

Total	1901.735	41

Post Hoc Tests

Multiple Comparisons

Dependent Variable: MeanDailyup42daysgains
LSD

(I) Diet(until day 49	(J) Diet(until day 49	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval
					Lower Bound
Control	*A. karroo* 5g	-2.16931	2.73821	.434	-7.7282
	A. karroo 20g	-1.96190	3.18152	.541	-8.4207
	PM 25%	-7.59524*	3.40561	.032	-14.5090
	PM 50%	-10.71429*	2.90432	.001	-16.6104
	PM 75%	-11.36190*	3.18152	.001	-17.8207
	PM 100%	-10.36190*	3.18152	.003	-16.8207
A. karroo 5g	Control	2.16931	2.73821	.434	-3.3896
	A. karroo 20g	.20741	3.03065	.946	-5.9451
	PM 25%	-5.42593	3.26511	.105	-12.0545
	PM 50%	-8.54497*	2.73821	.004	-14.1038
	PM 75%	-9.19259*	3.03065	.005	-15.3451
	PM 100%	-8.19259*	3.03065	.011	-14.3451
A. karroo 20g	Control	1.96190	3.18152	.541	-4.4969
	A. karroo 5g	-.20741	3.03065	.946	-6.3600
	PM 25%	-5.63333	3.64489	.131	-13.0328
	PM 50%	-8.75238*	3.18152	.009	-15.2112
	PM 75%	-9.40000*	3.43643	.010	-16.3763
	PM 100%	-8.40000*	3.43643	.020	-15.3763
PM 25%	Control	7.59524*	3.40561	.032	.6815
	A. karroo 5g	5.42593	3.26511	.105	-1.2026
	A. karroo 20g	5.63333	3.64489	.131	-1.7662
	PM 50%	-3.11905	3.40561	.366	-10.0328

	PM 75%	-3.76667	3.64489	.308	-11.1662
	PM 100%	-2.76667	3.64489	.453	-10.1662
PM 50%	Control	10.71429*	2.90432	.001	4.8182
	A. karroo 5g	8.54497*	2.73821	.004	2.9861
	A. karroo 20g	8.75238*	3.18152	.009	2.2936
	PM 25%	3.11905	3.40561	.366	-3.7947
	PM 75%	-.64762	3.18152	.840	-7.1064
	PM 100%	.35238	3.18152	.912	-6.1064
PM 75%	Control	11.36190	3.18152	.001	4.9031
	A. karroo 5g	9.19259	3.03065	.005	3.0400
	A. karroo 20g	9.40000*	3.43643	.010	2.4237
	PM 25%	3.76667*	3.64489	.308	-3.6328
	PM 50%	.64762*	3.18152	.840	-5.8112
	PM 100%	1.00000*	3.43643	.773	-5.9763
PM 100%	Control	10.36190	3.18152	.003	3.9031
	A. karroo 5g	8.19259	3.03065	.011	2.0400
	A. karroo 20g	8.40000	3.43643	.020	1.4237
	PM 25%	2.76667*	3.64489	.453	-4.6328
	PM 50%	-.35238*	3.18152	.912	-6.8112
	PM 75%	-1.00000*	3.43643	.773	-7.9763

*. The mean difference is significant at the 0.05 level.

Weight Gain per bird per day at 49 days of age

Oneway

Descriptives

MeanDailyG

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Control	7	53.9286	4.82984	1.82551	49.4617	58.3954

A. karroo 5g	9	56.5000	3.23313	1.07771	54.0148	58.9852
A. karroo 20g	5	54.3500	2.80401	1.25399	50.8684	57.8316
PM 25%	4	60.0625	1.76039	.88019	57.2613	62.8637
PM 50%	7	62.9643	4.64226	1.75461	58.6709	67.2577
PM 75%	5	62.6500	5.85929	2.62035	55.3747	69.9253
PM 100%	5	61.2500	5.15085	2.30353	54.8544	67.6456
Total	42	58.5298	5.36168	.82732	56.8589	60.2006

Test of Homogeneity of Variances

MeanDailyG

Levene Statistic	df1	df2	Sig.
.622	6	35	.712

ANOVA

MeanDailyG

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	541.561	6	90.260	4.959	.001
Within Groups	637.090	35	18.203		
Total	1178.650	41			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: MeanDailyG 49
LSD

(I) Diet(until day 49	(J) Diet(until day 49	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval
					Lower Bound
Control	*A. karroo* 5g	-2.57143	2.15009	.240	-6.9363

	A. karroo 20g	-.42143	2.49818	.867	-5.4930
	PM 25%	-6.13393*	2.67414	.028	-11.5627
	PM 50%	-9.03571*	2.28051	.000	-13.6654
	PM 75%	-8.72143*	2.49818	.001	-13.7930
	PM 100%	-7.32143*	2.49818	.006	-12.3930
A. karroo 5g	Control	2.57143	2.15009	.240	-1.7935
	A. karroo 20g	2.15000	2.37971	.372	-2.6811
	PM 25%	-3.56250	2.56382	.173	-8.7673
	PM 50%	-6.46429*	2.15009	.005	-10.8292
	PM 75%	-6.15000*	2.37971	.014	-10.9811
	PM 100%	-4.75000	2.37971	.054	-9.5811
A. karroo 20g	Control	.42143	2.49818	.867	-4.6501
	A. karroo 5g	-2.15000	2.37971	.372	-6.9811
	PM 25%	-5.71250	2.86202	.054	-11.5227
	PM 50%	-8.61429*	2.49818	.001	-13.6859
	PM 75%	-8.30000*	2.69834	.004	-13.7779
	PM 100%	-6.90000*	2.69834	.015	-12.3779
PM 25%	Control	6.13393*	2.67414	.028	.7051
	A. karroo 5g	3.56250	2.56382	.173	-1.6423
	A. karroo 20g	5.71250	2.86202	.054	-.0977
	PM 50%	-2.90179	2.67414	.285	-8.3306
	PM 75%	-2.58750	2.86202	.372	-8.3977
	PM 100%	-1.18750	2.86202	.681	-6.9977
PM 50%	Control	9.03571*	2.28051	.000	4.4060
	A. karroo 5g	6.46429*	2.15009	.005	2.0994
	A. karroo 20g	8.61429*	2.49818	.001	3.5427
	PM 25%	2.90179	2.67414	.285	-2.5270
	PM 75%	.31429	2.49818	.901	-4.7573
	PM 100%	1.71429	2.49818	.497	-3.3573
PM 75%	Control	8.72143	2.49818	.001	3.6499
	A. karroo 5g	6.15000	2.37971	.014	1.3189
	A. karroo 20g	8.30000*	2.69834	.004	2.8221
	PM 25%	2.58750*	2.86202	.372	-3.2227

	PM 50%	-.31429*	2.49818	.901	-5.3859
	PM 100%	1.40000*	2.69834	.607	-4.0779
PM 100%	Control	7.32143	2.49818	.006	2.2499
	A. karroo 5g	4.75000	2.37971	.054	-.0811
	A. karroo 20g	6.90000	2.69834	.015	1.4221
	PM 25%	1.18750*	2.86202	.681	-4.6227
	PM 50%	-1.71429*	2.49818	.497	-6.7859
	PM 75%	-1.40000	2.69834	.607	-6.8779

*. The mean difference is significant at the 0.05 level.

