INFLUENCE OF TECTONA GRANDIS AND OXIDIZED OIL ON NUTRIENT DIGESTIBILITY IN WEANER RABBITS

BY

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CERTIFICATION

The is to certify that this project has been read and approved as meeting the requirement of the Department of Agricultural Technology, Institute of Applied Sciences, Kwara State Polytechnic, Ilorin for award of Higher National Diploma in Agricultural technology.

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DEDICATION

This project is dedicated to Almighty God who granted me the wisdom, moral knowledge and understanding and who had made it possible for me to embark on and complete this project work.

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I Thank Almighty God for sparing my life to this moment and for bestowing on me grace, all honour, praise and adoration to the Almighty God.

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Abstract

The experiment was carried out to determine the haematological parameters of weaned rabbit fed diet containing Tectona grandis and oxidized oil. Twenty four homogenous sex rabbit kits at four weeks old was randomly allocated to four dietary treatments D1, D2, D3 and D4, non-oxidized oil, oxidized oil, oxidized oil plus BHA and oxidized oil plus 10% TGLM respectively, replicated three times. The rabbit were fed and managed for eight weeks. The following digestibility parameter were measured; dry matter, crude protein, ether extract and crude fibre. The result shows that dry mater and ether extract were not affected (P>0.05) by dietary treatment while crude protein and crude fibre were better digested in diet 4: Feed containing 3% oxidized oil and 10% TGLM. Feed containing 3% oxidized oil and 10% TGLM had better crude protein digestibility and thereby recommended.

TABLE OF CONTENTS

CHAPTER ONE

1.0. INTRODUCTION

1.1. INTRODUCTION

The growth and productivity of weaner rabbit are heavily influenced by the quality and composition of their diets. During the early growth phase, rabbits experience significant physiological changes that increase their susceptibility to oxidative stress and digestive inefficiencies (Olukosi and Dono, 2019; Huang *et al.*, 2022).

This necessitate the exploration of feed additives that not only enhance nutrient utilization but also mitigate oxidative damage. Among such additives is plant based supplement and oxidized oil which has shown promising effects on improving animal health and performance (Ma *et al.*, 2021).

Oxidized oil which arise from lipid oxidation during processing or prolonged storage are often regarded as detrimental due to their potential to induce oxidative stress and impair metabolic functions (Chowdhury *et al.*, 2018). Oxidized oil containing reactive aldehydes and lipid peroxides that can disrupt cellular homeostasis when consumed in excess (Chowdhury *et al.*, 2018).

However, moderate inclusion of oxidized oil in the diet has been hypothesized to stimulate antioxidant defense systems, especially when combined with potent natural antioxidants (Chowdhury *et al.*, 2018).

Several plants have proven to have an antioxidant effect on growth performance of weaner rabbit by which the demand for antioxidants of plant origin capable of replacing synthetic antioxidants in feeds and foods has increased considerably in recent tears. Many herbs and spices contain active components capable of exerting antioxidant action such as phenolic substance (Flavonoids, Tannins, Phenolic Acids and phenolic determine) and vitamins E, C and A. These plants feed against oxidative deterioration during storage, and enhancing the oxidative stability of meat and meat products during storage or ripening for the latter purpose. Herbs and spices (oregano, rosemary, sage, thyme, cinnamon, mint, ginger, clove etc.) or their extracts (prepared from the plant material). Can be also directly added to the meat products during processing (Oke*et al.,* 2024).

Tectona grandis (Teak) is a tropical tree crop, commonly valued for its timber, but its value are rich source of bioactive compounds including tannins, flavonoids, terpenoids and phenolic acids. These compounds have well documented antioxidant, antimicrobial and anti-inflammatory properties making them valuable in modulating oxidative stress and improving gut health (Femi-Oloye*et al.,*2020).

Phytogenic additive such as Tectona grandis are increasingly recognized for their ability to enhance nutrient absorption by supporting enzymatic activities and improving intestinal morphology, which is crucial for weaner rabbits (Olukosi and Dono, 2019). Digestibility is a critical parameter for assessing the efficiency of feed utilization, malondialdehyde (MDA), superoxide dismutase (SOD), and glutathione peroxidase

(GPx) provide valuable insight into the physiological status of animals under dietary interventions (Huang *et al.,* 2022).

Butylated hydroxyl anisole (BHA) is a synthetic phenolic antioxidant, comprising two isomers: 85% of 2 tert-buty 1.4methoxyphenole and 15% of 3-fert-buty-4-methoxyphenole (Wu *et al.,* 2022) it is used mainly as a food preservative because of its chain breaking function in lipid peroxidation (Wu *et al.,* 2022). Animal studies demonstrated a wide range of biological behaviors towards this compound. Dietary administration of BHA was reported to protect rats against acute radiation exposed and multiple xenobiotic (Kahl, 1984). It was also reported to inhibit chemically induced tumor (Kahl, 1984). The defensive activities of BHA are attributed to its potential capacity to stimulate phase 2 detoxifying enzymes such as epoxide hydrolases, glutathione s-transferases, uredines 5 - diphosphos- glucuronosy transferases and quinone reducetase. It also modulates cytochrome - p450 mono oxygenase activity, which is involved in pathways of detoxification and carcinogenase. Antioxidant activities are usually associated with better metabolism and vital organs functionality, according to Wu *et al*. (2022).

1.2. Objectives

Main Objective

To evaluate the effects of Tectona grandis leaf meal and oxidized oil on the nutrient digestibility in weaner rabbits.

