COMPARATIVE ASSESSMENT OF YIELD AND MEAT QUALITY OF THREE GIANT AFRICAN LAND SNAIL SPECIES AT DIFFERENT AGE GROUPS

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIESAHMADU BELLO UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE IN ANIMAL SCIENCE

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

MARCH, 2021

DECLARATION

I declare that this dissertation titled "**Comparative Assessment of Yield and Meat Quality of Three Giant African Land Snail Species at Different Age Groups**" has been carried out by me in the Department of Animal Science, Ahmadu Bello University, Zaria, under the supervision ofProf. M. Jibir and D. Zahraddeen.The information derived from the literature has been duly acknowledged in the text and the list of references provided. No part of this dissertation was previously presented for another degree or diploma at any University.

JUMAH, Fatimah Adeitan ……..…. ……..……

Signature Date

CERTIFICATION

This dissertation entitled "**Comparative Assessment of Yield and Meat Quality of Three Giant African Land Snail Species at Different Age Groups**" meets the requirements governing the award of Master Degree of Animal Science Department, Ahmadu Bello University, Zaria and it is approved for its contribution to knowledge and literary presentation.

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Dean, Postgraduate School Signature Date

DEDICATION

Momma, this is for you.

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AR-RAQEEB, the ever watchful guardian, which of your favours will I deny. Absolutely none thank you for your protection and sustenance.

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ABSTRACT

This study was conducted to evaluate the effects of species and age on the yield and quality of edible snail meat. A total of 180 snails were sourced from Merchant Farms, Ibadan, Oyo State. Thirty (30) snails each from the young and mature of *Achatina achatina, Achatina fulica and Achachatina marginata* were used in a 3 x 2 x 4 (specie x age x storage time) factorial arrangement in a Completely Randomized Design. The live weight, mouth width, shell length and shell width were taken. Sensory evaluation was carried out on the fried snail meat from each specie, from the two age groups (young and mature). Samples of the fried snail meat were also evaluated for microbial count (total aerobic and coliform) for a 21-day storage period (0, 7, 14 and 21) using the standard plate count procedure of serial dilution. The results showed that the chemical composition of the three species at both ages (young and mature) differ significantly ($P<0.05$) different. Crude fiber was not found in all the species and the age groups. Crude protein and ether extract of *A. marginata* differed significantly ($P<0.05$) from the other two species while *A. fulica* differed significantly ($P<0.05$) in ash content. Similarly, age significantly ($P<0.05$) influenced ether extract with mature ones having the highest value. Conversely, the young have more ash content than the mature snails ($P<0.05$). There were significant ($P<0.05$) differences in carcass weight, meat yield, yield of viscera and cooking loss; with *A. marginata* recording highest in all the parameters investigated. Specie difference also significantly ($P<0.05$) influenced shell weight, shell length, shell width, mouth length and mouth width; with *A. marginata* recording the highest values in all the parameters. Results from organoleptic assessment showed that *A. marginata* at mature stage were most preferred by the panelists However age, species and storage days significantly ($P<0.05$) influencedthe total aerobic count obtained. It can be concluded that optimum yield can be obtained from *A. marginata* at both young and mature stage. *A. marginata*at mature stage had the highest crude protein andwas generally accepted by the panelists, while *A.fulica* had more minerals at both young and mature stage also the microbial load at all the storage periods were not above the borderline for ready to eat meat product. However, above day 0 TAPC during the storage period revealed thatday 7 had lower microbial load than day 14, and 21.

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CHAPTER ONE

1.0 INTRODUCTION

Snail meat has been consumed by humans throughout the world since prehistoric times (Cobbinah *et al.*,2008). Many countries have large international market for snails and a great deal of them exports snails for foreign exchange. Among these are China, France, Italy and many other European countries (Elmslie, 1982). Available data show that Ghana exported 620 kg of snails in 1994 to the Netherlands and 1,050kg to the U.S.A (Ablordeppey and Asamoah, 2003). Also, the availability of some edible snails in Nigeria, their popularity and acceptability nationwide, the potential for export, including the emerging technologies for their production have largely contributed towards the present renewed interest in snail farming (Amusan and Omidiji, 1998). It is also a major source of income to the people (Ezeama, 2000).

The interest in snail farming around the world stems from snails' high quality protein for human consumption and medicinal value. For instance, protein from snail meat is said to be very rich in all essential amino acids such as lysine, leucine, arginine and tryptophan (Imevbore and Ademosun, 1988). Snail meat has been found to be higher in protein content (37 – 51%) compared to that of guinea pig (20.3%), poultry (18.3%), fish (18%), cattle (17.5%), sheep (16.4%) and swine (14.5%). Iron content (45 – 59mg/kg), low in fat (0.05 – 0.08%), sodium and cholesterol level (Bayode, 2009).The comparative nutritive value of snail meat to some animal protein sources have been studied by some researchers. In an instance, the protein contents of 88.37 and 82.42 were discovered in snail and pork, respectively (Imevbore and Ademosun, 1988). It essentially contains high level of iron, calcium and phosphorus (Dada *et al.*, 1999).

Snail meat competes favourably with poultry egg and flesh in essential amino acids and digestible protein (Imevbore, 1990).

Snail farming can conveniently be done in our back yards. This is due to the fact that snail farming is environmentally friendly and can be done with little skill and cash (Akinnusi, 1998; NRC, 1991). The faecal outputs of snails neither smell nor make the environment filthy in any way. Snails are also good converters of vegetable protein to useful animal protein (Obi *et al.*, 2001). Snail farming is also a high profit-yielding venture and requires little capital when compared to other forms of animal farming.

Snail consumption rate is rising because people are now avoiding red meat for perceived health reasons (Omole *et al.,* 2006). The galacton present in its abdominal gland serves as a medicinal substance of high immunological value, which cures tuberculosis, ulcer, asthma and circulatory disorders (Ugwuowo, 2009). Okonkwo *et al.* (2000) also pointed out that snail meat is useful in the treatment of some human diseases like anaemia, hypertension, asthma etc. while its shell can be used in the production of buttons, rings and other jewelry. The shell is also used as a source of calcium in the production of livestock and poultry feed (Ademosun and Omidiji, 1999) and also used in liming to reduce soil acidity. The shell mainly composed of calcium carbonate ($CaCO_3$) which is also used as an ornamental material and for washing cooking utensils such as pots and kettles clean (Ayodele and Asimalowo, 1999). Snail mucus can be used traditionally in treating the umbilical cord by nursing mothers (Ademosun and Omidiji, 1999). Snails are often utilized for a lot of decorative works and carvings such as flower vases, ash trays and other interior decoration thus making them to have additional economic values (Baba and Adeleke, 2006).

1.1 Problem Statement

In Nigeria, the edible land snails are fast becoming culinary delicacies and demand has been so great that snail farming is gaining importance (Odaibo, 1997). Efarmspro (2006) reported that wild snails population is declining rapidly due to indiscriminate hunting of snails before they reach maturity, also due to bush burning, use of agro-chemicals, deforestation and change in weather. The seasonality of the supply of snails limits their use on continuing basis without processing the meat. During the dry season, snails aestivate and become very scarce and expensive but in the rainy season they are abundant and cheap. Different species of the Giant African Land Snail attained maturity at different age (Cobbinah *et al;*2008). In spite of the potentials and advantages of snail farming, widespread participation in its production by farmers is yet to be achieved in Nigeria (Baba and Adeleke, 2006). Bulk of snail meat eaten in Nigeria is sourced from the wild with few coming from commercial breeding and production farms. This is probably attributed to lack of awareness of the economic potentials of this micro livestock (Baba and Adeleke, 2006; ENADEP 2009). The yield, quality and sensory traits of meat from species of economic importance both at juvenile and matured stage are grossly understudied. This research therefore was designed to obtain information about the specie that optimizes yield and quality, and determine the quantum of meat they can supply in relation to their stage of growth (young and mature).

1.2 Justification of the Study

There is little work available on sensory evaluation of snail meat and the little ones are often focused on the effect of feed given to a single species of snail without any estimation on yield and quality in relation to age. More so, there is little work on the yield and quality of snail meat from various species of economic importance commonly found in tropical Africa such as

Achatina achatina, Achatina fulica, Archachatina marginata, Archachatina ventricosa, and *Limicolaria*. Ebenebe *et al.* (2011) also opined that information on yield of snail meat at a particular age and the rates of growth for *A. marginata, A. achatina and A. fulica* snails are scarce in literature.

The few published works include Odaibo (1997) on snail and snail farming; Cooper and Knowler (1991) on snails and snail farming (an introduction); Adeyeye (1996) on waste yield, proximate and mineral composition of three different types of land snails found in Nigeria; Adeyeye (1998) on the mineral composition of the haemolymph of three different types of land snails consumed in Nigeria; and Adeyeye and Afolabi (2004) on the amino acid composition of three different types of land snails consumed in Nigeria; Oduro *et al.* (2002) Meat yield and quality of selected snail species in Ghana; Emelue *et al.*(2013) Processing and preservation of snail in Benin city, Nigeria; Antwi (2009) innovative methods for processing snail (*Achatina achatina*) meat powder of high microbiological and sensory qualities. This research was design to bridge the gap created by paucity of information about the yield and quality of snail meat from species of economic importance in relation to their stage of maturity. The results/findings will serve as a guide to producers, processors; policy makers, existing and emerging farmers as per the specie of economic importance. It will also form a premise for consumer preference.

1.3 Objectives of the Study

The objective of the study was to assess the yield and quality of three edible land snail species (*Achatina achatina, Achatina fulica and Achachatina marginata*) meats.

The specific objectives of the study were as follows:

i. To determine the chemical composition of fresh meat from the three species of Giant African land snails at different age groups.

ii. To determine the organs and shell characteristics of the three species of Giant African land snails at different age groups.

iii. To find out the organoleptic properties of fried snail meat processed from three species of Giant African land snails at different age groups.

iv. To find out the storage quality of fried snail meat processed from three species of Giant African land snails at different ages.

1.4 Hypotheses

The following were hypotheses for the research:

H_a: There are significant differences in the chemical composition of fresh snail meat from three Giant African lands snails at different ages.

H_a: There are significant differences in the organ and shell characteristics of snail meat from three species of Giant African land snails at different ages.

H_a: There are significant differences in the organoleptic properties of fried snail meat processed from three species of Giant African land snails at different ages.

H_a: There are significant differences in the storage quality of fried snail meat processed from three species of Giant African land snails at different ages.

CHAPTER TWO

2.0 Literature Review

2.1Origin and Distribution of Giant African Land Snails

The giant African Snails are pulmonate, nocturnal, hermaphroditic gastropods of the family Achatinidae. According to Hodasi (1995), the snails occur in sub-Saharan Africa, ranging from the Gambia in the West to the Lake Chad region in the East and that they extends southwards to the Orange River in South Africa. Monney (1994), showed that in Ghana, two species of the *Achatina* genus, namely *Achatina achatina* and *Achatina fulica*, and two species of the A*rchachatina* genus, namely *Archachatina degneri* and *Archachatina marginata* are known to occur.

2.1.1 Distribution of *A. marginata*

The species occur in western African; Cameroun through Democratic Republic of the Congo and can be found in the Carribean, in the Martinique. It is still unknown how the specie reached Martinique but it is possible they are intentionally introduced as pets or by workers returning from West Africa. Hence, the natural spread of this species is very slow; however, unintentional spread by individuals for foods and as folk medicine is very common. This specie has not yet become established in the United States, but it is considered to represent a potentially threat as a pest and invasive species which could negatively affect agriculture, natural ecosystem or commerce. Therefore it has been suggested that this species be given top national quarantine significance in the United States (Cowie *et al.,* 2009).

2.1.2 Distribution of *A. achatina*

Achatina achatina originates from the West African rainforest belt, from Guinea through Nigeria. Because *A. achatina* is the most prized species for consumption in Ghana it is becoming

increasingly rare in the wild. Several ecotypes (locally adapted populations of *A. achatina*) can be found, with differences in growth rates, size, aestivation (dormancy) patterns, colour and even flavour. The differences in size may be explained partly by differences in the length of the aestivation period; the shorter the aestivation period, the longer the feeding period and the larger, therefore, the ecotype (Cobbinah*et al.*,2008).

2.1.3 Distribution of *A. fulica*

The species originated in the coastal regions of East Africa (Kenya, Tanzania), and spread by the 19th century into Southern Ethiopia, Southern Somalia, and Northern Mozambique. During the 19th century it was introduced into India and the Indian Ocean islands. During the 20th century it was introduced, sometimes intentionally, into South East Asia, East Asia (Taiwan, Korea, and Japan), Australasia and the Pacific, the USA (now eradicated in various states), the Caribbean, Central America and South America (Brazil) (Cobbinah *et al*.,2008).

2.2Classification of the Edible Land Snails

The edible land snails belong to the phylum Mollusca (soft bodied) and the class Gastropod (stomach-footed). A comprehensive classification of the edible land snail is shown in Fig 1.

Molluscs belong to the group metazoa, which include the unsegmented flat worms (Yoloye, 1984). Land gastropods have a calcium store for shell building. Three basic morphological characteristics can be recognized in all members of the molluscs phylum.

