Chapter One

Introduction

Success of poultry industry depends on good management, good hygiene and economic sufficient feed. Poultry industry in the Sudan now is facing great problems, mainly the feed, which represents about 75% or more of the total cost of production, due to the competition between human and animal, scarce in crop production and human population growth (Mukhtar and Abd-Rahim, 2012). Protein and energy are the most costly components in poultry diets, especially the plant protein (Mukhtar, 2007), (Khan et al., 2006).

Sunflower (Helianthus annus) is one of the important annual crops of the world grown for oil (Salunkhe et al., 1991). Sunflower seed meal (SFM) is considered as a good source of vegetable protein and vegetable oil.

However, in recent years there is an increase in the interest of commercial cultivation production in the Sudan. There has been increased in growing sunflower for edible vegetable oil production in part of the world (Musharaf, 1991).

However, high fiber content of sunflower seed meal increased viscosity of gut contents, poor digestibility and poor chicks' performance (Rad and Keshavarz, 1976; Furlan et al., 2001). The testa of SFM is rich in non-starch polysaccharides (NSPs) which reduce the digestibility of the SFM (Annison, 1993). These negative effects can be overcome by supplementation of diets with suitable exogenous enzymes (Gracia, 2003; Munasser, 2011; Mukhatr, 2012; Mukhatr and Abd-Rahim, 2012 and Mariam et al., 2013).

Commercial xylam 500 is assumed to degrade high fiber content of NSP resulting in increased nutrient availability to poultry chicks (Khan et al., 2006; Tavernari et al., 2008; binbarik, 2010; Munasser, 2011 and Mariam, 2013).

Therefore, objectives of this study were to investigate the nutritional value of SFM as protein source with and without enzyme supplementation on the performance, carcass characteristics, blood constituents, serum metabolites, enzyme activities and economic feasibility of broiler chicks.

Chapter Two

Literature Review

2.1. Description:

Sunflower plant is a tall, erect herbaceous annul plant belonging to the family of Asteraceae of the genus, Helianthus. Its botanical name is Helianthus annuus. The plant possesses a large inflorescence, and its name is derived from the flower's shape and image, which is often used to capture the sun. The sunflower is an erect, coarse and tap-rooted with rough hairy stem 2-10 ft tall. Towards the apex of the plant, there may be a few side stems. The central stem is light green to reddish green and covered with stiff spreading hairs. The leaves are mostly alternate, egg-shaped to triangular and entire or toothed, although some of the small upper leaves may have smooth margins and a lanceolate shape (Pelczar, Rita, 1993).

The flower heads are 7.5-15 cm wide and at the end of branches, it consist of numerous central disk florert that yellow to brown, they are surrounded by approximately 20-40 ray floret.

2.2. Distribution

The sunflower is a common and wide spread road side-weed. It’s common in open sites in many different habitats throughout North America, South Africa, China and Colombia (Molina Rosito, 1975; Gleason, 1968; Gibbs et al., 1987; Long and Lakela, 1971).

2.3. Production:

Sunflower is the important oil seed crop of the world and it ranks third in the production next to groundnut and soybean. The world production of sunflower seeds increased from 36-31 million metric tons between 2004 and 2006 (FAO, 2007).

Sunflower meal is available wide- world population was 13.5 million tons in 2012-2011 (Oil World, 2011). The European Union (EU-27) is main producer and importer; it produced 3.3 million tons and used 5.7 million tons in 2009-2010. Other main producers and exporters were Ukraine 2.5 million tons, Russia 2.3 million tons and Argentina 1.21 million tons, Turkey, Israel and Egypt are main importers after EU (FAS, 2011).

Sunflower is new edible oil crop in Sudan; many production constraints are responsible for fluctuation in its production and productivity. In Sudan, oil seed crops rank second after cereals in area and total production. The country's oil seed production rests mainly in Sesame, groundnut and cottonseed, while sunflower has been introduced recently into the cropping sequence. Sunflower is a promising oil seed in Sudan (Mohamed, 2010). Extensive commercial production of sunflower was initiated in Sudan in the late 1980's and the early 1990's with the introduction of hybrids from Australia and South America (El-Ahmaidi, 2003 and Nour et al., 2005). The production was established mainly in rain fed areas if the country and to a lesser extent in irrigated conditions.

In the Sudan, sunflower grain output increased sharply by 71.4% to reach 12 thousand tons in 2004/05 season compared with 7 thousand tons in the previous season (Central Bank of Sudan, 2005).

2.4 Nutritional attributes:

Sunflower seeds rich sources of protein, minerals such as calcium and phosphorus (Salunkhe et al., 1991).

Satish and Shrivastava (2011) reported that proximate analysis of sunflower air-dried seeds (g/100 g) as 4.12 moisture, 2.996 Crude fibers, and 33.92 total lipids. 24.9 CP, 30.1 total carbohydrates, 4.5 reducing sugar and 25.6 non-reducing sugar. Minerals and ash content 4.84, water insoluble ash 1.75, water soluble ash 3.5, calcium 0.12, phosphorus 0.4 and energy 527.03 Kcal. Fatty acid composition of seeds oil (g/100g) as palmit 2.44-16.0, oleic 18.1-10.72, Linoleic 13.78-18.2, Linolenic 0.24-18.3, amino acids of seed oil as methionine 0.254-0.443, lysine 0.57-0.861, tryptophan 0.22-0.33, Cysteine 0.147-0.476 and Arginine 1.586-2.194.

Proximate analysis of decorticated sunflower seeds in Gezira state (Sudan) was reported by Syda et al., (2011) as 93.8% DM, 30.71% CP, 13.2% EE, 13.0% CF, 20.75% NFE, 7.14 Ash and 2622 Kcal/Kg ME, while Mahmoud et al., (1993) reported 30.62% CP and 11.52% EE.

However, Mahamed et al., (2013) found that chemical composition of decorticated sunflower meal as 41.6% CP, 14.7% EE, 8.9% CF, 7.1% crude Ash, 0.96% methionine, 0.45% cysteine and 1.75% lysine.

Variations in chemical composition of sunflower mean might be attributed to location, micro and macro environmental factors or to the different processing methods, which determine the composition of this ingredient used as feedstuff.

Fagbenro and Adeparusi, (2010) recorded the chemical compostion of raw sunflower seed meal as (g/100g) 9.48 moisture, 40.01 CP, 20.28 EE, 12.8 CF, 5.89 potassium, 12.19 calcium, 14.58 sodium, 17.17 Magnesium, 0.02 Manganese, 0.03 Iron and 0.01 Copper.

Batal and Dale, (2010), reported that nutrient content of sunflower seed meal of solvent and expeller extract as 93% DM, 1760 and 2310 ME Kcal/KG, 42 and 41% CP, 1.5 and 1.6% methionine, 0.7 and 1.8% cysteine, 1.7 and 2.0% lysine. 0.5 Vs 0.65% tryptophan, 2.3 Vs 7.6 crude fat, 21 Vs 21% CF, 7.0 Vs 6.8% Ash, 0.4 Vs 0.43 Calcium and 1.0% Total phosphorus respectively.

Sunflower is rich in linoleic acid (Senkoylu and Dale, 1999). As well as naturally occurring antioxidants (Rebole et al., 2006). Sunflower meal is considered to be lysine-deficient in several monogastric species (Poncet et al., 2003; Steen, 1989; Villamide et al., 1998 and MeNab, 2002). Sunflower meal is aslo available source of calcium, phosphorus and B Vitamins (Grompone, 2005).

2.5. Anti-nutritional factors:

Anti-nutritional factors are those substances generated in natural fees stuffs by the normal metabolism of species and by different mechanisms, which exerts effect contrary to optimum nutrition (Akande and Doma, 2010). These substances found in most foods, they are poisonous, and they are protecting them-selves from being eaten. Since anti-nutrient occurring in small quantities that they cause no harm (Farzana, 2005).

Anti-nutritional factors are mainly organic compounds, which when present in a diet may affect the health of the animal or interfere with normal feed utilization, and they occur as natural constituents of plant and animal feeds, as artificial factors added during processing or as contaminant of the ecosystem (Barens and Amega, 1984).

Anti-nutritional factors in feedstuffs are classified according to their chemical nature and their activity in animals as chemical natures, in this category are acids, enzymes, nitrogenous compounds, saponsins, tannins, glucosinlates and phenolic compounds. Factors interfering with the digestion, utilization and availability of minerals of dietary protein and carbohydrates for example, tannins, trypsin or protease inhibiters, saponsins and haemagglutinins, phytate, oxalate, glucosinolates and gossypol (Nityanand. 1997).

The anti-nutritional factors in new varieties of sunflower seed are cyanide (4.10/mg CN/100mg), tannin 0.637g/160g, oxalate 0.106g/100g and haemagglutinin 1:58 (Statish and Shrivastva, 2011), Fagbenro and Adaperasi, (2010) found the anti-nutrient composition of raw sunflower seed meal as trypsin inhibitor 0.34 mg/g, 0.23% lectin, 2.85 mg/100g tannin, 13.15 mg/100g phytin, 4.11% saponin and 16.141 mg/100g oxalate.

2.6. Uses:

The seeds are used for snacks and for bird food, a preparation of the seeds has been widely used for cold and coughs, treatment of malaria, as a diuretic and expectorant (Heiser, 1976).

Sunflower stalks have been used as fuel, fodder for livestock, food for poultry and ensilage (Heiser, 1976), hulls could be used for litter for poultry or returned to the soil composed, also hulls are used in manufacturing ethyl alcohol and furfural, in lining play wood and in growing yeast.