Specific Objectives

i. To determine the protein and crude fat digestibility of rabbit fed Tectona grandis leaf meal and oxidized oil.

ii. To evaluate the fibre and dry matter digestibility of rabbit fed Tectona grandis leaf meal and oxidized oil.

1.3. Justification

Over the years the performance of rabbits and other livestock spices have been faced with a challenges of feeding and feed availability, often use oxidized oil provide excellent source of energy but still exposed livestock to oxidative stress. The use of *Tectona grandis* leaf meal may serve as antioxidants to combat the effect of oxidized oil and the resulting oxidative stress and digestibility in weaner rabbits. Therefore, it is imperative to investigative whether *Tectona grandis* leaf meal can improve digestibility in weaner rabbit fed oxidized oil.

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1. Cooking oil

Cooking oils are an integral part of a human diet as they are used in almost all types of food preparations including frying, baking, sautéing, dressing, marinades and extrusion cooking. There are various types of cooking oils classified based on their different sources, examples include palm oil, arachis oil (peanut/groundnut oil), coconut oil, avocado oil, fish oil, flax oil, soybean oil, canola oil, sunflower oil, olive oil, corn oil, sesame oil and other vegetable oils. Cooking oils are an indispensable part of our daily diet because they serve as sources of lipid which is an important source of energy, a major part of biomembrane (Vaskova&Buckova, 2015) and serve as building blocks for several hormones. Furthermore, the nutritive value and health benefits of these oils are enormous and this can be attributed to their respective constituents such as fatty acid composition (the proportion of saturated to unsaturated fats; and monounsaturated to polyunsaturated fats) and types of natural antioxidants including vitamin A, vitamin E and carotenoids which protect cells and tissues from being damaged by free radicals. Cooking oils are either consumed fresh or thermally oxidized (Obohet al., 2014), but mostly thermally oxidized. Thermal oxidation occurs when the fresh form of cooking oils is heated at high temperatures during various food preparations to increase palatability (Obohet al., 2014). Thermal oxidation is a usual domestic practice in Africa (Obohet al., 2010) to improve organoleptic properties of food (Warner, 2004). This practice is not limited to various homes; it is also a regular practice in restaurants and commercial food industry where deep-fat frying and baking occur at very high temperatures. In the commercial food industry, reuse of cooking oils over a period of time is common in order to maximize profit. During cooking, various chemical reactions occur including thermal oxidation, due to oil exposure to high temperatures in the presence of air and moisture. Consequently, cooking oil disintegrates and generates volatile compounds; different monomers and polymers [Andrikopouloset al., 2002]. Some of the major factors that influence the value of cooking oil in the course of food preparations include temperature, heating period, oil type, level of saturation, and the presence of antioxidant [Gupta, 2005]

2.2. Oxidized oil

Global frying of food in heated oil/fat is a popular method of food preparation to develop desirable flavour, aroma, golden brown and crispy texture. The repeated heating, however, of oils and fats at deep frying temperature (150 to 190°C), particularly for extended period, predisposes the unsaturated fatty acids to thermal oxidation and polymerization leading to a partial transformation of unsaturated fatty acids into saturated and trans-fatty acid. As a result of oxidation, free radicals, peroxides and secondary oxidation products including ketones and aldehydes are formed (Treset al., 2013). Oils retrieved from frying industry can be a convenient energy source for animal feed (Treset al., 2013). Provision of feed, containing oxidized oil, to broilers and turkeys resulted in a decreased growth performance and feed efficiency (Engberget al., 1996; Jankowski et al., 2000) possibly due to a decreased feed intake because of off flavour, reduced palatability and digestibility of the feed. Oxidized fat in diets has a significant effect on the production of lipid rancidity in meat products that leads to an increased drip loss and a decrease in its shelf life (Delleset al., 2015). The contribution of oxidized fats to overall energy consumption has been distinctly expanded in developed countries mainly because of increased fast food consumption comprised of heated and processed dietary fats, including frying oil. The current review highlights the response of modern poultry to supplementation of oxidized oil on growth performance, nutrients digestibility, gut health, carcass characteristics, meat quality, blood chemistry and tissue oxidative status.

2.3. Lipid Oxidation

Lipid oxidation Lipid oxidation is a procedure where oxidants including free radicals or non-radical species invade lipids having carbon-carbon double bond(s) that involve hydrogen abstraction from a carbon with oxygen insertion, particularly in PUFAs, leading to production of *hydroperoxides* and lipid peroxyl radicals (Yin *et al.*, 2011). The process of lipid oxidation is divided into three phases including initiation, propagation and termination with each phase consuming and producing primary, secondary and tertiary complexes, respectively. Lipid oxidation consists of a chain reaction that yields and utilizes substances including peroxides, aldehydes and polar compounds by weakening the oil antioxidant capability. The level of oxidation varies and depends upon oil composition, temperature and extent of thermal processing. Since there is no single measure to evaluate the oxidation status of oil, it is biologically more descriptive to test different markers of oxidation. (Lindblomet al., 2019). Many peroxidation compounds including acids, aldehydes, and polymerized fatty acids formed during lipid peroxidation process can be assessed to evaluate the severity of lipid peroxidation (Kerr et al., 2015). The peroxide value (PV) measures primary products including lipid peroxides and hydroperoxides contents that are produced in the initiation phase. The PV is expressed as milliequivalents per kilogram (meq kg-1) and tends to be highest in the initiation phase and decreases in the propagation and termination phases (Shursonet al., 2015). The propagation phase produces secondary oxidation products including aldehydes, ketones and acids which are commonly estimated by thiobarbituric acid reactive substances and p-anisidine value. P-anisidine value measures the total molecular weight of saturated and unsaturated aldehydes. Thiobarbituric acid reactive substances are indirect measure of malondialdehyde, formed in lipid peroxidation, whereas there are other aldehydes contributing to the thiobarbituric acid reactive substances value not specific to lipid peroxidation (Kerr et al., 2015). The termination phase follows the propagation phase and is supposed to yield the most harmful products of lipid peroxidation relative to DNA, protein or lipid damage.