2.3 Morphological and Anatomical Characteristics of Giant African Land Snails

2.3.1 The Mantle

This is a specialized sheet of tissue that secretes the shell and in many groups folds, down over the visceral mass leaving a mantle cavity (Malcom *et al.*,1976). The shell of a mature *Achatina*

achatina is about 10-14cm long at maturity. The shell has black wave streaks on yellowish brown background. The shell collar is pink and the skin is black with white spots. It is cone shaped. The apex of the shell is pointed in *Achatina achatina* while that of *Achachatina marginata* is blunt.

2.3.2 The Muscular Foot

This is an organ of slow locomotion, burrowing and swimming and also carries sense organ and the head. The head of *Achatina* bears long slender usually flexible feelers know as tentacles. Numerous teeth like projections called the radula are present in the mouth of the snail. The outer part of the edible portion is rough with white patches. The sole of the smooth ventral surface of the foot is usually light greyish in colour while the dorsal surface is blackish. The pedal mucous gland secrets mucus while facilitates the snail movement. It also prevents the snail and the delicate sole of the foot from drying (Segun, 1975).

2.3.3 Visceral Mass

It lies above the foot and carries the internal organs. The visceral mass of *A. achatina, which* is not eaten by man, makes about fine turns of coiling. It comprises the internal organs such as the heart, kidney, loop of intestine and reproductive organs etc. (Amusan and Omole 2000). Akinnusi (1998) stated that the visceral mass is unsegmented and the digestive system is well developed, with a mouth and anus. The mouth carries a hard rasping organ known as radula. The nervous system is concentrated in the head.

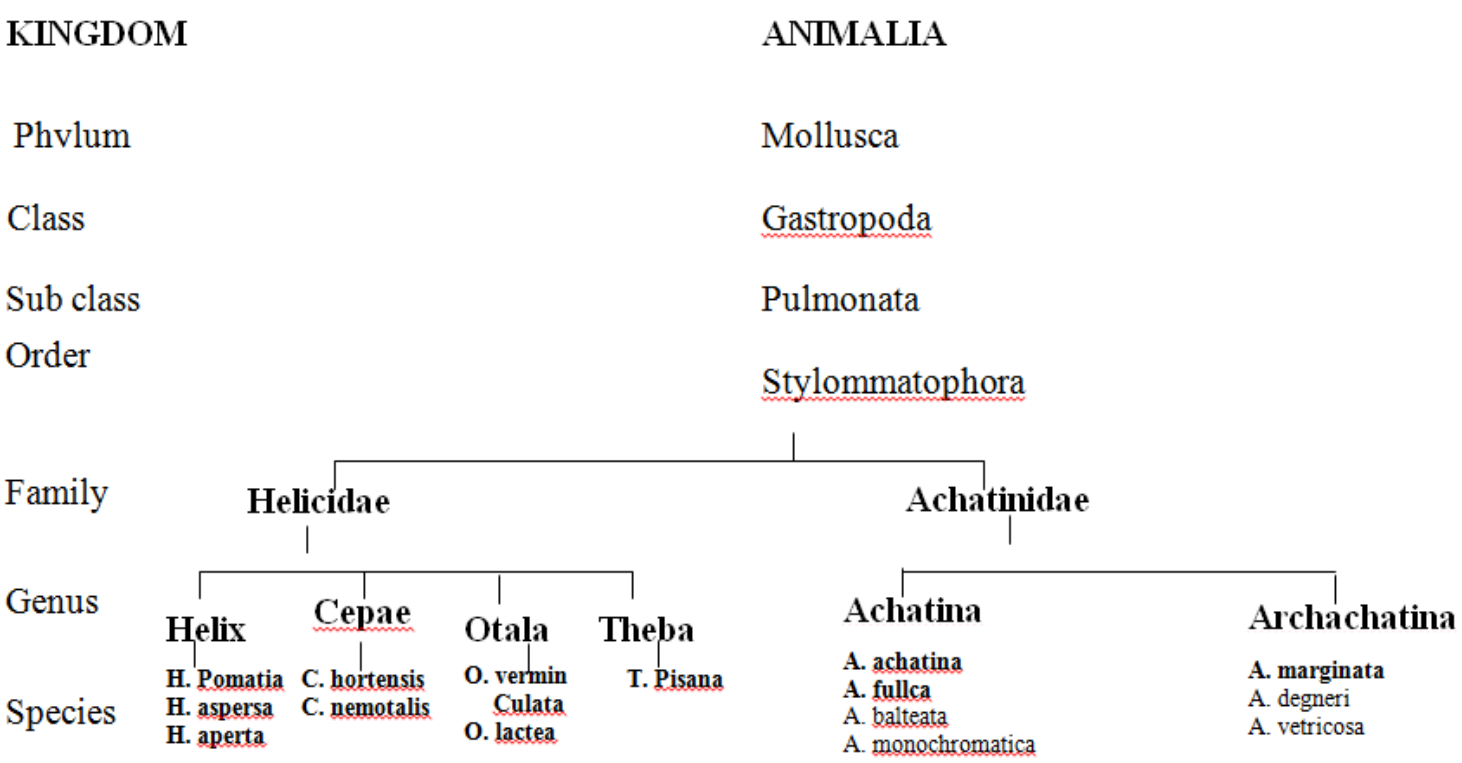


Fig 1: A comprehensive classification of the edible land snail

(Source: (Elufidipe, 2009)

2.4 Growth of Giant African Land Snails

Some snails grow faster than others within the same snail population and under the same conditions. Some will take longer time to mature. The long maturity period has been suggested to help the species survive harsh weather condition (Abakwam, 2016) Several factors can greatly influence the growth of snails. The factors include as follows: population density, stress such as noises, light, vibration, unsanitary conditions, irregular feedings, being touched etc, feed, temperature and moisture, and the breeding technology used. Adeparusi (2001) reported a reduction in growth rate of *Archachatina marginata* during the adverse condition of hamattan. They obviously went into aestivation with storage of water and a covering of epiphragm to prevent such external influence. The author further reported that a broken epiphragm was rapidly rebuilt in 2-3 days, while it takes two weeks for a broken epiphragm to disintegrate. The snail farmers had always sought after the appropriate inclusion of calcium on snail diet. Thompson and Cheney (1996) reported that 40% limestone flour promoted good growth in *Helix aspersa*. Daouda (1993) used 15% oyster shell for growing *Achatina achatina*. Amubode and Ogogo (1995) also used 70% bone meal and 30% Oyster shell in diets for *Archachatina marginata*. Low calcium intake will slow the growth rate and cause the shell to be thinner. Rebecca and Sheldon (2004) reported that snails may eat paint or attack walls of buildings and even eat dirt while seeking calcium.

A newborn's shell size depends on the egg size since the shell develops from the egg's surface membrane. As the snails grow, the shell is added onto in increments. Eventually the shell will develop a flare or reinforcing lip at its opening. This shows that the snail is now matured, and there will be no further growth. African giant land snails can live for 5 to 6 years although, just a few manage to live up to 15 years before they die (Akinomide, 1997). Growth is actually

measured by shell size, since a snail body weight varies and fluctuates, even in 100% humidity. The growth rate varies considerably between individuals in each population group. Adult size, which is related to the growth rate, also varies, thus the fastest growers are usually the largest snails. Eggs from larger, healthier snails also tend to grow faster and thus larger. Dryness inhibits growth and even stops activity. When it becomes too hot and dry in summer, the snail becomes inactive, seals its shell and aestivates until cooler, moister weather returns.

2.5 Overview of Snail Industry

In West Africa, snail meat has traditionally been a major ingredient in the diet of people living in the high forest belt (the forested area other than the savannah forest). In Côte d'Ivoire, for example, an estimated 7.9 million kg are eaten annually (Cobbinah *et al.*,2008). In Ghana, it is clear that demand currently outstrips supply. International trade in snails is flourishing in Europe and North America. However, in spite of the considerable foreign and local demand, commercial snail farms such as those in Europe, South-East Asia and the Americas hardly exist in Africa. In Ghana, Nigeria and Côte d'Ivoire, where snail meat is particularly popular, snails are gathered from the forest during the wet season (Cobbinah *et al.*,2008). In recent years, however, wild snail populations have declined considerably, primarily because of the impact of such human activities as deforestation, pesticide use, slash and-burn agriculture, spontaneous bush fires, and the collection of immature snails. It is therefore important to encourage snail farming (heliculture) in order to conserve this important resource (Cobbinah *et al.*, 2008).

Snails have a long standing importance as a source of human food and products from snail belong to foodstuff with high nutritional value (Tremlova, 2001), containing food energy, high quality proteins, vitamins and minerals. They are eaten by the rich and poor, urban and rural dwellers as well as in all continents of the world. The snail stands in the same position in the

world with fin, adductor and abalone which is popular all over international markets, especially Europe and America (ZASBDC, 2008). International consumption of snail products is about 400,000 tons which is equivalent to about 2,000,000 tons of fresh snail (ZASBDC, 2008). In forest zone of West Africa, snails are known to significantly contribute to the proteins and iron contents of the diets of the rural populace (Ogbeide, 1971: Ajayi *et al*., 1978) and the species, *Archachatina marginata,* is found mainly in the forest zone of Nigeria. In many parts of the world, considerable attention has been directed on studies relating to carcass evaluation and body composition of meat animals (Owen and Norman, 1977: Joksimovic and Ognjanovic, 1977) including snails (Ajayi, *et al.,* 1978). This is partly for providing information necessary for a full evaluation of improvements in nutrition, general management and genetic up-grading of the meat animals under consideration and partly because the knowledge of (and information on) the size and weight of the edible portion as well as the chemical composition from a particular type of animal can greatly assist in more efficient marketing or pricing of such an animal. It is known, judging from results obtained from previous studies on conventional meat animals, that the proportion considered to be edible differs from one type of animal to another.

2.6 Description of Commercial Snail Species

2.6.1 *Achatina achatina*

Achatina achatina snails are reputedly the largest land snails in the world. *A.achatina* can grow up to 30cm in body length and 25cm in shell height. Average adult shell length is 18cm, with an average diameter of 9cm. The conically shaped, fairly pointed shell is brownish with a characteristic stripe pattern hence the name tiger snail**(**Cobbinah *et al.,* 2008)

2.6.2 *Achachatina marginata*

This is called the big black snail, commonly found in the forests along the coasts of West Africa. The shell has a mottled colour of black, brown and white and is very thick. The shell is wider at the posterior end (Apex) compared to others (Awesu, 1980; FAO 1986). The fleshy part (foot) is dark-brown in colour. Some small breeds of white skin are found in some areas. It lays between 4-16 eggs per lutch, the hatchlings weighed between 2.0-5.0g. At maturity, they are 11-19cm long and weight 150-800gm. They grow to full size in 18-24 months. The dark skinned type is the most preferred snail in Nigeria (Amusan and Omidiji, 1998).

2.6.3 *Achatina fulica*

Achatina fulica (garden snail, foolish snail) is a large snail, reaching 20 cm in length or occasionally more, with a shell length up to 20 cm and a maximum diameter of 12 cm. The conical, spiraled shell is predominantly brown with weak, darker banded markings across the spiral. Colouration is highly variable, depending on diet. A mature snail averages 250 g in weight. The snails may reach sexual maturity in less than a year. Larger snails continue to feed on plant materials, but feed increasingly on detritus as they age. Normally, they live for 3-5 years**(**Cobbinah *et al.,* 2008)

Table 2.1: Differences between the three Giant African Land Snails

Parameters	*A.achatina*	*A. marginata*	*A. fulica*
Meat softness	Softer	Soft	Softest
Body colour	Dark blue	Dark brown	Light brown
Body back line	Black	Black	Brown
Tentacles/eye	Dark brown/black	Dark brown/back	Light brown/brown
Shell design	Specific to type	Specific to type	Specific to type
Shell apex	Pointed	Blunt	Pointed
Shell strength	Strong	Very strong	Weak
Shell transparency (Juvenile)	Translucent/Opaque	Translucent/Opaque	Transparent/translucent
Adaptability	Less adapted	More adapted	Most adapted

Source: Akintomide (2004)

2.7 Snail Production in Nigeria

The two main areas of snail consumption in the world are Western Africa and Western Europe (Owolabi, 2002). In spite of the considerable external and local demand, commercial snail farms such as those in Europe, South-East Asia and the America do not exist in West Africa. In Nigeria, Ghana and Cote d'Iviore where snail meat is particularly popular, snails are gathered from the forests. (Owolabi, 2002). One of the important alternative sources of animal protein, which has received relatively scanty attention in Nigeria is the snail. Elsewhere, the potential of snail as source of high quality protein has long been recognized. For instance, snail breeding started as far back as the beginning of 20th century (Ayodele and Asimalowo, 1999) and the Romans raised snails on farms and fed them with special herbs to improve their taste and increase overall snail meat availability (Odiabo, 1997), even today, commercial snail production continues to be an important economic activity in several countries including Italy and France (Baba and Adeleke, 2006).

In spite of the potentials and advantages of snail farming, widespread participation in its production by farmers has not been achieved in Nigeria. Much of the snails marketed in Nigeria are from the wild. Few farmers exist for commercial breeding and production of snail. This is attributed to a lack of awareness of the economic potentials of this micro livestock (Baba and Adeleke, 2006).

Snail farming (Heliculture) is an evolving industry that is laying a solid foundation for long-term economic freedom for the people involved. The business yields good returns. Many Nigerian entrepreneurs are beginning to think that way. The need to achieve food security (produce enough food) for an estimated population of about 206 million (NPC, 2020) has always worried

the government of Nigeria and several schemes were implemented in the past to achieve this objective (FAO, 2003).

