EFFECTS OF SYNTHETIC ASCORBIC ACID AND BAOBAB FRUIT PULP MEAL SUPPLEMENTATION AS SOURCES OF ASCORBIC ACID IN LAYER AND BROILER DIETS DURING COOL-WET AND HOT-DRY SEASONS

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DECEMBER, 2012.

DECLARATION

I declare that the work of this thesis entitled ***"Effects of Synthetic Ascorbic Acid and Baobab Fruit Pulp Meal Supplementation as Sources of Ascorbic Acid in Layer and Broiler Diets During Cool-Wet and Hot-Dry Seasons"*** has been written by me and that it is a record of my own research works and it has not been presented in any previous publication for a higher degree.

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Date:_____

The above declaration is confirmed

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(Major Supervisor)

Date:_____

CERTIFICATION

This thesis entitled ***"Effects of Synthetic Ascorbic Acid and Baobab Fruit Pulp Meal Supplementation as Sources of Ascorbic Acid in Layer and Broiler Diets During Cool-Wet and Hot-Dry Seasons"*** By Stella Laruba Adeosun meets the regulations governing the award of the Degree of Doctor of Philosophy of Ahmadu Bello University Zaria and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to my amiable Husband, Pastor (Prof.) James Olasunkanmi Adeosun and our Children Faith, Hope –Dave, Love and Gift for being there when I needed them most.

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ABSTRACT

Six experiments were conducted within cool-wet and hot-dry seasons of 2008/2009 to study the effects of ascorbic acid (AA) and dietary levels of dried baobab fruit pulp meal (BFPM) supplementation as sources of ascorbic acid in layer and broiler diets. Chemical analysis of BFPM was carried out. Three studies were conducted in cool-wet season. The other three hot-dry season trials were replicas of the cool-wet season trials. The first experiment for the cool-wet season was on the effects of AA and BFPM supplementations on the performance of laying hens. In this first experiment, two hundred and fifty two, 44 weeks old ShikaBrown commercial layers obtained from the National Animal Production Research Institute (NAPRI) were used. There were seven dietary treatments of three replicates each and each replicate had 12 birds. Diet groups 2, 3 and 4 had AA at levels 100, 200 and 300mg/kg respectively while diet groups 5, 6 and 7 representing BFPM diets contained BFPM at 3.5, 7.0 and 10.5% inclusion levels respectively. Diet 1 which served as the control contained neither AA nor BFPM. This experiment which was laid out in a completely randomized design (CRD) lasted for twelve weeks. Experiments 2 and 3 were also carried out in the cool-wet season to determine the effects of dietary supplementations of AA and BFPM on broiler birds at the starter (Experiment 2) and finisher (Experiment 3) phases respectively. The starter phase lasted for 4 weeks while the finisher phase lasted for 3 weeks. Oba-Marshal breed of broiler birds were used. The hot-dry season feeding trials though replicas of cool-wet season, had six treatments, that is, 3 levels of AA, 2 levels of BFPM and one control. The fourth experiment was carried out during hot-dry season to determine the effects of AA and BFPM diets on the performance of laying hens. Two hundred and seventy ShikaBrown® commercial layers were used with each treatment replicated three times and each replicate consisted of 15 birds. For the hot-dry season broiler feeding trials, there were also six treatments. Each treatment was replicated three times with each replicate consisting of 20 birds for starter (Experiment 5) phase and 12 birds per replicate for the finisher phase (Experiment 6). All diets were formulated to meet the NRC (1994) requirements. At the end of finisher phases for both cool-wet and hot-dry season studies, carcass

studies were carried out to determine the effects of AA and BFPM supplemented diets on carcass characteristics. BFPM analysis revealed the following: 3.31% crude protein, 9.27% crude fibre, 2.12% ether extract, 79.20% Nitrogen Free Extract, 6.29% ash, 1.25% calcium, 2.10% phosphorus and 0.03% iron. The AA content was 299.75mg/100g. Anti-nutritional factor contents of 0.26mg/100g Tannin, 0.12mg/100g phytate, 0.48mg/100g oxalate 0.04mg/100g saponin and Trypsin inhibitor, 1.6mg/100g. The results for feeding trials indicated that ascorbic acid supplementation up to 200mg/kg of diet and 3.5% dietary level of Baobab fruit pulp meal significantly improved performances of both layers and broilers in both seasons. Ascorbic acid supplementation of 200mg/kg also improved the performance of laying hen compared to the control diets as reflected in improved final weights, body weight changes, hen-day egg production, feed intake, kg feed/dozen eggs and feed cost/dozen eggs during the hot-dry season, but it had no significant effect on final weight and body weight change during the cool-wet season. In the broiler experiments, ascorbic acid supplementation improved the performance of broiler chicks both in the cool-wet and in the hot-dry seasons. The performance of broiler starter chicks for final weight, weight gain, feed intake, feed conversion ratio and feed cost/bird during the cool-wet season improved progressively as the level of ascorbic acid supplementation increased from 100mg/kg to 300mg/kg. The highest level of ascorbic acid supplementation resulted in the least mortality rate of broiler chicks during the cool wet season. At the broiler finisher's phase, ascorbic acid supplementation improved the performance of birds up to 200mg/kg of diet. The result further indicated that ascorbic acid supplementation increased feed intake during the hot-dry season. Baobab Fruit Pulp Meal (BPFM) in laying hens diets was able to improve performance significantly ($P<0.05$) up to 3.5% in the diet as reflected in better final weight, change in body weight, feed intake, kg feed/dozen egg and feed cost/dozen eggs in both seasons. Furthermore, the results revealed that inclusion of BFPM at up to 3.5% in the diet impacted positively on the ability of the laying hen to withstand heat stress but it had little or no effect on egg quality. Increasing the level of BFPM beyond 3.5% was found to be uneconomical and counter productive for both broiler

starters and layers during both seasons. The bulkiness and powdery nature of the BFPM diets could probably have been responsible for the decline in the performances of broiler birds fed 7.0 and 10.5% BFPM supplementations. Hen-day egg production was improved by 7.1% and 19.1% in cool-wet and hot-dry seasons respectively. There were also 83.37% and 100% reduction in bird mortality for cool-wet and hot-dry seasons respectively in the laying hens. For the broiler finishers, weight gain was improved by 14.63% and 21.38% for cool-wet and hot-dry seasons respectively. It was found that supplementations of AA and BFPM in diets were more effective during the hot-dry season compared to the effect in the cool-wet season. It is therefore recommended that performances of laying hens and growth in broiler finisher flocks can be improved by supplementations of diets with Ascorbic acid at 200mg/kg of diet or by the addition of 3.5% BFPM to the diets during both cool-wet and hot-dry seasons. For the broiler starter, Ascorbic acid at 300mg/kg diet or 3.5% dietary inclusion of BFPM supported optimum performances during cool-wet and the hot-dry seasons.

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CHAPTER ONE

1.0 INTRODUCTION

Poultry production forms an important component of Nigeria's livestock sub-sector. The enterprise is unique and offers the highest turnover rate and quickest returns to investment outlay in livestock enterprises (Ogundipe and Sanni, 2002). Therefore this has assisted in increasing the level of economic independence of farmers in Nigeria. Poultry nutrition experts have access to a large volume of information which has allowed them to optimize the particular production parameters most important to poultry producers.

A good example of this information is supplied by the National Research Council (NRC, 1994) for poultry. Allied poultry industry also provides a continual supply of new feed additives to improve poultry productivity or make poultry production cheaper and more profitable.

However, knowledge related to bird stress management appeared to be limited. Poultry are constantly subjected to conditions that induce stress. Examples of such conditions include heat, cold, exposure to pathogenic organisms, transportation, movement, nutritional imbalances, handling, management and pecking (Njoku, 1986). The environment under which birds are reared in intensive production system in the tropical countries is far from the ideal. Stress management is low and this can lead to reductions in production performances in poultry farming. For instance, Nigeria is characterized by ecological variations with such distinct seasonal changes like hot dry season (March to June), cool wet season (late June to early October) and cool dry season or harmattan (November to February). Balogun *et a*l (1996) stated that when one or more of the needed environmental factors are either not provided for or sub-optimally provided,

then the objective of intensive poultry production to maximize performance to obtain high economic return will be defeated. High ambient temperatures are of major concern to broilers and layer producers because they reduce feed intake, live weight gain and feed efficiency. Cyclic high temperatures lead to increase mortality rates and reduced growth rates in broiler flocks. Economic losses due to heat prostration increase as temperature approaches 38^{o}C (Joiner and Huston, 1957; Siegel 1971; Smith and Oliver, 1971; Bottje and Harrison, 1985). Other studies indicated that the reduced intake of essential nutrients as a result of heat stress led to reduced egg production, egg weight, egg shell thickness and body weight (Muller and Sunde, 1975; Dale and Fuller, 1980; Valencia *et al,* 1980, Tanor *et al,* 1984). Therefore, a diet formulated to provide all necessary nutrients for productive efficiency at low environmental temperatures becomes less adequate as temperature increases.

Utilization of ascorbic acid (vitamin C) has been one of the means used in alleviating stress problems in poultry production. Some reports suggested that under stress conditions for instance, in hot climates, supplementation of poultry diet with ascorbic acid was beneficial (Kassim and Norziha, 1995). Ascorbic acid has been characterized as a non-essential component of poultry diet. Chatterjee *et al*, (1975) reported that ascorbic acid can be synthesized intrinsically by birds. Parkar and Kendler (1963) however reported that during periods of heat stress, the capacity of birds to synthesize ascorbic acid was reduced and that dietary supplementation of ascorbic acid reduced mortality in domestic birds. In the studies with layers, Thompson and Moreng (1959) reported an improvement in egg shell quality when vitamin C was added to the diet. In contrast, Harms and Waldroup (1961) and Nestor *et al* (1972) reported that addition of ascorbic acid in the diets of birds during stress did not affect shell quality or egg production.

Ascorbic acid occurs naturally in many plant parts such as in the leaves and fruits. Baobab (*Adansonia digitata*) fruit pulp has been found to contain a significant amount of ascorbic acid. Phyto Trade Africa (2006) reported 300mg/100g of ascorbic acid in the Baobab dry fruit pulp. Addition of this natural source of vitamin C to poultry diets could be beneficial in alleviating stress problems associated with poultry production.

Nigeria is characterized by different seasons, notably hot and cool seasons. These seasons have remarkable effects on poultry production. For instance, hot season does not favour egg and broiler production. If profitable poultry production has to be sustained all year round, then addition of stress reducing materials like vitamin C in the diet of poultry may go a long way in alleviating some of the stress problems associated with poultry production. Therefore evaluation of the nutritional values of Baobab dried fruit pulp as a source of ascorbic acid in the diet of poultry will substantiate the beneficial effects of this material in the diets of broiler and layer chickens.

The objectives of these studies are to:

i. Evaluate the nutritional value of Baobab (*Adansonia digitata*) dried fruit pulp as a source of ascorbic acid in poultry diets.

ii. Evaluate the anti-stress properties of Baobab fruit pulp meal in poultry production

iii. To compare the effectiveness of Baobab Fruit Pulp Meal as a source of vitamin C with the commercially prepared vitamin C tablets in layer and broiler diets.

iv. To determine the cost effectiveness of using synthetic vitamin C and Baobab Fruit Pulp Meal as a natural source of vitamin C in poultry diets.

CHAPTER TWO

2.0 REVIEW OF LITERATURE

2.1 Causes of stress in poultry production

Poultry are constantly subjected to conditions that induce stress. Notable among these stressors are high ambient temperatures, relative humidity, nutritional imbalances, diseases, exposure to pathogenic organisms, transportation and management (Njoku, 1990). Similarly Ayo *et al* (1996) stated that the concept of stress embraces numerous deleterious factors such as biologically active substances, toxins, pathogenic and physical factors. Below are some of stressors affecting the performance of poultry production.

2.1.1 Effect of ambient temperatures and relative humidity on poultry production (physical factors)

Effects of high ambient temperature which induces stress in poultry had been extensively studied (Bottje and Harrison 1985; Njoku, 1990; Balogun *et al.,* 1996). Ayo *et al.,* (1996) indicated that high ambient temperatures and relative humidity result in heat stress in poultry and that they have significant effects on egg and broiler production. This is because of the relationship that exist between ambient temperatures and metabolic rate in the body of these animals. During low ambient temperatures, metabolic rate is increased while in high ambient temperatures, it decreases (Ayo *et al.,* 1996). Every species of animals have their specific temperature zone called the zone of comfort or well being (Playschenkov and Sidorov, 1987; Church and Pond, 1988). Animals do not experience heat or cold at this point. Thermoneutrality varies among species but ranges between 11^{o}C to 25^{o}C (Oluyemi and Robert, 1979; Ogbogu, 1988; Georgyevsky, 1990). The lower range of this zone called critical temperature is characterized by increase in heat production in the body of the animal as a result of increase in the metabolic rate and

decrease in heat loss. In order to replace energy spent on heat production, the animal consume more feed (Playschenkov and Sidorov, 1987), whereas at high temperatures, animals want to loose heat, therefore consume less feed. Heat stress is evident at 32^{o}C through depressed feed intake. Therefore hot season does not favour egg and broiler production because of the heat stress experienced during this period.

2.1.2 Relationship between nutrition and incidence of disease in poultry production

It has been established that poor nutrition is the major cause of loss in poultry production. Poor nutrition predisposes birds to diseases and poor immune response to vaccines (FAO 2003). Diseases such as highly infectious viral Newcastle disease, fowl cholera, coccidiosis, gumboro and fowl pox are associated with climatic and nutritional stress problem (FAO, 2003). Parasitic infestation of the liver by microorganisms such as *Eimeria acervulina,*and *Mycobacterium avium* may lead to stressful situation in poultry which eventually result in reduced feed intake (Kechik and Sykes, 1979; Jaeschke and Keller, 1982).

2.1.3 Effects of age and season on poultry production

In laying birds, production cycle is in phases. The first phase is characterized with high number of egg production but with small egg size. This stage is from point of lay to around forty two weeks of age. Within this period, production levels grow to its peak and peak production is obtained for a few months after. The flock begins to experience a gradual decrease to about seventy weeks of age and finally the last stage sets in, with few but large size eggs (Oluyemi and Robert, 1979). Hence age of birds determines the number and size of eggs laid. Increase in age leads to increase in egg size. Dafwang (1987) considering this fact suggested that layers should be raised such that their peak

production will not fall within the hottest months when birds usually experience heat stress. By this, farmers will avoid economic loses resulting from heat stress. He further noted that when pullets were started in January, such birds will come in lay around May or June which is the end of the hottest month. Therefore birds will escape the heat stress but will only experience the adverse effect of heat stress only towards the end of their laying cycle, which will then come between March and May of the following year. Similarly Bawa *et al* (2001) reported that the highest egg production can be obtained during the early dry season (between November and January).

Other factors that induce stress in poultry include transportation, debeaking and force molting (Njoku 1990).

2.2 Effects of stress on poultry

Effects of stress on poultry production has been extensively documented (Dafwang, 1987; Njoku, 1990; Balogun, *et al.,* 1996; McKee *et al*, 1996; Xiang *et al.,* 2002; Bawa *et al.,* 2003 and FAO, 2003). These effects of stress as seen in poultry flocks reduce production and physiological parameters, such as feed intake, weight gain, reproduction and defensive mechanisms against diseases (Ayo *et al.,* 1996). Below are some of the specific effects of stress on poultry production.

2.2.1 Drop in egg production

High ambient temperature increases heat stress on laying birds. Heat stress that begins at about 32^{o}C depresses voluntary feed intake. Therefore hot season does not favour egg production (Oluyemi and Robert 1979). Ogbogu (1988) reported that the reduced egg size and number occurring at temperatures of 30-40^{o}C is due to reduced feed intake. The shell and internal quality of egg are also reduced drastically because protein

and minerals particularly calcium and vitamins consumed were not enough to meet the demand for these nutrients for egg production. High mortality rates were observed in Leghorn pullets raised under high ambient temperatures (Payne, 1966). It has also been reported that poor nutrition and infectious diseases cause low egg production and mortality (Jaeschke and Keller, 1982; Kekeocha, 1985). A typical effects of ambient temperature on egg production is presented in table 2.1.

Table 2.1: Temperature and its effects on egg production

Temperature (^{o}C)	Effects on layer performance
11 – 26	Good production
26 – 28	Some reduction in feed intake
28 – 32	Reduced feed intake, increased water intake, reduced egg size and thin egg shell.
32 – 35	Slight panting observed
35 – 40	Heat prostration sets in, house must be kept cool
40 and above	Increased mortalities due to heat stress

Source: Kekeocha (1985)

2.2.2 Effects of heat stress on broiler production

It was reported that one of the causes of mortality in broiler production is pulmonary hypertension syndrome (PHS). This phenomenon occurs among birds kept at high altitudes of 2000–3000m above sea levels (Van Blerck, 1985; Albers and Frankenhuis, 1990). Xiang *et al* (2002) stated that modern broilers are susceptible to PHS because of rapid growth which increases demand for oxygen. This forces the heart to maintain an elevated cardiac output which results in increased blood pressure in pulmonary circulation, leading to hypertrophy of the heart. Heat stress also results in

reduced feed intake, slow rate of growth and at the critical stage leads to high mortality among broiler flocks (Joiner and Huston, 1957, Smith and Oliver, 1971; Bottje and Harrison, 1985).

2.2.3 Effect of heat stress on reproductive performance

Climatic factors particularly high environmental temperature had adverse effects on the reproductive performance of farm animals. Low conception rate is noticed in hot environment. Heat induced embryonic mortality in extreme heat is observed in pigs. Heat stress also delays sexual maturity in pullets raised under high environmental temperatures. High ambient temperatures of up to 34^{o}C that occur in hot-dry season decreased the quality and quantity of spermatozoa and sperm motility by 50% (Venter *et al.,* 1973; Bazhov and Komlatsky, 1989; Ayo *et al.,* 1996).

2.2.4 Effects of heat stress on immunization

Studies have shown that high ambient temperature reduces post-vaccination immunity. This is because heat stress depresses leucocyte phagocytic activities and cellular differentiation in plasma cells. The immunological response is weak and therefore does not ensure resistance to diseases. Vaccination failures are more common in hot-dry season of the year than in wet season (Ayo *et al.,* 1996; FAO, 2003). High ambient temperature had also resulted to high mortality and reduced growth rate among broiler chickens (Bottje and Harrison, 1985).

2.3 Stress reduction mechanisms in poultry production

In view of the economic losses and other problems related to stress conditions, producers make effort either at removing the stressors or minimize the effects of the stress conditions to enable efficient production in birds.

When farm animals are exposed to stress factors, they develop their defensive mechanisms to combat the stressors. This situation is referred to as General Adaptation Syndrome. Their ability to overcome the stress depends on the extent and magnitude of the stressor (Ayo *et al.,* 1996). When the stress factor is high and with prolonged action, this will overwhelm the body defensive mechanisms. Maintaining the body temperatures of farm animals will only be possible if heat loss is equal to heat produced. This equilibrium is maintained by physiological mechanism of thermoregulation, which could either be chemical or physical (Babsky and Pokrovsky, 1990).

2.3.1 chemical thermoregulation

Chemical thermoregulation is effected by increasing or reducing the metabolic rate in body cell (Babsky and Pokrovsky, 1990). It has been established that dietary modifications to reduce the energy content of feeds so as to minimize the adverse effects of high ambient temperatures in poultry proved beneficial (Payne, 1966; De Andrade *et al.*, 1977, Oluyemi and Adebanjo, 1979; Schenck, *et al.*, 1992). It was reported that as dietary level of lysine increased in pig diets at temperatures of 20–30^{o}C, weight gain, also increased linearly (Schenck, *et al.,* 1992). Other studies also indicated that supplemental ascorbic acid to the diets of chickens had beneficial effects on growth, production and disease defensive performance of the immune system (Oluyemi and Adebanjo, 1979; Shulga, 1980; Kafri and Cherry, 1984; Pardue *et al.;* 1985; Balogun *et al.,* 1996).

2.3.2 Physical thermoregulation

Physical thermoregulation is effected by altering the rate of heat loss through evaporation, heat emission by convection and conduction (Babsky and Pokrovsky, 1990). Ayo *et al* (1996) reported that sweating is a means by which animals resist heat stress. In

farm animals, ability to withstand heat stress via physical thermoregulation decreases in the following order: Horse/camel → cattle → small ruminants → pigs. It is completely absent in rabbits and chickens. (Georgyersky, 1990).

The skin evaporative heat loss widens the thermal comfort temperature zone by $7^{o}C$ (Berman and Meltze,r 1973). Animal species with poorly developed sweat glands keep themselves cool by panting (for example in the chicken) or find shade or water as in swine (Church and Pond, 1988). Other methods proposed by Oluyemi and Adebanjo (1979), included cold water dipping, spraying with water, increasing ventilation and proper housing design. All year round poultry production can be made possible by using appropriate heat reduction mechanisms that are not labour intensive such as supplementation of ascorbic acid in diets using natural or synthetic sources.

2.4 Metabolic importance of ascorbic acid in animal diets

Ascorbic Acid (vitamin C) is a six carbon compound present in all living tissues with the highest concentration in the adrenals, liver and pituitary gland of animals. Higher animals except man, guinea pigs, monkeys and fish have ability to synthesize enough ascorbic acid to meet their physiological needs under normal health condition. Animals that are incapable of intrinsic biosynthesis of vitamin C lack L–glunolactone oxidase, an enzyme essential for the biosynthetic pathway of vitamin C. It is because most animals can biosynthesize vitamin C that nutritionist do not consider it essential (Njoku, 1990). According to Kolb (1985), many factors are responsible for the synthesis and consumption of vitamin C in animals. He reported that age of an animal and its nutritional status influence the synthesis of ascorbic acid. He noted this in piglets and calves in which during the foetal and intra-uterine development, the ascorbic acid in the liver of pig and cow fetuses increased due to increased transfer of ascorbic acid from mothers to fetuses

but that if after birth, piglets or calves are given rations without supplemental ascorbic acid, the ascorbic acid levels in the blood plasma dropped rapidly. He further said that the ability of calves to synthesize vitamin C increases significantly only from about 50 days of age. Furthermore, insufficient supply of nutrients particularly protein and deficiency of vitamin E inhibit the synthesis of ascorbic acid. If an insufficient supply of protein is maintained for a long time, the concentration of many enzymes in the hepatocytes drop and the synthesis of ascorbic acid is also reduced (Chandrasekhara and Rao, 1968). In the hen, starvation for 24 hours resulted in a reduction of ascorbic acid concentration in the blood plasma by 50% (Constantine, 1979). In chicks, the concentration of ascorbic acid in the blood plasma increases from 0.5mg/dl on the 5^{th} day after hatching to about 2.0mg/dl on the 30^{th} day and at the age of 56 days, the liver contained a total of 20mg/dl (Hornig and Frigg, 1979). In race horses for instance, it was observed that a race of a 20–30 minutes duration leads to a reduction in the concentration of ascorbic acid in the blood by 30%.

Warris (1979) also reported a reduction of Ascorbic acid in blood plasma by 32% in pigs after transportation to a slaughter house. In a diseased domestic animal, the synthesis of ascorbic acid is reduced and its concentration in blood plasma dropped. When the Ascorbic Acid concentration in the cells reduced due to diseases the rates of various biochemical reactions and performance of various cell types also reduced, for example, phagocytic activity of the leucocytes. Administration of ascorbic acid has been beneficial in various infectious diseases of domestic animals (Jaeschke and Keller, 1982). In the studies carried out on chicks suffering from coccidiosis, a reduction in the blood level of haemoglobin from 9 to 6 mg/dl and of ascorbic acid from 1.44 to 0.8mg/dl was observed but this was restored to normal after the administration of ascorbic acid (Joshi *et al.,*

1974). In addition Kechik and Sykes (1979) reported that when the levels of ascorbic acid in the intestinal tract, liver, adrenals and blood plasma dropped in the course of 5 to 8 days after infection with *Eimera acervulina,* supplementation with ascorbic acid at 1g/kg feed prevented the reduction. Pavlov (1970) also reported beneficial effect on resistance to infection with a daily administration of ascorbic acid at a dose of 3 to 5mg/kg body weight. Phagocyte activity was also improved by supplementary administration of ascorbic acid. Vitamin C supplementation is also advisable after surgery because it promotes the formation of collagen by fibroblasts, osteoblasts and osteocytes.

It has been reported that laying hens exposed to heat stress had their concentration of ascorbic acid in the blood plasma reduced. Under this condition, the egg shell thickness is reduced due to the reduction in the formation of tropocollagens by the gland cells of ovaries and the fragility of the egg shell was reduced by supplementing the feed with ascorbic acid at 50mg/kg (Pardue *et al.,* 1985). Ayo *et al*. (2007) reported that during stress, the generation of Reactive Oxygen Species (ROS) is high to the level that overwhelms tissue antioxidant defense systems. The extent of the stress in the animal depends on the ability of the tissue to detoxify ROS which also in turn depends on the level of antioxidant defenses in the body. It has also been discovered that antioxidant supplementation provides beneficial effects against stress induced damages (Minka and Ayo, 2007).

The available information in literatures indicate the potential role of ascorbic acid as an antioxidant in alleviating adverse effects of environment on modern poultry production especially during the dry season (Ayo and Sinkalu, 2003; Adekola and Ayo, 2006). Ayo *et al.* (1996) reported that rectal temperature is a reliable index in the assessment of responses of birds to thermally stressful environment. Ayo and Sinkalu

(2007) further stated that body temperature of pullets can be reduced during the hot season of the year by supplementing ascorbic acid in the diet as this enhances the productivity and health of birds during this season. Finally, it has been established that ascorbic acid plays an extremely important role from both nutritional and therapeutic point of view. This compound is able to cure scurvy, a symptom that occurs in humans whose diet is deficient in fresh fruits and vegetables. Ascorbic acid protects organisms against free radicals because it is the most effective anti-oxidant in hydrophilic compartments. It participates in various metabolic processes such as collagen biosynthesis in connective tissues, neurotransmitter metabolism and in the steroid hormones synthesis.

2.5 Performance of birds fed supplemental ascorbic acid

Various studies have shown that supplemental ascorbic acid in the diets of poultry have beneficial effects on growth, production and defensive performance of the immune system. In the production of broilers, Alisheikov (1980) reported that 75mgAA/kg diet had beneficial effect on growth and it reduces death losses.