Leaves of sunflower can be used as cattle feed, while the stems contain a fiber which may be used in paper production. Sunflowers can be processed into bean nut butter alternative, sunflower butter. In Germany, it is mixed with rye flour to make bread. It is also sold as food for birds and can be used dietary in cooking and salads and used as a source of oil (Kindscher, 1987). The roasted seeds have been used as coffee substitute.

The sunflower oil, extracted from the seed, is used for cooking, as carrier oil and to produce margarine and biodiesel, as it is cheaper than olive oil. The seedcake used as a livestock feed. Some varieties grown as ornamental plants (Heiser, 1976).

Sunflower seeds control cell damage, thus playing a role in preventing cancer, because seeds are a good source of selenium which as proven enemy of cancer. They contain bone-healthy minerals (calcium, magnesium and copper). As a bonus, seeds contain Vitamin E, which helps ease arthritic pain. The magnesium is sunflower seeds is reputed for soothing the nerves, this easing a way stress, migrains and helping you relax. They ease every condition that is inflammatory in nature, such as joint pain, gastric ulcers, skin eruptions, asthma, because sunflower seeds are leaded with anti-oxidants (Heiser, 1976 and Kindscher, 1987).

Morman, (1986) found the sunflower leaves used to treat kidneys, for chest pains and pulmonary troubles (Glmore, 1977), oil from the seeds was used to lubricate or paint the face and body, seeds used as stimulant the appetite, a decoction of sunflower rooted protected sucking children and to alleviated rheumatism, root to treat snakebite, along with much ritual and ceremony (Camazine and Bye, 1980). Women who become pregnant while still nursing a child tock a sunflower seed medicine to prevent sickness in the child (Kindscher, 1992).

The hulls or shells are mostly composed of cellose. They are burned as biomass fuel (Zabaniotou et al., 2008).

2.6.1. Sunflower meal as ruminant feed:

Sunflower meal has been used to feed ruminant for a long time and was already praised in the 19th century as an excellent ingredient (Cornevin, 1982). Numerous experiments have since confirmed that even in its non-dehulled farm, sunflower meal is used without problems in ruminant diets as protein supplement.

Sunflower meal is suitable as the sole source of supplemental protein in diets for dairy cows (Blair, 2011). Milk production was similar when partially dehulled (Schingoethe et al., 1977) or fully dehulled sunflower meal (Parks, 1981), replaced soybean meal in dairy cow diets (Blair, 2011). In the US, sunflower meal has been widely used in beef cow supplementation programs (Anderson, 2002).

Brunschwig et al., (2002) replaced rapeseed meal in high yielding dairy cows up to 15% and found no effect milk yield and composition. Addition of sunflower meal to maize bran, 4kg/day crossbred zebu cows in Tanzania by Mlay et al., (2005) increases milk yield (8.1 Vs 6.61 L/day), and no effect on milk consumption. Jabbar et al., (2008) found no effect on milk yield and milk fat but lower weight gain when they replaced cottonseed meal concentrate by 18-40% SFM in lactating crossbred cows rations.

Sunflower meal can be used as the sole source of protein in beef rations and in commonly SFM with other protein source, equal animal performance in commonly observed based on iso-niterogenous diets from different source (Richardson et al., 1981 and Anderson, 2002).

Numerous trials have been tested successfully the inclusion of SFM in fattening lamp diets as a substitute for soybean meal, cotton seed meal or groundnut meal. SFM was also found to promote better wool growth than cotton seed meal due to its higher content in sulphur amino acids (Richardson et al., 1981; Suliman et al., 2007; Santos-Silva et al., 2003; and Louvandini et al., 2007).

SFM can replace other protein source in the diets of dairy ewes. Expeller sunflower cake (6% oil) tends to increases milk concentration of the CLA-c9tll isomer and of unsaturated fatty acids (Amores et al., 2010; Dutta et al., 2002; Irshaid et al., 2003 and Mandaluniz et al., 2010).

2.6.2 Use of sunflower meal in poultry diets:

Sunflower oil meal by-products obtained after the extraction oil from decorticated sunflower seeds. Begin a good source of vegetable protein (40% CP), the sunflower meal can be developed as a good vegetable protein supplement for different poultry.

In poultry feeding, sunflower meal is considered as a protein rich but lysine-deficient and high fiber ingredient, whose fiber fraction is mainly composed of insoluble sugars, resulting in low ME values that depend on the actual fiber content (Villamide et al., 1998). It may be cost effective to use sunflower meal for poultry diets in countries where soybean meal is not available or too expensive (Senkoylu et al., 1999.

Dehulled sunflower meal have higher ME values than non-dehulled meals, as they contain more protein and less fiber. Mechanical-extracted sunflower meal has a higher ME value due to its larger oil content, but its less valuable as a protein source due to its lower protein. Process may have complex effects, positive and negative, on the nutritional value of sunflower meal (San Juan et al., 2000 and Zhang et al., 2004). Diets containing large amount of sunflower meal including high oil meal, tend to be bulky, resulting in lower feed consumption. Reducing bulkiness by pelleting increases feed intake and subsequently performance (Senkoylu et al., 2006).

The use of sunflower meal in animal feeding has been limited due to the high fiber content caused by residual seed hulls. The meal quality in terms of digestibility for poultry and monogasteric as well as protein content، is very variable (Coombs and Hall، 1999 and Rat and Keshavarz، 1976).

Silva, (1990) reported that sunflower meal can be used in diets in complement with other lysine-rich feed sources, but the high level of fiber in SFM contributes to a reduction in the energy digestibility of the diets.
Cortamira et al., (2000) found that SFM in substitution of soybean meal requires the addition of vegetable oil and lysine in diet.

In rabbit feeding, SFM is a dual purposes raw material, being both a source of balanced protein and a source of lignin-rich fiber. It is an ingredient suitable for rabbit feeding without technical restriction provided that protein level, protein quality and fiber composition are taken in account in diet formation. SFM supplies only about 70% of the lysine requirement for growing and breeding rabbits, but exceeds the requirements for sulfur amino acids, theronine and trptophan (Lebas, 2004).

2.6.3. Use of SFM in laying hens:

As a consequence, SFM is a more suitable ingredient for laying hens than for birds with higher protein and energy requirement, such as broilers and turkeys (CETIOM, 2003). It is a possible to introduce up to 30% of SFM, in layer diets without affecting performance (Deaton et al., 1979). In other birds species, pelleting may also improve feeding efficiency by decreasing the bulkiness of SFM based diets, for instance in water fowl diets (Vetesi et al., 1998).

In turkey diets, the inclusion rate of SFM seems to be more limited (less than 14%), as turkey have higher requirements for protein and amino acids because sunflower meal may induce undesirable effects (Juskiewicz et al., 2010).

Syda et al., (2011) studied the substitution of groundnut meal by diet. They concluded that SFN can be use alternative protein source ingredient up to 26% in layer diets and can replace 100% groundnut meal without hazard effects. Substitution of 50% groundnut meal or inclusion of 13% SFM in layer diets resulted in the best performance of layers in term of feed intake, body weight gain, egg number, egg mass, feed conversion ratio, laying and highest profit.

Karunajeewa et al., 1999; Vieira et al., 1992; Aslam, Mirza and Sial, 1992; Senkoylu and Dale, 1999; Casartelli et al., 2006 and Talha and Yaguob, (2008) reported that SFM can substitute groundnut meal in layers ration without altering the laying hens performance, also could completely substitute soybean meal.

Elzubeir (1991) and Musharaf, (1991), revealed that SFM can be used in layers ration and that layers will benefit more from SFM inclusion in their diets.

Shi et al., (2012) replaced soybean meal by sunflower seed meal in laying hens at 8.26, 16.52 and 24.84%. They reported that there was no adverse effect on performance, egg quality, and fatty acid content in addition to significant lowering of egg yolk cholesterol. It was concluded that 10% of high fiber sunflower meal can be used in laying hen diets without adverse effect on performance and egg parameters (Rezaei and Hafezian, 2007) Rao et al. (2009) found that soybean meal could be replaced completely with sunflower meal as the principal protein source in layer chick diet (1 to 28 day of age).

Fafiolu et al., 2013 concluded that the use of undecorticated sunflower seed meal supplemented with a multi-enzyme mixture improved performance, egg quality and nutrient utilization at different stages of laying.

2.6.4. Use of SFM in broilers:

Research work done on broilers (Ibrahim and Elzubeir, 1991; Musharaf, 1991; Senkoylu and Dale, 1999; Tevernari et al., 2008; Rao et al., 2009 and Talha and Yagoup, 2008), studied the effect of replacing groundnut cake with decorticated sunflower cake on broiler chicks performance, they found that decorticated sunflower cake can replace up to 100% of groundnut in broiler chicks starter and finisher diets.

Mandal et al., (2003), reported that inclusion of undecorticated SFM of 0.0, 5.0 and 10% level replacing part of soybean meal in broiler chicks' diet had no significant effect in body weight gain and feed intake during starter or finisher period. Replacement of groundnut cake in the diet of growing chickens by sunflower cake improved growth rate an efficiency of utilization of energy and protein (Singh and Parasad, 1979).

