

OPTIMUM LEVEL OF UTILIZATION OF COOKED SWEET POTATO MEAL
(*Ipomoea batatas* LAM) IN BROILER CHICKEN DIETS

BY

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JUNE, 2014

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**DEPARTMENT OF ANIMAL SCIENCE,
FACULTY OF AGRICULTURE,
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ZARIA, NIGERIA**

JUNE, 2014

DECLARATION

I declare that the work in this thesis entitled “Optimum level of utilization of cooked sweet potato meal (*Ipomoea batatas* LAM) in broiler chicken diets” has been carried out by me in the Department of Animal Science, under the supervision of Professor I. I. Dafwang and Professor. F. O. Abeke. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

Ismaila jahun yakubu

Date

CERTIFICATION

This thesis entitled “OPTIMUM LEVEL OF UTILIZATION OF COOKED SWEET POTATO MEAL (*Ipomoea batatas*) IN BROILER CHICKEN DIETS” by Ismaila Yakubu Jahun meets the regulations governing the award of the degree of Master of Science in Animal Science of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literacy presentation.

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DEDICATION

I dedicate this work to my late father Malam Hussain Idris, my mother Hajiya Zainab Hussain, my beloved wife Amina Musa Ismail, my brothers M. Yakubu Hussain, Ado Yakubu and my children: Maryam Ismail, Ahmed Ismail and Abdulmalik Ismail for their support, prayers endurance and understanding.

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ABSTRACT

Proximate composition of cooked sweet potato meal (CSPM) was determined using AOAC (1990) methods. Four experiments were conducted with two set of birds. The first two experiments were carried out to determine the optimum level of utilization of cooked sweet potato meal (CSPM) in broiler diets and the variety of preference in the second experiments. Two hundred and seventy one-week old broiler chicks (hubbard breed) with an average weight of 93g were randomly allotted to six dietary treatments during experiment 1, with three replicates of 15 birds per replicate in a Completely Randomized Experimental Design. The experimental diets consisted of six levels of weight for weight substitution of maize with CSPM at 0, 10, 20, 30, 40 and 50% respectively. Results showed that at the starter phase birds on 5.4% CSPM diet had higher weights than all the other treatments including the control diet in terms of final weight, total weight gain, daily weight gain and feed conversion ratio. At the finisher phase, significant differences ($P>0.05$) were noted in the final weight, weight gain, daily weight gain, feed conversion ratio and feed cost as the level of CSPM increased in the diet. Growth performance was significantly depressed even at 10% CSPM replacement for maize. The carcass analysis also showed significant differences ($P>0.05$) in most parameters, but there was no clear cut trend except for the weight of liver that increased as the level of CSPM exceeded 10%. Dietary inclusion of CSPM significantly reduced the digestibility of DM, CF, EE and ash. Fibre digestibilities decreased linearly as CSPM replacement increased from 0 – 50%, while the ash retention also decreased linearly as CSPM increased from 0 – 30% of maize replacement. There was no mortality at both phases. In the second experiment, three varieties (white, orange and yellow) of CSPM were evaluated for proximate composition and anti-nutritional factors. At starter phase, One hundred and eighty one-week old broiler chicks (Hubbard breed) of mixed

sex with an average weight of 80g were randomly allotted to four dietary treatments with three replicates of 15 birds each in a Completely Randomized Experimental Design. The experimental diets consisted of diets formulated without sweet potato (control), 10% white-flesh CSPM, 10% orange-flesh CSPM and 10% yellow-flesh CSPM respectively. Performances of birds fed the three varieties of CSPM were better than those of birds fed the control diet at the starter phase, while at the finisher phase, significant ($P>0.05$) better performance was observed in the control group. They had better live weight, dressed weight, % breast, % thighs, % back cut and % shank than the values for the three varieties of CSPM. Nutrient digestibilities were generally higher in the bird fed control diet. White flesh CSPM based diet had relatively higher digestibility coefficient than orange and yellow flesh CSPM based diets. It was concluded that, broiler chickens at the starter phase can optimally tolerate a maximum of 5.4% CSPM in their diets. White-flesh variety of CSPM supported optimal performance at 10% dietary inclusion level with concomitant reduction in feed cost per kilogram. Further studies are recommended to determine replacement value of CSPM in broiler finisher diets.

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CHAPTER ONE

INTRODUCTION

Livestock play a very important role in the Nigerian economy contributing about 12.7% of the agricultural GDP (CBN, 1999). The Nigerian livestock population comprised of about 14 million cattle, 34.5 million goats, 22.1 million sheep, 114.3 million poultry, 0.9 million donkeys, 0.2 million horses, 0.09 million camels, 3.3 million cats, 1.7 million rabbits, 0.5 million guinea pigs, and 0.06 million giant rats (RIM, 1992). It is a common knowledge that meals without any piece of meat are a regular diet for a larger proportion of Nigerians. Nigerians consume less than 10g of protein per person per day out of which only about 3.2g is animal protein. This falls short of the FAO's recommended daily intake of 30g per caput per day (Dafwang, 2006). The high cost of animal protein in developing countries is the major constraint militating against the availability of the much-needed high quality protein food for the low income people. An increase in the standard of living almost inevitably calls for an increase in demand for animal protein. This situation calls for the production of fast growing animals like poultry. (Balogun, *et al.*, 2003).

As laudable as poultry is in bridging animal protein gap in Nigeria, the industry faces a lot of problems. The most important problem is sub-standard nutrition which needs urgent attention. This is because the production potential of birds depends mainly on the type of feed given (Egbewande, 2009). Good quality food is one of the reasons for livestock production, it involves the wise use of available feed ingredients in formulating a palatable, economical, and nutritionally balanced ration for livestock and poultry (Cole, 1966). Reduction in the cost of poultry feeds is by far the most important focus of researchers at least in the developing countries today (Oyedeji, *et al.*, 2003). Ayuk and Essien (2009) observed that feed gulps more than 80% of the total cost of running any poultry enterprise.

The keen competition between man and poultry for grains has been implicated in the rising cost of poultry production, (Ademosun and Esthiett, 1980 as cited in Oruwari *et al.*, 2003). Unfortunately, the survival of the poultry industry is dependent on the availability of feedstuff, which are mainly components of human food. There is therefore need for the animal nutritionist to radically seek for alternatives to the inadequate and expensive conventional feedstuffs to forestall an impending serious food crisis. (Okah and Onwujiariri, 2010). The rising cost of maize necessitate a research for cheaper and locally available non-conventional energy feed stuff such as sweet potato (*Ipomoea batatas* LAM). Considering the fact that sweet potato (*Ipomoea batatas* LAM) is traditionally grown as staple crop in many developing countries like Nigeria, this makes it locally available and relatively cheap. Sweet potato is widely adapted to divers altitudes (up to 2000 M) and temperature conditions. It requires practically low cash inputs and minimal agronomical practices and it competes better with weeds than other root and tuber crops (Scott, 1995). Moreover, it has low anti-nutritional factors, low fibre, high nitrogen free extract and is highly palatable. It can be incorporated into the diet of monogastric animals as a source of energy without any detrimental effect on their health and performance, thereby reducing the cost of feeding. Sweet potato is capable of thriving and yielding well on poor soils and may be a saving grace for the poultry industry (Afolayan, 2010).

Sweet potato is one of the world's most important food crops. Its main nutritional importance has been its starch content. However, sweet potato can also be a source of other nutritionally important dietary factors such as Vitamin A, Ascorbic acid, Thiamin, Riboflavin and Niacin (Dominguez, 1990). The few available reports agree that sweet potato can be incorporated into diets of chickens but should not be made the sole source of energy (Lee,1979; Lee, 1980; Winarno, 1982 and Tewe, 1991) as cited by in Afolayan, (2010).

Carbohydrates generally make up 80 to 90% of the dry weight of sweet potato roots, however, the uncooked starch of the sweet potato is very resistant to hydrolysis by amylase but when cooked, its susceptibility to the enzymes increases. Thus, after cooking, the easily hydrolysable starch fraction of sweet potato is reported to increase from 4 to 55%. (Cerning – Beroard and Le Devidich, 1976). Arising from several reports highlighted, it is well established that reduction of feed cost is a major concern of poultry producers, therefore replacement of part of traditional corn diet with a lower-cost alternative feed stuff like cooked sweet potato meal requires the assessment not only of the poultry performance and carcass characteristics, but also the general acceptability by birds (Poste, 1990).

1.1 RESEARCH HYPOTHESIS

- Ho. Partial replacement of maize with CSPM in the diets of broiler chickens does not have any significant effect on nutrient retention and utilization by the birds.
- HA. Partial replacement of maize with CSPM in the diets of broiler chickens have significant effect on nutrient retention and utilization by the birds.
- Ho. There is no significant difference in nutrient retention and utilization by broiler chickens fed diets containing three common varieties of cooked sweet potato meal.
- HA. There is significant differences in nutrient retention and utilization by broiler chickens fed diets containing three common varieties of cooked sweet potato meal.
- .

1.2 OBJECTIVES OF THE STUDY

- To evaluate the effect of partial replacement of maize with CSPM on growth performance and nutrient digestibility of broiler chickens at starter and finisher phases of feeding.

- To investigate the effect of partial replacement of maize with CSPM on carcass yield of broiler chickens.
- To determine the optimum replacement level of maize with CSPM in broiler chicken diets.
- To compare the performance in nutrient digestibility and utilization of broiler chickens fed the three common varieties of CSPM.
- To determine the economics of partial replacement of maize with CSPM in broiler production.

CHAPTER TWO

LITERATURE REVIEW

2.1 Description of Sweet Potato

Sweet Potato (*Ipomoea batatas* LAM.) is a tuberous-rooted perennial mainly grown as an annual. The roots are adventitious, mostly located within the top 25 cm of the soil. Some of the roots produce elongated starchy tubers. Tuber flesh colours can be white, yellow, orange and purple, while skin colour can be red, purple, brown or white. The stems are creeping slender vines, up to 4m long. The leaves are green or purplish, cordate, palmately veined, born on long petioles. Sweet Potato flowers are white or pale violet, axillary, sympetalous, solitary or in cymes. (Duke, 1983, Ecocrop, 2010).

Sweet potato is cultivated for food in more than 100 countries. The area under cultivation was estimated to be 8.5 million Ha in 2009 with a worldwide tuber yield of 12648 kg/ha (FAO, 2010). The main sweet potato producers are China, Indonesia, Vietnam, India, Philippines and Japan in Asia, Brazil and the USA in the Americas and Nigeria, Uganda, Tanzania, Rwanda, Burundi, Madagascar, Angola and Mozambique in Africa (FAO, 2010).

2.2 Origin and Distribution of Sweet Potato

The center of origin is thought to be between the Yucatan Peninsula of Mexico and the mouth of the Orinoco river, in Venezuela. Sweet potato is said to be as old as 8000 years since when first found in Peru. It is now widely cultivated between 40⁰N and 32⁰S up to 2000 M (and up to 2800 M in equatorial regions) (Ecocrop, 2010; Paneque, 1992). Sweet Potato is cultivated wherever there is sufficient water to support their growth; optimal annual rainfalls for growth ranges between 750 – 2000 mm. When rainfall is below 850 mm

irrigation may be necessary but it should be stopped before harvest in order to prevent the tubers from rotting, sweet potato is a warm – season annual, requiring 20-25⁰C average temperature and full sunlight for optimal development. Sweet potato thrives in well-drained loamy soils with high humus content that provides warm and moist environment to the roots. Optimal soil pH is between 5 and 7 (Ecocrop, 2010; Ecoport, 2010; Paneque, 1992). Sweet potatoes is mildly drought–tolerant and can survive dry spells during the summer. However, low humidity impairs crop quality even if the plant resumes growth after a water stress (Paneque, 1992, Ecoport, 2010). In Nigeria, there has been a gradual increase in the production of sweet potato; particularly in the northern part of the country where it is available in the markets all year round. (Afolayan, 2010).

2.3 Chemical Composition of Sweet Potato

The main nutritional importance of sweet potato has been its starch content. However, it can also be a source of other nutritionally important dietary factors, such as vitamin A, ascorbic acid, thiamin, riboflavin and niacin. However, sweet potato has low protein, fat and fibre levels, but the high nitrogen–free–extract fraction in this tuber is indicative of their main potential value as an energy source. Vines have a lower carbohydrate content but are higher in fibre and protein and so their principal nutritive value is as a source of vitamins and protein (Dominguez, 1990).

2.3.1 Carbohydrates in Sweet Potato

The principal constituent of edible carbohydrate is starch together with some sugars. Starches are made up of two main polymers, a straight chain glucose polymer called amylose, which usually constitute about 10-30 percent of the total, and the branched chain

glucose polymer, amylopectin, which makes up the rest. The proportion depends on the specie of root crop (Afolayan, 2010). In addition to starch together with some sugars, root crops also contain some non-starch polysaccharides; including cellulose, pectins and hemicelluloses; as well as other associated structural proteins and lignins, which are collectively referred to as dietary fibre. Sweet potato is a significant source of dietary fibre as its pectin content can be as high as 5 percent of the fresh weight or 20 percent of the dry matter at harvest (Collins and Walter, 1982). Fresh sweet potato tuber contains approximately 20% starch and 5% simple sugars. (Ayuk, 2004).

The structure of sweet potato starch does not differ from that of cereals and mandioca. (Szyliet *et al.*, 1978), the difficulty with its digestion could very well relate to the larger size of the starch molecule (25 μm), compared to the latter (12 μm). The carbohydrates content of sweet potato tubers consist of starch, sugars and small amount of pectins, hemicelluloses and cellulose (Lebot, 2009). Sugar content can be extremely variable, usually between 1 and 12% DM, but some US cultivars contained as much as 38% DM of sugars. The sugar composition of a cultivar, especially the sucrose values gives a reliable indication of its sweetness (Lebot, 2009).