Food security is the state of self-sufficiency in food production achieved by developing and implementing policies, aimed at guaranteeing availability of food for the family as well as crops/raw materials for domestic industries, trade and export. According to FAO (2003), one of the objectives of the food security project (FSP) is to contribute to sustainable improvement in national food security and poverty eradication, especially, those that improve the environment and comfort of homestead such as windbreak, apiculture, snail production and wild life domestication. Asheye, *et al,* (2001) reported that snail could be used to reduce the problem of nutrition. Over 80% of the Nigerian populace is poor to whom protein products such as meat are a rare luxury. To avert the dangers of malnutrition, especially among children, the giant African land snail is a good substitute of a source of protein (Bayode, 2009).

According to Olukayode (2005), snail farming is an investment for the present and the future. A very simple and exciting way of making provision for the rainy day/inactive old age. The death rate of snails is very low. Training period is very short and trainees are assured of adequate knowledge to make them establish and manage successful farms. Snails' farming is one of the most lucrative businesses that one can embark upon, either on small or large scale, with very low initial capital out lay. Snails are very prolific (they reproduce very fast). It is estimated that if one start a snail farm with one thousand adult snails, one is sure to harvest over 16,000 snails in six months and 160,000 snails in 12 months (Olukayode, 2005).

In spite of the various agricultural development strategies adopted in Nigeria, protein intake (estimated at less than 10g per capital per head) remains a far cry from the Food and Agriculture

Organization (FAO) recommended minimum requirement of 35g (Kehinde *et al*., 2002). Snail farmers in Nigeria were only a few. They start in small scale. The reason is because the awareness is yet to be created. The World Bank has taken a step to fund the research into snail production. They must have studied the feasibility of snail farming and had convinced ideas that it will boost the economy of the world (ENADEP, 2009).

2.7.1 Fattening of snails

The young snails are transferred to fattening cage after 6 months. Feed should be provided in excess of daily requirement. The cage must remain damp to prevent aestivation which reduces snail activity and growth (ENADEP, 2009).

2.7.2 Maturity

After 6 months, the *Achatina fulica* is about 35mm long and may already be sexually matured. Sexual maturity takes 6 to 16 months depending on weather and the availability of calcium.*Archachatina marginata* mature asexually between 10 to 12 months, while that of *Achatinaachatina* is 8 to 10 months. *Achatina achatina* reaches a body weight of between 80 and 250g in 18 months to two years, whereas adult *Archachatina Marginanta* weights about 350g or more (Bayode, 2009). When the temperature falls below 7.2^0C snails hibernate, under 12.2^0C the snails are inactive and under 10^0C , all growth stops (ENADEP, 2009). At the age of 15 months, their shells have become hardened and they are ready to be sent to market as very mature adult. is brownish with a characteristic stripe pattern (hence the name tiger snail).

2.8 Nutritional Value of Snail Meat

Snails have a long standing importance as a source of human food and products from snail belong to foodstuff with high nutritional value (Tremlova, 2001), containing food energy, high quality proteins, vitamins and minerals. Snail meat tastes good and it is also good for the body. It serves as special delicacy in the diet. Studies conducted on snails indicated that snail meat is particularly rich in protein and iron (Akinnusi, 1998). The fresh flesh of the land snail contains at least 70% water while its dry matter consists of high quality protein with high contents of Lysine, Leucine, Arginine and Tryptophan. In addition to the high levels of protein and iron, snail meat also contains high levels of calcium and phosphorus. It is low in sodium, fat and cholesterol (Elufidipe, 2009).

Investigation by Akinnusi (1998) revealed that snail meat contains 70% of water while its dry matter is high in essential amino acids such as lysine, leucine, arginine, tryptophan and 30% minerals. Snail is also a source of calcium ortho phosphate, a chemical substrate for curing kidney diseases (Imevbore and Ademosun, 1988). A recent study has also shown that the glandular substances from edible snails cause agglutination of certain bacteria; this could be of value against a variety of ailments including whooping cough (Cobbinah *et al*., 2008).

Snails, like shellfishes are highly nutritional balanced food (Ifon and Umoh, 1987). The meat of snails is highly relished and considered a delicacy in the West African zones, especially in Nigeria and Ghana (Agbelusi and Ejidike, 1992; Cobbinah *et al.,* 2008). It is high in protein (12-16%), iron (45-50) mg/kg and a good source of calcium. Snails have a low fat and low cholesterol content compared to other protein sources like poultry and pigs. According to Cobbinah (1997), the meat of *A. marginata* has 12–60% protein, 0.05–0.8% fat and 45–50 mg/kg iron content. Also snails have almost all the amino acids needed by humans (Cobbinah *et al.*,

2008). Ajayi (1978) reported that snails have low lipid and saturated fatty acids, which have important health implication and may be beneficial to hypertensive patients and others who do not take fatty foods. In European countries like France, cooked land snails are an expensive and sought out meal. Escargot is a dish of cooked land snails, usually served as an appetizer in France and in French restaurants (Manaphraim 2013).

The table below shows the nutritional value of snail as reported by different authors.

Table 2.2Proximate Composition (%) of Snail Meat

Parameters (%)	***Ejidike, and Afolayan (2010)***	***Emelue and Dododawa (2017)***	***Olatidoye and Sobowale (2016)***			***Ebunoluwa et al. (2015)***		
			AA	***AM***	***AF***	***AM***	***AA***	***AF***
Moisture	9.4	37.10	67.89	55.89	55.89	76.34	75.26	74.20
Crude Protein	52.9	61.25	16.01	16.97	15.57	18.30	18.42	19.45
Fat	1.4	3.25	1.19	1.33	1.02	2.16	2.20	2.18
Ash	5.0	5.50	5.52	5.79	5.02	1.14	1.13	1.12
NFE	-	30.00	77.13	76.98	77.84	2.06	2.99	3.10
Crude Fibre	-	0.00	-	-	-	-	-	-

AA = Achatina achatina, AM = Archachatina marginata, AF = Achatina fulica,

2.9 Composition of Snail Meat

The data provided below originate from Nigerian studies of the Giant African Land Snail species *Archachatina marginata*. It can only be assumed that the composition and nutritive value of the other two Giant African Land Snail species are more or less the same (Cobbinah*et al.*,2008)

Table 2.3: Approximat*e* dressing percentage of snail meat.

Total lives weight	**100%**	**Remarks**
Meat	40%	Edible foot of the snail
Shell	30%	
Viscera	17%	
Body fluids	13%	Haemolymph

Source: (Cobinnah*et al.*,2008)

2.10 Health Benefits of Snail Meat

Snail meat has traditionally been a major ingredient in the diet of most people living in the forest belt of West Africa and it has been consumed since prehistoric times (Beckett, 1964; Cobbinah, 1993). In addition to being rich in nutrient, snail meat has been shown to have medicinal value and can treat ailments including whooping cough and other conditions (Akinnusi, 1998). Due to its high iron content it is considered important in the treatment and prevention of anaemia. In the past, it was recommended as a means of combating ulcers and asthma (Akinnusi, 1998). In traditional homes, snail meat is used to prepare light soup and 'kontomere' soup in Ghana and pepper soup in Nigeria (Samuel, 2009). The bluish liquid obtained from snail has high iron content and is used for treatment of anemia, hypertension and poor sight (Imevbore and Ademosun, 1988). The formulations from this liquid can be used to treat burns, abscesses and other wounds, measles, small pox and some skin diseases (Bayode, 2009). In Ghana, the bluish liquid is believed to be good for infants' development (Asheye *et al.*,2001). According to Amao *et al;*(2007), snail meat is recommended in the past for treatment of ulcer, asthma and even at the imperial court. In Rome, it was thought to contain aphrodisiac properties (arousing or increasing sexual desire) and was often served to visiting dignitaries in the evenings. Snail meat being rich in calcium, potassium, magnesium and iron is recommended for a hypertensive and pregnant women. It is important source of protein to human diet, additional source of income to farmers.

The Zinc obtained from snail is a valuable factor in the maintenance of healthy prostate gland (Fabian, 1999). The glandular substances from the edible snail cause agglutination of certain bacteria which could be of value against a variety of ailments including whooping cough (Cobbinah, 1993). In folk medicine, the bluish liquid obtained when the meat has been removed from the shells is believed to be good for infants development. It is believed in some quarters,

that snail meat contains pharmacological properties of values in counteracting high blood pressure.

2.11 Factors affecting the consumption of snail Meat

The close contact of snails with soil and their uncontrolled feeding pattern make the snail susceptible to microbial contamination. Snails inherently have high populations of indigenous bacteria and coliforms and other poisonous substances which they ingest (ICMSF, 2005). The meat can be easily contaminated by pathogens and serve as vehicle of transferring infectious agents to consumers. Kirkan *et al.* (2006) reported the presence of *L. monocytogenes* in fresh snail sample which notably could have been contaminants from soil. So, despite rich nutritional values of snail, the involvement of the molluscs in the transmission of infection mostly as secondary host for pathogens makes some people reluctant to consumption of snail meat.

Price is a major constraint to snail meat consumption; due to its scarcity, snail meat is more expensive than other meat of food animals. Snail meat (GSA) at Global Foods was $15.98 per pound, while the average price for USDA Choice sirloin steak and boneless chicken breast at the local grocery stores were $5.99 and $2.99 per pound, respectively (Olaleye, 2013).

Cleaning and prepping live snails for cooking is a constraint because it involves several processes which include storing the snails in bucket or sack in a shaded and cool place for up to 4 days without food, to enable the snails to discharge all aliments in their intestinal tract (Cobbinah *et al.,* 2008). Upon extraction of the snail meat from its shell, the snail requires washing with vinegar or lime or lemon juice several times to remove the slime on its body. Then it requires parboiling with salt and vinegar to kill pathogen (Cobbinah *et al.,* 2008). Although snail meat is very nutritious, there are many superstitious beliefs about snails; while some are positive; others portray the eating of snails as a taboo. Some cultures believe that eating snails

makes an individual sluggish or slow due to the slimy nature of the snail's secretion (Olaleye, 2013).Gomot (1998) stated that the consumption of snail meat in rural areas is closely associated with the condition of the surrounding forest and a densely populated region with few forestshaving snail meat contributing less to their total meat consumption.

Table 2.4: Differential attitude towards snail meat consumption between urban and rural inhabitants

Statements	Urban (n=72)	Rural (n=43)
1. Snail meat is a taboo in my area	1.29	1.35
2. Snail meat is irritating	1.32	1.42
3. it adds variety to food	4.00	4.19
4. It is the best meat	4.00	2.19
5. It is forbidden and should not be eaten at all	2.01	3.53
6. Snail meat is highly medicinal	3.47	4.16
7. It is very expensive and unaffordable	4.35	4.05
8. I love snail meat	3.96	4.23
9. Snail meat is very nutritious	4.11	2.40
10. My religion is against consumption of snail meat	2.08	2.88
11. Source of snail meat is very distant	3.19	2.91
12. The meat is tasteless	2.61	3.72
13. The processing of snail meat takes a lot of time	3.92	2.49
14. I dislike the species of snail I see in my area	2.65	2.65
Grand mean	**3.07**	**3.01**

NB: any mean score that is less than or equal to 3.00 implies disagreement with the statement, while any mean that is greater than 3.00 implies agreement with the statement (Agumagu and Adesope, 2006).

2.12 Predators, Parasites and Diseases of Snails

There are a number of predators, parasites and diseases which snail farmers must be aware of if mortality rate is to be kept to a minimum (Cobbinah, 1993).

2.12.1 Predators

The major predators of snails are field mice, rats and shrews, frogs and toads, thrushes, crows, lizard, centipede, carabid beetle and larva, snakes, millipedes, drilled and domesticated birds such as ducks and turkeys. The frogs tend to take only the young snails, while reptiles eat both the eggs and the snails (Cobbinah, 1993). In areas with high bird predation, it is necessary to use cover nets over the pens. Keeping some of the predators out may require building fence, between 15 and 30 cm high and digging the ground around the pens. It is also advisable to set bait or traps outside the snail farm area. Leftover food should be removed regularly from pens because some predators, particularly rats and field mice, are attracted by the uneaten food. These predators can decimate a farm in a few days. The main predators, however, are humans. A snail farmer must introduce any measures he or she considers necessary to protect the farm against poachers

2.12.2 Parasites

According to Cobbinah (1993), the major parasite on snails was found to be *Alluaudihella flavicornis*. This species belongs to the same family as the housefly and the adult resembles the adult housefly. A flavicornis lays 20-40 eggs in the snail shell or on the snail. The eggs hatch in about 1 week and the small, cream-coloured worms start feeding on or in the body tissue. They feed until the body is reduced to a putrefying mass, and then pupate within the shell. After a 10-day incubation period, the adults emerge. The best protection against these flies is to cover the pens with nylon mesh. Ectoparasitic mites are sometimes found on the snails in hatch boxes. They appear to be secondary parasites, usually occurring on inactive snails. Some nematodes are

known to attack European species of edible snails. However, there are no reports of nematodes parasitizing *A.achatina*.

