Influence of Cooking Methods on Nutritional Quality of Rabbit Meat Sausage Fed *Tectona Grandis* Leaf Meat and Oxidized Oil

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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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Abstract

The experiment was carried out to determine the Influence of Cooking Methods on Nutritional Quality of Rabbit Meat Fed Tectona Grandis Leaf Meat 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 rabbits were slaughtered conventionally and meat excised within one hour post mortem, processed into sausage and subjected to oven cooking, smoking and sus vide cooking methods. the proximate composition of the sausage was determined. The dry matter, fat and ash content were not significantly (P>0.05) affected while moisture content, crude protein, fibre and NFE content were significantly (P<0.05) higher in smoke rabbit meat sausage. Smoking impacted positively on the nutritional composition of the rabbit meat sausage and improved the nutritional qualities.

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CHAPTER ONE
1.0.INTRODUCTION
1.1. INTRODUCTION
Rabbit has been identified as an animal with enormous potential because of its unique attributes such as high prolificacy, rapid growth rate, small body size, short generation interval, and encouraging forage utilizing ability (Egbo *et al*., 2021). This has caused the increase in growth of rabbit industries in many African countries, and subsequently, the feeding challenges being faced by the rabbit's breeders. This created the need for a search for alternative feed resources that support the normal health and enhances the performance of the rabbits. 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 (Ayyat *et al*., 2021).

In commercial farms, growing rabbits are usually fed ad-libitum. After weaning in rabbit, the early-life fast growth rate is accompanied by high feed intake, leading to high cost of production. Scarcity of feed resource has been the main limiting factors in the production of livestock products to meet the animal protein requirements of human and other industrial needs which has been identified to affect rabbit production (Ayodeji, 2015).

Conventional feed stuffs used in compounding feeds for domesticated animals are scarce and costly due to completion between livestock and human, coupled with global warming, humans and animals like rabbits, pigs and poultry compete for the limited and scarce ingredients. This has resulted into increasing cost of production which makes animal protein less affordable to most developing countries. To mitigate against the increasing feed cost, there is the need for the integration of some non-conventional feed sources which has no direct human feed value into livestock production (Netra, 2020).

Most green forages used in rabbit feeding are available in abundance only during the rainy season while little are available during the dry season in a quantity that cannot be fed as whole but used to supplement the limited conventional feed stuffs. Thus, there is need to source plant protein which will be available especially throughout the season, hence the focus on the *Tectona grandis* plant.

T. grandis Linn (Family-Verbenaceae) commonly called Teak is one of the most famous timbers in the world and is renowned for its dimensional stability, extreme durability and hardness (ICFRE, 2009). Teak is also used in a variety of ways, the woody part used 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 for dyeing of silk, wool and cotton. The leaf is used traditionally for medicinal purpose. The bark is regarded as an astringent and considered useful in bronchitis. Various valuable compounds have been isolated and identified from the stem, bark, root and leaves of the tree (Komarayati and Wibisono, 2020). Activated charcoal can be prepared from its saw dust (Indira and Mohanadas, 2002; ICFRE, 2009).

Traditionally, it is used against bronchitis, biliousness, hyperacidity, diabetes, leprosy, astringent, and helmintiasis (Varier, 1996). The wood powder paste has been used against bilious headache and swellings (Varier, 1996). Teak wood is acrid, cooling, laxative, sedative to gravid uterus and useful in treatment of piles, leucoderma and dysentery (Sumthong *et al*., 2006). Leaf extract are widely used in the folklore for the treatment of various kinds of wounds, especially burns (Sumthong *et al*., 2006). The plant various part has been reported to be used as bactericidal, the leaf, stem, seed and root have been documented to inhibit the growth of several fungi and bacteria (Neamatallah, 2005), as expectorant, anti-inflammatory and anthelmintic properties, antifungal activity (Suseela and Parimala, 2017), antioxidant activity **(**Sharma and Bhat 2009). Other scientific study shows the importance and the analysis of nutritional, phytochemical composition, *in vitro* antioxidant and antimicrobial properties of *T. grandis* by other authors (Suseela and Parimala, 2017).

Inclusion of oil in the diet of rabbit provide an important high energy density to increase the metabolizable energy of rabbit diets, though the high content of unsaturated fatty acids in vegetable oils makes them susceptible to oxidation with the generation of lipid peroxides if exposed to high temperature, especially when they are used in animal feeding in hot climates (Fangfang *et al.,* 2015). Liu *et al*. (2012) reported that animals consuming oxidized lipids suffer decreased feed utilization and performance, oxidative stress and tissue lipid oxidation and, adverse effects on redox indices and shelf life of meat (Fangfang *et al.,* 2015). This has also manifested reduced activities of antioxidant enzymes and elevated transcript levels of oxidative stress-responsive genes (Awada *et al.*, 2012).

Recently, some higher plants have been researched to contain phytochemicals and antioxidants which has the capacity to ameliorate oxidative effects of oxide oils (Fangfang *et al.,* 2015). *Tectona grandis* falls into the category of plant with dense phytochemicals effective as antioxidants and antimicrobials, and to improve animal performance and produced products safe for human health.

Studies have shown that adding plant and vegetables such tomatoes, cherry tissues, spice (garlic and onions), rich in antioxidants to meat before cooking, is effective to reduce the concentration of HAAs (Jinap *et al*., 2015). Research revealed the addition of natural products containing antioxidants may act as free radical scavengers, such as polyphenols from cherry, spices, natural extracts and fresh virgin olive oil has improved quality on cooked meat (Quelhas et al. 2010). *T. grandis* rich in antioxidants may serve an alternative to vegetables and spices to improve the quality in a heat processed rabbit meat.

During processing meat undergo weight loss, modification of water holding capacity, muscle fibre shrinkage, change in texture, colour changes and development of aroma (Wei *et al*., 2021). The changes in meat during processing are strongly dependent on water loss and protein denaturation, composition and characteristics of muscle, heating methods as well as temperature and time combination regime (Koszucka and Nowak, 2019; Faith and Eldos, 2015). This can lead to undesirable modification in meat such as decrease in nutritional qualities due to loss in vitamin, minerals, lipid oxidation as a result of change in fatty acids composition. The heating sequence of meat, consequently affects its physical and sensory properties of the final products (Wei *et al*., 2021).