Feed Intake per bird per day at 42 days of age

One way

Descriptives

MeanIntake1and2for42

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
control	7	62.3138	6.92571	2.61767	55.9086	68.7190
A. karroo 5g	6	75.4792	7.19349	2.93673	67.9301	83.0283
A. karroo 20g	6	59.3333	8.68947	3.54746	50.2143	68.4524
PM 75%	6	69.1905	10.89006	4.44585	57.7621	80.6189
PM 100%	7	70.6709	6.73543	2.54575	64.4417	76.9002
PM 50%	5	75.4429	5.97596	2.67253	68.0227	82.8630
PM 25%	6	69.0804	11.87748	4.84896	56.6157	81.5450
Total	43	68.5257	9.73532	1.48462	65.5297	71.5218

Test of Homogeneity of Variances

MeanIntake1and2for42

Levene Statistic	df1	df2	Sig.
1.045	6	36	.413

ANOVA

MeanIntake1and2for42

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1343.164	6	223.861	3.056	.016
Within Groups	2637.443	36	73.262		
Total	3980.607	42			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: MeanIntake1and2for42
LSD

(I) Diets	(J) Diets	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
control	*A. karroo* 5g	-13.16539*	4.76198	.009	-22.8231	-3.5077
	A. karroo 20g	2.98044	4.76198	.535	-6.6773	12.6382
	PM 75%	-6.87670	4.76198	.157	-16.5344	2.7810
	PM 100%	-8.35714	4.57516	.076	-17.6360	.9217
	PM 50%	-13.12908*	5.01184	.013	-23.2936	-2.9646
	PM 25%	-6.76658	4.76198	.164	-16.4243	2.8912
A. karroo 5g	control	13.16539*	4.76198	.009	3.5077	22.8231
	A. karroo 20g	16.14583*	4.94174	.002	6.1235	26.1681
	PM 75%	6.28869	4.94174	.211	-3.7336	16.3110
	PM 100%	4.80825	4.76198	.319	-4.8495	14.4660
	PM 50%	.03631	5.18294	.994	-10.4752	10.5478

	PM 25%	6.39881	4.94174	.204	-3.6235	16.4211
A. karroo 20g	control	-2.98044	4.76198	.535	-12.6382	6.6773
	A. karroo 5g	-16.14583*	4.94174	.002	-26.1681	-6.1235
	PM 75%	-9.85714	4.94174	.054	-19.8795	.1652
	PM 100%	-11.33759*	4.76198	.023	-20.9953	-1.6798
	PM 50%	-16.10952*	5.18294	.004	-26.6210	-5.5980
	PM 25%	-9.74702	4.94174	.056	-19.7693	.2753
PM 75%	control	6.87670	4.76198	.157	-2.7810	16.5344
	A. karroo 5g	-6.28869	4.94174	.211	-16.3110	3.7336
	A. karroo 20g	9.85714	4.94174	.054	-.1652	19.8795
	PM 100%	-1.48044	4.76198	.758	-11.1382	8.1773
	PM 50%	-6.25238	5.18294	.236	-16.7639	4.2591
	PM 25%	.11012	4.94174	.982	-9.9122	10.1324
PM 100%	control	8.35714	4.57516	.076	-.9217	17.6360
	A. karroo 5g	-4.80825	4.76198	.319	-14.4660	4.8495
	A. karroo 20g	11.33759*	4.76198	.023	1.6798	20.9953
	PM 75%	1.48044	4.76198	.758	-8.1773	11.1382
	PM 50%	-4.77194	5.01184	.347	-14.9364	5.3925
	PM 25%	1.59056	4.76198	.740	-8.0672	11.2483
PM 50%	control	13.12908*	5.01184	.013	2.9646	23.2936
	A. karroo 5g	-.03631	5.18294	.994	-10.5478	10.4752

	A. karroo 20g	16.10952	5.18294	.004	5.5980	26.6210
	PM 75%	6.25238	5.18294	.236	-4.2591	16.7639
	PM 100%	4.77194*	5.01184	.347	-5.3925	14.9364
	PM 25%	6.36250	5.18294	.228	-4.1490	16.8740
PM 25%	control	6.76658*	4.76198	.164	-2.8912	16.4243
	A. karroo 5g	-6.39881*	4.94174	.204	-16.4211	3.6235
	A. karroo 20g	9.74702	4.94174	.056	-.2753	19.7693
	PM 75%	-.11012	4.94174	.982	-10.1324	9.9122
	PM 100%	-1.59056	4.76198	.740	-11.2483	8.0672
	PM 50%	-6.36250	5.18294	.228	-16.8740	4.1490

*. The mean difference is significant at the 0.05 level.

Feed Intake per bird per day at 49 days of age

Descriptives

MeanIntake

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
control	7	63.9847	6.78226	2.56345	57.7121	70.2572
A. karroo 5g	6	77.6607	6.93182	2.82990	70.3862	84.9352
A. karroo 20g	6	60.5575	8.52094	3.47866	51.6154	69.4997
PM 75%	6	67.6151	10.63547	4.34191	56.4538	78.7763
PM 100%	7	68.6582	7.24341	2.73775	61.9591	75.3572
PM 50%	5	74.6881	6.08871	2.72295	67.1280	82.2482

PM 25%	6	67.9663	11.37779	4.64496	56.0260	79.9065
Total	43	68.4823	9.48427	1.44634	65.5635	71.4011

Test of Homogeneity of Variances

MeanIntake

Levene Statistic	df1	df2	Sig.
.936	6	36	.481

ANOVA

MeanIntake

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1222.756	6	203.793	2.871	.022
Within Groups	2555.205	36	70.978		
Total	3777.961	42			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: MeanIntake
LSD

(I) Diets	(J) Diets	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
control	*A. karroo* 5g	-13.67602*	4.68715	.006	-23.1820	-4.1700
	A. karroo 20g	3.42715	4.68715	.469	-6.0788	12.9331
	PM 75%	-3.63039	4.68715	.444	-13.1364	5.8756
	PM 100%	-4.67347	4.50327	.306	-13.8065	4.4596
	PM 50%	-10.70340*	4.93308	.037	-20.7082	-.6986
	PM 25%	-3.98158	4.68715	.401	-13.4876	5.5244
A. karroo 5g	control	13.67602*	4.68715	.006	4.1700	23.1820

