EFFECTS OF FEEDING PROCESSED CASTOR *(Ricinuscommunis)*SEEDS AND CAKE MEALSON THE PERFORMANCE CHARACTERISTICS OF BROILER CHICKENS

BY

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DEPARTMENT OF ANIMAL SCIENCE,
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NIGERIA.

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Declaration

I declare that the work in this thesis entitled "EFFECTS OF FEEDING PROCESSED CASTOR*(Ricinuscommunis)* SEEDS AND CAKE MEALS ON THE PERFORMANCE CHARACTERISTICS OF BROILER CHICKENS"has been carried out by me in the Department of Animal Science,Ahmadu Bello University, Zaria. 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 this or any institution.

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Certification

This thesis entitled "EFFECTS OF FEEDING PROCESSED CASTOR*(Ricinuscommunis)* SEEDS AND CAKE MEALS ON THE PERFORMANCE CHARACTERISTICS OF BROILER CHICKENS" by OYEDUNNI OYENIRAN meets the regulations governing the award of the degree of Master of Science of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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Abstract

Two feeding trials were conducted using isonitrogenous diets to determine the effects of processed small seeded variety of dehulledcastor seeds and castor seed cake on performance of broiler chickens. In broiler studyone , 216 day-old broiler chicks and 204 , five weeks old broiler finishers were used for the starter and finisher phase respectively. Completely randomized design (CRD) was applied in both studies . The starter phase for experiment one lasted 0 – 4 weeks while the finisher phase lasted 5 – 9 weeks . There were four treatments during each phase. Each treatment was replicated three times. The experimental diets for study one contained CS B60 at 0 % (control), 10 %, 20 % and 30 % levels for diets 1 to 4 respectively.For the second broiler study, 225 one week old broiler chicks and 135, six weeks old broiler finisherswere used for the starter and finisher phases respectively. The starter phase lasted 1 – 5 weeks while the finisher phase from lasted 6 – 9 weeks respectively. There were five treatments for the starter phase. This was reduced to three treatment for the finisher phase. The experimental diets for the starter phase contained CSC B60 at 0% (control), 10% CSC B60 with 0.25% L-Lysine and 0.25% DL-Methionine supplementations (diet 2), 10% CSC B60 with 0.5% L-Lysine and 0.5% DL-Methionine supplementations (diet 3), 20%CSC B60 with 0.25% L-Lysine and 0.25% DL-Methionine supplementations (diet 4), and 20% CSC B60 with 0.5% L-Lysine and 0.5%DL-Methionine supplementations (diet 5). The diets for the finisher phase contained CSC B60 at 0% (control), 10% CSC B60 with 0.33% L-Lysine and 0.25% DL-Methionine supplementations (diet 2), 10% CSC B60 with 0.66% L-Lysine and 0.5%DL-Methionine supplementations (diet 3). Aminoacid supplementations therefore involved adding to the supplemented diets twice the amount of lysine and Dl- methionine contained in the lower

supplemented 10% or 20% CSC B60 diets . Each treatments were replicated three times during both starter and finisher phases. Chemical analyses of the castor seeds showed increased crude protein value, decreased crude fiber and ether extract values as the duration of cooking increased. Anti-nutritional factor contents showed decreased phytate, haemagglutinin, tannins and oxalate contents of CSC B60 compared to the unprocessed raw castor cake (RCSC) (P< 0.O5) . The results for broiler study 1 showed final weight, Total weight gain and Feedintake of broiler birds decreased steadily and Feed to gain ratio increased as the level of CS B60 increased in the diets. Dressing percentage decreased with increasing CS B60 levels.Apparent Crude fibredigestibilities for birdsdecreasedasdietary levels ofCS B60increased. No significant differences were observed for PCV, Hb and TP across treatments (P >0.05) . The results for broiler study 2 showed no significant effects of supplementing with extra 0.25% amino acids supplementations above the normal 0.25% supplementations on the growth and feed utilization of the birds fed CSC B60 containing diets. During the starter phase, most of the birds fed 20 % CSC B60 diets with or without extra amino acids supplementations died. For this reason , the two treatments containing 20% CSC B60 were removed from the finisher phase of the experiment. Dressing percentage decreased for the 10%CSC B60 diet with or without extra 0.25% amino acids supplementations. The same trend was observed for breast (%), back (%), thigh (%) and neck (%). No significant differences were observed in the PCV, Hb concentrations and for blood TP values acrosstreatments (P >0.05) . It was concluded that diets containing CS B60 or CSC B60with 0.5%L-Lysine and DL-methionine supplementations for the starterand 0.66% L-Lysine and 0.5%DL- methionine were not suitable as feed ingredients in broiler starter or finisher diets.

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CHAPTER 1

1.0 INTRODUCTION

One of the challenges facing Nigerian livestock industry today is the high cost of conventional feedstuff used in compounding animal feeds.The conventional or primary protein sources like soya bean, groundnut cake, fish meal and cotton seed cake are not only expensive but also competed for by humans and other industrial users(Akinmutimi, 2001). The increasing cost of these ingredients is unprecedented. The importance of utilizing cheaper non-conventional feedstuffs has been emphasized. The non-conventional feedstuff considered in this study is castor seeds and castor seed cake (obtained after oil extraction). The effort to use castor seed and the cake, if successful, may reduce the cost of feed production and subsequently that of animal production in general and may increase the production of the livestock sector of Nigerian Agriculture (Annongu and Joseph, 2008).

Castor seed and castor seed cake are obtained from castor oil plant (*Ricinus communis L*). It is an angiosperm that belongs to the *Euphorbiaceae* or spurge family. Thus, castor oil plant is not a legume. It grows in the tropical and temperate regions throughout the world, either wild or cultivated. In Nigeria, commercial production of the castor oil plant is rare. The annual production figure is unknown. The plant is commonly found growing in the wild around homes, farms, streams and river banks. It is called by different names such as “Zurman” in Hausa, “Ukpaka” in Ibo, “Sharai jojo” in Tiv, “Ogiri” in Idoma, “Kpamfini” in Nupe and “Ewe Laa” in Yoruba**.**Castor oil plant is widely cultivated in the southern states of Nigeria where the dehulled seeds are popularly use as flavour enhancing food condiment(Achi, 2005).

Castor seed cake is obtained after oil is pressed-out (oil extraction) from the castor seeds. Reports have shown practical use of castor seeds and its cake in livestock feeding (Martins *et al.*, 1982; Okorie andAnugwa,1987; Ani and Okorie, 2002). However the use of castor seeds and castor seed cake as a feed ingredient in poultry rations is limited by the presence of phytotoxins, primarily ricin and ricinine (Liener, 1986), extremely potent allergen (Horton and Maurice, 1989) and high fiber levels in undehulled seeds (Browning *et al*., 1990). Besides, castor seeds protein is known to be deficient in lysine and sulphur containing amino acids (Satar *et al.*, 1979; Browning *etal.*, 1990; Ani and Okorie, 2009; Ani, 2007). The castor seed cake is deficient in lysine and methionine (Davendra, 1988). The anti-nutritional factors and nutrients deficiency hindered the use of both castor seeds and castor seeds cake meals as source of protein in rations of pig, poultry andrabbits.

1.1 Justification of the Study

Castor seed has a crude protein content ranging from 21 - 48 % depending on the extent of decortication and oil extraction process (Adedeji *et al.*, 2006). The cake contained about 32 – 48% crude protein depending on levels of decortications and deoiling (Rama Rao, 2004). Castor seed cake has high crude protein which is similar to that obtained from most conventional protein feed resource such as soybean meal and peanut meal (Akande *et al.*, 2012).However, the seed and the cake are not fully utilized as feed ingredient in livestock ration because of its toxicity due to the presence of ricin, ricinine, thermostable castor allergens (Ani and Okorie, 2009). The various methods of processing legume seeds for incorporation into poultry feeds can be used for processing castor seeds. It is expected that traditional methods employed in processing of castor seed and cake, namely hydrothermal treatment, soaking and fermentation, may considerably reduce the levels of the anti-

nutritional factors (Enujiugha and Ayodele-Oni, 2008).Feeding trials with animals have shown that detoxified castor seed and castor seed cake can be used as protein supplement for ruminant, pigs and chicks (Ani and Okorie, 2006; Oso *et al.*, 2011; Akande *et al.*, 2011). Studies have also shown that nutrients and enzyme supplementation may enhance the nutritional quality of diets formulated using castor seeds (Okorie *et al.*, 1988; Babalola *et al.*, 2006; Ani, 2007). Although recommended inclusion in poultry beyond which it will have adverse effect on performance is 10 % of the diet composition,this study examined different detoxification/processing methods of castor seeds and castor seed cake with the aim ofmaking available the high protein content for enhanced productivity of broiler birds.

1.2 Objectives of the Study

The objectives of this study were:

i. To determine the effect of duration of boiling of castor seeds and castor seed cake on chemical compositions and on the levels of anti-nutritional factors.

ii. To determine the effects of feeding graded level of boiled castor seeds on growth performance, carcass characteristics, nutrient digestibility and haematological parameters of broiler chickens.

iii. To determine the effects of lysine and methionine supplementations on the utilization of boiled castor seed cake containing diets.

1.3 Research Hypotheses

$H_0$1: Boiling does not improve chemical compositions nor having any effect on the reduction of anti-nutritional factors of castor seeds and castor seed cake.

$H_0$2: Boiled castor seed meal and castor cakeare both unsuitable as feed ingredients for broiler starter and finisher diet formulations

H_0 3: Lysine and methionine supplementations cannot enhance the utilization of processed castor seed cake meal in broiler starter and broiler finisher diets**.**

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 General Description of Castor Plant

Castor plant belongs to the Euphorbiaceae or spurge family (Akande *et al.* 2012) and it is not a legume. It is the only member of the genus *Ricinus* and has no immediate relatives (IGS, 2009). Many different species have been described but all are thought to be different types of *Ricinus Communis L*. The name *Ricinus* is a Latin word for tick. The seed is so named because it has markings and a bump at the end which resembles certain ticks (Ombrello, 2011).

Kingdom:	*Plantae*
Order:	*Malpighiales*
Family:	*Euphorbiaceae*
Sub-family:	*Acalyphoideae*
Genus:	*Ricinus*
Species:	*Communis*
Binomial Name:	*Ricinus communis*

Castor plant is native to the Ethiopian region of tropical East Africa (Akande *et al.* 2012). The history of castor plant is not very clear. It is said that the plant originated in the tropical belt of India and Africa. While the plant is native only to Africa, people have introduced it around the world and it is called by various names in different languages (Ombrello, 2011).

Herodotus, the father of history, states that the Egyptians used a type of oil to burn their lamps and for other purposes which was made from the seeds of *Ricinus* in the 4th century BC. He named it “Kiki” and till now castor is cultivated in Greece by the same name.

Theophrastus and Dioscorides stated that the oil is not worth eating but very good if applied externally as a medicine. They gave the detailed description of the plant around 1st century and the process of extracting oil from the seeds. The plant is cultivated till the fifteenth century but slowly become unpopular. By the 18th century, its production practically ceased in Europe. This is the period when the name changed to castor (CRN India, 2011).

The common name "castor oil plant" is probably derived from its use as a replacement for castoreum, a perfume-base made from the dried perineal glands of the beaver (*castor* in Latin). Its other common name is palm of Christ (or *Palma Christi*) which is derived from castor oil's reputed ability to heal wounds and cure ailments (Castor Oil Plant, 2011).

Castor plant is a suckering perennial shrub which can reach the size of a small tree (around 12 meters), but it is not cold-hardy (Castor Oil Plant, 2011). The glossy leaves are 15 - 45 centimeters long and has a long stalk. The leaves alternate and palmate with 5 – 12 deep lobes with coarsely toothed segments. In some varieties, the leaves are dark reddish purple or bronze when young, gradually changing to a dark green, sometimes with a reddish tinge, as they mature. The leaves are green in some varieties. In other varieties, a pigment masks the green colour of all the chlorophyll-bearing parts (that is, the leaves, stems and young fruits), so that they remain a purple to reddish-brown throughout the lifespan of the plant. Those that possess dark leaves can be found growing next to those with green leaves. The stems and the spherical, spiny seed capsules also vary in pigmentation. The fruit capsules of some varieties are more conspicuous than the flowers. Male flowers are yellowish-green. Female flower have prominent red stigmas (Brickell, 1996). The fruits have a spiny, greenish to reddish - purple capsule containing large, oval, shiny, bean-like seeds with variable brownish mottling. The spiny seed pod or capsule is composed of three sections or

carpels which split apart at maturity. Each carpel contains a single seed. As the carpel dries and splits open, the seed is often ejected with considerable force. The seed has a warty appendage called the caruncle which promote the dispersal by ant (myrmecochory).

According to Akande *et al.* 2012, castor plant differs in many notable traits such as plant height (dwarf or tall), leaf shape and colour, stem colour (green, gray, purple and red), nature of pod (dehiscent or indehiscent), seed size (small or large), seed coat colour (white or brown). In Nigeria, there are smooth indehiscent pod type and spiny dehiscent type which are widely distributed across the country. Since no suitable machine has been reported for decorticating and dehulling castor fruit, it is economically viable to consider the dehiscent type over the indehiscent type because of the need for decortication.