Table 2.1 Proximate Composition of Major Root and Tuber crops

CROPS	DM	CP	EE	CF	ASH	NFE	Mcal/kg
Cassava (M. esculenta) ³	36	2.5	0.6	2.9	3.8	90	3.2
Potatoes (S. tuberosum) ¹	21	12.1	0.9	3.9	5.0	78	3.6
Sweet Potatos (I. batatas) ³	28	5.4	0.5	0.3	3.2	89	3.2
Taro (C. esculenta) ²	24	3.4	0.7	3.3	3.2	89	3.3
Water Yam (D. alata) ³	34	5.2	0.8	2.6	5.2	83	3.2
White Yam (D. rotundata) ³	31	6.4	0.4	2.7	4.3	86	3.7
Chinese Yam (D. esculent) ¹	20	8.9	0.6	3.5	4.3	83	3.3
Coco Yam (Xanthosoma Sp) ¹	41	5.9	0.8	2.6	1.7	89	3.6

Sources: 1 Khajarem *et al*: (1979)

Sources: 2: Harris *et al*: (1982)

Sources: Oyenuga and Fetuga (1975)

Table 2.1 shows the proximate composition of major root and tuber crops. Maize and sweet potato were reported to have comparable metabolizable energy value of 14.5 and 14.8 MJ/kg respectively (Woolfe, 1992). Fetuga and Oluyemi, (1976) reported that dehydrated sweet potato roots are superior energy sources compared with dehydrated cocoyam, yam and plantain meals. The digestibility of sweet potato carbohydrate fraction was reported to be above 90% inspite of the cellulose, hemicellulose and insoluble pectin amounting to 3.26, 4.95 and 0.6 percent respectively (Ravindran, 1995). However, Woolfe, (1992) reported that its starch decreased with the period of storage, while the levels of its reducing sugars, total sugars and total dextrins increased.

2.3.2 Protein Content of Sweet Potato

Sweet potato is low in protein. Analysis by Dominguez (1990) and Noblet *et al.*, (1990) showed that Sweet Potato contains 6.4% and 4.4 crude protein as shown in Table 2.2. These figures are in agreement with the 5.0% recorded by Eka (1990), and 5.36% recorded by Afolayan (2010). However, several environmental factors such as growing season (Bouwkamp *et al.*, 1985 and Lin, 1989), accumulated rainfall (Lin, 1989), location (Bradbury *et al.*, 1985) genotype (Purcell *et al.*, 1982), Edmond and Ammerman, (1971), nitrogen fertilization (Purcell *et al.* 1982 and Zhang *et al.* 1998) as well as cultural management and growth duration have been reported to influence protein content in sweet potatoes (Purcell *et al.* 1976). Yang (1982) reported that protein content of sweet potato varies between 2.0–7.5%, depending on the cultivar and treatment.

Table 2.2 Chemical Compositions of Sweet Potato Roots (% Dry matter)

	Noblet <i>et al</i> ., (1990)	Dominguez (1990)
Dry matter	----	29.2
N x 6.25	4.4	6.4
Ash	3.1	5.3
ADF	4.2	5.5
NDF	6.9	-----
Lignin	0.7	-----
Ether extract	0.6	-----
Gross energy (Mj/kg)	17.1	16

A range of 1.27% to 10.05% with the mean of 4.5% crude protein was reported by Li (1982). In another experiment with American cultivars, Dickey *et al.* (1984) reported 4.38% to 8.98% with the mean of 6.29% crude protein. However, Purcell *et al.* (1972) reported crude protein content range from 1.7% to 11.8% (dry weight basis). It is believed that nitrogen fertilizer increases the protein content of sweet potato but decreases the lysine, while aspartic acid and free amino acids increases. Also leafy growth increases at the expense of tuber production (Afolayan, 2010). Eka (1990) reported that, the protein of sweet potato are of high biological value, containing many of essential amino acids.

Table 2.3 Amino Acid Content of Sweet Potato Roots and Vine (g/100g protein)

		Purcell <i>et al.</i> (1972)	Li (1982)	Walter <i>et al.</i> (1978)
Essential amino acids		Roots	Vines	
Isoleucine	3.8	4.2-10.1	3.9-5.1	4.9
Leucine	7.0	7.8-9.2	6.2-7.9	9.6
Phenylalanine	6.7	11.9-13.6	7.2-10.1	10.6
Methionine and Cystine	3.5	2.8-3.8	3.0-3.9	2.8
Threonine	4.2	5.5-6.3	5.1-6.1	5.3
Tryptophan	1.0	0.8-1.2	=====	==
Valine	4.9	6.8-8.3	4.9-8.2	6.3
Lysine	7.0	4.2-7.2	4.3-4.9	6.2
Chemical score	100	80-109	85-110	80

Phenylalanine + tyrosine.

Source: Fuller and Chamberlain,(1982).

The protein of sweet potato is of acceptable nutritive value, with a chemical score of 82 and sulphur amino-acids (methionine and cystine) as the major limiting factor (Purcell *et al.*, 1972) as shown in Table 2.3. The quality of protein depends on the severity of heat treatment during the processing of sweet potato products (Walter *et al.*, 1983). When unheated sweet potato flour was added to wheat in the diet of rats at 30 percent level, the biological value of the diet was increased from 72 to 80 owing to the improved protein value (Afolayan, 2010). A similar result was obtained when sweet potato flour replaced rice (Yang, 1982). Afolayan, (2010) reported that SPM contains 92.76% DM, 5.36% CP, 2.93% Total ash, 0.71% ether extract, 9.22% CF, 81.78% NFE, 3050 MEKcal./kg, 8.90mg/100g TIA, 0.67 mg/100g HCN and 0.082g/100g Phytic acid.

2.3.3 Lipid Content of Sweet Potato

Sweet potato like other root crops have low lipids content (Afolayan, 2010). Monday and Mueller (1977) put the sweet potato lipid content at about 2.7 percent. These are mainly lipids of the cell membrane, which enhance cellular integrity, offer resistance to bruising and help to reduce enzymic browning. Most of the lipids contain equal amounts of unsaturated fatty acids, linoleic and linolenic acids and the saturated fatty acids stearic and palmitic. This statement was supported by the fatty acid analysis carried out by Osagie and Opute (1981) as shown in Table below:

Table 2.4 Fatty Acid Analysis of the Total Neutral and Polar Lipid Fractions from Sweet Potato

Lipid		% Fatty Acid						
Classes		14.0	16.0	18.0	18.1	18.2	18.3	20.0
Total lipids	t	21.7	4.6	0.6	58.2	12.2	1.6	
Non polar lipids	t	35.2	2.1	0.4	46.6	12.9	1.3	
Glycolipids	t	23.4	1.7	0.3	58.8	12.7	1.1	
Phospholipids	t	34.3	3.8	1.3	50.0	8.0	t	

t = not estimated

Source: Osagie and Opute (1981)

2.3.4 Vitamin Contents of Sweet Potato

Most roots and tubers contain only negligible amounts of beta carotenes (vit.A precursors) with the exception of selected varieties of sweet potato. Deep coloured varieties are richer in carotenes than white cultivars. Afolayan, (2010) and Dominguez, (1990) reported that, sweet potato is a source of important dietary factors, such as ascorbic acid, thiamin, riboflavin and niacin. One of the nutritional advantages of sweet potato is sufficient and regular ingestion of sweet potato leaves, together with the tubers of high beta-carotene varieties can meet the consumers daily requirement of vitamin A, and hence prevent the dreadful disease known as xerophthalmia, which is responsible for nutritional blindness in many sub-saharan countries and in Asia (Afolayan, 2010). The dessert type of sweet potato is even higher in beta-carotene and it has been estimated that an intake of 13g/day will be sufficient to meet the vitamin A requirement of humans. Most of the root crops contain small amount of the vitamin B group sufficient to supplement normal dietary sources for humans. The B group of vitamins acts as a co-factor in enzyme systems involved in the oxidation of food and the production of energy. For every 1,000 Kcal of carbohydrate ingested, about 0.4 mg of vitamin B, (thiamine) is needed for proper digestion. Sweet potato contains 0.8-1.0 mg/1000 kcals which is about double this requirement (Afolyan, 2010). Villareal *et al.* (1985) estimated that a hectare of land planted with sweet potato will provide about eight times as much vitamin B₁₂ (riboflavin) as a hectare planted with rice. Ananzonwu–Bello (1977) have estimated vitamin B content of raw sweet potato and reported 127, 23 and 0.63 mg/100g thiamine, riboflavin and niacin respectively. The values reported for the cooked sweet potato were however lower for thiamin (117mg/100g) and niacin (0.57mg/100g) but higher for riboflavin (29mg/100g). However, vitamin C occurs in appreciable amounts in

several root crops, sweet potato inclusive. There is a report of the occurrence of some vitamin E, up to 4mg per 100g in sweet potato (Afolayan, 2010)

2.3.5 Mineral Content of Sweet Potato

Sweet potato tuber is rich in minerals such as Ca, P, K, Na, Cl, Fe, Cu, and Mn. (Table 2.5) shows that potassium is the major mineral in sweet potato while sodium tends to be low. This makes some root crops particularly valuable in the diet of patients with high blood pressure, who have to restrict their sodium intake. In such cases the high potassium to sodium ratio may be an additional benefit (Meenely and Battarblee, 1976). However, high potassium foods are usually omitted in the diet of people with renal failure (McCay *et al.*, 1975). As root crops are low in phytic acid relative to cereals, those minerals liable to inactivation by dietary phytic acid are more available than in cereals. In addition, the high vitamin C concentration in some root crops may help to render soluble iron and make it more available than in cereals and other vegetable foods.

Table 2.5 Mineral Content of Sweet Potato

Minerals	Amount
Ca (mg/100g)	25.0
P (mg/100g)	28.0
K (mg/100g)	508.0
Na (mg/100g)	54.0
Fe (Ug/Kg)	64.0
Cu (Ug/Kg)	62.0
Mn (Ug/Kg)	9.3
Cl (Ug/Kg)	26.0

Source: Ananzonwu-Bello (1977)

2.4.0 Anti-nutritional Factors in Sweet Potato

There are many non-nutrient substances present in root and tuber crops, which limit their wider use. Some of these substances are either potentially toxic or may adversely affect the feed intake and bioavailability of nutrients. Compounds which act to reduce nutrient utilization and or feed intake are often referred to as anti-nutritional factors (ANF). These substances may be grouped into cyanogenic-glycosides, proteinase inhibitors, oxalates, phytates, tannins, alkaloids/steroids and acidity factors. Some of them are sensitive to normal processing temperatures, while others are resistant to these temperatures. (Afolayan, 2010).

2.4.1 Trypsin Inhibitors in Sweet Potato

The presence of trypsin inhibitors in the raw sweet potato tubers could decrease the protein digestibility in mixed feed. Sweet potatoes contain trypsin inhibitors which may reduce ability to utilize protein if eaten raw (Wanda, 1995). The vines do not produce this effect because they do not contain great quantities of inhibitors. Very small amounts of proteinase inhibitors, trypsin and chymotrypsin inhibitors have been reported by Sumathai and Pattabiraman (1975) and Bradbury and Hollway, (1988). Various levels of trypsin inhibitor activity (TIA) in sweet potato cultivars have been reported (Lin and Chen, 1980; Dickey *et al.* 1984; Bradbury *et al.* 1985; Dominguez, 1990 and Afolayan, 2010).

Table 2.6 Percentage Inhibition of Trypsin in Sweet Potato and Soybean

Specimen	Inhibition (%)
Raw Soybean	89.5
Soybean meal	33.7
Raw Sweet Potato	78.8
Cooked Sweet Potato	16.7
Fresh vines	26.1
Vine meal	16.7

Source: Dominguez (1990)

The trypsin inhibitors can be destroyed or reduced to minimum by preheating the raw sweet potato roots. Moist heat treatment at temperatures above 80°C are effective in eliminating trypsin inhibitor activity in sweet potatoes Ravindran (1995). Dominguez, (1992) reported that cooking improves the feeding value of the tubers since it reduces trypsin inhibitors and improves starch digestibility. He however reported that trypsin inhibitor content is very variable between varieties (2.6 to 32.0) Tui/g. Cooking sweet potato is therefore necessary on account of two factors; to increase its starch digestibility and reduce presence of trypsin inhibitors as shown in Table 2.6 above (Dominguez, 1990). There is a significant correlation between the trypsin inhibitor content and the protein content of sweet potato varieties. Lawrence and Walker (1976) have implicated TIA in sweet potato as a contributory factor in the disease enteritis necroticans. Trypsin inhibitors are of no consequence in cooked sweet potato. Boiling or heating to 90°C for several minutes inactivates and removes acidity in sweet potato (Obidairo and Akpochafo, 1984 and Wanda, 1995). Sasi and Padmaja (2003) reported that when sweet potato tuber was cooked between 17 and 31% trypsin inhibitor activity remained and when it was prepared into flour, only 5 – 12% trypsin inhibitor activity was found.

2.4.2 Oxalate in Sweet Potato

The presence of oxalates has also been reported in sweet potato by (Raven and Smith, 1976 and Smith, 1982), though only in minute quantities. Oboh *et al.* (1989) recorded the mean value of total oxalate content of 49 varieties of sweet potatoes as 0.71% of DM. Zhang and Corke, (2001) reported that, raw sweet potato contains oxalate up to 1.2g/Kg DM. The presence of non-identified factors, which inhibit the digestive and metabolic processes, are suggested in sweet potato based rations. These factors caused low dry matter

digestibility and low metabolizable energy and protein values, when the rations contained adequate and high quality proteins (Gerpacio *et al.* 1978).

Afolayan, (2010) reported that the low level of phytic acid (0.091g/100g), HCN (0.96Ug/100g) and TIA (9.01mg/100g) in raw sweet potato is below the levels that have been injurious to poultry. The slight increase experienced in TIA as the dietary sweet potato meal (SPM) increased suggest that sweet potato as a tuber crops contains higher TIA than maize, the cereal crop it replaced in the diets.

2.5 The Uses of Sweet Potato in Poultry Feeding

Sweet potato tuber, vines and foliage product have been evaluated in many forms as feedstuff for livestock. They were fed raw, cooked, dehydrated or as silage (Afolayan, 2010). Results from various studies; Rosemberg and Sen, (1952), Yoshida and Morimoto, (1958), Edmond and Ammerman, (1971) Job *et al.* (1979) and Oboh, (1986) point to dehydrated sweet potato as a fairly suitable in partial replacement for energy in livestock diets. Turner *et al.* (1976), evaluated various rations containing cooked sweet potato and a protein supplement for poultry feeding and reported that broiler chicks fed on the maize based control diet reached slaughter weight faster than those fed on sweet potato diets, however, broilers fed cooked sweet potato based diets had higher dressing percentages. Results of the organoleptic evaluation of birds slaughtered at 13 weeks of age showed that meat from chickens fed a diet in which 75% of the corn was replaced by sweet potato, had the best flavour (Mohammed *et al.*, 1974). Yoshida and Morimoto (1958) and Ravindran (1995) reported the carbohydrate fraction in sweet potato was about 90% digestible in chicks. However, the level of starch decreased with period of storage and instead the level of reducing sugars, total sugars and total dextrin increased (Woolfe, 1992). Fetuga and Oluyemi

(1976) obtained a coefficient of metabolizable energy of 90.9 or 87.2 in diets where the tuber replaced 25 or 40% of the glucose in a basal diet. At both levels, the rate and efficiency of gain were best for the sweet potato diets. These results suggested that, as an energy source, sweet potato tuber is as efficiently utilized as maize by chicks. Lee and Yang (1979) reported that chickens fed diets containing a 24 percent substitution of corn with sweet potato grew as well as on the all-corn diet, with no significant difference in carcass quality while the egg yolk contained more vitamin A.