1.2. Objectives

General objectives

To evaluate the influence of different cooking methods on nutritional composition rabbit meat sausage fed *T. grandis* leaf meal and oxidized oil diets.

Specific objectives

- To determine the effects of different cooking methods on the protein and ether extract composition of rabbit meat sausage made from rabbit fed *T. grandis* leaf meal and oxidized oil.
- To determine the effects of different cooking methods on ash and fibre content of rabbit meat sausage made from rabbit fed *T. grandis* leaf meal and oxidized oil.

1.3. Justification

In order to create wholesome and healthy meat products, there is need to reduce to the barest minimum the effect of oxidative stress on rabbit meat fed oxidized oil. Also to reduce the negative effects on meat during cooking. Due to the phytochemical contents and antioxidant properties of *T. grandis*, it dietary supplementation in rabbit meal could improve the physicochemical properties of rabbit meat processed using different cooking techniques, such as oven grilling, sous-vide, micro waving and smoking.

CHAPTER TWO

2.0.LITERATURE REVIEW

2.1. LIVESTOCK PRODUCTION

Livestock systems occupy about 30 percent of the planet's ice-free terrestrial surface area and are a significant global asset and plays a key role in global food system as one of the main sources of animal protein (milk, meat and egg), contribute to crop productivity through provision of draught power and manure, and to the livelihood in low and middle income countries (Robinson, 2011). The livestock sector is increasingly organized in long market chains that employ at least 1.3 billion people globally and directly support the livelihoods of about 600 million poor smallholder farmers in the developing world (Robinson, 2011).

Livestock are important in supporting the livelihoods of poor farmers, consumers, traders, and labourers throughout the developing world. The greatest impact of livestock in sustainable development is designed to help the poor in enhancement of livestock-production systems, during the past decade, it contributed to total Nigerian livestock cash income (Adams, 2016).

In Nigeria, presently, there has been incidence of extreme poverty and malnutrition in the country, livestock contribute directly to the economy through employment generation, increase in savings and investment, foreign exchange earnings, contribution to human food and nutrition. Livestock also contribute indirectly to food security by increasing crop output through providing manure, and serve as a buffer to mitigate the impact of fluctuations in crop production on the availability of food for human consumption, thereby, stabilizing food supply. Despite its smaller output compared with that of staple crops, productivity and income growth in the livestock sector have strong income multiplier and poverty reduction impacts (Adams, 2016).

2.2.1. Effects high cost of conventional feed and the need for exploring novel feedstuffs

Nutritious animal feeds are essential for full development and productivity of animals. Animal feeds are not readily available and where they are they are not easily affordable for an average farmer (Agboola and Balcilar, 2012). Since farmers go into animal production for profit they need to obtain feed at a price where they do not only break-even: but also make reasonable profit. Perhaps the livestock industry of ruminants does not feel the impact as much as the poultry industry which is mostly intensive in nature requiring constant supply of feeds for maximum productivity unlike the livestock which can still be fed on pastures and forage or allowed to scavenge for food. Due to the high cost of feeds, various research alternatives have sought for other means of providing animal feeds to ameliorate the effects of cost of feed such as the use of activated sludge (Ibitoye *et at*., 2010). Many livestock and poultry farmers compound their own feed themselves for their farm animals but they face the challenges of raw materials for compounding the feed which may be very expensive or unavailable (Etuk *et al*., 2014). Attempt has recently been taken to reduce the cost of feed, including the incorporation of agro-industrial by-products in broiler diets as an energy source (Sugiharto and Ranjitkar, 2019). However, some limitations may exist when using agro-industrial by-products as ingredients in rabbit ration. The high and low contents of fibre and protein in the by-products may limit the digestibility and thus inclusion level of such by-products (Sugiharto *et al.,* 2018a). In addition to the agro-industrial by-products, the application of leaf meal as the ingredient in broiler feeds has also been conducted (Sugiharto *et al.,* 2018a). Compared to agro-industrial by-products, the content of crude protein in leaf meal is much higher (Tesfaye *et al*., 2013). This may be beneficial in reducing the proportion of the conventional expensive protein-rich feed ingredients in rabbit ration.

It has been known that some particular foliage contain a number of bioactive compounds that are beneficial for the health of livestock (Rama *et al*., 2019). These compounds include vitamins, phenolic acids, flavonoids, isothiocyanates, tannins and saponins (Vergara-Jimenez *et al*., 2017). In this regard, the use of leaf meal in livestock feeds may not only reduce the cost of feeds, but also elicit health-promoting effect on animals. The use of leaf meal in broiler diets may be limited because of high content of crude fibre (Ubua *et al.,* 2019). In general, rabbits showed high tolerance to dietary fibre, and therefore feeding diets containing high levels of leaf meal may improve nutrient digestibility and thus alleviated growth performance of rabbit (Shi-Yi *et al*., 2019).

2.2. TECTONA GRANDIS Linn

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 pair; 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 center 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 leave from

November to January. The flowers appear from June to September and fruits ripen from November to January (ICFRE.2009).

Taxonomy of *T. grandis* Linn

Kingdom	Plantae	
Super division	Angiosperms	
Division	Eudicots	
Class	Asterids	
Order	Lamiales	
Family	Verbenaceae	
Genus	*Tectona*	
Species	Grandis	(ICFRE.2009).

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 such as tannin, flavonoids, phenol and saponins 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; Indira and Mohanadas, 2002).

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). As part of making *T. grandis* available in Nigeria, University of Ilorin, Ilorin North Central Nigeria has embark on massive plantation of this economic viable tree.

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 (Sumthong *et al*., 2006; Neamatallah *et al*., 2005).