The toxicity of castor seed is a reason why most farmers do not grow the crop extensively. However, castor oil has become the wave of the future biodiesel with several hundreds of uses ranging from lubrication, cosmetics, medicine and biodiesel production. This has been an impetus to a country like Nigeria such that Benue State Government received over two billion naira for castor oil seed production initiative in 2008 (Akande *et al.,* 2012). The castor oil plant has many uses, particularly the thick and yellowish or almost colorless oil obtained from the seeds.

The plant has many other uses. All parts of the plants have one form of use or the other (Cadha, 2006). Even after the oil has been removed from the castor seeds, the residue (that is, castor seed cake) makes an excellent fertilizer (Cadha, 2006; Ombrello, 2011). The crop residue and the leaves are used in making paper and wallboards. Castor leaves are used in feeding Silkworm. About 75 kg of the leaves are required to produce 1 kg of "Eri" silk

cocoons. The powdered leaves has insecticidal activity, probably due to the presence of the alkaloid ricinine (Cadha, 2006). Alcoholic extract of castor leaves have been found to be hepatoprotective in rats. Methanolic extract of the leaves has been used in antimicrobial testing against eight pathogenic bacteria in rats and shows antimicrobial properties. The extract is not toxic. The pericarp of castor seeds shows central nervous system effect by improving memory consolidation at low doses in mice. At high doses, the mice quickly died. Water extract of the root bark showed analgesic activity in rats. Ethanolic extract of root bark showed anti-histamine and anti-inflammatory properties.

2.2 Castor Oil and its Commercial Values

Castor seeds are the main product from the plant because of the oil in them. The oil is obtained from castor seed after oil extraction process. It is one of the first medicinal oils in the world. Castor oil is one of the world most versatile natural product. There are an astonishing number of industrial applications of castor oil and its derivatives. Dehydrated castor oil is a drying oil used extensively in paints and varnishes. In fact, one of the largest single market for castor oil in the United State of America is in the paint and varnishes industry. Some experts say that dehydrated castor oil has similar qualities to linseed oil and tung oil, two of the most important drying oil. Its resistant quality makes it ideal for coating fabrics and as protective coverings and insulation of food containers (Trevino and Trumbo, 2002; Somani *et al*., 2003; Akande *et al.*, 2011). Castor oil is the primary raw material for the production of sebacic acid, the basic ingredient in the production of nylon and other synthetic resins and fibers. Approximately 3 tons of castor oil are required to produce one ton of nylon (Cadha, 2006). The superiority of castor oil and its ability to cling to very hot moving parts makes it an outstanding oil for racing engines. It imparts a distinctive aroma

to the exhaust of these engines. Castor wax is a hard wax produced by the hydrogenation of pure castor oil. It is used for making shoe polish, electrical condenser, carbon paper and as solid lubricant (Trevino and Trumbo, 2002; Somani *et al*., 2003). Although castor oil is rather malodorous and distasteful, it is the source of several synthetic flower scents and fruit flavours such as jasmine, apricot, peach, plum, rose, banana and lemon. The chemical responsible for these flavours and aroma are obtained from ricinoleic acid. In fact, ricinoleic acid comprises of about 90% of the total triglyceride fatty acids of castor oil (Cadha, 2006). Castor oil is used in manufacturing of soaps, inks, plastics, brake fluids and certain insecticidal oil. It is also useful in dyeing and finishing of textile products and preservation of leather (Cadha, 2006; Ogunniyi, 2006). Ricinoleic acid in castor oil inhibits the growth of many viruses, bacteria, yeast and moulds. Topical application of castor oil exert remarkable analgesic and anti-inflammatory effects due to the presence of ricinoleic acid (Akande *et al.,* 2011).

2.3 Castor Seeds: Physical Characteristics and Commercial Values

It is also referred to as Castor beans or Castor bean meal. Physical characteristics of castor seeds varieties found in Nigeria are shown in table 2.1 (Akande *et al.,* 2012). The seeds of the castor plants that grow in Northern States of Nigeria have been classified into seven distinct varieties according to their sizes and colours (Van Rheenen, 1976).

Table 2.1: Physical characteristics of two main varieties of castor seeds in Nigeria.

Parameter	Large seeded variety	Small seeded variety
Whole fruit (g)	1.29 ±0.12	0.238±0.01
Whole seed (g)	0.68 ±0.1	0.116±0.02
Husk (g)	0.604±0.01	0.122±0.02
Testa (g)	0.168±0.002	0.036±0.003
Kernel (g)	0.515±0.01	0.08±0.01
Percentage seed	52.7±2.15	48.7±2.12
Percentage kernel	75.7±2.55	69.0±2.53
Husk : seed ratio	0.89±0.07	1.05±0.08
Coat : kernel ratio	0.33±0.01	0.45±0.01
Oil : cake ratio	0.33±0.01	0.37±0.01
Seed width (cm)	1.30±0.17	0.45±0.03
Seed thickness (cm)	0.74±0.09	0.40±0.05
Seed height (cm)	1.75±0.09	0.85±0.03

Adapted from Akande *et al.* 2012.

Since size is a continuous variation, an attempt to identify all categories will definitely be cumbersome. Hence, two varieties are recognized in this study: large seeded variety major (LSV) and small seeded variety minor (SSV). Variation within each variety may be attributed to season of collection (dry or rainy season), soil type and possible cross breeding during flowering. The SSV usually grow wild but commonly found along road sides, river banks, residential areas and waste lands. The LSV is traditionally cultivated in the eastern part of Nigeria. The seed is popularly used as food condiment called "Ogiri" (Achi, 2005). The seeds are composed of about 25 % husk (hull) and 75 % kernel. The percentage of pod and husk vary in the two varieties of seed. LSV has less of both pod and husk compared to SSV. LSV is about six times the size of the SSV. More husks are essentially generated than the kernel in SSV compared to LSV, thus more waste or by-products are produced during seed processing of the SSV. About 92% dehulling are achieved with LSV while 83% dehulling for SSV. It is difficult to dehull the SSV and more time are wasted in dehulling. This is due to its relatively smaller size. A reasonable percentage of kernels that are lost during dehulling process and higher quantity of waste are generated for SSV compared to LSV. For instance, one tonne of castor seed can generate about 530 kg of kernel for LSV when dehulled whereas about 490kg kernel of SSV can be recovered from the same quantity of seed. This has a serious implication on costs accrued from processing and transportation of the seed especially when large tonnage is considered commercially. Most reports on feeding of castor seed meal to livestock preferred the LSV. This may be adduced to its relative ease of handling and processing. Since high fibre content of undehulled castor seed constitute a serious nutritional impediment to its use in feeding animals, the LSV will offer better overall

value in livestock feeding due to ease of handling, lesser waste production and higher kernel yield. Literature reports indicated that the oil content of the seed varies from 35 to 55 per cent of the weight of the seeds (Oplinger *et al.,* 1990). A mechanical press with hydraulic can only remove about 70% of the available oil in castor seeds and further extraction with petroleum ether will remove the residual oil.

2.4 Castor Seed Cake

This is also called "Poonac", "Pomace", Castor cake, Castor beans cake, castor cake meal or Castor residue (Cadha, 2006). Castor seed cake is obtained after the oil is pressed out (extracted) from the seeds. The de-oiled residue of castor seeds (castor seed cake) that remained after extraction contains toxins and allergens. The toxins are water-soluble and not lipid soluble. So they remain in the cake and are not released during the pressing process. The cake contained about 32 - 48% crude protein depending on levels of decortications and deoiling (Rama Rao, 2004). Castor cake has popularly found application as a fertilizer which is far below its potential. Despite the unhealthy toxins in the cake, if it can be successfully detoxified, it could become an important new generation feed resource.

Castor seed cake has high crude protein which is similar to those of most conventional protein feed resources such as soybean meal and peanut meal (Akande *et al.,* 2012). No single mechanical method has been successfully used for the total extraction of castor oil leaving the cake with varying level of oil. Mechanical pressing will only remove about 70% of the oil present. An effective method to recover more than 99% of the oil present in castor seeds is mechanical in combination chemical (hexane) extraction (Marter, 1981). It has also been suggested that castor bean cake should be properly de-oiled before use as a livestock feed to avoid reduced nutrient utilization (Akande *et al.,* 2011). This observation

may be related to the purgative effect of the oil which prevented absorption of the nutrients in the intestine.

2.5 Nutrient Profile of Castor Seeds and Castor Seed Cake

Proximate compositions of un-dehulled and dehulled full fat castor seeds and castor seed cake are shown in Table 2.2. The protein content of castor seed varies from 21 - 48 % depending on the extent of dehulling (decortication) and oil extraction process (Adedeji *et al.,* 2006). Compared to un-dehulled full-fat castor seeds, un-dehulled castor seed cake contains higher values of dry organic matter, crude protein, fat, fibre, mineral matter, soluble carbohydrate except for the gross energy and crude fat contents. Dry matter content, crude fat, ash content and gross energy were higher in dehulled full-fat castor seeds than those in dehulled castor seed cake while the reverse was the case with the crude protein, crude fibre and soluble carbohydrate. Proximate analysis of un-dehulled and dehulled full-fat castor seeds and castor seed cake showed that both contained high quantities of valuable nutrients (protein, nitrogen free extract, ether extract, crude fibre and high total ash content) signifying the presence of high levels of macro- and micro-minerals. The presence of high nutrients suggests that castor seeds and castor seed cake may serve as useful feedstuffs for livestock if properly processed (Lewis and Elvin, 1977; Gohl, 1981; Weiss, 1983; Okorie *et al.,* 1985). Toxic substances such as ricin, ricinine, hydrocyanide, allergens and other alkaloids have however limited the use of castor seeds for humanand animals.

Table 2.2: Proximate composition of full-fat castor seeds and castor seeds cake

Nutrients	Un-dehulled		Dehulled	
	full-fat castor seed	castor seed cake	full-fat castor seed	castor seed cake
Dry matter (%)	92.97 ± 0.90	98.15 ± 1.03	98.13 ± 0.62	98.00 ± 0.99
Crude protein (%)	20.78 ± 0.97	31.06 ± 0.90	21.87 ± 0.48	35.43 ± 0.44
Crude fat (%)	51.20 ± 0.47	19.40 ± 0.73	55.50 ± 2.66	25.10 ± 0.21
Crude fibre (%)	4.98 ± 0.20	11.90 ± 0.57	2.50 ± 0.05	4.43 ± 0.05
Total ash (%)	7.75 ± 0.13	11.10 ± 0.03	9.40 ± 0.40	7.14 ± 0.07
Solublecarbohydrate, NFE (%)	7.96 ± 0.00	24.69 ± 0.00	8.86 ± 0.00	24.88 ± 0.00
Gross energy kcal/g	6.50 ± 0.00	5.14 ± 0.00	6.53 ± 0.00	5.60 ± 0.00

Adapted from Annongu and Joseph, 2008. All values are determined from the averages of three trials. Gross energy was calculated according to the method of Carpenter and Clegg [2]:

$$\frac{CP \times 5.8}{100} + \frac{EE \times 9.3}{100} + \frac{CF \times 4.2}{100} + \frac{NFE \times 4.2}{100}$$

Macro- and micro-minerals of un-dehulled and dehulled full-fat castor seeds and castor seed cakeare shown in Table 2.3. Un-dehulled castor cake contains higher values of both macro- and micro-minerals than un-dehulled full-fat castor seeds. Dehulled castor seed cake contains higher values of phosphorus, calcium and potassium than the dehulled full-fat castor seeds, while the opposite was recorded for magnesium and sodium. The macro- and micro-mineral compositions of un-dehulled and dehulled castor seed and castor seed cake revealed that they contain sufficient amounts of these nutrients to meet the nutritional requirements of animals if the anti nutrients in the castor seeds that could inhibit utilization or availability of the minerals are removed by adequate treatment of the castor seeds or the cake.

The amino acid composition of un-dehulled and dehulledcastor seed cake compared with that of soybeans as a standard plant protein is shown in Table 2.4. Amino acid profile analysis of castor seed cake is similar to that of soybeans commonly used as a reference standard plant protein. The amino acid profiles of both un-dehulled and dehulledcastor seed cakes are closely related in values to that of soybeans. However, castor seed cake is found to be deficient in certain indispensable amino acids like iso-leucine, tryptophan, lysine and Methionine (Adedeji *et al.,* 2006; Annongu and Joseph, 2008). There is therefore a need to supplement the deficient amino acids in foods or diets containing treated castor seed cake for optimum utilization by the animals.

Table 2.3: Macro- and micro-mineral composition of full-fat castor seed meal and castor seeds cake

Macro elements	Un-dehulled		Dehulled	
(mg/100g)	full-fat castor seed	castor seed cake	full-fat castor seed	castor seed cake
Phosphorus	3.40	5.60	3.30	6.40
Calcium	19.37	27.22	30.34	32.21
Magnesium	49.95	61.47	57.82	48.59
Potassium	21.89	23.61	19.62	23.17
Sodium	74.32	105.29	73.45	56.87
Microminerals, ppm				
Copper	0.88	5.33	0.88	0.44
Iron	51	72	26	49
Manganese	1.62	8.08	0.81	0.81
Cobalt	1.64	1.64	-	-
Lead	-	-	-	-

Adapted from Annongu and Joseph, 2008.