The performance of two-week old broiler chickens fed rations containing sweet potato root meal replacing 0, 50, 75 and 100% of corn in the rations up to 6 weeks of age was studied (Gerpacio *et al.*, 1978). The comparison was carried out on the basis of feed intake, weight gain, feed efficiency, dressing percentage and digestibility or availability of the major nutrients (dry matter, fibre, protein and energy). It was reported that the performance of birds fed sweet potato especially at the higher levels was less satisfactory compared to corn, suggesting that for the tuber, only 50% or at the most, 75% replacement of the corn is advisable. Woolfe (1992) also reported the replacement of 50% to 75% maize in poultry fed with dried sweet potato flour without adverse effect on the growth of broiler chickens. Nguyen *et al.* (2001) recommended 20% and 30% sweet potato inclusion for young birds under 8 weeks and layers respectively. In a similar experiment Maphosa *et al.* (2003) reported that the inclusion of sweet potato produced negative effect on the performance of broiler chickens. A significant decline in weight gain was noticed with increase in the inclusion of sweet potato during the starter and finisher phases respectively. There was also a numerical decline in the feed intake, though not significantly different for up to 75% maize replacement level. Feed conversion declined with increase in inclusion of sweet potato meal though not significantly up to 50% inclusion level. Mortality was said to

increase with increase in sweet potato inclusion beyond 25% level. Ravindran and Sivakanesan (1996) reported that the level of SPM had no effect on mortality rate. Maphosa *et al.* (2003) also showed that sweet potato inclusion produced a relatively higher ($P>0.05$) weight of pancreas, intestine and caeca for birds on and above 50% maize replacement levels, which was not different from those on control diet. Sweet potato had no effect on carcass quality of broiler chickens at eight weeks of age. Maphosa *et al.* (2003) recommended the inclusion of sweet potato at a level of 50% maize replacement in broiler finisher but none in starter diets.

In another experiment, sweet potato meal (SPM) was fed to broiler chicks by Afolayan, (2012) at graded levels of 0, 10, 20, 30, 40, 50 and 60% on weight for weight substitution for maize. Results showed that the weight gain, feed cost and total cost of raising birds decreased significantly while feed cost/kg weight gain and feed efficiency increased. The control, 10% and 20% SPM diets groups gave similar feed efficiency on weight to weight replacement of maize with SPM. In a separate experiment birds were fed at 0, 10, 20, 30, 40 and 50 in isonitrogenous broiler starter diets performance of those on 0, 10 and 20% SPM diets was not different from that of 30% when diets were made isonitrogenous (Afolayan, 2010). However, results of the boiler finisher experiment showed that SPM had a significant adverse effects on performance at levels beyond 20% when SPM was used to replace maize on weight to weight basis. Performance was not affected until SPM was included beyond 30% level in isonitrogenous diets.

Agwunobi (1999) recommended 27% and 30% levels of sweet potato in the starter and finisher diets respectively. Sobamiwa (1988) had earlier used sweet potato up to the level of 20% in the diet of laying chickens and reported no significant differences in daily

feed intake, total egg production, average egg weight, average final live weight and feed conversion ratio when compared with the control diet.

Tewe, (2001) evaluated the suitability of sun-dried sweet potato as poultry feed and found out that body weight gain and nutrient utilization reduced significantly with the inclusion of sweet potato at the levels of 50% and 100% maize replacement in broiler chicken diets, while performance was better in oven-dried sweet potato rations at all levels. Canope *et al.* (1977) found that cooking improved digestibility of all nutrients, but especially of nitrogen. In a trial with broiler chickens placed on diets having 0, 10, 20, 30, 40 and 50 percent maize replacement levels, performance was found to be optimal at 30% maize replacement level compared with birds on the control diet, performance parameters were inferior on oven-dried sweet potato diets at the starter phase. At finisher phase, favourable results were obtained at up to 30% maize replacement level. Dressed carcass was reported to show poorer results ($P>0.05$) for the test diet while the dressing percentages were similar with control group (Tewe, 2001). It was reported that mortality increased with higher levels of sweet potato inclusion, being higher in sun-dried complete maize replacement diet. Abdominal fat decreased ($P>0.05$) with increase in sweet potato inclusion while replacement of maize with sweet potato decreased ME at levels above 30% at starter phase. The presence of un-identified factors, which inhibit the digestive and metabolic processes were suggested in sweet potato based rations. These factors caused low dry matter digestibility and low metabolizable energy and protein values even when the rations contained adequate and high quality proteins. (Gerpacio *et al.*, 1978).

Dried sweet potato vines can be used in poultry rations as a source of protein and carotenoids, particularly beta-carotene and xanthophylls and have been included in diet to enhance yellow pigmentation of broiler skins and egg yolks. Early – harvested vines were as

efficient as alfalfa meal at colouring yolks. Late – harvested vines were less efficient at colouring broiler skin (Woolfe, 1992). An optimum of 10% level of sweet potato inclusion in broiler diets has been suggested, as higher levels resulted in decrease of dry matter intake and body weight gain (Berhan, *et al.* 2010) and levels of 20-30% reduced the feed conversion efficiency (Kagya – Agyemang *et al.*, 2008). However, dried vines included at up to 16% in broiler chicken diets have been shown to be as efficient as alfalfa meal for growth rate, feed intake and feed efficiency (Ferrel *et al.*, 2000) and 15% could be economically feasible if birds are sold on eviscerated carcass weight basis rather than live weight (Wude and Berhan, 2009).

CHAPTER THREE

MATERIALS AND METHODS

3.1: Experimental Site

The study was conducted at the Research Farm of the Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria. Zaria is located within the Northern Guinea Savannah zone of Nigeria, on the Latitude $11^{\circ} 9' 45''$ N and Longitude $7^{\circ} 38' 8''$ E, at an altitude of 610M above sea level (Ovimaps, 2012).

3.2: Source of Experimental Birds

The 270 experimental day old broiler chicks of Hubbard strain (mixed sexes) were obtained from Zarm Farm at Illomena Kwara State

3.3: Experiments 1 and 2: Partial Replacement Value of Cooked Sweet Potato Meal (CSPM) for Maize in Broilers Diets (1–4 and 5-8 weeks)

3.4: Source and Processing of Sweet Potato Tubers

Fresh sweet potato tubers used for the study were purchased from Bomo village, Sabon Gari Local Government Area of Kaduna State. The fresh tubers were washed, sliced to about 4cm length and 2cm thickness and cooked in boiled water at 100°C for 45minutes and thereafter sun dried for 10 days on concrete floor to reduce enzymatic and microbial reactions which may lead to spoilage. The dried cooked sweet potato tubers were then milled using a hammer mill before incorporation into the diets.

3.4.1: Determination of Proximate Composition of Raw and Cooked Sweet Potato Meal (SPM)

Samples of raw and cooked sweet potato tubers were sun dried on concrete floor for 10 days. The dried samples were then milled separately using a hammer mill and subjected for their chemical composition, according to the methods described by AOAC (1990).

Nutrient determined were percent crude protein (CP), crude fiber (CF), ether extract (EE), ash and nitrogen free extract (NFE). However metabolizable energy in kcal/kg was calculated using the procedure described by (Pauzenga, 1985) as shown below:

$$\text{ME kcal/kg} = (37 \times \% \text{CP} + 81.8 \times \% \text{EE} + 35 \times \% \text{NFE})$$

3.4.2: Experimental Diets (Experiments 1 and 2)

The experiments comprised of six dietary treatments, containing 0, 10, 20, 30, 40 and 50% levels of CSPM substituted for maize. The starter (1 week old) and finisher (5 weeks old) diets contained 2900 and 3000 Kcal/kg metabolisable energy respectively as shown in Tables 3.1 (page 29) and 3.2 (page 30) respectively.

3.4.3: Experimental Design and Management of Experimental Birds

A total of two hundred and seventy one week old boiler chicks, Hubbard strain, mixed sexes, were used for the study at the starter phase (1-4 weeks experiment 1). At the end of the starter phase, the birds were pooled and fed a control diet from 4 – 5 weeks old. The same number of 270 five weeks old broiler chickens were used for the finisher phase (5-8 weeks experiment 2). The birds were weighed and randomly allotted to six dietary treatments. Each treatment had 45 birds that were divided into 3 replicate groups of 15 birds each. Treatments were arranged in a Completely Randomized Experimental Design. The birds were reared in a deep litter system. Wood shavings were provided to serve as litter materials. The replicate pens were equipped with feeding troughs and drinkers. Feed and water were provided *ad libitum* daily. All recommended health practices were strictly followed and light provided in the night hours, at both starter and finisher phases.

3.4.4: Data Collection

The birds were weighed at the beginning of the experiment and then weekly after. Data was collected on initial weight, final body weight, body weight gain, daily weight gain, feed intake, daily feed intake, feed conversion ratio (FCR), feed cost per kg, feed cost per kg gain, feed cost per bird, income above feed expenses (IAFE) and mortality.

Table 3.1: Composition of Broiler Starter Diets with Graded Levels of CSPM

Ingredients	% Replacement of Maize with CSPM					
	00	10	20	30	40	50
Maize	54.00	48.60	43.20	37.80	32.40	27.00
CSPM	00.00	5.40	10.80	16.20	21.60	27.00
Soybean cake	18.00	18.00	17.90	17.75	17.50	17.30
Groundnut cake	20.00	20.00	20.00	20.00	20.00	20.00
Fish Meal	3.00	3.00	3.00	3.00	3.00	3.00
Palm Oil	1.00	1.00	1.10	1.25	1.50	1.70
Bone Meal	3.00	3.00	3.00	3.00	3.00	3.00
Common Salt	0.30	0.30	0.30	0.30	0.30	0.30
D-L Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15	0.15	0.15
*Vitamin mineral Premix	0.30	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis						
ME Kcal/kg	2966	2953	2948	2940	2941	2938
Crude Protein (%)	23.63	23.43	23.18	22.91	22.60	22.32
Crude fibre (%)	3.43	3.56	3.85	4.06	4.26	4.46
Ether Extracts (%)	5.04	4.88	4.88	4.80	4.88	4.91
Calcium (%)	1.26	1.26	1.26	1.26	1.26	1.26
Available P. (%)	0.69	0.69	0.69	0.69	0.67	0.67
Lysine (%)	1.25	1.25	1.25	1.24	1.23	1.23
Methionine (%)	0.62	0.62	0.61	0.60	0.59	0.59
Feed cost (₹/kg)	86.36	84.24	82.25	80.32	78.50	76.62

*Bio mix (B) vitamins-min-premix provide per kg of diet: Vit. A, 10,000 iu; vit. D₃, 2,000 i.u. it. B₁₂, 5.50mg; Folic acid, 0.75mg; Choline Chloride, 300 mg; Niacin, 27.5mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Iodine, 10mg; Cobalt 0.2mg; Antioxidant. 1.25mg.

Table 3.2: Composition of Broiler Finisher Diets with Graded Levels of CSPM

Ingredients	% Replacement of Maize with CSPM					
	00	10	20	30	40	50
Maize	60.00	54.00	48.00	42.00	36.00	30.00
CSPM	00.00	6.00	12.00	18.00	24.00	30.00
Soybean cake	14.00	13.50	13.00	12.70	12.50	12.00
Groundnut cake	18.00	18.00	18.00	18.00	18.00	18.00
Fish Meal	3.00	3.00	3.00	3.00	3.00	3.00
Palm Oil	1.00	1.50	2.00	2.30	2.50	3.00
Bone Meal	3.00	3.00	3.00	3.00	3.00	3.00
Common Salt	0.30	0.30	0.30	0.30	0.30	0.30
D-L Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15	0.15	0.15
*Vitamin mineral Premix	0.30	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis						
ME Kcals/kg	3025	3038	3052	3054	3051	3064
Crude Protein (%)	21.50	21.06	20.61	20.26	19.95	19.51
Crude fibre (%)	8.26	7.46	7.67	7.79	7.61	7.32
Ether Extracts (%)	5.04	5.34	5.64	5.75	5.76	6.06
Calcium (%)	1.25	1.25	1.24	1.24	1.24	1.24
Available P. (%)	0.69	0.68	0.67	0.67	0.66	0.66
Lysine (%)	1.15	1.13	1.11	1.10	1.10	1.10
Methionine (%)	0.60	0.59	0.58	0.57	0.56	0.55
Feed cost (₦/kg)	83.86	81.11	80.36	78.37	76.26	74.51

*Bio mix (B) vitamins-min-premix provide per kg of diet: Vit. A, 10,000 iu; vit. D₃ 2,000 i.u. it. B₁₂, 5.50mg; Folic acid, 0.75mg; Choline Chloride, 300 mg; Niacin, 27.5mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Iodine, 10mg; Cobalt 0.2mg; Antioxidant. 1.25mg.

3.4.5: Digestibility Trial

A digestibility trial was carried out at the end of (8 weeks of age) of the finisher phase of the experiment, in a metabolic cages. Three birds were randomly selected from each treatment, (1 bird per replicate group). The birds were placed in alternate cages, with polythene bag attached to the base of each cage compartment. The birds were fed with the control diet for 7 days adjustment period and fasted for 24 hours with only water given to them. An equal quantity of 116g experimental diets were allocated to each bird by 8:00am daily. Total droppings were collected daily, separated from feeds and other extraneous materials manually, weighed, bulked together and kept in a deep freezer. At the end of the six days, the birds were starved overnight. The remaining faeces were then collected on the 7th day. The total droppings were thawed and weighed after they were thoroughly mixed together and oven dried for 72 hours at 65⁰C. The dried droppings were then weighed and ground after which samples were taken for proximate analysis along with the sample of experimental feed given. Digestibility was determined for crude protein, crude fibre, ether extract, ash and nitrogen free extract using the equation:

$$\text{Nutrient Retention} = \frac{\text{Nutrient intake} - \text{Nutrient output}}{\text{Nutrient intake}} \times \frac{100}{1}$$

3.4.6: Carcass Analysis

At the end of the finisher phase, three birds (3) were selected from each treatment (1 bird per replicate group) reflecting the average weight of their pen for carcass analysis. The selected birds were fasted overnight but given water, they were then weighed, bled by severing their jugular veins, scalded in hot water, defeathered and eviscerated. The head, neck, shanks and viscera were removed to get the dressed weight. Dressing percentage, weight of organs and various parts of the body were measured. The head, shanks, abdominal

fat and organs were expressed as a percent of live weight while the cut up parts were expressed as a percentage of dressed weight.