2.4. Influence of dietary oxidized oil in poultry

1. Effects on growth performance

Growth performance is measured in terms of feed intake (FI), body weight gain (BWG) and feed conversion ratio (FCR) and, in general, reflects the nutritional quality of the diet. Development of rancid odour and off flavour due to secondary oxidation products including aldehydes can influence palatability and feed intake in poultry. These oxidation products reduced fat retention to 1.4% and energy value of the diet by 1%, resulting in a lower BWG in broilers (Tavarezet al., 2011). Tavarez et al. (2011) performed a study to examine the influence of oil quality (PV: 180 meq kg–1 of oil) and antioxidant inclusion (blend of ethoxyquin and propyl gallate at two levels; 0 or 135 mg/kg) in broilers and observed that antioxidant supplemented diets increased FI by 2.4% and BWG by 4%, whereas FCR remained unaffected compared to the birds in control group (PV: 1 meq kg–1). Zhang et al. (2011) executed a trial to examine the effects of oxidized oil with and without supplementation of antioxidant on growth performance in broilers during 4 to 6 weeks of age and found no significant effects in broilers fed control diet (5% fresh vegetable or animal fat), diet with oxidized fats (5% fresh vegetable or animal fat, PV: 100 meq kg–1) and diet containing oxidized fat supplemented with antioxidants (5% fresh vegetable or animal fat, 200 ppm BHA, 500 IU vitamin E). Tan et al. (2018 a), similarly, offered diets containing 4% fresh (PV: 20 meq kg–1), mildly oxidized (PV: 140 meq kg–1), moderately oxidized (PV: 183 meq kg–1) and highly oxidized (PV: 277 meq kg–1) fish oil to broilers during 1 to 21 days to evaluate their effects on growth performance.

2. Effects on nutrients digestibility

Acikgoz et al. (2011) investigated the nutrients digestibility in broilers by supplementing the oxidized (PV: 148 meq kg–1) oil with or without vitamin E and did not observe any significant effect on digestibility coefficients of crude protein and fat in male broilers during the grower phase (22–42 days). The apparent crude-fat digestibility was, however, decreased from 95% (fresh fish oil) to 91% (PV: 200 meq kg–1) and 74% (PV: 400 meq kg–1) in mink (Borstinget al., 1996). Borsting et al. (1996) executed a study to examine the digestibility response of broilers fed oxidized oil based diets (PV: 156 meq kg–1) and reported no significant difference in the retention of DM and nitrogen, whereas about 1.6% reduction in energy and fat retention was observed compared with the birds fed fresh oil based diets.

3. Effects on gut health

Gastrointestinal tract is an organ system that mediates uptake of nutrients. Healthy gut is, therefore, the foundation for optimum performance of the birds. Gut health includes effective digestion and absorption of nutrients and operative immune response. Intestinal villi is a basic site for the nutrients absorption and its surface area mainly controls absorption efficiency of nutrients. High digestive and absorptive functions of the intestine is directly related to increased villus height and surface area of intestine (Da Rocha et al., 2012). Da Rocha et al. (2012) conducted a study on turkeys to evaluate gut health in response to feeding of oxidized soybean oil (PV: 250 meq kg–1). The study showed that birds fed diets containing oxidized soybean oil had 14% decrease in villus height, which the authors related to the effects of primary and secondary oxidation products on intestinal epithelium. Some of the oxidation products including aldehydes, acids, ketones and esters were assumed to have deleterious effects that led to destruction of the brush border membrane (Kimura et al., 1984).

4. Effects on carcass characteristics and meat quality

Heating of oil may lead to decreased capability of the broilers to metabolize and utilize energy as a result of increased primary, secondary and tertiary oxidation products that may enhance the oxidative stress in the birds (Ehret al., 2015). Ehr et al. (2015) concluded that the oxidative products destroy the fat-soluble vitamins (A, D, E and K) and reported 25% decreased concentration of α-tocopherol in white and dark muscles of broilers fed diets supplemented with 5.5% thermally oxidized (PV: 400 meq kg–1) sunflower oil compared with birds fed fresh (PV: 1 meq kg–1) oil based diets. This reduced concentration of α-tocopherol may be due to the damage of some α-tocopherol contents in the diets by the dietary oxidized oil before offered to the broilers. A part of the α-tocopherol present in tissue may protect the tissue lipids from oxidation. Engberg et al. (1996) examined the effects of oxidized oil (PV: 156 meq kg–1) based diets on tocopherol (vitamin E) levels and observed reduced concentrations of α and γ-tocopherol in all tissues of broilers. Zdunczyk et al. (2002) documented that inclusion of oxidized fat (PV: 150 meq kg–1) in turkey's diets caused 48.9% reduction in tocopherol concentration in hepatic cells. Jensen et al. (1997) performed an experiment to evaluate the effects of oxidized oil (PV: 156 meq kg–1) on meat quality and observed 41.7% reduction of α-tocopherol level in breast muscles and 47.6% reduction in thigh muscles. The study also reported that the concentration of α-tocopherol in muscles was 50% lower on a weight-to-weight basis in breast muscles compared to thigh muscles, regardless of the feeding regime.