2.12.3 Diseases

Little is known of the diseases, which attack *A. achatina* in West Africa. The main disease, which has been reported to date, is a fungal disease, spread through physical contact by the snails licking slime from each other's bodies, (Cobbinah, 1993). It is possible that two major diseases affecting European species also affect African species because the causal organisms of these diseases do occur in the natural range of *A. achatina*. The first disease is a bacterial disease, caused by *Pseudomonas*; it leads to intestinal infections, which may spread rapidly amongst dense populations of snails. The second disease is caused by the fungus *fusarium*, which attacks the eggs of *Helix aspersa*. The affected eggs turn reddish-brown and development stops. This disease is commonly referred to as 'rosy eggs disease'.

Basic hygiene will prevent the spread of diseases. Pens should be cleaned out regularly to remove excreta and uneaten food, as well as any other decaying matter that may serve as substrate for pathogenic organisms. It is also advisable to sterilize the soil in hutch boxes (Cobinah, 1993).

2.13 Microbial Contamination Associated with Snail Meat

Snails are gastropods and tend to walk on their belly. They may be found gliding on the surface of soils or buried under the soil or leaves. For this reason, the shell and meat of snails are exposed to a spectrum of microoganisms. Live bacteria may be present in lymph nodes and certain parts of the body, some of which may remain after evisceration (Girard, 1992). Live bacteria are also found in the gut of animals which play a useful role in digestion. Some of these microoganisms find their way to the carcass during dressing processes (Wilson, 1981). Other

sources of microbial contamination include the hands, tools, utensils, clothing and others used in preparing the snail meat before drying. Microorganisms associated with snail meat include aerobic mesophils, halophilic bacteria, coliforms, faecal coli, *Clostridium* spp., *Staphylococcus aureus* and molds (Harris *et.al* 1975; Speck 1984).

These different kinds of microorganisms have different characteristics. Some may multiply rapidly at around 10 ℃ while others multiply rapidly at different temperatures. Some contain proteolytic enzymes which attack the protein portion of the meat causing putrefaction which results in the production of an unpleasant putrid odour. Others also cause fat oxidation to produce free fatty acids of unpleasant smell. Some have little or no effect on the meat while some microorganisms may release gummy substances producing slimes on the meat (Wilson, 1981).

The close contact of wild snails with soil and their uncontrolled feeding pattern make the snail susceptible to microbial contamination. Snails inherently have high populations of indigenous bacteria and coliforms and other poisonous substances which they ingest (ICMSF, 2005). The meat can be easily contaminated by pathogens and serve as vehicle of transferring infectious agents to consumers. Kirkan *et al.* (2006) reported the presence of *L. monocytogenes* in fresh snail sample which notably could have been contaminants from soil. So, despite rich nutritional values of snail, the involvement of the molluscs in the transmission of infection mostly as secondary host for pathogens makes it necessary to study the microbiology of the resident snail. The fact the consumption of field-collected snails may lead to bacterial infection, the provision of a systemic farming of snails will help solve both the problem of depletion of snail populations as well as provision of a relatively wholesome meat with less microbial contaminations (Upatham *et al.*, 1988).

2.13.1 Spoilage Organisms

Chemical reactions that cause offensive sensory changes in foods are mediated by a variety of microbes that use food as a carbon and energy source. These organisms include prokaryotes (bacteria), single-celled organisms lacking defined nuclei and other organelles, and eukaryotes, single-celled (yeasts) and multicellular (molds) organisms with nuclei and other organelles. Some microbes are commonly found in many types of spoiled foods while others are more selective in the foods they consume. Multiple species are often identified in a single spoiled food item but there may be one species (a specific spoilage organism, SSO) primarily responsible for production of the compounds, causing off-odours and flavours (Ellin, 2007). Within a spoiling food, there is often a succession of different populations that rise and fall as different nutrients become available or are exhausted. Some microbes such as lactic acid bacteria and molds secrete compounds that inhibit competitors (Gram *et al.*, 2002).

2.14 Harvesting and Yield of Snail

According to Cobinnah, *et al.* (2008) the age and size at which snails should be collected from the snailery obviously depends on the farming objective: whether the snails are grown for personal use or for the market. Snails grown for personal use can be harvested according to the farmer's needs; whereas customer preferences dictate the optimum size and consequently age of snails harvested for the market. Snails usually need to grow for at least one year to reach their proper size and weight. It is recommended to harvest snails by the time they reach two years, because after this age their rate of growth slows down. However results from interviews of 50 consumers conducted by Emelue *et al.* (2013) showed that about 56%, 30% and 14% preferred the big, medium and small snail sizesrespectively. Yield is the main quality parameter in the

processing of meat because it determines the amount of available product for sale and is therefore of direct economic importance.

2.15 Meat Quality

Meat quality is a generic term used to describe properties and perceptions of meat. It includes attributes such as carcass composition and conformation, the eating quality of the meat, health issues associated with meat and production-related issues including animal welfare and environmental impact (Maltin *et al.*, 2003). These factors combine to give an overall assessment of meat quality by the ultimate arbiter, the consumer. The critical point of appraisal of meat quality occurs when the consumer eats the product, and it is this outcome, together with views of colour, healthiness and price, that determine the decision to re-purchase (Boleman *et al*., 1997). Meat quality evaluation is important in improving meat production (Barbera and Tassone, 2006). For instance in the processing of meat, yield is the main quality parameter, it determines the amount of available product for sale and is therefore of direct economic importance (Aaslyng, 2002). However, consumer evaluation of eating quality is the major determinant of meat quality, with tenderness, juiciness and flavour of meat being the most important elements (Martin *et al*., 2003). However, the main source of consumer complaint and the primary cause of failure to re-purchase is the variability in eating quality, especially tenderness (Bindon and Jones, 2001).

According to Kassim (2013) the quality of meat products could be assessed based on certain intrinsic and extrinsic characteristics. It is nevertheless better reflected by consumers' perception, which although different from the real and objective quality, it determines the purchase of the product. Factors influencing demand for product quality are found to be linked to the social, economic and cultural context and other factors affecting diet habits (Kassim, 2013). The quality of meat products could be assessed on the basis of a number of attributes and this includes

evaluation and assessment of oxidative and flavour deterioration and how microbiologically safe the product is. Some of the methods of assessing meat quality include cooking loss and microbial assessment.

2.15.1 Cooking loss

Cooking is a process of heating meat at sufficiently high temperatures that denature proteins and make it less tough and easy to consume (Garcia- Segovia *et al.,* 2006). Cooking loss, which is one of the meat quality parameters, refers to the reduction in weight of meat during the cooking process (Vasanthi *et al.,* 2006). Among different methods to evaluate cooking effects on meat, the cooking loss measurement represents the most rapid and important to estimate some correlated quality characteristics such as juiciness and evaluate some economic aspects (Bertram *et al*., 2004). Most of the water in the living muscle is held within the myofibrils and any large changes in the distribution of water within the meat structure originate from changes in this spacing. Cooking induces structural changes which decrease the water holding capacity of the meat. As observed by Palka and Daun (1999), increasing the temperature to 100°C causes the meat structure to become more compact due to a significant decrease in fiber diameter. During heating at varying temperatures (37–75°C), meat proteins denature and cause structural changes such as transversal and longitudinal shrinkage of muscle fibers and connective tissue shrinkage (Offer, 1984).

The sensory quality of the processed product has an indirect economic importance because it influences, most especially, how often a consumer buys the same product again, which expectedly, would influence the amount of product sold (Aaslyng, 2002). Quality indicators in the raw meat that can predict the yield of the processed meat are especially pH and water-holding capacity, whereas the sensory quality of the processed meat can be influenced by the colour, the

meat/fat distribution and the fat quality in the raw meat (Aaslyng, 2002). Consumers concern for meat and meat products have greatly increased during past decade (Min and Ahn, 2005). This will greatly influence the quantity of the raw meat and meat products purchased. Lennernas *et al.* (1997) reported that quality and healthfulness are among the most important factor that influences the choice of consumers for foods. Research and development on value-added meat products are limited. Previous studies on nutritional information on local meat and meat products revealed some food consumption data/information and isolated reports on nutritional quality of local meat products. With the consumption of processed meat products on the increase, it is pertinent to monitor the qualities of such food products.

2.15.2 Microbiology Assessment of Meat

Microbial contamination of meat leads to rapid spoilage and thus seriously affects the consumer acceptance and economic loss (Fakhruddin *et al.,* 2003). During processing and storage, the meat is more prone to pigment and lipid oxidation, thus decreasing organoleptic qualities of the meat products and posing a major problem in the storing convenience of meat products (Pearson *et al*., 1983; Verma and Sahoo, 2000). The bacterial safety and rate of spoilage depends upon the numbers and types of micro-organisms initially present, the rate of growth of those microorganisms, the conditions of storage (temperature and gaseous atmosphere) and characteristics (pH, water activity *a*w) of the meat (James and James, 2002).

2.16 Processing of Snail Meat

Snail meat is a popular food widely distributed inSouthern Nigeria (Arene *et al.,* 1999). It is also a major source of income to the people (Ezeama, 2000). However, spoilage sets in after 48 hours of harvest while shrinking accelerates the spoilage rate as the meat cannot be kept in acceptable

conditions after approximately 12 hours. This is why the preservation of the meat has become a major concern to both processors and consumers (Ezeama, 2000).

According to Cobinnah, *at al.* (2008), freshly gathered snails that have just eaten (except if collected when aestivating or hibernating) can be used directly, but all faeces and dirt must be removed in the kitchen. Cobinnah maintained that it is easier and more hygienic to have the snails defecate before use, to be stored them in a basket or sack in a cool, shaded place without food for four days, to enable them to discharge all aliments in their intestinal tract and subsequently washed, boiled and dressed. The procedure for washing, dressing and boiling is highlighted in sections 2.16.1, 2.16.2 and 2.16.3 respectively.

2.16.1 Washing

Snails are poured in a bucket with water, with some salt and a dash of vinegar. Lemon or lime juice can be used instead of vinegar. Immediately, the snails will start to discharge their slime: a milky, whitish liquid. Throw away the water and repeat the washing procedure until the water remains clear (Cobinnah,*et al*, (2008).

2.16.2 Dressing

The snail is extracted from its shell, draining off the body fluid or haemolymph (unless local recipes call for its use), remove the viscera (heart, stomach, kidney, liver, intestines) and cut off the head. The meat is now ready for boiling, stewing, frying depending on the cooking technique required by local snail recipe (Cobinnah,*et al*, (2008)

2.16.2 Boiling

After washing, the snails are poured into boiling water, with some salt and vinegar, or lime or lemon juice, and boil thoroughly for at least 5 minutes. *Achatina fulica* (and possibly the other Giant African Land Snail species) is reported to be an intermediate vector of the Rat lungworm

and other diseases potentially lethal to humans. Improperly cooked *Achatina fulica* meat may act as a major source of human infection in places where it is commonly eaten by people, such as in asia. Thorough boiling is essential(Cobinnah,*et al,* (2008)

2.16.4 Frying

Frying is a food processing method used to prepare both homemade and industrial products, which is widespread due to the sensory and organoleptic characteristics that make fried food more attractive to consumers (Simeon *et al*., 2012). It is a very convenient method of cooking as it is fast and requires little food preparation (Fillion and Henry, 1998). Another reason for its great popularity is that frying generates very palatable foods due to the fat content, the crisp texture and rich flavours. It is an extremely complex process involving many factors some of which are dependent on the process itself and others on the food and the type of fat used (Fillion and Henry, 1998). It is mainly a dehydration process with three distinctive features compared to other processes;

- The high temperature of the oil (around 180^0C) allows rapid heat transfer and a very short cooking time (only a few minutes).
- The temperature inside the product does not usually exceed 100^0C (Califano and Calvelo, 1991).
- The process does not involve water hence there is no leaching out of water-soluble compounds, but instead some frying fat is absorbed in replacement or exchange of water lost by evaporation.

There are two main methods of frying, which are shallow and deep frying

Shallow frying:In shallow frying, food is cooked in a frying pan with a little amount of oil or fat. The oil or fat is heated to the appropriate temperature and the food is put into the heated

oil. The food is turned over a few minutes or is stirred around a couple of times before it is cooked and dished out.

Deep frying:This involves frying in a large amount of oil. The fat is usually heated to about 350^0F (177^0C) and the hot fat completely covers the food. Deep frying is primarily a dehydration process, which means that water and water-soluble substances are extracted fromthe product being deep fried and transferred to the cooking fat, and at the same time the product being deep fried absorbs surrounding fat (Choe and Min, 1997). If the product to be deep fried is placed in hot fat, the water on the surface evaporates and moves from the inside of the product being deep fried to the outer layer to compensate for the loss of water at the surface. During frying, the culinary fat or oil acts as a heat transfer medium and at the same time becomes an important ingredient of the fried food due to water loss as well as penetration of oil into the food (Ghita *et al*., 2010). As the water released does not readily move from the hydrophilic surface of the food to the hydrophobic cooking fat, a thin layer of steam forms between the fat and the product being deep fried (Abiona *et al*., 2011). The speed of the transfer depends more or less on the structure of the outer-crust. As soon as the transfer of the water ends, the temperature inside the food starts to rise above 100^0C. At this point the typical deep-frying aroma, taste and the gold yellow colour begin to develop and the formation of acrylamide begins. The moisture released from the food forms a protective shield, preventing direct contact of oxygen to the fat surface. The quality of the product cooked depends on (temperature, frying time, fryer type; frying oil (properties of the oil (chemical and physical) and additives, contaminants and the food (properties of food-chemical and physical, preparation, ingredients interchange with oil (Varela, 1988).