3.4.7: Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA) using the General Linear Model (SAS package 2002). Significant differences between treatment means were separated using Least Significant Differences (LSD). Trend analysis was used to determine the optimum level.

3.5: Experiments 3 and 4: Performance of Broiler Chickens (1-4 and 5-8weeks) fed Three Varieties of CSPM at 10% Level of Replacement for Maize in the Control diet

3.5.1: Source and Processing of Three Varieties of Sweet Potato Tubers

Three common varieties of sweet potato tubers (white-fleshed, orange-fleshed and yellow-fleshed), abbreviated as CSPM = Cooked Sweet Potato Meal, RWSPM = Raw white-fleshed sweet potato meal, CWSPM = Cooked white-fleshed sweet potato meal, ROSPM = Raw Orange-fleshed sweet potato meal, COSPM = Cooked Orange-fleshed sweet potato meal, RYSPM = Raw Yellow-fleshed sweet potato meal and CYSPM = Cooked Yellow-fleshed sweet potato meal. The three varieties were purchased fresh from Bomo village, Sabon Gari Local Government Area of Kaduna State. The fresh tubers were washed, sliced to about 4cm length and about 2cm thickness, cooked in boiled water at 100⁰C for 45 minutes and sun dried for 10days on concrete floors to reduced moisture content to minimum, in order to minimize the enzymatic and microbial reactions that can lead to spoilage. The dried cook sweet potato tubers where then milled separately using hammer mill before incorporation into the diet.

3.5.2: Determination of Proximate Composition of the Three Varieties of Sweet Potatoes Meal (Raw and Cooked)

Samples of the three common varieties (white-flesh, orange-flesh and yellow-flesh) of raw and cooked sweet potato tubers were sun dried on concrete floor for 10 days. The dried samples were then milled separately using a hammer mill and subjected for their proximate composition, according to the methods described by AOAC (1990).

Metabolizable energy in kcal/kg was calculated for each variety using the procedure described by (Pauzenga, 1985) as shown below:

$$\text{ME kcal/kg} = (37 \times \% \text{CP} + 81.8 \times \% \text{EE} + 35 \times \% \text{NFE}).$$

3.5.3: Determination of Anti-nutritional Factors of the Three Varieties of Sweet Potato Meal (Raw and Cooked)

Phytic acid was determined by the method of Reddy *et al.* (1982) in which percent phytic acid was calculated using the formula: % phytic acid = $X \times 1.19 \times 100/2$. Where X = Titre value $\times 0.00195$. Cyanide was extracted with 0.1 M Ortho- H_2PO_4 and estimated using an auto analyzer according to the method of Rao and Hahn (1984). Trypsin inhibitor activity was determined using benzoyl-DL-arginine-P-nitroanilide (BAPNA) as substrate by the method of Kakade *et al.* (1974). Tannin was determined using the method of Mega (1982). Percentage tannin was calculated using the formula: % Tannin = Absorbance $\times$ Average gradient $\times$ Dilution factor/ 10,000. Oxalate determination was carried out as described by Fasset (1966). It was calculated by 1ml of 0.05N $\text{KMnO}_4 = 0.0225$ anhydrous oxalic acid. % Oxalic acid = Titre value $\times 0.00225 / 2 = \text{T.U} \times 0.1125$.

3.5.4: Experimental Diets (Experiments 3 and 4)

The best results among the replacement level of CSPM determined from experiments 1 and 2 were used as the inclusion rate for the three different varieties of sweet potato tubers

(white-fleshed, Orange-fleshed and Yellow-fleshed CSPM) which replaced 10% of maize in the control diet Tables 3.3 (page 35) and 3.4 (page 36) respectively.

Table 3.3: Composition of Broiler Starter Diets with Three Varieties of Cooked Sweet Potatoes Replacing 10% of Maize in the Control Diet

Ingredients	Control	Varieties of CSPM		
		White-flesh	Orange-flesh	Yellow-flesh
Maize	54.00	48.60	48.60	48.60
CSPM	00.00	5.40	5.40	5.40
Soybean Cake	18.00	18.00	18.00	18.00
Groundnut Cake	20.00	20.00	20.00	20.00
Fish Meal	3.00	3.00	3.00	3.00
Palm Oil	1.00	1.00	1.00	1.00
Bone Meal	3.00	3.00	3.00	3.00
Common Salt	0.30	0.30	0.30	0.30
D-L Methionine	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15
*Vitamin mineral premix	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00
Calculated Analysis				
ME Kcals/Kg	2966	2969	2987	2969
Crude Protein%	23.63	23.47	23.85	23.78
Crude Fibre %	3.43	3.30	3.30	3.30
Ether Extract %	5.04	4.85	4.86	4.86
Calcium %	1.26	1.26	1.26	1.26
Available P. %	0.69	0.69	0.69	0.69
Lysine %	1.25	1.25	1.25	1.25
Methionine %	0.62	0.62	0.62	0.62
Feed Cost	94.43	87.28	87.28	87.28

(~~Rs~~/Kg)

*Bio mix (B) vitamins-min-premix provide per kg of diet: Vit. A, 10,000 iu; vit. 0₃2,000 i.u it. B₁₂, 5.50mg; Folic acid, 0.75mg; Choline Chloride, 300 mg; Niacin, 27.5mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Iodine, 10mg; Cobalt 0.2mg; Antioxidant. 1.25mg.

Table 3.4: Composition of Broiler Finisher Diets with Three Varieties of Cooked Sweet Potatoes Replacing 10% of Maize in the Control Diet

Ingredients	Varieties of CSPM (10%)			
	Control	White-flesh	Orange-flesh	Yellow-flesh
Maize	60.00	54.00	54.00	54.00
CSPM	00.00	6.00	6.00	6.00
Soybean Cake	14.00	14.00	14.00	14.00
Groundnut Cake	18.00	18.00	18.00	18.00
Fish Meal	3.00	3.00	3.00	3.00
Palm Oil	1.00	1.00	1.00	1.00
Bone Meal	3.00	3.00	3.00	3.00
Common Salt	0.30	0.30	0.30	0.30
D-L Methionine	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15
*Vitamin Mineral Premix	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00
Calculated Analysis				
ME Kcals/Kg	3025	3028	3031	3028
Crude protein %	21.50	21.30	21.75	21.64
Crude Fibre %	7.06	7.91	7.90	7.91
Ether Extract %	4.05	3.84	3.84	3.84
Calcium %	1.25	1.25	1.25	1.25
Available P. %	0.69	0.68	0.68	0.68
Lysine %	1.15	1.13	1.13	1.13
Methionine %	0.60	0.59	0.59	0.59
Feed Cost (₹/Kg)	94.43	87.28	87.28	87.28

*Bio mix (B) vitamins-min-premix provide per kg of diet: Vit. A, 10,000 iu; vit. D₃ 2,000 i.u. it. B₁₂, 5.50mg; Folic acid, 0.75mg; Choline Chloride, 300 mg; Niacin, 27.5mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Iodine, 10mg; Cobalt 0.2mg; Antioxidant. 1.25mg.

3.5.5: Experimental Design and Management of Experimental Birds (1-4 and 5-8weeks)

A total of one hundred and eighty one-week old boiler chicks, Hubbard strain, mixed sexes, were used for the study at the starter phase (1-4weeks experiment 3). At the end of starter experiment, the birds were pooled and fed with control diet from 4 – 5weeks old. One hundred and sixty eight 5-weeks old broiler chickens were used at the finisher phase (5-8weeks experiment 4). Treatments were arranged in a Completely Randomized Experimental Design. The birds were weighed and randomly allotted in to 3 replicate groups of 14 birds each to the four dietary treatments. The birds were reared on a deep litter system. Wood shavings were provided to serve as litter materials. The pens were equipped with feeding troughs and drinkers. Light was provided at night hours. Feed and water provided *ad libitum* daily. All recommended health practices were strictly followed in both starter and finisher phases.

3.5.6: Data Collection

Birds were weighed at the beginning of each experiment for their initial weight and then weighed weekly. Data was collected on initial weight, final body weight, average daily weight gain, feed intake and leftover of feeds were measured. Feed conversion ratio, feed cost per kg and cost of feed per kg gain were calculated and mortality was recorded as it occurred.

3.5.7: Digestibility Trial

A digestibility trial was carried out at the end of the finisher phase as described in experiment 2 earlier.

3.5.8 : Carcass Analysis

Carcass evaluation was carried out using similar procedures described in experiment 2.

3.5.9: Statistical Analysis

All data generated in the study were subjected to analysis of variance (ANOVA) using the SAS procedures of (2002). Significant differences between treatment means were separated using the Least Significant Differences (LSD). Correlation analysis were also used to determine the degree of association and the effect of thermal treatment as it affects composition of SPM using the SAS package.

CHAPTER FOUR

RESULTS

4.1: Proximate Analysis and Anti-nutritional Composition of Raw and Cooked Sweet Potato Meal (SPM)

Results of proximate composition of CSPM are presented in Table 4.1. It had 5.19% crude protein content (CP), 6.67% crude fibre (CF), 1.06% ether extract (EE), 4.20% total ash, 82.88% nitrogen free extract (NFE) and 3180 Metabolizable Energy in kcal/kg of diet. Cooking tended to increase the level of CF, EE and Ash, but the values were not statistically different ($P>0.05$).

The proximate chemical composition of raw and cooked white-flesh (TIS 8164), orange-flesh (TIS 8441) and yellow-flesh (TIS 0087) varieties of SPM, is presented in Table 4.2a. Crude protein values for both raw and cooked sweet potato meals ranges between 5.10 - 6.79 and 5.62 - 7.14% respectively. Range of values for raw in terms of crude fiber, ether extract, ash, nitrogen free extract and metabolizable energy kcal/kg were as follows: 0.24 - 0.37%, 0.48 - 0.53%, 2.89 - 4.55%, 87.94 - 90.47% and 3414 - 3544 ME kcal/kg respectively. The value ranged obtained after cooking were 5.62 – 7.14% CP, 0.25 – 0.30% CF, 0.47 – 0.59% EE, 3.17 – 4.67% ash, 87.35 – 90.33% NFE, while the ME ranged between 3369 and 3494 kcal/kg in cooked sweet potato meal across varieties. Significance differences ($P>0.05$) existed between varieties in terms of their nutrient content (Table 4.2b).

Table 4.1: Proximate Composition of Sweet Potato (Raw and Cooked)

SPM	Raw	Cooked
Dry matter (%)	89.11	92.83
Crude protein (%)	5.94	5.19
Crude fibre (%)	6.36	6.67
Ether extract (%)	0.98	1.06
Ash (%)	3.85	4.20
Nitroge free extract (%)	82.87	82.88
ME (kcal/kg)	3200	3180

Biochemical Laboratory, Department of Animal Science, Ahmadu Bello University, Zaria.
SPM=sweet potato meal, ME=metabolizable energy.

Table 4.2a: Proximate Composition of Three Varieties of Raw and Cooked Sweet Potatoes

SPM	White-flesh		Yellow-flesh		Orange-flesh	
	Raw	Cooked	Raw	Cooked	Raw	Cooked
Dry matter (%)	84.20	88.50	76.54	81.40	73.43	85.50
Crude protein (%)	5.60	5.93	5.10	5.62	6.79	7.14
Crude fibre (%)	0.32	0.30	0.37	0.29	0.24	0.25
Ether extract (%)	0.50	0.47	0.53	0.59	0.48	0.59
Ash (%)	3.11	3.46	2.89	3.17	4.55	4.67
Nitrogen free extract (%)	90.47	89.84	91.11	90.33	87.94	87.35
ME (kcal/kg)	3414	3494	3421	3417	3544	3369

Biochemical Laboratory, Department of Animal Science, Ahmadu Bello University, Zaria. SPM=sweet potato meal, ME=metabolizable energy.

Table 4.2b Chemical composition of three varieties of CSPM

SPM	Raw SPM						Cooked SPM					
	White	Yellow	Orange	Mean	SEM	LOS	White	Yellow	Orange	Mean	SEM	LOS
Dry matter (%)	84.20 ^a	76.54 ^b	73.43 ^b	78.06	3.20	*	88.5 ^a	81.4 ^b	85.5 ^{ab}	85.13	2.06	*
Crude protein (%)	5.60 ^b	5.10 ^b	6.79 ^a	5.83	0.50	*	5.93 ^b	5.62 ^b	7.14 ^b	6.23	0.46	*
Crude fibre (%)	0.32 ^a	0.37 ^a	0.24 ^b	0.31	0.04	*	0.30 ^a	0.29 ^a	0.25 ^b	0.28	0.02	*
Ether extract (%)	0.50 ^b	0.53 ^a	0.48 ^c	0.50	0.01	*	0.47 ^b	0.59 ^a	0.59 ^a	0.55	0.04	*
Ash (%)	3.11 ^b	2.89 ^b	4.55 ^a	3.52	0.52	*	3.46 ^b	3.17 ^b	4.67 ^a	3.77	0.46	*
Nitrogen free extract (%)	90.47 ^a	91.11 ^a	87.94 ^b	89.84	0.97	*	89.84 ^a	90.33 ^a	87.35 ^b	89.17	0.92	*
ME Kcal/kg	3414 ^b	3421 ^b	3544 ^a	3459.67	42.22	*	3494 ^a	3417 ^b	3369 ^b	3426.67	36.41	*

Superscripta, b, = Means within the same row with different superscripts are significantly different (P>0.05) from one another. SEM=Standard Error Means, LOS=Level of significances, NS= not significant.