Table 2.4: Amino acid profile of Un-dehulled and dehulled castor seed cake compared with soybeans as standard plant protein

Amino acid (g/16 gram of N)	Undehulled castor seed cake	Dehulled castor seed cake	Soybeans
Lysine	4.11	4.48	6.30
Histidine	1.38	1.88	2.70
Arginine	8.00	9.36	8.10
Aspartic acid	6.42	7.66	11.80
Threonine	3.00	3.88	3.90
Serine	2.13	3.02	5.20
Glutamic acid	13.19	15.64	17.90
Proline	2.76	3.08	5.90
Glycine	0.56	1.11	4.40
Alanine	3.96	5.02	4.30
Cystine	0.53	0.86	1.60
Valine	5.46	4.93	5.10
Methionine	2.06	2.86	1.60
Iso-leucine	3.09	1.61	7.90
Leucine	5.90	8.56	5.10
Tryptophan	-	-	1.30

Adapted from Annongu and Joseph, 2008.

Annongu and Joseph, 2008 reported that the proximate analysis, mineral composition and amino acid profile analysis of castor seeds and castor seed cake have shown that the seeds and cake contain high levels of nutrients with potentials to meet the nutritional needs of farm animals if given proper treatments and supplementation with the deficient limiting amino acids. Currently, research into methods that will permit efficient processing and detoxification to enable full utilization of the castor seeds and castor seeds cake as alternatives to conventional feedstuffs is being give consideration (Ani, 2007; Oso *et al.*, 2011).

2.6 Factors Affecting the Nutritional Quality of Castor Seeds and Castor Seed Cake

Shortage and high cost of some conventional plant protein sources such as cowpea, soybean and groundnut cake have called for alternative plant materials (legume grains) which are rich in protein and of less industrial use and human preference (Akinmutimi, 2001). An example of such seeds is castor seed. Reports have shown practical use of castor seeds and its cake in livestock feeding (Martins *et al.*, 1982; Okorie andAnugwa,1987; Ani and Okorie, 2002). However the use of castor seeds and castor seed cake as feed ingredient in poultry rations is limited by the presence of phytotoxins, primarily the ricin and ricinine (Liener, 1986). These are extremely potent allergens (Horton and Maurice, 1989). Also the fibre levels are high in undehulled seeds (Browning *et al*., 1990). Besides, castor seeds protein is known to be deficient in lysine and sulphur containing amino acids (Satar *et al.*, 1979; Browning *etal.*, 1990; Ani and Okorie, 2009; Ani, 2007). The castor seed cake is deficient in lysine and methionine (Davendra, 1988). The anti-nutritional factors and nutrients deficiencies hindered the use of both castor seeds and castor seeds cake meals as sources of protein in rations of pig, poultry andrabbits.

Ricin component of the castor seeds remain a serious impediment limiting the application of castor seed meal in animal diet (EFSA, 2008). Ricin is the most notorious deadly poison found in abundance in the seed and in smaller amounts throughout the remaining plant parts. Ricin is a highly toxic naturally occurring protein found in castor oil plant. Besides ricin, castor seed meal contains ricinine. Ricinine is a relatively harmless alkaloid and an extremely potent allergen (Horton and Maurice, 1989). The toxins in the seeds are water-soluble and not lipid soluble. So the toxins remain in the castor seed cake and are not released during oil extraction process.

The various methods of processing legume seeds for incorporation into poultry feeds can be used for processing castor seeds. These processing methods include heat treatment (such as cooking, roasting and autoclaving), soaking, fermenting as well as their combination (Fashina-Bornbata and Tewe, 1995; Ogundipe, 1980). The adoption of any of the processing methods is influenced by cost, location, environmental factors, choice and facilities available at the farmers disposal (Bawa, *et al*, 2003a). These processing methods have effects on proximate compositions and levelsof destruction of anti-nutrients of the grain legume (Najime 2003, Bawa *et al*, 2003b and Abeke*et al*, 2003).

2.7 Processing of Castor Seeds and Castor Seed Cake by Heat Treatment

Since the discovery of the beneficial effects of heat treatment on the nutritional value of raw legume grains, the challenge of Animal Nutritionists has been to determine the appropriate level of heat treatment for optimum utilization. The most common way by which legumes are processed is by subjecting them to heat though this depends on the variety or type of grains. It has been established that heat treatment exert beneficial effects by destroying the anti-nutritional factors inherent in legume grains (Balogun *et al*, 2001).

Although it reduces the availability of some amino acids, heat treatment is the most widely used processing method (Dhuradhar and Cheng, 1990). Heat treatment causes denaturation of proteinaceous inhibitors and it is a good method of decreasing the activity of lectins, trypsin and chemotrypsin inhibitors (Hanovar *et al.,* 1962; Kadam *et al.,* 1987; Van der Poel *et al.,* 1990; Estevez *et al.,* 1991). The effects of heat treatment depends on temperature and time duration of processing (Van der Poel *et al.,* 1990; Ichihara *et al.,* 1994; Quin *et al.,* 1996; Kaankuka *et al.,* 2000). Excessive heat treatment can result in reduction in protein solubility and it may destroy certain amino acids (Almas and Bender, 1980; Metebe, 1989; Dhurandhar and Chang, 1990; Van Barneveld *et al.,* 1993). It is therefore expedient to find the appropriate condition of heating which can maximize the destruction of anti-nutritional factor and minimize damage to the feed protein.

Investigation on the effects of thermal treatment on certain anti-nutritional compounds in the seeds of Lab lab show that autoclaving seems to be the most efficient method of improving *in-vitro* protein digestibility and eliminating the anti-nutrients such as phyto-heamaglutinin, hydrogen cyanide and oligosaccharide, inherent in the seeds (Ekpenyong and Borcher, 1980; Vijayakumari *et al.,* 1995). Another method of heat treatment that have been shown to inactivate anti-nutritional factor include steam heating at various pressure (Smith and Circle, 1978).

Several reports have shown that processing of legume by cooking and roasting reduced their anti-nutritional factor to a threshold level (Faris and Singh, 1990; Kaankuka *et al.,*1996; Iyayi and Egbarevbe, 1998). According to Ogundipe (1980), boiling in water and toasting (commonly referred to as dry frying or roasting) are the most commonly used methods in developing countries.

Cooking can destroy some level of anti-nutritional factors (Jambunathan and Singh, 1980). Various researchers have boiled or cooked castor seeds for variable length of time (Okorie*et al.*,1985; Ani and Okorie, 2002; Aniand Okorie, 2005). Balogun *et al.,* 2001 reported that 30 minutes cooking time for soybean is adequate for its inclusion in diet of weaning and growing pigs. Bawa*et al.* (2003b) indicated that cooking lablab seeds at 100 ^{0}C for 45 minutes significantly decreased trypsin inhibitory activity (TIA), phytic acid, tannin and cyanide levels. To ensure standardization of cooking time, the ratio of water to seed should be 3 : 1 and as soon as the legume grain are poured into the boiling water, the specified time of cooking can then be recorded (Balogun *et al.,* 2001). A lot of nutrients are lost in water during the boiling process (Ogundipe, 1980; Bawa *et al.,* 2003a). Advantages of boiling the castor seeds include uniform cooking, low cost of processing and ease of adoption by both literate and the illiterate farmers.

Processing of legumes by roasting reduced their anti-nutritional factor of legume grains to a threshold level. Udedibe (1995) and Olupona *et al.* (1998) reported that heat treatment alone was not sufficient to significantly destroy the anti-nutritional factor to a threshold level, especially glucosides. Toasting involves dry frying of castor oil seed in an open pan with constant stirring to prevent charring (Akanji *et al*, 2003). The advantage of toasting as a processing method includes reduction of nutrient loss through leaching as in the case of boiling and the fact that it does not need to be dried in the sun, making it the best method of processing beans in the wet season. However, it has been reported by Abeke (1997) that charring may occur which may adversely affect the nutrients in the seeds.

2.8 Processing of Castor Seeds and Castor Seed Cake by Fermentation

Fermentation usually involve pouring water (slightly warm or even boiled) on the seeds and then covered in an air-tight container and then allowing it to stand for a few days in the water. This will allow natural fermentation to take place. After duration of fermentation, the water is drained off and the material sun dried. The warm water helps to weaken the outer, tougher seed coat and softens it for adequate and quick fermentation to take place. Ologhobo *et al.* (1993) stated that the length of time depends on the size of the grain legume. Sometimes, enzymes and other substrates are added to the water to quicken the fermentation process. The principle of this processing method is that certain microbes and enzymes act to destroy certain anti-nutritional factors in grain legume seeds. Some of the enzymes involved in the fermentation process include phytases and trypsinases. Faris and Singh (1990) reported that the nutritive value of legume based fermented foods were higher than their raw component. Leiner (1981) reported the destruction of trypsin inhibitor during fermentation. Fermentation has certain advantageswhich include ease of operation, low cost, and it can be adopted by both peasant and large scale farmers (Oso *et al.*, 2011).

2.9 Processing of Castor Seeds and Castor Seed Cake by Soaking

This involves placing the grains into a known quantity of water and allowing it to stay for certain duration of time. Soaking differs from fermentation in that microbial activities did not take place. To avoid microbial activities (fermentation), the water should be replace as many times as possible within 24 hours. Nwokolo and Orji (1985) also showed that soaking in water and cooking can also improve nutritional status of legume grains. Ologhoho (1989) reports that soaking in water and germination are the most effective method of reducing phytic and oxalic acid in soybeans.

CHAPTER 3

3.0 MATERIALS AND METHODS

3.1 Location

Three experiments were conducted in Zaria at the Poultry Unit of the Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria. Zaria is located within the northern Guinea Savannah Zone on Latitude 11^0 9' 45"N and Longitude 7^o 38 8" E at an altitude of 610m above sea level. (Ovimaps.2012)

3.2 Source and Processing of Castor Seeds and Castor Seed Cake

Dehulled, small-seeded variety of castor seeds were purchased from a farmer in Shika, Zaria, Kaduna State, Nigeria. To obtain the cake, castor seeds were toasted using a locally fabricated toaster at a temperature of 70 ^{o}C until a brown colour was achieved. The seeds were then de-oiled using locally fabricated mechanical oil extractor.

The castor seeds and castor seed cake were subjected boiling. Briefly, water was brought to boiling point in an aluminum cooking pot. Dehulled castor seeds or the castor seed cake was placed in a muslin cloth and tightened. This was placed in the boiling water (at the rate of 200 grams to 1 litre of water), that is 100^0C, and then covered. Firewood was used as source of heat. From the moment the castor seeds or the cake was placed into the boiling water, the specified time of cooking was taken. Castor seeds or the cake was boiled for durations of 0, 15, 30, 45 and 60 minutes and representative samples removed for chemical analysis at the specified times of cooking. Thereafter, the samples were sun-dried for three days.

3.3 Preliminary Study

3.3.1 Analysis of castor seeds and castor seed cake for their chemical compositions

The unprocessed raw and all the processedcastor seeds or castor seed cakes were analyzed fortheir proximate compositions. according to the A.O.A.C. (1990) procedures.To determine the dry matter, weighed samples were placed into an oven at 100 ^{o}C for 24 hours. The dry matter was then determined based on weight loss. Macro Kjeldahl method was used in determining nitrogen content (N). The crude protein was calculated as N × 6.25. Total ash was determined as the residue remaining after incinerating the sample at 600 ^{o}C for 3 hours in a muffled furnace. Ether extract and Crude fibre were determined using the A.O.A.C.(1990) methods.

3.3.2 Analysis of castor seeds and castor seeds cake for their anti-nutritional factors

3.3.2.1 Determination of phytic acid

Phytate phosphorus was determined by the method of Wheeler and Ferrel (1971). A known weight of each ground sample was soaked into 100 ml of 2 % HCl for 5 hours and filtered. Twenty -five (25) cm^3 of the filtrate was put into a conical flask. Fifty (50) cm^3 of 0.3 % potassium thiocyanate solution was added. The mixture was titrated in standard solution of $FeCl_3$ until a brownish yellow colour persisted for 5 minutes. The concentration of $FeCl_3$ was 1.04 % w/v.

Calculation:

Mole ratio of Fe to Phytate = 1:1

$$\text{Concentration of Phytate phosphorus} = \frac{\text{Titre value} \times 0.064}{1000} \times \text{Weight of Sample}$$

3.3.3.2 Determination of haemagglutinin

Haemagglutinin was determined as described by Akande *et al.,* 2011. It was conducted by haemagglutination assay in round-bottomed wells of microtitre plates using 1% (v/v) trypsinised cattle blood erythrocytes suspension in saline phosphate buffer, pH 7.0 (Makkar *et al*., 1997). The haemagglutination activity was defined as the minimum amount of the kernel material (in mg per mL of the assay medium) which produced agglutination. The minimum amount was the material per mL of the assay medium in the highest dilution that was positive for agglutination. One Haemagglutinating Unit (HU) was defined as the least amount of material per mL in the last dilution giving positive agglutination (Grant *et al*., 1983).