	A. karroo 20g	17.10317*	4.86408	.001	7.2384	26.9680
	PM 75%	10.04563*	4.86408	.046	.1808	19.9105
	PM 100%	9.00255	4.68715	.063	-.5034	18.5085
	PM 50%	2.97262	5.10149	.564	-7.3737	13.3189
	PM 25%	9.69444	4.86408	.054	-.1704	19.5593
A. karroo 20g	control	-3.42715	4.68715	.469	-12.9331	6.0788
	A. karroo 5g	-17.10317*	4.86408	.001	-26.9680	-7.2384
	PM 75%	-7.05754	4.86408	.155	-16.9224	2.8073
	PM 100%	-8.10062	4.68715	.093	-17.6066	1.4054
	PM 50%	-14.13056*	5.10149	.009	-24.4769	-3.7842
	PM 25%	-7.40873	4.86408	.136	-17.2735	2.4561
PM 75%	control	3.63039	4.68715	.444	-5.8756	13.1364
	A. karroo 5g	-10.04563*	4.86408	.046	-19.9105	-.1808
	A. karroo 20g	7.05754	4.86408	.155	-2.8073	16.9224
	PM 100%	-1.04308	4.68715	.825	-10.5491	8.4629
	PM 50%	-7.07302	5.10149	.174	-17.4193	3.2733
	PM 25%	-.35119	4.86408	.943	-10.2160	9.5136
PM 100%	control	4.67347	4.50327	.306	-4.4596	13.8065
	A. karroo 5g	-9.00255	4.68715	.063	-18.5085	.5034
	A. karroo 20g	8.10062	4.68715	.093	-1.4054	17.6066
	PM 75%	1.04308	4.68715	.825	-8.4629	10.5491
	PM 50%	-6.02993	4.93308	.230	-16.0347	3.9748
	PM 25%	.69189	4.68715	.883	-8.8141	10.1979
PM 50%	control	10.70340*	4.93308	.037	.6986	20.7082
	A. karroo 5g	-2.97262	5.10149	.564	-13.3189	7.3737
	A. karroo 20g	14.13056	5.10149	.009	3.7842	24.4769

	PM 75%	7.07302	5.10149	.174	-3.2733	17.4193
	PM 100%	6.02993*	4.93308	.230	-3.9748	16.0347
	PM 25%	6.72183	5.10149	.196	-3.6245	17.0681
PM 25%	control	3.98158*	4.68715	.401	-5.5244	13.4876
	A. karroo 5g	-9.69444*	4.86408	.054	-19.5593	.1704
	A. karroo 20g	7.40873*	4.86408	.136	-2.4561	17.2735
	PM 75%	.35119	4.86408	.943	-9.5136	10.2160
	PM 100%	-.69189	4.68715	.883	-10.1979	8.8141
	PM 50%	-6.72183	5.10149	.196	-17.0681	3.6245

*. The mean difference is significant at the 0.05 level.

Appendix B

Carcass parts

Post Hoc Tests

LSD

(I) Diets	(J) Diets	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
control	*A. karroo* 5g	3.72222	2.04668	.074	-.3762	7.8206
	A. karroo 20g	7.68056*	2.28826	.001	3.0984	12.2627
	PM 75%	-3.11111	2.50666	.220	-8.1306	1.9084
	PM 100%	-3.64444	2.14658	.095	-7.9429	.6540
	PM 50%	-6.11111*	2.28826	.010	-10.6933	-1.5290
	PM 25%	-8.86111*	2.28826	.000	-13.4433	-4.2790
A. karroo 5g	control	-3.72222	2.04668	.074	-7.8206	.3762
	A. karroo 20g	3.95833	2.28826	.089	-.6238	8.5405
	PM 75%	-6.83333*	2.50666	.008	-11.8528	-1.8138
	PM 100%	-7.36667*	2.14658	.001	-11.6651	-3.0682
	PM 50%	-9.83333*	2.28826	.000	-14.4155	-5.2512
	PM 25%	-12.58333*	2.28826	.000	-17.1655	-8.0012
A. karroo 20g	control	-7.68056*	2.28826	.001	-12.2627	-3.0984
	A. karroo 5g	-3.95833	2.28826	.089	-8.5405	.6238
	PM 75%	-10.79167*	2.70750	.000	-16.2134	-5.3700
	PM 100%	-11.32500*	2.37803	.000	-16.0869	-6.5631
	PM 50%	-13.79167*	2.50666	.000	-18.8112	-8.7722
	PM 25%	-16.54167*	2.50666	.000	-21.5612	-11.5222
PM 75%	control	3.11111	2.50666	.220	-1.9084	8.1306
	A. karroo 5g	6.83333*	2.50666	.008	1.8138	11.8528
	A. karroo 20g	10.79167*	2.70750	.000	5.3700	16.2134
	PM 100%	-.53333	2.58887	.838	-5.7175	4.6508
	PM 50%	-3.00000	2.70750	.273	-8.4217	2.4217

	PM 25%	-5.75000*	2.70750	.038	-11.1717	-.3283
PM 100%	control	3.64444	2.14658	.095	-.6540	7.9429
	A. karroo 5g	7.36667*	2.14658	.001	3.0682	11.6651
	A. karroo 20g	11.32500*	2.37803	.000	6.5631	16.0869
	PM 75%	.53333	2.58887	.838	-4.6508	5.7175
	PM 50%	-2.46667	2.37803	.304	-7.2286	2.2953
	PM 25%	-5.21667*	2.37803	.032	-9.9786	-.4547
PM 50%	control	6.11111*	2.28826	.010	1.5290	10.6933
	A. karroo 5g	9.83333*	2.28826	.000	5.2512	14.4155
	A. karroo 20g	13.79167*	2.50666	.000	8.7722	18.8112
	PM 75%	3.00000	2.70750	.273	-2.4217	8.4217
	PM 100%	2.46667	2.37803	.304	-2.2953	7.2286
	PM 25%	-2.75000	2.50666	.277	-7.7695	2.2695
PM 25%	control	8.86111*	2.28826	.000	4.2790	13.4433
	A. karroo 5g	12.58333*	2.28826	.000	8.0012	17.1655
	A. karroo 20g	16.54167*	2.50666	.000	11.5222	21.5612
	PM 75%	5.75000*	2.70750	.038	.3283	11.1717
	PM 100%	5.21667*	2.37803	.032	.4547	9.9786
	PM 50%	2.75000	2.50666	.277	-2.2695	7.7695

*. The mean difference is significant at the 0.05 level.