Shulga (1980) stated that 50mgAA/kg diet improved the development of immunity after vaccination. Other researchers explained that because ascorbic acid has anti –stress effects and also its production is reduced during stress, it is important that the diets of poultry be supplemented with it (Freeman, 1971; Syke, 1978; Kassim and Norziha, 1995). Many more researchers have reported that dietary ascorbic acid supplementation resulted in better efficiency in broiler flocks (Kafri and Cherry, 1984; Pardue *et al*.,1985; Kutlu and Forbes, 1993; Sahin and Kucuk,2001). A positive response to supplemental ascorbic acid in growth rate and feed intake of heat stressed broiler chickens was observed at 200mg/kg diet (Njoku, 1986). Similarly, Kutlu and Forbes (1993) reported that broiler

chicks reared under heat stress at 36^{o}C experienced reduced growth rate, feed intake and feed efficiency but ascorbic acid supplementation at 250mg/kg diet improved these parameters. From a study with layers, Thompson and Moreng (1959) found that addition of dietary ascorbic acid enhances egg quality under high ambient temperatures. Kassim and Norziha (1995) reported improvement in egg production, Haugh unit value and shell thickness. They concluded that vitamin C in layer diet enhances performance. Contrary to this, Harms and Waldrop (1961) and Nestor *et al.,* (1972) found that addition of ascorbic acid in the diets of birds during stress did not affect shell quality or egg production.

Xiang *et al.,* (2002) working with broilers under cool environmental temperatures stated that inclusion of vitamin C in the diet reduced the incidence of Pulmonary Hypertension Syndrome (PHS). They further explained that rapid growth in broiler leads to this phenomenon. Birds' demand for more oxygen as a result of rapid growth forces the heart to maintain elevated cardiac output. This increases blood pressure within pulmonary circulation leading to hypertrophy of the heart. Earlier on, Sillau *et al.,* (1980) observed that broilers kept at about 300m above sea level developed PHS, cardiac hypertrophy, heart failure and oedema. Similar problems were also reported by Van Blerck (1985) and Albers and Frankenhuirs (1990). Villar – Patino *et al.,* (2002) found that ascorbic acid in the diet of broilers kept at an altitude of 2200m above sea level reduced cardiac lipid peroxidation and increased growth performance of broilers at risk of ascites syndrome. They also observed total plasma protein and packed cell volume increased significantly at dietary level of 450mgAA/kg diet. Wideman (1988) also indicated that one of the causes of mortality in broiler chicks is PHS. Celik and Ozturkean (2001) also admitted that addition of ascorbic acid increased body weight gain, feed conversion and carcass weight in broilers. Vitamin C is an antioxidant that

participates in the elimination of oxygen derived free radicals (Bottje and Wideman, 1995). Though exogenous vitamin C is not essential for the chicken that is maintained under normal conditions, it may however become essential for birds under environmentally, pathologically or nutritionally stressful conditions. Ladmakhi *et al.,* (1997) indicated that addition of vitamin C at 500mg/kg diet reduced the incidence of PHS in commercial broilers reared under high ambient temperatures.

The recommended physiological doses of ascorbic acid for domestic animals are 200 to 300mg/kg diet for small animals and 3g/kg diet for large animals (horses, cattle). Doses far in excess of physiological doses (megadoses) inhibit the bactericidal activity of leukocytes (Shilotri and Bhat, 1977).

2.6 Baobab plant (*Adansonia digitata L*)

In an attempt to counteract the detrimental effects of oxidative damages to the biological system caused by Reactive Oxygen Species (ROS), researchers have supplemented human diets with antioxidants, especially those derived from natural sources. The ethnobotanical researches have highlighted the antioxidant capacity of natural antioxidant phyto extracts, with particular attention on Adansonia digitata L (Bombacaceae) (Yazzid *et al.,* 1994; and Phyto Trade Africa, 2006). The Baobab plant, known as African tree is said to be a valuable source of energy, protein and a non-conventional feedstuff. It is grown in the arid and semi–arid regions of the world. The trees are tolerant to high ambient temperatures and long span of drought. The leaves, bark and fruits of this tree are used in several African regions as foodstuff and for medicinal purposes. For this reason, Baobab is named "the small pharmacy" or Chemist tree" (Kerharo and Adam 1974; Etkin and Ross, 1982). Similarly, Yazzid *et al.,* (1994) reported that the leaves are used for making soup. Obizoba and Amaechi (1983) stated

that the pulp is used as a beverage and in food preparation. In Africa, Baobab fruit is used as famine food to prepare decoctions, sauces and natural refreshing drink due to its nutritional properties (Lunven and Andrian, 1960; Obizoba and Anyika, 1994; Lockett *et al.*, 2000).

The baobab fruit pulp is contained in a hard resistant external shell or capsule called epicarp, the internal ripe fruit endocarp is floury, dehydrated and powdery with slices that enclose seeds and filaments (Nour *et al*., 1980). The fruit pulp is naturally dehydrated, powdery, whitish coloured with slight sweet-acid taste. The pulp can be separated from the shell and seed using a knife and its processing does not require chemical treatment (Magdi, 2004). Furthermore, Addy and Eteshola (1984) reported that fermented seeds are used to flavour soup, while the roasted seeds are used in a dish to substitute pea nut. The pulp is therapeutically employed as febrifuge, analgesic, anti-diarrhoea or anti-dysentary and for the treatment of small pox and measles (Kerharo and Adam, 1974).

2.6.1 Chemical composition of baobab fruit pulp

Several studies have been published on baobab pulp. Data on the macro and the micro-nutrients: (amino acids, fatty acids and proximate analysis) are available in the literature. The chemical compositions reported indicated that baobab pulp is a good source of energy, minerals, vitamins and good quality protein (Leakey, 1999; Manfredini *et al.*, 2002; Magdi, 2004; Phyto Trade Africa 2006; Chadare *et al.,* 2009).

The Baobab tree (*Andansonia digitata L*) is presented in Figure 1 while the Baobab pods are presented in Figure 2. The cross- section of Baobab pod is presented in Figure 3.



Fig.1: Baobab tree (*Adansonia digitata* L)



Fig. 2: Baobab pods

2.6.2 Crude protein contents of boabab fruit pulp

There are no wide variations on the values of crude protein reported from different studies carried out on baobab fruit pulp. Berker (1983) reported that baobab pulp from Senegal contains 2.7% crude protein, in Malawi, 3.1%CP was recorded by Saka (1995). Similarly, Phyto Trade Africa (2006) gave a range of 2.03 to 3.24% crude protein for baobab pulps obtained from different localities. This range falls within the values reported by Berker (1983) and Saka (1995). Magdi (2004) also indicated 3.2% crude protein for baobab fruit pulp.

2.6.3 Carbohydrate content of baobab fruit pulp

The basic component of baobab fruit pulp is the carbohydrate, an energy source. Berker (1983) indicated 73.3% carbohydrate, while Saka (1995) reported 79.4%. A range of total carbohydrate as obtained by Phyto Trade Africa (2006) showed 78.3 to 78.9% of which the available carbohydrate ranges between 25 to 33%. The differences were attributed to regions and age of the plants.

2.6.4 Crude fibre content of baobab fruit pulp

The crude fibre content of baobab pulp reported in the literature varies among authors. Values such as 9.9, 8.3 and 5.4% were reported by Berker (1983), Saka *et al.,* (1994) and Magdi (2004) respectively. On the other hand, Phyto Trade Africa (2006) gave a range of total dietary fibre content of between 45 to 54%. This is by far higher than what many other reports in the literatures revealed. This could be the reason why some authors further reported that out of about 79% carbohydrate content of baobab pulp only about 33% is available.



Fig.3: Cross-section of baobab pod

2.6.5 Calcium content of baobab fruit pulp

The importance of calcium in poultry diet particularly for the laying flock cannot be overemphasized. There is much variation in the calcium content of Baobab fruit pulp. The following values of 1156, 3420 and 295mg/kg were reported by Saka *et al.,* (1994), Glew *et al.,* (1997) and Magdi (2004) respectively. The Herbal Sciences International Ltd reported in Phyto Trade Africa (2006) a range of 2570 to 3700mg/kg. There was no report on the phosphorus content of Baobab fruit pulp.

2.6.6 Ash content of baobab fruit pulp

The ash content of baobab fruit pulp recorded by various authors do not vary so much. Phyto Trade Africa (2006) indicated a value of 5.5g/100g. Magdi (2004) reported 4.5, which was slightly below the value reported in the Phyto TradeAfrica report.

2.6.7 Ascorbic acid content of baobab fruit pulp

Baobab fruit pulp has been known to contain a high amount of ascorbic acid which makes it a valuable source of antioxidant substance. The ascorbic acid content of baobab fruit pulp was said to be between 150 to 499mg/100g (Manfredini *et al.,* (2002). Agbessi-Dos-Santos (1987) had earlier reported 169mg/100g ascorbic acid in baobab pulp, while Eromosele *et al.,* (1991) reported 337mg/100g Ascorbic acid., The Phyto Trade Africa (2006) indicated 300mg/100g pulp.

2.6.8 Amino acids content of baobab fruit pulp

Baobab pulp has been reported to contain excellent amino acid profiles of both the essential and non-essential amino acids. Table 2.2 shows the amino acid profile of Baobab seed and fruit pulp.

Table 2:2 Amino acid composition of the baobab seeds and fruit pulp meal

Amino Acid	Seed (mg/100g protein)	Fruit pulp (mg/100g protein)
Aspartic acid	10.3	6.4
Glutamic acid	23.7	6.5
Serine	6.1	3.2
Histidine	2.2	1.2
Glycine	8.6	2.9
Threonine	3.8	2.8
Arginine	8.0	7.6
Alanine	7.1	3.3
Prolamine	6.9	2.2
Tyrosine	1.5	20.6
Methionine	2.0	0.2
Valine	5.9	4.8
Phenylalanine	4.0	4.4
Isoleucine	3.6	2.2
Leucine	7.0	4.3
Lysine	5.0	1.7
Cystine	1.5	1.0

Source: Magdi, 2004.

2.6.9 Fatty acid content of baobab fruit pulp

Berker (1983) reported 0.2% fat, Saka *et al.,* (1994) reported 4.30% while Glew *et al.,* (1997) reported 2.3% fat content in the Baobab pulp. On the other hand, Magdi (2004) reported a value as low as 0.31% fat. The Phyto Trade Africa (2006) gave a range of 13.3 to 20.4% fat content which is much higher than what many authors reported.

2.7.0 Anti-nutritional factors in plants

Among the major factors limiting the use of many tropical plants as feedstuffs in livestock production is the presence of diverse range of compounds capable of

precipitating deleterious effects in man and animals. These compounds which reduce feed intake and nutrient utilization are referred to as Anti-Nutritional Factors (ANF) or food toxicants (Umoh, 1998). The manifestation of the toxicity ranges from reduction in feed consumption and nutrient utilization to profound neurological effects or even death. Some of these antinutritional factors include; phytates, tannins, hydrogen cyanide, oxalates, saponins and trypsin inhibitors.

2.7.1 Phytates in plants

Phytates are compounds formed by the combination of inositol with six molecules of phosphoric acid. Phytic acid (myo – inositol hexaphosphate) is a common constituent of many plant foods especially seeds. This molecule is charged with six phosphate groups extending from the central inositol ring structure. Phytic acid forms insoluble salt with some essential minerals like calcium, iron, zinc and magnesium thereby rendering them unavailable for absorption into the blood stream. Since phytates cannot be absorbed and animals particularly the monogastrics have limited capacity for hydrolysing the phytate molecule, a negative effect of phytic acid on mineral bioavailability can be expected. Ogwu (2010) reported the negative effect of phytic acid. He stated that low absorption of zinc was noticed in chicks fed phytate. Ogwu (2010) further reported negative effect of phytic acid on the absorption of calcium, iron and magnesium. Robert and Yudkin (1961) also stated that phytic acid inhibit calcification in rats. Ruminants possess the enzyme phytase in their digestive tract which help in hydrolyzing phytates, making the nutrients available. The non-ruminants have no phytase in their system, therefore their diets must therefore be supplemented with more of the essential minerals or with the enzyme phytase to reduce the effects of phytic acid.

Though phytate is an anti-nutrient, it was also reported to be a phyto nutrient as it has antioxidant property. Mineral binding property of phytic acid is said to be responsible for preventing colon cancer by reducing oxidative stress in the human intestinal tract (Vucenik and Shamsuddin, 2003). The trypsin inhibitor activity, phytic and tannin concentration of Baobab seed and fruit pulp are presented in Table 2.3.

Table 2.3: Trypsin inhibitor activity and concentration of phytic acid and tannin in baobab seed and fruit pulp

ANTI-NUTRIENT	SEED	FRUIT
Trypsin inhibitor Activity (TIU/mg)	5.7 ± 0.6	5.8 ± 0.3
Phytic Acid (mg/100g)	73.0 ± 9	2.6 ± 0.3
Tannin (% catechin equivalent)	23.0 ± 21.8	0.9 ± 0.10

Source: Magdi (2004).

2.7.2 Tannins in plant

These are high molecular weight polyphenolic compounds found in a wide variety of food. It is usually found in the bark, fruits, leaves and roots of plants (Ogwu, 2010). The astringent bitter taste from tannin causes dry and pucky feeling following the consumption of unripened fruit or red wine (McGee, 2004).

Tannins combine with digestive enzymes and with other proteins making them un-available for digestion process (Binta and Khetarpaul, 1997; Abara, 2003). The presence of tannin causes browning or pigmentation problem in both fresh and processed foods. Tannins act as an anti-nutritional factor in two ways. Firstly, it provokes an astringent reaction in the mouth, making the food unpalatable. Secondly, they complex with and precipitate the proteins in the gut, thereby reducing digestibility or inhibiting digestive enzyme. This has implication on livestock nutrition because they inhibit the activity of

some enzymes like trypsin, chemotrypsin, amylase and lipase. Tannin inhibitory effect is attributed to its ability to form a complex with protein and it can also interfere with dietary iron absorption.

2.7.3 Hydrogen cyanide in plants

Cyanides are compounds that contain cyano groups $C \equiv N$ which consists of carbon atom with triple bonds to a nitrogen atom. The study of Liener (1990) shows that cyanides occur in several important food plants such as roots e.g. (cassava), tubers (yam), Legume seeds (kidney and lima seeds) and oil seeds (Linseed). Hydro cyanide is poisonous and its effect has been attributed to its affinity for metals like iron and copper. It complexes with haemoglobin, an oxygen carrier in the blood and also combines with copper through cytochrome oxidase thereby inhibiting its function as oxidative enzyme in electron transfer and thus preventing cells from producing ATP for energy aerobically (Smith and Oliver, 1971).

2.7.4 Oxalates in plants

These compounds occur naturally in plants. While they play a great protective role in plants that contain them, they interfere with absorption of essential minerals such as calcium, iron and to some extent zinc. They are anti-nutrients that bind and form a complex with calcium, forming calcium oxalate crystals. Ladeji *et al.* (2004) reported that oxalates prevent absorption and utilization of calcium by the body, causing diseases like rickets in children and osteomalacea in adults. Thompson and Yoon (1984) also stated that many metal ions form insoluble precipitate with oxalate. A prominent example is calcium oxalate, the primary constituent of the most common kind of kidney stone, which they further explained might have taken place in the digestive tract. The crystals

are retained in the kidney after renal filtration as kidney stone. This is detrimental to human health.

2.7.5 Saponins in plants

These chemicals are found in nature particularly in various plant species. They produce soap-like foams when shaken in aqueous solutions. They have a haemolytic action and are highly toxic to cold blooded animals (Hostettman and Marston, 1995). In plants, saponins act as anti-feedants to protect plants against microbes and fungi. However saponins are bitter to taste and so can reduce palatability of plants and livestock feeds or even expose them to life – threatening toxicity (Foerster, 2006).

2.7.6 Trypsin inhibitors in plants

Trypsin is an enzyme secreted in mammals by the pancreas and plays an important role in protein digestion in the intestine. Trypsin activity is blocked by the action of the inhibitor that complexes to the site where trypsin could couple therefore inhibiting the digestion of protein (McDonald *et al.,* 1995). The effect have been shown in growth suppression and pancreatic hypertrophy in experimental animals (Liener, 1980 and Magdi, 2004). Magdi (2004) further reported that baobab fruit pulp like other plants contain trypsin inhibitor, phytate and tannin but their levels as indicated from his study are below the levels found in legumes which make it safer for consumption. Similarly, Phyto Trade Africa (2006) did phytochemical screening of baobab fruit pulp for all classes of anti-nutrients and found that the levels were low or below the limit expected to show toxic effects to animals. Table 2.4 show the permissible level of anti-nutritional factors in animals.

In legume seeds, different treatment approaches have been used to remove or reduce the anti nutritional factors so as to incorporate them in livestock feeds (Ogundipe *et al,* 2003; Bawa *et al.,* 2003; Abeke, 2005). There is therefore a need for studies to determine the role that baobab fruit pulp can play as a feed ingredient for livestock especially for poultry.

Table 2.4: Permissible levels of Anti-nutrients in animal

Anti-nutritional factors	**Permissible level (mg/kg body weight)**
Phytate	6.4
Oxalate	10 – 20
Tannin	15
Saponin	0.54
Hydrogen cyanide	5 – 50

Source: Ogwu, 2010

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Sources of baobab fruit pulp and synthetic ascorbic acid

Dried baobab fruit pulp meal used in this study was purchased from Sabon Gari Market in Zaria. Synthetic ascorbic acid was purchased from a pharmaceutical shop in Samaru. It is available in tablet forms manufactured by MOPSON pharmaceutical.

3.1.1 Chemical analysis of baobab fruit pulp

Chemical analysis of the dry baobab fruit pulp was carried out according to AOAC (1990) methods to determine the proximate composition (dry matter, crude protein, crude fibre, ether extract and ash contents). The major minerals such as calcium, phosphorus and iron were also determined. The ascorbic acid (vitamin C) content was also determined in the Biochemistry Laboratory of Food Science and Technology Programme of the Institute for Agricultural Research, Ahmadu Bello University.

3.1.2 Determination of anti-nutritional factors in baobab fruit pulp

(i) Determination of phytate content of baobab fruit pulp

Four grams of powdered baobab fruit pulp meal was weighed out and soaked in 1000ml of 2% hydrochloric acid for four hours and filtered. 25mls of the filtrate was taken into a conical flask and $5cm^3$ of 0.3% ammonium thiocynate solution was added. The mixture was titrated with a standard solution of iron (III) chloride until a brownish yellow colour persisted for 5 minutes. The phytic acid was therefore determined by the procedure of Reddy *et al.,* 1989. Three replicate determinations were carried out and their mean values calculated:

Calculation: 1cm^3 of 0.02m $FeCL_3$ = 0.60lmg phytate

Concentration of Phytate Phosphorus =

$$\frac{\text{Titer value x 0.601 phytate}}{\text{1000 x weight of sample}}$$

(ii) Determination of Tannins Contents of Baobab Fruit Pulp

The principle used was based on the reaction of Folin – Denis reagent with filtered sample solution and orthophosphoric acid which gives a colour that can be determined colorimetrically, using the method of Price *et al.,* 1978.

0.5g of baobab fruit pulp was weighed into a 100ml conical flask. 50cm^3 of distilled water was added and allowed to boil gently for 1 hour on a hot plate. The solution was filtered while still warm into a 50cm^3 volumetric flask. The filter paper was washed and added into the solution and made to volume when cooled. 0.3cm^3 of tannic acid was taken into a range of 0.5cm^3, 1.0cm^3, 1.5cm^3, 2.0cm^3, 2.5cm^3 and 3.0cm^3 corresponding to 0.05mg, 0.1mg, 0.15mg, 0.2mg, 0.25mg and 0.3mg of the sample and 3cm^3 of aliquot of the sample was pipetted into a 50cm^3 volumetric flask. To both standards and sample, water was added until half-full. 2.5cm^3 of Folin – Denis reagent was added to each flask followed by the addition of 10ml of 17% (W/v) sodium carbonate solution and diluted to 50cm^3 marks and mixed. These were allowed to stand in water bath at 25^{o}C for 5 minutes. The optical density (absorbance) reading was taken at 760nm wave length using distilled water as blank, the calibration curve, was used to determine the concentration of tannins

Calculation:

$$\text{Soluble tannins (\%)} = \frac{\text{Concentration (graph) x Extract Volume}}{10 \quad \text{Aliquot Vol x Sample Weight}}$$

(iii) Determination of hydrogen cyanide content of baobab fruit pulp

The hydrocyanic acid content of Baobab fruit pulp was determined according to (AOAC, 1980). 10gms of homogenous dry baobab fruit pulp was soaked in a mixture of 200cm^3 distilled water and 10ml of orthophosphoric acid. The mixture was left for 12 hours to release all bounded hydrogen cyanide (HCN).

A drop of anti – foaming agent (tannic acid) and anti – bumping agent was added and the solution distilled until 150ml of the distillate was collected in a conical flask and diluted with 40ml of distilled water. 8ml of 6mole/dm^3 ammonium hydroxide and 2cm^3 of 5% potassium iodide solution was added. The solution was titrated with 0.02mole/dm^3 silver solution using a micro burette until a faint but permanent turbidity was obtained. Determinations were in triplicate and their mean values calculated. 1ml 0.02 mole/dm^3 of $AgN0_4$ = 1.08mg HCN

Calculation:

$$\% \text{ cynanide} = \frac{\text{Absorbance of test}}{\text{Absorbance of standard}} \times \text{Concentration of standard}$$

(iv) Determination of oxalate content of baobab fruit pulp

The method used was that of Oke (1966). 1.5g sample was weighed into a 250ml volumetric flask and digested with 190ml distilled water and 10ml of 6N hydrochloric acid. It was incubated in a water bath at 90^{o}C for 5 hours. The mixture was centrifuged and filtered into a 250ml volumetric flask and the filtrate made up to mark with distilled water. 50ml aliquot of the extract was mixed with 25ml 6N HCL and the mixture evaporated to about 25ml on a hot plate. The brown precipitate formed was filtered off and washed with hot distilled water. The combined solution washing was titrated with concentrated ammonia until pink yellow. The solution was then heated on a hot plate to about 90^{o}C. The oxalate was precipitated with 10% (W/v) calcium chloride solution.

After keeping the mixture over night, it was filtered and precipitated and washed with distilled water until calcium free as tested with bench sodium hydroxide. The precipitate was then washed with 25% (V/V) sulphuric acid solution and diluted with 125m with distilled water. It was warmed to 90^{o}C and titrated with 0.05N potassium permanganate solution.

$CaC_2 0_4 + H_2S04 \longrightarrow CaS04 + H_2C_20_4$

$2MnO_4 + 5C_2O4^{2-} + 16H \longrightarrow 2Mn^{2+} + 10C^{o}_2 + 8H_20$

Calculation:

1mg 0.05N$KMn0_4$ = 2.2mg Oxalate

$$\text{Oxalate} = \frac{T \times Vme \times DF \times 10^5}{Mr \times W}$$

T = Titre Value of $KMn0_4$

Vme = Volume Mass equivalent of $KMn0_4$ (0.0033g)

DF = Dilution factor = $Vtotal/V_A = 1$

Mr = Mole ratio in reaction between oxalate and $KMn0_4$ = 1.1

W = Weight of sample

(v) Determination of saponin content of baobab fruit pulp

The method used was that of Hudson and El-Difrawi, (1979). 10g of dry baobab fruit pulp was taken into 100cm^3 of 20% aqueous ethanol in water and agitated with a magnetic stirrer for 12 hours at 55^{o}C. The solution was filtered using Whatman No 1 filter paper. The residue was re–extracted with 300cm^3 of 20% aqueous ethanol, the extract was combined and reduced to about 40cm^3 under vacuum using rotary evaporator. The extract and 20cm^3 diethyl ether were transferred into 250cm^3 separatory funnel and shaken vigorously. The aqueous layer was discarded. The process of purification was repeated until a colourless aqueous extract was obtained. The pH of the remaining

aqueous solution was adjusted to about 4.5 by adding 4g of sodium dichloride and the solution was shaken with 60ml N – butanol. The combined butanolic extract was washed twice with 10ml of 5% aqueous NaCl and evaporated to dryness in a fume cupboard to give a crude saponin which was weighed.

Calculation

$$\% \text{ Saponin} = \frac{\text{weight of saponin} \times 100}{\text{Weight of sample}}$$

(vi). Determination of trypsin inhibitor content of baobab dry fruit pulp

The powdered fruit pulp of baobab (*Adansonia digitata L)* was extracted for three hours with petroleum ether of bp 60 – 80^{o}C at room temperature. The ether free material was sieved through a 40mm mesh screen. One gram of each sample was suspended in 20mg of 0.05N HCl and kept in a refrigerator overnight at 4^{o}C. The insoluble matter was removed by centrifugation at 800rpm for 20 minutes in Unipan Centrifugation model No.310. The supernatant was used as trypsin inhibitor (TI) extract and diluted 1:1000 with water before use. The trypsin inhibitor activity (TIA) of sample extracted was assayed according to the method of Kakade *et al.* (1969).

3.2 COOL-WET SEASON FEEDING TRIALS (EXPERIMENTS 1-3)

Three feeding trials were carried out during the cool-wet season between June and September, 2008. The three trials were as follows:

EXPERIMENT 1: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the performance and egg quality characteristics of laying hens (44 –56 weeks) during cool – wet season.

EXPERIMENT 2: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the growth performance of broiler starters (2 – 5 weeks) during cool – wet – season.

EXPERIMENT 3: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the growth performance and carcass characteristics of broiler finishers (6–9 weeks) during cool – wet season.

3.2.1 EXPERIMENT 1: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the laying performance and egg quality characteristics of laying hen (44–56 weeks) during cool-wet season

In this study, two hundred and fifty two, 44 weeks old ShikaBrown commercial layers were used. The birds were divided into 7 treatment groups and replicated three times with each replicate consisting of twelve birds. There were 3 levels of ascorbic acid designated as T_2, T_3 and T_4 in which ascorbic acid preparations in tablets forms were added at the rate of 100, 200 and 300mg/kg diet respectively. The Baobab Fruit Pulp Meal was added at 3 levels at the rates of 3.5; 7.0 and 10.5% of diets respectively. These were designated as T_5, T_6 and T_7 respectively. There was also a control diet (T_1) in which there was no supplemental ascorbic acid nor Baobab Fruit Pulp Meal (Table 3.1). The feeds were iso-nitrogenous and completely randomized design (CRD) was used. Feed and water were supplied *ad libitum* throughout the experimental period that lasted for 12 weeks. The indices measured and calculated included initial weight, final weight, body weight change, feed intake, kg feed/dozen egg, Hen – day egg production, feed cost/dozen eggs and mortality rate. The eggs collected from each treatment for three consecutive days towards the end of every 28 days periods were used to estimate egg quality characteristics. Average weight of the eggs were taken. After weighing, five eggs from each replicate were broken out and with the aid of a venier calipers, the albumin heights were measured which were used to calculate the Haugh unit values, using the formula proposed by Haugh (1937).