2.3. PHYTOCHEMICAL CONSTITUENTS OF *Tectona grandis*

Several classes of phytochemicals like alkaloids, glycosides, saponins, steroids, flavonoids, proteins and carbohydrates have been reported in *Tectona grandis* (Oudhia, 2003). Secondary metabolites such as tectoquinone, 5-hydroxylapachol, tectol, betulinic acid, betulinic aldehyde, squalene, lapachol were also extracted from the plant (Oudhia, 2003). 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 *Tectona grandis* (Rodney *et al*., 2012). 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 *Tectona grandis* (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 betulinic acid, trichione, β-sitosterol and sqaulene.Roots are rich in lapachol,tectol, tectoquinone, β-sitosterol, and diterpenes, tectograndinol (Goswami *et al*., 2009).

2.3.1. Pharmacological activities of *Tectona grandis*

Teak is considered as one of the major constituents 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**: have been employed against 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 treating haemostatic, depurative, anti-inflammatory and vulnerary. They are beneficial against inflammations, leprosy, skin diseases, pruritus, stomatitis, indolent ulcers, haemorrhages and haemoptysis. **The wood**: is used as Acrid, cooling agent, laxative, sedative to gravid uterus, also useful in treatment of piles, leucoderma and dysentery. Oil extracted from parts of the plant is best for headache, biliousness, burning pains particularly over a region of liver (Oudhia, 2003). **The roots**: are useful in anuria and retention of urine (Oudhia, 2003). 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 Neamatallah *et al*. (2005). 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), *Klebsiella pneumoniae* (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 (Mahesh and Jayakumaran, 2010).

- **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 Thulasidas and Bhat (2007).

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**

Jagetia and Baliga (1984) examined the antioxidant activity of *T. grandis* Linn. Leaf extracts employing four *in vitro* assay systems, that is, the 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 a 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 (Sharma and Bhat, 2009).

- **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, significantly 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 (Aboudoulatif *et al*., 2008).

- **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 found to 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 (Faezia *et al*., 2020).

2.4. Rabbit Production

The main advantages of small-scale rabbit farming (Rabbitary) are that, it requires minimal capital investment. Rabbits are easily managed by young and old, male and females with virtually no financial risk, as backyard or garden enterprise, requiring very little space.
Rabbits are prolific breeders, producing large quantities of tasty meat for home consumption. Their rate of production is faster than that of pigs, goats or sheep. Under properly management cared, a female rabbit (doe) can produce more than 15 times her own weight in offspring in a year. Under natural conditions, she delivers a litter every 31 days. In controlled conditions, however, she produces between 4 and 12 in one kidding only four or five litters a year (Eyinla, 2021).

Rabbits are efficient food converter into meat hence, they turn food to weight rapidly. A baby rabbit weighs about 57 g when born, doubles its weight in six days, and in about 30 days its weight will have increased in eightfold or more. At second month, Californian or New Zealand White breed will, if well looked after, will weigh over 2 kg. A young rabbit reaches maturity at five months but can be slaughtered at the end of the third month; at this stage, a Californian White would probably weigh about 3 kg. In Europe and elsewhere, it is common practice to slaughter rabbits at the age of two months but this is rarely done in

West Africa, where the slaughter houses generally prefer mature animals (Adeola, 2018; FAO, 2005).

Breeds of Rabbit

In Europe, rabbits are raised for meat and pelt production. White pelts are preferred, the standard commercial breeds are the white - furred varieties. In West Africa, the farmers are concerned with producing a meaty type, not with the color of the pelt. Care is usually taken to select strains which are both prolific breeders and efficient converters of food. They should have a high ratio of meat to bone (Chenmiao *et al*., 2021).

Rabbits are usually classified according to their weight, colour and hair. The weight categories are small (3 to 4 pounds), medium (9 to 12 pounds), and large (14 to 16 pounds). For meat production, medium-weight New Zealand Whites are best, followed by Californians and chinchilla. For laboratory use, the choice of breed depends on the specifications and requirement. Angora rabbits are the only breed used for wool production (Robert *et al*., 2005; FAO, 2005).

The local African rabbits are usually the easiest to manage. Although they are smaller than the imported breeds, they suffer less from disease. Also, the does have more teats than the breeds from other regions (exotic breeds), enabling them to nurse more offspring. If a good local doe is mated with a good exotic male (buck), the female offspring will not only be stronger, healthier and meatier but will possess 10 teats.

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 feeding behaviour

Different points must be underlined and taken account in the daily practice of rabbit feeding

- Total rabbit digestive transit of 16-24 hours is relatively short when compared to other herbivorous animal which is about 60 hours for a cow or 30 hours for a guinea pig.
- Contrary to the ruminants, an increase of the diet's fibrous content induces acceleration of the speed of transit time in the rabbit. Rabbit has a high capacity to high fiber intake level of its ration: daily feed intake increases with the diet's fibrousness as demonstrated. This is mainly the consequence of the regulation of the energy daily intake: fiber digestibility is lower than the average digestibility value of the diet. Thus, an increase of the fiber content induces a decrease of the digestible energy content. In order to obtain enough energy, the rabbit offset the lowest energy concentration by an increase of the daily intake of the more diluted ration (Ayyat *et al*., 202).
- The instantaneous capacity of ingestion is limited by the stomach small capacity: a content of about 15-18 g of dry matter for a stay of 1 to 2 hours and an average daily intake of 110-120 g (for a growing rabbit of 2kg) (Gidenne *et al*., 2010a).
- When it is fed *ad libitum* a pelleted complete diet, the rabbit makes about 35-40 meals per day (3-5 g each), mainly during the dark part of the 24 hours. If the feed is distributed in limited quantity, the ingestion begins immediately after the distribution, but the rabbit makes the same number of meals per day just closer to each other.
- With pellets feeding, the rabbit spends about 10% of the 24 hours cycle to feed. If the feed is presented as meal instead of pellets this duration is multiplied by 1,5 to 2 and a great part of this time is devoted to scratch in the feeders to search more interesting fractions or particles. If the daily ration contents an important part of forages, this time could be multiplied by 3 or 4.