Pinheiro et al., (2002) found better economic performance when broilers were fed 4% SFM form 36-42 day of age. Lucio et al., (2011) studied the effect of SFM inclusion in diets formulated on total or digestible amino acid basis fed to broilers of 22 to 42 days of age. They found that inclusion of 15% of SFM worsen feed conversion ratio and the use of SFM does not influence the carcass and cuts yield. Also Rama Rao et al., (2006) verified that SFM can replace up to two thirds of soybean meal in broiler diets.

Broiler fed diets containing 35% SFM performed better than those fed a diet containing canola meal (Kocher et al., 2000), similar results were found with a 20% inclusion of SFM in low-energy broiler diets (Aftab, 2009). Waldroup et al., (1970) recorded possible inclusion of SFM up to 20% with no lysine supplementation, which was later confirmed by Valdivie et al., (1982) and Zatari and Sell, (1990). However, Furlan et al., (2001) asserted that up to 15% of SFM can be included in broiler feed with no effect on performance, provided lysine is supplemented.

Nassiri et al., (2012) concluded that increasing levels of SFM in the diet quadraticaly effect (in grower and finisher phases), but body weight gain (in starter and grower phase) were linearly affected. Therefore sunflower meal can be used in broiler diets at levels up to 140g/kg and its fiber content has no significant effect on nutrient intake.

Adenij et al., (2007) studied the replacement value of high fiber Hulled sunflower seed cake for soybean cake in broiler diets at 0, 25, 50 and 70% levels. The study suggested that not more than 50% HSFSCP (22% crude fibers) could be replaced with soybean cake protein in the diet of broiler chicken without adverse effect.

Kamal and Khalid, (2013) conducted to evaluate the effect of undecorticated sunflower seed meal on the performance of broiler. Result indicated that incorporation of sunflower seed meal had no significant (P>0.5) effects on feed intake, live weight gain, feed conversion ratio, mortality, hot and chilled percentages.

It was concluded that addition of sunflower up to 15% to replace groundnut had no harm or undesired effects.

Adejuno and Williams (2006) reported that sunflower meal can replace groundnut cake and soybean meal up to 75% level without negative effect on performance and production in broiler chicken diets.

Rehman et al., (2002) studied the effect of substitution of soybean meal with canola and sunflower meal on the performance of broilers, the results showed that the weight and dressing percentage were comparatively improved (P<0.05) where SFM was used as source of protein.

However, CM and SFM could successfully replace 50% of SBM. The 100% substitution of SBM with SFM resulted in high feed consumption with poor weight gain, feed conversion ratio, carcass weight, dressing percentage and liver enlargement which could be attributed to comparative poor nutritional value and mycotoxin susceptibility of SFM.

2.7 Enzyme supplementation to SFM-Based diets:

Monogastric animals like poultry, pigs etc. lack the alloenzymes from rumen microflora and thus it become necessary to incorporate the enzymes in their diets in order to derive optimal nutrient utilization from complex feed matrix. Feed enzyme are added to animal feed to increase the availability of nutrient by digesting the feed component during storage or after consumption within the gastrointestinal tract , some of the enzymes that have been used over the past several years and have potential for use in feed industry include cellulose (β-gluconase) , xylanase and associated enzymes , phytase, proteases and galactosidases . Most of the enzymes used in the feed industry have been applied for poultry to neutralize the effect of viscous, non-starch polysaccharides in cereals such as burley, wheat, rye and triticale.

The application of industrially produced enzymes, amylase and protease, to enhance starch and protein utilization in animal nutrition date back to the late 1950's or early 1960's (Burnett, 1962).

A resume of exogenous enzyme used in poultry diets. Biologically, enzymes are protein, catalyzing all metabolic processes in animal, plants and microorganisms. Every enzyme has its own unique properties, like specific activity, substrate affinity, stability, pH and temperature sensitivity, and can be classified by the substrate upon which it reacts.

The testa of SFM and cereal grains is rich in non-starch polysaccharides (NSPs) which reduce the digestibility of the SFM/cereal grains. These NSPs are polymeric carbohydrates which differ in composition and structure from starch (Annison, 1992) and possess chemical cross linking among them and therefore, are not well digested by poultry (Annison, 1993). A part of these NSP is water soluble which notorious for forming a gel like viscous consistency in the intestinal tract (Pettersson, 1987). Predominantly water soluble and viscous arabino xylans (belong to pentason group) are assumed to be the factor responsible for the low metabolizable energy (ME) in cereal grains (Choct and Annison, 1990), resulting in relatively per chick performance (Friesen et al., 1992).

These pentasons, which were the main constituents of the endosperm cell wall of cereal grains, greatly increase the water intake by the bird which leads to unmanageable little problems caused by wet and sticky dropping (Dunn, 1996). Similarly β-glucanase also adversely affects all nutrients, especially protein and starch utilization is known to give rise to highly viscous conditions in the small intestine of the chicks (Hesselman and Aman, 1996).

Research suggest these negative effects of NSP can overcome by supplementation of diets with suitable exogenous enzyme preparations (Zanella et al.,1999; Gracia et al., 2003 and Wyatt, 1997), as those hydrolyze the non-starch polysaccharides, which then could be used by the birds, increasing for instance, energy utilization (Tavernari, et al., 2008).

Enzymes have been developed to reduce the negative effect of NSP and improve the feeding value of cereal base diets. Xylanase and β−gluconase are the enzymes most effective for supplementing cereal-based diets. Studies have shown that application of Xylanase and β−gluconase in creed based diets improved bird performance and increase nutrient digestibility (Petterrson et al., 1990; Bedford and Classen; 1992; Friesent et al., 1992; Marquardt et al., 1994).

The treatment of diet or of individual ingredients with enzymes may aid in increasing overall digestibility and reducing variability of ingredients by disrupting cell walls to allow better across of digestive enzymes to the encapsulated nutrients , destroying ANF's and supplementing birds' own digestive enzymes array in situations when they are overwhelmed (Camphell et al ., 1992 , Jeroch et al ., 1995).

Supplementation of exogenous enzyme to those diets use cereal grains (barley and wheat) can eliminate ANF, enhance feed digestibility, improved feed conversion ratio, reducing feed cost (Bedford and Morgan 1996).

Bedford (1996) studied the effect of enzymes on digestion. He concluded that chicken are often compromised in its digestive capacity such that addition of exogenous enzymes can improve productive performance, also exogenous enzymes can improve digestion by augmenting the chick's own capacities for protein, starch and fat digestion by removing ANF's which interfere with the normal processes of digestion, or by digestion of fiber components that would otherwise pass undigested throughout the gastrointestinal tract. Although interaction of microflora in both small intestine and caecum with the digesta makes determination of accurate feeding value of a fiber degrading enzyme particularly difficult to assess by classical digestibility techniques . Exogenous enzymes may in the future be seen to play a significant role not only in animal nutrition but most certainly in digestive tract health.

Bharathid Hassan et al., (2010) studied the effect of enzyme supplementation to nutrient reduced diet on performance of broilers. In feed trial in broilers (0-6 wks) fed diets supplemented with enzyme at (0 , 250 , 500 , 750 and 1000 g/ton) of feed with appropriate reduction in metabolizable energy (ME- 1.25 , 2.5 , 3.75 and 5%) , crude protein (CP- 0.75 , 1.5 , 2.25 and 3%) , methonine + cystine (0.5, 1 , 1.5 and 2%) , available phosphorus (2.2 , 4.4 , 6.6 and 8.8%), the weight gain was increased significantly (P<0.05) in 750 g/ton (1633.50g) and 1000g/ton (1602.00g) over the control (1505.00g). The increase in weight gain was 7.9% in 750g/ton and 6.1% in 1000g/ton enzyme supplemented group over that of control. The feed intake (F1) significantly (P<0.05) increased in 750g/ton over the other groups. Further the (F1) was decreased by 3.8 and 2.3% in 250 of 500g enzyme supplemented groups (1.84 in 250 , 1.92 in 500, 1.90 in 750 and 1.88 in 1000g /ton) compared to the control (2.00) . Among the enzyme added groups the best feed efficiency was observed in 250g/ton of enzyme supplemented group. Enzyme supplementation was able to reduce the feed cost per Kg weight gain by 9.07, 5.83, 8.23 and 10.22% in 250, 500, 750 and 1000g/ton of enzyme supplemented groups respectively over the control.

Nadeem et al., (2005) studied the effect of non-starch polysaccharide degrading enzymes on growth performance of broiler chicks, he concluded that supplementation of NSPDE in commercial broiler diets improved the efficiency of feed utilization only during starter phase and failed to do so during the finisher phase. NSPDE supplementation did not influence the carcass tracts except relative liver weight.

Senkoylu et al., (2004) studied the possibilities of using high oil-sunflower meal and enzyme mixture in `layer diets, he concluded that HO-SFM could practically replace soybean meal or full fat soybean and could success fully be included at 20% in laying hen rations, Grindazyn GP 5000 could significantly improve feed efficiency and lowered feed cost in sunflower meal based commercial layer rations.

Gerendal et al., (1997) concluded that soybean meal can be replaced partly with solvent extracted sunflower meal supplemented with lysine, methonine and energy in grower and finisher diets for broiler without adverse effect on performance and nutrient digestibility. Enzyme supplementation improved feed conversion and protein efficiency in broiler chicks fed diets containing a high level of sunflower meal.

Oliveira et al., (2007) evaluated two SFM inclusion levels (0.0 and 15%) with or without enzyme complex (cellulose, protease and amylase) in the diet of 21-42 day old broilers and did not find any significant interactions between SFM and the enzyme complex.