Table 3.1: Composition of experimental diets for layers with ascorbic acid or baobab fruit pulp supplementations during cool-wet season

Ingredients	Control	Ascorbic Acid Levels (mg/kg)			BFPM Levels (% of Diets)		
	T_1 0.00	T_2 100	T_3 200	T_4 300	T_5 3.5	T_6 7.0	T_7 10.5
Maize	56.21	56.20	56.19	56.18	52.14	48.07	44.00
Groundnut Cake	18.09	18.09	18.09	18.09	18.66	19.25	19.08
Soybean Cake	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Wheat Offal	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Limestone	6.83	6.83	6.83	6.83	6.83	6.83	6.83
Bone Meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Vit. Trace Mineral Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Lysine	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Ascorbic Acid	-	0.01	0.02	0.03	-	-	-
Boabab Fruit Pulp	-	-	-	-	3.50	7.0	10.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis:							
Metabolizable energy (Kcal/kg)	2632.00	2632.00	2632.00	2632.00	2616.62	2600.00	2582.13
Crude protein (%)	17.00	17.00	17.00	17.00	17.00	17.00	17.00
Ether extract (%)	4.59	4.59	4.59	4.59	4.56	4.52	4.49
Crude fibre (%)	3.05	3.05	3.05	3.05	3.26	3.52	3.66
Calcium (%)	3.75	3.75	3.75	3.75	3.75	3.75	3.75
Available Phosphorus (%)	0.61	0.61	0.61	0.61	0.61	0.61	0.60
Lysine (%)	0.79	0.79	0.79	0.79	0.79	0.79	0.79
Methionine (%)	0.74	0.74	0.74	0.74	0.66	0.66	0.60

Biomix layers premix supplied the following per kg diet Vit. A, 8500i.u; Vit. D_3, 1500 I.U; Vit. E, 10mg; Vit. K, 1mg; Thiamine, 1.5mg; Riboflavin, 4.5mg; Pyridoxine B_6, 3mg; Niacin, 15mg; Vit B_{12}, 0.015mg; Pantothenic acid, 4.5mg; Folic Acid, 0.6mg; Biotin, 0.5mg; Choline Chloride, 175mg; Antioxidant, 1.25mg; Manganese, 40mg; Zinc, 30mg; Iron, 20mg; Copper, 3mg; Iodine, 1mg; Selenium, 0.2mg; Cobalt 0.2mg.

$$HU = 100 \log_{10} (H + 7.6 - 1.7^{W\,0.37}) G$$

Where

HU = Haugh Unit Value

H = Observed albumeh height in mm

G = The gravitational constant

W = Observed weight of eggs in gm

Other measurements taken include egg weight, shell weight, shell thickness and yolk index.

The HU values were graded as follow :

AA: 72 and above

A: 71 - 60

B: 59 – 31

C: 30 or below

The higher the values the better the quality of the egg.

3.2.2: EXPERIMENT 2: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the growth performance of broiler starter (2 – 5 weeks)

Three hundred and fifteen, two weeks old Oba Marshal broiler chicks were used in this experiment. These birds were distributed to seven treatment groups and replicated three times with each replicate having 15 birds. There were 3 levels of commercial tablets form of ascorbic acid supplemented at the rates of 100, 200 and 300mg/kg diet for treatment of groups 2,3 and 4 respectively. Groups 5,6 and 7 had Baobab Fruit Pulp Meal added to their diets at the rates of 3.5, 7.0 and 10.5% respectively. The control diet had neither supplemental Ascorbic acid supplemented nor Baobab Fruit Pulp Meal and this was labeled as T_1 or group 1.

The diets were iso-nitrogenous and iso-caloric (Table 3.2). The birds were fed and watered on *ad libitum* basis throughout the starter period that lasted for 3 weeks. All management practices were observed and vaccination schedule recommended by the ABU Veterinary Teaching Hospital was followed. Weekly data collections included initial weight, final weight, body weight gain, feed consumption, feed conversion ratio, feed cost/kg body weight gain and mortality rate.

Table 3.2: Composition of experimental diets for broiler starters with ascorbic acid or baobab fruit pulp supplementation during cool-wet season

	Control	Ascorbic Acid Levels (mg/kg)			Baobab Fruit Pulp Meal (%)		
Ingredients	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**
	0	**100**	**200**	**300**	**3.5**	**7.0**	**10.5**
Maize	47.18	47.17	47.16	47.15	42.47	37.74	33.05
Groundnut Cake	33.00	33.00	33.00	33.00	33.82	34.53	35.24
Soybean Cake	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Fish Meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Palm oil	2.00	2.00	2.00	2.00	2.42	2.91	3.40
Limestone	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Bone Meal	3.28	3.28	3.28	3.28	3.28	3.28	3.28
Salt	0.35	0.35	0.35	0.35	0.35	0.25	0.35
Vit. Trace Mineral Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Methionine	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Ascorbic Acid	-	0.01	0.02	0.03	-	-	-
Boabab Fruit Pulp	-	-	-	-	3.50	7.00	10.50
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis:							
Metabolizable Energy (Kcal/kg)	2943.00	2943.00	2943.00	2943.00	2941.00	2941.00	2941.00
Crude protein (%)	23.90	23.90	23.90	23.90	23.90	23.90	23.90
Ether extract (%)	6.57	6.57	6.57	6.57	6.89	7.32	7.69
Crude fibre (%)	3.89	3.89	3.89	3.89	4.16	4.42	4.82
Calcium (%)	1.28	1.28	1.28	1.28	1.28	1.28	1.28
Available Phosphorus (%)	0.64	0.64	0.64	0.64	0.64	0.64	0.69
Lysine (%)	1.30	1.30	1.30	1.30	1.30	1.30	1.30
Methionine (%)	0.90	0.90	0.90	0.90	0.90	0.90	0.88

Biomix broilers premix supplied the following per kg diet Vit. A, 10.000 I.U; Vit. D_3, 2000I.U; Vit. E, 25mg; Vit. K_3, 2mg; Vit B_1, 1.8mg; B_2, 5mg; Niacin, 27.5mg; Pantothenic acid 7.5mg; Vit B_6, 3.0mg; Vit. B_{12}, 0.015; Folic Acid, 0.075mg; Biotin, 0.06mg; Choline Chlorides 300mg; Cobalt, 0.2mg, Copper 3.0mh; iodine, 1mg; Iron, 20mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg.

3.2.3 EXPERIMENT 3: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the growth performance and carcass characteristics of broiler finishers (6 – 9 weeks)

The aim of this study was to determine the effects of a commercial form of Ascorbic acid (tablets) and AA Acid from a natural source (Baobab Fruit Pulp Meal) on the growth performance of broiler finishers during the cool – wet season. The study lasted for 3 weeks. There were seven dietary treatments replicated 3 times with twelve birds in each replicate. Diet treatments T_2, T_3 and T_4 had ascorbic acid added at the levels of 100, 200 and 300mg/kg diets while Baobab Fruit Pulp Meal was added at rates of 3.5, 7.0 and 10.5% to the diets for treatments T_5, T_6 and T_7 respectively (Table 3.3). A control diet that contained neither of the two sources of ascorbic acid was also formulated and labeled as treatment one (T_1). The layout of the experiment was a completely Randomized Design. The initial weight of the birds were equalized as much as possible at the beginning of the feeding trial. The weekly data collections and calculations were carried out on final weight, weight gain, feed intake, feed conversion ratio, feed cost per kg body weight gain and on mortality rates. At the end of the trial, 3 birds from each replicate group were selected and slaughtered for carcass evaluation. Birds were slaughtered by placing their heads downward into the slaughtering cones before severing the jugular vein with a sharp knife. After the blood had fully drained out, birds were scalded in hot water. Feathers were plucked manually and evisceration done. Carcasses were weighed and dressing percentages as well as the weights of giblets and abdominal fat pad were calculated and expressed as percent of live weights.

Table 3.3: Composition of experimental diets for broiler finishers with ascorbic acid or baobab fruit pulp meal supplementations during cool - wet season

	Control	Ascorbic Acid Levels (mg/kg)			BFPM Levels (%)		
Ingredients (%)	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**
	0	**100**	**200**	**300**	**3.5**	**7.0**	**10.5**
Maize	59.03	59.02	59.01	59.00	54.48	49.96	45.42
Groundnut Cake	2.30	22.30	22.30	22.30	22.79	23.62	24.29
Soybean Cake	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Fish Meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Palm Oil	1.70	1.70	1.70	1.70	2.08	2.45	2.83
Limestone	0.01	0.01	0.01	0.01	-	-	-
Bone Meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Vit. Trace Mineral Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Methionine	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Ascorbic Acid	-	0.01	0.02	0.03	-	-	-
Boabab Fruit Pulp	-	-	-	-	3.50	7.00	**10.50**
Total 100.00	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis:							
Metabolizable energy (Kcal/kg) 3058.03	3058.03	3058.03	3058.03	3058.06	3058.15	3058.70	
Crude protein(%)	21.70	21.70	21.70	21.70	21.70	21.70	21.70
Ether extract (%)	4.83	4.83	4.83	4.83	4.78	4.74	4.69
Crude fibre (%)	3.17	3.17	3.17	3.17	3.15	3.12	3.10
Calcium (%)	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Available Phosphorus (%)	0.67	0.67	0.67	0.67	0.67	0.67	0.67
Lysine (%)	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Methionine (%)	0.83	0.83	0.83	0.83	0.82	0.82	0.82

Premix supplied the following per kg diet Vit. A, 8,500I.U; Vit. D_3, 1500 I.U; Vit. E, 10mg; Vit. K_3, 1.5mg; Vit B_1, 1.6mg; Vit B_2, 4mg; Niacin, 20mg, Pantothenic acid 0.75mg; Vit B_6, 1.5mg; Vit. B_{12}, 0.01mg; Folic Acid, 0.5mg; Biotin, 0.75mg; Choline Chloride 175mg; Cobalt, 0.2mg; Copper, 5mg; iodine, 1mg; Iron, 20mg; Manganese, 40mg; Selenium, 02mg; Zinc, 30mg; Antioxidant, 1.25mg

3.3. HOT-DRY SEASON FEEDING TRIALS (EXPERIMENTS 4-6)

The trial conducted in the Hot-dry season were replicas of those conducted during the cool-wet season. The only difference was the fact that only two dietary levels of Baobab Fruit Pulp Meal (3.5% and 7.0% of the diets) were tested. The 10% BFPM was dropped during the hot-dry season study due to poor performances on this diet in the cool-wet season studies.

EXPERIMENT 4: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the performance, egg quality characteristics, haematological status, and rectal temperatures of laying hens (30 – 42 weeks) during hot dry season.

EXPERIMENT 5: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the growth performance, and haematological status of broiler starters (0 – 4 weeks) during hot dry season.

EXPERIMENTS 6: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the growth performance and carcass characteristics of broiler finishers (6 – 9 weeks) during hot dry season.

3.3.1 EXPERIMENT 4: Effects of Dietary Levels of Ascorbic Acid and Baobab Fruit Pulp Meal on the Performance, Egg Quality Characteristics Heamatological Status and Rectal Temperatures (^{o}C) or Laying Hens (30 – 42 Weeks) during hot-dry season

The aim of this experiment was to determine the effect of commercial preparations of ascorbic acid (as tablets) and Ascorbic Acid within Baobab Fruit Pulp, (as the natural source) in laying hens diets during the hot dry season of the year. Two hundred and seventy – ShikaBrown® Commercial layers (aged 30 weeks) obtained from National Animal Production Research Institute (NAPRI) were used in this study. There were three levels of Ascorbic acid and two levels of Baobab fruit pulp meal in the diets plus a control diet containing neither of the two sources of ascorbic acid. Each treatment was replicated three times. Dietary supplemental levels of Ascorbic acid were 100, 200 and 300mg/kg of

diet representing treatments T_2, T_3 and T_4 respectively, while Baobab pulp meal was included at 3.5% and 7.0% representing treatments T_5 and T_6 respectively. T_1 represented the control diet where neither ascorbic acid nor BFPM was included. The composition of the experimental diets were as shown in Table 3.4. The diets and water were provided for the layers *ad libitum* throughout the experimental period that lasted for 12 weeks. All management practices and routine vaccination schedules were done as recommended for Zaria area by the ABU Veterinary Teaching Hospital. The weights of birds were equalized at the beginning of the feeding trial. The rations were made iso-nitrogenous. The experiment was laid out in a Completely Randomized Design (CRD). Production parameters measured or calculated included: Initial weight, Final weight, Body weight change, Feed consumption, kgfeed/dogen eggs, Hen-Day egg production, Feed cost per dozen eggs and mortality rates. The eggs collected from each treatment for three consecutive days towards the end of every 28 days period were used to estimate egg quality characteristics. Average weights of the eggs were taken. After weighing, five eggs from each replicate were broken out and with the aid of venier calipers, the albumin heights were measured which were used to calculate the Haugh Unit Values, using the formula proposed by Haugh (1937).

$$HU = 100\log_{10}(H + 7.6 - 1.7W^{0.37})G$$

Where

HU = Haugh Unit Value

H = Observed albumin height in mm

G = The gravitational constant

W = Observed weight of egg in gm

Table 3.4: Composition of experimental layer diets with ascorbic or baobab fruit pulp supplementations during hot-dry season study

	Control	Ascorbic Acid Levels (mg/kg)			BFPM Levels (%)	
Ingredients (%)	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**
	0	100	200	300	3.5	7.0
Maize	56.21	56.20	56.19	56.18	52.14	48.07
Groundnut Cake	18.09	18.09	18.09	18.09	18.66	19.25
Soybean Cake	5.00	5.00	5.00	5.00	5.00	5.00
Wheat Offal	10.00	10.00	10.00	10.00	10.00	10.00
Limestone	6.83	6.83	6.83	6.83	6.83	6.83
Bone Meal	3.00	3.00	3.00	3.00	3.00	3.00
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vit. Trace Mineral Premix	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.15	0.15	0.15	0.15	0.15	0.15
Lysine	0.12	0.12	0.12	0.12	0.12	0.12
Ascorbic Acid	-	0.01	0.02	0.03	-	-
Boabab Fruit Pulp	-	-	-	-	3.50	7.0
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis:						
Metabolizable energy (Kcal/kg)	2632.00	2632.00	2632.00	2632.00	2616.62	2600.00
Crude protein (%)	17.00	17.00	17.00	17.00	17.00	17.00
Ether extract (%)	4.59	4.59	4.59	4.59	4.56	4.52
Crude fibre (%)	3.05	3.05	3.05	3.05	3.26	3.52
Calcium (%)	3.75	3.75	3.75	3.75	3.75	3.75
Available phosphorus (%)	0.61	0.61	0.61	0.61	0.61	0.61
Lysine (%)	0.79	0.79	0.79	0.79	0.79	0.79
Methionine (%)	0.74	0.74	0.74	0.74	0.66	0.66

Biomix layers premix supplied the following per kg diet Vit. A, 8500I.U,Vit. D_3, 1500 I.U; Vit. E, 10mg; Vit. K, 1mg; Thiamine, 1.5mg; Riboflavin, 4.5mg; Pyridoxine, 3mg; Niacin, 15mg; Vit B_{12}, 0.015;Pantothenic acid, 4.5mg; Folic Acid, 0.6mg; Biotin, 0.5mg; Choline Chlorides 175mg; Antioxidant, 1.25mg;Manganese, 40mg; Zinc, 30mg; Iron, 20mg; Copper, 3mg; iodine; 1mg; Selenium, 0.2mg; cobalt 0.2mg.

At exactly 6 weeks after the commencement of the experiment, three birds from each replicate were selected and blood samples taken. The blood samples were collected via the wing vein of the birds. The blood samples were kept in test tubes containing anti-coagulant Ethylene Diamine Tetra Acetic Acid (EDTA) and used for the haematological studies in which packed cell volume (PCV), haemoglobin (Hb) and total protein (TP) were determined.

Rectal temperatures were recorded from three birds per replicate, three days a week at the hours of 09:00, 12:00 and 15:00. The clinical digital thermometer (The Hartman's Digital Thermometer Plc Company, England) was inserted into the claoca about 2-3cm into the rectum. The readings were taken as soon as the value of the thermometer remained constant.

3.3.2 EXPERIMENT 5: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the growth performance and haematological status of broiler starters (0–4 weeks) during hot-dry season

This experiment was conducted to examine the effects of commercial preparations of Ascorbic Acid tablets and Baobab Fruit Pulp as a natural source of vitamin C on the growth performance of broiler starter birds (0-4weeks). There were six dietary treatments consisting of 3 dietary levels of ascorbic acid (100, 200 and 300mg/kg diet) and 2 dietary levels of Baobab Fruit Pulp Meal (3.5 and 7.0%). There was also a control diet which contain neither Ascorbic Acid nor the Baobab Fruit Pulp Meal. The broilers diets were formulated to meet the NRC (1994) nutrient requirements. Ascorbic Acid supplemented diets at 100, 200 and 300mg/kg diet represented treatment T_2, T_3 and T_4 respectively while Baobab Fruit Pulp Meal diets at 3.5 and 7.0% of diet represented treatment T_5 and T_6 respectively. Treatment T_1 served as the control diet. There were a total of six dietary treatments. Each treatment was replicated three times with 20 birds per replicate. The diets and water were supplied *ad libitum*. The weights of birds were equalized as much as possible. All diets were made iso-nitrogenous and iso-caloric (Table 3.5).

The experiment was laid out in a Completely Randomized Design (CRD). The parameters measured include; initial weight, final weight gain, body weight gain, feed intake, feed conversion ratio, feed cost per kg body weight gain and mortality rate. At the end of the fourth week, blood samples were collected via the wing vein from three birds from each replicate. The blood samples were used to determine the haematological status such as the packed cell volume (PCV). haemoglobin content (Hb) and the total protein (TP).

3.3.3 EXPERIMENT 6: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the growth performance and carcass characteristics of broiler finishers (6–9 weeks) during the hot-dry season

This experiment was conducted to determine the effects of commercial preparations of Ascorbic Acid (tablet form) and Baobab Fruit Pulp Meal (BFPM) as sources of ascorbic acid on the growth performance and carcass characteristics of broiler finisher birds (6-9 weeks). This study was conducted during the hot-dry season (March to May). The experiment involved three supplemental levels of commercial preparations of Ascorbic Acid and two dietary levels of Baobab Fruit Pulp Meal. There was also a control diet containing neither of the two sources of ascorbic acid. A total of two hundred and sixteen birds were used in this study. There were six treatments replicated three times with each replicate having twelve birds. The diets for the broiler finishers were formulated to meet the NRC (1994) nutrient requirements. Ascorbic acid was added to the diet at 100, 200 and 300mg/kg of diets for treatments T_2 T_3 and T_4 respectively and the Baobab Fruit Pulp Meal supplemented at the rate of 3.5% and 7.0% of the diets for treatment T_5 and T_6 respectively. There was a control diet labeled as (T_1), in which neither of the two supplemental sources of AA was added. Feed and water were supplied *ad libitum*. The weights of birds were equalized as much as possible from the beginning of the feeding trial. All diets were iso-nitrogenous and iso-caloric (Table 3.6).

Table 3.5: Composition of experimental diets for broilers starters (0-4weeks) with ascorbic acid ore baobab fruit pulp meal supplementations during hot-dry season

	Control	Ascorbic Acid Levels (mg/kg)			BFPM Levels (%)	
Ingredients (%)	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**
	0	**100**	**200**	**300**	**3.5**	**7.0**
Maize	47.18	47.17	47.16	47.15	42.47	37.74
Groundnut Cake	33.00	33.00	33.00	33.00	33.82	34.53
Soybean Cake	10.00	10.00	10.00	10.00	10.00	10.00
Fish Meal	3.00	3.00	3.00	3.00	3.00	3.00
Palm Oil	2.00	2.00	2.00	2.00	2.42	2.50
Limestone	0.50	0.50	0.50	0.50	0.50	0.50
Bone Meal	3.28	3.28	3.28	3.28	3.28	3.28
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vit. Trace Mineral Premix	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.26	0.26	0.26	0.26	0.26	0.26
Methionine	0.18	0.18	0.18	0.18	0.18	0.18
Ascorbic Acid	-	0.01	0.02	0.03	-	-
Boabab Fruit Pulp	-	-	-		3.50	7.0
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis:						
Metabolizable energy (Kcal/kg)	2943.00	2943.00	2943.00	2943.00	2941.00	2941.00
Crude protein (%)	23.90	23.90	23.90	23.90	23.90	23.90
Ether extract (%)	6.57	6.57	6.57	6.57	6.89	7.32
Crude fibre (%)	3.89	3.89	3.89	3.89	4.16	4.42
Calcium (%)	1.28	1.28	1.28	1.28	1.28	1.42
Available phosphorus (%)	0.64	0.64	0.64	0.64	0.64	0.64
Lysine (%)	1.30	1.30	1.30	1.30	1.30	1.30
Methionine (%)	0.90	0.90	0.90	0.90	0.90	0.90

Biomix premix supplied the following per kg diet Vit. A, 10,000 I.U;Vit. D_3, 2000I.U; Vit. E, 25mg; Vit. K_3 2mg; 1.8mg; B_2, 5mg Naicin; 27.5mg; Pantothenic acid 7.5mg;Vit. B_6, 3.0mg;Vit. B_{12}, 0.015mg ;Folic Acid, 0.075mg; Biotin,0.6mg; Chlorides 300mg; Cobalt, 0.2mg; Copper 3.0mh;Iodine, 1mg; Iron, 20mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg.

The experiment was laid out in a completely randomized design. The parameters measured include; initial weight, final weight, body weight gain, feed intake, feed conversion ratio, feed cost per kg body weight gain and mortality rate. At the end of the finisher phase, six birds per treatment were selected on the basis of the average pen weight and these were used for carcass evaluation. Birds were slaughtered by placing their heads downward into the slaughtering cones before severing the jugular vein with a sharp knife. After the blood had fully drained out, birds were scalded in hot water. Feathers were plucked manually and evisceration done. Carcasses were weighed and dressing percentage for each carcass as well as the weights of giblets and abdominal fat pad were calculated and these were expressed as percent of the live weights.

3.4 Data Analysis

All data collected were summarized and subjected to the analysis of variance using general linear model SAS (2007). Comparative analyses of variance for the responses of birds to the diets were performed. Where ANOVA showed significance, treatment means were separated using Duncan's Multiple Range Test (Steel and Torrie, 1980).

Table 3.6: Composition of experimental diets for broiler finisher birds with ascorbic acid or baobab fruit pulp meal supplementations during hot-dry season

	Control	Ascorbic Acid Levels (mg/kg)			BFPM Levels(%)	
Ingredients	**T_1** 0	**T_2** 100	**T_3** 200	**T_4** 300	**T_5** 3.5	**T_6** 7.0
Maize	59.03	59.02	59.01	59.00	54.48	49.96
Groundnut Cake	22.30	22.30	22.30	22.30	22.79	23.62
Soybean Cake	10.00	10.00	10.00	10.00	10.00	10.00
Fish Meal	3.00	3.00	3.00	3.00	3.00	3.00
Palm Oil	1.07	1.07	1.07	1.07	2.08	2.45
Limestone	0.01	0.01	0.01	0.01	-	-
Bone Meal	3.00	3.00	3.00	3.00	3.00	3.00
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vit. Trace Mineral Premix	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.21	0.21	0.21	0.21	0.21	0.21
Methionine	0.15	0.15	0.15	0.15	0.15	0.15
Ascorbic Acid	-	0.01	0.02	0.03	-	-
Boabab Fruit Pulp	-	-	-	-	3.50	7.0
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis:						
Metabolizable energy (Kcal/kg)	3058.03	3058.03	3058.03	3058.03	3058.06	3058.15
Crude protein (%)	21.70	21.70	21.70	21.70	21.70	21.70
Ether extract (%)	4.83	4.83	4.83	4.83	4.78	4.74
Crude fibre (%)	3.17	3.17	3.17	3.17	3.15	3.12
Calcium (%)	1.25	1.25	1.25	1.25	1.25	1.25
Available Phosphorus (%)	0.67	0.67	0.67	0.67	0.67	0.67
Lysine (%)	1.15	1.15	1.15	1.15	1.15	1.15
Methionine (%)	0.83	0.83	0.83	0.83	0.82	0.82

premix supplied the following per kg diet: Vit. A, 8500I.U; Vit. D_3, 1500I.U;Vit. E, 10mg;Vit. K_3, 1.5mg;Vit. B_1, 1.6mg; Vit. B_2, 4mg; Niacin 20mg; Pantothenic Acid 5mg; Vit. B_6, 1.5mg; Vit. B_{12}, 0.01mg; Folic Acid, 0.5mg; Biotin, 0.75mg; Choline Chlorides 175mg; Cobalt 0.2mg; Copper, Iodine 1mg; Iron 20mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 20mg; Antioxidant1.25mg.

CHAPTER FOUR

4.0 RESULTS

4.1 Results of the proximate analysis and anti-nutritional factor contents of baobab fruit pulp

The result of the proximate composition (Table 4.01) indicates that BFPM contains 3.31% crude protein, 9.27% crude fibre, 2.12% ether extract, 79.20% Nitrogen Free Extract and 6.29% Ash. It also contains 1.25% calcium, 2.10% phosphorus and 0.03% iron. The ascorbic acid content was 299.75mg/100g.

Table 4.02 shows the results of the Anti-Nutritional Factors present in the Baobab Fruit Pulp. The Baobab Fruit Pulp contains 0.26mg/100g Tannin, 0.12mg/100g Phytate, 0.48mg/100g Oxalate, 0.04mg/100g, Saponin and Trypsin inhibitor of 1.06mg/100g.

Table 4.01: Proximate, mineral and ascorbic acid composition of baobab fruit pulp (% air dry basis)

Component	%
Dry matter	94.00
Crude protein	3.31
Crude fibre	9.27
Ether Extract	2.12
Nitrogen Free Extract	79.20
Ash content	6.29
Calcium	1.25
Phosphorus	2.10
Iron	0.03
Ascorbic Acid	299.85mg/100g

Table 4.02: Anti-nutritional factors in baobab fruit pulp

Antinutrient compound	Baobab fruit pulp meal (mg/100g)
Tannin	0.26
Phytic Acid	0.12
Oxalate	0.48
Saponin	0.048
Trypsin Inhibitor Activity	1.06

4.2 Results For Experiment 1: Cool-Wet Season Layer Feeding Trials

The results for experiments 1 carried out during the cool – wet season, are presented in the sections below.

4.2.1: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on laying performance and egg quality characteristics of laying hens (44 – 56 weeks) during the cool-wet season

Tables 4.03 and 4.04 show the effects of dietary levels of Ascorbic Acid (AA) and of Baobab Fruit Pulp Meal (BFPM) on the performance of laying hens fed during cool – wet season of the year. Table 4.03 shows significant ($P<0.05$) effects of diets on the final weight, body weight change, feed intake, kg feed/dozen eggs, feed cost/dozen eggs, Hen – day – egg production and percent mortality. Birds fed 3.5% BFPM diet had the best performance in terms of final weight, body weight change, hen – day egg production, kg feed/dozen eggs and feed cost per dozen eggs. Ascorbic Acid diets at 200 and 300mg/kg of diet gave comparable results for final weight, body weight change feed intake and feed cost/dozen eggs.