Post Hoc Tests

Multiple Comparisons

Dependent Variable: MeanIntake
LSD

(I) Diets	(J) Diets	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
control	*A. karroo* 5g	-13.67602*	4.68715	.006	-23.1820	-4.1700

	A. karroo 20g	3.42715	4.68715	.469	-6.0788	12.9331
	PM 75%	-3.63039	4.68715	.444	-13.1364	5.8756
	PM 100%	-4.67347	4.50327	.306	-13.8065	4.4596
	PM 50%	-10.70340*	4.93308	.037	-20.7082	-.6986
	PM 25%	-3.98158	4.68715	.401	-13.4876	5.5244
A. karroo 5g	control	13.67602*	4.68715	.006	4.1700	23.1820
	A. karroo 20g	17.10317*	4.86408	.001	7.2384	26.9680
	PM 75%	10.04563*	4.86408	.046	.1808	19.9105
	PM 100%	9.00255	4.68715	.063	-.5034	18.5085
	PM 50%	2.97262	5.10149	.564	-7.3737	13.3189
	PM 25%	9.69444	4.86408	.054	-.1704	19.5593
A. karroo 20g	control	-3.42715	4.68715	.469	-12.9331	6.0788
	A. karroo 5g	-17.10317*	4.86408	.001	-26.9680	-7.2384
	PM 75%	-7.05754	4.86408	.155	-16.9224	2.8073
	PM 100%	-8.10062	4.68715	.093	-17.6066	1.4054
	PM 50%	-14.13056*	5.10149	.009	-24.4769	-3.7842
	PM 25%	-7.40873	4.86408	.136	-17.2735	2.4561
PM 75%	control	3.63039	4.68715	.444	-5.8756	13.1364
	A. karroo 5g	-10.04563*	4.86408	.046	-19.9105	-.1808
	A. karroo 20g	7.05754	4.86408	.155	-2.8073	16.9224
	PM 100%	-1.04308	4.68715	.825	-10.5491	8.4629
	PM 50%	-7.07302	5.10149	.174	-17.4193	3.2733
	PM 25%	-.35119	4.86408	.943	-10.2160	9.5136

PM 100%	control	4.67347	4.50327	.306	-4.4596	13.8065
	A. karroo 5g	-9.00255	4.68715	.063	-18.5085	.5034
	A. karroo 20g	8.10062	4.68715	.093	-1.4054	17.6066
	PM 75%	1.04308	4.68715	.825	-8.4629	10.5491
	PM 50%	-6.02993	4.93308	.230	-16.0347	3.9748
	PM 25%	.69189	4.68715	.883	-8.8141	10.1979
PM 50%	control	10.70340*	4.93308	.037	.6986	20.7082
	A. karroo 5g	-2.97262	5.10149	.564	-13.3189	7.3737
	A. karroo 20g	14.13056*	5.10149	.009	3.7842	24.4769
	PM 75%	7.07302	5.10149	.174	-3.2733	17.4193
	PM 100%	6.02993	4.93308	.230	-3.9748	16.0347
	PM 25%	6.72183	5.10149	.196	-3.6245	17.0681
PM 25%	control	3.98158	4.68715	.401	-5.5244	13.4876
	A. karroo 5g	-9.69444	4.86408	.054	-19.5593	.1704
	A. karroo 20g	7.40873	4.86408	.136	-2.4561	17.2735
	PM 75%	.35119	4.86408	.943	-9.5136	10.2160
	PM 100%	-.69189	4.68715	.883	-10.1979	8.8141
	PM 50%	-6.72183	5.10149	.196	-17.0681	3.6245

*. The mean difference is significant at the 0.05 level.

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Breast
LSD

(I) diets	(J) diets	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
control	*A. karroo* 5g	18.125000	35.610968	.613	-53.55616	89.80616
	A. karroo 20g	69.375000	35.610968	.058	-2.30616	141.05616
	PM 75%	-51.339286	36.860853	.170	-125.53634	22.85776
	PM 100%	-49.910714	36.860853	.182	-124.10776	24.28634
	PM 50%	-19.196429	36.860853	.605	-93.39348	55.00062
	PM 25%	34.375000	35.610968	.339	-37.30616	106.05616
A. karroo 5g	control	-18.125000	35.610968	.613	-89.80616	53.55616
	A. karroo 20g	51.250000	35.610968	.157	-20.43116	122.93116
	PM 75%	-69.464286	36.860853	.066	-143.66134	4.73276
	PM 100%	-68.035714	36.860853	.071	-142.23276	6.16134
	PM 50%	-37.321429	36.860853	.317	-111.51848	36.87562
	PM 25%	16.250000	35.610968	.650	-55.43116	87.93116
A. karroo 20g	control	-69.375000	35.610968	.058	-141.05616	2.30616
	A. karroo 5g	-51.250000	35.610968	.157	-122.93116	20.43116

	PM 75%	-120.714286*	36.860853	.002	-194.91134	-46.51724
	PM 100%	-119.285714*	36.860853	.002	-193.48276	-45.08866
	PM 50%	-88.571429*	36.860853	.020	-162.76848	-14.37438
	PM 25%	-35.000000	35.610968	.331	-106.68116	36.68116
PM 75%	control	51.339286	36.860853	.170	-22.85776	125.53634
	A. karroo 5g	69.464286	36.860853	.066	-4.73276	143.66134
	A. karroo 20g	120.714286*	36.860853	.002	46.51724	194.91134
	PM 100%	1.428571	38.069726	.970	-75.20181	78.05895
	PM 50%	32.142857	38.069726	.403	-44.48753	108.77324
	PM 25%	85.714286*	36.860853	.025	11.51724	159.91134
PM 100%	control	49.910714	36.860853	.182	-24.28634	124.10776
	A. karroo 5g	68.035714	36.860853	.071	-6.16134	142.23276
	A. karroo 20g	119.285714*	36.860853	.002	45.08866	193.48276
	PM 75%	-1.428571	38.069726	.970	-78.05895	75.20181
	PM 50%	30.714286	38.069726	.424	-45.91610	107.34467
	PM 25%	84.285714*	36.860853	.027	10.08866	158.48276

PM 50%	control	19.196429	36.860853	.605	-55.00062	93.39348
	A. karroo 5g	37.321429	36.860853	.317	-36.87562	111.51848
	A. karroo 20g	88.571429*	36.860853	.020	14.37438	162.76848
	PM 75%	-32.142857	38.069726	.403	-108.77324	44.48753
	PM 100%	-30.714286	38.069726	.424	-107.34467	45.91610
	PM 25%	53.571429	36.860853	.153	-20.62562	127.76848
PM 25%	control	-34.375000	35.610968	.339	-106.05616	37.30616
	A. karroo 5g	-16.250000	35.610968	.650	-87.93116	55.43116
	A. karroo 20g	35.000000	35.610968	.331	-36.68116	106.68116
	PM 75%	-85.714286*	36.860853	.025	-159.91134	-11.51724
	PM 100%	-84.285714*	36.860853	.027	-158.48276	-10.08866
	PM 50%	-53.571429	36.860853	.153	-127.76848	20.62562

*. The mean difference is significant at the 0.05 level.