Results of anti-nutritional factors analysis conducted on the three different varieties (raw and cooked) of sweet potato meals: white-flesh (TIS 8164), orange-flesh (TIS 8441) and yellow-flesh (TIS 0087)) cultivars. The order of decrease in anti-nutritional factors as shown in Table 4.3a. are as follows: phytate (RWSPM > ROSPM > RYSPM), cyanide (RWSPM > RYSPM > ROSPM), TIA (RYSPM > RWSPM > ROSPM), tannins (RWSPM > RYSPM > ROSPM) and oxalate (ROSPM > RWSPM > RYSPM). The range of anti-nutritional factors in raw sweet potatoes are: 0.44 – 0.62 (phytate), 1.44 – 1.84 (cyanide), 5.70 – 8.56 (TIA), 0.60 – 0.88 (tannins) and 1.48 – 2.26 (oxalate). There were significance differences ($P>0.05$) among the three varieties in the composition of their anti-nutritional factors (Table 4.3b). Varietal differences does not follow a particular trend in the content of anti-nutritional factors. RWSPM recorded higher concentration in phytate, cyanide and tannins, while RYSPM and ROSPM recorded higher values in TIA and oxalate respectively. Heating had drastic reduction effect on all anti-nutritional factors, it had the greatest reduction effect on Tannins and TIA.

Percent reduction of anti-nutritional factors after cooking of fresh sweet potato tubers at a temperature of 100°C for 45 minutes, ranged from 52.17 – 54.84%, (phytate), 35.42 – 53.30% (cyanide), 67.37 – 76.87% (TIA), 87.10 – 96.67% (tannins) and 44 – 70.80% (oxalate). The percent reduction in (Table 4.3a) showed the impact of thermal treatment on varieties of sweet potato tubers. Concentration of anti-nutritional factors generally reduced after cooking. Correlation analysis results, indicated strong negative relationship between varieties of cooked sweet potato meals.

Generally, heating had drastic reduction effect on all anti-nutritional factors, with greatest reduction effect on TIA and Tannins.

Table 4.3a Anti Nutritional Factors Present in Three Varieties of SPM (mg/100g)

	Phytate	Cyanide	TIA	Tannins	Oxalate
RWSPM	0.62	1.84	7.11	0.88	1.50
CWSPM	0.28	0.86	2.11	0.04	0.84
Percent reduction (%)	54.84	53.30	7032	95.45	44
ROSPM	0.46	1.44	5.70	0.60	2.26
COSPM	0.22	0.93	1.86	0.02	0.66
Percent reduction (%)	52.17	35.42	67.37	96.67	70.80
RYSPM	0.44	1.66	8.56	0.62	1.48
CYSPM	0.20	0.84	1.98	0.08	0.62
Percent reduction (%)	54.55	49.40	76.87	87.10	58.11

Biochemical Laboratory, Food Science and Technology Research programme. Institute for Agricultural Research (IAR) Samaru, Zaria.

CSPM=Cooked Sweet Potato Meal

RWSPM=Raw white-fleshed sweet potato meal

CWSPM=Cooked white-fleshed sweet potato meal

ROSPM=Raw Orange-fleshed sweet potato meal

COSPM=Cooked Orange-fleshed sweet potato meal

RYSPM=Raw Yellow-fleshed sweet potato meal

CYSPM=Cooked Yellow-fleshed sweet potato meal

TIA=Trypsin inhibitor activity

Table 4.3b: Differences of anti-nutritional factors present in 3 varieties of SPM
(mg/100g)

SPM	Raw						Cooked					
	white	orange	yellow	Mean	SEM	LOS	white	orange	yellow	Mean	SEM	LOS
Phytate	0.62 ^a	0.46 ^b	0.44 ^b	0.51	0.06	*	0.28 ^a	0.22 ^b	0.20 ^b	0.23	0.02	*
Cyanide	1.84 ^a	1.44 ^b	1.66 ^{ab}	1.65	0.12	*	0.86 ^b	0.93 ^a	0.84 ^b	0.88	0.03	*
TIA	7.11 ^{ab}	5.70 ^b	8.56 ^a	7.12	0.83	*	2.11 ^a	1.86 ^b	1.98 ^{ab}	1.98	0.07	*
Tannins	0.88 ^a	0.60 ^b	0.62 ^b	0.70	0.09	*	0.04 ^b	0.02 ^b	0.08 ^a	0.05	0.02	*
Oxalate	1.50 ^b	2.26 ^a	1.44 ^b	1.75	0.26	*	0.84 ^a	0.66 ^b	0.62 ^b	0.71	0.07	*

Super scripts a, b = Means within the same row with different superscripts are significantly different (P>0.05) from one another . SEM=Standard Error Means, LOS=Level of significances and NS= not significant.

4.2: Experiment (1 and 2): Partial Replacement Value of Cooked Sweet Potato Meal (CSPM) for Maize in Broiler Diets (1 – 4 and 5-8weeks).

4.2.1: Partial Replacement Value of Cooked Sweet Potato Meal (CSPM) for Maize in Broiler Starter Chickens Diets (1 – 4 weeks).

The performance of broiler starter chickens fed varying levels of CSPM is presented in (Table 4.4). There were significant differences ($P>0.05$) in all the parameters. Birds fed 5.4% CSPM which is 10% replacement for maize had the best growth performance in terms of final weight, weight gain and feed conversion ratio. Fifty percent replacement of maize by CSPM had the lowest. There were no significant differences between control and 20% CSPM groups in terms of final weight, weight gain and daily weight gain ($P>0.05$). The two diets were however better than 30 and 40% CSPM replacement (Table 4.4). Dietary group on 20% CSPM replacement had the highest feed intake per bird followed by 10% CSPM replacement group and was statistically the same ($P>0.05$) with the 30 and 40% CSPM replacement group. Control group recorded the least feed intake which was not different with 30, 40 and 50% CSPM statistically ($P>0.05$). There were a linear decreased in feed cost/Kg across treatment groups. The 10% CSPM replacement group had the least and the best feed cost/Kg gain, but was statistically the same with 40% CSPM replacement followed by 30% CSPM replacement. This was statistically the same with observation in 20 and 50% CSPM replacement (Table 4.4). Control group recorded the highest feed cost/Kg gain, but was not different with 20 and 50% CSPM replacement groups statistically ($P>0.05$). Fifty percent CSPM replacement had the least feed cost/bird and the total cost/bird. There were no mortality recorded in this experiment.

Table 4.4: Performance of Broiler Starter Chickens (1-4 weeks) Fed Graded Levels of CSPM in Place of Maize in the Control Diet.

Parameters	% replacement of maize with CSPM						SEM	LOS
	0	10	20	30	40	50		
Initial weight (g/bird)	92.86	92.99	92.85	93.02	92.99	93.04	0.15	NS
Final weight (g/bird)	675.00 ^b	711.11 ^a	688.89 ^b	653.33 ^c	655.45 ^c	620.00 ^d	8.98	*
Weight gain (g/bird)	582.13 ^b	618.12 ^a	596.04 ^b	560.32 ^c	565.46 ^c	526.96 ^d	8.55	*
Daily weight gain (g/bird)	20.79 ^b	22.08 ^a	21.29 ^b	20.01 ^c	20.19 ^c	18.82 ^d	0.31	*
Feed intake (g/bird)	1189.56 ^c	1226.89 ^b	1256.67 ^a	1204.22 ^{bc}	1204.00 ^{bc}	1195.33 ^c	13.64	*
Daily feed intake (g/bird)	56.65 ^c	58.42 ^b	59.84 ^a	57.34 ^{bc}	57.33 ^{bc}	56.92 ^c	0.65	*
FCR	2.04 ^b	1.98 ^a	2.11 ^c	2.15 ^d	2.13 ^{dc}	2.27 ^e	0.02	*
Feed Cost (₦/Kg gain)	176.49 ^c	166.48 ^a	173.41 ^{cb}	172.71 ^b	167.28 ^a	173.79 ^{cb}	1.60	*
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NS

Superscripts abcd = Means with different superscripts in the same row are significantly (P>0.05) different. SEM = Standard Error of Means, FCR= Feed Conversion Ratio, NS=Not Significant and LOS = Level of Significance.

4.2.2: Partial Replacement Value of CSPM for Maize in Broiler Finisher Diets (5-8 weeks)

Table 4.5 shows the performance of broiler chickens at finisher phase when fed 10-50% replacement of CSPM for maize. The partial replacement of maize with CSPM significantly decreased growth performance linearly from 0 to 50% level of replacement. The control performed significantly ($P>0.05$) better than all other treatment groups in terms of final weight, weight gain, daily weight gain and income above feed expenses. The 6% CSPM which is (10% replacement for maize) was next to control and was significantly ($P>0.05$) better than the remaining treatment groups in terms of final weight, weight gain, feed conversion ratio and feed cost/kg gain. There were no significant differences ($P>0.05$) between 20, 30 and 40% CSPM replacement treatment groups in terms of final weight, weight gain and daily weight gain. Birds fed 50% CSPM replacement recorded the least performance in final weight, weight gain and daily weight gain (Table 4.5). There were no significant differences ($P>0.05$) in feed intake across the dietary treatments.

There were no significant difference ($P>0.05$) between control and 10% CSPM replacement groups in terms of feed conversion ratio FCR (Table 4.5). They recorded the best FCR, followed by 20, 30 and 40% CSPM replacement groups that were statistically the same ($P>0.05$). Fifty percent (50%) CSPM replacement recorded the poorest FCR (Table 4.5). Control group had the least feed cost/kg gain but, was statistically ($P>0.05$) the same with 10% CSPM replacement group. They are closely followed by 30% CSPM replacement group which was statistically not different from 20 and 40% CSPM replacement groups. Replacement of CSPM for maize at 50% had the poorest feed cost/kg gain and was statistically ($P>0.05$) the same with the 20 and 40% CSPM replacement groups.

Table 4.5: Performance of Broiler Finisher (5 – 8 weeks) Fed Graded Levels of CSPM in Place of Maize in the Control Diet.

Parameters	% replacement of maize with CSPM						SEM	LOS
	0	10	20	30	40	50		
Initial weight (g/bird)	885.44	889.56	890.55	885.45	889.55	885.89	2.53	NS
Final weight (g/bird)	2410.88 ^a	2273.33 ^b	2046.44 ^c	2110.11 ^c	2117.78 ^c	1930.22 ^d	40.18	*
Weight gain (g/bird)	1525.44 ^a	1383.78 ^b	1155.89 ^c	1224.66 ^c	1228.22 ^c	1044.33 ^d	39.55	*
Daily weight gain (g/bird)	54.48 ^a	49.42 ^b	41.28 ^c	43.74 ^c	43.86 ^c	37.29 ^d	1.41	*
Feed intake (g/bird)	3237.40	3137.60	3181.40	3180.80	3168.30	3189.10	72.57	NS
Daily feed intake (g/bird)	115.62	112.06	113.62	113.60	113.15	113.90	2.59	NS
FCR	2.12 ^a	2.27 ^a	2.76 ^c	2.64 ^{cb}	2.50 ^b	3.06 ^d	0.11	*
Feed cost (₦/kg gain)	178.18 ^a	184.36 ^a	222.19 ^{cb}	207.06 ^b	210.70 ^{cb}	227.98 ^c	8.71	*
IAFE (at ₦700/Kg)	1313.40 ^a	1233.49 ^b	1106.82 ^c	1131.08 ^c	1151.61 ^c	1021.96 ^d	33.54	*
Mortality (%)	00	00	00	00	00	00		NS

Superscript abcd = Means with different superscripts in the same row are significantly (P>0.05) different. SEM = Standard Error of Means, FCR = Feed Conversion Ratio, IAFE = Income Above Feed Expenses at ₦700/Kg. NS = Not Significant, g=gram and LOS=Level of Significance.

There was a linear decrease in feed cost/kg and total cost/bird across the treatments with the 40 and 50% CSPM dietary replacement having the least cost/bird (Table 4.5). At the market price of ₦700/kg of dressed carcass of broiler, the control group had the highest income above feed expenses followed by birds fed with 10% CSPM replacement diet which was better than the remaining treatments. CSPM at 50% replacement had the least income above feed expenses (Table 4.5). There was no mortality in this experiment.

4.2.3: The Effect of Partial Replacement of Maize with CSPM on Carcass Characteristics of Broiler Finisher (8 weeks of age)

Table 4.6 shows the summary of the carcass characteristics. Control recorded the highest dressed weight followed by 10% CSPM replacement which was similar to 20, 30 and 40% CSPM replacement groups statistically ($P>0.05$). Control group recorded the highest weight of breast but was statistically ($p>0.05$) similar with 10 and 40% CSPM replacement dietary groups. Birds fed 10, 30 and 40% CSPM replacement diets were statistically ($P>0.05$) the same and were better than 20 and 50% CSPM replacement in breast weight. Fifty percent CSPM replacement group recorded least weight of breast. Back cut of birds fed 30% CSPM replacement diet was statistically ($P>0.05$) the same with 10 and 50% CSPM replacement groups. Birds on 20% CSPM replacement group recorded the highest weight of wings which was statistically ($P>0.05$) not different with 40% CSPM replacement diet, control group had the least weight of wings. Birds fed with 10, 30, 40 and 50% CSPM replacement diets were statistically the same in weight of wings. Control group recorded the highest weight of neck, but was statistically similar with 10% CSPM replacement diet. The 20% CSPM replacement group had the least which was statistically not different ($P>0.05$)

with 30 and 40% CSPM replacement groups in weight of neck. However, 30, 40 and 50% CSPM replacement were statistically the same in weight of neck (Table 4.6).

Birds fed with 40% CSPM replacement diet had the highest weight of gizzard which was statistically the same with 20 and 50% CSPM replacement groups, followed by control group which was statistically the same with 10, 20 and 50% CSPM replacement groups. The 30% CSPM replacement group had the poorest but, was statistically ($P>0.05$) similar to 10% CSPM replacement group. The 50% CSPM replacement group recorded the least percent abdominal fat but was not different with the control, 10, 20 and 40% CSPM replacement groups statistically ($P>0.05$). Birds fed with the 30% CSPM replacement diet recorded the highest percent abdominal fat, but was statistically the same with control, 10, 20 and 40% CSPM replacement groups (Table 4.6).

Fifty percent CSPM replacement group recorded the highest weight of liver, followed by 20 and 40% CSPM replacement which were statistically not different with the 30% CSPM replacement. The 10% CSPM replacement and control groups recorded the least weight of liver and was statistically not different ($P>0.05$) with the 30% CSPM replacement. There were no significant differences ($P>0.05$) between control, 20, 30, 40 and 50% CSPM replacement groups in intestinal length. Birds fed 10% CSPM diet had the highest length but was statistically the same ($P>0.05$) with the control and 40% CSPM groups. Significant differences were noticed in most parameters but they followed no clear cut trend except for the liver that increased as the level of CSPM exceeded 10%.

Table 4.6: Effect of Partial Replacement of Maize with Cooked Sweet Potato Meal on Carcass Characteristics of Broiler Chickens.