3.3.2.3 Determination of tannin

Tannin was determined using the standard method described by A.O.A.C. (1990). Two grams of the dried sample was boiled with 300 ml of distilled water. This was diluted in a standard volumetric flask and filtered through a non absorbent cotton wool. A volume of 25 ml of the infusion was measured into a two- litre porcelain dish and titrated with 0.1N $KMnO_4$ (0.1N $KMnO_4$ was standardized against 0.1N oxalic acid) until the blue solution changed to green; then few drops of 0.1N $KMnO_4$ was added. The titer was multiplied by 0.0066235 to obtain the amount of tannin in the sample. The equation is given below:

0.1N oxalic acid = 0.0066235 g tannin

3.3.2.4 Determination of oxalate

The total oxalic acid of the powdered sample was determined by weighing 2 grams into a 250 ml flask. Then, 190 ml distilled water and 10 ml of 6M hydrochloric acid were added. The mixture was warmed for 1 hour on boiling water bath, cooled, transferred into 250 ml volumetric flask, diluted to volume and filtered. Four drops of Methyl red indicator were added followed by concentrated ammonia until the solution turned faint yellow. It was then heated to 100 ^{0}C, allowed to cool, and then filtered to remove precipitate containing ferrous ions. The filtrate was boiled and 10 ml of 5 % Calcium chloride was added with constant stirring. It was then allowed to stand overnight. The mixture was then filtered through Whatman No 40 filter paper. Then the precipitate was washed several times with distilled water and transferred to a beaker and 5 ml of 25 % sulphuric acid was added to dissolve the precipitate. The resultant solution was maintained at 80 ^{0}C and titrated against 0.5 % potassium permanganate until the pink colour persisted for approximately one minute. A blank was also run for the test sample from the amount of $KMnO_4$ used, the oxalate content of the unknown sample was calculated using the equation below:

1 ml of $KMnO_4$ = 2.24 mg oxalate

3.4 Broiler Study 1:

Performance Characteristics of Broiler Chickens fed Diets Containing Graded Level of Castor Seeds Boiled for 60 Minutes (CS B60)

3.4.1 Experimental diets for broiler feeeding study 1

Four iso-nitrogenous diets were formulated to meet the NRC recommended nutrient requirements of crude protein of 23 % for the broiler starter birds and 20 % for the broiler finisher birds. Castor seeds boiled for 60 minutes gave the best values of proximate chemical compositions compared to other cooking duration.Based on the increased crude

protein value and decreased crude fiber and CS B60 was selected and fed at graded levels of 0 %, 10 %, 20 % and 30 % in the 23 % crude protein diets for broiler starter birds (Table 3.1) and 20 % crude protein diets for broiler finisher birds (Table 3.2).

3.4.2 Experimental animals, design and management

Day-old broiler chicks used for this trial were Hubbard strains of birds. Birds were reared on deep litter floored pens. Kerosene stoves, lanterns and coal pots were used as sources of heat. Sources of illumination were day-light during day time and Kerosene lanterns during night time. All routine vaccinations were administered: (1^{st} and 2^{nd} doses of Lasota and1^{st} and 2^{nd} doses of Gumboro vaccinations). The experimental diets and drinking water were supplied*ad-libitum*.

Two hundred and sixteen day-old broiler chicks were used for the starter phase (0 – 4weeks). The chicks were weighed and randomly assignedusing completely randomized design to four dietary treatments with each having three replicates. Each replicate had 18 birds making atotal of 54 birds per treatment. Broiler starter diets containing castor seeds boiled for 60 minutes (CS B60) were fed for four weeks. At the end of the starter phase which lasted for four weeks, all the birds were pooled and fed a common diet for one week (between 5 and 6 weeks of age) before the commencement of the finisher phase. Two hundred and four, six weeks old broiler birds were used for the finisher phase (5 – 9 weeks). The birds were weighed and randomly assigned to four dietary treatments with each treatment having three replicates.Each replicate had 17 birds making a total of51birds per treatment. Diets containing castor seed boiled for 60 minutes (CS B60) were fed for the four weeks duration of the finisher phase.

Table 3.1: Composition of broiler starter diets containing graded levels of castor seeds boiled for 60 minutes (CS B60) and calculated chemical analysis.

Ingredients	0 %	10 %	20 %	30 %
Maize	47.87	48.98	48.78	47.35
Groundnut cake	31.23	22.12	13.31	4.75
CS B60	0.00	10.00	20.00	30.00
Soyabean meal (44 % CP)	6.00	6.00	6.00	6.00
Maize offal	5.00	5.00	5.00	5.00
Palm oil	4.00	2.00	1.00.	1.00
Blood meal	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00
Limestone	1.00	1.00	1.00	1.00
Vitamin mineral premix*	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20
Methionine	0.15	0.15	0.15	0.15
Common salt	0.30	0.30	0.30	0.30
Total	100	100	100	100
Calculated Analysis				
Crude protein (%)	23.00	23.00	23.00	23.00
M.E kcal/kg	2962.47	2995.71	3072.81	3197.07
Crude fibre (%)	3.43	4.26	5.08	5.87
Calcium (%)	1.29	1.20	1.16	1.14
Avail P (%)	0.71	0.71	0.71	0.71
Lysine (%)	1.13	1.25	1.40	1.48
Methionine (%)	0.45	0.46	0.45	0.50

* Vitamin-mineral premix provided per kg of diet: Vitamin A: 10,000i.u, Vitamin $D_3$2000 i.u, Vitamin E: 23.00mg, Vitamin K_3: 2.0mg, Vitamin B_1: 1.8mg, Vitamin B_2: 5.50mg, Niacin: 27.5mg, Calcium Pantothenate:7.5mg, Biotin: 0.06mg, Vitamin B_{12}: 0.015mg, Folic acid: 0.75 mg, Choline Chloride: 300mg, Manganese: 40mg, Iron: 66.68mg, Zinc 30mg, Copper: 3.0mg, Iodine: 1.0mg, Cobalt: 0.2mg, Selenium: 0.2mg, , Antioxidant:1.25mg.

Table 3.2: Composition of broiler finisher diets containing graded levels of castor seeds boiled for 60 minutes (CS B60) and calculated chemical analysis.

Ingredients	0 %	10 %	20 %	30 %
Maize	56.43	57.53	56.64	48.76
Groundnut cake	22.67	13.57	5.46	3.34
CS B60	0.00	10.00	20.00	30.00
Soyabean meal (44 % CP)	6.00	6.00	6.00	6.00
Maize offal	5.00	5.00	5.00	5.00
Palm oil	4.00	2.00	1.00	1.00
Blood meal	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00
Limestone	1.00	1.00	1.00	1.00
Vitaminmineral premix	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20
Methionine	0.15	0.15	0.15	0.15
Common salt	0.30	0.30	0.30	0.30
Total	100	100	100	100
Calculated Analysis				
Crude protein (%)	20.00	20.00	20.25	20.50
M.E (kcal/kg)	3039.69	3072.83	3144.56	3209.78
Crude fibre (%)	3.33	4.17	4.99	5.85
Calcium (%)	1.45	1.36	1.29	1.16
Avail P (%)	0.70	0.70	0.70	0.70
Lysine (%)	1.00	1.12	1.25	1.46
Methionine (%)	042	0.44	0.45	0.46

* Vitamin-mineral premix provided per kg of diet: Vitamin A:8,500 i.u, Vitamin $D_3$1500 i.u, Vitamin E: 10.00mg, Vitamin K_3: 1.50mg, Vitamin B_1: 1.6mg, Vitamin B_2: 0.04mg, Niacin: 20mg, Calcium Pantothenate:0 .05mg, Biotin: 0.75mg, Vitamin B_{12}: 0.01mg, Folic acid:0.5mg, Choline Chloride: 175mg, Manganese: 40mg, Iron: 20mg, Zinc 30mg, Copper: 3.00 mg, Iodine: 1.0mg, Cobalt: 0.20mg, Selenium: 0.2mg, Antioxidant: 1.2mg.

During both periods of the starter and finisher phases of the study (0 – 9 weeks), the birds were weighed weekly and leftover feeds were recorded. Performance characteristics were monitored in terms of total weight gain, feed intake, feed conversion ratio and mortality. At the end of the nine weeks feeding trial, one birdsper pen (that is, bird whose weights were equal or close to the mean weight of the birds in the pen) making a total of three birds per treatment were used for haematological analysis. The birds were fasted for 24 hours and then sacrificed by decapitation. About 3mls of blood were collected into sample bottles containing EDTA. Blood samples obtained were used to determine PCV, Hb concentration, TP and total cholesterol. At the end of the trials, carcass analysis was determined using two birds per pen making a total of six birds per treatment were randomly selected and used.

3.4.3 Carcass analysis

At the end of the nine weeks for both broilers feeding trials, twobirds whose weights were equal or close to the mean weight of the birds in the pen were selected and slaughtered for carcass analysis. The selected birds were slaughtered by severing the neck with sharp knife and allowed to bleed completely. They were then dipped in hot water, de-feathered and eviscerated.

The weight at slaughter, de-feathered weights anddressing percentage were taken and expressed as percentage of live weights. Carcass weights were taken and expressed as percentage of live weight to obtain the dressing percentage. The weights of the thigh, wings, breast, back, head, leg and neck were recorded and expressed as percentage of live weights. Relative organ weights were also taken and expressed as percentage of live

weights. The organs considered include liver, kidney, heart, lung, spleen, emptygizzard and emptyIntestine. Intestinal lengths were measured in centimeters.

3.4.4 Haematological determinations

The haematological analysis was done through standard procedures. The PCV was determined by the microhaematocrit method and the Hb concentration was determined by the cyanomethaemoglobin method (Schalm *et al*., 1975). Determination of TP and cholesterol were carried out following standard procedures (Meyer *et al*., 1992; Evans, 1996), using randox reagents and a spectrophotometer (Spectrum lab, England). Total white blood cell counts (WBC) were determined by the haemocytometer method while the differential count smears were prepared and stained by the Leishman technique and enumerated by the longitudinal counting method (Schalm *et al*., 1975).

3.4.5 Nutrient digestibility studies

At the end of the finisher phase of broiler study 1, nutrient digestibility studies were carried out using 24 birds (that is, two bird/replicate) as described by Ani and Okorie, 2009. The birds were housed individually in a battery cage and their droppings were collected from separate cages in detachabletrays beneath the wire mesh floor for 7 days. The droppings werepacked in a labelledpolythene bag, weighed and oven dried.Samples werepreserved until analyzed. The dried samples were assayed for their proximate chemical compositions according to the A.O.A.C. (1990) procedures in the Nutrition Laboratory of the Department of Animal Science, Ahmadu Bello University, Zaria. Digestibility coefficients were calculated using the formula below:

$$\text{Coefficient Digestibility} = \frac{\%\ \text{nutrient in diet} - \%\ \text{nutrient in feaces}}{\%\ \text{nutrient in diet}} \times 100$$

3.4.6 Data Collections

For all feeding trials, feed consumption, animals weights and mortalities were monitored. Feed Intake was recorded on weekly basis bydeductingtheweight leftover feeds at the end of the week from the weight offeeds provided at the beginning of the week. This was recorded as weekly feed intake. Body weight gains were computed on a weekly basis.

3.5 Broiler Study 2:

Performance Characteristics of Broiler Chickens fed Diets Containing GradedLevel of Castor Seeds Cake Boiled for 60Minutes (CS B60) without or with L-lysine and Dl-methionine Supplementations

3.5.1 Experimental diets

Three iso-nitrogenous diets were formulated to meet the NRC standard for crude protein of 23 % for the broiler starter birds and 21 % for the broiler finisher birds.

Based on increased crude protein value and decreased crude fiberand ether extract obtained from Broiler Study 1, CS B60 was selected and fed at graded levels. 23 % crude protein diets were formulated for the broiler starter phase (Table 3.3) and 21 % crude protein diets for the broiler finisher phase (Table 3.4). Boiled castor seed cake was fed at 0%dietary level, 10 % dietary level with 0.25% L-lysine and0.25% Dl-methionine supplementations, 10 % dietary level with 0.5% L-lysine and0.5% Dl-methionine supplementations, 20 % dietary level with 0.25% L-lysine and0.25% Dl-methionine supplementations and at 20 % dietary level with0.5% L-lysine and0.5% Dl-methionine supplementations. Aminoacidsupplementations therefore involved adding to the supplemented diets, twice the amounts of L-lysine and Dl-methionine contained in thelower supplemented10 % or 20% CSC B60 diets.

3.5.2 Experimental animals, design and management

Two hundred and twenty-five day-old Hubbard strains broiler chicks and one hundred and thirty five six-week old Hubbard strains broiler chickens were used for the starter and finisher phases respectively. Management of birds and vaccinations were as for broiler study 1.The chicks were fed a common diet for one week (0 – 1week) after which they were and randomly assigned to pens on the basis of their weights. The birds were randomly assigned using completely randomized designto five dietary treatments for the starter phase and three dietary treatments for the finisher phase, with each treatment having three replicates. Each pen had 25 birds making a total of 75 birds per treatment for the starter phase while Each penhad 15 birds making a total of 45 birds per treatment for the finisher phase (due to elimination of 20% CSC B60 diets from the finisher phase). Diets containing castor seed cake boiled for 60 minutes (CSC B60) were fed for four weeks duration each for the starter and finisher phases.