5. Effects on blood chemistry and tissue oxidative status

The influence of dietary oxidized oil on biochemical indices in the blood of poultry is presented in Table 4. Blood chemistry is a biochemical profile that is a reliable indicator of health and provides valuable information for evaluation of health status (Abdi-Hachesooet al., 2011). Jankowski et al. (2000) evaluated the influence of fat (combination of rapeseed oil and poultry fat) with varied degrees of oxidation (PV: 50, 100 and 150 meq kg-1) on tocopherol as well as retinol concentrations in turkeys and reported that oxidized fat (PV: 150 meq kg-1) caused 29.7% reduction in tocopherol and 2.8% reduction in retinol concentration in serum compared to control group (PV: <5 meq kg–1). Engberg et al. (1996) studied the effects of oxidized vegetable oils (PV: 156 meq kg-1) with 11% inclusion level (9% rapeseed and 2% soybean oils) on tocopherol and retinol concentrations in broilers. The study reported a 6% lower concentration of α-tocopherol in blood plasma of the birds compared with the fresh oil (PV: 1 meq kg–1), whereas the levels of γ-tocopherol and retinol in blood plasma were not affected. Tavarez et al. (2011) conducted an experiment to evaluate tocopherol level in serum of broilers fed oxidized oil (PV: 180 meq kg–1) based diets and found 58.5% lower tocopherol concentration compared to control group (PV: 1 meq kg–1).

2.5. *TECTONA GRANDIS Linn*

2.5.1. Morphology

Teak is a large tree, which can attain a height more than 30 m. It has a simple root system. Colour of the bark varies from pale brown to grey. Leaves have some distinct features by which it can easily be identified. It bears a pair of leaves that stands at right angle to the next upper or lower pair and in each pairs; two leaves are situated at a node on the opposite side. Young leaves are red in colour but become dark green at maturity. Leaves are broad towards apex, oval in outline, widest at the centre and bear small star shaped hairs. Inflorescence large, flowers are white in colour and become inflated at maturity. Fruit is fleshy and bears 1-4 seeds which are enclosed in a stony covering. Teak sheds leaves from November to January. The flowers appear from June to September and fruits ripen from November to January (ICFRE.2009).

2.5.2. Taxonomy of*T. grandis* Linn

Kingdom	Plantae
Super division	Angiosperms
Division	Eudicots
Class	Asterids
Order	Lamiales
Family	Verbenaceae

Genus	*Tectona*	
Species	Grandis	(ICFRE.2009).

2.5.3. Utilization

Teak is recognized as the best timber for the manufacture of door, window frames and shutters, wagon and carriage, furniture, cabinets, ships, agricultural implements, decorative flooring and wall paneling because of its moderate weight, appropriate strength, dimensional stability and durability, easy workability and finishing qualities and most appealing grain, texture, colour and figure (ICFRE, 2009).

Teak is also used in a variety of ways apart from its use as timber. Various parts of the tree, including the wood are credited with medicinal properties. Kernels yield fatty oil (about 2 per cent). Flowers are considered useful against a number of diseases such as biliousness, bronchitis and urinary discharges. Both flowers and seeds are considered diuretic. Leaves are used in indigenous medicine and their extract indicates complete inhibition of Mycobacterium tuberculosis. The leaves also contain yellow and red dyes, which have been recommended for dyeing of silk, wool and cotton. The leaves are occasionally used as plates for dining purposes, for making cheap umbrellas and for thatching temporary huts in some places. The bark is regarded as an astringent and considered useful in bronchitis. Various valuable compounds have been isolated and identified from the wood, bark, root and leaves of the tree. Activated charcoal can be prepared from its saw dust (ICFRE, 2009).

2.5.4. Distribution

Natural distribution of teak ranges from the Indian sub-continent through Myanmar and Thailand. It is common in deciduous forests and well-drained alluvial soils. India has one-third of the natural distribution. It is discontinuously distributed throughout Peninsular India below the latitude of 24°N, in the states of Madhya Pradesh, Maharashtra, Tamilnadu, Karnataka and Kerala. In Myanmar, the species is distributed throughout the country up to latitude 25°N. In Thailand, it occurs naturally up to 17.5°N and from 97° to 101°E in the watershed areas of Mae Khong, Salween and Chao Phya rivers. Teak has been introduced as a plantation species in as many as 36 tropical countries across tropical Asia, Africa and South and Central America (Indira and Mohanadas, 2002).

2.5.5. Use in Traditional Medicines

Apart from its wide spread application as timber plant, teak is also considered as a major constituent in many traditional medicines. The extracts prepared from various parts of teak are found to be effective against biliousness, bronchitis, diabetes, leprosy, anthelmintic etc. and thus shows expectorant, anti-inflammatory, anthelmintic properties. The plant extracts are also well known for analgesic, diuretic activity, gastroprotective activity, anti-haemolytic anaemia activity, Hair growth activity, Antioxidant activity etc. They are also used for treating inflammatory swelling (Neamatallah*et al.,* 2005).