Srinivasan and Jeichitra, (2012), investigated the effect of feeding different levels of SF cake and enzyme supplementation on egg quality traits of breeder quails. Results showed that the egg trails were neither influenced by feeding different levels of SFC nor by enzyme supplementation.

Alam et al., (2003) studied the effect of exogenous enzyme in diet on broiler performance. They found that the growth rate, feed intake, feed conversion ratio, dressing yield and profitability were increased by addition of exogenous enzymes.

Fafiolu et al., (2013) fed laying hens on diets containing undecorticated SFM with or without exogenous enzyme supplementation. Results of the early lay period showed significant reduced in feed intake and final weight values as the level of undecorticated SFM increased in the diet and feed intake and egg produced per hen day.

Mushtaq et al., (2009) conducted an experiment to study the influence of SFM based diets supplemented with exogenous enzyme and digestible lysine on performance, digestibility and carcass response of enzyme addition in low nutrient density and high SFM diets (300g/kg).

Moreover, digestible lysine is not suggested to be lowered than 10g during 1-21 day and it may be reduced to 9gm/kg if a single diet having high level of SFM in planned to be offered during 1-42 day.

Khan et al., (2006), studied the influence of exogenous enzymes supplementation to sunflower-corn based diet on digestive and performance traits in broilers. Results showed that birds fed the enzyme supplemented diets consumed more grow faster and had better feed conversion than those fed the control diet.

Slavica et al., (2012) reported that supplementation of poultry diets containing sunflower meal by different enzymes increasingly contribute to sustainable poultry forming by enhancing production efficiency, increasing the effectiveness of nutrient utilization and upgrading in environmental protection.

Chapter Three

Materials and methods

The study was carried out at poultry production farm, College of Agricultural Studies, Sudan University of Science and Technology, during the period of 25th November 2013- 9th January 2014 in which the average environmental temperature recorded were 19^{o} C and 27^{o} C of minimum and maximum temperature respectively.

3.1. Experimental diets:

The experimental diets were formulated to be iso-nitrogenous, iso-caloric to meet the minimum requirements of broiler chicks as recommended by the National Research Council (NRC, 1994). The ingredients composition, calculation and determination of the experimental diets are illustrated in table (1).

Table (1): Composition and nutritive content of basal diet and diets with different level of sunflower meal SFM (experimental diet):

Ingredients	***Control***	***5%***	***10%***	***20%***
Dura	65.5	64.0	61.35	54
Ground nut	13.0	12.85	12.0	10
Sesame cake	15.0	12.0	10.0	8
Concentrate	5.0	5.0	5.0	5
SFC	_	5.0	10.0	20
Shell	1.0	0.65	0.7	0.74
Salt	0.25	0.25	0.25	0.25
Lys.	0.1	0.13	0.185	0.26
Meth.	0.15	0.12	0.255	0.2
V. oil	_	_	0.260.26	1.55
Total	100%	100%	100%	100%

The commercial microbial xylam 500 (composed of 8000 U/gm, amylase and 1620 U/gm 1-4 β-xylanase, produced by Murex Company for Feed Enzymes Production) obtained from Khayrat ElNile, Khartoum, Sudan.

The experimental diets were formulated as follow:

Diet A served as negative control (without SFM and enzyme) diets B, C and D were contain different levels (5, 10 and 20%) of SFM respectively. Diets E, F, G and H were similar to diets A, B, C and D respectively, but they were supplemented with 50 gm xylam/Kg diet.

Table (2): analysis of nutritive value of basal diet and experimental diets with different levels of sunflower meal and enzyme supplementation:

	Sample type	**DM %**	**Ash %**	**C.P %**	**E.E %**	**C.F %**
Control (-)	Diet A	92.40	7.05	25.162	4.80	5.80
Control (+)	Diet E	92.10	6.94	20.698	4.60	6.20
SFC 5% (-)	Diet B	92.10	7.05	24.553	4.80	6.40
SFC 5% (+)	Diet F	91.00	7.03	25.771	5.20	5.60
SFC 10% (-)	Diet C	91.50	6.78	23.958	6.20	4.40
SFC 10% (+)	Diet G	91.00	7.03	21.666	8.40	9.60
SFC 20% (-)	Diet D	91.90	6.94	25.208	8.80	9.20
FSC 20% (+)	Diet H	91.80	7.73	24.375	4.60	6.20

3.2 Experimental of birds:

One hundred and ninety two seven day-old, unsexed broiler chicks, (Apper-aiker) with average 40 gm weight were used after a week of adaptation period. During the first three days the chicks were given multi-vitamins AD3E+coliston 0.2ml/1L drinking water. During the first week chicks were fed with the per-starter. Chicks were randomly distributed to eight treatment groups with three replicates of eight chicks per each. Feed and water were provided freely. Chicks were vaccinated against Gumboro (Hipra Gumboro) at 8 days of age and against Newcastle disease at 19 days old. Soluble vitamin compound and antibiotics colistine sulphate were given to the chicks before and after three days of the vaccination to guard against stress. The chicks were kept on 24 hour light program, the chicks in each replicate were housed in clean disinfected separated pens of an open system. Wood-shaving was used as litter material in each pen. A randomized block experimental design with four treatments in a 4×2 factorial arrangement (4 sunflower meal inclusion levels: 0, 5, 10, and 20%; and supplementation or not of enzyme) with 3 replicates of 8 chicks each.

3.3. Housing:

Chicks were kept in an open wire mesh-side poultry house. The house was constructed on concrete floor. The roof was made of metal sheets; the sided were permanently covered with sacks. The pens ($1m^2$) inside the house were prepared using mesh partitioning. Each pen was supplied with 2.5 gallon drinker and 5 Kg feeder which were cleaned and disinfected before starting feeding trial. The feeders and drinkers heights were adjusted according to the progressive growth of the chicks.

3.4. Parameters:

Chicks of each replicate were group weighted at weekly intervals and feed consumption was recorded at the time of weighing and the data were used to determine the performance parameters. Mortality was recorded daily throughout the experiment period.

3.5. Slaughter and carcass preparation:

At the end of experiment, 6 weeks, three birds that their body weights were close to group average from each treatment, were selected, after they were weighted individually. Blood samples were collected from two birds per group inheprinized test tubes, centrifuged and stored for analysis. Selected birds were slaughtered, scaled in hot water after bleeding, feather plucked manually then washed and eviscerated. Hot carcass, heart, head, gizzard, abdominal fat and liver were weighted, carcasses were chilled at 4^{o} C for 24 hours, then weighted (cold weight), then were sawed into two halves. The left side then divided into the commercial cuts (breast, thigh, and drumstick). Each cut was weighted individually then deboned to determine the weight of meat and bone of each cut. The meat was frozen for chemical analysis and panel test.

3.6. Chemical analysis:

Stored meat samples were cut into small pieces twice and duplicate samples were analyzed for crude protein, fat, ash and moisture content as described by the AOAC (2000). Diets were analyzed for DM by oven during method, ash by muffle furnace, CP by Kjeldahl method, EE by Soxhlet fat analysis. Nitrogen free extract (NFE) and metabolizable energy (ME) were calculated by the (Ellis, 1981) formula.

3.7. Panel Taste:

The stored right side of carcass of each bird was slightly seasoned, wrapped in aluminum foil and roasted at 190^{o} C for 70 minutes with average internal temperature of 88^{o} C and served warm. Ten semi-trained taste panels were used to score color, flavor, tenderness and juiciness of meat (Cross et al., 1978) and scale of 1-8 (Appendix…) the samples were served randomly to each judge and at room temperature. Water was provided for the panelists to rinse their mouth after tasting each sample.

3.8. Calculation:

The hot and cold carcass weights were expressed as a percentage of liver weight. The commercial cuts were expressed as a percentage of hot carcasses. Non-carcass components (heart, liver, gizzard and legs) were expressed as a percentage of the weight of its cut.

3.9. Statistical analysis:

Randomize Block Design was used for the study. The collected data were subjected to statistical analysis using analysis of variance technique. Multiple means comparisons were made using Duncan's Multiple Test (Sted and Torrie, 1982).

Chapter Four

The results

4. The result:

4.1. Performance results:

Results of broiler chicks performance fed on different levels of sunflower seed cake were illustrated in table (3). results showed that chicks fed on control diet supplemented with enzyme received significantly ($P<0.05$) the heaviest body weight, body weight gain, more feed intake and best feed conversion ratio compared to chicks fed on control diet without enzyme . Results also showed a numerical increase in body weight, body weight gain and feed intake with the level increase of sunflower seed cake with or without enzyme.

However, chicks fed on control diet without enzyme and chicks fed on 20% SFC with enzyme recorded the lowest and heaviest body weight, body weight gain and feed intake respectively.

Chicks fed on both control diet and 5% SFC supplemented with enzyme recorded significantly ($P>0.05$) the best FCR value while those fed on 10% SFC without enzyme showed significantly ($P>0.05$) the lowest FCR value compared to both control groups.

Results in **table (4)** showed no significant ($P>0.05$) differences in commercial cuts (breast, drumstick and thigh) weights values with or without enzyme for all SFC levels. Also there is no significant differences ($P>0.05$) between commercial cuts meat and bone ratio.

Results showed no significant (P>0.05) differences in fat accumulation, gizzard, head, heart and leg weight for chicks fed on different levels of SFC with or without enzyme as in **table (5)**. However chicks fed on different levels of SFC without enzyme showed numerically heavy weight for liver.