During both starter(1 – 5 weeks) and finisher (6 – 9weeks)periods, the birds were weighed weekly and leftover feeds were recorded. Performances of birds were monitored in terms of total weight gain, feed intake, feed conversion ratio and mortality rate. At the end of nine weeks of the trial, two birds per pen(that is, bird whose weights were equal or close to the mean weight of the birds in the pen) making a total of six birds per treatment were selected and used for haematological and carcass studies. The birds were sacrificed by decapitation and about 3mls of blood were collected in the sample bottles containing EDTA. Blood samples obtained were used to determine the PCV, Hb and total protein (TP) concentration. Hematologicaland carcassstudies and data collection were conducted as in Broiler Study 1.

Table 3.3: Composition of broiler starter diets containing castor seed cake boiled for 60 minutes (CSC B60)With normal(0.25% Lys + 0.25% Meth) or double(0.25% Lys + 0.25%Meth) aminoacid supplementation and itscalculated chemical analysis

Ingredients	0 %	10 % with 0.25%Lys+0.25%met	10 % with0.5%Lys+0.5% Met	20 % with0.25%Lys+0.25% Met	20 % with0.5%Lys+0.5% Met
Maize	45.48	44.02	44.82	42.80	43.63
Groundnut cake	27.80	20.25	18.95	12.45	11.13
CSC B60	0.00	10.00	10.00	20.00	20.00
Soyabean meal (44 % CP)	6.00	6.00	6.00	6.00	6.00
Maize offal	10.00	10.00	10.00	10.00	10.00
Palm oil	2.04	1.33	1.33	0.35	0.35
Fish meal (45 % CP)	1.50	1.50	1.50	1.50	1.50
Blood meal	2.00	2.00	2.00	2.00	2.00
Bone meal	3.20	3.00	3.00	3.00	3.00
Limestone	0.80	0.80	0.80	0.80	0.80
Vitamin mineral premix*	0.30	0.30	0.30	0.30	0.30
Lysine	0.33	0.25	0.5	0.25	0.5
Methionine	0.25	0.25	0.5	0.25	0.5
Common Salt	0.3	0.3	0.3	0.3	0.3
Total	100	100	100	100	100
Calculated Analysis					
Crude protein	23.00	23.00	23.00	23.00	23.00
M.E (kcal/kg)	2907	2918	2914	2910	2906
Crude fibre(%)	4.15	4.40	4.35	4.64	4.59
Calcium (%)	1.28	1.26	1.25	1.28	1.28
Avail P (%)	0.56	0.57	0.57	0.60	0.60
Lysine (%)	1.27	1.24	1.44	1.27	1.48
Methionine (%)	0.89	0.89	1.11	0.90	1.11

*Vitamin-mineral premix providedper kg of diet: Vitamin A: 10,000i.u, Vitamin $D_3$2000 i.u, Vitamin E: 23.00mg, Vitamin $K_{3:}$ 2.0mg, Vitamin B_1: 1.80mg, Vitamin B_2: 5.5mg, Niacin: 27.5mg, Calcium Pantothenate: 7.5mg, Biotin: 0.06mg, Vitamin B_{12}: 0.25mg, Folic acid: 1.00mg, Choline Chloride: 300mg, Manganese: 40mg, Iron: 66.68mg, Zinc 30mg, Copper: 3.0mg, Iodine: 1.0mg, Cobalt: 0.2mg, Selenium: 0.2mg, Growth promoters: 40.00, Antioxidant: 200mg

LYS: Lysine, Met-methionine.

Table 3.4:Composition of broiler finisher diets containing castor seed cake boiled for 60 minutes (CSC B60)with normal(0.33%Lys+ 0.25% Meth) or double(0.33% lys+ 0.25 %Meth) aminoacid supplementation and calculated chemical analysis

Ingredients	0 %	10 % with0.33%Lys +0.25%Met	10 % with 0.66%Lys+ 0.50%Met	20 % with0.33%Lys+ 0.25%Met	20 % with 0.66%Lys +0.50% Met
Maize	50.22	47.76	48.69	41.54	42.47
Groundnut cake	22.30	14.76	13.25	7.98	6.47
CSC B60	0.00	10.00	10.00	20.00	20.00
Soyabean meal (44 % CP)	6.00	6.00	6.00	6.00	6.00
Maize offal	10.00	10.00	10.00	10.00	10.00
Palm oil	3.00	3.00	3.00	6.00	6.00
Fish meal (45 % CP)	1.50	1.50	1.50	1.50	1.50
Blood meal	2.00	2.00	2.00	2.00	2.00
Bone meal	3.20	3.00	3.00	3.00	3.00
Limestone	0.80	0.80	0.80	0.80	0.80
Vitamin mineral premix*	0.30	0.30	0.30	0.30	0.30
Lysine	0.33	0.33	0.66	0.33	0.66
Methionine	0.25	0.25	0.50	0.25	0.50
Common Salt	0.3	0.3	0.3	0.3	0.3
Total	100	100	100	100	100
Calculated Analysis					
Crude protein (%)	21.00	21.00	21.00	21.00	21.00
M.E (kcal/kg)	3015	3049	3044	3211	3207
Crude fibre(%)	3.97	4.20	4.14	4.38	4.32
Calcium (%)	1.22	1.25	1.24	1.27	1.27
Avail P (%)	0.53	0.56	0.56	0.59	0.59
Lysine (%)	1.20	1.23	1.51	1.27	1.55
Methionine (%)	0.84	0.85	1.06	0.85	1.06

*Vitamin-mineral premix provided per kg of diet: Vitamin A: 8,500 i.u, Vitamin $D_3$1500 i.u, Vitamin E: 10mg, Vitamin K_3. 1.50mg, Vitamin B_1: 1.60mg, Vitamin B_2: 0.04mg, Niacin: 20mg, Calcium Pantothenate: 0.05mg, Biotin: 0.75mg, Vitamin B_{12}: 0.01mg, Folic acid: 0.5mg, Choline Chloride: 175mg, Manganese: 40mg, Iron: 20mg, Zinc 30:mg, Copper: 3.00 mg, Iodine: 1.0mg, Cobalt: 0.20mg, Selenium: 0.2mg, : , Antioxidant:1.2mg. LYS: Lysine, Met-methionine.

3.6 Data Analyses

All the data obtained were expressed as mean values. They were subjected to one-way analysis of variance (ANOVA) as described by Steel and Torrie (1980) using the SAS (1995) package. This was followed by Duncan multiple range *post-hoc* test whenever the ANOVA was found to be significant (Duncan, 1955).Values of $P < 0.05$ were considered significant.

CHAPTER 4

4.0 RESULTS

4.1 Preliminary Study

4.1.1 Effects of processing on proximate and chemical compositions of castor seed and castor seed cake

Proximate chemical composition of castor seeds boiled for different durations are shown in Table 4.1a, and that of castor seed cake boiled for 60 minutes (CSC B60) are shown in Table 4.1b

Boiling of castor seeds showed increases in dry matter, crude protein and nitrogen free extract values and decreases in crude fiber and ether extract compared to unprocessed raw castor seed.CS B60 had highest level of crude protein of 28.04 % and lowest level of crude fiber, ether extract and total ash.

4.1.2 Effects of processing methods on some anti-nutritional factors of castor seed and castor seed cake

Effects of boiling of castor seeds and castor seedcake for 60 minutes on some anti-nutritional factors are shown in Table 4.2a and 4.2b, respectively.

There were significant ($P < 0.05$) decreases in phytate and tannins contents of castor seeds boiled for 60 minutes(CS B60) compared to the unprocessed raw castor seeds (RCS). Oxalate level in CS B60 was similar to that of RCS. The percentage destruction of phytate, haemagglutinin, tanninsand oxalate after boiling castor seeds for 60 minutes were 14.86 %,19.63 %, 33.33 % and 14.52% respectively.

Table 4.1a: Effects of boiling at different durations on proximate composition of castor seeds

Parameters (%)	RCS	Duration of Boilingin minutes			
		15	30	45	60
Dry matter	95.03	96.28	96.09	95.91	95.84
Crude protein	22.81	25.92	26.89	27.68	28.04
Crude fiber	20.33	17.28	16.64	14.86	13.98
Ether extract	20.11	19.88	19.36	18.77	18.30
Total ash	3.50	3.57	3.96	3.31	3.13
Nitrogen free extract	30.25	30.35	32.85	35.39	36.55

RCS: unprocessed raw castor seed

Table 4.1b: Effects of boiling for 60 minutes on proximate chemical composition of castor seed cake (CSC)

Parameters (%)	Castor seed cake boiled for 60 minutes
Dry matter	94.87
Crude protein	32.03
Crude fiber	3.96
Ether extract	9.47
Total ash	6.74
Nitrogen free extract	47.80

Table 4.2a: Effects of boiling for 60 minutes on some anti-nutritional factors of castor seeds

Anti-nutritional Factors (mg/100g)	RCS	CS B60	SEM	LOS
Phytate	1.48 [a]	1.26 [b]	0.02	*
% of Phytate destroyed	-	14.86		
Heamagluttinins	1.07 [a]	0.86 [b]	0.03	*
% of Heamagluttinins destroyed	-	19.63		
Tanins	1.44 [a]	0.96 [b]	0.02	*
% of Tanins destroyed	-	33.33		
Oxalate	0.62	0.53	0.02	*
% of Oxalate destroyed	-	14.52		

[a,b]: Mean values within the same row with different superscripts are significantly different (* = P < 0.05)
RCS: unprocessed raw castor cake
CS B60: castor seeds boiled for 60 minutes
SEM: standard error of mean
LOS: level of significance

Table 4.2b: Effects of boiling for 60 minutes on some anti-nutritional factors of castor seed cake

Anti-nutritional Factors (mg/100g)	RCSC	CSC B60	SEM	LOS
Phytate	1.48 ^{a}	0.64^{b}	0.02	*
% of Phytate destroyed	-	56.76		
Haemagluttinins	**1.07** ^{a}	0.48^{b}	0.03	*
% of Haemagluttinins destroyed	-	55.14		
Tanins	1.44 ^{a}	0.64^{b}	0.02	*
% of Tanins destroyed	-	55.56		
Oxalate	0.62 ^{a}	0.46 ^{b}	0.02	*
% of Oxlate destroyed	-	25.81		

^{a,b}: Mean values within the same row with different superscripts are significantly different (*= P < 0.05)
RCSC: unprocessed raw castor seed cake
CSC B60: castor seed cake boiled for 60 minutes
SEM: standard error of mean
LOS: level of significance

There were significant (P < 0.05) decrease in phytate, haemagglutinin,tannins and oxalate of castor seed cake boiled for 60 minutes (CSC B60) compared to the unprocessed raw castor cake (RCSC). The percentage destruction of phytate,haemagglutinin, tannins and oxalate following boiling of castor seed cake for 60 minutes were 56.76 %, 55.14 %,55.56 % and 25.81 %respectively.

4.2 Broiler Study 1:
Performance Characteristics of Broiler Chickens fed Diets Containing Graded Level of Castor Seeds Boiled for 60 Minutes (CS B60)

4.2.1 Growth performance of broiler birds fed graded levels of CS B60 meals (0 – 4Weeks)

The performance of broiler birds fed diets containing graded levels of castor seeds boiled for 60 minutes (CS B60) during the starter phase (0 – 4 weeks) are shown in Table 4.3a. The results revealed that final weight, total weight gain and feed intake of birds fed the control diet (0 % CS B60) were significantly higher (P < 0.05) compared to other treatments containing boiled castor seeds. There was no significant difference in the feed to gain ratio between birds fed diets containing 0 % CS B60, 10 % CS B60 and 20 % CS B60. Also, there was no significant difference in mortality of birds across treatments.

4.2.2 Growth performance of broiler birds fed graded levels of CS B60 meals (5 – 9 Weeks)

The performance of broiler birds fed diets containing graded levels of castor seeds boiled for 60 minutes (CS B60) for the finisher phase (5 – 9 weeks) were as shown in Table 4.3b. The results indicated that final weight and total weight gain of birds fed the control diet (0 % CS B60) were significantly higher (P < 0.05) compared to other treatments containing boiled castor seeds. There were no significant differences in feed intake and feed to gain ratio. The mortality rates were similar across treatments.