Parameters	% replacement of maize with CSPM						SEM	LOS
	00	10	20	30	40	50		
Live weight (g/bird)	2319.00 ^a	2217.00 ^b	1999.33 ^d	2089.67 ^{cd}	2103.67 ^c	1898.33 ^e	49.61	*
Dressed weight (g/bird)	1426.70 ^a	1276.70 ^b	1215.00 ^{bc}	1188.30 ^{bc}	1206.70 ^{bc}	1129.30 ^c	56.96	*
Retail cut parts								
Breast (%)	30.22 ^a	29.41 ^{ab}	24.08 ^c	26.78 ^b	28.41 ^{ab}	20.81 ^d	1.33	*
Thighs (%)	31.78 ^b	33.63 ^{ab}	31.47 ^b	34.50 ^a	32.54 ^b	32.98 ^{ab}	0.78	*
Back cut (%)	22.42 ^b	24.74 ^{ab}	23.49 ^b	26.49 ^a	24.59 ^{ab}	23.71 ^b	1.22	*
Wings (%)	12.51 ^c	13.96 ^b	14.87 ^a	13.47 ^b	14.52 ^{ab}	13.49 ^b	0.40	*
Drum stick (%)	17.32 ^{ab}	16.13 ^b	16.49 ^b	18.07 ^a	15.22 ^b	16.18 ^b	0.71	*
Neck (%)	8.73 ^a	8.58 ^{ab}	7.02 ^d	7.26 ^{cd}	7.71 ^{cd}	7.85 ^{bc}	0.40	*
Organs								
Head (%)	3.38 ^a	2.45 ^e	2.69 ^{cd}	2.49 ^d	2.74 ^c	2.93 ^b	0.09	*
Shanks (%)	3.82	3.81	3.87	3.63	3.64	4.09	0.26	NS
Heart (%)	0.49 ^{bc}	0.52 ^a	0.49 ^b	0.48 ^c	0.45 ^d	0.50 ^b	0.01	*
Liver (%)	1.99 ^c	1.79 ^c	2.22 ^b	2.07 ^{bc}	2.22 ^b	2.48 ^a	0.11	*
Spleen (%)	0.13 ^{ab}	0.12 ^b	0.14 ^a	0.12 ^b	0.12 ^b	0.11 ^c	0.01	*
Full gizzard (%)	3.41 ^c	3.66 ^{bc}	3.43 ^c	3.45 ^c	3.79 ^{ab}	4.01 ^a	0.17	*
Empty gizzard (%)	2.54 ^b	2.32 ^{cd}	2.73 ^{ab}	2.17 ^d	2.84 ^a	2.57 ^{abc}	0.15	*
Length of intestine(cm)	239.33 ^{ab}	252.67 ^a	231.67 ^b	221.67 ^b	242.67 ^{ab}	222.00 ^b	9.0	*
Empty intestine, (%)	3.33 ^b	3.17 ^b	3.93 ^{ab}	3.88 ^{ab}	4.61 ^a	3.74 ^{ab}	0.55	*
Abdominal fat (%)	1.99 ^{ab}	2.22 ^{ab}	2.15 ^{ab}	2.58 ^a	2.37 ^{ab}	1.92 ^b	0.30	*

Superscripts a, b, c, d, e, = mean with different superscripts in the same row are significant (p>0.05) different. SEM = standard Error mean, NS=Not Significant, g=gram and LOS=Level of Significance.

4.2.4: Apparent Nutrient Digestibility of Broiler Chickens fed Varying Levels of CSPM (8 weeks of age)

The nutrient digestibility of DM, CP, CF, EE, Ash and NFE are presented in Table 4.7. The birds fed 20% CSPM replacement diet had the lowest DM digestibility, which was statistically ($P>0.05$) similar to those fed with 10, 40, and 50% CSPM dietary replacements. Control group had the highest DM digestibility value that was statistically the same ($P>0.05$) as 10, 30, 40 and 50% CSPM replacement groups respectively.

There were no significant difference ($P>0.05$) in CP digestibility between control, 10 and 20% CSPM replacement diets, this was closely followed by 50% CSPM replacement group that was statistically better than those on 30 and 40% CSPM replacement diets (Table 4.7). Percent crude fibre digestibility for birds fed control, 10 and 20% CSPM replacement diets were statistically ($P>0.05$) similar and significantly ($P>0.05$) better than the rest of the treatments with exception of 20% CSPM group which was statistically not different with 30 and 40% CSPM. The 50% CSPM replacement diet recorded the least crude fibre digestibility coefficient (Table. 4.7) Birds fed 20, 30 and 40% CSPM replacement groups had the highest nitrogen free extract digestibility. Birds on 30 and 40% CSPM replacement diets were statistically the same with the birds fed control, 10 and 50% CSPM replacement diets.

Dietary inclusion of CSPM replacement significantly reduced the digestibility of DM, CF, EE and ash. The fiber digestibility decreased linearly as CSPM inclusion increased from 0 – 50%, while ash digestibility also decreased linearly as CSPM increased from 0 – 30%.

In general, the digestibility of nutrients declined with increasing levels of CSPM inclusion in the diet, except for CP and Ash digestibility where the 50% CSPM replacement

had higher digestibility figures than 30 and 40% CSPM replacement for CP and 30% replacement for Ash. Digestibility coefficients were highest on the control diet and least on the 50% CSPM replacement and were statistically different ($P>0.05$) except for NFE.

Table 4.7: Apparent Nutrient Digestibility Coefficient of Broiler Chickens Fed Graded Levels of CSPM as Partial Replacement for Maize.

Parameters	% replacement of maize with CSPM						SEM	LOS
	0%	10%	20%	30%	40%	50%		
Apparent dry matter digestibility (%)	86.67 ^a	84.33 ^{ab}	82.67 ^b	85.67 ^a	84.33 ^{ab}	84.33 ^{ab}	1.25	*
Apparent crude protein digestibility (%)	84.00 ^a	84.33 ^a	83.67 ^a	68.00 ^c	66.67 ^c	75.00 ^b	2.06	*
Apparent crude fibre digestibility (%)	73.67 ^a	73.00 ^a	70.67 ^{ab}	68.00 ^b	67.33 ^b	55.33 ^c	2.14	*
Apparent Ether extract digestibility (%)	76.33 ^a	74.00 ^a	66.00 ^b	70.00 ^{ab}	60.33 ^c	55.67 ^c	3.23	*
Apparent Ash digestibility (%)	66.33 ^a	62.00 ^{ab}	57.33 ^b	50.00 ^c	55.67 ^b	57.67 ^b	2.43	*
Apparent NFE (%)	65.00 ^b	65.67 ^b	72.33 ^a	66.67 ^{ab}	67.33 ^{ab}	64.67 ^b	3.17	*

Superscript a,b,c, = Means with different superscripts in the same row are significantly (P>0.05) different. NFE = Nitrogen Free Extract, SEM= Standard Error Mean. NS= Not Significant and LOS=Level of Significance.

4.2.5: The Economic Analysis of Broiler Chickens fed Percent Replacement of Maize with CSPM Diets

There were a linear decreased in feed cost/kg across the treatments as shown in Table 4.12. The result showed that, the cost of producing a bird fed control diet was significantly higher ($P>0.05$) than the rest of the treatments. CSPM diet at 10% level of replacement, had the least and the best feed cost/kg gain which was statistically the same with control diet, but the 2 were better than 20, 30, 40 and 50% CSPM replacement groups.

Table 4.8 Economic Analysis of Experimental Diets of experiment 1

Measurement	% replacement of maize with CSPM						SEM	LOS
	0%	10%	20%	30%	40%	50%		
Cost of feed (₦/bird)	374.22 ^c	357.84 ^b	359.02 ^b	346.00 ^b	328.50 ^a	329.20 ^a	6.87	*
Cost of feed (₦/kg gain)	354.67 ^a	350.84 ^a	395.60 ^{cb}	379.77 ^{cb}	357.98 ^b	401.77 ^c	11.31	*
Total cost (₦/bird)	445.89 ^c	419.24 ^b	430.69 ^b	417.67 ^b	400.18 ^a	400.87 ^a	7.20	*
I.A.F.E (₦/bird)	1313.40 ^a	1233.49 ^b	1106.82 ^c	1131.08 ^c	1153.95 ^c	1021.95 ^d	33.54	*

Superscript a, b, c, = Means within the same row with different superscripts are significantly different ($P < 0.05$) from one another

IAFE=Income Above Feed Expenses (at ₦700/Kg)

SEM=Standard Error Means, LOS=Level of significances .

4.3: Experiment 3 and 4: Comparative Performance of Broilers (1-4 and 5-8weeks) fed Three Varieties of CSPM at 10% Replacement for Maize in the Control Diet.

4.3.1: Comparative Performance of Broiler Starters (1-4 weeks) fed Three Varieties of CSPM at 10% Replacement for Maize in the Control Diet.

The performance of broiler chickens fed three varieties of CSPM at 10% level of replacement for maize is presented in Table 4.8. Birds fed CSPM containing diets significantly performed better than birds fed control diet for final weight, weight gain, FCR and feed cost/kg gain which are the most important economic variables. This was regardless of variety. The orange - flesh CSPM variety recorded the highest final weight, weight gain and daily weight gain that was statistically similar ($P>0.05$) with the birds fed with white-flesh and yellow-flesh varieties. Control group had the least values in these parameters. The feed intake was not affected by the dietary treatments. The highest feed intake was noticed in birds fed with 10% orange-flesh variety, but was statistically the same ($P>0.05$) with the remaining treatments. Feed conversion ratio for orange-flesh and white-flesh varieties dietary group was significantly ($P>0.05$) better than other diets, followed by yellow – flesh variety diet. The control recorded the poorest FCR at starter phase (Table 4.8).

Birds fed with orange-flesh variety diet recorded the least and the best feed cost/Kg gain, but was statistically not different ($P>0.05$) with white-flesh and yellow-flesh varieties diets, while control group diet had the highest feed cost/Kg gain. However, control had the highest feed cost/bird compared to the three varieties of CSPM which were not significantly different from each other. Control recorded 2.22% mortality as to opposed 0.00% recorded in birds fed diets containing the three varieties of CSPM. Post mortem examination result conduct at veterinary teaching hospital A. B. U. Zaria showed that mortality recorded was said to be accidental.

Table 4.9: Comparative Performance of Broiler Starter (1 – 4 weeks) Fed Three Varieties of CSPM at 10% Partial Replacement for Maize.

Three varieties of Cooked Sweet Potato Meal						
Parameters	Control	White	Orange	Yellow	SEM	LOS
Initial weight (g/bird)	79.22	80.00	80.00	80.22	0.28	NS
Final weight (g/bird)	638.33 ^b	686.66 ^a	698.22 ^a	673.67 ^a	15.71	*
Weight gain (g/bird)	559.11 ^b	606.66 ^a	618.22 ^a	593.45 ^a	15.71	*
Daily weight gain (g/bird)	19.97 ^b	21.67 ^a	22.08 ^a	21.19 ^a	0.56	*
Feed intake (g/bird)	1195.33 ^a	1212.22 ^a	1194.00 ^a	1206.11 ^a	14.26	NS
Daily feed intake (g/bird)	56.93	57.72	56.86	57.43	0.47	NS
FCR	2.15 ^c	2.00 ^{ab}	1.93 ^a	2.03 ^b	0.05	*
Feed cost (₦/kg gain)	202.84 ^b	174.62 ^a	169.69 ^a	177.51 ^a	5.07	*
Mortality (%)	2.22 ^b	0.00 ^a	0.00 ^a	0.00 ^a	0.96	

Superscripts abcd = Means with different superscripts in the same row are significantly (P>0.05) different . SEM = Standard Error of means, FCR = Feed conversion ratio, NS=Not Significant and LOS=Level of significance.

4.3.2: Comparative Performance of Broiler Finishers fed Three Varieties of CSPM (5 - 8weeks) at 10% Replacement for Maize in the Control Diet.

The performance characteristics of broiler finisher chickens (5-8weeks) fed diets containing three varieties of CSPM replacement is presented in Table 4.9. Control group birds had significantly ($P>0.05$) higher final weight, total weight gain, and daily weight gain than other groups. Birds fed diets containing white-flesh variety replacement had significantly ($P>0.05$) higher final weight, total weight gain and daily weight gain than birds fed both orange and yellow flesh varieties. Birds fed white-flesh variety of CSPM diet also had the best FCR among the three varieties.

Feed intake was significantly highest ($P>0.05$) in the control group and was statistically the same with white-flesh variety group. However, feed intake of the birds fed white-flesh CSPM was statistically not different from those on orange-flesh and yellow-flesh varieties diet. Significant differences existed in FCR across the dietary treatments. Birds fed with control diet had the best value, followed by the birds fed white-flesh variety diet. The poorest FCR was noticed in birds fed orange-flesh and yellow-flesh varieties diet that were not different ($P>0.05$) statistically (Table 4.9).

Control group had the least and the best feed cost/Kg gain, but was statistically not different with the white-flesh variety group. Orange and yellow flesh varieties groups were statistically the same with each other. The control diet group had the highest feed cost/bird, while there were no significant differences ($P>0.05$) among the three varieties of CSPM in feed cost/bird.

In contrast to results obtained during the starter phase, the inclusion of CSPM in broiler finisher diets significantly depressed growth performance regardless of the variety. It was also observed that weight gain, feed cost/kg gain and IAFE for birds fed white-flesh

Table 4.10: Comparative Performance of Broiler Chickens (5 – 8 weeks) Fed Three Varieties of CSPM at 10% Partial Replacement for Maize.

Parameters	Three varieties of Cooked Sweet Potato Meal				SEM	LOS
	Control	White	Orange	Yellow		
Initial weight (g/bird)	966.26	985.11	987.11	986.78	9.70	NS
Final weight (g/bird)	2556.67 ^a	2337.75 ^b	2176.79 ^c	2211.44 ^c	37.58	*
Weight gain (g/bird)	1590.41 ^a	1352.63 ^b	1189.68 ^c	1224.67 ^c	34.79	*
Daily weight gain (g/bird)	56.80 ^a	48.31 ^b	42.49 ^c	43.74 ^c	1.24	*
Feed intake (g/bird)	3730.90 ^a	3656.30 ^{ab}	3564.20 ^b	3541.10 ^b	67.52	*
Daily feed intake (g/bird)	133.25 ^a	130.58 ^{ab}	127.29 ^b	126.47 ^b	2.78	*
FCR	2.35 ^a	2.70 ^b	3.00 ^c	2.91 ^c	0.08	*
Feed cost, (₦/kg gain)	214.48 ^a	227.90 ^a	252.95 ^b	245.02 ^b	7.22	*
IAFE (₦/bird)	1339.16 ^a	1222.47 ^b	1119.16 ^c	1143.62 ^c	25.44	*
Mortality (%)	4.44 ^b	2.22 ^a	2.22 ^a	2.22 ^a	0.55	*

Superscript abc = Means with different superscripts in the same row are significantly (P>0.05) different . SEM = Standard Error of Means, FCR = Feed Conversion Ratio, IAFE = Income Above Feed Expenses, g=gram, NS=Not Significant and LOS=Level of Significance.