2.17 Sensory Evaluation of Meat Products

Sensory or organoleptic qualities of meat are determined by sensory characteristics relating to colour, texture, aroma, flavour and juiciness. These are influenced by a number of factors including pre-slaughter handling, muscle composition, post slaughter biochemical reactions and technological factors (Nasir *et al.,* 2011). The sensory quality of the processed product has an indirect economic importance as it might influence the amount of sold product, especially how often a consumer buys the same product again (Aaslyng, 2002). All eating quality attributes are influenced by factors within the production system, including feeding strategies, gender and slaughter weight and also by processing methods (Wood *et al*., 1995). It is known that the sensory properties (smell, taste, colour, juiciness, texture and tenderness) represent the principal factors able to condition drastically the choices of the consumers at the moment of purchase, therefore, they have a role of primary importance regarding the qualification of the product (Porcu *et al*., 2007). The organoleptic test showed that the taste of the meat (which invariably determine consumers acceptability is a function of processing, preservation and the type of meat (Linda *et al.,* 1990). Flavour, appearance, tenderness and juiciness are very important attributes with regard to eating quality of meat (Wood *et al*., 1995).

2.17.1 Hedonic Scale

Hedonic scales are used to determine degree of acceptability of one or more products. This scale is a category-type scale with an odd number (five to nine) categories ranging from “dislike extremely” to “like extremely.” A neutral midpoint (neither like nor dislike) is included (Zoecklein, 2005). Consumers rate the product on the scale based on their response. Some of the sensory qualities include:

2.17.2 Flavour and Aroma

Flavour is experienced during mastication when volatiles are released in the oral cavity and aroma is perceived by the olfactory system. Flavour is generated from reactions of various flavour precursors including reducing monosaccharides and inosine monophosphate (IMP) during heating (Mottram and Madruga, 1994). Flavour is mainly generated during the heating process and the maillard reactions involving reducing carbohydrates and amino acids are one of the most important routes to flavour formation (Mottram, 1991). Reports have shown that cooking process in relation to flavour formation is significant and temperature is an important factor. For instance, Wood *et al*. (1995) showed that pork flavour increased as the core temperature of grilled steaks increased from 65 ºC to 80 ºC, while both juiciness and tenderness simultaneously decreased.

2.17.3 Tenderness

Tenderness is defined by the ease of mastication, which involves initial penetration by the teeth, the breakdown of meat into fragments and the amount of residue remaining after chewing (Lawrie, 1998). Meat tenderness is considered the most important palatability attribute of meat (Cross *et al.,* 1986) and it's a critical eating quality which determines whether consumers are repeated buyers (Koohmaraie *et al*., 1989). Variations in tenderness affect the decision to repurchase (Maltin *et al*., 2003). Tenderness is an integrated textural property composed of mechanical, particulate and chemical components. The mechanical characteristics include hardness, cohesiveness, elasticity, grittiness and fibrousness while the chemical characteristics of meat include juiciness and oiliness (Brewer and Novakofski, 2008). Tenderness being a complex trait depends on sarcomere length, muscle/connective tissue proteins and proteolytic degradation and these might have accounted for most variation in tenderness of meat (Koohmaraie *et al.,*

2002). Tenderness has also been shown to depend positively upon intramuscular fat (Aaslyng and Støier, 2004) and ageing (Wheeler and Koohmaraie, 1994), and negatively on the amount of connective tissue (Honikel, 1992).

2.17.4 Texture

Texture plays a crucial role in determining food quality, its acceptance by consumers and eventually their preferences (Guinard and Mazzuchelli, 1996; Szczesniak, 2002) and is one of the most important sensorial attributes in the process, selection and consumption of foods (Szczesniak, 2002). Bourne (1975) defined food texture as 'the response of the tactile senses to physical stimuli that result from contact between a part of the body and the food'. Other researchers have also included a contribution from the other senses, such as vision, hearing, olfaction, and kinesthesia in their definition (Szczesniak, 1990).

2.17.5 Juiciness

The two sensory descriptive words for juiciness, in cooked meat, are initial and sustained juiciness (Lyon and Lyon, 1989). Initial juiciness is the amount of fluid released by the cut surface of meat, during compression between the forefinger and thumb (AMSA, 1995). Initial juiciness of meat is positively correlated with the water holding capacity of meat, which is influenced by the muscle's ultimate pH at post mortem (Offer and Trinick, 1983). Sustained juiciness is described as the perceived juiciness after a few seconds of mastication, due to the presence of intramuscular fat stimulating saliva secretion (Lawrie, 1998). Juiciness is the feeling of moisture in the mouth during chewing. It is a dynamic attribute changing during the chewing process (Aaslyng, 2002). The content of intramuscular fat is positively correlated to juiciness (Cummings *et al*., 1999; Brewer *et al*., 2001). Juiciness is an important factor in sensory evaluation as it facilitates the chewing process as well as brings the flavour component in contact

with the taste buds (Aaslyng *et al.*, 2002). The juiciness of meat depends on the raw meat quality and the cooking procedure (Aaslyng *et al.,* 2002). Other factors like concentration of glycogen could also influence the juiciness as an increased concentration of glycogen have been reported to increase the juiciness in beef with a normal pH between 5.5 and 5.75 (Immonen *et al*., 2000).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

This study was conducted at the Animal Product Laboratory, Department of Animal Science, Ahmadu Bello University, Zaria. Zaria is located in the Northern Guinea Savanna zone on longitude $7^{0}38^{'}$ E and latitude $11^{0}10^{'}$N at an altitude of 671m above sea level (Ovimaps, 2017) with an annual rainfall of 1100mm and ambient temperature ranging from 26-32^{0}C (IARMS, 2019).

3.2 Experimental Design

A total of 180 snails were sourced from Merchant Farms, Ibadan, Oyo State. Thirty (30) snails each of both young and mature from each of the three species (*Achatina achatina, Achatina fulica and Achachatina marginata*) were used. The experiment was a 3 x 2 x 4 factorial arrangement in a completely randomized design (specie x age x storage). The main feed for the snails were pawpaw leaves. The matured ones have shell lips that is thickened and slightly turned out while the shell of the young ones are not thickened but fragile.

3.3 *Snail Age Group*

Species	***Age (m)***	
	Young	***Mature***
Achachatina marginata	5	12
Achatina achatina	5	12
Achatina fulica	5	12

3.4 Processing of Fresh Snail Meat

The snails were fasted for 12 hours to completely clean out their digestive system and to complete the purging process. Total mass of meat in each shell were determined by first removing the meat using a pointed rod to pierce through meat, twist and drag out (Oduro *et al.*, 2002). The snail meat from each specie were washed with lime to remove the slime then put in a pot with the addition of spices (5mg of spice to 5g of meat) and little water and were cooked for 20 minutes. The spices comprise of seasoning cube, salt, onions, ginger, curry and thyme. After cooking, the samples were fried in vegetable oil for 12 minutes. Sensory evaluation was carried out on the fried snail meat from the two age groups of the three species.

Table 3.1:Composition of the mixture of ingredients (spices) used for preparing the snail meat

Common name	Scientific name	Proportion in mixture (mg/g)
Salt	NaCl	1.0
Seasoning cube	Seasoning	1.5
Curry	Murraya Koenigi	0.5
Thyme	Thymus vulgaris	0.5
Ginger	Zingiber officinale	0.7
Garlic	Allum sativum	0.8

Source: Akinduro (2017)

3.5 Body measurements

The body weights of the snails were measured before slaughtering using a sensitive weighing scale. The shell length, shell width and mouth width, mouth length of the snails were measured using a vernier caliper.

3.6 Yield of Edible Meat

The weight of the edible, visceral and shell portion was measured after the slaughter. The measurements were done with a sensitive weighing balance. Cooking loss, meat yield, carcass weight, and yield of visceral were also calculated.

$$\text{Cooking loss} = \frac{\text{Initial weight of snail meat} - \text{weight of cooked meat}}{\text{Initial weight of snail meat}} \text{x } 100$$

$$\text{Meat Yield } = \frac{\text{Weight of edible parts}}{\text{Total weight}} \text{x } 100$$

$$\text{Yield of visceral} = \frac{\text{weight of visceral}}{\text{Total weight}} \text{x } 100$$

3.7 Chemical Analysis

Samples of fresh snail meat fromthethree species and from the two age groups were analyzed for their proximate composition according to AOAC (2005). The parameters considered include moisture, crude protein, crude fibre, ash, ether extract and nitrogen free extract contents. The analysis was carried out at the Biochemical Laboratory, Department of Animal Science, Ahmadu Bello University, Zaria.

3.8 Organoleptic Assessment

The product (fried snail meat) was assessed for overall acceptability using a 5-point hedonic scale as follows: (5) extremely like; (4) like; (3) neither like nor dislike; (2) dislike; (1) extremely dislike. A total of 20 panelists familiar with sensory attributes were used to assess the quality of fried snail meat. Clean water, tooth-picks, biscuit and serviette were provided for the panelists to enhance quality of evaluation. The products were served to the panelists in a good sanitary environment. Samples were blind coded and balanced for order of presentation.

3.9 Determination of total Microbial Count of Fried Snail Meat

Samples of the fried snail meat were evaluated for microbial count (total aerobic and coliform) over a 21-days storage period (0, 7, 14 and 21). The count was done using the standard plate count procedure of serial dilution by plating the sample in agar media on a petri dish ((AOAC, 2005; EDQM, 2007). The agar solidified and the colony grown within the agar before the count was done. Appropriate number (6) of plates was used for the serial dilution. The cultures were left for 12 h after which the total microbial count was done. Total viable count was done using Bacteria Nutrient Agar (EDQM, 2007). This was carried at the public health laboratory, Faculty of Veterinary Medicine, Ahmadu Bello University Zaria.

3.10 Statistical Analysis

Thedata generated was subjected to ANOVA with repeated measures using the General Linear Model (GLM) procedure of SAS (2004) while the mean separation was done with Duncan Multiple Range Test (DMRT). The following model was used;

Model I: Specie, Age and their interactions.

$Y_{ij} = \mu + T_i + S_j\ (T \times S\ )_{ij} + e_{ij}$

Y_{ijk} = Response parameters of the snail (observations),

μ = Population mean,

T_i = Fixed effect of species (3 *(Achatina achatina, Archachatina marginata, Achatina fulica)*

Sj = Fixed effect of age (young and mature)

$(TxS)_{ij}$= specie and age interaction

e_{ijk} = Error term

Model II: Specie, Age, Storage days and their interactions.

$Y_{ijk} = \mu + T_i + S_j + P_k\ (T \text{ x } S \text{ x } P)_{ijk} + e_{ijk}$

Y_{ijk} = Response parameters of the snail (observations),

μ = Population mean,

T_i = Fixed effect of species(3)*(Achatina achatina, Archachatina marginata, Achatina fulica)*

Sj = Fixed effect of age (young and mature)

P_k = Effect of storage periods (0,7,14,21 days)

$(TxS)_{ij}$= specie and age interaction

$(TxP)_{ik}$= specie and storage periods interaction

$(SxP)_{jk}$= age and storage periods interaction

$(T \text{ x } S \text{ x } P)_{ijk}$= specie, age and storage periods interaction

e_{ijk} = Error term

CHAPTER FOUR

4.0 RESULTS

4.1 Effects of Age on Chemical Composition of Fresh Snail Meat (Young and Mature)

Table 4.1 shows the effects of age on the chemical composition of fresh snail meat (young and mature). There were significant difference ($P<0.05$) across the age group in moisture, ether extract and ash contents of fresh snail meat. The moisture content for young and mature was 75.15% and 72.31%, respectively. The crude protein was 51.12% and 51.12% while ether extract was 1.61% and 1.72% for young and mature respectively. The ash content was 7.26% for young and 6.39% for mature, the nitrogen free extract were 40.01% and 40.74% for young and mature snails, respectively. Crude fibre was not detected in any of the samples.

4.2 Effect of Species on Chemical Composition of Fresh Snail Meat

Table 4.2 shows the effect of species on chemical composition of fresh snail meat. There were significant ($P<0.05$) differences in the moisture, crude protein, ether extract, ash content and NFE of the three species. Moisture contents were 73.72%, 71.47% and 74.55% for *A. achatina*(AA), *A. marginata (*AM)and *A. fulica*(AF)respectively with AF having the highest value and AM having the least. The crude protein values recorded were 48.80%, 52.34% and 51.67% while ether extract ranged from 1.60, 1.77 and 1.61 for *Achatina achatina, Archachatina marginata* and *Achatina fulica* respectively. The recorded ash values were 5.46, 6.41 and 7.85% while the values for NFE were 45.71, 40.03 and 38.91% for *Achatina achatina, Archachatina marginata* and *Achatina fulica* respectively. Crude fibre was not detected in any of the species.