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Gizzards
LSD

(I) diets	(J) diets	Mean	Std. Error	Sig.	95% Confidence Interval

		Difference (I-J)			Lower Bound	Upper Bound
control	*A. karroo* 5g	.000000	2.618967	1.000	-5.27171	5.27171
	A. karroo 20g	-2.500000	2.618967	.345	-7.77171	2.77171
	PM 75%	-4.196429	2.710888	.128	-9.65316	1.26031
	PM 100%	-5.625000*	2.710888	.044	-11.08173	-.16827
	PM 50%	-7.053571*	2.710888	.012	-12.51031	-1.59684
	PM 25%	-8.125000*	2.618967	.003	-13.39671	-2.85329
A. karroo 5g	control	.000000	2.618967	1.000	-5.27171	5.27171
	A. karroo 20g	-2.500000	2.618967	.345	-7.77171	2.77171
	PM 75%	-4.196429	2.710888	.128	-9.65316	1.26031
	PM 100%	-5.625000*	2.710888	.044	-11.08173	-.16827
	PM 50%	-7.053571*	2.710888	.012	-12.51031	-1.59684
	PM 25%	-8.125000*	2.618967	.003	-13.39671	-2.85329
A. karroo 20g	control	2.500000	2.618967	.345	-2.77171	7.77171
	A. karroo 5g	2.500000	2.618967	.345	-2.77171	7.77171
	PM 75%	-1.696429	2.710888	.535	-7.15316	3.76031
	PM 100%	-3.125000	2.710888	.255	-8.58173	2.33173
	PM 50%	-4.553571	2.710888	.100	-10.01031	.90316
	PM 25%	-5.625000*	2.618967	.037	-10.89671	-.35329
PM 75%	control	4.196429	2.710888	.128	-1.26031	9.65316
	A. karroo 5g	4.196429	2.710888	.128	-1.26031	9.65316
	A. karroo 20g	1.696429	2.710888	.535	-3.76031	7.15316
	PM 100%	-1.428571	2.799793	.612	-7.06426	4.20712

	PM 50%	-2.857143	2.799793	.313	-8.49283	2.77855
	PM 25%	-3.928571	2.710888	.154	-9.38531	1.52816
PM 100%	control	5.625000*	2.710888	.044	.16827	11.08173
	A. karroo 5g	5.625000*	2.710888	.044	.16827	11.08173
	A. karroo 20g	3.125000	2.710888	.255	-2.33173	8.58173
	PM 75%	1.428571	2.799793	.612	-4.20712	7.06426
	PM 50%	-1.428571	2.799793	.612	-7.06426	4.20712
	PM 25%	-2.500000	2.710888	.361	-7.95673	2.95673
PM 50%	control	7.053571*	2.710888	.012	1.59684	12.51031
	A. karroo 5g	7.053571*	2.710888	.012	1.59684	12.51031
	A. karroo 20g	4.553571	2.710888	.100	-.90316	10.01031
	PM 75%	2.857143	2.799793	.313	-2.77855	8.49283
	PM 100%	1.428571	2.799793	.612	-4.20712	7.06426
	PM 25%	-1.071429	2.710888	.694	-6.52816	4.38531
PM 25%	control	8.125000*	2.618967	.003	2.85329	13.39671
	A. karroo 5g	8.125000*	2.618967	.003	2.85329	13.39671
	A. karroo 20g	5.625000*	2.618967	.037	.35329	10.89671
	PM 75%	3.928571	2.710888	.154	-1.52816	9.38531
	PM 100%	2.500000	2.710888	.361	-2.95673	7.95673
	PM 50%	1.071429	2.710888	.694	-4.38531	6.52816

*. The mean difference is significant at the 0.05 level.

Appendix C

Sensory Evaluation

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles
						25th
Aroma Control	32	6.19	1.674	2	9	5.00
Aroma A. K. 5g	32	6.66	1.807	1	9	6.00
Aroma A.K. 20g	32	6.53	1.295	3	9	6.00
Aroma PM 25%	32	5.34	1.911	2	8	4.00
Aroma PM 50%	32	6.22	1.453	2	8	5.00
Aroma 75%	32	5.66	1.911	2	9	4.25
Aroma 100%	32	6.25	1.778	2	8	5.25

Descriptive Statistics

	Percentiles	
	50th (Median)	75th
Aroma Control	7.00	7.00
Aroma A. K. 5g	7.00	8.00
Aroma A.K. 20g	7.00	7.00
Aroma PM 25%	5.00	7.00
Aroma PM 50%	6.50	7.00
Aroma 75%	6.00	7.00
Aroma 100%	7.00	8.00

Friedman Test

Ranks

	Mean Rank
Aroma Control	4.20
Aroma A. K. 5g	4.81
Aroma A.K. 20g	4.52
Aroma PM 25%	3.05
Aroma PM 50%	3.81
Aroma 75%	3.39
Aroma 100%	4.22

Test Statistics[a]

N	32
Chi-Square	17.609
df	6
Asymp. Sig.	.007

a. Friedman Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles
						25th
Taste Control	32	6.28	1.464	3	9	6.00
Taste A. K. 5g	32	5.56	2.242	1	9	4.00
Taste A.K. 20g	32	6.03	1.823	2	9	4.25
Taste PM 25%	32	5.81	1.839	2	9	4.00
Taste PM 50%	32	6.28	2.098	1	9	5.00

Taste PM 75%	32	6.22	1.736	2	9	5.00
Taste PM 100%	32	6.03	2.250	1	9	5.00

Descriptive Statistics

	Percentiles	
	50th (Median)	75th
Taste Control	6.00	7.00
Taste A. K. 5g	6.00	7.75
Taste A.K. 20g	6.50	7.75
Taste PM 25%	6.00	7.00
Taste PM 50%	7.00	8.00
Taste PM 75%	6.50	7.75
Taste PM 100%	6.00	8.00

Friedman Test

Ranks

	Mean Rank
Taste Control	3.84
Taste A. K. 5g	3.55
Taste A.K. 20g	3.78
Taste PM 25%	3.83
Taste PM 50%	4.58
Taste PM 75%	4.23

Test Statistics[a]

N	32
Chi-Square	5.408
df	6
Asymp. Sig.	.493

Taste PM 100%	4.19

a. Friedman Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles
						25th
Juiciness Control	32	6.50	1.832	1	9	6.00
Juiciness A. K. 5g	32	5.66	2.042	1	9	4.00
Juiciness A.K. 20g	32	6.53	1.685	2	9	6.00
Juiciness PM 25%	32	6.50	1.849	2	9	5.00
Juiciness PM 50%	32	6.00	1.849	2	9	5.00
Juiciness 75%	32	5.84	1.969	1	9	5.00
Juiciness 100%	32	5.63	1.809	1	8	5.00

Descriptive Statistics

	Percentiles	
	50th (Median)	75th
Juiciness Control	7.00	8.00
Juiciness A. K. 5g	6.00	7.00
Juiciness A.K. 20g	7.00	7.75
Juiciness PM 25%	7.00	8.00
Juiciness PM 50%	6.00	7.75
Juiciness 75%	6.00	7.75
Juiciness 100%	6.00	7.00

Friedman Test

Ranks

	Mean Rank
Juiciness Control	4.22
Juiciness A. K. 5g	3.75
Juiciness A.K. 20g	4.56
Juiciness PM 25%	4.56
Juiciness PM 50%	3.86
Juiciness 75%	3.75
Juiciness 100%	3.30

Test Statistics[a]