Egg quality parameters (Table 4.04) showed significant ($P<0.05$) treatment effects on egg weight, shell weight, yolk index and Haugh unit value but there was no significant effects ($P>0.05$) on shell thickness. For egg weights, birds fed 300mgAA/kg diet had the best value, 63.88g which was not significantly different from those on 200mgAA/kg and 3.5% BFPM diets. Birds on the 3.5% BFPM diet had the highest Haugh Unit of 83.93 which was also similar to the values for the Ascorbic acid diets at 200 and 300mg/kg inclusion rates.

Table 4.03: Effects of dietary levels of ascorbic acid or baobab fruit pulp meal on the performance of laying hens (44 – 56 weeks) during cool – wet season

	Control	Ascorbic Acid (mg/kg)			Baobab Fruit Pulp Meal (%)			
Parameters	**0.00**	**100.00**	**200.00**	**300.00**	**3.5**	**7.0**	**10.50**	**SEM**
Initial weight (g/bird)	1700.33	1700.00	1700.00	1700.00	1700.00	1700.00	1700.00	0.21
Final weight (g/bird)	1786.67^{b}	1783.33^{b}	1786.67^{b}	1786.67^{b}	1816.67^{a}	1781.00^{b}	1760.00^{c}	5.12
Body weight change (g/bird)	86.34^{b}	83.33^{b}	86.67^{b}	86.76^{b}	116.67^{a}	81.00^{b}	60.00^{c}	3.27
Feed intake (g/bird/day)	118.40^{b}	118.67^{b}	121.20^{a}	121.64^{a}	121.64^{a}	120.63^{b}	117.78	0.48
Feed cost/kg (₦)	46.91^{a}	47.56^{a}	48.21^{bc}	48.86^{bc}	48.56^{bc}	50.18^{c}	51.68^{d}	0.51
Kg feed/dozen egg	2.35^{d}	2.24^{c}	2.22^{c}	2.17^{b}	2.12^{a}	2.24c	2.33^{d}	0.02
Feed cost/dozen egg (₦)	110.24^{c}	106.53^{a}	105.02^{a}	106.02^{a}	102.95^{a}	112.40^{c}	120.41^{d}	1.91
IAFE (₦/ bird)	129.76^{b}	133.47^{b}	134.98^{a}	133.98^{a}	137.05^{a}	127.65^{b}	119.59^{c}	1.69
Hen-day egg prod. (%)	60.23^{c}	61.78^{d}	66.25^{b}	65.25^{b}	68.79^{a}	65.30^{c}	59.34^{f}	0.39
Mortality (%)	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	5.56^{b}	0.84

a,b,c,d,e,f: Means with different superscripts on the same row are significantly different P<0.05)
SEM: Standard Error of Means
IAFE: Income above feed expenses at ₦20 per egg

Table 4.04: Effects of dietary levels of ascorbic acid or baobab fruit pulp meal on egg quality characteristics of laying hens (44– 56 weeks) during cool-wet season

Indices	Control	Ascorbic Acid (Mg/kg)			Baobab Fruit Pulp Meal (%)			
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	
	0.00	**100.00**	**200.00**	**300.00**	**3.5**	**7.0**	**10.5**	**SEM**
Egg weight (g)	60.75^{c}	60.99^{c}	63.51^{a}	$63,88^{a}$	63.06^{a}	61.96^{b}	59.56^{d}	0.48
Shell weight (g)	8.23^{c}	8.44^{b}	8.69^{a}	8.70^{a}	8.62^{a}	8.58^{a}	8.24^{c}	0.07
Shell thickness (mm)	0.48	0.48	0.48	0.48	0.48	0.47	0.47	0.01
Yolk index	0.46^{b}	0.46^{b}	0.47^{b}	0.47^{b}	0.48^{a}	0.47^{b}	0.46^{b}	0.004
Haugh Unit Value	81.01^{c}	81.66^{b}	83.47^{a}	83.81^{a}	83.93^{a}	82.31^{b}	80.56^{d}	0.69

a, b, c, d: Means with different superscripts on the same row are significantly different ($P<0.05$)
SEM: Standard Error of Means

4.2.2 Effects of dietary levels of ascorbic acid on the performance and egg quality characteristics of laying hens (44 – 56 weeks) during cool-wet season

Table 4.05 and 4.06 show the effects of dietary levels of Ascorbic Acid (AA) on the performance and egg quality characteristics of laying hens during cool – wet season. Table 4.05 shows significant ($P<0.05$) effects of dietary Ascorbic Acid levels on feed intake, kg feed/dozen egg, feed cost/dozen eggs, % Hen–Day Egg production and on percent mortality, but ascorbic acid supplementation had no significant effects on final weight and body weight change. It was noticed that AA supplementation at 300mg/kg diet had the least values for kg feed/dozen and feed cost per dozen eggs. There were no significant differences between 200 and 300 mg AA per kg diets on feed intake and on percent Hen-day egg production.

Egg quality indices presented in Table 4.06 showed significant ($P<0.05$) effects on egg weight, shell weight, yolk index and on Haugh unit value but there was no effect ($P>0.05$) on shell thickness. Increasing the level of AA supplementation beyond 200mg/kg did not have significant ($P>0.05$) improvement on the egg quality indices studied.

Table 4.05: Effects of dietary levels of ascorbic acid on the performance of laying hens (44 – 56 weeks) during cool–wet season

Parameters	Treatments Ascorbic Acid Level (mg/kg)				
	Control	100	200	300	SEM
Initial weight (g/bird)	1700.33	1700.00	1700.00	1700.00	0.21
Final weight (g/bird)	1786.67	1783.33	1786.67	1786.67	5.04
Body weight change (g/bird)	86.34	83.33	86.67	86.76	4.41
Feed intake (g/bird/day)	118.4^{b}	118.4^{b}	121.2^{a}	121.64^{a}	0.51
Kg feed/dozen egg	2.35^{c}	2.24^{b}	2.22^{b}	2.17^{a}	0.02
Feed cost/kg	46.91^{a}	47.56^{a}	48.21^{b}	48.86^{b}	0.38
Feed cost per dozen egg (₦)	110.24^{c}	106.52^{b}	105.02^{a}	106.02^{b}	0.35
IAFE (₦)	129.76^{b}	133.47^{a}	134.98^{a}	133.98^{a}	1.51
Hen – Day Egg Production (%)	60.23^{d}	61.78^{c}	65.25^{b}	66.44^{a}	0.63
Mortality	4.45^{b}	0.00^{a}	0.00^{a}	0.00^{a}	1.11

a,b,c,d: Means with different super scripts in the same row are significantly ($P<0.05$) different
SEM: Standard error of means
IAFE: Income above feed expenses at ₦20 per egg

Table 4.06: Effects of dietary levels of ascorbic acid on the egg quality characteristics of laying hens (44 – 56 weeks) during cool – wet season

Parameters	Treatments Ascorbic Acid Level (mg/kg)				
	Control	100	200	300	SEM
Egg weigh (g)	60.75[b]	60.99[b]	63.51[a]	63.88[a]	0.47
Shell weight (g)	8.23[c]	8.44[b]	8.69[a]	8.70[a]	0.04
Shell thickness (mm)	0.48	0.48	0.48	0.48	0.001
Yolk index	0.46[b]	0.46[b]	0.47[a]	0.47[a]	0.001
Haugh unit value	81.01[b]	80.96[b]	83.47[a]	83.18[a]	0.61

a,b,c: Means with different super scripts on the same row are significantly different ($P<0.05$)
SEM: Standard Error of Means

4.2.3 Effects of dietary levels of baobab fruit pulp meal on performance and egg quality characteristics of laying hens (44 – 56 weeks) during cool-wet season

The performance and egg quality characteristics of laying hens fed dietary levels of Baobab Fruit Pulp Meal (BFPM) as sources of ascorbic acid during the cool – wet season were as presented in Tables 4.07 and 4.08.

The results shown in Table 4.07 indicated significant ($P<0.05$) effects of diets on final weight, body weight change, Feed intake, kg feed per dozen egg, Feed cost per dozen egg, income above feed expenses, % Hen–day egg production and on mortality rate. There was a gradual decrease in final weight of birds as the level of BFPM in the diet increased from 3.5% to 10.5%. The same effect was also observed in body weight change, feed intake, kg feed per dozen egg and percent Hen – day egg production. The lowest feed cost per dozen egg was observed in the 3.5% BFPM dietary treatment. The best kg feed/dozen egg (2.12) and Hen – Day egg production (68.79%) were also observed in birds fed 3.5% BFPM diets. The control and 10.5% BFPM had similar but poorer results for percent mortality. No deaths were recorded for the 3.5% and 7.0% BFPM layer diets.

Table 4.08 shows significant ($P<0.05$) effects of dietary levels of BFPM on egg weight, shell weight, yolk index and on Haugh unit value but no significant effects was observed on shell thickness. A gradual decrease in egg weight, shell weight, yolk index and Haugh Unit Value was observed as the level of BFPM increased beyond 3.5% dietary level. Baobab Fruit Pulp Meal at 3.5% of the diet gave satisfactory results for egg quality characteristics.

Table 4.07: Effects of dietary levels of baobab fruit pulp meal on the performance of laying hens (44 – 56 weeks) during cool–wet season

Parameters	Treatment Baobab Fruit Pulp Meal Level (%)				
	Control	3.5	7.0	10.5	SEM
Initial weight (g/bird)	1700.33	1700.00	1700.00	1700.00	0.21
Final weight (g/bird)	1786.00^{ab}	1816.67^{a}	1781.00^{b}	1760.00^{b}	31.21
Body weight change (g/bird)	86.34^{b}	116.67^{a}	81.00^{c}	60.00^{d}	4.41
Feed intake (g/bird/day)	118.99^{b}	121.64^{a}	120.63^{a}	117.78^{c}	0.52
Kg feed/dozen egg	2.35^{c}	2.12^{a}	2.23^{b}	2.23^{b}	0.02
Feed cost/kg (₦)	46.91^{a}	48.56^{b}	50.18^{c}	51.68^{c}	0.69
Feed cost/dozen egg (₦)	110.24^{b}	102.95^{a}	112.40^{c}	120.41^{d}	0.93
IAFE(₦)	129.76^{b}	137.05^{a}	127.65^{b}	119.59^{c}	0.58
Hen–Day Egg production (%)	60.23^{c}	68.79^{a}	65.30^{b}	59.34^{d}	0.23
Mortality (%)	4.45^{b}	0.00^{a}	0.00^{a}	4.45^{b}	1.58

a,b,c,d: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard error of means
IAFE: Income above feed expenses at ₦20 per egg

Table 4.08: Effects of dietary levels of baobab fruit pulp meal on the egg quality characteristics of laying hens (44 – 56 weeks) during cool-wet-season.

Parameters	Treatments Baobab Fruit Pulp Meal Level (%)				
	Control	3.5	7.0	10.5	SEM
Egg weight (g)	60.75[c]	63.06[a]	61.96[b]	59.56[d]	0.51
Shell weight (g)	8.23[b]	8.62[a]	8.58[a]	8.24[b]	0.08
Shell thickness (mm)	0.48	0.48	0.47	0.47	`0.001
Yolk index	0.46[ab]	0.48[a]	0.46[a]	0.45[ab]	0.01
Haugh unit value	81.01[b]	83.93[a]	82.31[b]	80.01[c]	0.72

a,b,c,d: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard error of means

4.2.4 Comparative effects of control, ascorbic acid supplemented and baobab fruit pulp meal diets on the performance and egg quality characteristics of laying hen (44 – 56 weeks) during cool – wet season

The comparative effects of the control, the Ascorbic Acid (AA) supplemented and the Baobab Fruit Pulp Meal (BFPM) diets on the performance of laying hens and on egg quality characteristics during the cool – wet season were as presented in Tables 4.09 and 4.10.

Table 4.09 shows no significant ($P>0.05$) effects of diets on final weight and body weight change. Significant ($P<0.05$) effects of diets were observed on feed intake, kg fed/dozen eggs, feed cost per dozen egg, Hen – Day egg production and percent mortality. Birds fed AA and BFPM diets had comparable and better performances than the birds fed control diet in terms of feed intake, kg feed per dozen egg and % Hen-day egg production. Feed cost per dozen for the AA supplemented diet was the lowest while the value for the BFPM diets was the highest. Control diet had 4.5% mortality, BFPM had 1.45% but there was no record of mortality for birds fed AA diets throughout the period of study. Both AA and BFPM supplementations resulted in better layer performances in terms of % Hen day egg production, mortality rates and feed intake.

Table 4.10 shows significant ($P<0.05$) effects of diets on egg quality indices. The results indicate that birds on AA diets had highest shell weight (8.61g), followed by those fed BFPM diet. Birds on the AA diets had the best performance in terms of egg weight, shell weight and Haugh unit value.

Table 4.09: Comparative effects of control, ascorbic acid and baobab fruit pulp meal diets on the performance of laying hens – during cool wet – season

Parameters	Treatments Sources of Ascorbic Acid in diet			
	Control Diet	AA Diets	BFPM Diets	SEM
Initial weight (g/bird)	1700.33	1700.00	1700.00	4.12
Final weight (g/bird)	1786.67	1785.56	1785.89	11.23
Body weight change (g/bird)	86.34	85.86	85.89	10.46
Feed intake (g/bird/body)	118.49^{b}	120.56^{a}	120.01^{a}	0.94
Kg feed/dozen eggs	2.35^{b}	2.21^{a}	2.23^{a}	0.05
Feed cost/kg (₦)	46.91^{a}	48.21^{b}	50.14^{c}	0.81
Feed cost/dozen egg(₦)	110.24^{b}	105.86^{a}	119.92^{c}	1.74
IAFE(₦)	129.76^{b}	134.14^{a}	128.30^{b}	1.81
Hen – Day Egg production (%)	60.23^{b}	64.49^{a}	64.48^{a}	1.68
Mortality (%)	4.45^{b}	0.00^{a}	1.48^{a}	1.43

a,b,c: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard error of means
AA: Ascorbic Acid diets
BFPM: Baobab Fruit Pulp Meal Diet
IAFE: Income above feed expenses at ₦20 per egg

Table 4.10: Comparison of control, ascorbic acid and baobab fruit pulp meal on the egg quality characteristics of laying hens during cool-wet season

Parameters	Treatments Sources of Ascorbic Acid in diets			
	Control Diet	AA Diets Diets	BFPM Diets	SEM
Egg weight (g)	60.75[b]	62.42[a]	61.53[ab]	0.80
Shell weight (g)	8.23[c]	8.61[a]	8.48[b]	0.01
Shell thickness (mm)	0.48	0.48	0.48	0.01
Yolk index	0.47	0.47	0.47	0.01
Haugh Unit value	81.01[b]	82.54[a]	82.42[a]	8.85

a,b,c: Means with different superscript in the same row are significanty ($P<0.05$) different
SEM: Standard error of means
AA: Ascorbic Acid diets
BFPM: Baobab Fruit Pulp Meal Diet

4.3 Results For Experiment 2: Cool-wet season broiler starter feeding trial

The results for experiment 2 on broiler starter feeding trial during cool wet season are presented in the sections below.

4.3.1: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the growth performance of broiler starters (2 – 5 weeks) during cool-wet season

As shown in Table 4.11, dietary levels Ascorbic Acid and Baobab Fruit Pulp Meal in broiler starter diets had significant ($P<0.05$) effects on final weight, weight gain, feed intake, feed conversion ratio, feed cost/bird and on mortality rate. Birds on dietary AA levels of 300mg/kg had similar result and the best performances as those on 3.5% BFPM diets in terms of Final weight, Body weight gain, Feed conversion ratio, and feed cost per kg body weight. The performance of birds on the AA diets increased as the AA levels increased in the diets, performance on BFPM diet decreased as the level of BFPM increased. The 3.5% BFPM diets performed equally as the 300 mg AA diet for Final weight, weight gain, Feed cost per kg body weight and mortality rate. BFPM diets at 7.0% and 10.5% levels of inclusion performed very poorly in most of the parameters when compared with the control. (Table 4.11).

4.3.2 Effect of dietary levels of ascorbic acid on the growth performance of broiler starters (2 – 5 weeks) during cool-wet season

The effects of levels of Ascorbic Acid (AA) on the performance of broiler starters between the ages of 2 to 5 weeks are shown in Table 4.12. There were significant ($P<0.05$) improvements in broiler performance for final weight, weight gain, feed conversion ratio and feed cost/bird. The performances improved for these parameters as the dietary levels of AA increase. The best results were obtained with the 300mgAA diets.

Table 4.11: Effects of dietary levels of ascorbic acid levels or baobab fruit pulp meal on the growth performance of broiler starters (2 – 5 weeks) during cool – wet season

Indices	Control	Ascorbic Acid (mg/kg)			Baobab Fruit Pulp Meal (%)			SEM
	0.00	100.00	200.00	300.00	3.50	7.00	10.50	
Initial weight (g/bird)	146.67	146.67	146.67	146.67	146.67	146.67	146.67	0.00
Final weight (g/bird)	908.04^{b}	917.29^{b}	925.42^{b}	998.80^{a}	988.97^{a}	739.61^{c}	650.40^{d}	11,62
Weight gain (g/bird)	761.37^{b}	770.29^{b}	778.75^{b}	852.22^{a}	842.27^{a}	593.24^{c}	503.73^{d}	11.61
Feed intake (g/bird)	1796.61^{b}	1805.60^{b}	1818.37^{b}	1811.22^{b}	1896.34^{a}	1582.34^{c}	1468.91^{d}	33.55
Feed Conversion ratio	2.36^{bc}	2.34^{b}	2.33^{b}	2.13^{a}	2.25^{b}	2.67^{c}	2.92^{d}	0.11
Feed Cost /bird (₦)	105.85^{b}	105.30^{b}	102.20^{a}	100.84^{a}	103.43^{ab}	121.80^{c}	$133,85^{d}$	2.67
Mortality (%)	6.67^{b}	6.67^{bc}	4.45^{a}	2.22^{a}	2.22^{a}	2.22^{a}	8.89^{c}	1.51

a,b,c,d: Means with different superscripts on the same row are significantly different ($P<0.05$)
SEM: Standard Error of Means

Mortality rate also decreased as the dietary level of AA increased. Ascorbic Acid supplementation at 300AA/kg diet had the lowest feed conversion ratio and feed cost per kg weight gain. There were no significant effects on feed intake.

4.3.3: Effects of dietary levels of baobab fruit pulp meal on the growth performance of broiler starter (2 – 5 weeks) during cool-wet season.

The performance of broilers chicks fed graded dietary levels of Baobab Fruit Pulp Meal (BFPM) during the cool – wet season are as presented in Table 4.13. The results revealed significant ($P<0.05$) responses of broiler chicks (2 – 5 weeks) to dietary levels of BFPM in the diets. There were drastic significant ($P<0.05$) decreases in final weight, weight gain, and feed intake of broiler as the level of BFPM increased from 3.5% to 10.5%. Birds fed 3.5% BFPM resulted in better performance in all the parameters studied when compared with the control diets and those fed 7.0 and 10.5% BFPM diets. There were no definite pattern in the results for percent mortality.

4.3.4: Comparative effects of control, ascorbic acid supplemented and baobab fruit pulp meal on the growth performance of broiler starter (2 – 5 weeks)

Table 4.14 shows the comparison of the results for control, Ascorbic Acid (AA) and the Baobab Fruit Pulp Meal (BFPM) diets on the growth performance of broiler starters (2 - 5 weeks) during the cool – wet season. There were significant ($P<0.05$) improvements due to AA supplementations in the diets on the final weight, weight gain and Feed conversion ratio. Feed cost per kg gain improved numerically due to AA supplementation when compared with the control diet. The birds on BFPM diets had significantly lower performance ($P<0.05$) than the AA diets for all the parameters.

Table 4.12: Effects of dietary levels of ascorbic acid on the growth performance of broiler starters (2-5 weeks) during cool-wet season

Parameters	Treatment Ascorbic Acid Levels (mg/kg)				
	Control	100	200	300	SEM
Initial weight (g/bird)	146.67	146.67	1466.67	146.67	0.00
Final weight (g/bird)	908.04^{b}	917.29^{b}	925.42^{b}	998.80^{a}	18.15
Weight gain (g/bird)	761.37^{b}	770.29^{b}	778.75^{b}	852.22^{a}	17.44
Feed intake (g/bird)	1796.61	1805.60	1818.37	1811.22	26.16
Feed conversion ratio	2.36^{b}	2.34^{b}	2.33^{b}	2.13^{a}	0.06
Feed cost/ bird (₦)	105.85^{c}	105.30^{c}	102.20^{b}	100.84^{a}	1.97
Mortality (%)	6.67^{b}	6.76^{b}	4.45^{b}	2.22^{a}	0.40

a, b, c: Means with different superscripts in the same row are significantly ($P<0.05$) different.
SEM: Standard error of means

Table 4.13 Effects of dietary levels of baobab fruit pulp meal on the growth performance of broilers starters (2-5 weeks) during cool-wet season

Parameters	Treatment Baobab Fruit Pulp Levels (%)				
	Control	3.5	7.0	10.5	SEM
Initial weight (g/bird)	146.67	146.67	146.47	146.47	0.001
Final weight (g/bird)	908.04^{b}	988.97^{a}	739.61^{c}	650.40^{d}	14.51
Weight gain (g/bird)	761.37^{b}	842.27^{a}	593.24^{c}	503.73^{d}	14.44
Feed intake (g/bird)	1768.61^{b}	1896.34^{a}	1582.34^{c}	1468.91^{d}	26.16
Feed conversion ratio	2.35^{b}	2.25^{a}	2.67^{c}	2.92^{d}	0.06
Feed cost/bird (₦)	105.83^{a}	103.43^{a}	121.80^{b}	133.85^{c}	1.96
Mortality (%)	6.67^{b}	2.22^{a}	2.22^{a}	8.89^{b}	3.14

a,b,c,d: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard error of means

Table 4.14: Comparison of control, ascorbic acid supplemented and baobab fruit pulp meal diets on the growth performance of broiler starters (2 – 5 weeks) during cool – wet season

	Treatments Sources of Ascorbic Acid in diets			
Parameters	**Control Diets**	**AA Diets**	**BFPM Diets**	**SEM**
Initial weight (g/bird)	146.67	146.67	146.67	0.00
Final weight (g/bird)	908.04^{b}	947.17^{a}	783.76^{c}	15.88
Weight gain (g/bird)	761.37^{b}	800.50^{a}	646.35^{c}	13.81
Feed intake (g/bird)	1796.61^{a}	1812.40^{a}	1649.20^{b}	28.84
Feed conversion ratio	2.36^{b}	2.27^{a}	2.55^{c}	0.09
Feed cost/bird (₦)	106.83^{a}	103.11^{a}	119.69^{b}	5.19
Mortality (%)	6.67	4.45	5.19	2.85

a,b,c: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard error of means
AA: Ascorbic Acid diet
BFPM: Baobab Fruit Pulp Meal Diet

4.4 Results For Experiment 3: Cool-wet season broiler finishes feeding trial

The results on the effects of dietary Ascorbic Acid supplementation and Baobab Fruit Pulp Meal diets on the performance of broiler finishers during the cool-wet season are described below:

4.4.1: Effects of dietary levels of ascorbic acid supplementation and baobab fruit pulp meal diets on the growth performance and carcass characteristics of broiler finishers (6 – 9 weeks) during the cool-wet season

The effects of ascorbic acid and baobab fruit pulp meal on the performance and carcass characteristics of broiler finisher chickens are shown on Tables 4.15 and 4.16.

The results in Table 4.15 showed that dietary levels of ascorbic acid and baobab fruit pulp meal had significant ($P<0.05$) effects on Final weight, weight gain, Feed intake, Feed conversion ratio, Feed cost per kg gain, income above fed expenses and on the mortality rate. Dietary Ascorbic acid increased performance generally as the levels increased from 0 to 300mgAA/kg diet. BFPM levels on the other hand did not improve performance beyond 3.5% dietary inclusion level. Higher dietary levels of BFPM actually resulted in reduced performance when compared with the 3.5% BFPM and the control diets. Birds on 300mgAA/kg and 3.5% BFPM diets had similar and better performances compared to birds fed control diet.

The results for carcass characteristics are shown in Table 4.16. Significant ($P<0.05$) effects of diets were observed in the carcass characteristics in terms of carcass weight, dressing percentage and abdominal fat. There were no significant ($P>0.05$) effects of diets on percent giblets. Carcass weights and Dressing percentage increased as the dietary levels of AA increased. Diet containing 300mgAA/kg gave the best results for carcass weight and

Dressing percentage among the AA supplemented diets. For the BFPM diets, carcass weight and dressing percentage were significantly improved by the 3.5% diets. Beyond the 3.5% dietary inclusion, the performance decreased. The 300mg AA/kg diet and the 3.5% BFPM diet gave similar results for dressing percentage and abdominal fat percent. Abdominal fat percent was reduced by the 200 and 300AA/kg diet and by the BFPM diet when compared with the control diet.

4.4.2 Effects of dietary levels of ascorbic acid on the growth performance and carcass characteristics of broiler finishers (6 – 9 weeks) during cool-wet season

Effects of dietary levels of Ascorbic Acid on the growth performance and carcass characteristics of broiler finishers during the cool wet season were as presented in Tables 4.17 and 4.18 respectively. It was observed that broilers fed ascorbic acid (AA) diets had significantly better performance ($P<0.05$) than the birds on the control diets in terms of final weight, weight gain, feed conversion ratio and feed cost per kg body gain. There were significant ($P<0.05$) effects on feed intake. Feed intake increased with increase in the dietary levels of AA. The best performances for broiler finishers were obtained with the 200 and 300mgAA per kg diet. The result in Table 4.18 also revealed improvements in carcass weights and dressing percentage as the dietary level AA increased but no significant ($P>0.05$) effects of diets were noticed for percent giblet and abdominal fat deposits. Abdominal fats however showed a gradual decrease with the AA diets at 200 and 300 mg AA/kg. The best results for carcass characteristics were obtained with the 300mgAA per kg diet.