Table 4.1: Effects of Age on Chemical Composition of Fresh Snail Meat (Young and Mature)

Parameters	Age		
	Young	Mature	SEM
Moisture	75.15[a]	72.31[b]	0.070
Crude protein	51.12	51.12	0.632
Crude fibre	0.00	0.00	0.00
Ether extract	1.61[b]	1.72[a]	0.002
Ash	7.26[a]	6.39[b]	0.035
NFE	40.01	40.76	0.603

a,b = means with different superscript within the same row differs significantly (P<0.05)

SEM = Standard Error of Mean,

Table 4.2: Effects of Species on Chemical Composition of Fresh Snail Meat

	Species			
	AA	**AM**	**AF**	**SEM**
Parameters				
Moisture	73.72[b]	71.47[c]	74.55[a]	0.070
Crude protein	48.80[b]	52.34[a]	51.67[a]	0.632
Crude fibre	0.00	0.00	0.00	0.00
Ether extract	1.60[c]	1.77[a]	1.61[b]	0.002
Ash	5.46[c]	6.41[b]	7.85[a]	0.035
NFE	45.71[a]	40.03[b]	38.91[b]	0.603

abc = means with different superscript within the same row differs significantly ($p<0.05$)

AA = Achatina achatina, AM = Archachatina marginata, AF = Achatina fulica,SEM = Standard Error of Mean,

4.3 Interaction Effects of Age and Specie on the Chemical Composition of Fresh Snail Meat

Figure 2 and 3 shows the interaction effect of age and specie on the chemical composition of young and mature fresh snail meat. The interaction effect on moisture content at young stage were significantly different ($P<0.05$) across the species with AA recording the highest value (76.12%) followed by AF (75.35%) and AM (74.50%). However, at mature stage AF recorded the highest value (74.15%) followed by AA (71.90%) and AM (69.50%). The CP at young and mature stage were also significantly different with young and the mature of AM recording the highest values (53.74 and 57.56% respectively) followed by AF (51.04 and 49.78%) and the least value for crude protein was recorded in AA (46.06 and 49.78%). Crude fibre was not detected in any of the species at both young and mature stage. There were significant difference ($P<0.05$) in the ether extract within the species at both young and mature stage with the young of AM having the highest value (1.82%) and the young of AF having the least value (1.44%). Young AF gave the highest % ash (8.49), followed by young of AM (7.35), mature AF (7.20), young AA (6.10), mature AM (5.35) and the least was recorded in the young of AA (4.61). NFE values at mature and young stage were significantly different ($P<0.05$) and they ranged from (47.80%), (37.07%) and (39.03%) for young of AA, AM and AF respectively. At mature stage, the values ranged from 42.99%, 35.34% and 41.26% for AA, AM and AF respectively (see also appendix i).

4.4 Effects of Age on Carcass Characteristics of three Snail Meat

Table 4.4 shows the effect of age on carcass characteristics of three species of snail meat (young and mature). The live weight (199.17g), carcass weight (51.83g), percent yield of viscera (24.20%) and the meat yield (31.25%) of the mature snails were significantly ($P<0.05$) higher than that of the young snails while the percent cooking loss recorded for the young snails were significantly higher ($P<0.05$) (34.49%) than that of the mature snails.

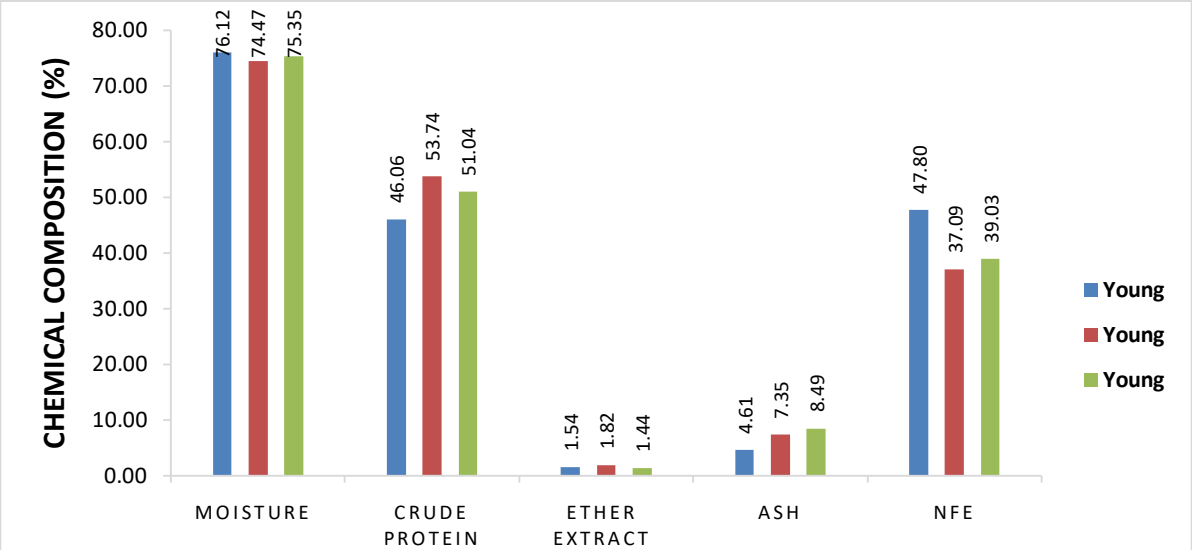


FIGURE 2: Interaction effects between age and species on chemical composition of young fresh snail meat

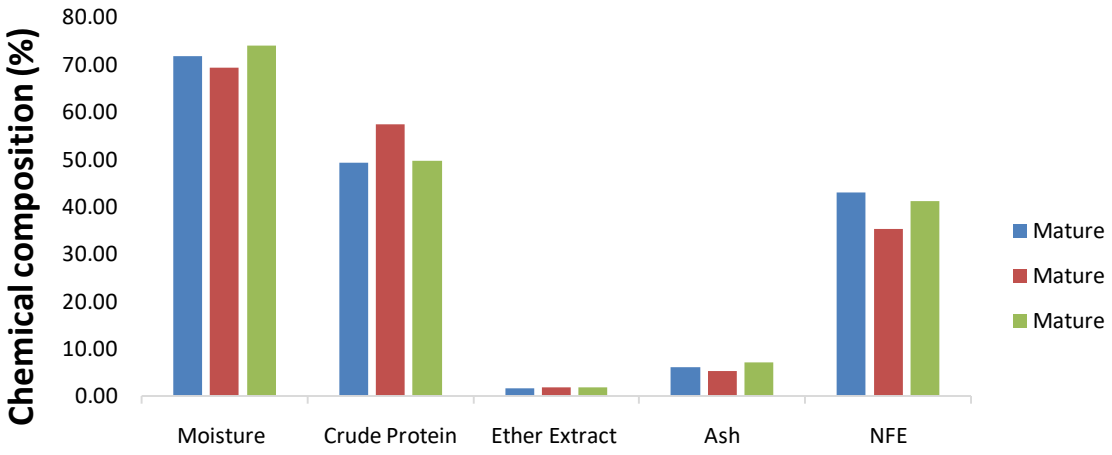


FIGURE 3: Interaction effects between age and species on chemical composition of mature fresh snail meat

Table 4.4: Effects of Age on Carcass Characteristics of three Species of Snails

Parameters (g)	Age		SEM
	Young	Mature	
Live weight (g)	81.53[b]	199.17[a]	2.23
Carcass weight (g)	25.48[b]	51.83[a]	1.18
Yield of Viscera (%)	16.74[b]	24.20[a]	0.79
Cooking loss (%)	34.49[a]	31.81[b]	0.32
Meat yield (%)	26.02[b]	31.25[a]	0.74

a,b = means with different superscript within the same row differs significantly ($p<0.05$)

SEM = Standard Error of Mean

4.5Effects of three Species of Snail on Carcass Characteristics

Table 4.5 shows the effect of the three species of snail on carcass characteristics. *Archachatina marginata* was the most significant (P<0.05) with live weight of (231.50g), carcass weight (69.93g), meat yield (30.20%) followed by *Achatina achatina* with live weight, carcass weight and meat yield of (151.95g), (36.70g), and (24.86%) respectively. while *Achatina fulica* had the least significant (P<0.05) weight (37.60g), carcass weight (9.35g) and meat yield (24.15%) . *Archachatina marginata* had the least (P<0.05) percent yield of visceral (19.10%) and cooking loss (30.44%) followed by *Achatina achatina* (21.67g and 35.99%) respectively. *Achatina fulica* breed however had higher significant (P<0.05) percentage of these parameters than the other two breeds.

4.6Interaction Effects of Age and Specie on Carcass Characteristics of Snail Meat

Figure 4 and 5 shows the interaction effect of age and specie on carcass characteristics of young and mature snail meat. There were significant differences (P<0.05) in the live weight and carcass weight across all the species and age groups. AM at mature stage had the highest value for live weight and carcass weight (320.00g and 92.60g) and is trailed by AA (222.70g and 49.60g), young of AM (143.00g and 47.25g) and young of AA (81.20g and 23.80g), respectively. The least values were recorded for AF at both young and mature stage. Also the percent yields of visceral and cooking loss were significantly higher for AF at both young and mature followed by AA while the least was recorded for AM. Meat yield was highest for the young AM (33.12%) followed by the young of AA (30.18%), mature AM (29.09%), mature AA (26.55%), young of AF (24.75%) and lastly mature AF (22.33%).(see also appendix ii)

Table 4.5: Effects of Specieson Carcass Characteristics

Parameters	AA	AM	AF	SEM
Live weight (g)	151.95^{b}	231.50^{a}	37.60^{c}	2.23
Carcass weight (g)	36.70^{b}	69.93^{a}	9.35^{c}	1.18
Yield of Viscera (%)	21.67^{b}	19.10^{c}	26.33^{a}	0.79
Cooking loss (%)	35.99^{b}	30.44^{c}	36.79^{a}	0.32
Meat yield (%)	24.86^{b}	30.20^{a}	24.15^{b}	0.74

abc = means with different superscript within the same row differs significantly ($p<0.05$)

AA = Achatina achatina, AM = Archachatina marginata, AF = Achatina fulica,SEM = Standard Error of Mean.

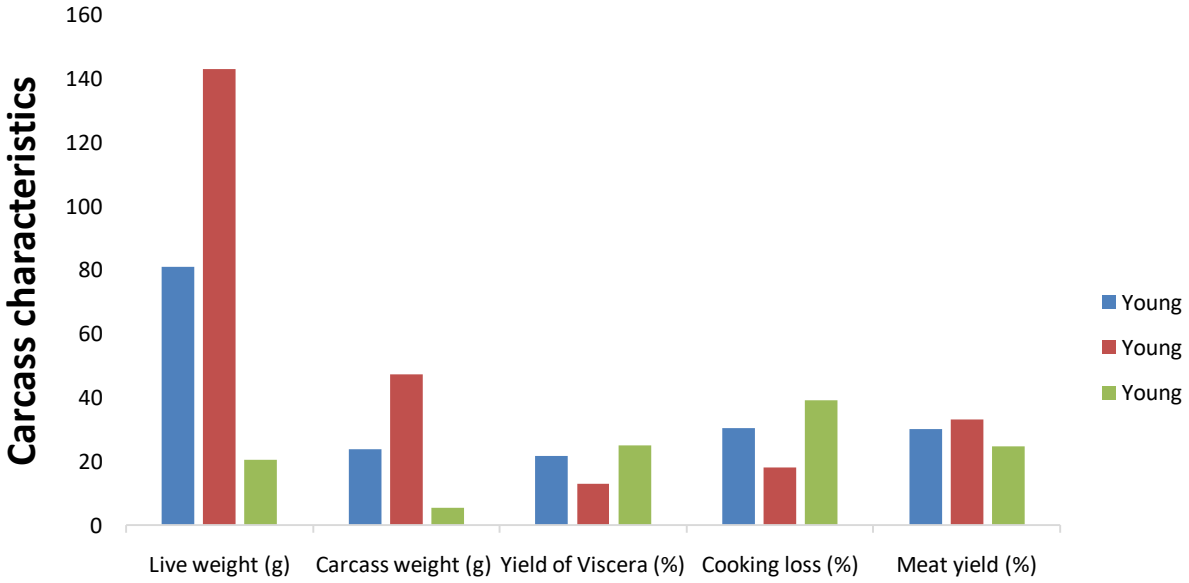


Figure 4: Interaction effect of age and species on carcass characteristics of young snails

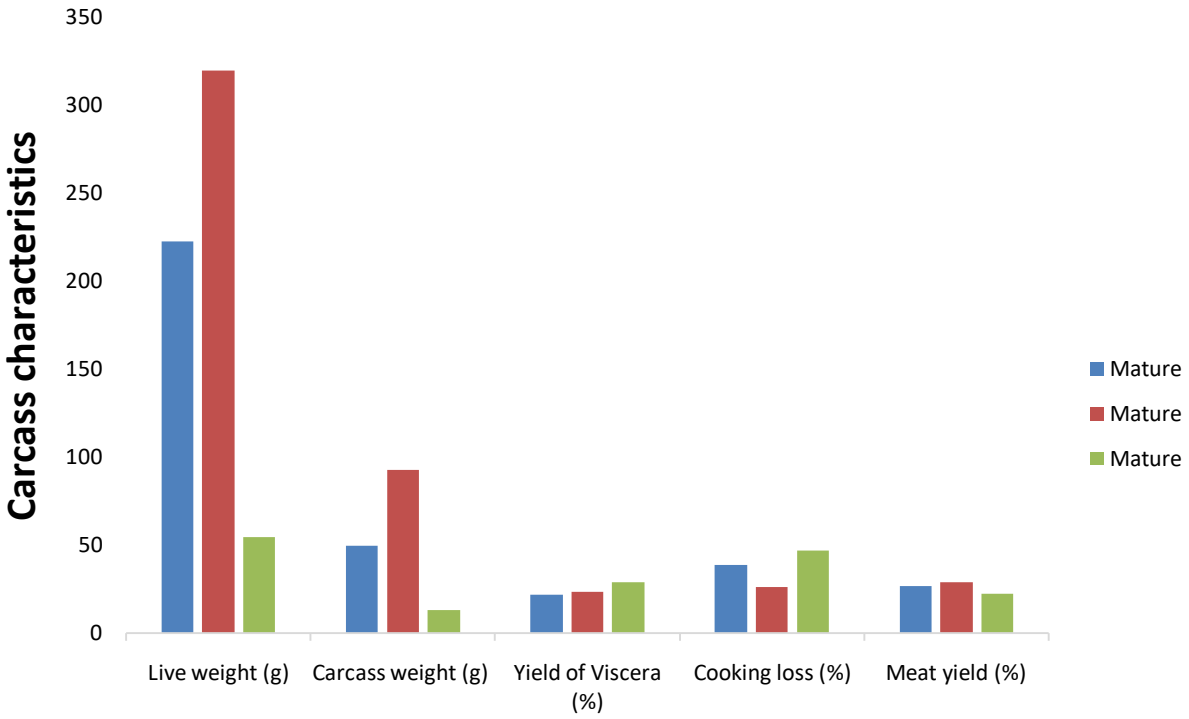


Figure 5: Interaction effect of age and species on carcass characteristics of matre snails

4.7 Effects of Age on Shell Parameters of the Species

Table 4.7 shows effect of age on shell parameters of the three species of snails. The mature snails is significantly different ($P<0.05$) from the young snails for all the shell parameters measured.