N	32
Chi-Square	9.776
df	6
Asymp. Sig.	.134

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles
						25th
Tenderness Control	32	6.53	1.586	3	9	6.00
Tenderness A. K. 5g	32	7.06	1.777	2	9	6.00
Tenderness A.K. 20g	32	6.00	1.951	2	9	5.00
Tenderness PM 25%	32	6.66	1.771	2	9	6.00
Tenderness PM 50%	32	6.25	1.867	1	9	5.00
Tenderness PM 75%	32	6.09	1.973	2	9	5.00
Tenderness PM 100%	32	6.19	2.455	1	9	5.00

Descriptive Statistics

	Percentiles	
	50th (Median)	75th
Tenderness Control	7.00	8.00
Tenderness A. K. 5g	7.00	8.75
Tenderness A.K. 20g	6.00	7.00

Tenderness PM 25%	7.00	8.00
Tenderness PM 50%	6.50	7.75
Tenderness PM 75%	6.00	7.00
Tenderness PM 100%	7.00	8.00

Friedman Test

Ranks

	Mean Rank
Tenderness Control	4.03
Tenderness A. K. 5g	4.70
Tenderness A.K. 20g	3.44
Tenderness PM 25%	4.34
Tenderness PM 50%	3.77
Tenderness PM 75%	3.69
Tenderness PM 100%	4.03

Test Statistics[a]

N	32
Chi-Square	8.427
df	6
Asymp. Sig.	.208

a. Friedman Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles
						25th
Preference Control	32	3.88	1.264	1	5	3.00
Preference A. K. 5g	32	3.75	1.270	1	5	3.00
Preference A.K. 20g	32	3.59	.979	2	5	3.00
Preference PM 25%	32	3.75	1.164	1	5	3.00
Preference PM 50%	32	3.81	1.230	1	5	3.25
Preference 75%	32	3.47	1.218	1	5	3.00

Preference 100%	32	3.25	1.566	1	5	2.00

Descriptive Statistics

	Percentiles	
	50th (Median)	75th
Preference Control	4.00	5.00
Preference A. K. 5g	4.00	5.00
Preference A.K. 20g	4.00	4.00
Preference PM 25%	4.00	5.00
Preference PM 50%	4.00	5.00
Preference 75%	4.00	4.00
Preference 100%	3.50	5.00

Friedman Test

Test Statistics[a]

N	32
Chi-Square	5.611
df	6
Asymp. Sig.	.468

Ranks

	Mean Rank
Preference Control	4.33
Preference A. K. 5g	4.17
Preference A.K. 20g	3.64
Preference PM 25%	4.16
Preference PM 50%	4.38
Preference 75%	3.83

Preference 100%	3.50

a. Friedman Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles
						25th
Aroma Control	32	6.19	1.674	2	9	5.00
Aroma A. K. 5g	32	6.66	1.807	1	9	6.00
Aroma A.K. 20g	32	6.53	1.295	3	9	6.00
Aroma PM 25%	32	5.34	1.911	2	8	4.00
Aroma PM 50%	32	6.22	1.453	2	8	5.00
Aroma 75%	32	5.66	1.911	2	9	4.25
Aroma 100%	32	6.25	1.778	2	8	5.25

Descriptive Statistics

	Percentiles	
	50th (Median)	75th
Aroma Control	7.00	7.00
Aroma A. K. 5g	7.00	8.00
Aroma A.K. 20g	7.00	7.00
Aroma PM 25%	5.00	7.00
Aroma PM 50%	6.50	7.00
Aroma 75%	6.00	7.00
Aroma 100%	7.00	8.00

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Aroma A. K. 5g - Aroma Control	Negative Ranks	11[a]	12.36	136.00
	Positive Ranks	17[b]	15.88	270.00
	Ties	4[c]		

	Total	32		
Aroma A.K. 20g - Aroma Control	Negative Ranks	8[d]	11.88	95.00
	Positive Ranks	14[e]	11.29	158.00
	Ties	10[f]		
	Total	32		
Aroma PM 25% - Aroma Control	Negative Ranks	20[g]	14.15	283.00
	Positive Ranks	8[h]	15.38	123.00
	Ties	4[i]		
	Total	32		
Aroma PM 50% - Aroma Control	Negative Ranks	14[j]	12.93	181.00
	Positive Ranks	12[k]	14.17	170.00
	Ties	6[l]		
	Total	32		
Aroma 75% - Aroma Control	Negative Ranks	16[m]	12.75	204.00
	Positive Ranks	8[n]	12.00	96.00
	Ties	8[o]		
	Total	32		
Aroma 100% - Aroma Control	Negative Ranks	15[p]	12.87	193.00
	Positive Ranks	12[q]	15.42	185.00
	Ties	5[r]		
	Total	32		
Aroma A.K. 20g - Aroma A. K. 5g	Negative Ranks	16[s]	14.59	233.50
	Positive Ranks	12[t]	14.38	172.50
	Ties	4[u]		
	Total	32		
Aroma PM 25% - Aroma A. K. 5g	Negative Ranks	24[v]	16.17	388.00
	Positive Ranks	6[w]	12.83	77.00
	Ties	2[x]		
	Total	32		
Aroma 75% - Aroma A. K. 5g	Negative Ranks	19[y]	16.11	306.00

Ranks

		N	Mean Rank	Sum of Ranks
Aroma 75% - Aroma A. K. 5g	Positive Ranks	8[a]	9.00	72.00
	Ties	5[b]		
	Total	32[c]		
Aroma 100% - Aroma A. K. 5g	Negative Ranks	13	15.00	195.00
	Positive Ranks	12[d]	10.83	130.00
	Ties	7[e]		
	Total	32[f]		
Aroma PM 25% - Aroma A.K. 20g	Negative Ranks	21	16.43	345.00
	Positive Ranks	8[g]	11.25	90.00
	Ties	3[h]		
	Total	32[i]		
Aroma PM 50% - Aroma A.K. 20g	Negative Ranks	17	14.68	249.50
	Positive Ranks	12[j]	15.46	185.50
	Ties	3[k]		
	Total	32[l]		
Aroma 75% - Aroma A.K. 20g	Negative Ranks	18	15.89	286.00
	Positive Ranks	10[m]	12.00	120.00
	Ties	4[n]		
	Total	32[o]		
Aroma 100% - Aroma A.K. 20g	Negative Ranks	14	11.54	161.50
	Positive Ranks	9[p]	12.72	114.50
	Ties	9[q]		
	Total	32[r]		
Aroma PM 50% - Aroma PM 25%	Negative Ranks	9	11.00	99.00
	Positive Ranks	16[s]	14.13	226.00
	Ties	7[t]		
	Total	32[u]		

Aroma 75% - Aroma PM 25%	Negative Ranks	12	11.38	136.50
	Positive Ranks	13[v]	14.50	188.50
	Ties	7[w]		
	Total	32[x]		
Aroma 100% - Aroma PM 25%	Negative Ranks	8	11.31	90.50
	Positive Ranks	18[y]	14.47	260.50