2.6. PHYTOCHEMICAL CONSTITUENTS OF *Tectona grandis*

Several classes of phytochemicals like alkaloids, glycosides, saponins, steroids, flavonoids, proteins and carbohydrates have been reported in *Tectona grandis* (Rodney *et al.,* 2012).Secondary metabolites such as tectoquinone, 5-hydroxylapachol, tectol, betulinic acid, betulinic aldehyde, squalene, lapachol were also extracted from the plant (Rodney *et al.,* 2012). Acetovanillone, E-isofuraldehyde, Evofolin, syringaresinol, medioresinol, balaphonin, lariciresinol, zhebeiresinol, 1- hydroxypinoresinol together with two new compounds Tectonoelin A and Tectonoelin B were extracted from the leaves of *Tectonagrandis.* 9,10 dimethoxy-2 methyl-anthra-1,4-quinone ,5-Hydroxylapachol along with tecomaquinone,methylquinizarin, lapachol, dehydroxy-α-lapachone were isolated from the heartwood of *Tectonagrandis* (Rodney *et al.,* 2012). Teak wood contains naphthoquinone (lapachol, deoxylapachol, 5-hydroxylapachol), naphthoquinone derivatives (α- dehydrolapachone, β-dehydrolapachone, tectol, dehydrotectol), anthraquinones (tectoquinone,1-hydroxy-2-methylanthraquinone, 2-methyl quinizarin, pachybasin), and also obtusifolin, betulinic acid, trichione, β-sitosterol and sqaulene.Roots are rich in lapachol,tectol, tectoquinone, β-sitosterol, and diterpenes, tectograndinol (Goswami*et al.,* 2009).

2.6.1. Pharmacological activities of *Tectona grandis*

Teak is considered as one of the major constituent in folklore medicines. Medicinally, it has various pharmacological activities like antibacterial, antioxidant, antifungal, anti-inflammatory, anti-pyretic, analgesic, anti-diuretic and hypoglycemic activities (Neha and Sangeeta, 2013).

Traditionally; **the bark**: is used as astringent, constipation, anthelmintic and depurative, also used in bronchitis, hyperacidity, dysentery, verminosis, burning sensation, diabetes, difficult labour, leprosy and skin diseases.**The leaves**: are used in haemostatic, depurative, anti-inflammatory and vulnerary. They are useful in inflammations, leprosy, skin diseases, pruritus, stomatitis, indolent ulcers, haemorrhages and haemoptysis.**The wood**: is used as Acrid, cooling, laxative, sedative to gravid uterus, useful in treatment of piles, leucoderma and dysentery. Oil extracted from the wood is best for headache, biliousness, burning pains particularly over a region of liver (Rodney *et al.*, 2012).**The roots**: are useful in anuria and retention of urine (Rodney *et al.,* 2012). While **the flowers**: are acrid, bitter dry and cures bronchitis, biliousness, urinary discharge (Varier, 1996). According to Unani system of medicine, oil extracted from the flowers is useful in scabies, and promotes the hair growth (Ragasa*et al.*, 2008).

- **Antibacterial activity**

Antibacterial activity of *T. grandis* bark extracts towards *S. aureus* and other bacterial strains was reported by Rafullah and Suleiman (1999). The leaf extracts of *Tectona grandis* was found to contain two quinones: naphthotectone and anthratectone that were mainly responsible for the antibacterial activity and good antiradical properties (Neamatallah*et al.,* 2005). The other active ingredient that contribute to antibacterial activity was found to be 5-hydroxy-1,4- naphthalenedione (Juglone). Mahesh and Jayakumaran (2010), showed the antibacterial activity of leaf, bark and wood extracts of *T. grandis* against *Staphylococcus aureus* (ATCC 25923), *Klebsiellapneumoniae*(ATCC 700603), hospital strains of *Salmonella paratyphi*and *Proteus mirabilis* by disc diffusion assay. They also found that methanol extract of leaf and ethyl acetate extract of wood was also able to show fairly good activity against gram positive and negative species. Teak extract present good antibacterial activity against both Gram positive (*S. aureus, B. subtilis)* and Gram-negative (*P. aeruginosa)* bacteria.

- **Antifungal activity**

The available literature reveals that tectoquinone and anthraquinone from teak sawdust, possess antifungal activity. Other phytochemicals reported from teak viz., juglone, lapachol and deoxylapachol (Naphthoquinones) also possess antimicrobial activity (Sumthong*et al.*, 2006).

The leaf and bark extracts of *Tectona grandis* prepared in solvents (ethanol, methanol, ethyl acetate and water) were tested for the antifungal activity against test fungi. The antifungal activity of the extract was assessed by the presence or absence of zone of inhibition which shows a clear zone of inhibition measured (in mm) around the discs. Antifungal and antibacterial activity of wood and bark of teak has been reported earlier by Sumthong*et al*. (2006).

Suseela and Parimala (2017)reported that both leaf and bark extracts of *Tectona grandis* prepared using ethanol, methanol, ethyl acetate and water were found to be efficient in inhibiting the growth of pathogenic bacteria and fungi. Among different extracts prepared using leaf and bark of teak plants, ethanolic extracts showed significant antibacterial and antifungal activity.

- **Antioxidant activity**

Sumthong*et al*. (2006) examined the antioxidant activity of *T. grandis* Linn. Leaf extracts employing four *in vitro* assay systems, i.e., Total phenolic content, reducing power, Super oxide radical scavenging activity, Inhibition of H_2O_2 induced erythrocyte haemolysis method, in order to understand the usefulness of this plant as a foodstuff as well as in medicine. The plant extracts of 17 commonly used Indian medicinal plants were examined for their possible regulatory effect on nitric oxide (NO) levels using sodium nitroprusside as an NO donor *in vitro*. *T. grandis* Linn shows potential scavenging activity among all other plant extracts. Antioxidant activity of leaf, bark and wood of Hexane, chloroform, ethyl acetate and methanol extracts was checked with 1, 2-diphenyl 1-picryl hydrazil (DPPH) and ABTS+ free radical. Ethyl acetate extract of wood showed very high activity with 98.6 % inhibition against DPPH and ABTS+ free radicals (Sumthong*et al.*, 2006).