- Two or 3 rabbits are able to eat simultaneously in the same feeder without competition problems because once the feed is taken in the feeder (5-10 seconds) each rabbit removes his head from the feeder to chew during 0.5 to 1 minute and then after introduces again the head in the feeder for 5-10 seconds (Gidenne *et al*., 2010a).
- When ambient temperature increases above 28-30°C the feed intake is reduced. This drawback could be partially, but only partially, offset by increasing the lipid concentration of the feed or by increasing the protein /energy ratio of the diet. Conversely, if the ambient temperature is below 10°C, the rabbit increases its food intake to compensate for the energy cost of thermoregulation. It can even endure a temperature of minus 15 to 20 ° C below zero in the condition of having a water source (Gidenne *et al*., 2010a).
- When a concentrate with low fiber diet compound diet and a dry fibrous material are given as free choice to rabbits, they prefer the concentrate. The fibrous material is consumed in only small quantities and the growth rate may be reduced (Gidenne *et al*., 2020; Lebas *et al*, 1997).
- The consequence is also an immediate increase of the sanitary risk for rabbits with digestive disorders by lack of fiber (Gidenne and Labas, 2006). If the fibrous material is presented fresh (green) the balance between concentrate and forage is more difficult to predict, and the recommendation is to propose the more palatable in restricted quantity (Gidenne *et al*., 2020).
- The maximum intake capacity of a rabbit per day is about 5 to 9% of its live weight expressed as dry matter. For example, dry matter intake of a rabbit doe varies from 3.5% of her live weight when she is empty and dry, up to 8-9% of the live weight at the peak of lactation. With the high-speed growth selected lines, the dry matter intake may represent up to 10% of the live weight at peak of growth (when 35-40 days old) (Gidenne *et al*., 2020).
- The need of water is about twice that of the dry matter intake, with an increase of the proportion when temperature is above 28-30°C. It means that if rabbits receive a daily ration with a minimum average content of 70-75% of humidity, water distribution is not "necessary" even if it is strongly recommended. In any other cases the distribution of clean water is absolutely necessary (Lebas, 2013).

2.5. METHOD OF COOKING

Cooking is the process of preparing food, by the analog skill often with the use of heat. Cooking techniques and ingredients very widely across the world, reflecting unique environmental, economic and cultural traditions. In cooking, there are some basic methods of cooking that are used. These commonly used basic cooking methods are divided into general groups. The groups are; Dry heat cookery methods and moist heat cookery methods. The method of cooking are divided into their two groups because of the way food is cooked and the type of heat that is used. (Myhrvoid, 1999).

2.5.1. Dry Heat Cookery Methods

In dry heat cooking methods, the food being cooked dies not use water to cook the food. The food left dry and heat is applied to cook. Fuck methods of cooking are baking, shallow, frying, deep frying, barbequing, grilling and roasting. While heat is applied to the food, the food cooks in its own juice or the water added to the food during its preparation evaporates during the heating process and their cooks the food. Heat is applied directly to the food by way of convection thus making the food to get cooked. The action or movement of heat around the food cooks it (Kitchen 101, 2012)

1. **PANFRYING (SHALLOW FRYING):** is a form of frying characterized by use of mineral cooking oil or fat just enough to lubricate the pan (although, in the case of greasy food such as bacon, no oil or fat may be needed). As a form of frying, pan frying relies on oil as the heat transfer medium and no correct temperature and time to retain the moisture in the food because of the partial coverage; the food must be flipped at least once to cook both sides. The faster and the best way to pan fry is to flip the cooked item very often, about every 15-50 seconds. This will cook the outside less and get it center cooked faster (Myhwoid, 1999)

2. **DEEP FRYING**: Is a cooking method in which food is submerged in hot fat or oil. This is normally performed with a deep fryer or chip pan. Due to the high temperature involved and the high heat conduction of oil, it cooks food extremely quickly. If performed properly, deep-frying does not make food excessively greasy because the moisture in the food repels the oil. The hot oil heats water within the foods, steaming it, oil cannot go against the direction of this powerful flow because (Due to its high temperature) the water vapor pushes the bubbles toward the surface (Herele, 2006). As long as the oil is hot enough and the food is not immersed in the oil for too long oil penetration will be confined to the outer surface. However, if the food is cooked in the oil for too long, much of the water will be lost and the oil will begin to penetrate the food. The correct frying temperature depends on the thickness and types of food, but in most cases it lies between 175 and 190˚c (545-575˚c) (BBC, 1999).

3. **BAKING**: Refers to the looking method that requires cooking in an enclosed space with dry heat. In conventional ovens, Dry heat is circulated around the backed good with a fan, the baked good is again cooked evenly from all sides but here it is cooked quicker and often far more precisely than a conventional oven can. The temperature in baking can vary

from as 250˚f to as high as 500˚f in home cooking (and upwards of 800˚f in professional pizza ovens). The cooking time varies with cooking temperature.

4. **ROASTING**: Is typically used to refer to cooking meats or vegetables uncovered in the oven .like baking roasting can caramelize and brown the crust or outside of ingredient- this cooking methods lends its name toured meats cooked in this fashion, the roast. When cooking large or tough cuts of meat, a cow temperature and a long cooking time is used. While a higher temperature and short cooking time is used when cooking smaller, tender cuts of meat and vegetables. Roasting can also refer to cooking or poultry on a split in front a flame or heating element. Cooking temperature in roasting can vary from as low as 250˚f to upward of 450˚f in home cooking

5. **BROILING / GRILLING**: Broiling and grilling are two methods that are very similar to each other similar enough to be categorized together for the home cook. Broiling and grilling use direct heat, often an open flame to cook something hot and fast. Grilling is typically considered to contain a flame on the bottom and broil an element on the top, either can refer to the use of a flame or using a heat source on the top or bottom usually ranging depending on region. Broiling and grilling both utilize very high temperature often the highest that can be achieved in home cooking with a very short time rarely more than ten minutes. {Salmon *et at.*, 2000}

6. **BAEBECUING:** Is a cooking method that is the exact opposite of grilling even though it often uses the fame dives where grilling of hot and fast, barbecues is flow and slow, utilizing indirect heat and a very low temperature .The meat poultry it then cooked over a long period of time, often upward of 4 hours and sometimes overnight. Barbecuing use a combination of cooking and smoking to impart fallow .The temperature of the barbecue can vary but is typically very low ,often below 300˚f and many times as low as 200˚f or less, often taken upward of 4 hours before doneness is achieved.