Table 4.15: Effects of dietary levels of ascorbic acid or baobab fruit pulp on the growth performance of broiler finishers (6 – 9 weeks) during cool – wet season

Parameters	Control	Ascorbic Acid (mg/kg)			Baobab Fruit Pulp Meal (%)			SEM
	0.00	100.00	200.00	300.00	3.5	7.0	10.50	
Initial weight (g/bird)	1041.67	1041.67	1041.67	1041.67	1041.67	1041.67	1041.67	0.66
Final weight (g/bird)	2025.23^{b}	2028.99^{b}	2348.26^{a}	2344.45^{a}	2348.70^{a}	2023.79^{b}	1934.58^{c}	15.30
Weight gain (g/bird)	984.56^{b}	987.32^{b}	1306.59^{a}	1303.59^{a}	1301.23^{a}	981.20^{b}	886.45^{c}	16.39
Feed intake (g/bird)	2527.02^{c}	2541.07^{c}	2569.61^{b}	2659.62^{b}	2669.68^{a}	2316.16^{d}	2171.80	21.08
Feed Conversion ratio	2.57^{c}	2.55^{c}	2.04^{a}	2.06^{a}	2.01^{a}	2.36^{b}	2.45^{bc}	0.11
Feed cost/kg (₦)	52.8^{a}	53.45^{ab}	54.10^{b}	54.75^{b}	53.39^{ab}	56.63^{c}	58.05^{d}	0.51
Feed cost/bird (₦)	133.43^{b}	135.82^{b}	139.02^{bc}	145.64^{c}	142.55^{c}	131.16^{a}	126.00^{a}	3.11
Feed cost/kg gain (₦)	135.7^{b}	136.3^{b}	110.36^{a}	112.79^{a}	107.31^{a}	133.65^{c}	142.22^{d}	3.23
IAFE (₦)	264.30^{b}	263.70^{b}	289.64^{a}	287.21^{a}	292.69^{a}	266.35^{b}	257.28^{c}	7.01
Mortality	8.33^{b}	5.55^{a}	2.78^{a}	2.78^{a}	2.78^{a}	2.78^{a}	5.55^{a}	2.19

A, b, c, d, e: Means with different superscripts on the same row are significantly different ($P<0.05$)
SEM: Standard error of means
IAFE: Income above feed expenses at ₦400 per kg live weight

Table 4.16: Effects of dietary levels of ascorbic acid or baobab fruit pulp on the carcass characteristics of broiler finishers at 9 weeks of age during cool – wet season

	Control	Ascorbic Acid (mg/kg)			Baobab Fruit Pulp Meal (%)			
Parameters	**0.00**	**100.00**	**200.00**	**300.00**	**3.5**	**7.0**	**10.50**	
Live weight (g)	2020.31^{c}	2030.40^{c}	2300.00^{b}	2340.10^{a}	2340.00^{a}	2025.0^{c}	1930.00^{d}	19.13
Carcass weight (g)	1521.19^{d}	1546.96^{d}	1758.35^{c}	1812.87^{b}	1845.32^{a}	1535.56^{d}	1399.25^{e}	18.53
Dressing (%)	75.33^{b}	76.19^{b}	76.45^{b}	77.47^{a}	78.86^{a}	75.83^{b}	72.50^{c}	1.45
*Giblet (%)	6.65	6.67	6.68	6.67	7.82	6.85	6.75	0.85
Abdominal fat (%)	3.42^{b}	3.57^{b}	2.79^{a}	2.76^{a}	2.83^{a}	2.61^{a}	2.48^{a}	0.18

a,b,c,d: Means with different superscripts on the same row are significantly different (P<0.05)
SEM: Standard Error of Means
*Giblet: Consists of Gizzard, Liver, Kidney, Lung, Heart, Spleen

Table 4.17: Effects of dietary level of ascorbic acid on the growth performance of broiler finishers (6 – 9weeks) during cool – wet season

Parameters	Treatments Ascorbic Acid Level (mg/kg)				
	Control	**100**	**200**	**300**	**SEM**
Initial weight (g/bird)	1041.67	1041.67	1041.67	1041.67	0.00
Final weight (g/bird)	2025.23^{b}	2028.99^{b}	2348.26^{a}	2344.44^{a}	165.22
Weight gain (g/bird)	984.56^{b}	987.32^{b}	1303.59^{a}	1302.78^{a}	44.38
Feed intake (g/bird)	2527.02^{b}	2541.07^{b}	2652.21^{a}	2659.62^{a}	68.11
Feed conversion ratio	2.57^{b}	2.55^{b}	2.04^{a}	2.06^{a}	0.10
Feed cost/kg (₦)	52.8^{a}	53.45^{a}	54.10^{ab}	54.75^{b}	0.82
Feed cost/bird (₦)	133.43^{a}	135.82^{a}	139.02^{ab}	145.64^{b}	1.53
Feed cost/kg gain (₦)	135.70^{b}	136.30^{b}	110.36^{a}	112.79^{a}	0.61
IAFE (₦)	264.30^{b}	263.70^{b}	289.64^{a}	287.21^{a}	2.11
Mortality (%)	8.33^{c}	5.55^{b}	2.78^{a}	2.78^{a}	1.72

a,b,c: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard Error of Means
IAFE: Income above feed expenses at ₦400 per kg body weight

Table 4.18: Effects of dietary levels of ascorbic acid on carcass characteristics of broiler finishers at 9 weeks during cool – wet season

Parameters	Treatments Ascorbic Acid Level (mg/kg)				
	Control	100	200	300	SEM
Live weight (g)	2020.31[b]	2030.4[b]	2300.00[a]	2340.1[a]	125.21
Carcass weight (g)	1521.91[b]	1546.96[b]	1758.35[a]	1812.87[a]	87.13
Dressing (%)	75.33[b]	76.19[ab]	76.45[a]	77.47[a]	1.12
Giblet (%)	6.65	6.27	6.88	6.67	0.72
Abdominal fat (%)	3.42	3.57	2.79	2.76	0.93

a,b: Means with different superscripts on the same row are significantly different ($P<0.05$)
SEM: Standard error of means
Giblet: Consists of Gizzard, Liver, Kidney, Lung, Heart, Spleen

4.4.3 Effects of dietary levels of baobab fruit pulp meal on the growth performance and carcass characteristics of broiler finisher (6 – 9 weeks) during cool-wet season

The effects of graded level of Baobab Fruit Pulp Meal (BFPM) as sources of Ascorbic Acid on the growth performance of broiler finishers (6 – 9 weeks) during the cool – wet season are as presented in Tables 4.19 and 4.20.

The results (Table 4.19) followed the same pattern that was noticed during the starter phase. Significant ($P<0.05$) effects of dietary levels of BFPM on the growth performance were observed. Birds fed 3.5% BFPM had the best performance in all the parameters studied. Birds on 7.0% BFPM compared with control in final weight, weight gain and feed intake, Feed intake decreased while feed cost/bird increased significantly ($P<0.05$) at the 10.5% level of BFPM inclusion in the diet.

Table 4.20 shows significant ($P<0.05$) improvement for carcass weight and dressing percentage, for the BFPM diets at 3.5% dietary levels of inclusion. Higher levels of BFPM inclusion in the diets tended to decrease carcass weight and dressing percentage.

Table 4.19: Effects of dietary levels of baobab fruit pulp meal on the growth performance of broiler finishers (6 – 9 weeks) during cool – wet season

Parameters	Treatments Baobab Fruit Pulp Meal Level (%)				
	Control	**3.5**	**7.0**	**10.5**	**SEM**
Initial weight (g/bird)	1041.67	1041.67	1041.67	1041.67	0.08
Final weight (g/bird)	2025.23^{b}	2348.70^{a}	2023.79^{b}	1934.58^{c}	165.22
Weight gain (g/bird)	981.66^{b}	1315.23^{a}	981.20^{b}	886.45^{c}	13.36
Feed intake (g/bird)	2427.3^{b}	2669.68^{a}	2316.16^{b}	2171.80^{c}	165.21
Feed conversion ratio	2.47^{c}	2.01^{a}	2.36^{b}	2.45^{c}	0.03
Feed cost/gain kg (₦)	52.80^{a}	53.39^{a}	56.63^{b}	58.05^{b}	0.73
Feed cost/bird (₦)	133.43^{c}	142.55^{b}	131.16^{b}	126.00^{a}	0.55
Feed cost/kg gain (₦)	135.7^{b}	170.31^{a}	133.65^{b}	142.22^{c}	2.56
IAFE(₦)	264.30^{b}	292.69^{a}	266.35^{b}	267.28^{c}	2.56
Mortality (%)	8.33^{c}	2.68^{a}	2.68^{a}	5.55^{b}	2.72

a,b,c,d: Means with different superscripts in the same row are significantly (P<0.05) different
SEM: Standard error of means
IAFE: Income above feed expenses at ₦400 per kg body weight

Table 4.20: Effects of dietary levels of baobab fruit pulp meal on the carcass characteristics of broiler finishers (6-9 weeks) during cool-wet season

Parameters	Treatments Baobab Fruit Pulp Meal Level (%)				
	Control	**3.5**	**7.0**	**10.5**	**SEM**
Live weight (g)	2020.31[b]	2340.00[a]	2025.0[b]	1930.00[c]	45.21
Carcass weight (g)	1521.91[b]	1845.32[a]	1535.56[b]	1399.25[c]	61.73
Dressing %	75.33[b]	78.86[a]	75.83[b]	72.50[c]	1.60
Giblet (%)	6.58	7.92	7.14	7.17	0.71
Abdominal fat (%)	3.42[c]	2.83[b]	2.48[a]	2.01[a]	0.47

a,b,c: Means with different superscripts in the same row are significantly different ($P<0.05$)
SEM: Standard error of means
Giblet: Consists of Gizzard, Liver, Kidney, Lung, Heart, Spleen

4.4.4 Comparison of control, ascorbic acid supplemented and baobab fruit pulp meal diets on the growth performance and carcass characteristics of broiler finishers (6 – 9 weeks) during cool-wet season.

The comparative effects of the control, ascorbic acid (AA) supplemented and Baobab Fruit Pulp Meal diets on the growth performance and carcass characteristics of broiler finishers are shown in Tables 4.21 and 4.22 respectively. There were significant ($P<0.05$) differences between birds fed AA supplemented, the BFPM and the control diets. It was observed that birds fed AA diets had significantly better performances with regards to final weight, weight gain, fed conversion ratio and lower percent mortality compared to those on BFPM and control diets. The AA supplemented diets resulted in the lowest feed cost per kg gain ($P<0.05$).

The carcass analysis presented in Table 4.22 also revealed significant ($P<0.05$) effects of AA diets on final weight, carcass weight and on dressing percentage. The AA supplemented diets gave significantly ($P<0.05$) higher values than the BFPM and the control diets.

Table 4.21: Comparative effects of control, ascorbic acid and baobab fruit pulp meal on the growth performance of broiler finishers (6 – 9 weeks) during the cool – wet season

Parameters	Treatments Sources of Ascorbic Acid in diets			
	Control Diet	AA Diet	BFPM Diet	SEM
Initial weight (g/bird)	1041.67	1041.67	1041.67	0.06
Final weight (g/bird)	2024.1^{b}	2240.56^{a}	2102.36^{ab}	156.25
Weight gain (g/bird)	985.56^{c}	1198.89^{a}	1060.53^{b}	61.20
Feed intake (g/bird)	2426.19^{a}	2517.63^{a}	2386.88^{b}	87.61
Feed conversion ratio	2.46^{c}	2.16^{a}	2.35^{b}	0.06
Feed cost/bird (₦)	52.8^{a}	54.10^{ab}	56.02^{b}	1.5
Feed cost/bird (₦)	133.43^{b}	140.16^{a}	133.24^{b}	1.43
Feed cost/kg gain (₦)	135.70^{c}	119.8^{a}	127.37^{b}	1.51
IAFE (₦)	264.30^{b}	280.18^{a}	272.11^{a}	4.56
Mortality (%)	8.33^{b}	3.10^{a}	5.34^{ab}	2.82

a,b,c: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard error of means
AA: Ascorbic Acid diet
BFPM: Baobab Pulp Meal Diet
IAFE: Income above feed expenses ₦400 per Kg

Table 4.22: Comparison of control, ascorbic acid and baobab fruit pulp meal on carcass characteristics of broiler finishers (6 -9 weeks) during cool – wet season

Parameters	Treatments Sources of Ascorbic Acid in diets			
	Control Diet	AA Diet	BFPM Diet	SEM
Live weight (g)	2020.31[b]	2223.5[a]	2098.33[b]	113.21
Carcass weight (g)	1521.91[b]	1706.06[a]	1593.38[b]	85.13
Dressing (%)	75.17[b]	76.71[a]	75.73[a]	0.41
Giblet (%)	6.62	6.61	7.51	0.21
Abdominal fat (%)	3.42[b]	2.81[a]	2.44[b]	0.06

a,b: Means with different superscripts in the same row are significantly different ($P<0.05$)
SEM: Standard error of means
AA: Ascorbic Acid diet
BFPM: Baobab Fruit Pulp Meal Diet
Giblet: Consists of Gizzard, Liver, Kidney, Lung, Heart, Spleen

4.5 Results for Experiment 4: Hot-Dry season Layer Feeding Trial

The results of the layers feeding trial during the hot– dry season are presented in the section below:

4.5.1: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the performance, egg quality characteristics, haematological status and rectal temperature of laying hens (30 – 42 weeks) during hot-dry season.

The effects of dietary levels of Ascorbic Acid (AA) and Baobab Fruit Pulp Meal (BFPM) as sources of ascorbic acid on the performance of laying hens, egg quality characteristics, rectal temperature (RT) and on blood chemistry status during the Hot – Dry Season were as shown in Tables 4.23, 4.24, 4.25 and 4.26 respectively.

Dietary AA and BFPM levels had significant ($P<0.05$) effects on final weight (g/bird), body weight change (g/bird), feed intake (g/bird), Hen – day egg production (%), feed cost/dozen egg (₦), kg feed/dozen egg and on percent mortality (Table 4.23). Treatment 4 (300mgAA/kg) gave the best performance for final weight, body weight change and feed intake. Treatment 4 also gave comparable result as obtained for 3.5% BFPM and 200mgAA/kg diets for final weight, body weight change and feed intake. Treatment T_5 with 3.5% BFPM gave the highest hen – day egg production and had the least feed cost/dozen eggs.

It was observed in (Table 4.24) that Ascorbic acid and Baobab fruit pulp meal diets had significant ($P<0.05$) effects on egg weight, shell weight and on Haugh unit score but had no significant effects ($P>0.05$) on the yolk index and on shell thickness. For the egg and shell weights, AA dietary levels at 200, 300mg/kg diets and the Baobab Fruit Pulp Meal at 3.5% level in the diet gave the best values. The highest Haugh Unit value

was observed for the Baobab diet at 3.5% level of inclusion which was also comparable with the ascorbic acid levels of 100.00, 200.00 and 300.00mg/kg diet.

Regarding the effect of ascorbic acid supplementations and Baobab fruit pulp diets on the rectal temperatures (RT) of laying hens during the hot– dry season., significant dietary effects ($P<0.05$) were observed in the rectal temperatures of laying hens at 12:00HR and 15:00HR but there was no significant effect ($P>0.05$) at 9:00HR. Birds on AA diets level of 300mg/kg had the lowest rectal temperature at 12:HR while at 15:HR, birds on BFPM at 3.5% had the lowest rectal temperature (Table 4.25).

Table 4.23: Effects of dietary levels of ascorbic acid supplemented or baobab fruit pulp meal on the performance of laying hens during hot – dry season

Parameters	ASCORBIC ACID (mg/kg)				BAOBAB FRUIT PULP (%)		
	Control	100	200	300	3.5	7.0	SEM
Initial weight (g/bird	1676.67	1676.33	1676.33	1676.33	1676.33	1676.33	1.00
Final weight (g/bird)	1840.00^{b}	1869.67^{c}	1900.00^{a}	1922.67^{a}	1990.00^{a}	1856,33^{c}	10.21
Body weight Change (g/bird)	163.67^{c}	193.33^{b}	223.67^{a}	246.69^{a}	223.4^{a}	180.00^{b}	15.81
Feed intake (g/bird/day)	117.93^{e}	118.84^{c}	120.28^{b}	121.74^{a}	120.82^{ab}	117.93^{c}	0.78
Hen – day- egg- Prod. (%)	61.84^{c}	67.09^{d}	74.58^{bc}	75.69^{ab}	76.29^{a}	72.59^{c}	0.72
Feed cost/kg (₦)	41.8^{a}	43.30^{a}	44.8^{ab}	46.3^{bc}	44.99^{c}	50.68^{c}	0.88
Feed Cost/dozen Egg (₦)	92.80^{b}	91.80^{b}	86.91^{a}	86.91^{a}	85.48^{a}	99.33^{c}	1.32
IAFE(₦)	82.20^{b}	88.20^{b}	93.09^{a}	93.09^{a}	94.52^{a}	80.67^{c}	0.51
Kg Feed/dozen egg	2.22^{c}	2.12^{c}	1.94^{ab}	1.91^{a}	1.90^{a}	1.96^{bc}	0.31
Mortality (%)	4.45^{b}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.91

a, b, c, d, e: Means with different superscripts in the same row are significantly different (P<0.05)
SEM: Standard Error of Means
IAFE: Income above feed expenses at ₦15 per egg

Table 4.24: Effects of dietary levels of ascorbic acid or baobab fruit pulp meal on the egg quality characteristics of laying hens (30 – 52 weeks) during hot – dry season

Parameter	TREATMENT						
	Control	Ascorbic Acid (mg/kg)			Baobab Fruit Pulp Meal (%)		
	0.00	100.00	200.00	300.00	3.5%	7.0%	SEM
Egg weight (g)	53.42^{c}	56.27^{b}	59.65^{a}	59.76^{a}	59.15^{a}	57.06^{b}	0.82
Shell weight (g)	7,93^{c}	8,20^{bc}	8.33^{b}	8.65^{a}	8.72^{a}	8.34^{ab}	0.14
Shell thickness (mm)	0.47	0.47	0.48	0.48	0.48	0.47	0.005
Yolk index	0.47	0.47	0.47	0.47	0.47	0.47	0.009
Haugh Unit Value	80.13^{b}	81.64^{ab}	81.61^{ab}	82.27^{a}	82.87^{a}	80.93^{b}	0.66

a, b, c, d, e: Means with different superscripts in the same row are significantly different ($P<0.05$)
SEM: Standard Means of Error

There were significant (P<0.05) effects of ascorbic acid and baobab fruit pulp meal levels on the blood parameters, (packed cell volume (PCV), hemoglobin (Hb) and total blood protein (TP) of layers during the hot – dry season. The highest PCV percent was found in birds fed BFPM at 3.5% of the diet. Birds on AA diets level of 300mg/kg and on Baobab fruit pulp diet at 3.5% of the diet had similar Haemoglobin concentration and Total blood protein (Table 4.26).

4.5.2: Effects of dietary levels of ascorbic acid on the performance egg quality characteristics, heamatological status and rectal temperature (^{o}C) of laying hens (30–42 weeks) during hot-dry season.

The effects of dietary levels of ascorbic acid supplementation on the performance, egg quality characteristics, rectal temperatures and blood chemistry of Laying hens during the hot – dry season were as shown in Tables 4.27, 4.28, 4.29 and 4.30.

Dietary ascorbic acid had significant (P<0.05) effects on final weight (kg/bird), body weight change (g/bird), feed intake (g/bird/day), % Hen – day egg production, kg feed/dozen egg, feed cost/dozen eggs (₦), and percent mortality. Diet containing 300mg AA/kg gave the best performance for all the parameters studied (Table 4.27). It was also observed that increasing dietary level of ascorbic acid from 0 to 300mg/kg in the feed for the laying birds correspondently increased the performance of these birds. There was no mortality recorded for all treatments with ascorbic acid supplementation except for the control diets.

Table 4.25: Effects of dietary levels of ascorbic acid or baobab fruit pulp meal on rectal temperatures (^{o}C) of laying hens during hot – dry season

	Control	Ascorbic Acid (mg/kg)			Baobab Fruit Pulp Meal (%)		
Time	**0.00**	**100.00**	**200.00**	**300.00**	**3.5**	**7.0**	**SEM**
9:00hr	40.10	40.05	40.06	40.10	40.09	40.05	0.05
12:00HR	41.83^{d}	41.80^{bc}	41.62^{ab}	41.59^{a}	41.63^{ab}	41.73^{c}	0.06
15:00HR	42.08^{c}	42.04^{c}	41.87^{b}	41.76^{a}	41.70^{a}	41.81^{ab}	0.06

a,b,c,d: Means with different superscripts in the same row are significantly different (P<0.05)
SEM: Standard Error of Means

Table 4.26: Effects of dietary levels of ascorbic acid or baobab fruit pulp meal on the haematological status of laying hens during hot – dry season

	TREATMENTS						
	Control	Ascorbic Acid (mg/kg)			Baobab Fruit Pulp Meal (%)		
Parameters	**0.00**	**100.00**	**200.00**	**300.00**	**3.5%**	**7.0%**	**SEM**
Packed Cell Volume (%)	28.33^{b}	$28,67^{b}$	30.0^{ab}	31.00^{a}	32.33^{a}	25.33^{c}	1.29
Haemoglobin Content (%)	9.63^{c}	9.90^{bc}	10.23^{b}	12.30^{a}	12.10^{a}	8.33^{d}	0.250
Total Blood Protein (g/dl)	6.60^{c}	6.67^{bc}	7.27^{b}	8.83^{a}	8.13^{a}	6.30^{c}	0.47

a,b,c,d: Means with different superscripts on the same row are significantly different ($P<0.05$)
SEM: Means Standard Error

It was also observed that dietary level of ascorbic acid had significant ($P<0.05$) effects on egg weight, shell weight, and on Haugh unit value but had no significant ($P>0.05$) effect on shell thickness and on the yolk index. For egg weight, it was noticed that (200mg AA/kg diet and 300mg/AA/kg diet gave the highest and similar values (Table 4.28).

Table 4.29 shows the effect of Ascorbic acid on the haematological status of laying hens during hot dry season. Significant ($P<0.05$) effects of Ascorbic Acid supplemented diets were observed on packed cell volume (PCV), hemoglobin content (Hb) and on total protein (TP). The highest percent PCV was attained at the 300mgAA/kg diet. The control, 100mg/AA/kg and 200mg AA/kg dietary treatments had similar results for haemoglobin and total blood protein. It was also observed that as the dietary level of ascorbic acid increased, the PCV, Hb and TP also increased.

Effects of ascorbic acid supplementation on the rectal temperature of laying hens during hot – dry season are as presented in Table 4.30. There were significant effects ($P<0.05$) of diets on rectal temperatures of the birds at 12:00hours and 15:00 hours. At 12:00hr and 15:00hr, the rectal temperature decreased as the level of ascorbic acid increased from 0 to 300mg AA/kg.

Table 4.27: Effects of dietary levels of ascorbic acid on the performance of laying hens during hot-dry season

Parameters	Treatments Ascorbic Acid level (mg/kg)				SEM
	0	100	200	300	
Initial Weight (g/bird)	1676.67	1676.33	1676.33	1676.33	0.41
Final weight (g/bird)	1840.00^{b}	1869.67^{a}	1900.00^{a}	1922.67^{a}	51.20
Body weight change (g/bird)	163.67^{b}	193.33^{b}	223.67^{a}	246.69^{a}	30.87
Feed intake (g/bird/day)	117.93^{b}	118.84^{b}	120.28^{ab}	121.74^{a}	0.81
Hen-Day-Egg Production (%)	61.84^{c}	67.09^{b}	74.58^{a}	75.69^{a}	0.93
Feed cost/kg (₦)	41.80	43.30	44.80	46.30	2.11
Kg Feed/dozen egg	2.22^{b}	2.12^{b}	1.94^{a}	1.91^{a}	0.04
IAFE (₦)	87.20^{b}	88.20^{b}	93.09^{a}	93.09^{a}	1.51
Feed cost/dozen eggs (₦)	92.80^{b}	91.80^{b}	86.91^{a}	86.19^{a}	1.80
Mortality	4.45^{a}	0.00^{b}	0.00^{b}	0.00^{b}	1.11

a,b,c: Means with different superscripts in the same row are significantly ($P<0.05$) different.
SEM: Standard Error of Means
IAFE: Income above feed expenses at ₦15 per egg

Table 4.28: Effects of dietary levels of ascorbic acid on the egg quality characteristics of laying hens during hot-dry season

	Treatments				
	Ascorbic Acid Level (mg/kg)				
Parameters	**0**	**100**	**200**	**300**	**SEM**
Egg weight (g)	53.42[b]	56.27[b]	59.65[a]	59.76[a]	0.95
Shell weight (g)	7.93[c]	8.20[b]	8.33[b]	8.65[a]	0.15
Shell thickness (mm)	0.47	0.47	0.48	0.48	0.01
Yolk index	0.47	0.47	0.47	0.47	0.01
Haugh Unit Value	80.13	81.64[a]	81.61[a]	82.27[a]	0.68

a, b, c: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard Error of Means

Table 4.29: Effects of dietary levels of ascorbic acid on the haematological status of laying hens during hot-dry season

Parameters	Treatments Ascorbic Acid Level (mg/kg)				
	0	**100**	**200**	**300**	**SEM**
Packed Cell Volume (%)	28.33^{b}	28.67^{b}	30.00^{a}	31.00^{a}	1.31
Haemaglobin Content (%)	9.63^{b}	9.90^{b}	10.23^{b}	12.30^{a}	0.19
Total blood protein (g/dl)	6.60^{b}	6.67^{b}	7.27^{ab}	8.83^{a}	0.52

a, b: Means with different superscript in the same row are significantly ($P<0.05$) different
SEM: Standard Error of Means

Table 4.30: Effects of dietary levels of ascorbic acid on the rectal temperature (^{o}C) of laying hens during hot-dry season

	Treatments Ascorbic Acid Level (mg/kg)				
Time	**0**	**100**	**200**	**300**	**SEM**
9:00Hr	40.10	40.05	40.06	40.10	0.09
12:00Hr	41.83^{b}	41.80^{ab}	41.62^{ab}	41.57^{b}	0.07
15:00Hr	42.08^{c}	42.03^{c}	41.87^{b}	41.73^{a}	0.10

a,b,c: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard Error Means

4.5.3 Effects of dietary levels of baobab fruit pulp meal on the performance, egg quality characteristics, haematological status and rectal temperatures of laying hens (30 – 42 weeks) during hot-dry season

The effects of Baobab Fruit Pulp Meal (BFPM) as a source of natural ascorbic acid on the performance of laying hens during hot – dry season were as presented in Tables 4.31, 4.32, 4.33 and 4.34.

Significant (P<0.05) effects of diets were observed on final weight (g/bird), body weight change (g/bird), feed intake (g/bird/day), % Hen – Day egg production, Kg feed per dozen eggs, feed cost per dozen egg, (₦), and on percent mortality (Table 4.31). Birds fed 3.5% BFPM diet gave the best performance in terms of final weight, body weigh change, % Hen day egg production, kg feed per dozen eggs and feed cost per dozen eggs. The birds on control diet and those on 7.0% BFPM diets exhibited similar but lower performances for those parameters listed. BFPM diets also performed significantly better than the control diet in term of mortality rate.