Table (3): performance of broiler chicks fed on different levels of SFM with or without enzyme:

Treatment	Enzyme	Final body weight	Weight gain	Feed intake	FCR
Control	With	2,402.3^{ab}	2241.0^{ab}	4010.4^{bd}	1.79^{c}
	Without	2127.5^{c}	1959.8^{c}	3768.4^{c}	1.92^{b}
Sunflower5%	With	2308.4^{abc}	2147.7^{abc}	4001.5^{d}	1.86^{bc}
	Without	2285.6^{bc}	2118.0^{bc}	4027.1^{bd}	1.90^{b}
Sunflower 10%	With	2414.3^{ab}	2240.1^{ab}	4366.5^{ab}	1.95^{ab}
	Without	2304.2^{abc}	2139.3^{abc}	4320.1^{abc}	2.03^{a}
Sunflower 20%	With	2564.3^{a}	2391.3^{a}	4518.0^{a}	1.90^{b}
	Without	2469.0^{ab}	2298.3^{ab}	4444.8^{a}	1.94^{ab}

*a-b-c-d values in the same raw with different letters are significantly different

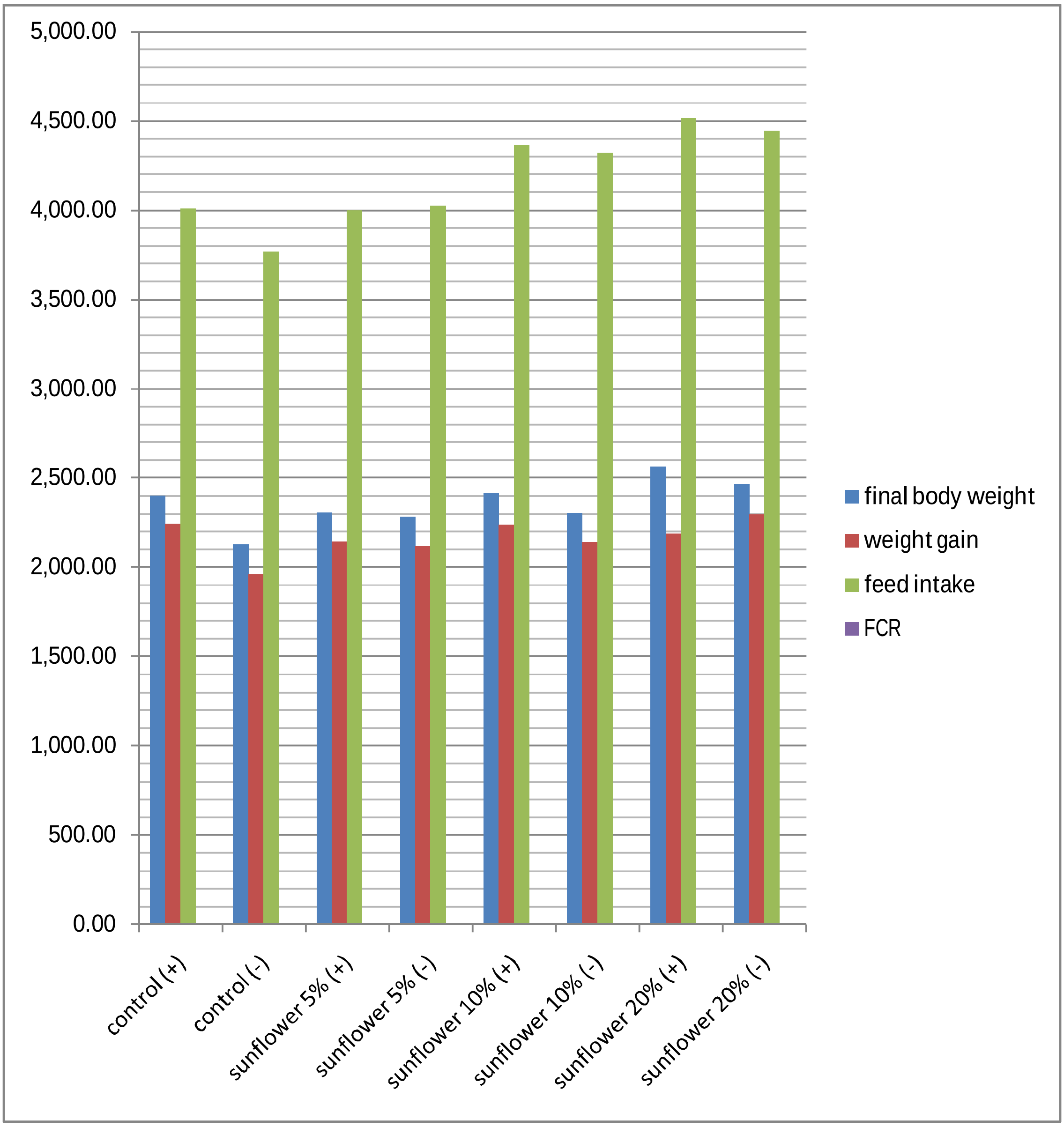

Figure (1): performance of broiler chicks fed on different levels of SFM with or without enzyme

Table (4): effect of experiment treatment on percent of commercial cuts from final body weight:

Treatment	Enzyme	Breast*	Drum*	Thigh*	Bone breast**	Meat breast**	bone drum**	Meat drum**	bone thigh**	Meat thigh**
control	With G	16.4[ab]	8.0[a]	7.5[a]	16.3 [ab]	86.7[a]	13.5[a]	88.4[a]	23.6[ab]	76.4[a]
	Without A	16.6[ab]	8.0[a]	6.0[ab]	7.5[c]	87.6[a]	11.3[a]	86.5[a]	18.9[b]	77.1[a]
Sunflower 5%	With E	17.8[ab]	7.8[a]	6.5[a]	17.4[a]	86.6[a]	14.6[a]	85.3[a]	25.2[ab]	74.8[a]
	Without B	16.3[ab]	7.0[a]	6.8[ab]	7.2[c]	88.8[a]	14.9[a]	85.1[a]	22.5[ab]	77.5[a]
Sunflower 10%	With F	17.8[ab]	7.2[a]	6.5[a]	13.5[abc]	86.6[abc]	13.5[a]	86.5[a]	21.7[b]	78.3[ab]
	Without C	16.6[ab]	7.7[a]	6.6[a]	10.2[abc]	89.8[ab]	13.5[a]	86.5[a]	18.2[b]	77.8[a]
Sunflower 20%	With H	16.4[ab]	7.7[a]	6.9[a]	9.5[bc]	90.0[ab]	16.3[a]	83.8[a]	29.0[a]	71.0[ab]
	Without D	17.7[ab]	6.9[a]	6.5[a]	9.7[abc]	90.1[ab]	14.5[a]	85.5[a]	24.2[ab]	75.8[a]
SE+		1.64	0.542	0.669	3.39	3.334	2.837	2.917	3.11	3.11

*as % of final body weight **as% of their cuts

a-b-c-d values in the same raw with different letters are significantly different

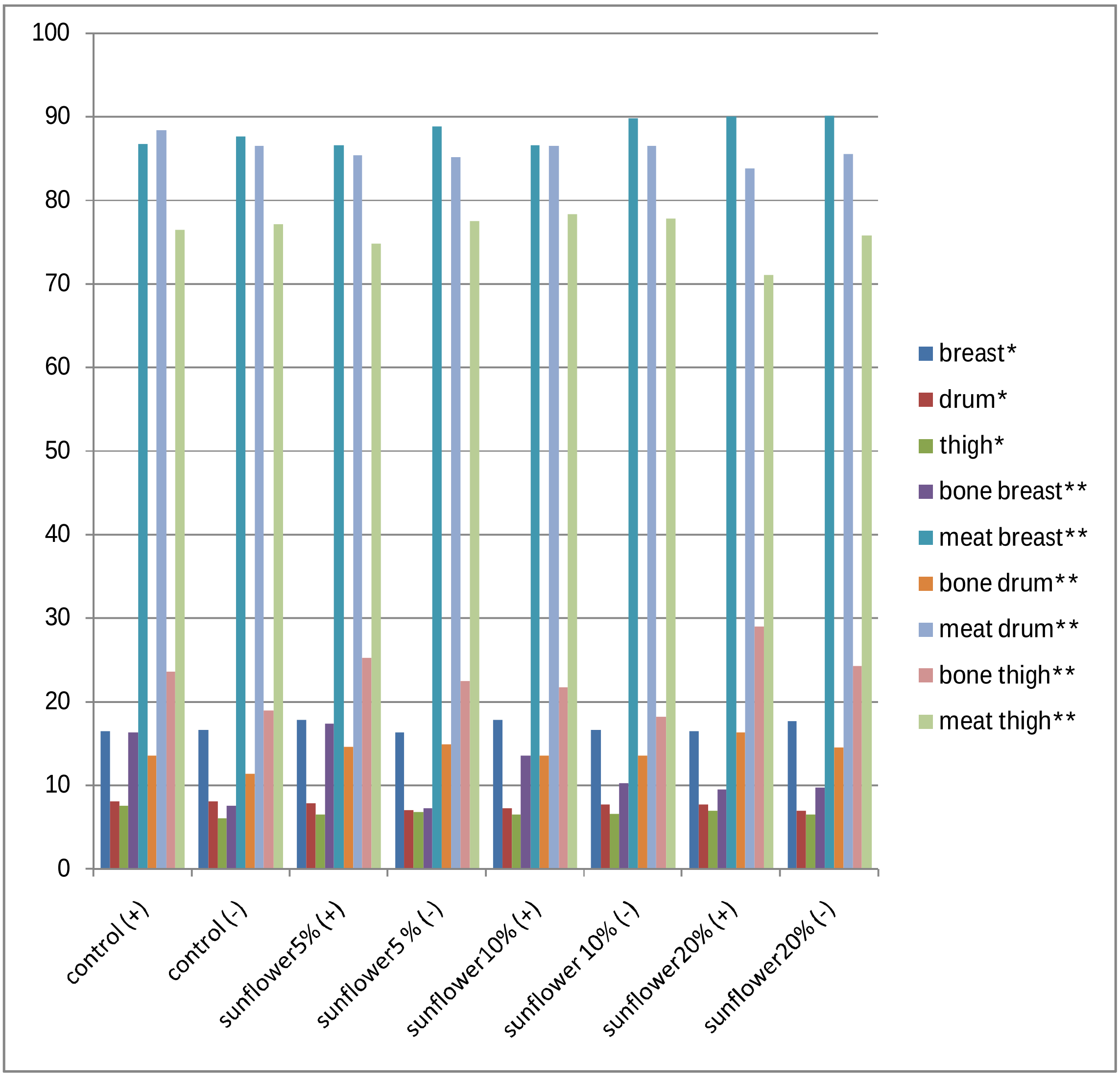

Figure (2): effect of experiment treatment on percent of commercial cuts from final body weight