- **Anti-haemolytic anaemia activity**

Traditional oral report indicates that *T. grandis* Linn, is used in the treatment of anemia in Togo (Aboudoulatif*et al.*, 2008). The ethanol extract of leaves of *T. grandis* Linn was evaluated on anemia model of rat induced by intraperitoneal injection of phenylhydrazine at 40 mg/kg for 2 days. This anemia which resulted from the early lysis of the RBCS was naturally reversed 7 days later by the regeneration of these blood cells due to the increase of the reticulocytes. Oral administration of leaves ethanol extract of 1 mg/kg/day and 2 mg/kg/day, to the rats previously treated with phenylhydrazine, significant increased the concentration of Hb, RBCs number, haematocrit and reticulocytes rate mainly 7 days after phenylhydrazine administration. So the study suggested that, the extract could stimulate erythropoiesis process and which may increase the number of young RBCs (reticulocytes) (Aboudoulatif*et al.*, 2008).

- **Anti-inflammatory Activity**

Denaturation of proteins is a well-documented cause of inflammation. As part of the investigation on the mechanism of the anti-inflammation activity, ability of different solvent plant extract protein denaturation was studied. It was effective in inhibiting heat induced albumin denaturation. Maximum inhibition 89.61% was observed from methanol extract followed byethanol 86.81% and water 51.14%. All the solvent extracts inhibited the albumin denaturation, the methanol extract stood first compared to ethanol and water extracts. Aspirin, a standard anti-inflammation drug showed the maximum inhibition 75.89% at the concentration of 200μg/ml (Shruthi*et al.,* 2012).

- **Anti-ulcer Activity**

Lapachol, a naphthaquinone isolated from the roots of *Tectona grandis* given at a dose of 5 mg/ kg twice daily for 3 days was foundto have an anti-ulcerogenic effect on subsequently induced experimental gastric and duodenal ulcers in rats and guinea-pigs. Its action appears to be associated with an effect on the protein content of gastric juice, and it reversed aspirin-induced changes in peptic activity, protein and sialic acid (Shruthi*et al.*, 2012).

2.6. RABBIT PRODUCTION

Rabbits (*Oryctolaguscuniculus*) are small herbivorous mammals widely used in research, as pets, and for meat and fur production. Their efficient feed conversion, high reproductive rates, and adaptability make them an excellent model for studying dietary interventions and nutritional strategies. The increasing competition between rabbit for available gains and feed coupled with Nigeria's neglect of Agriculture, has led to high cost of available feed resources.

Rabbit meat is lean meat of high nutritive value, because it is rich in essential amino acids, polyunsaturated fatty acids (PUFA), vitamins, minerals, low in cholesterol contents, and does not contain uric acid compared with other meats. The profitability of rabbit farms is partly depending on the effectiveness of weaned rabbits to grow healthy and to protect them from high mortality rates during the fattening period. Antibiotics are frequently used in the diets of growing rabbits because digestive disturbances are the main reason for morbidity and mortality in the rabbit industry.

The aim of livestock farmer is to produce the animal protein in the shortest possible time to meet the demand for animal protein. To achieve this aim, the use of antibiotic growth promoter in livestock production to promote growth by enhancing feed utilization and inhibition of pathogens activities are being considered by the farmers. However, the awareness of possible microbial resistances in farm animals and the eventual antibiotic residue in animal products later formed a major discouragement for the use of antibiotic growth promoter for animal production (Ayodele, 2016). This thereafter fuelled the search for and the use of the alternative to antibiotic growth promoters or complementary medicines to enhance performance, immunomodulation, and general health maintenance in animal production. Herbs of medicinal values are currently in increasing demand as they are being found suitable for the animal with the benefits of low cost and total safety. Medicinal plant parts, when incorporated in the rabbit diets, could serve as protein source suitable for replacing in full or part the conventional and expensive protein feedstuff and also as a phytobiotic growth promoter (Oloruntola*et al*. 2016). Herbs in monogastric diets are known for impacting the metabolism by combating microbial activities and stress (Dhama*et al*. 2015) through the prevention of pathogens colonization and enhancement of the digestive enzymes production and activities by the phytogenic components of the plants' parts (Dhama*et al*. 2015). Numerous plants possess anti-microbial traits which are synthesized during secondary metabolism of the plant (Ayodele, 2016).

2.6.1 Importance of Rabbits in Livestock Production

- Meat Production: Rabbit meat is a lean, high-protein source with low cholesterol levels, making itidealforhealth-consciousconsumers.

- ReproductiveEfficiency:Rabbitshaveshortgestationperiods(28–31days),highlitter sizes,and theabilitytobreedthroughouttheyear,ensuringsteadyproduction.
- Adaptability:Rabbitscanthriveindiverseenvironmentsandutilizeforages,agricultural by-products, andunconventionalfeedresourcessuchasleaves.

2.6.2. Rabbit Nutrition

Rabbits feed on fresh and dry legumes and grasses, and occasionally on roots and tubers, straw and stem. They are one of the few animals that do not compete with humans for available limited conventional feed. Unlike the poultry farmer, the small-scale rabbit fanner should not face problems with food supplies at any time of the year. Even when the grasses have withered, the leaves from tall trees and shrubs are available for food. However, care must be taken as to what is given to young rabbits and pregnant and nursing does, as they are particularly sensitive to some plants (Fawzia *et al.,* 2020).