CSPM replacement were significantly better than for orange and yellow-flesh varieties ($P>0.05$).

At the market price of ₦700/kg of dressed broiler, birds on control diet provides the highest income above feed expenses (IAFE), followed by white-flesh variety group. There were no significant differences ($P>0.05$) between orange-flesh and yellow-flesh varieties in IAFE. Control group recorded the highest percent mortality in comparison with the other treatments groups (Table 4.9).

4.3.3: Carcass Characteristics of Broiler Chickens fed Three Varieties of CSPM at 10% Level of Replacement for Maize in the Control Diet (8 weeks of age)

Table 4.10 shows the carcass characteristics of broiler finisher chickens fed three varieties of CSPM at 10% level of replacement for maize in the control diet. There were no significant differences ($P>0.05$) in drum stick, wings, head, gizzard, liver and intestinal length across treatment groups. Birds fed control diet recorded the highest live weight, followed by white and yellow flesh varieties. Orange-flesh group had the least live weight that was statistically the same with the yellow-flesh variety group (Table 4.10). There were no significant differences among the birds fed three varieties diet in terms of dressed weight and dressing percentage, control group had the highest dressed weight. Birds fed control diet recorded the highest breast weight that was not different ($P>0.05$) with white-flesh variety group statistically. Orange-flesh birds group had the least weight of thighs which was the same with the white and yellow flesh varieties groups statistically ($P>0.05$). Control group had the highest weight of thighs, but was statistically not different ($P>0.05$) with white and yellow flesh varieties. Birds fed with white-flesh variety, recorded the least weight of back cut which was statistically the same with orange and yellow fleshed varieties groups (Table 4.10).

Table 4.11: Effect of Feeding Percent Replacement of Three Varieties of Cooked Sweet Potato Meal for Maize on Carcass Characteristics of Broiler Finisher Birds.

Parameters	Three varieties of cooked sweet potato meals				SEM	LOS
	Control	White	Orange	Yellow		
Live Wight (g/bird)	2584.33 ^a	2269.67 ^b	2154.67 ^C	2222.00 ^{bc}	40.85	*
Dress weight (g/bird)	1767.33 ^a	1472.00 ^b	1371.67 ^b	1382.00 ^b	54.48	*
Retail cut parts						
Breast (%)	32.48 ^a	29.51 ^{ab}	25.15 ^b	28.10 ^b	1.79	*
Thighs (%)	33.96 ^a	31.60 ^{ab}	29.04 ^b	32.68 ^{ab}	1.93	*
Back cut (%)	28.63 ^a	24.20 ^b	26.54 ^{ab}	25.61 ^{ab}	1.88	*
Wings (%)	13.00	12.54	14.29	12.74	0.97	NS
Drum Stick (%)	19.80	18.75	19.00	19.93	1.57	NS
Neck (%)	6.43 ^b	9.40 ^a	8.45 ^a	8.81 ^a	0.69	*
Organs						
Head (%)	2.76	2.96	3.16	2.86	0.23	NS
Shanks (%)	5.23 ^a	4.33 ^b	4.40 ^b	3.48 ^c	0.18	*
Heart (%)	0.42 ^c	0.46 ^b	0.48 ^a	0.46 ^b	0.006	*
Liver (%)	3.11	2.95	2.93	2.76	0.25	NS
Spleen (%)	0.11 ^{ab}	0.10 ^b	0.11 ^{ab}	0.12 ^a	0.01	*
Full gizzard (%)	3.57	3.56	3.55	3.30	0.43	NS
Empty gizzard (%)	2.90	2.76	2.28	2.47	0.32	NS
Length of intestine (cm)	242.67	231.33	223.33	237.67	16.63	NS
Full intestine (%)	6.21	6.36	6.62	5.75	0.50	NS
Empty intestine (%)	4.83 ^a	3.76 ^b	3.72 ^b	4.00 ^b	0.40	*
Abdominal fat (%)	3.92 ^{ab}	3.73 ^{ab}	4.31 ^a	3.11 ^b	0.41	*

Superscripts a,b,c = Mean with difference superscripts in the same row are significant (P > 0.05) different. SEM = Standard Error Mean, NS=Not Significant, g=gram and LOS=Level of Significance.

Control group had the highest weight of back cut but was statistically ($P>0.05$) the same with the orange and yellow flesh varieties diets. Birds fed white-flesh variety recorded the highest weight of neck that was statistically ($P>0.05$) the same with orange and yellow fleshed varieties groups. Least weight of neck comes from birds fed control diet (Table 4.10).

There were no significant differences ($P>0.05$) between control, white and orange flesh varieties groups in percent abdominal fat, but yellow-flesh recorded the least. Group on white CSPM diet had the least percent spleen, but yellow CSPM group had the highest which was statistically ($P>0.05$) not different with the bird on control and orange-flesh diets (Table 4.10).

Results of carcass analysis follows the pattern of growth depression observed in the growth performance data (Table 4.9). Except for wings, drum stick, head, gizzard, length of intestine and full intestine whose data were not significantly different across treatments. The carcass dress weight and weight of all cut parts on the control were higher than on the three varieties of CSPM. Where significant differences noticed, did not follow a clear trend except in weight of heart where birds fed the 3 varieties recorded higher weight than the control group

4.3.4: Nutrient Digestibility of Broiler Finishers fed Three Varieties of CSPM as Replacement for Maize in the Control Diet (8 weeks of age)

The result of nutrient digestibility of broiler chickens fed three varieties of CSPM substituted for maize at 10% level of replacement for maize is presented in Table 4.11. No significant differences ($P>0.05$) noticed in dry matter (DM) and crude protein (CP) digestibility across the dietary treatments groups. However birds fed control diet had the highest crude fibre (CF) digestibility that was statistically the same with the birds on white-

flesh variety diet. The white-fleshed group was statistically not different with orange-flesh and yellow-flesh varieties groups. There were a linear decrease in ether extract digestibility ranging from control, white, orange, and yellow- flesh varieties diets respectively. Broiler chickens fed white-flesh variety diet recorded the highest ash digestibility coefficient values but, was statistically not different with control and orange-flesh groups. Yellow-flesh variety group had the least percent ash digestibility (Table 4.11). However, orange-flesh variety had the lowest NFE digestibility, but was statistically not different with yellow-fleshed variety. Yellow-flesh value was statistically ($P>0.05$) not different with white-fleshed. Control had the best NFE digestibility. yellow-fleshed variety. Yellow-flesh value was statistically ($P>0.05$) not different with white-fleshed. Control had the best NFE digestibility (Table 4.11).

The nutrient digestibility were generally higher in the birds fed CSPM free diets. White-flesh CSPM replacement diet had relatively higher digestibility coefficient than orange and yellow flesh CSPM replacement diets. CP and ash were better digested by birds fed white flesh CSPM diet than the bird fed control diet (CSPM-free), orange and yellow flesh CSPM replacement diets (Table 4.11).

Digestibility coefficient values were higher than 60% in all the nutrient evaluated. Ash digestibility was relatively lower than other nutrient components. Fiber was more digested than NFE and ash in almost all varieties and the control group. The minimum dry matter digestibility was 82% (in yellow-flesh variety) and highest in orange-flesh variety (Table 4.11).

Table 4.12: Apparent Nutrient Digestibility Coefficient of Broilers Fed 10 % of Three Common Varieties of Cooked Sweet Potato Meal for Maize (8 weeks of age)

Dietary Levels of three Varieties of Cooked Sweet Potato Meal						
Parameters	Control	White	Orange	Yellow	SEM	LOS
Apparent dry matter digestibility (%)	91.33	89.33	91.33	89.00	1.53	NS
Apparent crude protein digestibility (%)	83.33	85.00	83.00	83.33	2.15	NS
Apparent crude fibre digestibility (%)	77.00 ^a	73.00 ^{ab}	70.00 ^b	68.00 ^b	3.03	*
Apparent ether extract digestibility (%)	91.00 ^a	84.00 ^b	77.33 ^c	70.67 ^d	1.74	*
Apparent Ash digestibility (%)	68.67 ^{ab}	70.67 ^a	64.33 ^{ab}	60.33 ^b	4.66	*
Apparent NFE (%)	75.67 ^a	71.00 ^b	66.00 ^c	69.33 ^{bc}	2.27	*

Superscripts abcd = Means with different superscripts in the same row are significantly (P>0.05) different. NFE = Nitrogen Free Extract, NS=Not Significant ,SEM=Standard Error Mean and LOS=Least Significant Difference.

CHAPTER FIVE

DISCUSSION

5.1.1: Proximate Composition of Raw and Cooked Sweet Potato Meal

The crude protein obtained in this analysis (5.19%) was slightly lower than the 6.4% and 5.36% obtained by Dominguez, (1990) and Afolayan, (2010) respectively, but was higher than 4.4% reported by Noblet *et al.* (1990). The metabolizable energy value 3180kcal/kg DM was close to 3050kcal/kg DM reported by Afolayan, (2010). However, the crude fibre obtained 6.67% was below the 9.22% previously obtained by Afolayan (2010), but was higher than the 0.3% as reported by Harris *et al.*, (1982). Ether extract value of 1.06% obtained was higher than the 0.6% and 0.71% value obtained by Noblet *et al.* (1990) and Afolayan, (2010) respectively. In contrary, it was lower than the 2.7% reported by Monday and Mueller (1977). The total ash value of 4.2% was higher than 3.1% and 2.93% values respectively obtained by Noblet *et al.* (1990) and Afolayan, (2010), but was lower than 5.3% Ash reported by Dominaguez, (1990). The differences observed may be as a result of varietal differences and condition under which the crop was grown. Cooking tended to increase the level of CF, EE, ash and NFE but was statistically similar with the raw SPM (Table 4.1).

The proximate chemical composition of the three varieties of SPM raw and cooked (white-flesh, orange-flesh and yellow-flesh), is presented in Table 4.2. Crude protein values obtained in this study for both raw and cooked sweet potato meals 5.10 - 6.79 and 5.62 - 7.14% respectively, fell within the ranges of 1.7% to 11.8%, 1.27% to 10.05% and 4.38% to 8.98% reported by Purcell *et al.* (1972); Li, (1982) and Dickey *et al.* (1984) respectively. The differences observed may be due to differences in the cultivars (Yang, 1982), soil type

(Bradbury *et al.* 1985), the quantity or type of fertilizer used (Purcell *et al.* 1982 and Zhang *et al.* 1998) and condition under which the crop was grown (Purcell *et al.* 1976). Range of values for raw and cooked sweet potato tuber in terms of crude fiber 0.24 - 0.37% and 0.25 – 0.30% respectively were lower than 0.7% and 9.22% reported by Noblet *et al.* (1990) and Afolayan (2010) respectively but was similar with 0.3% reported by Harris *et al.* (1982). Ether extract 0.48 - 0.53% and 0.47 – 0.59% respectively were lower than 0.6 and 0.71% obtained by Noblet *et al.* (1990) and Afolayan (2010) respectively but was higher than 0.5% reported by Harris *et al.* (1982). Ash 2.89 - 4.55% and 3.17 – 4.67% were lower than 5.3% obtained by Dominguez (1990) but were similar to 3.2, 3.1 and 2.93% reported by Harris *et al.* (1982), Noblet *et al.* (1990) and Afolayan (2010) respectively. Nitrogen free extract 87.94 - 90.47% and 87.35 – 90.33% were higher than 81.79% obtained by Afolayan (2010), but was similar to value 89% reported by Harris *et al.* (1982). The differences noticed may be as a result of differences in the cultivars, soil type quantity or type of fertilizer used, condition under which the crop was grown and the procedure used in proximate analysis of the samples.

5.1.2: Anti-nutritional Factors Present in the Three Varieties of Sweet Potato Tubers (Raw and Cooked)

The order of decrease in anti-nutritional factors as shown in Table 4.3a : phytate (RWSPM > ROSPM > RYSPM), cyanide (RWSPM > RYSPM > ROSPM), TIA (RYSPM > RWSPM > ROSPM), tannins (RWSPM > RYSPM > ROSPM) and oxalate (ROSPM > RWSPM > RYSPM). The range of anti-nutritional factors in raw sweet potatoes are: 0.44 – 0.62 (phytate), 1.44 – 1.84 (cyanide), 5.70 – 8.56 (TIA), 0.60 – 0.88 (tannins) and 1.48 – 2.26 (oxalate) was a result of varietal differences. Various levels of trypsin inhibitor activity (TIA) in sweet potato cultivars have been reported (Bradbury *et al.* 1985 Dickey *et al.* 1984;

Lin and Chen, 1980, Dominguez, 1992, and Afolayan, 2010). However percent reduction of anti-nutritional factors after cooking of fresh sweet potato tubers at a temperature of 100°C for 45 minutes ranges from 52.17 – 54.84%, (phytate), 35.42 – 53.30% (cyanide), 67.37 – 76.87% (TIA), 87.10 – 96.67% (tannins) and 44 – 70.80% (oxalate). This results agree with findings of Dominguez, (1992) who reported that trypsin inhibitors can be destroyed or reduced to minimum by preheating the raw sweet potato roots. However moist heat treatment at temperatures above 80°C was reported to be effective in eliminating trypsin inhibitor activity in sweet potatoes Ravindran *et al.* (1995). Varietal differences does not follow a particular trend in the content of anti-nutritional factors. RWSPM recorded higher concentration in phytate, cyanide and tannins, while RYSPM and ROSPM recorded highest values in TIA and oxalate respectively. Tannins and TIA responded excellently to thermal treatments, while cyanide exhibited poor response to thermal treatment irrespective of varietal differences.