Table (5): the effect of experimental diet in non carcass component:

treatment	enzyme	Fat	gizzard	head	heart	leg	Liver	Neck
Control	With G	36.7^{a}	62.7^{a}	45.3^{a}	11.3^{a}	68.3^{a}	45.3^{a}	78.0^{ab}
	Without A	21.3^{a}	49.3^{a}	44.7^{a}	13.7^{b}	92.3^{a}	55.3^{a}	93.3^{a}
Sunflower 5%	With E	27.3^{a}	47.7^{a}	44.7^{a}	10.7^{a}	70.7^{a}	43.0^{a}	74.3^{ab}
	Without B	35.7^{a}	58.0^{a}	45.3^{a}	10.3^{a}	81.0^{a}	51.3^{ab}	67.7^{b}
Sunflower 10%	With F	35.0^{a}	52.3^{a}	44.0^{a}	13.7^{b}	85.0^{a}	49.7^{abc}	91.0^{a}
	Without C	29.7^{a}	61.3^{a}	45.3^{a}	13.3^{b}	85.7^{a}	52.0^{abc}	68.6^{b}
Sunflower 20%	With H	26.3^{a}	62.0^{a}	48.3^{a}	13.3^{ab}	88.3^{a}	49.7^{a}	75.0^{ab}
	Without D	35.0^{a}	61.7^{a}	47.7^{a}	11.3^{b}	92.3^{a}	54.0^{abc}	84.6^{ab}
SE+		10.614	8.466	4.52	1.908	13.345	8.215	9.36

A-b-c the value in the same raw with different letters is significantly different.

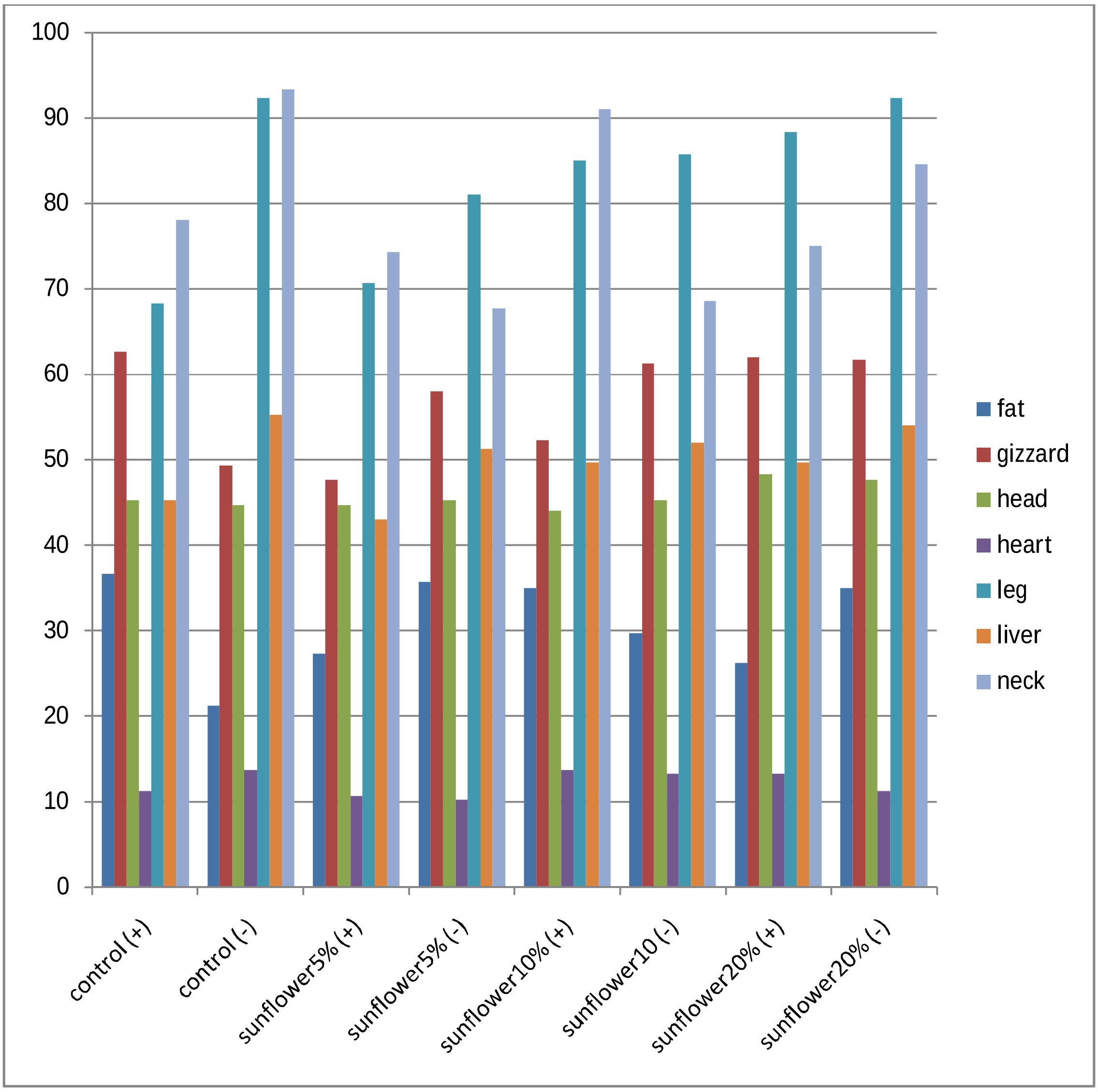

Figure (3): the effect of experimental diet in non carcass component

Meat showed no significant (P>0.05) difference, for the parameters ash, erode protein, dry matter and fat deposition for all experimental chicks as explained in table (6).

Table (6): Meat analysis:

Treatment	Enzyme	ASH	CP	DM	FAT
Control	With G	3.93[a]	24.88[a]	32.84[a]	4.52[a]
	Without A	3.91[a]	25.63[a]	32.44[a]	4.53[a]
Sunflower 5%	With E	3.95[a]	24.56[a]	32.61[a]	4.79[a]
	Without B	3.95[a]	24.68[a]	32.78[a]	4.37[a]
Sunflower 10%	With F	3.93[a]	25.18[a0]	32.81[a]	4.67[a]
	Without C	3.92[a]	25.36[a]	32.56[a]	4.66[a]
Sunflower 20%	With H	3.94[a]	24.90[a]	32.39[a]	4.69[a]
	Without D	3.96[a]	25.16[a]	32.69[a]	4.40[a]
SE+	-	0.0831	0.2828	0.1257	0.2478