Rabbit have the ability to utilize forages and fibrous agricultural by-products are attributes in favor of rabbit production. Though there are two types of nutrition programs are used for raising rabbits: hay and grain diets or commercial balanced pellet rations. Pellets meet all of a rabbit's nutritional requirements and are more convenient than formulating a hay and grain ration. Pregnant does and those with litters should fed ad-libitum. Bucks and does without litters need 6 to 8 ounces of pellets a day. When raising Angora rabbits, you should avoid feeding hay because the dust will contaminate the wool and lower its quality. Rabbits require fresh, clean water every day (Iyeghe-Erakpotobor*et al.,* 2002). Automatic watering systems offer a continuous water supply while reducing waste and contamination. A doe and her litter need 1 gallon of water a day in warm weather. Rabbits also enjoy receiving small amounts of greens as a treat. In spite of these apparent advantages, rabbit production has not yet achieved its potential in the tropics. Productivity is 50% or less of what is typical in temperate areas (a characteristic not unique to rabbits). While heat stress is a major factor accounting for the low productivity, inadequate nutrition is also very important. The limiting nutritional factor is probably digestible energy. Feeding programs that incorporate cull bananas, plantains, cassava, and various tropical fruits, sugar cane products, and agricultural byproducts such as rice bran and other grain-milling by-products, should be developed. These materials are excellent sources of digestible energy, and can be used to supplement legume forages (e.g. tree legumes) which are good sources of protein (Shi-yi*et al.,* 2019).

Rabbit have been reported to perform better on different feed ration ranging from fodder, forage, grains and forage combination and compounded feed (Heba*et al.,* 2021). Heba*et al*. (2021) reported that while digestibility of protein, fibre and energy of tropical grasses is very low in rabbits, many of the tropical legumes are as digestible as temperate forages. High digestibility of dry matter, crude protein, crude fibre and nitrogen free extract was reported by Iyeghe-Erakpotobor**,** (2006) indicating that the rabbits were able to utilize nutrients in the high forage and low concentrate combinations. Iyeghe-Erakpotobor**,** (2006) reported that combinations of concentrate, grass and forage would be adequate for grower rabbits. Though soybean forage treatments gave the lowest rate of gain, the difference was not significant. In the rural areas where soybean cheese waste meal, groundnut haulms, sweet potato vines and soybean forage are available, these could be efficiently utilized for feeding grower rabbits.

In general, rabbits will eat about 80 percent of available plants. However, they have their favourites, including the leaves below the crown of cabbages (*Brassica aleracea*), groundnut leaves, juice plant (*Euphorbia heterophylla*), *Centrosemapubescens*and wild marigold (M*elantherascandens*). They eat all types of grass. Although freshly cut and dried greens, together with food waste from the house, are suitable for small-scale enterprises (FAO, 2005). Fortunately, the availability of pellets in West Africa has increase the development of rabbit farming on a commercial scale. It is possible, however, for rabbit farmers to mix their own feeds which will meet the requirements of a balanced diet and ensure fast growth, good milk production and good health. Although the rabbit is regarded as herbivorous animal, many rabbit farmers feed their animals with poultry feed, which often contains dried fish. Rabbits will consume dried but not fresh fish (De-Blas and Mateos, 2010).

CHAPTER THREE

3.0. MATERIALS AND METHODS

3.1. Study Area

The experiment was carried out at the Department of Agricultural Technology Garden, Institute of Applied Sciences, Kwara State Polytechnic, Ilorin, Kwara State.

3.2. Construction of rabbit hutch

Four tiers rabbit hutch with four units per tier was constructed using galvanized iron mesh, the hutch was housed in a pen well ventilated and conducive for rabbit rearing.

3.3. Sample collection and processing

Tectona grandis*:* - *Tectona grandis* leaf was harvested from Kwara State Polytechnic School Farm. The leaves was identified at the Department of Biology, Kwara State Polytechnic,Ilorin, Nigeria. The leaves were air-dried at 35±2^{0}C for 4 days and milled using locally fabricated attrition milling machine into semi-powder to pass through a 3.0 mm sieve. The ***Tectona grandis* leaf meal** (TGML) was packaged in polythene plastic bags, sealed, and kept at 34±3 ^{0}C for further use.

Rabbits*:* - - rabbit kittens to be used for the experiment was purchased form a reputable rabbit farm within Ilorin, the pureness of the breed was ascertained at Botany Unit University of Ilorin, Ilorin, Kwara State, Nigeria.

Preparation of Oxidize oil

Soya bean oil was obtained from a reputable groceries store. Soybean oil was heated at 180^{0}C for 10 min stir in the open with access to air. The oil was heated five times with cooling interval of 5 h per heating as described by Jaarin and Kamisal (2012) and Leong *et al*. (2012).

3.4. Experimental design

Twenty four homogenous sex rabbit kits at four weeks old was randomly allocated to four dietary treatments D1, D2, D3 and D4 as highlighted below, with four replicates and 2 rabbit kits per replicate, the distribution was in such a way that each group was homogenous in weight. Diet D2, D3 and D4 was supplemented with oxidize oil at 3.0%.

D1……… Treatment one (Control diet + normal oil)

D2………Treatment two (Control diet + oxidized oil).

D3.. Treatment three (Control diet + oxidized oil + Butylated hydroxyl anisole (BHA).

D4……… Treatment four (best diet with TGLM + oxidized oil).

3.5. Animal feeding and management

The homogeneous sex kits rabbits at 6 weeks of age was purchased from reputable rabbit farm in Ilorin, was acclimatized for two weeks while feeding them on control diet with 0% TGLM (Table 1 experiment 2) before randomly assigning them to treatments. The kits was fed on experimental diets *ad-libitum* with adequate supply of cool clean water.

The rabbit was given adequate management. The pen was kept clean and other precautions taken into consideration as the need may require.