It was also observed in Table 4.32 that BFPM diets had significant (P<0.05) effects on Egg weight, Shell weight and on Haugh unit score but had no significant (P>0.05) effects on Shell thickness and Yolk index, A decrease in egg weight, shell weight and Haught Unit were noticed as dietary levels of BFPM increased. There were significant P<0.05) effects of diets on the PCV, Hb and TP of laying hens fed BFPM diets (Table 4.33). The table also shows that laying hens fed 3.5% BFPM diets gave the highest values. The control and 7.0% BFPM diets had similar but lower PVC, Hb and TP values than 3.5% BFPM diet.

Table 4.34 shows the effects of BFPM diets on the rectal temperatures of laying hen during hot-dry season. Significant (P<0.05) effects of diets on rectal temperatures were observed at 12.0 and 15:00hrs. Birds fed 3.5% and 7.0% BFPM diets gave lower values for rectal temperatures than the control diets. The 3.5% BFPM diets resulted in the lowest rectal temperature at both 12.00 and 15.00hrs.

Table 4.31: Effects of dietary levels of baobab fruit pulp meal as a source of ascorbic acid on the performance of laying hens during hot – dry season

Parameters	Treatments Baobab Fruit Pulp Meal Level (%)			
	0	3-5	7.0	SEM
Initial weight(g/bird)	1676.67	1676.33[a]	1676.33	0.37
Final weight (g/bird)	1840.00[b]	1990.00[a]	1856.33[b]	24.50
Body weight change (g/bird)	163.33[c]	223.4[a]	180.00[b]	14.27
Feed intake (g/bird/day)	117.90[b]	120.82[a]	117.93[b]	0.93
Hen-Day Egg production (%)	61.84[c]	76.29[a]	72.59[b]	0.53
Feed cost/kg (₦)	41.8[a]	44.99[ab]	50.68[c]	1.52
Kg Feed/dozen egg	2.22[c]	1.90[a]	1.96[b]	0.04
IAFE (₦)	87.20[b]	94.52	80.67[c]	1.22
Feed cost/dozen egg (₦)	92.80[b]	85.48[a]	99.33[c]	1.82
Mortality	4.45[a]	0.00[b]	0.00[b]	1.28

a,b,c: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard Error of Means
IAFE: Income above feed expenses at ₦15 per egg

Table 4.32: Effects of dietary levels of baobab fruit pulp meal as a source of ascorbic acid on the egg quality characteristics of laying hens during hot – dry season

	Treatments Baobab Fruit Pulp Meal Levels (%)			
Parameters	**0**	**3.5**	**7.0**	**SEM**
Egg weight (g)	53.32[b]	59.15[a]	57.06[a]	1.27
Shell weight (g)	7.93[c]	8.72[a]	8.34[b]	0.10
Shell thickness	0.47	0.48	0.47	0.03
Yolk index	0.47	0.47	0.47	0.01
Haugh unit value	80.13[b]	82.87[a]	80.93[b]	0.63

a,b,c: Means with different superscripts in the same row are significantly ($P<0.05$) different.
SEM: Standard Error of Means

Table 4.33: Effects of dietary levels of baobab fruit pulp meal as a source of ascorbic acid on the haematological status of laying hens during hot-dry season

	Treatments			
	Baobab Fruit Pulp Meal Levels			
Parameters	**0**	**3.5**	**7.0**	**SEM**
Packed cell volume (%)	28.33[b]	32.33[a]	25.33[c]	1.73
Haemoglobin content (%)	9.60[b]	12.10[a]	8.83[c]	0.27
Total blood protein (g/dl)	5.50[b]	8.13[a]	6.30[b]	0.36

A,b,c: Means with difference superscripts in the same row are significantly ($P<0.05$) different

SEM: Standard Error of Means

Table 4.34: Effects of dietary levels of baobab fruit pulp meal as a source of ascorbic acid on the rectal temperature (^{o}C) of laying hens during hot-dry season

	Treatment Baobab Fruit Pulp Meal Level (%)			
Time	**0**	**3.5**	**7.0**	**SEM**
9:00Hr	40.10	40.09	40.05	0.13
12:00Hr	41.83[a]	41.63[c]	41.73[b]	0.05
15:00Hr	42.08[a]	41.70[c]	41.88[b]	0.08

a,b,c: Means with different superscripts in the same row are significantly (P<0.05) different

SEM: Standard Error of Means

4.5.4: Comparative effects of the control, ascorbic acid supplemented and baobab fruit pulp meal diets on the performance, egg quality characteristic haematological status and rectal temperature of laying hens (30–42 weeks) during the hot-dry season

The comparison of the effects of control diets, Ascorbic Acid and Baobab fruit pulp meals (BFPM) supplementations as sources of Ascorbic acid (AA) in layer diets were as shown in Tables 4.35, 4.36 4.37, and 4.38.

The results presented in Table 4.35 showed that Ascorbic acid supplementation gave comparable results as the BFPM diets for final body weight, body weight change, feed intake, hen–day egg production, feed cost/dozen eggs, and for percent mortality. Ascorbic acid supplementation gave significantly better result than the control diet for final weight and body weight change. Both the ascorbic acid supplementation and the BFPM diets gave better results for feed intake, kg feed/dozen-egg, feed cost/dozen egg, percent hen–day egg production and percent mortality than the control diet.

Table 4.36 shows the effects of (both Ascorbic acid and BFPM) diets on egg quality characteristics. Egg weight, shell weight and Haugh unit score were significantly higher for both the AA supplemented and the BFPM diets compared to the values obtained for the control diet. Both ascorbic acid diet and the BFPM diet had no significant effects on shell thickness and Yolk index.

Table 4.37 revealed that both Ascorbic acid and Baobab fruit pulp meal diets gave higher values for Haemoglobin content and for Total proteins compared to the control diet. Dietary treatments had no significant effect on Packed Cell Volume.

Table 4.38 indicated that both the Ascorbic acid supplemented diets and the BFPM diets resulted in lower rectal temperatures at 12:00 and 15:00hrs than the control diet. Dietary treatments had no significant ($P>0.05$) effect on rectal temperature at 9:00hrs.

Table 4.35: Comparison of performance of laying hens (30–42 weeks) fed control, ascorbic acid and baobab fruit pulp meal during hot–dry season

Parameters	Treatments Sources of Ascorbic Acid in diet			
	Control Diet	AA Diet	BFPM Diet	SEM
Initial weight (g/bird)	1676.76	1676.67	1676.50	0.97
Final weight (g/bird)	1840.00^{b}	1897.45^{a}	1867.65^{ab}	15.21
Body weight change (g/bird)	163.33^{b}	220.78^{a}	191.17^{ab}	24.12
Feed Intake (g/bird/day)	117.90^{b}	120.90^{a}	119.38^{ab}	1.02
Hen-Day-Egg Production (%)	61.84^{b}	72.45^{a}	74.79^{a}	1.86
Feed cost/kg (₦)	41.80	44.80	45.84	2.11
Kg feed/dozen egg	2.22^{b}	1.99^{a}	1.93^{a}	0.05
Feed cost/dozen egg (₦)	92.80^{b}	89.15^{a}	92.41^{b}	0.27
IAFE (₦)	87.29^{b}	91.46^{a}	87.60^{b}	1.6
Mortality	4.45^{b}	0.00^{a}	0.00^{a}	1.05

a,b: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard Error of Means
AA: Ascorbic Acid diet
BFPM: Baobab Fruit Pulp Meal Diet
IAFE: Income above feed expenses at ₦15 per egg

Table 4.36: Comparison of effects of control diet, ascorbic acid or baobab fruit pulp meal supplemented diets on the egg quality characteristics of laying hens during hot-dry season

Parameters	Treatments Sources of Ascorbic Acid in diets			
	Control Diet	AA Diet	BFPM Diet	SEM
Egg weight (g)	53.37[b]	58.56[a]	59.10[a]	1.170
Shell weight (g)	7.93[b]	8.39[a]	8.58[a]	0.160
Shell thickness	0.470	0.477	0.475	0.019
Yolk index	0.47	0.47	0.47	0.015
Haugh unit value	80.13[b]	81.84[a]	81.50[a]	0.7

a,b: Means with different superscripts in the same row are significantly (P<0.50) different
SEM: Standard Error of Means
AA: Ascorbic Acid diet
BFPM: Baobab Fruit Pulp Meal Diet

Table 4.37: Haematological status of laying hens fed control, ascorbic acid and baobab fruit pulp meal diets during hot-dry season

Parameters	Treatments Sources of Ascorbic Acid in diet			
	Control Diet	AA Diet	BFPM Diet	SEM
Packed Cell Volume(%)	28.33	29.89	28.83	1.81
Haemoglobin Content (%)	9.62[b]	10.81[a]	10.47[a]	0.72
Total Protein (g/dl)	6.60[b]	7.59[a]	7.22[a]	0.63

a,b: Means with different superscripts in the same row are significantly (P<0.05) different
SEM: Standard Error of means
AA: Ascorbic Acid Diet
BFPM: Baobab Fruit Pulp Meal Diet

Table 4:38: Comparative effects of control, ascorbic acid supplemented and baobab fruit pulp meal diets on the rectal temperature (^{o}C) of laying hens during hot – dry season

	Treatment Sources of Ascorbic Acid in diets and corresponding rectal temperature (^{o}C)			
Time	**Control Diet**	**AA Diet**	**BFPM Diet**	**SEM**
9:00Hr	40.10	40.06	40.07	0.08
12:00Hr	41.83^{b}	41.66^{a}	41.73^{ab}	0.07
14:00Hr	42.08^{b}	41.79^{a}	41.79^{a}	0.10

a,b: Means with different letter superscripts on the same row are significantly ($P<0.05$) different
SEM: Standard Error of Means
AA: Ascorbic Acid diets
BFPM: Baobab Fruit Pulp Meal Diets

4.6 Results For Experiment 5: Hot-Dry Season Broiler Starter Feeding Trial

The results of the broiler starter feeding trials conducted during the hot– dry season are presented under the various sections below.

4.6.1: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the growth performance and haematological status of broiler starters (0 – 4 weeks) during hot-dry season

The response of broiler starter chicks to dietary levels of Ascorbic acid and the Baobab Fruit Pulp meal diets are shown in Tables 4.39 and 4.40. Final live weights show significant ($P<0.05$) differences among treatment means. Birds fed 3.5% BFPM had the best performance in terms of final weight, weight gain, feed intake and feed conversion ratio (Table 4.39). The next best results were from birds fed 300mg/kg Ascorbic Acid diet. There were no significant ($P>0.05$) differences among treatment means for feed cost per kg gain. Birds fed 100mg AA/kg diet had the least cost. There were significant ($P<0.05$) differences among treatment means for mortality rate. The control and 100mgAA/kg diets had the highest mortality rates followed by 200 and 300mgAA/kg diets. Significant ($P<0.05$) differences were also observed (Table 4.40) among treatment means for the blood parameters studied. Birds fed 300mgAA/kg and 3.5% BFPM had higher values for packed cell volume, haemoglobin and total blood protein concentrations while the 7.0% BFPM diet had the lowest values for these parameters.

Table 4.39: Effects of dietary levels of ascorbic acid or baobab fruit pulp meal on the growth performance of broiler starters (0 – 4 weeks) during hot – dry season

Parameters	Control	Ascorbic Acid (mg/kg)			Baobab Fruit Pulp Meal (%)		
	0.00	100.00	200.00	300.00	3.5	7.0	SEM
Initial weight (g/bird)	55.83	55.83	55.83	55.83	55.83	55.83	0.59
Final weight (g/bird)	570.37^{c}	611.56^{d}	680.53^{b}	685.07^{b}	747.54^{a}	676.32^{c}	10.32
Weight gain (g/bird)	514.54^{e}	556.73^{d}	625.68^{b}	630.07^{b}	691.71^{a}	620.16^{c}	10.15
Feed intake (g/bird)	1406.44^{f}	1476.78^{c}	1625.68^{c}	1641.08^{b}	1760.9^{a}	1589.28^{d}	10.110.
Kg feed/kg gain	2.74^{b}	2.65^{ab}	2.60^{a}	2.57^{a}	2.54^{a}	2.56^{a}	0.06
Feed cost/bird (₦)	130.54	129.49	130.54	133.50	130.50	133.17	2.6
Mortality %	10.00^{b}	10.00^{b}	8.33^{b}	3.33^{a}	1.67^{a}	0.00	1.9

a, b, c, d, e, f: Means with different superscripts in the same row are significantly (P<0.05) different.
SEM: Standard Error of Means

Table 4.40: Effects of dietary levels of ascorbic acid or baobab fruit pulp meal on blood status of broiler starters (0–4 weeks) during hot – dry season

Parameters	Control	Ascorbic Acid (mg/kg)			Baobab Fruit Pulp Meal (%)		
	0.00	100.00	200.00	300.00	3.5	7.0	SEM
Packed Cell Volume (%)	28.33^{c}	28,67^{c}	28.67^{c}	31.67^{a}	30.33^{a}	25.67^{d}	1.05
Haemoglobin content (%)	10.41^{c}	10.47^{c}	11.07^{b}	11.93^{a}	11.63^{a}	9.17^{d}	0.36
Total protein (g/dl)	6.07^{c}	7.00^{b}	7.00^{b}	7.83^{a}	7.70^{a}	5.03^{d}	0.5

a,b,c,d: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard Error of means

4.6.2 Effects of dietary levels of ascorbic acid on the growth performance and haematological status of broiler starters (0 – 4 weeks) during hot-dry season

The responses of broiler chicks to dietary levels of Ascorbic Acid (AA) fed during hot – dry season study are shown on Tables 4.41 and 4.42. Table 4.41 shows that Ascorbic Acid (AA) supplementation significantly ($P<0.05$) improved final weight, body weight gain, feed intake, feed conversion ratio, feed cost/bird and mortality rate. Increasing dietary levels of AA resulted in improvements in the parameters studied. The diet with 300mg AA/kg performed best with regard to final weight, weight gain, feed intake and also had lowest percent mortality. 100mgAA/kg diet resulted in the least feed cost per kg body weight. Table 4.42 shows the effect of dietary AA levels on haematological parameters. Significant ($P<0.05$) differences were observed between treatments for Packed Cell Volume (PCV), Haemoglobin content (Hb) and Total blood protein (TP). 300mgAA/kg diet resulted in significantly higher (PCV) than the other AA diets. For Heamoglobin content, 200mgAA/kg and the 300mgAA/kg diets resulted in higher values than the control and the 100mgAA/kg diets. For Total protein however, all the Ascorbic Acid supplemented diets gave significantly ($P<0.05$) higher Total protein values than the control diet.

Table 4.41: Effects of dietary levels of ascorbic acid on the growth performance of broiler starters (0-4 weeks) during hot-dry season

Parameters	Treatments Ascorbic Acid Levels (mg/kg)				
	0	**100**	**200**	**300**	**SEM**
Initial weight (g/bird)	55.83	55.53	55.83	55.53	0.59
Final weight (g/bird)	570.37^{b}	611.56^{b}	680.53^{a}	685.07^{a}	12.88
Weight gain (g/bird)	514.54^{c}	556.73^{b}	625.10^{a}	630.07^{a}	12.75
Feed intake (g/bird)	1406.44^{d}	1476.72^{c}	1625.68^{b}	1641.08^{a}	12.80
Feed conversion ratio	2.74^{c}	2.65^{bc}	2.60^{a}	2.57^{a}	0.06
Feed cost/bird (₦)	130.54^{b}	129.49^{a}	130.9^{b}	132.54^{c}	0.51
Mortality (%)	10.00^{b}	10.00^{b}	8.33^{b}	3.33^{a}	2.15

a,b,c: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard Error of Means

Table 4.42: Effects of dietary levels of ascorbic acid on the haematological status of broiler starters (0-4 weeks) during hot-dry season

Parameters	Treatments Ascorbic Acid Levels (mg/kg)				
	0	**100**	**200**	**300**	**SEM**
Packed cell volume(%)	28.33[b]	28.67[b]	28.67[b]	32.00[a]	1.29
Haemoglobin content(%)	10.41[b]	10.47[b]	11.07[a]	11.63[a]	0.39
Total protein (g/dl)	6.07[b]	7.00[a]	7.00[a]	7.17[a]	0.86

a, b: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard error of means

4.6.3 Effects of dietary levels of baobab fruit pulp meal on the growth performance and haematological status of broiler starters (0–4 weeks) during hot-dry season.

Effect of dietary levels of Baobab Fruit Pulp Meal on the growth performance of broiler starter chicks are shown on Table 4.43. The Baobab fruit pulp meal (BFPM) as a source of Ascorbic (AA) in the diet of broiler chicks enhanced the growth performance of broilers. Significant ($P<0.05$) effects of diets were observed on final weight, body weight gain, feed intake and feed conversion ratio. From the table, it was observed that increasing dietary levels of BFPM beyond 3.5% did not show any further beneficial effect on the performance of the broiler chicks. It was also observed that increasing the dietary levels of BFPM led to a decrease in percent mortality. There was no significant ($P>0.05$) difference in feed cost per kg gain in body weight among the dietary treatments.

Results of the Haematological study presented on Table 4.44 revealed that the percent Packed Cell Volume (PCV), Haemoglobin concentration (Hb) and Total protein (TP) levels were significantly ($P<0.05$) improved by 3.5% dietary inclusion of BFPM. These parameters were however not improved beyond 3.5% BFPM in the diets. In fact, there were significant decreases in those values at the 7% dietary inclusion of BFPM.

Table 4.43: Effects of dietary levels of baobab fruit pulp meal on the growth performance of broiler starters (0-4 weeks) during hot-dry season

Parameters	Treatment Baobab Fruit Pulp Meal Levels (%)			
	0	3.5	7.0	SEM
Initial weight (g/bird)	55.83	55.83	55.83	0.48
Final weight (g/bird)	570.37^{c}	747.54^{a}	676.36^{b}	12.89
Weight gain (g/bird)	414.54^{c}	691.71^{a}	620.76^{b}	12.88
Feed intake (g/bird)	1406.40^{c}	1760.9^{a}	1589.28^{b}	10.64
Feed conversion ratio	2.74^{b}	2.54^{a}	2.56^{a}	0.06
Feed cost/bird (₦)	130.54	130.50	133.17	2.73
Mortality (%)	10.00^{c}	1.67^{b}	0.00^{a}	0.96

a,b,c: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard error of means

Table 4.44: Effects of dietary levels of baobab fruit pulp meal on the haematological status of broiler starters (0-4 weeks) during hot-dry season

Parameters	Treatments Baobab Fruit Pulp Meal Levels (%)			
	0	**3.5**	**7.0%**	**SEM**
Packed cell volume (%)	28.34[b]	30.33[a]	25.67[c]	0.75
Haemoglobin content (%)	10.41[b]	12.70[a]	9.17[c]	0.20
Total protein (g/dl)	6.07[b]	7.70[a]	5.03[c]	0.85

a,b,c: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard error of means

4.6.4 Comparative effects of the control, ascorbic acid supplemented and baobab fruit pulp meal diets on the performance and haematological status of broiler starters (0–4 weeks) during hot-dry season.

Table 4.45 and 4.46 show the comparative effects of Ascorbic acid (AA) and Baobab Fruit Pulp Meal (BFPM) diets as compared to the control diet on the growth performance and Haematological status of broiler starters during hot – dry season.

From Table 4.45, it was observed that there were significant ($P<0.05$) differences among treatment means for final weight, weight gain, feed intake, feed conversion ratio and on mortality rates. The diets however had no significant ($P>0.05$) effect on feed cost/bird. Broilers fed BFPM diets performed better than those fed the AA supplemented and control diets. The percent mortality was highest for the control diet while BFPM diet had the lowest percent mortality. Table 4.46 also shows that the birds fed AA supplemented diet performed better with regards to PCV, Hb and TP than those on the BFPM and control diets.

Table 4.45: Comparison of the control, ascorbic acid and baobab fruit pulp meal diets on the performance of broiler starters (0–4 weeks) during hot – dry season

Parameters	Treatment Sources of Ascorbic Acid in Diet			
	Control Diets	AA Diets	BFPM Diets	SEM
Initial weight (g/bird)	55.83	55.42	55.28	0.59
Final weight (g/bird)	570.37^{c}	659.05^{b}	711.69^{a}	21.46
Weight gain (g/bird)	514.54^{c}	603.83^{b}	656.29^{a}	21.26
Feed intake (g/bird)	1406.31^{c}	1581.25^{b}	1675.03^{a}	42.96
Feed conversion ratio	2.74^{c}	2.61^{b}	2.55^{a}	0.06
Feed cost/kg body weight (₦)	130.84	130.98	131.84	2.41
Mortality (%)	10.00^{c}	6.11^{b}	0.83^{a}	2.2

a,b,c: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard error of means
AA: Ascorbic Acid Diets
BFPM: Baobab Fruit Pulp Meal Diets

Table 4.46: Comparison of the control, ascorbic acid and baobab fruit pulp meal diets on the haematological status of the broiler starters (0–4 weeks) during hot – dry season

Parameters	Treatment Sources of Ascorbic Acid in diets			
	Control Diets	AA Diets	BFPM Diets	SEM
Packed cell volume (%)	28.33[b]	29.78[a]	28.00[b]	1.39
Haemoglobin content (%)	10.41[b]	11.16[a]	10.93[a]	0.68
Total protein (g/dl)	6.07[b]	7.07[a]	6.37[b]	0.87

a,b: Means with different superscripts in the same row are significantly (P<0.05) different
SEM: Standard error of means
AA: Ascorbic Acid Diets
BFPM: Baobab Fruit Pulp Meal Diet

4.7 RESULTS FOR EXPERIMENT 6: Hot-Dry Season Broiler Finisher Feeding Trial

The results for the broiler finisher feeding trial during the hot-dry season are presented in the section below:

4.7.1 Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the growth performance and carcass characteristics of broiler finishers (6–9 weeks) during hot-dry season

The effects of Ascorbic Acid (AA) and Baobab Fruit Pulp Meal (BFPM) diets on the growth performance of Broiler finishers fed during hot dry season are shown in Tables 4.47 and 4.48. The results show that Ascorbic acid and Baobab fruit pulp meal diets had significant effects ($P<0.05$) on all the parameters studied (Table 4.47). The birds fed Ascorbic acid at the inclusion levels of 200 or 300mgAA/kg diet and those fed Baobab fruit pulp meal at the rate of 3.5% of the diets showed comparable performances for final weights, weight gain, feed intake and feed conversion ratio. The birds fed 7.0% BFPM diet and those on the control diet showed lower performances for all the parameters. Ascorbic acid diet at 300mg/kg had significantly ($P<0.05$) the lowest feed cost/bird and those birds on 200mgAA and 3.5% BFPM were comparable. The birds fed 7.0% BFPM diets had the highest feed cost per kg body weight compared to other treatments.

Table 4.48 shows effects of dietary levels of ascorbic acid and baobab fruit pulp meal on carcass characteristics of broilers finishers. Significant effects of diets ($P<0.05$) were observed among treatment means. Birds fed 3.5% BFPM diets gave the best values for live weights, Carcass weights and dressing percentages when compared with other treatments. There was no significant effect ($P>0.05$) of diets on abdominal fat.

Table 4.47: Effects of dietary level of ascorbic acid or baobab fruit pulp meal on the growth performance of broiler finishers (6 – 9) weeks during hot – dry season

	Control	Ascorbic Acid (mg/kg)			Baobab Fruit Pulp Meal (%)		
Parameters	0.00	100.00	200.00	300.00	3.5	7.0	**SEM**
Initial weight (g/bird)	1025.00	1025.00	1025.00	1025.00	1025.00	1025.00	0.00
Final weight (g/bird)	1738.54^{c}	1757.34^{c}	1950.17^{a}	1956.88^{a}	1954.54^{a}	1832.53^{b}	28.72
Weight gain (g/bird)	713.53^{c}	732.30^{c}	925.17^{a}	931.33^{a}	929.60^{a}	607.52^{b}	28.79
Feed Intake (g/bird)	2021.44^{d}	2162.16^{c}	2280.40^{a}	2284.24^{a}	2287.32^{a}	2250.36^{b}	14.75
Feed conversion ratio	2.99^{c}	2.96^{bc}	2.46^{a}	2.48^{a}	2.46^{a}	2.79^{b}	0.15
Feed cost/kg (₦)	52.80^{a}	53.45^{a}	54.10^{a}	54.75^{ab}	55.39^{b}	56.63^{b}	1.11
Feed Cost/bird (₦)	106.73^{a}	115.57^{b}	123.35^{c}	125.05^{c}	126.68^{c}	127.42^{c}	2.63
Feed cost/kg gain (₦)	157.87^{b}	158.21^{b}	133.09^{a}	135.79^{a}	136.26^{a}	157.00^{a}	2.85
IAFE (₦)	242.13^{b}	241.79^{b}	266.91^{a}	264.21^{a}	263.74^{a}	242.00^{b}	3.5
Mortality (%)	11.11^{c}	8.33^{bc}	8.33^{bc}	5.56^{a}	5.56^{a}	2.78^{a}	3.17

a,b,c,d,e: Means with different superscripts in the same row are significantly different (P<0.05)
SEM: Standard Error of Means
IAFE: Income above feed expenses at ₦400 per kg body weight

Table 4.48: Effects of dietary levels of ascorbic acid or baobab fruit pulp on carcass characteristics of broiler finishers (6–9 weeks) during hot–dry season

Parameters	Control	Ascorbic Acid (mg/kg)			Baobab Fruit Pulp Meal (%)		
	0.00	100.00	200.00	300.00	3.5	7.0	SEM
Live weight (g)	1730.50^{e}	1766.67^{d}	1900.33^{b}	1903.33^{b}	1960.00^{a}	1813.36^{c}	15.77
Carcass weight (g)	1095.93^{e}	1115.42^{d}	1304.67^{b}	1326.81^{b}	1419.43^{a}	1250.63^{c}	15.61
Dressing (%)	63.33^{d}	63.14^{d}	68.65^{c}	69.71^{b}	72.42^{a}	68.97^{c}	0.95
*Giblet (%)	6.85^{b}	7.88^{a}	7.88^{a}	7.89^{a}	7.92^{a}	6.89^{b}	0.31
Abdominal fat (%)	2.27	2.54	2.54	2.79	2.57	2.27	0.5

a,b,c,d,e: Means with different superscripts in the same row are significantly different (P<0.05)
SEM: Standard Error of Means
Giblet: Consists of Gizzard, Liver, Kidney, Lung, Heart, Spleen

4.7.2 Effects of dietary levels of ascorbic acid on the growth performance of broiler finishers (6– 9 weeks) during hot-dry season

The effect of dietary levels of Ascorbic Acid (AA) on the growth performance and Carcass characteristics of broiler finishers (6–9 weeks) fed during the hot – dry season are shown on Table 4.49 and 4.50. The results for the finisher phase were similar to those obtained during the broiler starter phase. Table 4.49 shows significant effects of diets on final weight, weight gain, feed intake, feed conversion ratio and feed cost /bird. Ascorbic Acid supplementations at 200 or 300mg/kg consistently resulted in better final weight, weight gains, feed intakes, feed conversion ratios and feed cost/gain than the 100mgAA/kg and the control diets. The 300mgAA/kg diet gave the lowest feed cost/bird while the control diet gave the highest value.