Boiling or heating to 90°C for several minutes inactivates and removes acidity in sweet potato (Obidairo and Akpochafo, 1984 and Wanda, 1995). Sasi Kiran and Padmaje (2003) reported that when sweet potato tuber was cooked between 17 and 31% trypsin inhibitor activity remained and when it was prepared into flour, only 5 – 12% trypsin inhibitor activity was found. The presence of oxalates has also been reported in sweet potato by (Raven and Smith, 1976 and Smith, 1982), though only in minute quantities. Oboh *et al.*, (1989) recorded the mean value of total oxalate content of 49 varieties of sweet potatoes as 0.71% of DM. Zhang and Corke (2001) reported that, raw sweet potato contain oxalate up to 1.2g/Kg DM. The differences observed may be due to the differences in the cultivars, soil type and condition under which the crop was grown.

5.2: Performance of Broiler Chicks (1-4 weeks) to Percent Dietary Replacement of Maize with Cooked Sweet Potato Meal

The better performance recorded on the 10% replacement of maize with CSPM that is 5.4%, may be as a result of the ability of broiler chickens to efficiently utilized CSPM 5.4% level of inclusion. The result obtained is slightly lower than the report of Berhan and Wude (2010) who suggested 10% as optimum level of utilization of sweet potato by broiler chicken as higher levels resulted in decrease in birds weight gain. It is different from the report of Nguyen *et al.* (2001) who recommended 20% sweet potato inclusion for young birds. However, the result disagree with Afolayan *et al.* (2012) who fed broiler chickens at starter phase with raw sweet potato at 0, 10, 20, 30, 40, 50 and 60% levels and reported a linear decrease in the final weight and weight gain. The differences observed may be due to cooking of sweet potato tubers.

Dietary group on 20% CSPM replacement had the highest feed intake per bird followed by 10% CSPM replacement group and was statistically the same ($P>0.05$) with the 30 and 40% CSPM replacement group. Control group recorded the least feed intake which was not different with 30, 40 and 50% CSPM statistically ($P>0.05$). The trend of feed intake contradicted what was previously reported by Maphosa *et al.* (2003) who noticed a linear decrease in feed intake with increased levels of sweet potato in broiler starter chicken diet. The feed intake in this study was similar to that of Lee and Yang (1979) who replaced maize with about 24% SPM in broiler starter diet. They noticed no adverse effect on general performance of the birds. The significant increase in feed intake and FCR may be due to cooking of sweet potato tuber and fine grinding of the particle size which increased the surface area for enzymatic activities and reduced the TIA to bearable level. There was a linear decrease in feed cost/kg of feed which is in agreement with observations of many

researchers (Domiguez 1990, Ayuk and Essien 2009 and Afolayan 2010). Zero mortality recorded in this experiment, may be due to toxin free diet and good flock management practiced.

5.3.1: Performance of Broiler Finishers fed Percent Replacement Levels of Maize with CSPM

The inclusion CSPM replacement for maize significantly and linearly decreased growth performance in broiler finisher chickens. The reduction in weight gain observed in birds fed the CSPM containing diets may be as a result of bulkiness of the feed that resulted to poor digestibility and feed conversion ratio at the finishing stage of broilers. The reduction in weight gain observed in birds fed with varying levels of CSPM, is in agreement with what was obtained by Maphosa *et al.*, (2003) and Afolayan, (2010), who both reported decrease in weight gain of broiler finisher chickens when fed with various levels of sweet potato meal. However, it disagree with the observations of Ayuk and Essien, (2009) who obtained no significant differences when 0-40% sweet potato levels were used, but noticed a significant reduction at 50% level of replacement of sweet potato meal (SPM). Lack of significant difference among the treatments groups in feed intake noticed in this study is contrary to Maphosa *et al.* (2003) and Afolayan, (2010) findings who reported decrease in feed intake with increased inclusion levels of sweet potato meal in broiler finisher diets. This may also be as a result of cooking sweet potato tubers.

Results of feed cost agrees with what was obtained by Maphosa *et al.* (2003), Ayuk and Essien, (2009); and Afolayan, (2010), who both reported a linear decrease in the feed cost with inclusion of sweet potato in broiler diet.

5.3.2 : Effect of Feeding Replacement of Maize with CSPM on Carcass Characteristics of Broiler Chickens (8 weeks of age)

Significant difference were noticed in most of the parameters but they followed no clear cut trend except for the liver that increased as the levels of CSPM exceeded 10%. Birds fed CSPM containing diets showed good percentages of various cut parts and this may be attributed to the reasonable reduction of the anti-nutritional factors of CSPM. The result is in agreement with Turner *et al.*, (1976) who examined various diets consisting of cooked sweet potato and a protein supplement for poultry feeding which shows higher dressing out percentage. Dressed carcass was reported by Tewe (2001) to show poorer result ($P>0.05$) for the test diets while the dressing percents were similar. Maphosa *et al.* (2003) reported that depression in weight gain of birds given sweet potato meal was associated with the changes in the relative weight of organs, which he attributed it to an involvement of anti-nutritional factors.

5.3.3: Apparent Nutrient Digestibility of Broiler Chickens fed Varying Percent Replacement Levels of CSPM (8 weeks of age)

The results obtained showed that, dietary inclusion of CSPM significantly reduced the digestibility of DM, CF, EE and ash. This may be as result of bulkiness of the diets containing high level of CSPM. At lower percent replacement levels of 10-20% CSPM diets, CP digestibility was significantly the same with the control group. This may be as a result of cooking sweet potato tubers. Oyenuga and Fetuga (1975) reported that cooking did not significantly affect the utilization of energy, but it increased the digestibility of the nutrient. Canope *et al.* (1977) found that cooking improved digestibility of all nutrients, but especially of nitrogen. These results showed a remarkable similarity in the crude protein digestibility of maize and CSPM at 10 - 20% replacement, which may be as a result of cooking that

ameliorated level of anti-nutritional factors problem that milited chickens from utilizing sweet potato tuber.

5.3.4: The Economic Analysis of the Experimental Diets

The result showed that, the cost of producing a bird with control diet was significantly higher ($P > 0.05$) than the rest of the treatments. Ten percent CSPM group recorded the best cost of feed per kg gain which was statistically not different with the control group, but they were better than the rest of the treatments. This showed that the cost of using control and 10% CSPM diets were most economical in producing a unit weight of broiler chicken as they gave the best feed efficiency and conversion ratio. The result confirmed the findings of Feltwell and Fox, (1979) and Nesheim *et al.* (1979) who suggested that a unit cost of feed used in producing a unit of poultry meat should be given the greatest importance rather than the conversion ratio of the feed.

5.4: Comparative Performance of Broiler Starter Chicks (1-4 weeks) fed Three Varieties of CSPM at 10% Partial Replacement for Maize.

Birds fed three varieties of CSPM at 10% level of replacement for maize in the control diet performed significantly better than the control in growth parameters. This result showed that, replacing 10% of maize with CSPM brings better performance than 100% maize diet at starter phase of broiler chickens. This may be as a result of cooking sweet potato tubers. Dominguez, (1992) reported that cooking improves the feeding value of sweet potato tubers since it reduces trypsin inhibitors activity and increase starch digestibility. Sasi and Padmaje (2003) reported that when Sweet Potato tuber was cooked, between 17 and 31% trypsin inhibitor activity remained and when it was prepared in to flour, only 5-12% trypsin inhibitor was found.

The higher feed intake noticed may be as a result of sucrose value that gives a reliable indication of CSPM sweetness. Lebot, (2009) reported that, sugar content is extremely variable, usually between 1 and 12% DM, but some U.S. cultivars contains as much as 38% DM of sugars. The decreased in the feed cost observed with the inclusion of CSPM in broiler diets, agrees with the results obtained by Maphsa *et al.* (2003), Ayuk and Essien, (2009) and Afolayan *et al.* (2012), who reported a linear decreased in the feed cost with inclusion of sweet potato.

5.5: Comparative Performance of Broiler Finishers (5-8 weeks) fed Three Varieties of CSPM at 10% Partial Replacement for Maize.

Birds fed with white-fleshed variety as replacement for maize performed best among the three varieties, and this may be attributed to the higher feed intake and efficiency of gain that may be due to preferences by the birds, because of differences in the cultivars and sugar content in each variety. This suggested that white-fleshed (CSPM) could be better supplement for maize as an alternative energy source of broiler chickens, because feed cost/kg gain were statistically similar with control.

5.5.1: Carcass Characteristics of Broiler Chickens fed Three Varieties of CSPM at 10% Replacement for Maize.

The carcass characteristics of broiler finisher chickens fed three varieties of CSPM at 10% level of replacement. There were no significant differences in most of the parameters measured. Where significant differences noticed, did not follow a clear trend except in weight of heart where birds fed the 3 varieties recorded higher weight than the control group and this may be attributed to the impact of CSPM on the volume of blood in broiler chickens. The percent weight of abdominal fat recorded in this study disagree with the

findings of Gerpacio, (1978) who reported a linear decreased of fat with increased levels of sweet potato inclusion.

The similarities observed in carcass weight between the birds fed 3 varieties replacements and the control group may be attributed to lower percent replacement of maize with CSPM. Turner et al (1976) examined various diets consisting of cooked sweet potato meal and a protein supplement for poultry feeding and shows higher dressing out percentage.

5.5.2: Nutrient Digestibility of Broilers fed Three Varieties of CSPM (8 weeks of age)

Digestibility coefficient values were higher than 60% in all the nutrient evaluated. Ash digestibility were relatively lower than other nutrient components, this may be as a result of higher digestibility of cooked sweet potato tubers in feeding broiler. The result is in agreement with the findings of Dominguez (1990) who reported that cooking did not significantly affect the utilization of energy, but increased the digestibility of the nutrients. Fiber was more digested than NFE and ash in almost all varieties and the control group. The minimum dry matter digestibility was 82% (in yellow-flesh variety) and highest in orange-flesh variety. This result implies that white-flesh variety was more digestible by broiler chickens than the other varieties. It was closer to control group, and was better than Orange-flesh and Yellow-flesh varieties statistically ($P>0.05$). This is supported by the result obtained in this experiment in the final weight, daily weight gain and FCR in broiler finisher.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1: SUMMARY

Four experiments were conducted with two set of birds. The first two experiments were carried out to determine the optimum level of utilization of cooked sweet potato meal (CSPM) in broiler diets. CSPM replaced maize at 0, 10, 20, 30, 40 and 50%. Results for the starter phase showed that 5.4% CSPM diet which is 10% replacement of maize supported optimum performance in terms of final weight, weight gain, daily weight gain and feed conversion ratio. Birds fed 20% CSPM diet recorded highest daily feed intake at starter phase. There was a linear decrease in the feed cost per kilogram across the dietary treatments. There was no mortality in this experiment.

At the finisher phase the control diet performed significantly better than all the diets containing CSPM. On carcass evaluation results, significance differences were noticed in most parameters, but they followed no clear cut trend except for the liver that increased as the replacement levels of CSPM exceeded 10%. Dietary treatments significantly influenced apparent digestibility of DM, CP, CF, EE and ash. Dietary inclusion of CSPM significantly reduced the digestibility of DM, fiber, EE and ash. The fibre digestibility decreased linearly as CSPM inclusion increased from 0 – 50%, while ash digestibility also decreased linearly as CSPM increased from 0 – 30%.

Nutritional evaluation of three the varieties of CSPM at 10% level of replacement revealed that, birds fed the three varieties performed better than the control in terms of final

weight, weight gain, daily weight gain and feed conversion ratio at starter phase. There was also a reasonable reduction in feed cost due to CSPM inclusion.

At the finisher phase the birds fed control diet had the best performance which was statistically not different ($P > 0.05$) from the birds fed white CSPM diet in most of the parameters. However, diet containing the three varieties were cheaper compared to control. Mortality was least (2.22%) in the birds fed three varieties compared to 4.44% in the control group. Carcass analysis result showed no significant differences in most of the parameters.

The nutrient digestibility were generally higher in the birds fed CSPM free diets. White-flesh had relatively higher digestibility coefficient than orange and yellow flesh CSPM base diets. CP and ash were better digested by birds fed white-flesh CSPM than the birds fed control, orange and yellow flesh CSPM diets.

6.2: CONCLUSION

It was concluded that broiler chicks can optimally tolerate not maximum of 5.4% CSPM which is 10% replacement for maize in their diets at starter phase. The inclusion of CSPM as 10% replacement for maize in broiler diet brought about reduction in feed cost. For the finisher phase however inclusion of CSPM diet resulted in reduced weight gain even at the 10% replacement of maize. White-flesh variety of CSPM was the best among the three common varieties of sweet potato in broiler feeding.

6.3: RECOMMENDATION

- 1- Ten percent replacement for maize which is 5.4% CSPM at the broiler starter phase is recommended.

- 2- Among the three common varieties of CSPM, white-flesh variety is recommended in broiler feeding and production.
- 3- Further studies are recommended to determine the replacement value of CSPM in broiler finisher diets.

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Appendix 1.

Cost of feed ingredients used in formulating broiler starter diets in September 2011
(₦/kg).

S/N	Feed Ingredients	Prices
1	Maize	63
2	CSPM	23.81
3	Soybean cake	113
4	Groundnut cake	88
5	Fish meal	63
6	Palm oil	233.3
7	Bone meal	43
8	Salt	60
9	Methionine	1300
10	Lysine	680
11	*Vit-min-prem.	480

CSPM=cooked sweet potato meal

Appendix 2.

Cost of feed ingredients used in formulating broiler starter diets in November 2011
(₦/kg).

S/N	Feed Ingredients	Prices
1	Maize	63
2	CSPM	23.81
3	Soybean cake	113
4	Groundnut cake	88
5	Fish meal	63
6	Palm oil	233.3
7	Bone meal	43
8	Salt	60
9	Methionine	1300
10	Lysine	680
11	*Vit-min-prem.	480

CSPM=cooked sweet potato meal

Appendix 3.

Cost of feed ingredients used in formulating broiler starter diets in January 2012 (₦/kg).

S/N	Feed Ingredients	Prices per
1	Maize	68
2	CSPM	22.50
3	Soybean cake	128
4	Groundnut cake	103
5	Fish meal	168
6	Palm oil	216
7	Bone meal	48
8	Salt	70
9	Methionine	1200
10	Lysine	680
11	*Vit-min-prem.	400

CSPM=cooked sweet potato meal

Appendix 4.

**Cost of feed ingredients used in formulating broiler starter diets in March 2012
(₦/kg).**

S/N	Feed Ingredients	Prices
1	Maize	68
2	CSPM	22.50
3	Soybean cake	128
4	Groundnut cake	103
5	Fish meal	168
6	Palm oil	216
7	Bone meal	48
8	Salt	70
9	Methionine	1200
10	Lysine	680
11	*Vit-min-prem.	400

CSPM=cooked sweet potato meal