3.6. Experimental diets

Table 3: - Ingredient and calculated chemical composition of experimental diets

Ingredient	TGLM %replacement for wheat offal			
	TGML 0% +3% N.O	TGML 0% +3% O.O	TGML 0% + BHA 150g/kg + 3% O.O	TGML10% + 3% O.O
Maize	16	16	16	16
Corn bran	10	10	10	10
Wheat offal	30	30	30	20
TGLM	0	0	0	10
Palm kernel cake	30	30	30	30
Groundnut cake	5	5	5	5
Bone meal	5	5	5	5
Salt	0.25	0.25	0.25	0.25
Vit./Min. Premixes	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Oil	3 N. O.	3 O.O	3 O.O.+BHA	3 O.O

Total	100kg	100kg	100kg	100kg

TGML. *Tectona grandis* leaf meal

N.O. Normal Oil

O.O. Oxidized Oil

BHA. Butylated hydroxyl anisole

Calculated Nutritional Value				
Digestible Energy (Kcal/kg)	2364.98	2364.98	2364.98	2390.15
Crude protein (%)	15.19	15.19	15.19	15.04
Crude fat (%)	5.12	5.12	5.12	4.90
Ash (%)	3.85	3.85	3.85	3.80
Crude fibre (%)	7.65	7.65	7.65	7.40
Calcium (%)	1.71	1.71	1.71	1.71
Phosphorus (%)	1.12	1.12	1.12	1.12

3.7. Experimentation

The following parameters was analyzed and data was collected

Digestibility trial

One rabbit from each of the replicate group was used for the trial to make three rabbits per treatment. The rabbits were transferred to a metabolism cage adapted from a layer cage and one rabbit constituted a replicate for the digestibility trial. They were allowed to get used to the cages for a period of 3 days during which they was fed the experimental diets. They was fasted for a period of 24 hours to ensure total elimination of the GIT content and then fed for a period of four days.

A faecal sample was collected for 5 days, including the fasted day to ensure total collection of the faeces. Polythene sheets was spread under the cages to collect rabbit faeces. The daily collections was dried in an oven at 60 ^{0}C and analyzed for proximate composition as described by AOAC (2005).

3.8. Statistical Analysis

All data generated was subjected to analysis of variance (ANOVA) in a completely randomized design (CRD) using SAS, (2005). The statistical significance was considered at P<0.05, data was subjected to a repeated measured analysis.

CHAPTER FOUR

4.0. RESULT AND DISCUSSION

4.1. RESULT

Table 4Nutrient digestibility of rabbits fed diet supplemented with oxidized oil and with or without 10% TGLM

Item (%)	TGML 0% +3% N.O	TGML 0% +3% O.O	TGML 0% + BHA 150mg/kg + 3% O.O	TGML10% + 3% O.O	SEM	*P*value
Dry matter	39.63	39.68	39.87	39.77	0.34	0.073
Crude protein	56.66^{a}	46.41^{b}	53.03^{a}	54.42^{a}	0.12	<0.001
Ether extract	59.77	60.28	60.48	58.19	0.83	0.055
Crude fiber	31.90^{c}	34.58^{a}	33.44^{b}	33.40^{b}	0.36	0.004

$^{a, b, c}$ Means in a row with no common superscript differ significantly (P< 0.05). Values are means of three replicates.

Nutrient digestibility

Dry matter (DM) and ether extract (EE) digestibility (table 4) were not significantly affected by the dietary treatment (P > 0.05). While the crude protein (CP) and crude fibre (CF) were significantly ($P < 0.05$) affected by the dietary treatment. Crude protein digestibility was high (P < 0.05) in TGML 0%+3% N.O, TGML 0%+ BHA 150mg/kg + 3% O.O and TGML10% + 3% O.O, protein was poorly digested in TGML 0%+3% O.O.

Crude fibre was better digested ($P < 0.05$) in TGML 0%+3% O.O diet with oxidized oil alone, compared to other treatment diets.

4.2. DISCUSSION

The dry matter and ether extract digestibility were unaffected while protein digestibility was favoured by feeding 10% TGML and oxidized oil. This revealed that the TGML was able to mitigate the oxidative effect of the oil fed to the rabbit. Syed *et al.* (2022); Mei *et al.*, (2023); Mosad*et al.*, (2024) reported that *T. grandis* leaf and it extracts possess a powerful antioxidant and cytotoxic activities, having the potential to suppress the activities of free radical. Thousands of diverse natural products are produced by plants and many of these are involved in plant defense (Pooja*et al.*, 2021). Mosad*et al*. (2024) report phenolic compounds containing free hydrogen are largely responsible for antioxidant activity in *T. grandis* leaf. Thus contributing to the growth performance of rabbit fed 10% TGML and oxidized oil in this study. He also reported significant correlation between total phenolic content and the DPPH antioxidant activity of the defatted 90% methanolic extract of TGML as well as its derived fractions. This might confer on *T. grandis* the ability to impact positively on rabbit performance.

CHAPTER FIVE

5.0. CONCLUSION AND RECOMMENDATION

5.1. CONCLUTION

The result of the study revealed that crude protein (CP) and crude fibre (CF) were affected by the dietary treatment while dry matter and ether extract were not affected by dietary treatment. Crude protein was better digested in TGML10% + 3% O.O while poorly digested in TGML 0%+3% O.O.

5.2. RECOMMENDATION

Among the digestibility parameter measured dry matter and ether extract were not affected, but crude protein was better digested in rabbit fed diet 4 TGML10% + 3% O.O and therefore recommended.

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