4.8 Effects of Species on Shell Parameters of the Species

Table 4.8 shows effect of species on shell parameters of the three species of snail. *Archachatina marginata* recorded the highest mean for all the shell parameters measured followed by *A. achatina* and *A. fulica.*

4.9 Interaction Effects of Age and Species on Shell Parameters of Snail

Figure 6 and 7 shows the interaction effect of age and specie on shell parameters of young and mature snail. There were significant differences ($P<0.05$) in the shell weight, shell length, shell width, mouth length and mouth width with AM at mature stage having the highest value followed by AA at mature stage, AM at young stage, AA at young stage while the least values of all the parameters were recorded for AF at both young and mature stage. (see also appendix iii)

Table 4.7: Effects of Age on Shell Parameters

Parameters	Age		SEM
	Young	Mature	
Shell weight (g)	30.73[b]	57.50[a]	1.56
Shell length (cm)	10.04[b]	14.06[a]	0.14
Shell width (cm)	14.35[b]	18.82[a]	1.37
Mouth length (cm)	4.75[b]	6.55[a]	0.04
Mouth width (cm)	2.62[b]	6.04[a]	0.85

a,b = means with different superscript within the same row differs significantly ($p<0.05$)
SEM = Standard Error of Mean.

Table 4.8: Effect of Species on Shell Parameters

Parameters	AA	AM	AF	SEM
Shell weight (g)	47.85^{b}	73.84^{a}	10.65^{c}	1.56
Shell length (cm)	13.31^{b}	14.49^{a}	8.34^{c}	0.14
Shell width (cm)	17.33^{b}	20.50^{a}	11.93^{c}	1.37
Mouth length (cm)	5.84^{b}	7.46^{a}	3.66^{c}	0.04
Mouth width (cm)	3.47^{b}	5.16^{a}	2.41^{b}	0.85

abc = means with different superscript within the same row differs significantly ($p<0.05$)
AA = Achatina achatina, AM = Archachatina marginata, AF = Achatina fulica, SEM = Standard Error of Mean.

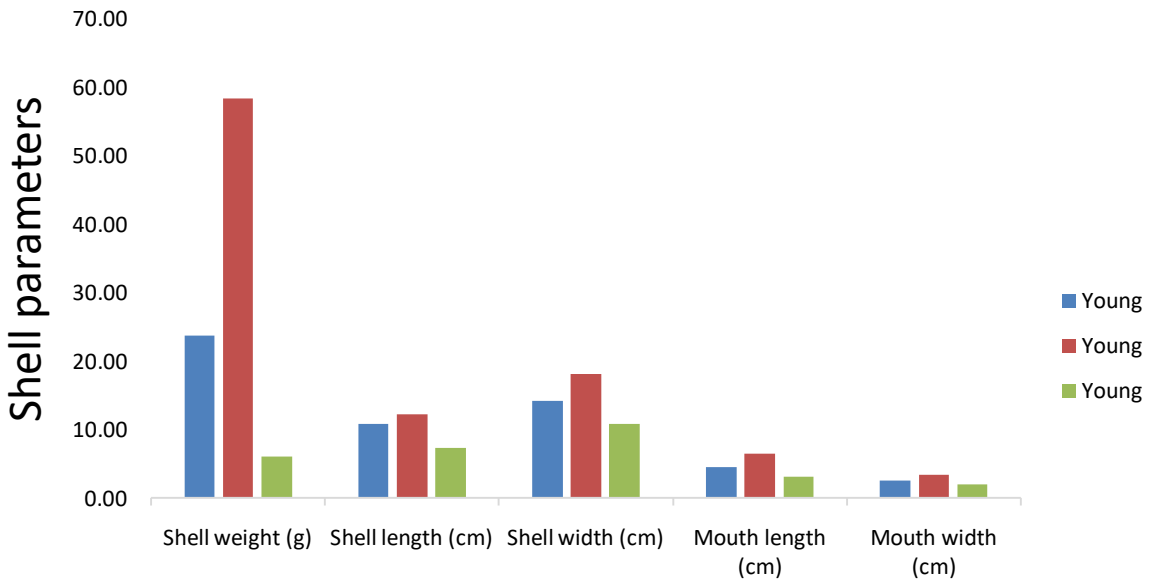


Figure 6: Interaction effects between age and species on shell parameters of young snails

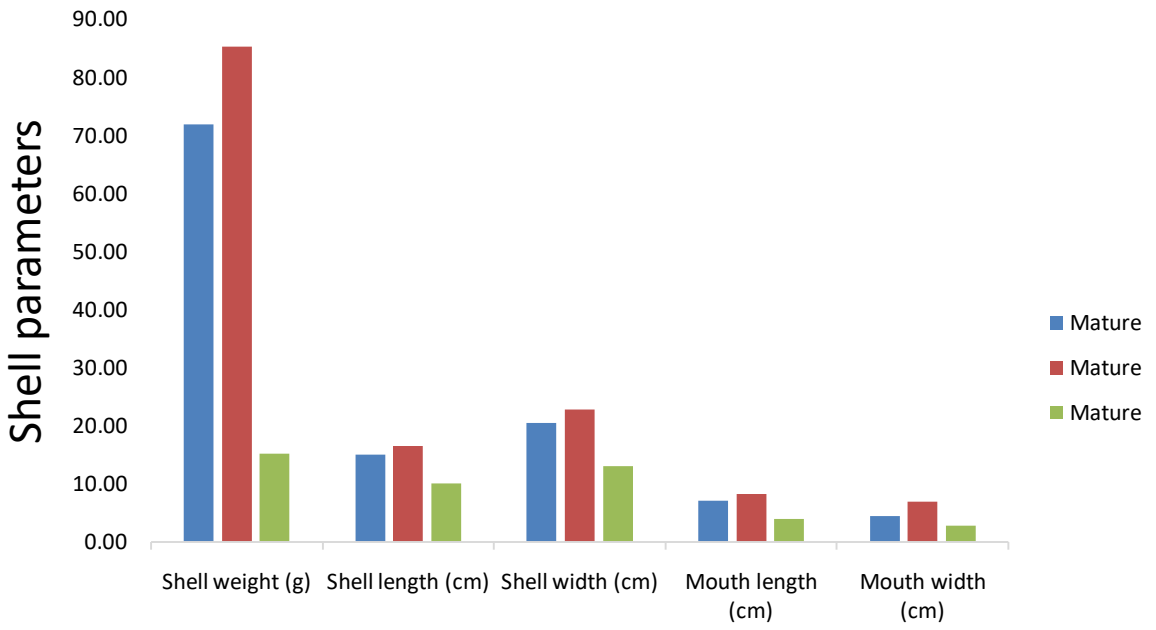


Figure 7: Interaction effects between age and species on shell parameters of matured snails

4.10 Effects of Age on the Organoleptic Properties of Fried Snail Meat of the three Species

Table 4.10 shows the effect of age on the organoleptic properties of fried snail meat from three species. The age of snail does not have significant effect (P>0.05) in all the organoleptic parameters measured at both young and mature stages.

4.11 Effects of Species on Organoleptic Properties of Fried Snail Meat of the three Species

Table 4.11 shows the effect of species on organoleptic properties of fried snail meat from three species. Results obtained showed that specie of snail does not have any significant effect (P>0.05) in all the organoleptic parameters measured.

4.12 Interaction Effects of Age and Specie on the Organoleptic Properties of Fried Snail Meat

Figure 8 and 9 shows the interaction effect of age and specie on the organoleptic properties of young and mature fried snail meat from three species of snail. There were significant differences (P<0.05) for all the sensory parameters measured. The meat of AM at mature stage was the most preferred by the panelists and also the meat of AA at young stage and AM at mature stage were adjudged to be more tender than others by the panelists (P<0.05). The organoleptic traits of the meat from all the species were comparable with each other. The colour, texture, flavor, tenderness and juiciness of mature *A. marginata* were all favoured and most ideal for the panelist (P<0.05) (see also appendix iv).

Table 4.10: Effects of Age on Organoleptic Properties of Fried Snail Meat

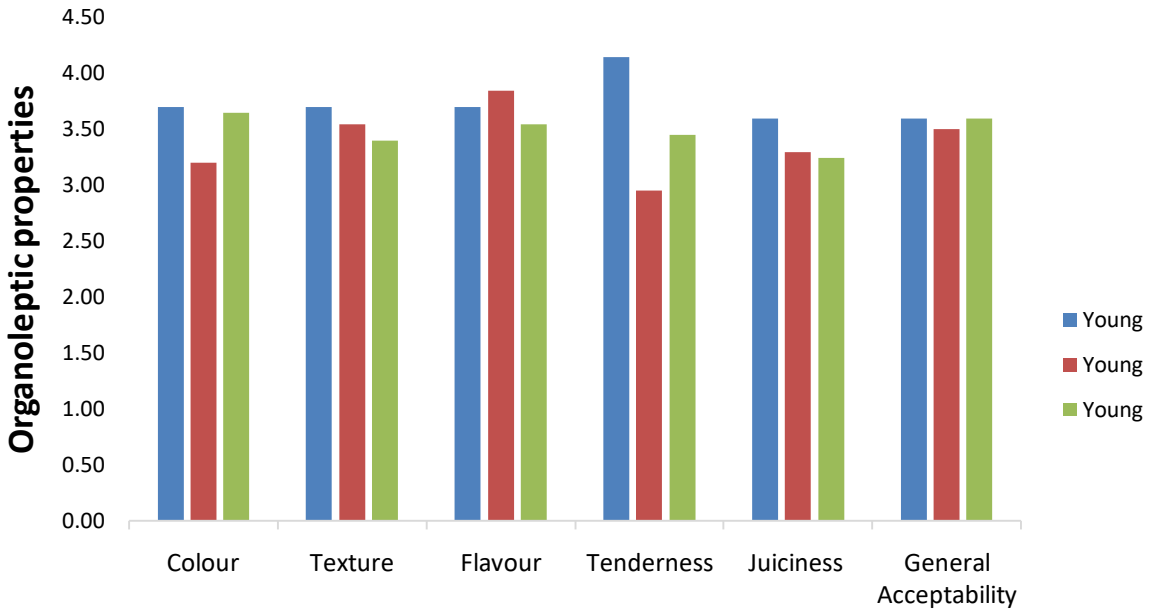
Parameters	Age		SEM
	Young	**Mature**	
Colour	**3.52**	**3.38**	**0.27**
Texture	**3.55**	**3.50**	**0.23**
Flavour	**3.70**	**3.48**	**0.23**
Tenderness	**3.52**	**3.52**	**0.24**
Juiciness	**3.58**	**3.38**	**0.27**
General Acceptability	**3.57**	**3.48**	**0.29**

AA = Achatina achatina, AM = Archachatina marginata, AF = Achatina fulica, SEM = Standard Error of Mean.