2.5.2. MOIST HEAT COOKERY METHOD

In moist heat cookery method, liquid used as a medium to cook the food, could be water, coconut cream or oil. These liquid are added to the food before heat applied to it or sometimes heat is applied to liquid before the food is added into the cooking utensils to be cooked. The moist heat cookery method include; boiling, steaming, stewing and basting all these moist heat cooking methods use liquid to cook the food.

1. **BOILING:** is the most intense and often most destructive of the moist heat cooking methods. Boiling creates a very large, vigorous bubble which indicates a temperature of 212˚f because of the intense cooking process oiling creates this is usually used only for

hardly ingredients. Water boil at 212˚f {100˚c} at sea level but in denier it boils at 212˚f {95˚c}. Because of this, boiling water at high elevation might not always be hot enough to cook an ingredient thus often requiring additional baking time cooking times can vary depending on the ingredient, boiling is typically a very quick process (kitchen 101, 2012).

2. **BRAISING:** Is one of the moist heat cooking methods which stipulate both the temperature and amount of liquid used. Braising is typically used for slow cooking meats by using for vegetables and other foods. Braising can be done on the stove or in the oven. Braising uses a medium low temperature while cooking times can vary depending on the ingredient, braising is typically a fairly slow process.

3. **STEAMING**: Is probable the most delicate cooking method and is often used to cook delicate ingredients or in applications where the shape of the food needs to be retained. Steaming is a low to high temperature cooking process. Steaming requires rack inserted. Steaming should always be covered (Kitchen l0l, 2012).

4. **BASTING:** This method cooking is usually associated with roasting. The juice or liquid that comes out the meat being cooked is spooned over the roast frequently while it is being roasted. The outer part of the meat is moistened frequently during the cooking process with the juice that is being spooned over. Usually, the extra juice from the cooked meat is added to a mixture to make the sauce.

2.6. EFFECT OF COOKING

Effect of cooking temperature on the absorbance of the sarcoplasmic fraction (A) The transverse (B) and longitudinal (C) shrinkage of fibre and the shrinkage of connective tissue (D) prepared from four different animals using leaf m: biceps femories (Tornberg *et al*., 1997) of my ofilxular proteins are extractected which on heating create a disease protein network: agel, that holds water efficiently by capillary forces.

The quality of that protein network is influenced by a number of factors interacting in complicated way, as retain it. Offer *et al*. (1989) have confirmed that this drip loss arise predominately from the longitudinal channels through the meat between the fiber bundles, in order to be able to understand aid control changes in water accumulated and lost in those channels.

Cooking induces structural changes, which decrease the water holding capacity of the meat. The review by ‘’Offer (1984)’’ summaries the structural changes occurring on cooking as follow when the treasure shrinkage to the fiber axis occurs mainly at 40-60˚c this when the gap already present at rigor between the fiber and their surrounding endomysium at 60-

70˚c the conductively shrink longitudinally, the extent of shrinkage increasing with temperature. This shrinkage causes the great water loss that is obtained on cooking. It is then presumed that water is expelled by pressure existed by shrinking connective tissue on the aqueous solution in the extracellular void.

2.7. EFFECT OF HEAT

Some of the heat induced changes in meat that are thought to influence tenderness were summarized by Paul (1963). These include changes in moisture, fat, muscular fiber diameter and extensibility, shear and connective tissue and content and characteristic**.**

2.7.1. EFFECT OF COOKING ON TENDERNESS

As cooking progress, the contractile proteins in meat become Tess tender, and the major connective tissue protein (collagen) becomes tender. Thus for cuts that are low in connective tissues such as steaks and chops from the vibe and loin the recommended method of cooking is dry heat including pan frying, broiling, roasting or barbecuing (Herrera-mendez, *et al*., 2006) tenderness of meat changes during heating due to the transformations in connective tissue and Myofibrila protein. When heated in presence of water collagens dissolves, which in the crushing of meat, while Myofibrila proteins denatured which causes the meat increased in hardness (Bertram *et al*., 2004) and shrinkage both wosswise and long muscle fibers and connective tissue (Barbera and Tassone, 2006) Dry heat vases the temperature very quickly and the flavor of meat will develop before the contractile proteins have the opportunity to become significantly less tender (Barbera and Tassone, 2006).

For cuts with high amount of connective tissue such as those from the fore shank, heel of round and chuck the those from the fore shank heel of round, and chuck the recommended method of cooking is long and slow at low temperatures using moist heat such as braising the application of moist heat for a long time at a low temperatures (275-325˚f) results in conversation of tough collagen into tender gelation and makes the makes type of cut more tender compared with dry heat cooking of one of the less tender cuts of meat (Bertram *et al*., 2004)

During heat treatment, meat loses 20-40% of its total initial weight due to fluid leakage with the increasing temperature (Zhong *et al*., 2007). Cooking loss is strong associated with fiber shrinkage and there by impacts the overall process efficiently and general consumer acceptance of the product. Extent of shrinkage is important to the consumers, because when treating with different thermal processes, that cause undesirable changes in meat structure, they can perceive increased shrinkage as an indication of low quality (Barbera and Tassone, 2006).

2.7.2. HEAT EFFECTS ON JUICINESS

As meat is heated, it will lose some water due to evaporation and drip loss. The amount of water lost will depend on the temperature and length of time the meat is cooked and the water holding capacity of the meat marbling (intramuscular fat) and subcutaneous fat offer some protection against water evaporation during cooking. Cooking loss measurement is a vapid and valid method of assessing the degree of heat treatment on meat, because it reflects the degree of its juiciness, as well certain economic aspects (Bertram *et al.*, 2004).