Ranks

		N	Mean Rank	Sum of Ranks
Aroma 100% - Aroma PM 25%	Ties	6[a]		
	Total	32[b]		
Aroma 75% - Aroma PM 50%	Negative Ranks	13[c]	11.46	149.00
	Positive Ranks	8	10.25	82.00
	Ties	11[d]		
	Total	32[e]		
Aroma 100% - Aroma PM 50%	Negative Ranks	10[f]	15.90	159.00
	Positive Ranks	15	11.07	166.00
	Ties	7[g]		
	Total	32[h]		
Aroma 100% - Aroma 75%	Negative Ranks	9[i]	14.06	126.50
	Positive Ranks	17	13.21	224.50
	Ties	6[j]		
	Total	32[k]		

Test Statistics[a]

	Aroma A. K. 5g - Aroma Control	Aroma A.K. 20g - Aroma Control	Aroma PM 25% - Aroma Control	Aroma PM 50% - Aroma Control	Aroma 75% - Aroma Control
Z	-1.565[b]	-1.035[b]	-1.836[c]	-.142[c]	-1.561[c]

Asymp. Sig. (2-tailed)	.118	.301	.066	.887	.119

Test Statistics[a]

	Aroma 100% - Aroma Control	Aroma A.K. 20g - Aroma A. K. 5g	Aroma PM 25% - Aroma A. K. 5g	Aroma 75% - Aroma A. K. 5g	Aroma 100% - Aroma A. K. 5g
Z	-.099[b]	-.704[b]	-3.238[c]	-2.851[c]	-.884[c]
Asymp. Sig. (2-tailed)	.921	.481	.001	.004	.377

Test Statistics[a]

	Aroma PM 25% - Aroma A.K. 20g	Aroma PM 50% - Aroma A.K. 20g	Aroma 75% - Aroma A.K. 20g	Aroma 100% - Aroma A.K. 20g	Aroma PM 50% - Aroma PM 25%
Z	-2.787[b]	-.701[b]	-1.911[c]	-.725[c]	-1.724[c]
Asymp. Sig. (2-tailed)	.005	.483	.056	.468	.085

Test Statistics[a]

	Aroma 75% - Aroma PM 25%	Aroma 100% - Aroma PM 25%	Aroma 75% - Aroma PM 50%	Aroma 100% - Aroma PM 50%	Aroma 100% - Aroma 75%
Z	-.708[b]	-2.179[b]	-1.181[c]	-.095[c]	-1.253[c]
Asymp. Sig. (2-tailed)	.479	.029	.237	.924	.210

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

c. Based on positive ranks.

Appendix D

Questionnaire for Sensory Evaluation

QUESTIONNAIRE: CONSUMER ACCEPTABILITY OF CHICKEN MEAT

NAME OF JUDGE: ____ JUDGE NO:________

<table>
<tr><td colspan="3">PLEASE CIRCLE WHICHEVER IS APPLICABLE</td></tr>
<tr><td>GENDER: Male / Female</td><td>AGE: 18-25 / 26-30 / 31-40 / 41-45 / 46+</td><td>CONSUMPTION OF CHICKEN : More than 3 times per week / 1-2 times per week / 2x per month / Approx 4 times a year / NEVER</td></tr>
<tr><td colspan="2">RACE GROUP: BLACK / COLOURED / WHITE / INDIAN</td><td><u>HOW DO YOU RATE YOUR GENERAL KNOWLEDGE OF CHICKEN MEAT?</u> Total novice / Moderate knowledge / Above average / Connoisseur</td></tr>
</table>

INSTRUCTIONS

- PLEASE SMELL THE SAMPLES FROM **LEFT TO RIGHT**.
- RANK THE SAMPLES ON THE FOLLOWING SCALES FOR **DEGREE OF LIKING**. IN EACH CASE, **CIRCLE** THE NUMBER NEXT TO THE PREFERRED ANSWER.

	CODE		**CODE**		**CODE**		**CODE**		**CODE**	
How do you like the SMELL/ARO MA Of the chicken??	9	Like extremely	9	Like extremely	9	Like extremely	9	Like extremely	9	Like extremely
	8	Like very much	8	Like very much	8	Like very much	8	Like very much	8	Like very much
	7	Like moderately	7	Like moderately	7	Like moderately	7	Like moderately	7	Like moderately
	6	Like slightly	6	Like slightly	6	Like slightly	6	Like slightly	6	Like slightly
	5	Neither like nor Dislike	5	Neither like nor Dislike	5	Neither like nor Dislike	5	Neither like nor Dislike	5	Neither like nor Dislike
	4	Dislike slightly	4	Dislike slightly	4	Dislike slightly	4	Dislike slightly	4	Dislike slightly
	3	Dislike moderately	3	Dislike moderately	3	Dislike moderately	3	Dislike moderately	3	Dislike moderately
	2	Dislike very much	2	Dislike very much	2	Dislike very much	2	Dislike very much	2	Dislike very much
	1	Dislike extremely	1	Dislike extremely	1	Dislike extremely	1	Dislike extremely	1	Dislike extremely

	CODE		**CODE**	
How do you	9	Like extremely	9	Like extremely

like the **SMELL/AROMA** **Of the chicken??**	8	Like very much	8	Like very much
	7	Like moderately	7	Like moderately
	6	Like slightly	6	Like slightly
	5	Neither like nor Dislike	5	Neither like nor Dislike
	4	Dislike slightly	4	Dislike slightly
	3	Dislike moderately	3	Dislike moderately
	2	Dislike very much	2	Dislike very much
	1	Dislike extremely	1	Dislike extremely

INSTRUCTIONS

- PLEASE TASTE THE SAMPLES FROM **LEFT TO RIGHT**.
- RINSE YOUR MOUTH WITH **WATER** BEFORE BEGINNING. RINSE YOUR MOUTH AND TAKE A BITE OF THE APPLE SLICE BETWEEN THE SAMPLES. TAKE A **GENEROUS BITE** FROM EACH SAMPLE
- RANK THE SAMPLES ON THE FOLLOWING SCALES FOR 1] **DEGREE OF LIKING**& 2] **PURCHASE INTENT**. IN EACH CASE, **CIRCLE** THE NUMBER NEXT TO THE PREFERRED ANSWER.