Table 4.3a: Effects of feeding boiled castor seed meals on performance of broiler starter bird(0-4 weeks)

Parameters	0 %	10 %	20 %	30 %	SEM	LOS
Initial weight (g)	44.44	44.44	44.44	44.44	0.80	NS
Final weight (g)	274.25 ^{a}	127.29 ^{b}	68.30 ^{c}	40.74^{c}	10.51	*
Total weight gain	229.81^{a}	82.85^{b}	23.86 ^{c}	- 3.7 ^{c}	10.68	*
Feed intake (g)	661.99 ^{a}	377.78 ^{b}	242.43 ^{c}	230.81 ^{c}	18.39	*
Feed to gain ratio	2.89 ^{a}	4.56^{a}	10.16^{a}	- 28.24 ^{b}	7.42	*
Mortality (%)	5.56	1.85	1.85	0.00	2.07	NS

^{a,bc}: Mean values within the same row with different superscripts are significantly different (* $P < 0.05$)
NS; not significant
SEM: standard error of mean
LOS: level of significance

Table 4.3b: Effects of feeding boiled castor seed meals on performance of broiler finisher bird (6-9 weeks)

Parameters	0 %	10 %	20 %	30 %	SEM	LOS
Initial weight (g)	277.83	248.95	250.76	249.13	59.59	NS
Final weight (g)	723.95 ^{a}	452.13 ^{b}	427.07 ^{b}	214.16 ^{c}	61.92	*
Total weight gain (g)	446.12 ^{a}	203.18 ^{b}	176.31 ^{b}	-34.97^{c}	61.30	*
Feed intake (g)	1825.40	1200.90	1129.30	820.00	231.24	NS
Feed to gain ratio	4.09	5.91	6.41	-23.45	8.17	NS
Mortality (%)	5.56	1.85	1.85	0.00	2.07	NS

^{a,b,c}: Mean values within the same row with different superscripts are significantly different (* = P < 0.05)
NS: not significant
SEM: standard error of mean
LOS: level of significance

4.2.3 Carcass characteristics of broiler birds fed graded levels of boiled castor seed meal (CS B60)

The carcass characteristicsof broiler birdsfed diets containing graded levels of boiled castor seedswere as represented in Table 4.3c. The results indicated that birds fed the control diet (0 % CS B60) had higher ($P < 0.05$) de-feathered weightcompared to those of other treatments containing boiled castor seeds. The dressing percentage and neck weight of bird fed diets containing 10 % and 20 % of CS B60were similar ($P > 0.05$) to those fed the control diet. The head was significantly higher ($P < 0.05$) in broiler birds fed diets containing 20 % and 30 % of CS B60 compared to those fed diets containing 0 % and 10 % of CS B60 that were similar. The wings of birds fed diets containing 10 % CS B60 were similar ($P > 0.05$) to those fed the control diet.

The relative organ weightsof broiler fed diets containing graded levels of boiled castor seeds are represented in Table 4.3d. There were no significant differences ($P > 0.05$) in the weights of liver, kidney, heart, lungs, spleen,empty gizzardandempty intestine as well as the intestinal length across the treatments.

4.2.4 Nutrient digestibility in broiler birds fed graded levels of boiled castor seed meal CS B60)

There were no significant differences ($P > 0.05$) observed for dry matter, crude protein, total ash and nitrogen free extract digestibility across the dietary treatments. However, significant decrease in the CF and increase in the ether extract were observed in birds fed diet containing 30 % of boiled castor seeds (CS B60) compared to those of other treatments (Table 4.3e).

Table 4.3c: Effects of feeding boiled castor seed meals on carcass characteristics of broiler bird birds at 9wks of age

Parameters	0 %	10 %	20 %	30 %	SEM	LOS
Live weight (g)	716.67 ^{a}	450.00 ^{b}	433.33 ^{b}	216.67 ^{c}	59.51	*
Slaughtered weight (%)	98.65	94.22	91.43	89.89	2.27	NS
De-feathered weight (%)	95.83 ^{a}	89.65 ^{b}	86.12 ^{b}	82.60 ^{c}	2.87	*
Dressing (%)	79.14 ^{a}	77.30 ^{a}	75.93 ^{a}	67.94 ^{b}	3.54	*
Thigh (%)	23.11	23.14	19.17	17.98	1.99	NS
Wings (%)	11.72 ^{a}	9.23 ^{ab}	8.01 ^{b}	6.66 ^{b}	0.92	*
Breast (%)	17.53	16.67	15.93	12.85	1.87	NS
Back (%)	15.27	13.51	11.40	11.16	1.71	NS
Head (%)	3.76 ^{b}	3.54 ^{b}	6.53 ^{a}	7.37 ^{a}	0.66	*
Leg (%)	4.62	4.92	7.11	7.27	0.78	NS
Neck (%)	9.10 ^{a}	8.45 ^{a}	7.80 ^{a}	4.65 ^{b}	0.88	*

^{a,b}: Mean values within the same row with different superscripts are significantly different (* P < 0.05)
NS: not significant;
SEM: standard error of mean;
LOS: level of significance

Table 4.3d: Effects of feeding boiled castor seed meals on relative organ weight of broiler bird birds at 9wks of age

Parameters	0 %	10 %	20 %	30 %	SEM	LOS
Liver(%)	2.32	1.56	2.54	3.20	0.34	NS
Kidney (%)	0.34	0.51	0.74	0.78	0.14	NS
Heart (%)	0.50	0.48	0.55	0.68	0.06	NS
Lungs (%)	0.68	0.48	0.48	0.68	0.09	NS
Spleen (%)	0.20	0.04	0.06	0.08	0.05	NS
Empty Gizzard (%)	2.60	3.24	3.83	4.15	0.57	NS
Empty Intestine (%)	5.03	4.42	4.59	5.49	0.79	NS
Intestinal Length (cm)	205.00	234.67	310.67	202.00	42.59	NS

NS:not significant;
SEM:standard error of mean
LOS:level of significa

Table 4.3e: Effects of feeding boiled castor seed meals on nutrient digestibility of broiler birdbirds at 9wks of age

Parameters (%)	0 %	10 %	20 %	30 %	SEM	LOS
Dry matter	58.91	60.36	61.97	60.12	6.13	NS
Crude protein	24.67	26.23	20.67	19.43	4.23	NS
Crude fiber	18.78^{b}	47.10^{a}	21.68^{b}	8.83^{c}	3.60	*
Ether extract	43.74 ^{b}	38.52 ^{b}	46.52 ^{b}	57.60 ^{a}	3.31	*
Ash	58.27	58.56	65.15	58.82	29.35	NS
Nitrogen free extract	10.70	13.46	17.65	11.29	3.98	NS

^{abc}: Mean values within the same row with different superscripts are significantly different (* = P < 0.05)
SEM: standard error of mean
LOS: level of significance

4.2.5 Haematological parameters of broiler birds fed graded levels of boiled castor seed meal (CS B60)

There were no significant differences ($P > 0.05$) in the values for packed cell volume, haemoglobin concentration and total protein of broilers across 4.treatments(Table 3f).

Table 4.3f: Effects of feeding boiled castor seed meals on haematological parameters of broiler birds at 9weeks of age

Parameters	0 %	10 %	20 %	30 %	SEM	LOS
Packed cell volume (%)	27.33	22.00	25.00	21.67	3.00	NS
Haemoglobin (g/dl)	9.10	7.20	5.63	7.20	1.73	NS
Total Protein (g/dl)	4.37	2.9	3.93	3.87	0.53	NS

NS: not significant
SEM: standard error of mean
LOS: level of significance

4.3 Broiler Study 2:
PerformanceCharacteristics of Broiler Chickens fed Diets Containing Castor Seeds Cake Boiled for 60 Minutes (CS B60) with Normal orDouble Aminoacid Supplementation

4.3.1 Effectoffeedingextra (0.25% lysine and 0.25%methionine)supplementation on growth performance of broiler birdsfed CSC B60meal(1– 5Weeks)

The performance of broiler birdsfed diets containing boiled castor seed cake (CSC B60) with normal 0.25% lysineand 0.25% methionine and extra (double) 0.25% lysine and0.25% methionine supplementations for the starter phase were as shown in Table 4.4a. None of the birds survived when fed diets containing 20 %CSC B60 with normal 0.25% lysine and 0.25% methionine and extra (double) 0.25% lysine and0.25% methioninesupplementations.The results revealed that final weight, weight gain and feed consumption of birds fed the control diet (0 % CSC B60)were higher ($P < 0.05$) compared to those fed diets containing 10 % CSC B60with normal 0.25% lysineand 0.25% methionine and extra (double) 0.25% lysine and 0.25% methionine supplementations. Feed to gain ratio of birds fed the controldiet was significantly lower ($P < 0.05$) compared to those of birds fed 10 % CSC B60 withnormal 0.25% lysine and 0.25% methionineand 10 % CSC B60 withextra(double)0.25% lysine and 0.25% methionine supplementation. There was no significant difference ($P > 0.05$) in the mortality rates of birds feddiets containing 0 %, 10 % with normal or doubleamino acid supplementations.

4.3.2 Effect of feeding extra(0.33% Lysine and 0.25%DI- methionine) on growth performance of broiler birds (6 – 9Weeks) .

The performanceof broiler birdsfed diets containingboiled castor seed cake with normal 0.33% lysine and 0.25% methionine and extra 0.33% lysine and 0.25% methionine

Table 4.4a: Effects of feeding boiled castor cake meals withextra (double) 0.25% Lys and 0.25% meth **)** supplementation on growth performance of broiler starter bird (1-5 weeks)

Parameters	0 %	10% with 0.25%lys+ 0.25% met	10 % with 0.5% lys + 0.5% met	20 % with 0.25% lys + 0.25% met	20 % with 0.5% lys + 0.5% met	SEM	LOS
Initial weight (g)	105.55	105.55	105.55	105.55	105.55	2.57	NS
Final weight (g)	668.89 ^{a}	406.92 ^{b}	450.00 ^{b}	-	-	37.14	*
Total weight gain (g)	563.33 ^{a}	301.03 ^{b}	343.45 ^{b}	-	-	36.22	*
Feed intake (g)	1576.67 ^{a}	1293.73 ^{b}	1205.55 ^{b}	-	-	58.26	*
Feed to gain ratio	2.82 ^{c}	4.33 ^{a}	3.52 ^{b}	-	-	0.22	*
Mortality (%)	0.00	4.45	0.00	100	100	1.48	NS

^{a,b}: Mean values within the same row with different superscripts are significantly different (*P < 0.05)
NS: not significant
SEM: standard error of mean
LOS: level of significance
LYS:lysine
DL- meth :methionine

supplementations during thefinisher phase were as shown in Table 4.4b. The initial weights of birds fedthe control diet (0 % CSC B60) was significantly higher ($P < 0.05$)

Compared to those of birds fed 10% CSC, weight gain and feed consumption of birds fed the control diets were significantly higher ($P< 0.05$)compared to those of birds fed 10% CSC B60 with normal 0.33% lysine and 0.25% methionine and extra (double) 0.33% lysine and 0.25% methioninesupplementation. There was no significant difference in mortality rate of birds fed the control diets, 10 % CSC B60withnormal 0.33% lysine and 0.25% methionine and extra (double) 0.33% lysine and 0.25% methioninesupplementations.

4.3.3 Carcass characteristic of broiler bird fed CSC B60mealdiet with normal 0.33% lysine and 0.25% methionine and extra 0.33% lysine and 0.25% methionine supplementations.

The carcass characteristicsof broiler birdsfed diets containing castor seed cake boiled for 60 minutes (CSC B60)with normal or double L-lysine and DL-methionine supplementationwere as shown in Table 4.4c.The result indicated that the de-feathered weight of broiler birds fed the control diets was significantly higher ($P < 0.05$) compared to those of birds fed 10 % CSC B60 with nornal0.33% lysine and 0.25% methionine and 10 % CSC B60 with extra0.33% lysine and 0.25% methionine supplementation. Dressing percentage of the birds fed the control diet were significantly higher ($P < 0.05$) than those fed 10 % CSC B60 with normal 0.33% lysine and 0.25% methionine and extra 0.33% lysine and 0.25% methionine supplementations. Thigh weight and backweight of birds fed the control diet were similar to those of 10 % CSC B60 withnormal

Table 4.4b: Effects of feeding boiled castor cake meals with extra (double) 0.33% Lys and 0.25% meth supplementation on growth performance of broiler finisher bird (6 -9 weeks)

Parameters	0 %	10 % with 0.33% lys+ 0.25% met	10 % with 0.66% lys + 0.5% met	SEM	LOS
Initial weight (g)	668.89 [a]	406.92 [b]	450.00 [b]	25.55	*
Final weight (g)	2135.00[a]	1221.50 [b]	1458.3[b]	122.07	*
Total weight gain (g)	1466.10 [a]	814.90 [b]	1008.30[b]	112.40	*
Feed intake (g)	5454.70 [a]	3984.30 [b]	4414.30 [b]	201.51	*
Feed to gain ratio	3.73	4.92	4.48	0.39	NS
Mortality (%)	4.44	11.11	6.67	4.69	NS

[a,b]: Mean values within the same row with different superscripts are significantly different (* P < 0.05)
NS: not significant
SEM: standard error of mean
LOS: level of significance
LYS : lysine
DL-meth :methionine

Table 4.4c:Effects of feeding boiled castor cake meals withextra (double) 0.33% Lys and 0.25% meth supplementation on carcass characteristics of broiler bird at 9 weeks of age

Parameters	0 %	10 % with0.33% lys + 0.25% met	10 % with 0.66% lys + 0.5% met	SEM	LOS
Live weight (g)	2133.30 ^{a}	1266.70 ^{b}	1466.70 ^{b}	92.96	*
Slaughtered weight (%)	97.65	94.49	95.45	1.01	NS
De-feathered weight (%)	95.30 ^{a}	87.08 ^{b}	88.42 ^{b}	1.92	*
Dressing (%)	79.63^{a}	69.94^{b}	69.16^{b}	2.02	*
Thigh (%)	23.09	20.55	20.60	1.05	NS
Wings (%)	9.18	9.22	8.41	0.72	NS
Breast (%)	18.30 ^{a}	15.35 ^{b}	14.59 ^{b}	1.03	*
Back (%)	15.63	14.68	13.74	0.78	NS
Head (%)	2.79 ^{c}	3.08 ^{b}	3.07 ^{b}	0.09	*
Leg (%)	4.05	4.78	5.11	0.28	NS
Neck (%)	5.56	5.28	4.79	0.38	NS

^{a,b,c}: Mean values within the same row with different superscripts are significantly different (* P < 0.05)
NS: not significant
SEM: standard error of mean
LOS: level of significance
Lys : lysine
DL-meth : methionine

0.33% lysine and 0.25% methionine and 10%CSC B60 with extra 0.33% lysine and 0.25% methionine supplementation. The breast weight of broiler birds fed the control diet was significantly higher ($P < 0.05$) compared to those of other treatments fed diets containing CSC B60. The percentage of the head was lower in birds fed the control diet compared to those of birds fed 10 % CSC B60 with normal lysine and dl -methionine and 10 % CSC B60 with extralysine and dl -methionine supplementation.