2.7.3. HEAT EFFECTS ON FLAVOUR

Flavor is the mixture of the sensation from taste, smell, pressure, temperature, (Hot, Cold) and mild pain. Cooking releases volatiles from protein and fat which changes the flavor of the meat. New compounds may also be formed as is the case with sugar – amine browning or the warmed order flavor caused by oxidative change.

2.7.4. EFFECT OF COOKING ON MEAT HEATING QUALITY

Muscle is made up of muscle fiber groups, surrounded and supported by connective tissue which contains collagen fibers. Collagen fibers from cross-links to stabilize and strength muscle. Different muscles have varying amounts of connective tissue related to the amount and type of work the muscle has to do. By contrast a muscle such as the tender coin (fillet) which sit on the inside of the spine near the pelvic does very little work, so contain no connective tissue. As a result this muscle is very tender. The tender coin will not be suited for casserole cooking as its structure will be completely broken down. This cut is suited to pan frying, grilling, or boiling (MLA, 2004).

Different cooking methods can alter eating quality MLA, (2004) indicated that rump firer was better utilized as roast, strut frying on thin slice However, other cuts such as the tendering, were not improved by roasting. Some examples of the relationship are shown in the table below

2.7.5. OTHER HEALTH ISSUES

Cooking dairy products may increase a productive effect against colon cancer. Researchers at the University of Toronto suggest that ingesting uncooked or unpastering dairy products may reduce the risk of colorectal cancer (Carpet *et al*., 1995). Deep fry in restaurants may contain high level of trans fat which is known to increase level of low-density lipoprotein that may increase risk of heart diseases sand other conditions. However, many fast food chains have now switched to Trans-fat free alternatives for deep frying.

CHAPTER THREE

3.0. MATERIALS AND METHODS

3.1. Study Area

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

3.2. Sample collection and processing

- ***Tectona grandis****:* - *Tectona grandis* leaf was harvested, air dried under shade to 15% moisture content, the leaf was grind into powder (*Tectona grandis* leaf meal TGML) and stored.
- ***Rabbits****:* - 24 rabbit kits were obtained from reputable farm in Ilorin, Kwara State.
- ***Oxidized Soya bean oil****:* - soya bean oil was obtained from a reputable groceries store. Soybean oil was heated at 180^0C 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).

3.3 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).

3.4. Experimental diets

Table 1: - 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

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. The kits was dewormed for ectoparasite and endoparasite, and was given broad spectrum antibiotics against infections.

3.6. Experimental animal and sampling for cooking

One rabbit each was randomly selected from each dietary treatment and replicate (i.e. one rabbit each from the four replicate per treatment, 4 x 3 = 12 samples in all). The rabbits were fasted for 16 hours before slaughter, without feed but with cool clean fresh water. The rabbit was slaughtered conventionally according to the method described by Soren and Julio, (2020). The Longissimus thoracis et lumburum (LTL) muscle was excised within one-hour postmortem, the epimysium connective tissues and external fat was removed from the LTL samples to be used and freeze thawed before subjecting to different cooking methods.

3.7. Sausage formulation

The materials for sausage production are shown in the Table 5 below. The meat to be used for the sausage was the Longissimus thoracis et lumburum (LTL) muscle of rabbit from experiment three while other materials such as fat, flour and materials for the recipe was purchased from reputable store within Ilorin.

Table 2: Sausage formulation

Materials	%
Meat	70.00
Soya oil	15.00
Wheat flour	10.00
Spices	1.40
Ice	2.35
Salt	0.75
Sugar	0.50

Sodium nitrite	0.015
Total	**100**

3.8 Sausage preparation

Flow chart for preparation of rabbit meat sausage.

Rabbit meat

|

Wash to remove blood stain

|

Cut into smaller chunks

|

Mincing through 1.5mm plate

|

Add salt, sugar and sodium nitrate

|

Addition of ice— mixing

|

Addition of oil

|

Addition of wheat flour

|

Chopping/mincing I.5mm to form a perfect mix

|

Emulsion

|

Stuffing of emulsion in casings

|

Cooking using different methods

|

Cooling

|

Packaging/Analysis

Figure 1, preparation of rabbit meat sausage

3.9 Cooking methods

The cooking methods to be employed in the research include;

Oven grilling: - The sausages stuffed in food grade collagen casing were oven grilled in a preheated oven to 190^0 C – 200^0 C for 20 minutes until an internal temperature of 72 ^{0}C was reached in an electrical powered grilling (CG20, Hobert, OH, USA) machine. Sausage samples were turned at regular interval of 5 minutes to avoid burning and to aid even distribution of heat in sausage. Pointed mouth Meat thermometer that measure up to 350 ^{0}C was employed.

Sousvide: - a slow heat-vacuum sealed cooking techniques. Sausage stuffed in food grade collagen casing were vacuum packed in a polyethylene bags and sealed by vacuum packaging machine (Audionvac VMS 153, Derby, UK). The vacuum-packed sausage were heated by submerging in water bath (PolyScience. IL, USA) at 65^0 C for 2-4hours. The temperature was monitored using ( ) thermometer. After cooking the sausages were immediately cooled to room temperature for further analysis.

Smoking: - smoking was done with locally designed and carefully constructed smoking kiln. Burning (*Parkia biglobosa*) wood was used to generate gentle smoke in the smoking chamber. The sausages stuffed in food grade collagen casing were smoke-heated to an internal temperature of 72 ^{0}C using meat thermometer to measure internal heat of the sausage.

2.10. Determination of proximate composition

Samples was analyzed chemically according to the official methods of analysis described by the Association of Official Analytical Chemist (A.O.A.C., 2005). All analysis was carried out in triplicate.

2.12. Statistical Analysis

All data generated was subjected to analysis of variance (ANOVA) in a completely randomized design (CRD) using SPSS, (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 3: result of the effect of different cooking methods on nutritional composition rabbit meat sausage fed *T. grandis* leaf meal and oxidized oil diets.