Table 4.50 shows the effect of the AA dietary levels on carcass characteristics of the broilers. It was observed that increasing dietary levels of AA had positive effects on carcass weights and dressing percentage. The effects of diets on giblets and abdominal fat which were significant ($P<0.05$), did not show any meaningful pattern.

Table 4.49: Effects of dietary levels of ascorbic acid on growth performance of broiler finishers (6-9 weeks) during hot–dry season

Parameter	Treatment Ascorbic Acid Level (%)				
	Control	100	200	300	SEM
Initial weight (g/bird)	1025.00	1025.00	1025.00	1025.00	0.00
Final weight (g/bird)	1738.53^{b}	1757.34^{b}	1950.17^{a}	1956.88^{a}	36.93
Weight gain (g/bird)	713.53^{b}	732.30^{b}	925.17^{a}	913.88^{a}	36.96
Feed intake (g/bird)	2021.44^{c}	2162.16^{b}	2283.40^{a}	2284.24^{a}	15.96
Feed conversion ratio	2.99^{a}	2.96^{b}	2.52^{a}	2.48^{a}	0.12
Feed cost/bird (₦)	106.73^{a}	115.57^{b}	123.35^{c}	125.05^{c}	2.01
Feed cost/gain (₦)	157.87^{b}	158.21^{b}	133.09^{a}	135.79^{a}	2.33
IAFE (₦)	242.13^{b}	241.79^{b}	266.91^{a}	264.21^{a}	4.13
Mortality (%)	11.11^{d}	8.33^{c}	5.55^{b}	2.78^{a}	2.41

a,b.c.d: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard error of means
IAFE: Income above feed expenses at N400.00 per kg/body weight.

Table 4.50: Effects of dietary level of ascorbic acid on the carcass characteristics of broiler finishers (6 – 9 weeks) during hot – dry season

Parameters	Treatment Ascorbic Acid Level (mg/kg)				
	control	100	200	300	SEM
Live weight (g)	1730.50[c]	1766.67[b]	1900.33[a]	1903.33[a]	28.11
Carcass weight (g)	1095.93[c]	1115.42[b]	1304.67[a]	1326.81[a]	25.20
Dressing (%)	63.33[b]	63.14[b]	68.65[a]	69.71[a]	0.320
Giblet (%)	6.85[b]	7.39[b]	7.88[a]	6.89[b]	0.39
Abdominal fat (%)	2.77[b]	2.76[b]	2.54[a]	2.79[b]	0.20

a,b.c: Mean with different superscript in the same row are significantly ($P<0.050$) different
SEM: Standard error of means
Giblet: Consist of Gizzard, Liver, Kidney, Lung, Heart, Spleen

4.7.3 Effects of dietary levels of baobab fruit pulp meal on the growth performance and carcass characteristics of broiler finishers (6-9 weeks) during hot-dry season.

The effects of the Baobab Fruit Pulp Meal (BFPM) dietary levels on the performance and on the carcass characteristics of broilers finishers are shown in Tables 4.51 and 4.52. The results presented on Table 4.51 shows positive ($P<0.05$) effects of BFPM on final weight, weight gain, feed intake, feed cost/bird, percent mortality and on feed conversion ratio. The birds fed 3.5% BFPM had higher final weight, weight gain, feed intake, and better feed conversion ratio than the 7.0% BFPM and the control diets. Table 4.52 showed significant effects ($P<0.05$) of diets on carcass characteristics, dressing percentage, giblet and abdominal fats. Treatment with 3.5% BFPM in the diet resulted in better performances with regard to carcass weight, dressing % and giblet % when compared with the control and the 7.0% BFPM.

4.7.4 Comparative effects of control, ascorbic acid supplemented and baobab fruit pulp meal diets on the growth performance and carcass characteristics of broiler finishers (6 - 9 weeks) during hot-dry season

Treatment effects of Ascorbic Acid (AA) and Baobab Fruit Pulp Meal as sources of AA on the growth performance of broiler finishers (6 – 9 weeks) compared with the results for the birds on the control diet are presented in Tables 4.53 and 4.54. Table 4.53 shows significant ($P<0.05$) effect of diets on the performance of broiler finishers fed AA supplemented and BFPM diets. The performances of birds fed AA supplemented and the BFPM diets were similar for final weight, weight gain, feed intake, feed conversion ratio and percentage mortality but the diets had no significant ($P>0.05$) effects on feed cost/bird. Both the AA and the BFPM diets performed equally and with better performances when compared with the control diet.

Table 4.51: Effects of dietary levels of baobab fruit pulp meal on growth performance of broiler finishers (6 – 9 weeks) during hot – dry season

Parameters	Treatments Baobab Fruit Pulp Meal Levels (%)			
	Control	3.5	7.0	SEM
Initial weight (g/bird)	1025.00	1025.00	1025.00	0.00
Final weight (g/bird)	1738.53^{c}	1954.54^{a}	1832.53^{b}	20.77
Weight gain (g/bird)	713.44^{c}	929.60^{a}	807.52^{b}	20.72
Feed intake (g/bird)	2021.44^{b}	2287.32^{a}	2250.36^{a}	131.88
Feed conversion ratio	2.99^{c}	2.46^{a}	2.79^{b}	1.03
Feed cost/birds (₦)	106.73^{b}	126.68^{a}	127.42^{a}	3.08
Feed cost/gain	157.87^{b}	137.26^{a}	158.00^{b}	5.11
IAFE (₦)	242.13^{b}	263.74^{a}	247.00^{b}	2.11
Mortality (%)	11.11^{c}	5.55^{b}	2.78^{a}	3.92

a,b,c: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard error of means
IAFE: Income above feed expenses at ₦400 per kg body weight

Table 4.52: Effects of dietary levels of baobab fruits pulp meal on carcass characteristics of broiler finishers (6 - 9 weeks) during hot – dry season

	Treatments Baobab Fruit Pulp Meal Levels (%)			
Parameter	Control	3.5	7.0	SEM
Level weight (g)	1730.50^{c}	1960.00_{a}	1813.36^{b}	13.01
Carcass weight (g)	1095.93^{c}	1419.43^{a}	1250.63^{b}	10.21
Dressing (%)	63.33^{c}	72.42^{a}	68.97^{b}	0.64
Giblet (%)	6.85^{b}	8.02^{a}	6.89^{b}	0.54
Abdominal fat (%)	2.77^{b}	2.87^{b}	2.27^{a}	0.20

a,b,c: Means with different superscripts in the same row are significantly different ($P<0.05$)
SEM: Standard Error of Means
Giblet: Consists of Gizzard, Liver, Kidney, Lung, Heart, Spleen

The results for the carcass analysis were as shown in Table 4.54. Significant ($P<0.05$) improvements were also observed in carcass weight and dressing percentage of birds fed the AA and BFPM diets compared with the results for the control diets. No significant effect ($P>0.05$) of diets was observed for the giblet and abdominal fat pad.

Table 4.53: Comparative effects of control, ascorbic acid and baobab fruit pulp diets on the growth performance of broiler finishers (6-9 weeks) during hot – dry season

Indices	Treatments			
	Control Diet	AA Diet	BFPM Diet	SEM
Initial weight (g/bird)	1025.00	1025.00	1025.00	0.00
Final weight (g/bird)	1738.53^{b}	1888.13^{a}	1893.55^{a}	49.52
Weight gain (g/bird)	713.54^{b}	863.40^{a}	868.84^{a}	49.51
Feed intake (g/bird)	2120.30^{b}	2240.23^{a}	2268.80^{a}	27.93
Feed conversion ratio	2.99^{b}	2.56^{a}	2.56^{a}	0.14
Feed cost/bird (₦)	106.73^{b}	121.32^{a}	127.05^{a}	4.95
Feed cost/gain (₦)	157.87^{b}	142.36^{a}	147.13^{a}	5.91
IAFE (₦)	242.13^{b}	257.64^{a}	252.87^{a}	4.71
Mortality (%)	11.11^{b}	5.55^{ab}	4.77^{a}	2.96

a,b: Means with different superscripts in the same row are significantly (P<0.05) different
SEM: Standard error of means
AA: Ascorbic Acid diet
BFPM: Baobab Fruit Pulp Meal Diet
IAFE(₦): Income above feed expenses at ₦400 per kg body weight.

Table 4.54: Effects of feeding control, ascorbic acid supplemented and baobab fruit pulp diets on the carcass characteristics of broiler finishers (6 - 9 weeks) during hot – dry season

Parameters	Treatment Sources of Ascorbic Acid in Diets			
	Control Diet	AA Diet	BFPM Diet	SEM
Live weight (g)	1730.50[c]	1856.67[a]	1886.68[a]	26.13
Carcass weight (g)	1095.93[c]	1248.97[b]	1335.03[a]	21.41
Dressing (%)	63.33[b]	61.15[b]	70.68[a]	1.46
Giblet (%)	6.85	7.29	7.46	0.46
Abdominal fat (%)	2.71	2.77	2.42	0.11

a,b: Means with different superscripts in the same row are significantly ($P<0.05$) different
SEM: Standard error of means
AA: Ascorbic Acid diet
BFPM: Baobab fruit pulp diet
Giblet: Consists of Gizzard, Liver, Kidney, Lung, Heart, Spleen

4.7.5 Comparison of improvements in bird performances due to ascorbic acid and baobab fruit pulp meal supplementations in broiler and laying hens diets during cool-wet and hot-dry seasons

Tables 4.55 and 4.56 further indicate the economic importance of inclusion of Ascorbic Acid and Baobab Fruit Pulp Meal in the diets on the performance of broiler finishers and laying hens during cool-wet season and hot-dry seasons.

Effects on Laying Hens

The inclusion of AA and BFPM improved hen-day egg production by 7.1% and 19.1% for cool-wet and Hot-dry seasons respectively above the control. Kgfeed/dozen was improved by 5.53% and 11.71%. Similarly, there were 83.37% and 100% mortality reduction for cool-wet and hot-dry season respectively. (Table 4.5.5.)

Effects on Broiler Starter Performance

The comparison of improvement in performance of broiler starter phase due to inclusion of Ascorbic acid and Baobab Fruit Pulp Meal in diets indicated that final weight was improved above values for control diet by 4.69% and 20.16% during Cool-wet and Hot-dry seasons respectively. Weight gain was improved by 4.98% in cool-wet season and 22.45% in hot-dry season. Feed intake was improved by 3.66% and 15.77% in Cool-wet and Hot-dry seasons respectively. The percentage reductions in mortality were 27.74% and 30.60% for cool-wet season and Hot-dry season respectively.

Effects on broiler finisher performance

For the broiler finishers weight gains were improved by 14.63 and 21.38 for cool-wet and hot-dry seasons respectively. The percent reduction of mortality in broiler finishers were 42.35% and 55.17% for cool-wet and hot-dry seasons respectively.

General observations

It is evident from these tables (4.55, 45.6 and 4.57) that supplementations of the AA and BFPM improved performances of broiler starters, broiler finishers and laying hens in both cool-wet and hot-dry seasons. The table further indicated that these supplementations were more effective in improving performances of broilers and laying hens during hot-dry season than cool-wet season.

Table 4.55 Comparison of improvement due to ascorbic acid and baobab fruit pulp meal supplementations on performance of laying hens during cool-wet and hot-dry seasons

Parameters	Cool-wet season (%)	Hot-dry Season (%)
Hen-day egg production	7.1	19.1
Kg feed/dozen egg	5.53	11.71
Feed cost/dozen egg	0.38	6.21
Body weight change	0.54	26.11
% Reduction in Mortality	83.37	100.00

Table 4.56 Comparison of improvement due to ascorbic acid and baobab fruit pulp meal supplementation on performance of broiler starter during cool-wet and hot-dry season

Parameters	Cool-wet season (%)	Hot-dry Season (%)
Final Weight	4.69	20.16
Weight gain	4.98	22.45
Feed intake	3.66	15.77
% Reduction in Mortality	27.74	30.60

Table 4.57 Comparison of improvement of the effect of ascorbic acid and baobab fruit pulp meal supplementations on performance of broiler finishers during cool-wet and hot-dry seasons

Parameters	Cool-wet season (%)	Hot-dry Season (%)
Final weight	7.28	8.76
Feed intake	1.07	6.33
Weight gain	14.63	21.28
% Reduction in Mortality	42.35	55.17

CHAPTER FIVE

5.0 DISCUSSIONS

5.1 Chemical composition and anti-nutritional factor contents of baobab fruit pulp meal

The results of the chemical analysis indicate 3.31% crude protein, 9.27% crude fibre, 2.17% either extracts, 79.2% nitrogen free extract and 6.29 % ash. These values fell within the range of values earlier reported (Berker, 1983; Saka *et al.,* 1994; Saka 1995; Magdi, 2004). Similarly the ascorbic acid content of 299.75mg/100gm obtained from the chemical analysis fell within the range of 150 to 499mg/100g reported by Manfredini *et al* (2002) but it slightly fell below 337mg/100g and 300mg/100g reported respectively by Eromosele *et al* (1991) and Phyto Trade Africa (2006). The result of the chemical analysis of Baobab Fruit Pulp Meal showed no indication that it contains high levels of anti-nutritional factors that can pose any serious threat to its utilization in poultry diets especially if it is used at low levels of inclusion.

5.2 Experiment 1: Cool-Wet season Layer Feeding Trial

5.2.1 Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the performance and egg quality characteristics of laying hens (44 – 56 weeks) during cool – wet season

5.2.1.1 Performance of layers fed ascorbic acid and baobab fruit pulp meal supplemented diets

There were significant ($P<0.05$) effects of diets on final weight, body weight change, feed intake, kg feed/dozen eggs, feed cost/dozen egg, hen-day egg production and percent mortality. Supplementation of Baobab Fruit Pulp Meal (BFPM) as a source of natural ascorbic acid in laying hens diet was tolerated by the birds up to 3.5% level of inclusion. This level of BFPM was superior to 300mgAA/kg diet in all the parameters studied during cool wet season. Ascorbic acid diets at 200 and 300mg/kg gave

comparable results for final weight, body weight change, feed intake and feed cost/dozen eggs. The fact that both BFPM and AA supplemented diets resulted in better performance of layers during the cool-wet season underscore the importance of inclusion of AA in layer diets as earlier reported by Kassim and Norziha (1995), Njoku (1986) and Balogun *et al* (1996). Further increase to 10.5% BFPM in layer diets led to decrease in almost all the parameters studied such as final weight, body weight change, feed intake, kg fed/ dozen eggs, feed cost/dozen egg suggesting that BFPM supplementation in laying hens should not exceed 3.5% during the cool-wet season. Definitely excessiveness of BFPM at 7.0% and 10.5% supplementations will be counter-productive. From this study 200mgAA/kg and 3.5% BFPM were optimum for layers fed supplementation during cool-wet season.

The supplementation of ascorbic acid (AA) and baobab fruit pulp meal (BFPM) in laying hens led to significant ($P<0.05$) increase in the cost of kg feed when compared with the control diet. Feed cost was similar for 200 to 300mgAA/kg and for the 3.5% BFPM diet. The increase in the cost of feed per/kg diet as the levels of AA and BFPM increased was due to the additional cost of purchasing these additives (Onimisi, 2010).

Feed cost per dozen eggs decreased as the levels of AA in the diet increased, for the BFPM diet, feed cost per dozen eggs increased as the levels of BFPM increased, while the kg feed consumed per dozen eggs decreased as the dietary inclusion of BFPM increased. This may be explained due to the high market price of the BFPM.

It was found from this study that addition of AA at 200-300mgAA/ kg and 3.5% BFPM had similar and comparable results on feed intake, feed cost/kg diet, feed cost per dozen eggs and income above feed expenses (IAFE). The farmer supplementing layer

diets with AA at 200 to 300 mg/kg and BFPM at 3.5% in the diet during cool-wet season will make more profit than using unsupplemented diets.

5.2.1.2 Effects of ascorbic acid and baobab fruit pulp meal on egg quality characteristics during cool-wet season

Significant ($P<0.05$) treatment effects on egg quality parameters such as egg weight, shell weight, yolk index and Haugh unit value were noticed but non significant effect ($P>0.05$) on shell thickness. In egg quality characteristics, ascorbic acid (AA) at 200 and 300mg/kg gave similar results and comparable with 3.50% BFPM except in the yolk index where 3.5% BFPM was superior. However, 200mgAA/kg diet was sufficient for good egg quality characteristics. This results agree with the report of Kassim and Norziha (1995) who reported improvement in Haugh unit value but the result contrasted the report of Nestor *et al* (1972) who found that AA inclusion in the diets of birds during stress did not affect egg quality. As indicated above, 200mgAA/kg and 3.55 BFPM were optimum for layers during cool-wet season.

5.2.2 Effects of dietary levels of ascorbic acid on the performance and egg quality characteristics, of laying hens (44 – 56 weeks) during cool-wet season

During the cool-wet season laying hens responded to ascorbic acid supplementation up to 300mg/kg diet but there were no significant differences between 200mg/kg AA and 300mg/kg in feed intake, percentage mortality and in all the egg quality parameters studied. The fact that ascorbic supplementation resulted in zero mortality compared with control shows that beyond lowering body temperature as observed during the hot-dry season also, ascorbic acid might in addition must have boosted the immunity of the birds during the cool-wet season. This is evident by the prevalence of diseases associated with the cool-wet season poultry production. This

observation agrees with the earlier report of Alisheikov (1980) and Shulga (1980) who both reported that AA at 75mg/kg diet and 50mg/kg diet respectively improved immunity after vaccination. The immunity provided could have led to the zero mortality observed in this study. During the cool-wet season, 200mg AA/kg feed was optimum for better layer performance and good egg quality characteristics.

5.2.3 Effects of dietary levels of baobab fruit pulp meal on the performance and egg quality characteristics of laying hens (44 – 56 weeks) during cool-wet season

Only BFPM supplementation at 3.5 % consistently resulted in better layer performance and egg quality characteristics than the control. Further increase in the level of BFPM to 7.0 % or 10.5 % did not result in corresponding better performance of laying hens and did not affect the egg quality (Table 4.08). This observation suggests that 3.5% BFPM supplementation in layer diets during the cool-wet season was adequate. The poor performance with 7.0 % and 10.5 % BFPM diets could be due to powdery and bulky nature of the BFPM. The bulky nature of the BFPM may lead to reduced feed intake at high inclusion rate while the powdery nature may also lead to low acceptability of the diet.

The results of this study shows that 3.5% inclusion of BFPM enhanced the quality of eggs produced by laying egg during the cool-wet season.

5.2.4 Comparative effects of control, ascorbic acid and baobab fruit pulp meal supplemented diet on the performance and egg quality characteristics of laying hens (44 – 56 weeks) during cool-wet seasons

Both sources of vitamin C resulted in similar but better performance of laying hens than the control except in shell weight and feed cost/dozen eggs. It is glaring that apart from BFPM supplementation reducing the heat-related stresses in the laying hens, it

also increase the immunity of the laying hens against outbreak of diseases as earlier reported by Kerharo and Adam (1974) who opined that the Baobab pulp could be used therapeutically as febrifuge, analgesic, anti-diarrhea and anti-dysentery. On the other hand, ascorbic acid supplementation resulted in better feed cost/dozen eggs, better egg shell quality and egg weight than BFPM and the control diets suggesting that ascorbic acid should be preferred for quality egg production.

5.3 Experiment 2: Cool-Wet Season Broiler Starter Feeding Trial.

5.3.1: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the growth performance of broiler starters during cool-wet season (2-5 weeks)

In cool–wet season, broiler starters responded favourably to the 3.5% BFPM supplementation and to the 200 and 300mgAA/kg diets as reflected in final weight, weight gain, feed intake, feed conversion ratio and feed cost/kg body weight (Table, 4.11). There were no significant differences between 200 and 300mg AA/kg in feed intake, feed cost/kg body weight and mortality. Generally, during the cool-wet season, ascorbic acid at 300mg/kg broiler starter diet and BFPM at 3.5% level in the diet gave best results in terms of weight gain and feed conversion ratio. BFPM diets beyond 3.5% level of inclusion gave poor results.

5.3.2: Effects of dietary levels of ascorbic acid on the growth performance of the broiler starters (2-5 weeks)

Only 300mg/kg ascorbic acid supplementation consistently resulted in better growth performances of the broiler chicks than the control as reflected in final weight, weight gain, feed conversion ratio, feed cost/bird and percent mortality (Table, 4.12). This result further confirms that there are many roles played by the ascorbic acid in addition to reducing the heat stress. It appears that ascorbic acid also increased the appetite of the

chicks which eventually resulted in better weight and feed conversion ratio with the 300mg/kg AA than the other lower AA levels and the control. This result underscores the necessity for inclusion of ascorbic acid in broiler diets to reduce stress as earlier reported by Ayo *et al.* (1996), Balogun *et al.* (1996) and FAO (2003). From these results it is evident that 300mgAA/kg diet was the optimum for better performance of broiler chicks during cool-wet season.

5.3.3: Effects of dietary levels of baobab fruit pulp meal on the growth performance of broiler starters (2-5 weeks) during cool-wet season

Baobab fruit pulp meal supplementation in broiler chicks was beneficial up to 3.5 % level of inclusion. The apparent depression in the growth performance of the chicks as the level of BFPM increased to 7.0 or 10.5 % may be due to the powdery and bulky nature of this materials and its influence in the feed might have reduced feed acceptance by birds as indicated by the low feed intakes (Table 4.13). The probable interaction of BFPM with digestive system of the young chicks could have also been responsible for the poor responses at higher levels of BFPM (Binta and Khetarpaul, 1997). This shows that 3.5 %BFPM supplementation was the optimum level of inclusion for broiler starter diet during the cool-wet season.

5.3.4: Comparative effects of control, ascorbic acid and baobab fruit pulp meal supplemented diets on the growth performance of the broiler starters (2-5 weeks) during cool-wet season.

Ascorbic acid supplementation was more beneficial to the broiler starters diets during the cool-wet season as reflected in better final weight gain, weight gain and feed conversion ratio compared with control and BFPM diets. The apparent depression observed with 7.0 and 10.5% BFPM supplementations could be due to powdery nature of

the BFPM as the level of inclusion increased. Ironically, excessive BFPM have been implicated for reducing growth of animals and particularly chicks as they lower digestibility by complexing with digestion process (Binta and Khetarpaul, 1997; Abara, 2003; Smith *et al.,* 1991; Ladeji *et al.,* 2004; Thompson and Yoon, 1984; Ogundipe *et al.,* 2003; Foerster, 2006). In general terms in order to improve performance of broiler chicks during cool-wet season, AA supplementation should be preferred above the BFPM supplementation in broiler chicks diets.

5.4 Experiment 3: Cool-Wet Season Broiler Finishers Feeding Trial

5.4.1 Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the growth performance and carcass characteristics of broiler finishers (6-9 weeks) during cool-wet season.

5.4.1.1 Performance of broiler finishers fed ascorbic acid and baobab fruit pulp meals supplemented diets during cool-wet season.

The results in Table 4.15 showed that dietary levels of Ascorbic Acid (AA) and Baobab Fruit Pulp Meal (BFPM) had significant ($P<0.05$) and positive effects on final weight, weight gain, feed intake, feed conversion ratio, feed cost per bird and on percent mortality.

Broiler finishers responded maximally to 200mgAA/kg supplementation and to the 3.5% BFPM diet especially with regard to final weight, weight gain and feed conversion ratio. The better feed intake with 3.5% BFPM inclusion compared to the results obtained for all other treatments might have facilitated better feed conversion ratio and consequently higher final weight and weight gain. However, increasing the levels of BFPM beyond 3.5% resulted in depressed growth of birds during the cool-wet season. The higher levels of BFPM supplementation (7.0 and 10.5%) resulted in poorer growth of broilers in the finisher phase during the cool-wet season and therefore higher BFPM

dietary inclusion rates should be discouraged. The fact that there was no significant (P>0.05) difference between the 200 and 300mgAA/kg diets suggest that 200mgAA/kg might just be enough for broiler finisher performance. This results agree with the findings of Njoku (1986) and Balogun *et al* (1996) who reported that AA supplementation was necessary in poultry diets. The optimum levels of AA and BFPM supplementation in broiler finisher diets during cool-wet season therefore should be 200AAmg/kg and 3.5% BFPM respectively.

Table 4.15 also shows that inclusion of ascorbic acid (AA) and baobab fruit pulp meal (BFPM) had significant (P<0.05) positive effects on feed cost per kg gain compared with the control diet. Consistent improvements were noticed as the levels of AA and BFPM in diet increased. Feed conversion ratio decreased with increase in AA levels but it increased as that of BFPM levels increased beyond 3.5%. Birds on AA diets were able to utilize their diet more efficiently to make up for the cost of feed. Ascorbic acid levels of 200mg/kg diet and of 300mg/kg diets and the BFPM at 3.5 of diet resulted in better IAFE than the control, 100mgAA/kg, 7.0 and the 10.5% BFPM diets. Since a non-significant (P>0.05) difference was observed between 200 and 300mgAA/kg diet, it is therefore recommended that 200mgAA/kg and 3.5%BFPM supplementations were adequate for broiler finishers during the cool-wet season.

5.4.1.2 Carcass characteristics of broiler finishers (6-9 weeks) during cool wet season

The results for carcass characteristics as shown in Table 4.16 indicate significant (P<0.05) effects of diets on carcass weight, dressing percent and abdominal fat. No significant (P>0.05) effects of diets was observed for % giblet. Carcass weight and dressing % increased as dietary levels of AA increased. For the BFPM diets, carcass

weight and dressing % were significantly (P<0.05) improved by the 3.5% diets. The higher levels of 7.0 and 10.5% BFPM in diets resulted in poor carcass weights and dressing percentage.

5.4.2: Effects of dietary levels ascorbic acid on the growth performance and carcass characteristic of broiler finishers (6-9 weeks) during cool-wet season

Ascorbic acid supplementations increased the performance of broiler finishers up to 300mg/kg diet but there were no significant differences between the 200mg/kg and 300mg/kg diets in all the growth and carcass characteristics of broiler finishers measured during the cool-wet season. Similar observations were reported earlier by Njoku (1986). The implication of this result is that 200mgAA/kg diet was adequate for broiler finisher diets.