The relative organ weightsof broiler birdsfed diets containingcastor seed cake boiled for 60 minutes (CSC B60)with normal 0.33% lysine and 0.25% methionine and extra 0.33% lysine and 0.25% methioninesupplementationwere as shown in Table 4.4d.The percentages weight of the liver were lower in birds fed the control diets compared to those of birds fed 10 % CSC B60 with normal0.33% lysine and 0.25% methionineand 10 % CSC B60 withextra 0.33% lysine and 0.25% methionine supplementation. The intestinal length in birds fed the control diet was similar to those of birds fed 10 % CSC B60with extra 0.33% lysine and 0.25% methionine supplementation,but higher than those of birds fed diet containing 10 % CSC B60with normal 0.33% lysine and 0.25% methionine supplementation

4.3.4 Haematological parameters of broiler birds fedCSC B60 with normal 0.33% lysine and 0.25% methionine and extra (double) 0.33% lysine and 0.25%methionine supplementation

There was no significant difference ($P > 0.05$) recorded in the packed cell volume, haemoglobin concentration and total protein of birds across the dietary treatments (Table 4.4e).

Table 4.4d: Effects of feeding boiled castor cake meals with extra (0.33% Lys and 0.25 % DL-meth) supplementation on relative organ weight of broiler birdsat 9 weeks of age

Parameters	0 %	10 % with 0.33% lys +0.25% met	10 % with 0.66% lys + 0.50% met	SEM	LOS
Liver (%)	2.30^{c}	2.78^{b}	3.09^{b}	0.20	*
Kidney (%)	0.50	0.59	0.50	0.08	NS
Heart (%)	0.56	0.35	0.55	0.07	NS
Lungs (%)	0.55	0.52	0.74	0.17	NS
Spleen (%)	0.13	0.10	0.12	0.06	NS
Empty Gizzard (%)	2.72	3.14	3.02	0.32	NS
Empty Intestine (%)	3.86	4.74	5.18	0.24	NS
Intestinal length (cm)	273.33^{a}	238.00^{c}	266.33^{ab}	15.67	*

^{a,b}: Mean values within the same row with different superscripts are significantly different (* $P < 0.05$)
NS: not significant
SEM: standard error of mean
LOS: level of significance
LYS : lysine
DL-meth: methionine

Table 4.4e: Effects of feeding boiled castor cake meals with extra (0.33%Lys and 0.25% meth) supplementation on haematological parameters of broiler bird at 9 weeks of age

Parameters	0 %	10 % with 0.33% lys + 0.25% met	10 % with 0.66% lys + 0.50% met	SEM	LOS
Packed cell volume(%)	31.67	26.00	32.67	1.98	NS
Haemoglobin (g/dl)	10.43	8.63	10.87	0.67	NS
Total Protein (g/dl)	3.20	2.13	2.47	0.26	NS

NS: not significant
SEM: standard error of mean
LOS: level of significance
Lys : lysine
DL-meth : methionine

CHAPTER 5

5.0 DISCUSSION

5.1 Preliminary Study

5.1.1 Effects of processing on proximate chemical composition of castor seeds and castor seed cake

Castor seeds boiled for 60 minutes (CS B60) tend to have better overall chemical composition that may be utilized in animal diet. This is based on their high crude protein content of 28.08 % compared to other castor seeds (CS) processed at different boiling durations. In addition, low levels of crude fibre, ether extract and total ash were observed in CS B60 compared to other CS processed at different boiling durations. There are generally decrease in crude fibre and ether extract of the processed CS compared to unprocessed raw castor seeds as cooking duration increase. The decrease may be attributed to leaching of some of the nutrient and volatilization of fat during boiling process (Iyayu and Egbarevba, 1998; Nsa *et al.,* 2010, 2011). Total ash content of 3.13 % recorded for CS B60 differ from 9.40 reported by Annongu and Joseph, (2008) for full fat castor seed meal. Processing method, the type of soil on which the castor plant was grown and specie difference are some of the factors that may be responsible for the variations (Ojewole *et al.,* 2005).

5.1.2 Effects of processing methods on anti-nutritional factors of castor seeds and castor seed cake

Values obtained for anti-nutritional factors (phytate, tannins, haemagglutinin and oxalates) dropped significantly for castor seeds and castor seed cake boiled for 60 minutes (CS B60 and CSC B60) compared to levels in the raw castor seeds. Nsa *et al.* (2011) made similar observation in thermally treated *Milleta obanensis* seeds. Previous studies had demonstrated that wet-heat treatment of castor seeds reduced the anti-nutritional factors

especially the heat labile anti-nutrients (Ani, 2007). The finding in the present study agreed, in part, with the report of Akande *et al.* (2011) who reported a decrease in lectin content of castor seed cake. Thus, the results obtained in this study indicated that the wet-heat treatment employed by boiling for 60 minutes significantly reduced the levels of anti-nutrients in castor seeds and castor seed cake boiled for 60 minutes.

5.2 Performance of Broiler Chicken fed Diets Containing Castor Seeds Boiled for 60 Minutes (CS B60)

There was decreased feed intakeby broiler starter birds fed diets containing boiled castor seeds (CS B60) compared to the control (0 % CS B60). This may be attributed to poor palatability caused by thepresence of appetite depressing factors in the diets (Ani and Okorie, 2006). The general decreased final weight and total weight gain observed in birds fed diets containing boiled castor seeds during the starter phase may be due to poor feed intake caused by the presence residual ricin in the processed castor seeds. The presence of residual ricin in diet containing processed castor seeds have been reported to contribute to growth depression (Ani, 2007). Although feed intake and growth depression were observed in the starter phase, feed conversion ratiosof birds feddiets containing 10 % and 20 % CS B60 were similarto that ofthe control diet. These may indicate that nutrients absorbed by birds fed diets containing graded level of CS B60 were utilized for maintenance but not for growth. The results for the finisher phase of the present study were similar to those of the starter phase. Therefore, the consequential effects of feeding broiler birds with dietscontaining CS B60 at 10 % inclusion level or more resulted in poor growth performance.

Carcass yields (particularly the thigh, wings, breast, back and neck) obtained from birds fed the control diet were higher than the yields obtained from birds fed diets containing CS B60. This may be attributed to low feed intake and inability of the birds to convert feed into meat. Esonu *et. al.* (2002) and Nwoche *et. al.* (2006) made similar observations when they fed *Microdermis puberula leaf* meal and palm oil, respectively, to broiler bird. Relative organ weights of birds fed diets containing graded levels of CS B60 did not reveal any significant effects of diets. However, there were numerical increases for empty gizzard and empty intestine with increasing CS B60 levels in the diets. This suggests impaired gastrointestinal tract function. The finding agrees with the reports of Ani and Okorie (2005) and Ani (2007) who reported that such impairment may be due to presence of residual ricin in the diets which logically increased with increasing level of boiled castor seeds in the diets. The results of apparent nutrient digestibility show that there were significant decrease in the CF and increase in the ether extract observed in birds fed diet containing 30 % boiled castor seeds compared to those of other treatments. These imply poor fibre retention and high oil content retention respectively, and may be indicative of inefficient nutrient utilization. The decreased CF and increased ether extract observed in birds fed diet containing 30 % boiled castor seeds may be possibly due to the dietary factors causing poor digestion of nutrients (Akande *et. al.,* 2011).

5.3 Performance of Broiler Chicken fed Diets Containing Castor Seed Cake Boiled for 60 Minutes (CSC B60) With Normal or Extra (Double) L-Lysine And DL-Methionine Supplementations

Broiler starter and finisher birds fed diets containing (0 %, 10 % and 20 %) of castor seedcake boiled for 60 minutes (CSC B60)with normal and extra (double) L-lysine and DL-methioninesupplementations followed similar trends as observed in broiler study 1

using castor seed meals. This may be attributed to poor palatability due to the presence of residual ricin which increased in the diets as the dietary level of CSC B60 increased. Ani (2007) made similar observations. Although the level of detoxification of castor seed cake (CSC) was higher than in the castor seeds as evidenced by the percentages of anti-nutrient destroyed (Table 4.2a and 4.2b), performance of broiler birds fed diets containing 10% CSC B60 and above were poor compared to the control diet (0 % CSC B60). This is evidenced by the significantly better final weight, weight gain and feed consumption of broiler birds fed the control diet compared to those fed diets containing CSC B60. It is well established that poor palatability will cause depressed feed intake leading to decreased final weight and weight gain and consequently resulting in poor feed conversion ratio. The resultant effect of poor diet palatability is inadequate intake of nutrients required to sustain rapid growth and development (Esonu *et al.*, 2002).

The result of this study indicated that broiler birds cannot withstand diets containing 20 % CSC B60 with normal 0.25% lys and 0.25% meth and extra 0.5% lys and 0.5% meth supplementations. This is evidenced by the 100 % mortality observed after feeding bird diets containing 20 % CSC B60 with normal and extra (double) amino acids supplementations within the two days of the starter phase of the study. Adedeji *et al.* (2006) made a similar observation in rabbits fed boiled castor seed meal. Therefore, the consequential effects of feeding CSC B60 at 10 % and above inclusion level with normal and extra (double) L-lysineand DL-methionine supplementation in broiler diets is poor growth performance.

However, there was positive interactions observed between 10 % CSC B60 level in the diet and supplementation with L-lysine and DL-methionine. These are shown by improved

growth performance of broiler birds fedsupplemented 10 % CSC B60with extra (double) 0.33% lysand 0.25% methionine diet compared to birds fed 10 % CSC B60 with normal 0.33% lys and 0.25% methionine diet. The growth performance, however, of broiler birds fed amino acid supplemented CSC B60 diets still could not measure up to the standard obtained for birds fed the control diet. This finding disagrees with the reports of Ani and Okorie (2009) and Ani (2007) who stated that processed castor bean meal can be included in the diets at 15 % level with DL-Methionine and L-Lysine supplementations respectively. Perhaps, there is varietal difference between the castor seeds used by them(large seeded) and the variety used in this study (small seeded). Also, castor seed cake meal was used in this study whereas they used castor seeds meal.

Generally, there wasbetter results of carcass yield of broiler birds fed the control diet compared to those fed diets containing CSC B60. This is evidenced by the significant ($P < 0.05$) increase in the dressed and breast weights and decrease in head weight of broiler birds fed the control diet compared to those fed diets containing CSC B60. Significant ($P < 0.05$) decrease in the intestinal length in birds fed diets containing 10 % CSC B60 with amino acid supplementations compared to those fed the control diet may be due to poor gastrointestinal tract motility. This may indicate poor gastrointestinal function at higher CSC levels.

CHAPTER 6

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

1. Proximate chemical composition of the castor seeds showed increased crude protein value and decreased crude fiber, ether extract and total ash values as the duration of cooking increased. Anti-nutritional contents showed decreased ($P < 0.05$) phytate and tannins contents of castor seeds boiled for 60 minutes (CS B60) and decreased ($P < 0.05$) phytate, haemagglutinin, tannins and oxalate values in castor seed cake boiled for 60 minutes (CSC B60) compared to the non-boiled raw castor cake (RCSC).
2. Broiler diets containing 10% or more of castor seed boiled for 60 minutes resulted in poor final weight, weight gain, feed consumption and feed to gain ratio compared to the diet containing no boiled castor seeds during starter and finisher phases.
3. Diet containing 10 % castor seed cake boiled for 60 minutes with extra (double) 0.33% lysine and 0.25% methionine supplementations improved performance of broiler birds slightly above diets containing 10% CSC B60 with normal 0.33 % lysineand 0.25% methionine supplementations. However, birds fed diets containing 10 % CSC B60 with extra amino acid supplementations could not attain the level of performance of birds fed the control diet containing 0 % CSC B60.