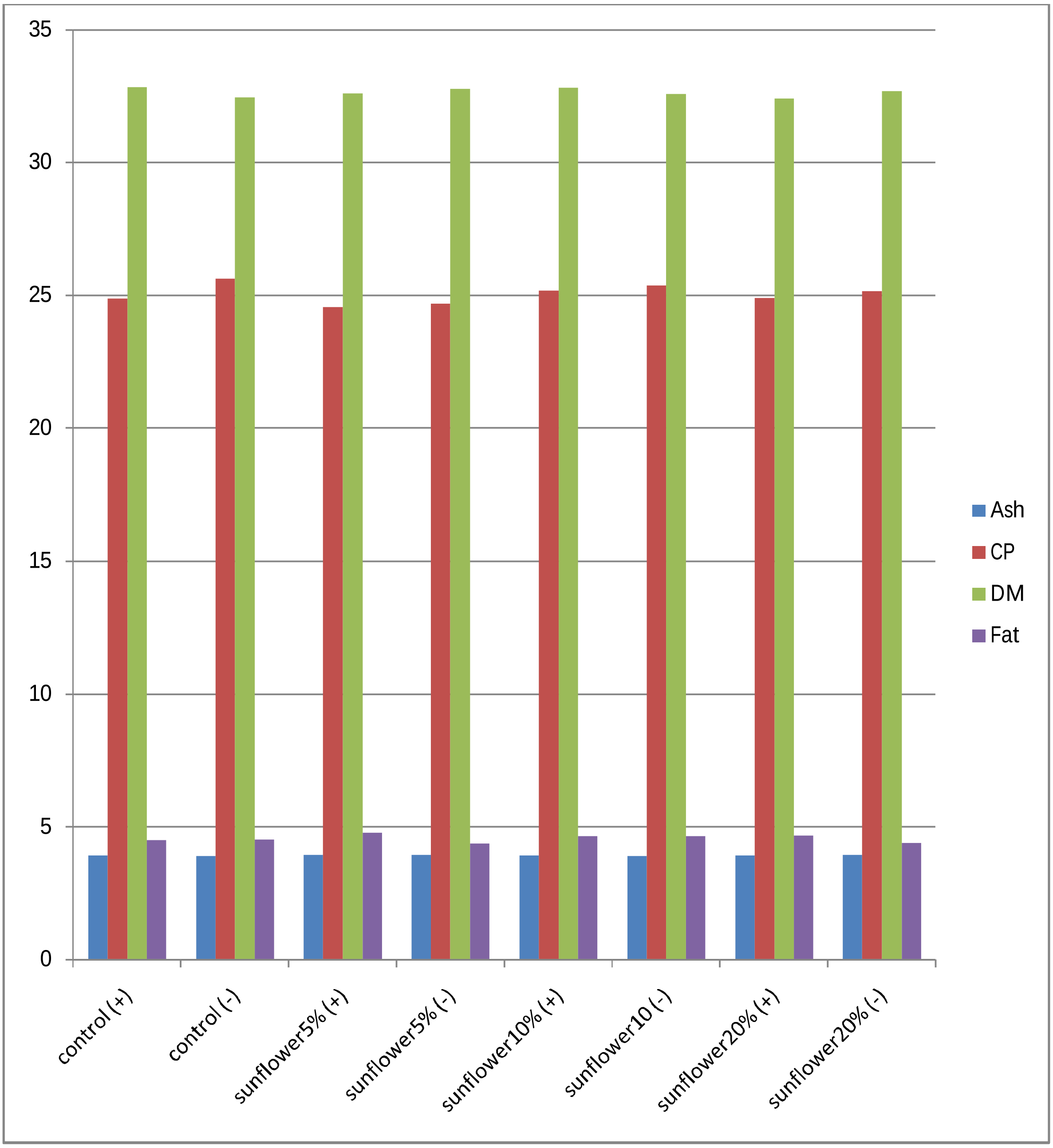

Figure (4): Meat analysis

4.2 Panel Taste:

The average subjective meat quality Scores (tenderness, color, flavor and juiciness) were not affected significantly by inclusion of SFM with or without enzyme supplementation among the tested groups as shown in **table (7)**.

Table (7): panel taste

Treatment	enzyme	Tenderness	Flavor	color	Juiciness
Control	With	6.8	6.8	6.6	7
	without	6.5	6.4	6.4	6.6
Sunflower5%	With	7	6.9	6.6	6.9
	without	6.6	6.4	6.5	6.8
Sunflower10%	With	6.7	6.7	6.7	6.9
	without	6.6	6.7	6.6	7
Sunflower20%	With	6.6	6.7	6.7	6.8
	without	7	6.8	6.5	6.8

4.3 Serum constituents:

Also the results showed that addition of SFM with or without enzyme supplement has no significant difference in blood constituents as shown in **table (8).**

Table (8): effect of experimental diet on serum constituents

Treatment	**Chol.**	**Trig.**	**Gluc.**	**urea**	**creatinine**	**Ca.**	**Pho.**	**Uric Acid**	**T.P.**	**Hb**	**ALP**	**ALT**	**AST**
Control (+)	81	71	163	11	0.3	1.8	5	4.2	4	9.8	112	40	30
Control (-)	95	43	220	12	0.37	3.6	5	3.7	4	11.6	33	37	33
SFC 5% (+)	77	57	213	7	0.23	2.5	5	6.2	4	11	91	47	43
SFC 5% (-)	88	50	209	8	0.29	1.4	5	6.5	3.5	11.4	96	37	33
SFC 10% (+)	86	40	175	10	0.23	1.4	4.8	7.4	3.9	9.5	96	28	26
SFC 10% (-)	81	40	166	7	0.2	2.1	5	4.7	3.7	11.6	80	35	31
SFC 20% (+)	88	95	165	12	0.34	1.8	7.5	8.2	4.4	10.5	96	28	26
SFC20% (-)	86	86	165	12	0.5	1.1	5	4.5	3.9	10.9	121	33	30

4.4 Economical study:

All levels of SFC with or without enzyme supplementation recorded profit. However, 20% with enzyme recorded the best profitable ratio (1.282) followed by 20% without enzyme compared to control without (1.0) showed in **table (8).**

Table (9): economical study of adding SFM with or without enzyme supplement:

Treatment	Enzyme	Total cost	Total revenue	Profit	Profitability ratio
Control	With	19.3335	45.0754	25.7419	1.218
	Without	20.2398	51.5430	31.3032	1.216
Sunflower 5%	With	20.0535	48.7140	28.6605	1.113
	Without	20.3889	49.3971	29.0082	1.127
Sunflower 10%	With	21.3863	49.1993	27.8130	1.080
	Without	21.1315	51.5223	30.3908	1.181
Sunflower 20%	With	21.4312	52.7919	31.3607	1.218
	Without	22.0004	54.9999	32.9995	1.282

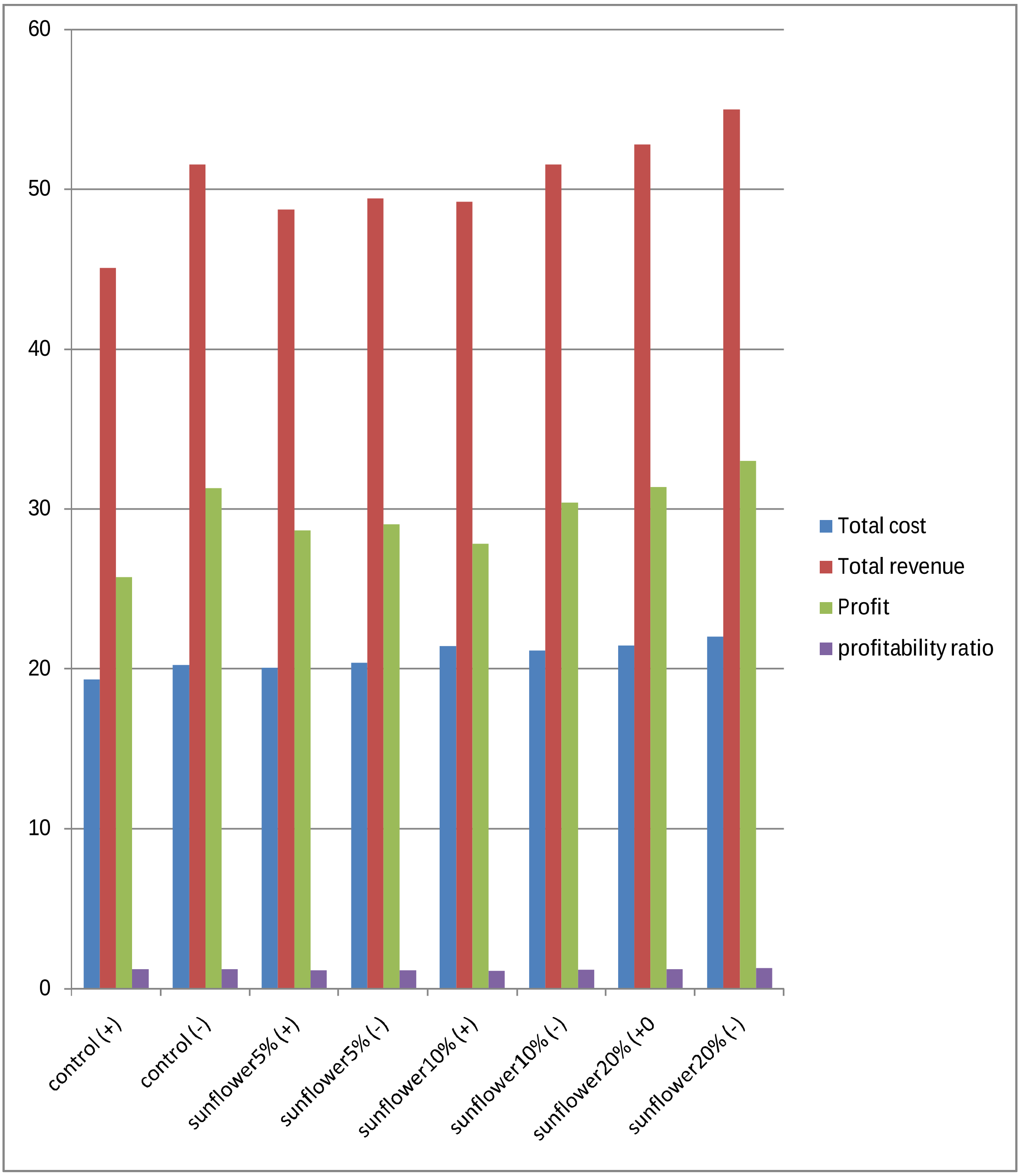

Figure (5): economical study of adding SFM with or without enzyme supplement:

CHAPTER FIVE

5.1. Discussion:

Sunflower is a promising new edible oil crop in Sudan (Mohammed, 2010). Sunflower meal is considered as a good source of vegetable protein (30.7_41.6%), high fiber content (8.9_13.0%) of it increased viscosity of gut contents, poor digestibility and poor chicks performance (Furlan et al., 2001).