5.4.3: Effects of dietary levels of baobab fruit pulp meal on the growth performance and carcass characteristics of broiler finishers (6-9 weeks) during cool-wet season

Baobab fruit pulp meal supplementation at 3.5% of broiler finishers diet resulted in better growth performance than the control diet and other dietary levels of BFPM. Attempt at increasing the level of BFPM to 7.0 % in broiler finishers diet during the cool-wet season resulted in depressed growth of broilers. This result is similar to what was observed during broiler starters study. This result simply suggests that 3.5 % BFPM supplementation was adequate for broiler finisher diets reared in the cool-wet season. The bulkiness of the BFPM could lower the proportions of other ingredients in the diets. The powdery nature of the BFPM could also be a factor causing reduced feed intake. Abdominal fat decreased as the level of BFPM in the diets increased. This attribute could

make broilers produced with BFPM supplementation to have higher demands due to less fatty deposits.

5.4.4 Comparative effect of control, ascorbic acid supplemented and baobab fruit pulp meal diets on growth performance and carcass characteristics of broiler finishers (6-9 weeks) during cool-wet season

Diets containing AA supplementation performed better than the BFPM diets with regard to weight gain, feed intake and feed conversion ratio. BFPM diets were however more effective for the production of low fat broilers, BFPM significantly reduced abdominal fat deposits than the AA supplemented and the control diets. BFPM supplementation in broiler diets may find ready acceptance with broiler farmers who will like to produce low fat broiler chickens and also because of the current quest for organic products. It is evident from this result that ascorbic acid supplementation is crucial for better broiler production as earlier reported (Payne, 1966; Oluyemi and Adebanjo, 1979; Schenck *et al.,* 1992; Kassim and Norziha, 1995; Balogun *et al.,* 1996).

5.5 Experiment 4: Hot-Dry Season Layer Feeding Trial

5.5.1: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the performance, egg quality characteristics, haematological status and rectal temperature of laying hens (30 – 42 weeks) during hot-dry season

5.5.1.1 Performance of layers fed ascorbic acid and baobab fruit pulp meal supplemented diets during hot-dry season

Ascorbic acid supplementation in layer diets resulted in better performance in laying hens during the hot-dry season. There was a progressive increase in final weight, body weight change, % Hen-day egg production, feed intake and lower feed cost per dozen eggs as dietary level of AA increased up to the 300mgAA/kg diets. This is a reflection of the vital role that ascorbic acid could play in enhancing the performance of

laying hens. The results for the 3.5% BFPM diet were similar to those of the 300mgAA/kg diet in hen-day egg production, feed cost per dozen eggs, kg feed per dozen eggs and in % mortality. Further increase in dietary level of BFPM to 7.0% of diet resulted in poorer performance of the birds. From this study, it is suggested that 3.5% BFPM diet was able to supply sufficient AA comparable to the amount contained in the 300mgAA/kg diet. This finding agreed with Adekola and Ayo (2006) who reported that AA supplementation alleviate the effect of heat stress in poultry birds.

5.5.1.2 Effect of ascorbic acid and baobab fruit pulp meal on egg quality characteristics of layers (44-56 weeks) during hot-dry season

In terms of egg quality characteristics, there were similar performances in egg weight for birds fed 200mg to 300mgAA/kg diets and for the 3.5% BFPM diet. The 200mgAA and 300mgAA/kg diet as well as the 3.5% BFPM diet, resulted in better shell weight and Haugh unit values.

Improvement in egg quality found in this study agrees with the reports of Thompson and Moreng (1959) who reported that AA enhanced egg quality under high ambient temperature.

5.5.1.3 Haematological status of layers fed ascorbic acid and baobab fruit pulp meal supplemented diets during hot-dry season.

Table 4.26 shows the result of the haematological status of the laying hens during hot-dry season. It has been established that Packed Cell volume (PCV), haemoglobin content (Hb) and Total protein (TP) are important parameters used to access the health status of animals. Various levels of nutritional factors also have been discovered to affect blood indices in animals. Oladele and Ayo (1999) reported that reductions in the levels of some nutrients in feed resulted in decrease in PCV, Hb and TP of animals. The values of

25.33 to 32.33% PCV, 8.33 to 12.3% Hb and 6.30 to 8.83g/dl TP obtained from blood analysis in this study fell within the established normal values of 22-35% PCV, 7-13% Hb and 6-9g/dl TP reported by CCAC (1993) respectively. The aim of determining the haemoglobin content therefore was to ascertain the oxygen carrying capacity of the bird's circulatory system. Oladele and Ayo (1999) stated that birds with low oxygen carrying capacity can easily succumb to any form of respiratory disease while birds with high oxygen capacity are likely to withstand some levels of respiratory stress.

The difference in values of haemoglobical parameters might not be unconnected with effects of high ambient temperature (AT) experienced by the layers during the hot-dry season of the year. It has been reported that high AT reduces feed intake (Kekeocha 1985; Oluyemi and Robert, 1979; Ogbogu, 1988). Other researchers also reported that laying hens exposed to heat stress had low concentrations of Ascorbic acid in the blood plasma (Pardue *et al.,* 1985; Ayo *et al.,* 2007). They further reported that during stress, the generations of reactive oxygen species (ROS) was high to the level that overwhelms tissue anti-oxidant defence system. The high values for PCV, Hb and TP obtained with 200 to 300mgAA/kg and 3.5% BFPM in this study was an indication that AA at 200 to 300mg/kg diet and 3.5% BFPM in the diet were adequate for protecting laying hens against stress induced damages to the biological system (Minka and Ayo, 2007).

5.5.1.4 Rectal temperature (^{o}C) of layers fed ascorbic acid and baobab fruit pulp meal supplemented diets during hot-dry season

Table 4.25 shows the effects of ascorbic acid (AA) and the baobab fruit pulp meal (BFPM) on the rectal temperature (RT) of the laying hens during hot-dry season. It has been established that heat stress in birds can be evaluated by measuring the RT, because it is a true reflection of internal body temperature and a reliable index of the thermal balance

(Ayo *et al.,* 1998; Ayo and Sinkalu, 2007). The results of the present study indicated that RT of ShikaBrown® layers fell within the established normal range of 39.5-42^{o}C for the avian species (Freeman, 1971). The small variation observed in the RT values in this study agreed with the findings of Ayo *et al.* (1998) who discovered that RT varies with ambient temperature (AT) and the hours of the day during the hot-dry season. The layers were exposed to high AT range of 32-38^{o}C (Appendix 1) which was far above the thermoneutral zone of 13-25 (Oluyemi and Robert, 1979; Ogbogu, 1988; Kekocha, 1985, Georgyevsky; 1990). RT values for the control group were the highest for the 12 and 15 hour temperature readings. AA supplementation at 200 and 300mg/kg diet and BFPM dietary level of 3.5% were able to cause significant reductions in RT values in the laying hens in this study. The data obtained therefore showed that supplementations of AA and BFPM reduced RT of laying hens both at 12:00HR and 15:00HR. The finding corroborated the report of Ayo *et al.* (1996), Bottje and Harrison (1985), Njoku (1990) and Balogun *et al.* (1996) that high AT induces stress in poultry but such a stress can be combated by AA and BFPM supplementations in diets.

5.5.2: Effects of dietary levels of ascorbic acid on the performance, egg quality characteristics, haematological status and rectal temperature of laying hens (30 – 42 weeks) during hot-dry season.

There was zero mortality recorded in the ascorbic acid supplemented group. With regard to egg quality Table 4.28 shows non-significant response in yolk index. Significant positive responses were however observed with birds fed 200mg AA/kg and 300mg AA/kg in all egg quality parameters studied. Ascorbic acid supplementation at those levels were sufficient for reduction of stress in laying hens. Ascorbic acid levels of 200mg/kg and 300mg/kg diets consistently gave optimum and better layer performances

and egg quality values than the control diet. All levels of ascorbic acid diets resulted in better final weight and Haugh Unit value than the control diets. Ascorbic acid supplementation up to 200mg/kg diet was found to be adequate for optimum performance and for maintaining production of good egg quality by laying hens during hot-dry season. When stress factor is high and the duration is prolonged, the overall body defensive mechanism begins to breakdown hence, diseases and death may follow (Ayo *et al.,* 1996; Babsky *et al.,* 1990). The result of this study shows gradual increases in packed cell volume (PCV), haemoglobin content (Hb) and total protein (TP) which also attested to the fact that ascorbic acid supplementation helped in combating stress.

Progressive reductions in the rectal temperatures were also observed as the level of ascorbic acid increased (Table 4.30). This further confirms the stress-reducing effect of ascorbic acid supplementation in diets.

5.5.3: Effects of dietary levels of baobab fruit pulp meal on the performance, egg quality characteristics, haematological status and rectal temperatures of laying hens (30 – 42 weeks) during hot-dry season

Baobab fruit pulp meal (BFPM) supplementation in diets up to 3.5 % gave better performance and egg quality characteristics of layers than the control diet during the hot-dry season. BFPM diets also resulted in zero mortality. With these satisfactory results, especially at 3.5% BFPM dietary level, it appears BFPM dietary level of 3.5 was able to supply vitamin C to the level capable of reducing heat stress and hence lowering the risk of stress related diseases (Ayo *et al.,* 1996). Inclusion of BFPM beyond 3.5% of diets reduced the performance of laying hens. The poor performance of layers fed 7.0% BFPM diet as reflected also in the rectal temperature and hematological status was probably due to the bulky and powdery nature of the diet high in BFPM. Supplementation of BFPM in

layer diets did not have any significant effect on the shell thickness and yolk index. For optimum layer performance and for production of quality eggs, 3.5 % BFPM dietary inclusion was found to be adequate in layer diets during hot-dry season.

5.5.4: Comparative effect of the control, ascorbic acid supplemented diets and baobab fruit pulp meal on the performance, egg quality characteristics, haematological status and rectal temperature of laying hens (30 – 42 weeks) during hot-dry season.

When the ascorbic acid and BFPM diets were compared with the control, both supplements gave better results than the control diet for nearly all the parameters studied on layers during the hot-dry season, especially for Hen-day egg production, kg feed/dozen eggs, feed cost/dozen eggs and for income above feed expenses. There were no significant differences between the ascorbic acid and BFPM diets for all the parameters studied. This is an indication that BFPM supplementation especially at 3.5% of diet could replace 200mg AA/kg in layer diet without adverse effect. In addition, at 12:00Hr and 15:00Hr, both the AA and BFPM diets resulted in lower rectal temperature of the birds than the value obtained with the control diet. This further confirmed the fact that both the AA and the BFPM supplementations in diets can help to reduce heat stress in laying hens as earlier reported by Njoku (1990), Ayo *et al.* (1996) and Balogun *et al.* (1996). It is concluded that both ascorbic acid and baobab fruit pulp meal supplementations were capable of supporting layers for optimum performance, to improve egg quality characteristics, haematological status and for lowering the rectal temperature during hot-dry season.

5.6 Experiment 5: Hot-Dry Season Broiler Starter Feeding Trials

5.6.1: Effects of dietary levels of ascorbic acid and baobab fruit pulp meal on the growth performance and haematological status of broiler starters (0-4 weeks) during hot-dry season

5.6.1.1 Performance of broiler starters fed ascorbic acid and baobab fruit pulp meal diets during hot dry-season.

Ascorbic acid (AA) and Baobab fruit pulp meal (BFPM) increased the performance of broiler chicks as reflected in the values recorded for final weight, weight gain, feed intake and feed conversion ratio.

Generally, BFPM diets resulted in better performance than the AA supplementations in promoting growth in broiler chicks during hot-dry season. The least mortality rate was observed with 3.5% BFPM and 300mgAA/kg diets. This further confirms the role of AA in reducing the effect of heat stress in broiler starter chicks. This observation agrees with the earlier reports of Shulga (1980) that 50mgAA supplementation in broiler chick diet improved the development of chicks and reduced mortality and of Alisheikov (1980) who reported 75mgAA/kg in broiler chick diet had beneficial effects on growth and it reduced death losses. It can be concluded from this study that 3.5% BFPM performed better than the 300mgAA/kg diet in all the growth parameters measured on broiler chicks during the hot-dry season except for feed cost per kg body weight.

5.6.1.2 Haematological status of broiler starters (0-4 weeks) fed ascorbic acid and baobab fruit pulp meal diets during hot-dry season.

Table 4.40 shows the effects of ascorbic acid (AA) and baobab fruit pulp meal (BFPM) diets on the haematological status of broiler starter chicks during hot-dry season. Significant ($P<0.05$) differences were observed among treatment means for the blood

parameters studied. Birds fed 300mgAA/kg and 3.5% BFPM had higher values for packed cell volume (PCV), haemaglobin content (Hb) and total protein (TP) concentrations while 7.0% BFPM had the lowest values for those parameters. From this observation, AA diet at 300mg/kg and the BFPM diet at 3.5% level maintained PCV, Hb and TP values at the highest levels for broiler starter chicks during the hot dry season.

5.6.2 Effects of dietary levels of ascorbic acid on the growth performance and haematological status of the broiler starters (0-4 weeks) during hot-dry season

There were corresponding increases in the performance of broiler chicks as the level of ascorbic acid increased in the diet up to 300mg/kg as reflected in final weight, weight gain, feed intake, and feed conversion ratio. There were no significant differences in the results between 200mgAA/kg and 300mgAA/kg diets indicating that 200mg to 300AA per kg diet were enough for broiler starter chicks during hot-dry season. Furthermore, Hb, and TP values also did not show any significant difference during the 200 and 300mgAA/kg diets. Therefore, from this study, 200mg to 300mgAA/kg diet were adequate for broiler chick growth and development during the hot dry season.

5.6.3 Effects of dietary levels of baobab fruit pulp meal on the growth performance and haematological status of the broiler starters (0-4 weeks) during hot-dry season.

Baobab Fruit Pulp Meal (BFPM) at both 3.5 and 7.0% of diets significantly improved the performance of the birds than the control diets indicating that BFPM as a source of natural AA in diet was able to support broiler chicks' growth and development. 3.5% BFPM diet was however better than the 7.0% BFPM diet for all the parameters except for mortality rate. The results of the haematological status also indicated that 3.5 % BFPM supplementation was better for broiler chicks than the 7.0% BFPM diet as it

improved the PCV, HC and TP values of the blood (Table 4.44). BFPM supplementation of 3.5 % was also better than the control diet. The slight depression in growth performance with birds fed with 7.0 % BFPM diets suggest that higher level of BFPM was not advisable for broiler chicks possibly due to the powdery nature of that diet. High levels of BFPM in poultry diets have also been implicated for complexing with digestion process (Binta and Khetarpaul, 1997; Ogundipe *et al*., 2003; Forster, 2006). From the observation made above, 3.5 % BFPM in the diet was adequate for broiler starters diets during hot-dry season.

5.6.4: Comparative effects of control diet, ascorbic acid and the baobab fruit pulp meal diets on the growth performance and haematological status of the broiler starters (0-4 weeks) during hot-dry season.

Baobab Fruit Pulp Meal (BFPM) significantly increased the growth performance of broiler chicks during the hot dry season than the ascorbic acid and control diets even though AA supplemented diets were better than BFPM diets for PCV and TP values and 4.46). Therefore when considering which of the two sources of vitamin C to use as supplements in broiler starter diet during the hot dry season, BFPM should be preferred as it gives overall better performance than the synthetic ascorbic acid. BFPM supplementation should however not be higher than 3.5% level in the diet.

5.7 Experiment 6: Hot Dry Season Broiler Finisher Feeding Trials

5.7.1 Effects of dietary level of ascorbic acid and baobab fruit pulp meal on the growth performance and carcass characteristics of broiler finishers (6-9 weeks) during hot-dry season

5.7.1.1 Performance of broiler finishers fed ascorbic acid and baobab fruit pulp meal diets during hot-dry season

Table 4.47 indicated significant ($P<0.05$) effects of ascorbic acid (AA) and Baobab Fruit Pulp Meal (BFPM) diets on the growth performance of broiler finishers (6-9weeks) during the hot-dry season. Ascorbic acid supplementations of 200mg/kg and 300mg/kg as well as 3.5% BFPM in the broiler finisher diets improved the performance of broiler finishers as reflected in final weight, weight gain, feed conversion ratio, feed cost per kg body weight. Although 7.5% BFPM diet was better than the control diet, it produced poorer results than the 3.0% BFPM diet. This result agreed with the report of Njoku (1980) who found that AA supplementation at 200mg/kg diet improved growth and feed intake and it lowered heat stress in broiler chickens. From this result, it is evident that AA supplementations between 200mg/kg and 300mg/kg diet and BFPM inclusion in the diet at 3.5% dietary level were optimum under hot-dry season condition for maintaining better performance of broiler finishers.

5.7.1.2 Carcass characteristics of broiler finishers (6-9 weeks) fed ascorbic acid and baobab fruit pulp meal diets during hot-dry season.

Table 4.48 shows effects of dietary levels of ascorbic acid and baobab fruit pulp meal on carcass characteristics of broiler finishers during hot-dry season. Significant ($P<0.05$) effect of diets were observed among treatment means. Birds fed 3.50% BFPM gave the best values for live weight, carcass weight and dressing percentages when compared with the AA and the control diets. Comparative analysis of AA and BFPM

(Table 4.54) further confirms that BFPM supplementation was better than the AA diets in terms of carcass characteristics, which suggest that BFPM could be used as replacement for synthetic AA in broiler finisher diet during hot-dry season. Based on these results, it will be profitable to use 3.5% BFPM supplemented feeds for broiler finisher diets for better carcass quality.

5.7.2 Effects of dietary level of ascorbic acid on the growth performance of broiler finishers (6-9 weeks) during hot-dry season.

Broiler finishers responded to ascorbic acid supplementation favourably up to 300mg/kg but no significant differences were observed between 200mg/kg and 300mg/kg diets in all the growth parameters studied except for percent mortality in which the 300mgAA/kg diet gave lower death rate. Similar observation was made on carcass characteristics except for giblet and abdominal fat deposits where 200mg/kgAA supplemented diet resulted in better performance than the 300mg/kgAA supplemented diet. The similarity of the performances observed between the 200mgAA/kg and 300mgAA/kg diets simply suggest that 200mg/kgAA was adequate in broiler finisher diet during the hot dry-dry season. This result corroborated that of Njoku (1986) who reported that ascorbic acid supplementation at 200mg/kg of broiler diet was adequate for broiler chickens. Judging from the above observations, it appears that 200mg AA/kg diet was the optimum for broiler finishers during the hot dry season.

5.7.3 Effects of dietary level of baobab fruit pulp meal on the growth performance and carcass characteristics of broiler finishers (6-9 weeks) during hot-dry season

With the exception of percent mortality and abdominal fat deposit, 3.5 % BFPM supplementation resulted in better growth performance and better carcass values than the

control, and the 7.0 % BFPM diets. The 7.0 % BFPM diet was however superior for growth performances and carcass values to the control diet except for giblets. The 7.0 % BFPM diet was however not economical for the broiler finishers when compared with the 3.5% BFPM diets. It appears that the bulkiness of the BFPM limits the level of its inclusion in diet. Powdery nature could also have affected feed intake and feed conversion ratio. The activity of BFPM at higher dietary inclusion rate is not clearly understood but it was reported to have a complexing effect on the digestion process (Binta and Khetarpaul, 1997; Ogundipe *et al.,* 2003; Forster, 2006). This could probably explain the apparent depression in broiler finisher performance observed. Consequently, not more than 3.5% BFPM can be recommended for inclusion in broiler finisher diets.

5.7.4: Comparative effects of control, ascorbic acid and baobab fruit pulp meal on the growth performance and carcass characteristics of broiler finishers (6-9 weeks) during hot-dry season

At the broiler finisher stage both sources of AA performed better than the control in all the growth parameters of broiler finishers studied during the hot-dry- season (Table, 4.53). BFPM inclusion in diets however resulted in better carcass qualities (Table 5.54) than the ascorbic acid and the control diets. Furthermore it will be advisable to use BFPM in broiler finisher diets than the synthetic ascorbic acid in view of the recent move towards the production of organic chickens and eggs.

5.8 Seasonal Comparison of the Effects of Ascorbic Acid and Baobab Fruit Pulp Meal on the Performance of Broilers and Laying Hens (Cool-wet versus Hot-dry seasons)

5.8.1 Comparison of Improvements Due to Ascorbic Acid and Baobab Fruit Pulp Meal Supplementations on Performances of Broilers and Laying Hens in Cool-wet and Hot-dry seasons

Effects on laying hens

Table 4.55 shows that inclusion of AA and BFPM improves hen-day egg production by 7.1% and 19.1% for cool-wet and Hot-dry seasons respectively above the control. Kgfeed/dozen eggs was improved by 5.53% and 11.71%. Similarly, there were 83.37% and 100% mortality reduction for cool-wet and hot-dry season respectively.

Effects on broiler starters

The comparison of improvement in performance of broiler starters due to inclusion of Ascorbic acid and Baobab Fruit Pulp Meal Diet indicated that final weight was improved by 4.69% and 20.16% during Cool-wet and Hot-dry seasons respectively. Weight gain was improved by 4.98% in cool-wet season and 22.45% in hot-dry season. Feed intake was improved by 3.66% and 15.77% in Cool-wet and Hot-dry seasons respectively. The percentage reductions in mortality were 27.74% and 30.60% for cool-wet season and Hot-dry season respectively.

Effect on Broiler Finishers

For the broiler finishers, weight gains were improved by 14.63% and 21.38% for cool-wet and hot-dry seasons respectively. The percent reduction in mortality of broiler finishers were 42.35% and 55.17% for cool-wet and hot-dry seasons respectively. This suggest that inclusion of AA and BFPM in broilers and layers diets improved efficiency in this sub-sector of poultry production. These observations indicated that supplementations were more effective in improving performances of broilers and laying hens in hot-dry season than cool-wet season.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

Three studies were carried out during the cool-wet and three studies were carried out during the hot-dry seasons to investigate the effects of ascorbic acid (AA) supplementations and dietary levels of baobab fruit pulp meal (BFPM) as sources of vitamin C in poultry diets. For the cool-wet season study, there was one layer study, one broiler starter study and one broiler finisher study. These experiments were repeated during the hot dry season. In the cool-wet season study, Ascorbic Acid (AA) was supplemented in layer and in broiler diets at 100, 200, 300mg/kg diet while baobab fruit pulp meal was supplemented at 3.5, 7.0 and 10.5% of diet. The control diet contained neither the AA nor the BFPM. Chemical analysis of the BFPM was also carried out to determine the proximate composition and anti-nutritional factor contents. The experiments conducted during the hot-dry season were replicas of the cool-wet season studies expect that the 10.5% BFPM dietary treatment was dropped due to poor performance of the birds on that diet during the cool-wet season study. Also during the hot season, haematological studies were conducted on layers and broilers. Rectal temperatures were also determined on the laying hens. At the end of the broiler finisher study, carcass analysis was performed. The following observations were made.

6.2 Conclusions

a) Cool-Wet Season Trials

1. Optimum AA supplementation in layer diets was found to be 200mgAA/kg diet during cool-wet season.

2. BFPM at 3.5% of diet was optimum for layers in terms of feed intake, feed cost/dozen eggs, income above feed expenses, % Hen-day egg production and mortality rate.
3. Supplementation of Ascorbic Acid at 300mg/kg diets was found to be optimum for broiler starter during cool-wet season.
4. 3.5% BFPM was found to be optimum for broiler starter diet in terms of feed intake, weight gain, feed cost per bird and percent mortality.
5. For the broiler finishers, 200mgAA/kg diet resulted in better performance in terms of feed cost/bird, feed conversion ratio and income above feed expenses.
6. BFPM at 3.5% inclusion rate was found to be the optimum for broiler finishers as shown in terms of improved weight gain, feed intake, feed conversion ratio and income above feed expenses.

b) Hot Season Trials

1. The optimum dietary supplementation of ascorbic acid in laying hen diets during the hot-dry season was found to be 200mgAA/kg diet.
2. BFPM at 3.5% of diet was found to be the optimum for laying hens during the hot-dry season, in terms of Hen-day egg production and egg quality parameters
3. During the hot-dry season 300mgAA/kg diet was found to be the optimum inclusion in broiler starter diet as reflected in better weight gain, feed cost per bird and low percent mortality rate. .
4. Baobab fruit pulp meal supplementation at 3.5% of inclusion in broiler starter diets gave optimum performance.
5. In hot-dry season, 200mgAA/kg diet was optimum for broiler finishers.
6. BFPM at 3.5% inclusion level was adequate for broiler finishers during hot-dry season.

7 BFPM in addition to being comparable to synthetic ascorbic acid supplementation in all the broiler finishers' performances characteristics, also resulted in better carcass quality than the ascorbic acid during the hot-dry season.

8. There were higher improvements in the performances of birds due to effects of supplementations of AA and BFPM in layers and broiler diets in both seasons. The effects were however more pronounced during the hot-dry season than during the cool-wet season.

6.3 General Recommendations

Based on the results from this study, it was therefore recommended as follows:

1. Ascorbic acid and Baobab Fruit Pulp Meal at 200mg AA/kg diet and 3.5 % respectively are beneficial for layer and broiler finisher flocks during both cool-wet season and the hot-dry season.
2. Ascorbic acid at 300mg/kg diet or 3.5% dietary inclusion of BFPM in broiler starter diet resulted in best performances during cool-wet season and during the hot-dry season.
3. BFPM supplementation at 3.5% of broiler starter, broiler finisher and in layer diets can replace up to 300mgAA/kg diet during both cool-wet and hot dry season.
4. BFPM supplementation at 3.5% of diet was more beneficial as a source of vitamin C than the synthetic vitamin C in broiler starter diets during hot-dry season.
5. The use of Baobab Fruit Pulp Meal (BFPM) is recommended for production of organic poultry products in terms of eggs and broiler meat.

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APPENDIX I

Samaru Weather Monthly Mean 2008

Month	Relative Humidity (%)	Temperature (^{o}C)	
		Maximum	Minimum
1	20	29	16
2	12	32	20
3	20	39	22
4	37	37	22
5	64	35	21
6	73	33	21
7	79	31	20
8	82	30	19
9	77	31	25
10	58	33	18
11	21	34	13
12	21	32	15

Source: Institute of Agricultural Research Metrological Station Ahmadu Bello University, Zaria

Samaru Weather Monthly Mean 2009

Month	Relative Humidity (%)	Temperature (^{o}C)	
		Maximum	Minimum
1	15	34	14
2	9	36	17
3	10	38	20
4	49	38	23
5	61	35	22
6	71	33	21

Source: Institute of Agricultural Research Metrological Station Ahmadu Bello University, Zaria