	Cooking Methods				
Proximate %	Oven cooking	Smoking	Sus vide	MSE	Sig
Dry matter	36.89±4.64	40.82±0.02	38.87±0.01	11.56	0.275
Moisture content	60.44±0.02^{b}	59.18±0.02^{c}	61.13±0.01^{a}	2.93	0.000
Crude protein	10.50±0.02^{c}	11.13±0.03^{a}	10.82±0.02^{b}	0.79	0.000
Fat (ether extract)	2.41±0.01	2.51±0.01	2.44±0.09	0.01	0.153
Fiber	12.07±0.04^{b}	12.51±0.05^{a}	11.92± 0.03^{c}	0.28	0.000
Ash	6.14±0.01	6.21±0.02	6.10±0.04	0.02	0.130
NFE	8.25±0.08^{b}	8.60±0.02^{a}	8.42±0.06^{b}	0.09	0.019

Means with different superscript ^{abc} are significantly different (P<0.05) while means with the same superscript are not significant different (P>0.05).

The result of the effect of different cooking methods on the nutritional composition of rabbit meat sausage fed diets containing *T. grandis* leaf meal and oxidized oil diets is shown in table 3, above. The result of dry matter, crude fat (ether extract) and ash content were not significantly different (P>0.05), the cooking methods and different in diet composition the not influenced the dry matter, crude fat (ether extract) and ash content composition of the sausage made from the rabbit meat using different cooking methods. Numerically, the dry mater was high in smoking 40.82%, followed by sus vide 38.87% and low in oven cooking 36.89%, this was indicated in the significant differences (P<0.05) observed in the moisture content. The higher the dry matter, the lower the moisture content. Smoking with higher dry matter had lower moisture content, and this applied to other cooking methods, as dry matter increases the moisture content reduces. The protein composition of the rabbit sausage meat also defers, with smoking having high protein content. The trend revealed that the higher the dry matter, the lower the moisture content which resulted to high protein content. In this result smoking caused more loss of water content in the rabbit sausage leading to high dry matter, protein, fibre and nitrogen free extract NFE. Though no significant different in the fat and ash content but numerically, the value were higher in smoked sausage than other cooking methods.

CHAPTER FIVE

5.0. CONCLUSION AND RECOMMENDATION

5.1. **CONCLUSION**

The result of the effect of cooking methods on the nutritional composition of rabbit sausage meat shows that dry matter, fat content and ash content were not affected by the cooking methods, but numerically were high in the smoked rabbit meat sausage while crude protein, fibre and NFE were in the favour of smoked rabbit meat sausage.

5.2. **RECOMMENDATION**

Smoking, having impacted positively on to the nutritional composition of the rabbit meat sausage is thereby recommended.

REFERENCES

Egbo, M.L., Doma, U.D. and Lacdaks, A.B. (2021). Characterization of small scale rabbit production and management in Bauchi metropolis. Proceeding of the 26thAnnual Conference of Nigerian Society for Animal Production (NSAP), 18-21 March, ABU Zaria. 160-162.

Ayyat M. S., Abdel-latif K. M., Helal A. H. and Sagheer A. A. (2021). New Zealand white rabbit tolerance to chronic thermal stress at different dietary energy/protein levels. *Animal feed science and technology* 278: 114997.

Ayodeji O.F., Ganiyu O., Adedayo O.A., Oluwatoyin V.O., (2015). Consumption of Thermally Oxidized Palm Oil Diets Alters Biochemical Indices in Rats. *Beni-Suef University Journal of Basic and Applied Sciences,* 4(2), 150–156.

Netra P. Osti (2020). Animal feed resources and their management in Nepal Acta *Scientific Agriculture* 4 (1), 02-14, 2020.

ICFRE. Indian Council of Forestry Research and Education (2009), Dehradun. Teak (*Tectona grandis*). Dehradun, Forest Research Institute.

Komarayati S. and Wibisono H. W. (2020). Potential uses of teak litter for liquid smoke and other utilization: A review. *Materials science and engineering* 935(9), 012015.

Indira EP and Mohanadas K (2002). Intrinsic and extrinsic factors affecting pollination and fruit productivity in teak (*Tectona grandis* L.f.). *Indian J. Genetics & Plant Breeding* 2002; 62(3): 208–214.

Neamatallah A., Yan L., Dewar S.J. and Austin B. (2005). An Extract from Teak (*Tectona grandis*) Bark Inhibited *Listeria monocytogenes* and Methicillin Resistant *Staphylococcus aureus*. *Lett in Applied Microbio*, 2005; 41: 94–96.

Sumthong, P., Damveld, R.A., Choi, Y.H., Arentshorst, M., Ram, A.F., Vanden, (2006). Activity of Quinines From Teak (*Tectona grandis*) on Fungal Wall Stess. *Planta Medica,* 72(10): 943-944.

Varier, P.S. (1996). Indian Medicinal Plants: A compendium of 500 species. Vol 5. Orient Longman, Hyderabad, India. pp. 245-248.

Suseela L. and Parimala (2017). Antimicrobial Activities of Tectona Grandis Leaf And Bark Extracts. *European Journal of Pharmaceutical And Medical Research. 2017,4(12), 245-248.*

Fangfang Liang, Shouqun Jiang, Yi Mo, Guilian Zhou,and Lin Yang (2015).Consumption of oxidized soyabean oil increased intestinal oxidative stress and affected intestinal immune variables in yellow feathered broilers. *Asian-Australasian Journal of Animal Sciences* (AJAS)28(8): 1194- 1201

Liu Y J. Yang H.J., Yuan Y., Liu F.J., Tian L.X., Liang G.Y. and Yuan R.M. (2012). Effect of dietary oxidized fish oil on growth performance, body composition, antioxidant defence mechanism and liver histology of juvenile largemouth bass Micropterus salmoides. *Aquaculture nutrition* 18 (3), 321-331, 2012.

Jinap S., Shahzad Z. I. and Roshny M.P. (2015). Effect of selected local spices marinades on the reduction of heterocyclic amines in grilled beef (satay). *Food Science Technology* , 63(2): 919-926.

Quelhas I., Petisca C., Viegas O., Melo A., Pinho O. and O. Ferreira (2010). Effect of green tea marinades on the formation of heterocyclic aromatic amines and sensory quality of pan-fried beef. *Food chemistry*, 12(1): 98-104.