6.2 Conclusions and Recommendations

1. Both castor seeds and castor seed cake boiled for 60 minutes were found not suitable as feed ingredients for broiler chickens when fed at 10 % dietary level or more.
2. Amino acid supplementations with L-lysine and Dl-methionine did not improve utilization of diets containing 10 % or moreof castor seeds or castor seed cake boiled for 60 minutes.
3. Due to the results summarized above, castor seeds and castor seed cake boiled for 60 minutes were not suitable for broiler ration formulations

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LIST OF APPENDICES

Appendix 1: Raw data showing some anti-nutritional factors of castor seeds boiled for 60 minutes (CS B60)

Anti-nutritional Factors(mg/100g)	RCS	CS B55
PHYTATE	1.48	1.26
	1.48	1.26
HEAMAGLUTTININS	1.02	0.86
	1.02	0.86
TANINS	1.44	0.96
	1.44	0.96
OXYLATE	0.62	0.53
	0.62	0.53

Appendix 2: Raw data showing some anti-nutritional factors of castor seed cake boiled for 60 minutes (CSC B60)

Anti-nutritional Factors(mg/100g)	Raw Castor Seed	CSC B45
PHYTATE	1.48	0.64
	1.48	0.64
HEAMAGLUTTININS	1.02	0.48
	1.02	0.48
TANINS	1.44	0.64
	1.44	0.64
OXYLATE	0.62	0.46
	0.62	0.46

Appendix 3: Raw data of growth performance of broiler starter bird fed graded level of castor seeds boiled for 60 minutes (CS B60) meals (0-4 weeks)

Trt	Rep	Initial weigh (g)	Final weight(g)	Weight gain (g)	Feed consumption(g)	FCR	Mortality
	1	44.44	303.13	258.69	728.13	2.82	11.11
0 %	2	44.44	252.94	208.50	641.18	3.08	5.56
	3	44.44	266.67	222.23	616.67	2.78	0.00
	1	47.22	111.11	63.89	372.22	5.83	0.00
10 %	2	44.44	147.22	102.78	361.11	3.51	0.00
	3	41.67	123.53	81.86	400.00	4.89	5.56
	1	44.44	55.56	11.12	233.33	20.98	0.00
20 %	2	44.44	88.24	43.80	252.78	5.77	5.56
	3	44.44	61.11	16.67	241.18	14.47	0.00
	1	44.44	38.89	-5.55	226.47	-40.81	0.00
30 %	2	44.44	38.89	-5.55	243.75	-43.92	0.00
	3	44.44	44.44	0.00	222.22	0	0.00

Appendix 4: Raw data of growth performance of broiler finisher bird fed graded level of castor seeds boiled for 60 minutes (CS B60) meals (5-9 weeks)

Trt	Rep	Initial weigh (g)	Final weight(g)	Weight gain (g)	Feed consumption(g)	FCR	Mortality
	1	375	743.75	368.75	2306.25	6.25	11.11
0 %	2	252.94	705.88	452.94	1561.76	3.45	5.56
	3	205.56	722.22	516.66	1608.33	3.11	0.00
	1	322.22	400.00	77.78	1436.11	18.46	0.00
10 %	2	97.22	291.67	194.45	566.67	2.91	0.00
	3	327.41	664.71	335.30	1600.00	4.77	5.56
	1	333.89	394.44	55.55	1244.44	22.40	0.00
20 %	2	255.88	511.76	255.88	1155.88	4.52	5.56
	3	162.50	375.00	212.50	987.50	4.65	0.00
	1	355.56	277.78	-77.88	1152.78	-14.80	0.00
30 %	2	238.89	200.00	138.89	897.22	6.46	0.00
	3	152.94	164.71	11.77	410.00	34.83	0’00

Appendix 5: Raw data of carcass characteristics of broiler bird fed graded level of castor seeds boiled for 60 minutes (CS B60) meals

as at 9 wks of age

Trt	Rep	Live Weight (g)	Slaughtered Weight (%)	De-feathered Weight (%)	Dressing Percentage	Thigh (%)	Wings (%)	Breast (%)	Back (%)	Head (%)	Leg (%)	Neck (%)
	1	750	96.77	95.65	79.04	25.81	12.9	19.35	16.13	3.87	6.45	9.68
0 %	2	700	96.43	95.74	78.17	24.29	10.71	17.86	14.29	3.57	3.57	10.71
	3	750	92.31	96.09	80.22	19.23	11.54	15.38	15.38	3.85	3.85	6.92
	1	400	96.88	90.63	78.58	21.88	9.38	18.75	15.63	3.13	6.25	6.25
10 %	2	300	88.89	88.65	74.62	16.42	6.85	10.44	8.47	5	5.39	4.57
	3	650	96.88	89.68	78.69	15.63	3.75	9.36	9.38	2.5	3.13	3.13
	1	400	93.75	88.40	75.00	25	7.5	18.75	15	6.25	6.25	6.25
20 %	2	500	91.67	85.55	75.00	25	8.33	16.67	8.33	8.33	8.33	8.33
	3	400	88.89	84.40	77.78	19.4	8.2	12.36	10.88	5.03	6.75	6.75
	1	300	94.12	80.15	71.59	25.53	9.41	17.65	11.76	7.06	7.06	7.06
30 %	2	200	91.67	84.71	63.24	25	8.33	16.67	16.67	8.33	8.33	8.33
	3	150	83.88	82.93	69.00	18.88	9.96	15.69	12.11	6.73	6.42	6.42

Appendix 6: Raw data of relative organ weights of broiler bird fed graded level of castor seeds boiled for 60 minutes (CS B60) meals as at 9 wks of age

Trt	Rep	Live Weight (g)	Liver (%)	Kidney (%)	Heart (%)	Lung (%)	Spleen (%)	EmptyGizzard(%)	EmptyIntestine(%)	Intestinal length(cm)
	1	750	2.06	0.44	0.49	0.51	0.11	2.26	5.81	222
0 %	2	700	2.17	0.24	0.51	0.65	0.11	2.55	3.88	201
	3	750	2.72	0.34	0.49	0.9	0.37	3.98	5.4	192
	1	400	0.96	0.3	0.49	0.41	0.04	1.43	5.00	233
10 %	2	300	2.16	0.75	0.55	0.54	0.05	4.12	5.14	177
	3	650	1.55	0.49	0.39	0.5	0.03	4.17	3.13	294
	1	400	2.46	0.41	0.63	0.66	0.10	4.17	3.25	457
20 %	2	500	2.99	0.9	0.69	0.79	0.04	4.21	6.15	224
	3	400	4.16	1.04	0.72	0.59	0.1	3.12	4.36	251
	1	300	2.06	0.71	0.35	0.59	0.06	4.71	5.16	211
30 %	2	200	2.68	1.00	0.65	0.24	0.11	3.82	6.65	240
	3	150	2.87	0.51	0.65	0.62	0.01	3.91	4.65	155

Appendix 7: Raw data of nutrient digestibility (%) of broiler bird fed graded level of castor seeds boiled for 60 minutes (CS B60) meals

Trt	Rep	DM	CP	CF	OIL	ASH	NFE
	1	56.43	30.04	18.43	43.12	67.82	19.11
0 %	2	73.84	24.69	20.26	46.65	47.33	3.47
	3	46.46	19.27	17.71	41.45	54.19	9.52
	1	44.50	31.90	46.44	40.00	55.38	9.31
10 %	2	68.88	25.92	48.92	32.44	63.67	18.65
	3	67.70	20.89	45.88	43.11	55.48	12.42
	1	69.59	24.47	22.40	47.12	71.01	23.71
20 %	2	56.49	14.06	26.96	48.74	65.63	22.40
	3	59.83	23.47	14.61	43.71	55.53	6.84
30 %	1	55.17	26.05	9.39	63.68	65.58	16.02

	2	60.21	16.42	11.97	46.82	51.57	8.16
	3	64.98	15.82	4.987	62.31	56.78	9.70

Appendix 8: Raw data of haematological parameter of broiler birds fed

graded level of castor seeds boiled for 60 minutes (CS B60) mealsas at 9 wks of age

Trt	Rep	PCV (%)	Hb (g/dl)	TP (g/dl)
	1	25	8.3	3
0 %	2	27	9	6.1
	3	30	10	4
	1	21	7	3.2
10 %	2	19	6	2.2
	3	26	8.6	3.3
	1	28	9.3	4.2
20 %	2	24	0	3.7
	3	23	7.6	3.9
	1	13	4.3	4.1
30 %	2	31	10.3	4.4
	3	21	7	3.1

Appendix 9: Raw data of growth performance of broiler starter bird fed graded level of castor cake boiled for 60 minutes (CSC B60) meals (0-4 weeks)

Trt	Rep	Initial weigh (g)	Final weight(g)	Weight gain (g)	Feed consumption(g)	FCR	Mortality
0 %	1	103.33	693.33	590	1576.67	2.67	0
	2	110	733.33	623.33	1693.33	2.72	0
	3	103.33	580	476.67	1460	3.06	0
10 % with supplementation	1	103.33	442.86	339.53	1303.57	3.84	6.67
	2	110	403.57	293.57	1314.29	4.48	6.67
	3	103.33	373.33	270	1263.33	4.68	0
10 % without supplementation	1	103.33	496.67	393.34	1273.33	3.24	0
	2	110	436.67	326.67	1243.33	3.81	0
	3	103.33	416.67	313.34	1100	3.51	0

Appendix 10: Raw data of growth performance of broiler finisher bird fed graded level of castor cake boiled for 60 minutes (CSC B60) meals (5-9 weeks)

Trt	Rep	Initial weigh (g)	Final weight(g)	Weight gain (g)	Feed consumption(g)	FCR	Mortality
0 %	1	693.33	2300	1606.67	5728.33	3.57	0
	2	733.33	2193.33	1460	5443.33	3.73	0
	3	580	1911.54	1331.54	5192.31	3.90	13.33
10 % with Supplementation	1	442.86	1239.29	796.43	3832.14	4.81	0
	2	403.57	1363.64	960.07	4509.09	4.70	20.00
	3	373.33	1061.54	688.21	3611.54	5.24	13.33
10 % without Supplementation	1	496.67	1621.43	1124.76	4710.71	4.19	6.67
	2	436.67	1232.14	795.47	4325	5.44	6.67
	3	416.67	1521.43	1104.76	4207.14	3.81	6.67

Appendix 11: Raw data of carcass characteristics of broiler bird fed graded level of castor cake boiled for 60 minutes (CSC B60) mealsas at 9 wks of age

Trt	Rep	Live Weight (g)	Slaughter Weight (%)	De-feathered weight (%)	Dressing Percentage	Thigh (%)	Wings (%)	Breast (%)	Back (%)	Head (%)	Leg (%)	Neck (%)
0 %	1	2300	97.83	95.65	80.44	22.83	9.74	17.39	15.22	2.61	4	6.09
	2	2100	97.62	95.24	80.95	21.43	9.81	20	16.67	2.86	3.81	5.43
	3	2000	97.5	95	77.50	25	8	17.5	15	2.90	4.35	5.15
10 % with supplementation	1	1300	96.15	88.46	69.23	19.23	11.54	15.39	15.39	2.92	4.62	5.31
	2	1400	96.43	89.29	67.86	21.43	7.93	14.29	14.29	3.14	5.07	5.26
	3	1100	90.91	83.5	72.73	21	8.18	16.36	14.36	3.18	4.64	5.27
10 % without supplementation	1	1600	96.86	90.63	68.75	21.88	9.38	15.63	13.75	3.13	5.25	4.13
	2	1300	96.15	84.62	65.39	19.92	7.46	13.15	12.46	3.15	5.54	4.77
	3	1500	93.33	90	73.33	20	8.40	15	15	2.93	4.53	5.47

Appendix 12: Raw data of relative organ weight of broiler bird fed graded level of castor cake boiled for 60 minutes (CSC B60) mealsas at 9 wks of age

Trt	Rep	Liver (%)	Kidney (%)	Heart (%)	Lung (%)	Spleen (%)	EmptyGizzard(%)	Empty Intestine(%)	Intestinal Length (cm)
0 %	1	2.44	0.52	0.56	0.48	0.04	2.78	4.04	280
	2	1.95	0.48	0.62	0.53	0.24	2.52	3.33	265
	3	2.5	0.5	0.5	0.65	0.10	2.85	4.2	275
10 % with supplementation	1	3.08	0.85	0.38	0.69	0.15	3.39	4.23	240
	2	2.71	0.57	0.21	0.79	0.07	3.29	5.36	242
	3	2.55	0.36	0.46	0.09	0.09	2.73	4.64	232
10 % without supplementation	1	2.94	0.63	0.5	0.88	0.13	2.81	5.63	300
	2	2.85	0.46	0.54	0.62	0.230	2.85	4.31	219
	3	3.47	0.4	0.6	0.73	0	3.4	5.6	280

Appendix 13: Raw data of haematological parameter of broiler birds fed graded level of castor cake boiled for 45 minutes (CSC B45) meals as at 9 wks of age

Trt	Rep	PCV (%)	Hb (g/dl)	TP (g/dl)
0 %	1	30	10	2.8
	2	33	11	3.8
	3	32	10.3	3.0
10 % with Supplementation	1	28	9.3	2.4
	2	21	7.0	2.0
	3	29	9.6	2.0
10 % without Supplementation	1	32	10.6	2.2
	2	33	11	3.0
	3	33	11	2.2