These negative effects can be overcome by supplementation of diets with suitable exogenous enzyme (Gracia et al., 2003, Tavernari et al., 2008). Proximate analysis showed variations in sunflower meal (Mahmoud et al., (1993), Sayda et al., (2011) and Mohammed et al., (2013), these variations might be attributed to location, micro and macro- environmental factors or to the different processing methods.

Results obtained for chicks fed on different levels of SFM 5showed that the group fed on control diet supplemented with enzyme recorded significantly the best performance compared to other tested groups, also numerical increase in body weight, feed intake and weight gain with increase of SFM levels with or without enzyme.

These negligible results might be due to the high fiber content of SFM, its deficient in lysine and low content of vitamins. These results were in line with the findings of Quguz and Quguz, (2007) and Mandal et al., (2003), who added undecorticated SFM in different levels replacing part of soybean meal in broiler diet reported no significant effect in body weight gain and feed intake.

Results obtained for dressing percentages, legs, neck, non-carcass components (liver, heart, gizzard …etc.), abdominal fat, commercial cuts and their meat/bone ratio was not affected significantly neither by the SFM levels nor enzyme supplementation. These results were in line with findings of Sarica et al., (2005) and Arabi (2006) who reported that these parameters did not affected by enzyme supplementation also results were in line with the results of Pinheiro et al., (2002) who no influence to SFM in carcass and cuts yield when fed broiler chicks on diet containing 4% SFM from 36-42 day of age.

Results obtained showed that meat yield and the average of subjective quality scores (color, flavor, tenderness and juiciness) were not affected significantly by dietary treatments, all being at moderate values. These results were agreed with the results of (Mukhtar et al., 2013a).

The apparent health of the experimental chicks was good throughout the experimental period and in all treatments. This might be due to that environmental temperature during the experimental period fell within thermo neutral zone, or due to good sanitation or that supplementation of diets with SFM did not affect on mortality rate, the result was agreed with findings of Quguz and Quguz, (2007) who reported that the pharmacological properties of sunflower seed have been explored to identify a role in cardiovascular health. Also Makkawi, (2009), Bin Baraik (2010) and Mariam, (2013) found lower mortality with the diets supplemented with enzyme.

The results showed that addition of SFM at different levels with or without enzyme supplement has no significance difference on blood parameters. These results were agreed with the results of (Nassiri 2012) in cholesterol and calcium and protein concentrate but he mentioned that glucose and phosphorus concentration linearly increased as the dietary SFM levels increased.

The results of economical evaluations of the experimented diets showed that the inclusion of SFM to broiler diets improved the performance of chicks and resulted in economical benefits. Profitability ratio (1.282) for 20% SFM supplemented with enzyme recorded the highest value, although, all chicks fed on different levels of SFM with and without enzyme recorded high ratio of profit compared to control groups. These results were in agreement with the result of Pinheiro et al., (2002), who found better economic performance when broilers fed 4% SFM from 36-42 day of age.

5.2. Conclusion:

- Inclusion of SFM at different levels (5, 10 and 20%) to broiler diets had no negative effects on chicks' performance.
- Inclusion of commercial 500 xylam enzyme on diets containing different levels of SFM numerically improved the chicks performance, with no significant on commercial cuts, non-carcass components or meat subjective and objective attributes.
- The inclusion of SFM at different levels with and without enzyme reported economical benefits compared to the negative control group.

5.3. Recommendations:

- SFM is recommended to replace vegetable protein sources (groundnut and sesame cake) in broiler diets up to 20% without any adverse affects.
- Exogenous enzyme supplementation is recommended in diets with high fiber content (SFM) to improve performance.
- To increase the cultivation area and industry of sunflower crop to be available for poultry feeds.
- Conduct further studies to investigate the top level of SFM inclusion in broiler diets without any adverse effects.

CHAPTER SIX

6.1. Reference:

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6.2. APPENDIX

Appendix (1)

Temperature during experimental period

Week	maximum	minimum	Average
1st week	31	11	21
2nd week	30	12	21
3rd week	33.5	16	25.8
4th week	29	17	23
5th week	26.5	16.5	21

Appendix (2)

Analysis of sunflower meal (as fed bases):

Sample number	***DM%***	***Fat %***	***C.P %***	***C.F %***	***Ash %***	***NFE***	***ME***
1	94.12	15.30	26.94	19.00	7.14	31.62	2.6479
2	94.13	15.40	26.95	19.02	7.15	31.48	2.6486
mean	94.125	15.35	26.945	19.01	7.145	31.55	2.64825

Values are means of 2 samples

Appendix (3)

Average feed intake per bird weekly

Treatment	1st week	2nd week	3rd week	4th week	5th week
Control (+)	485.4	602.1	941.7	1033.6	947.7
Control (-)	427.7	535.1	680.5	875.1	1250
SFC 5% (+)	497	575.7	763.5	985.2	1166.5
SFC5% (-)	494.9	636.2	786.2	992.7	1138.3
SFC 10% (+)	531.3	610.8	836.6	1116.6	1229.4
SFC10% (-)	583.7	606.1	820.7	1044.8	1222.8
SFC 20% (+)	520.9	656.8	861.5	1129.5	1337.8
SFC 20% (-)	542.7	651.6	884.3	1158	1212.3

Appendix (4)

Average Body weight weekly per bird

Treatment	Starter	1st week	2nd week	3rd week	4th week	5th week
Cont.(+)	195.5	429.3	737.7	1254	1759.2	2402.3
Cont.(-)	167.7	339.5	637.1	978.7	1422.5	2127.5
SFC 5% (+)	160	360.3	720.1	1187	1737	2350.3
SFC 5% (-)	170.1	367	745.3	1187	1755	2285.6
SFC 10% (+)	174.2	401.8	752.6	1166.2	1754.5	2308.6
SFC10% (-)	165.1	387	731.7	1158.2	1710.3	2304.1
SFC 20% (+)	173	398.2	785.1	1266.8	1929.9	2569.3
SFC 20% (-)	170.7	403.2	780.4	1279.1	1915.3	2464.8

Appendix (5)

Average weight gain per bird weekly

Treatment	1st week	2nd week	3rd week	4th week	5th week
Cont.(+)	234.8	347	477.7	505.2	643.1
Cont.(-)	171.8	297.6	341.6	443.9	707.9
SFC 5% (+)	199.6	359.9	467.4	549.6	613.1
SFC 5% (-)	196.9	378.3	441.8	538.2	530.4
SFC 10% (+)	227.6	350.8	467.9	613.7	584.3
SFC10% (-)	221.9	344.7	426	552.1	593.9
SFC 20% (+)	225.3	386.9	481.7	661.5	635.9
SFC 20% (-)	232.5	377.1	498.8	636.3	549.5

Appendix (6)

Average final body weight

Replicates / Treatment		1	2	3	Average
Cont. (+)	G1 G2 G3	2513.63	2438.25	2254.88	2402.25
Cont. (-)	A1 A2 A3	2231.88	2236.63	1913.88	2127.46
5% SFC (+)	E1 E2 E3	2283.38	2372.63	2394.75	2350.25
5% SFC (-)	B1 B2 B3	2293.5	2320.75	2242.63	2285.63
10% SFC (+)	F1 F2 F3	2463	2310	2482.43	2418.48
10% SFC (-)	C1 C2 C3	2120.63	2349.5	2442.38	2304.17
20% SFC (+)	H1 H2 H3	2827.38	2447.57	2417.75	2574.23
20% SFC (-)	D1 D2 D3	2275.5	2605.75	2513.25	2464.83

Appendix (7)

Price of experimental ingredients

Ingredients	***Kg***	***Price (SDG)***
Dura	90	245
Ground nut	80	180
Sesame cake	50	150
Concentrate	50	600
SFC	80	110
enzyme	1	50
Shell	50	18
Salt	1	1
Lys.	1	50
Methonine	1	50
V. oil	1	6

Appendix (8)

Card used for judgment of subjective meat quality attributes

SENSORY EVALUATION CARD

Evaluate this sample for color, flavor, juiciness and tenderness. For each sample, use the appropriate scale to show your attitude by checking at the point that best describes your feeling about the sample. If you have any question please ask. Thanks for your cooperation

Name: **Date:**

Tenderness	**Flavor**	**Color**	**Juiciness**
8- Extremely tender	8- Extremely intense	8- Extremely desirable	8- Extremely juicy
7- Very tender	7- Very intense	7- Very desirable	7- Very juicy
6- Moderately tender	6- Moderately intense	6- Moderately desirable	6- Moderately juicy
5- Slightly tender	5- Slightly intense	5- Slightly desirable	5- Slightly juicy
4- Slightly tough	4- Slightly bland	4- Slightly undesirable	4- Slightly dry
3- Moderately tough	3- Moderately bland	3- Moderately undesirable	3- Moderately dry
2- Very tough	2- Very bland	2- Very undesirable	2- Very dry
1- Extremely tough	1- Extremely bland	1- Extremely undesirable	1-Extremely dry

2- Panel Taste

Serial	Sample code	Tenderness	Flavor	Color	Juiciness	Comments
1						
2						
3						
4						
5						


H1
20%+ Enz.


GLOVE


0.057
MAX.weight:30kg
MIN.weight:200g
Graduation:10g


0.098
TOTAL ($)
MAX.weight:30kg
MIN.weight:200g
Graduation:10g


G1
Cont.+ Enz.
3.020
MAX weight:30kg
MIN weight:200g
Graduation:10g


H,
20%+ Enz.
3264