Robinson T. (2011). Global Livestock Production System 152pp.

Adams O. K. (2016). Economic Impact of Livestock Production on The Society: A Case Study of Ikare Akoko Ondo State. *Journal of Agriculture and Veterinary Science (IOSR-JAVS).* Volume 9, Issue 12 Ver. I (Dec. 2016), PP 77-80 www.iosrjournals.org.

Agboola M.O. and Balcilar M. (2012). Impact of Food Security on Urban Poverty: A Case Study of Lagos State, Nigeria. Procedia - Social and Behavioral Sciences. 62 (2012): 1225–1229.

Ibitoye S., Orebiyi J.S. and James O. (2010). Effects of Socio-economic variables on credit needs of farmrs in Kogi state Nigeria. J.agric.ext. 5(2):537-541.

Etuk R., Grace R. E. and Baghebo M. (2014). Small and Medium Scale Enterprises (SMEs) and Nigeria's Economic Development. Med.j.soc.sci. 5(7):656-662.

Sugiharto S., Yudiarti T., Isroli I. and Widiastuti E. (2018a). The potential of tropical agro industrial by-products as a functional feed for poultry. *Iranian Journal of Applied Animal Science*, 8, 375-385.

Sugiharto S. and Ranjitkar S. (2019). Recent advances in fermented feeds towards improved broiler chicken performance, gastrointestinal tract microecology and immune responses: A review. *Animal Nutrition*, 5, 1-10. https://doi.org/10.1016/j.aninu.2018.11.001

Tesfaye E., Animut G., Urge M. and Dessie T. (2013). *Moringa olifera* Leaf meal as an alternative protein feed ingredient in broiler ration. *International Journal of Poultry Science*, 12, 289-297. https://doi.org/10.3923/ijps.2013.289.297

Ubua J A., Ozung P O. and Inagu P G. (2019). Dietary inclusion of neem (*Azadirachta indica*) leaf meal can influence growth performance and carcass characteristics of broiler chickens. *Asian Journal of Biological Science*, 12, 180-186. https://doi.org/10.3923/ajbs.2019.180.186

Shi-yi C., Feilong D., Xianbo J., Hanzhong L., Gong W. Z. and Song-Jia L. (2019). Gut microbiota with differential tolerance against the reduced dietary fibre level in rabbit. *Scientific reports* 9(1), 288-294.

Rodney L., Rosa M.V., Jose M.G.M., Clara N. and Francisco A.M. (2012). Tectonoelins, New Norlignans From Bioactive Extract of *Tectona grandis*. *Phytochem Lett*. 2012; 5: 382-386.

Neha K. and Sangeeta B. (2013). Phytochemical and Pharmacological Evaluation Of *Tectona Grandis* Linn. *International Journal of Pharmacy and Pharmaceutical Sciences* ISSN- 0975-1491 Vol 5, Issue 3, 2013.

Mahesh, S.K., and Jayakumaran N.A. (2010). Antibacterial, Cytotoxic and Antioxidant Potential of Different Extracts from Leaf, Bark and Wood of *Tectona grandis. Int. J. Pharm*. Sci. Drug. Res., 2010; 2(2): 155-158.

Jagetia G.C. and Baliga M.S. (1984). The Evaluation of Nitric oxide Scavenging Activity of Certain Indian Medicinal Plants In vitro: a Preliminary Study. *Naturwissenschaften*. 1984; 71(11): 581-582.

Suseela L. and Parimala (2017). Antimicrobial Activities of Tectona Grandis Leaf And Bark Extracts. *European Journal of Pharmaceutical And Medical Research*. *2017,4(12), 245-248.*

Fawzia A., Ibrahim M., and Sohair A. (2020). Effect of using pricklypiar and it by-products as alternative feed sources on performance of growing rabbit. Egyptian journal of rabbit science. 29(1), 99-124.

Fawzia A., Samia M., Muhammed B., Khalid M. and Showky E. (2016). Effect of dietary pomegranate product extract supplement in growth performance, digestibility and antioxidant status of growing rabbit. Tropical animal health and production. 52(1), 1893-1901.

Eyinla T. E. (2021). Household food insecurity and nutrient adequacy of under five children in selectd urban areas of Ibadan. *African Journal of Biomedical Research* 24(1), 41-46.

FAO (2005). Food and Agriculture Organization. Food Production Year. 50:160-168.
Chanmiao L., Shuhui W., Xianggui D., JIping Z., Xiangyang Y. and Ruiguang G. (2021). Exploring the genomic resources and analyzing the genetic diversity and population structure of Chinese indigenous rabbit breeds by RAD-seg. *BMC genomics* 22(1), 1-14.

Ayyat M. S., Abdel-latif K. M., Helal A. H. and Sagheer A. A. (2021). New Zealand white rabbit tolerance to chronic thermal stress at different dietary energy/protein levels. *Animal feed science and technology* 278: 114997.

Gidenne T., François L. and Laurence F. (2020). Feeding behaviour of rabbits. *Nutrition of the Rabbit*, 254-274, 2020.

Gidenne T., Lebas F., Fortun-Lamothe L., (2010a). 13. Feeding behaviour of rabbits. *In* de Blas C., Wiseman J., Nutrition of the rabbit, CAB International Ed., Wallingford, UK. 233-252.

Jaarin K. and Kamisah Y. (2012). Chapter 10: repeatedly heated vegetable oils and lipid peroxidation. *INTECH*: 211-228.

AOAC (2005). Official Method of Analysis. 18th Edition, Association of Officiating Analytical Chemists, Washington DC, Method 935.14 and 992.24.

Omojola A .B. et al. (2014). Physicochemical and Organoleptic Properties of Muscovy Drake Meat as Influenced by Cooking Methods. *Afr.J.food.Sc.* 8(4):184-189.

Omojola A .B. et al. (2009). Physicochemical and Organoleptic Properties of meat floss as Influenced by Cooking Methods. *Afr.J.food.Sc.* 6(4):114-119.