	CODE		**CODE**		**CODE**		**CODE**		**CODE**	
How do you like the **TASTE/FLAVOR** **Of the CHICKEN??**	9	Like extremely	9	Like extremely	9	Like extremely	9	Like extremely	9	Like extremely
	8	Like very much	8	Like very much	8	Like very much	8	Like very much	8	Like very much
	7	Like moderately	7	Like moderately	7	Like moderately	7	Like moderately	7	Like moderately
	6	Like slightly	6	Like slightly	6	Like slightly	6	Like slightly	6	Like slightly
	5	Neither like nor Dislike	5	Neither like nor Dislike	5	Neither like nor Dislike	5	Neither like nor Dislike	5	Neither like nor Dislike
	4	Dislike slightly	4	Dislike slightly	4	Dislike slightly	4	Dislike slightly	4	Dislike slightly
	3	Dislike moderately	3	Dislike moderately	3	Dislike moderately	3	Dislike moderately	3	Dislike moderately
	2	Dislike very much	2	Dislike very much	2	Dislike very much	2	Dislike very much	2	Dislike very much
	1	Dislike	1	Dislike	1	Dislike	1	Dislike	1	Dislike

		extremel y		extremel y		extremel y		extremel y		extremel y
How do you like the TASTE/FLAV OR Of the CHICKEN??	**CODE**		**CODE**							
	9	Like extremel y	9	Like extremel y						
	8	Like very much	8	Like very much						
	7	Like moderate ly	7	Like moderate ly						
	6	Like slightly	6	Like slightly						
	5	Neither like nor Dislike	5	Neither like nor Dislike						
	4	Dislike slightly	4	Dislike slightly						
	3	Dislike moderate ly	3	Dislike moderate ly						
	2	Dislike very much	2	Dislike very much						
	1	Dislike extremel y	1	Dislike extremel y						

INSTRUCTIONS

- PLEASE TASTE THE SAMPLES FROM **LEFT TO RIGHT**.
- RINSE YOUR MOUTH WITH **WATER** BEFORE BEGINNING. RINSE YOUR MOUTH AND TAKE A BITE OF THE APPLE SLICE BETWEEN THE SAMPLES. TAKE A **GENEROUS BITE** FROM EACH SAMPLE
- RANK THE SAMPLES ON THE FOLLOWING SCALES FOR 1] **DEGREE OF LIKING**& 2] **PURCHASE INTENT**. IN EACH CASE, **CIRCLE** THE NUMBER NEXT TO THE PREFERRED ANSWER.

	CODE		**CODE**		**CODE**		**CODE**		**CODE**	
How do you like the JUICINESS Of the CHICKEN ??	9	Like extremely	9	Like extremely	9	Like extremely	9	Like extremely	9	Like extremely
	8	Like very much	8	Like very much	8	Like very much	8	Like very much	8	Like very much
	7	Like moderately	7	Like moderately	7	Like moderately	7	Like moderately	7	Like moderately
	6	Like slightly	6	Like slightly	6	Like slightly	6	Like slightly	6	Like slightly
	5	Neither like nor Dislike	5	Neither like nor Dislike	5	Neither like nor Dislike	5	Neither like nor Dislike	5	Neither like nor Dislike
	4	Dislike slightly	4	Dislike slightly	4	Dislike slightly	4	Dislike slightly	4	Dislike slightly
	3	Dislike moderately	3	Dislike moderately	3	Dislike moderately	3	Dislike moderately	3	Dislike moderately
	2	Dislike very much	2	Dislike very much	2	Dislike very much	2	Dislike very much	2	Dislike very much
	1	Dislike extremely	1	Dislike extremely	1	Dislike extremely	1	Dislike extremely	1	Dislike extremely

	CODE		CODE	
How do you like the JUICINESS Of the CHICKEN ??	9	Like extremely	9	Like extremely
	8	Like very much	8	Like very much
	7	Like moderately	7	Like moderately
	6	Like slightly	6	Like slightly
	5	Neither like nor Dislike	5	Neither like nor Dislike
	4	Dislike slightly	4	Dislike slightly
	3	Dislike moderately	3	Dislike moderately
	2	Dislike very much	2	Dislike very much
	1	Dislike extremely	1	Dislike extremely

INSTRUCTIONS

- PLEASE TASTE THE SAMPLES FROM **LEFT TO RIGHT**.
- RINSE YOUR MOUTH WITH **WATER** BEFORE BEGINNING. RINSE YOUR MOUTH AND TAKE A BITE OF THE APPLE SLICE BETWEEN THE SAMPLES. TAKE A **GENEROUS BITE** FROM EACH SAMPLE
- RANK THE SAMPLES ON THE FOLLOWING SCALES FOR 1] **DEGREE OF LIKING**& 2] **PURCHASE INTENT**. IN EACH CASE, **CIRCLE** THE NUMBER NEXT TO THE PREFERRED ANSWER.

	CODE		**CODE**		**CODE**		**CODE**		**CODE**	
How do you like the TENDERNESS Of the CHICKEN??	9	Like extremely	9	Like extremely	9	Like extremely	9	Like extremely	9	Like extremely
	8	Like very much	8	Like very much	8	Like very much	8	Like very much	8	Like very much
	7	Like moderately	7	Like moderately	7	Like moderately	7	Like moderately	7	Like moderately
	6	Like slightly	6	Like slightly	6	Like slightly	6	Like slightly	6	Like slightly
	5	Neither like nor Dislike	5	Neither like nor Dislike	5	Neither like nor Dislike	5	Neither like nor Dislike	5	Neither like nor Dislike
	4	Dislike slightly	4	Dislike slightly	4	Dislike slightly	4	Dislike slightly	4	Dislike slightly
	3	Dislike moderately	3	Dislike moderately	3	Dislike moderately	3	Dislike moderately	3	Dislike moderately
	2	Dislike very much	2	Dislike very much	2	Dislike very much	2	Dislike very much	2	Dislike very much
	1	Dislike extremely	1	Dislike extremely	1	Dislike extremely	1	Dislike extremely	1	Dislike extremely

	CODE		CODE	
How do you like the TENDERNESS Of the CHICKEN??	9	Like extremely	9	Like extremely
	8	Like very much	8	Like very much
	7	Like moderately	7	Like moderately
	6	Like slightly	6	Like slightly
	5	Neither like nor Dislike	5	Neither like nor Dislike
	4	Dislike slightly	4	Dislike slightly
	3	Dislike moderately	3	Dislike moderately
	2	Dislike very much	2	Dislike very much
	1	Dislike extremely	1	Dislike extremely

	CODE		CODE		CODE		CODE		CODE	
	5	Definitely	5	Definitely	5	Definitely	5	Definitely	5	Definitely

Of the 7 above-mentioned diets, which CHICKEN would you prefer most??		would buy		would buy		would buy		would buy		would buy
	4	Probably would buy	4	Probably would buy	4	Probably would buy	4	Probably would buy	4	Probably would buy
	3	Maybe / Maybe not	3	Maybe / Maybe not	3	Maybe / Maybe not	3	Maybe / Maybe not	3	Maybe / Maybe not
	2	Probably would not buy	2	Probably would not buy	2	Probably would not buy	2	Probably would not buy	2	Probably would not buy
	1	Definitely would not buy	1	Definitely would not buy	1	Definitely would not buy	1	Definitely would not buy	1	Definitely would not buy

	CODE		**CODE**	
Of the 7 above-mentioned diets, which CHICKEN would you prefer most??	5	Definitely would buy	5	Definitely would buy
	4	Probably would buy	4	Probably would buy
	3	Maybe / Maybe not	3	Maybe / Maybe not
	2	Probably would not buy	2	Probably would not buy
	1	Definitely would not buy	1	Definitely would not buy