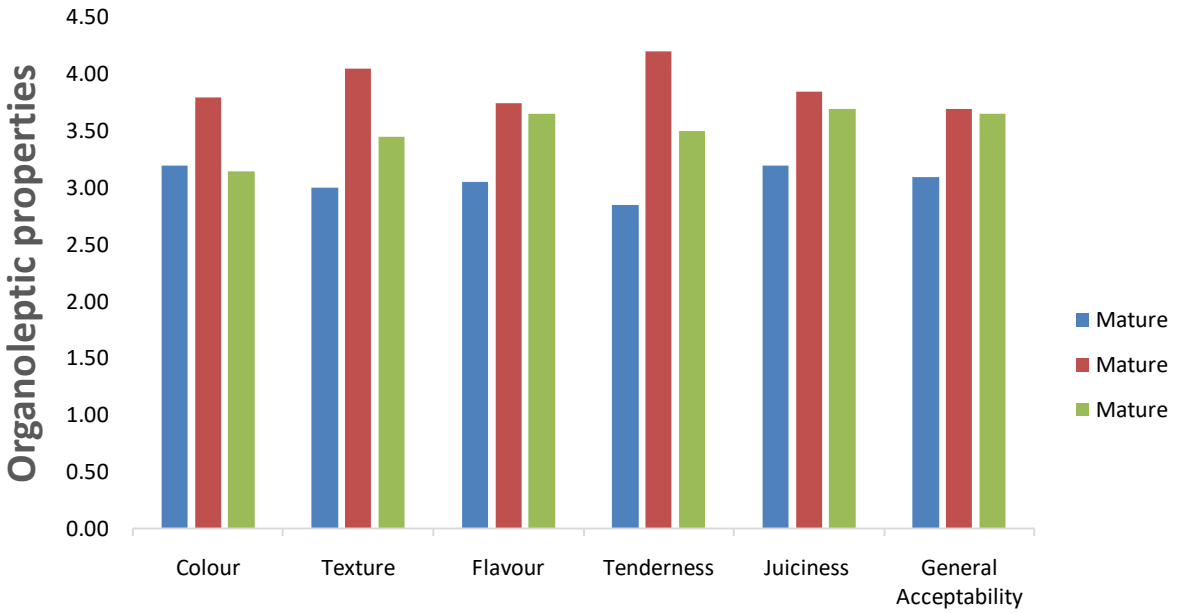
Table 4.11: Effects of Species on Organoleptic Properties of Fried Snail Meat

Parameters	AA	AM	AF	SEM
Colour	3.45	3.50	3.40	0.27
Texture	3.35	3.80	3.43	0.23
Flavour	3.38	3.80	3.60	0.25
Tenderness	3.50	3.58	3.48	0.24
Juiciness	3.40	3.58	3.48	0.27
General acceptability	3.35	3.60	3.63	0.29

AA = Achatina achatina, AM = Archachatina marginata, AF = Achatina fulica, SEM = Standard Error of Mean



Figureb 8: Interaction effects between species and age on organoleptic properties of young fried snail meat



Figureb 9: Interaction effects between species and age on organoleptic properties of mature fried snail meat

4.13 Effects of Age, Specie, Storage period and their Interaction on Microbial Count

Table 4.13 shows the effect of age, specie, storage days and their interaction on microbial count. The age shows significant variation ($P<0.05$). The mature snails have a higher total aerobic plate count (10×10^6 cfu/g) and the young having the lowest (7.92×10^6 cfu/g). The specie effect also shows significant difference ($P<0.05$) with *A. fulica* have a higher total aerobic plate count of (9.63×10^6 cfu/g) followed by *A. marginata* (9.25×10^6 cfu/g) and *A. achatina* (8.00×10^6 cfu/g). Similarly, storage days significantly ($P<0.05$) influenced the total microbial count of fried snail meat with day 21 having the highest bacterial load (12.33×10^6 cfu/g) whereas the least was observed at day 0 (6.33×10^6 cfu/g) and day 7 (6.17×10^6 cfu/g). There was significant difference ($P<0.05$) in the third tier of the interaction between Age, Specie and Storage days .

Table 4.13: Effects of Age, Specie, Storage Period and their Interaction on Microbial Count

PARAMETERS	***TAPC*** ($x10^6$) cfu/g
Age	
Young	7.92^b
Mature	10.00^a
SEM	0.47
Species	
AA	8.00^b
AM	9.25^a
AF	9.63^a
SEM	0.47
Storage	
0	6.17^c
7	6.33^c
14	11.00^b
21	12.33^a
SEM	0.47
Interaction	
A x S	*<0.001*
A x D	*<0.001*
S x D	*<0.001*
A x S x D	*<0.001*
SEM	0.47

abc = means with different superscript within the same column differs significantly

SEM = Standard Error of Mean, AA = Achatina achatina, AM = Archachatina marginata, AF = Achatina fulica,

A x S = Interaction between age and specie

A x D = Interaction between age and storage days

S x D = interaction between specie and storage days

A x S x D = interaction between age, specie and storage days

Cfu/g= coliform forming unit/ gram

CHAPTER FIVE

5.0 DISCUSSION

5.1 Effects of Age on the Chemical Composition of Fresh Snail Meat (Young and Mature)

There were significant difference ($P<0.05$) in the moisture and ash content of fresh snail meat across the age group with the young having higher values than the matured. The higher moisture content of the growing snails may be attributed to their young age because young animals are known to have higher moisture content than mature ones.This agrees with the result of Oduro *et al.* (2002) who reported a range in moisture content of 74-77% for growing snails. For the mature snails, the moisture content (72.31%) was lower than the value reported by Ebunoluwa *et al.*(2015) who observe a moisture content that ranged between 74-76% for mature snails. This disparity could be attributed to the relative humidity of the location where the snails were obtained and to the type of feed fed to the snails. The ash and ether extract values obtained in the present study were higher than the range reported by Olatidoye and Sobowale (2016) who reported a range of 5.02 – 5.79% and 1.02 – 1.33% for ash and ether extract respectively. However the ash content were within the range that was reported by Emelue and Dododawa (2017) who fed snails with diet from different protein sources. The similarity could be attributed to the same type of feed used in the present study. The feed material (pawpaw leaf) has been established to be very rich in protein and ash. The young snails recorded higher ash content, thus, implying the presence of more minerals in the growing snails than the mature ones. However, the mature snail recorded the highest value for ether extract which may imply more fatty acid derivable from the consumption of mature snails. The CP values obtained in this study for young and mature snails were 51.12 and 51.12% respectively. This is in line with the report of Bayode

(2009) who reported a CP range of 37 to 51% and that of Ejidike and Afolayan (2010) – 51% CP. However, Emelue and Dododawa (2017) reported a higher value of 61.25% CP for mature snails. It can be deduced therefore, that snail is a very good source of animal protein whether consumed at mature or young age. Crude fibre was not detected in snail meat and this agrees with the findings of Eruvbetine (2012) and Fagbuaro *et al.*(2006) who reported absence of crude fibre in snail meat. The NFE values obtained for both young (40.01%) and mature (40.76%) were above the value (30%) reported by Emelue and Dododawa (2017)

5.2 Effects of Species on Chemical Composition of Fresh Snail Meat

The proximate composition of snail meat showed some significant differences across all the three species with A.fulica having a significantly higher moisture ($P<0.05$). This issimilar to the findings of Babalola and Akinsoyinu(2009) who reported similar trend of highmoisture for AF followed by AA and least for AM. The CP values were contrary to the findings of Ebunoluwa *et al* 2015 whoreported 18.30, 18.42 and 19.45% for AM, AA and AF respectively. This disparity could be attributed to the feed and management of the snail. The ash and ether extract content were higher than the values reported by Olatidoye and Sobowale (2016) for ether extract (1.02 to 1.33%) and (5.02 – 5.79%) for ash. However the values of the ash content were comparable to those reported by Kalio and Etela (2011). This implies that snail meat is low in fat and rich in minerals. There was no trace of crude fibre recorded in all the samples and this is in tandem with the findings of Eruvbetine (2012) and Fagbuaro *et al.*(2006) who reported absence of crude fibre in snail meat. The NFE values recorded in this study were higher than what was reported by Ebunoluwa *et al.* (2015) and Babalola and Akinsoyinu (2009).

5.3 Interaction Effects between Species and Age on Chemical Composition of Fresh Snail Meat

The interaction between age and species showed significant difference ($P<0.05$) in the moisture, crude protein, ether extract, ash and NFE across specie and age group.Moisture content was higher in young snails and lower in mature ones across all species with AArecording the highest (76.12%) moisture content while AM had the lowest (69.47%) across the two age groups.Similar trend was reported by Oduro *et al.* (2002) observed a moisture content of 74 – 77% for growing snails.This could be attributed to their stage of growth and their preference for tenders leaves and shoots. The CP content was highest (57.565%) in mature AM and lowest (46.06%) in the young AA. This is comparable to what was reported by Bayode (2009) and Emelue and Dododawa (2017) who reported a CP range of 37 to 51% and 50 – 61.25% respectively.The higher CP of *A. marginata* could be attributed to its higher flesh to vicera ratio in comparison to AA and AF. It is also indicative from the findings that snail is a good source of protein and can be used to combat the shortage of animal protein in Nigeria. Crude fibre was not detected in all the samples at both young and mature stage similar to the report of Eruvbetine (2012). Ether extract of AM and AF were significantly higher ($p<0.05$) than that of AA with young of AM recording the highest (1.82%) followed by mature AF (1.80%). The least value for ether extract was recorded in young AF (1.44%). The results obtained on fat contents of Giant African Land Snails were comparable to the values reported by Imevbore and Ademusun (1998) who reported a range of 0.96 to 3.0%. This implies that snails are low in fat contentand could serve as replacement for meat that are high in cholesterol. The interaction between age and species of snails reveals that the young of *A. fulica*had more ash (8.49%), followed by the mature of the same specie (7.20%) similar to the trend observed for AM species. This is indicative that the mineral composition of snail meat

reduces with increase in age. Oduro *et al.* (2002) also reported higher ash content in growing *A. fulica*than mature ones. The interaction between age and specie also significantly affected the NFE contentswith the young of AA recording the highest and the mature of AM recording the least. This implies that age and specie influence the composition of snail meat with respect to nitrogen free extracts.

5.4: Effects of Age on Carcass Characteristics of the Species of Snails

The live weight, carcass weight, percent yield of viscera and meat yield of the mature snails were significantly ($P<0.05$) higher than that of the young snails while the percent cooking loss recorded for the young snails were significantly different ($P<0.05$) from those of the mature snails. Ebunoluwa *et al.* (2015) reported a lower value for the carcasses of mature snails which ranges between 12.94 to 39.70g. The variation could be due to difference in harvesting time and feeding/nutrition regime which affects their productivity. There were no accessible literature values for carcass weight, cooking loss and percent yield of viscera of young snails. However it could be seen that the smaller the size of the snail the higher the percent cooking loss.

5.5: Effects of three Species of Snails on Carcass Characteristics

Live weight, carcass weight, yield of viscera, cooking and meat yield differs significantly ($P<0.05$) across the species. This implies that carcass traits of snail differ from specie to specie and could be due to variation in the size of snail as is evident in *A. marginata* giving higher live weight, carcass weight and lower viscera yield. This conforms to the finding of Ebunoluwa *et al.* (2015) and Olubukola (2015) who reported higher live weights (113.58g and 213.20g respectively) for *A. marginata* in comparison with *A. fulica* and *A. achatina*.

5.6: Interaction Effects between Species and Age on Carcass Characteristics of Snail Meat

There were significant difference ($P<0.05$) in all carcass traits measured with *A. marginata* having higher live weight, carcass weight, and meat yield while the least values were recorded for *A. fulica*.This difference might be attributed to the comparative large size of *A. marginata* than the other 2 species. Cooking loss was also lowest in *A. marginata*when the species and age group were interacted. The significance difference observed in the carcass traits is indicative that yield and quality of snail meat is affected by the age and specie of the snail. Again, this could be attributed to the larger size of *AM*. Ebunoluwa *et al.* (2015) also recorded higher values in carcass traits for AMthan for AA and AF. In addition, the inedible portion (shell and offal) accounts for over 60% of the live weight while the edible portion accounts for less than 40% of the snail's live weight. It is seen that there is a linear relationship between the live weight and the weight of the edible portion, offal and shell of the snail. As the snail increases in size, the edible portion, shell and offal increase quantitatively such that larger sized snails contain larger amounts of edible portion, offal and shell. However, when the edible portion is expressed as a percentage of the live weight, it was found out that large sized snails contain proportionately less offal compared to small sized snail. This is similar to the report of Ajayi *et al.* (1978), Okonkwo, and Anyaene (2009).

5.7: Effects of Age on Shell Parameters of the Species

The effect of age on the shell weight, shell length, shell width, mouth length and mouth width showed significant ($P<0.05$) difference with the mature snails having an edge over the young snails. Oduro *et al*, (2002) reported that as shell length increased, total mass and meat mass also increased. It can be deduced that the age of snail is a contributing factor to the amount of meat that can be gotten from a snail and that as the snail weight and shell length increases other factors

like shell weight, shell width, mouth length and mouth width also increases. Okon *et al,* (2012) also opined that quantitative traits, namely; shell length, shell width, shell 'mouth' length and shell 'mouth' width are the best predictors of body weight.

5.8: Effects of Species on Shell Parameters of three Species of Snails

The effect of species on shell parameters measured shows significant difference ($P<0.05$) with *A. marginata* having the highest mean in all the shell parameters measured followed by *A. achatina* while *A. fulica* recorded the least in all these parameters. *Archachatina marginata* is the biggest snail species in the tropical West Africa. *A. marginata* recorded significantly higher average body weight and shell length than other snail species. Similarly, the aperture of *A. marginata* was longer/wider than those of *A. fulica* and *A. achatina* sdsimilar to the reports of (Idowu *et al.*, 2008; Okon and Ibom 2012; Ebunoluwa *et al* 2015; Ademolu *et al.*,2016).

5.9: Interaction Effects between Age and Species on Shell Parameters of Snail

The interaction effect between age and species showed significant difference ($P<0.05$) in all the shell parameters measured with *A. marginata* having an edge over the other two breeds. This could be as result of breed effect according to Cobinah *et al*,(2008) who reported that mature *A. achatina* weighs between 100 and 450g, *A. fulica* weighs 250g and *A. marginata* weighs 500g. These live weight figures gave *A. marginata* an edge which invariably translates to higher shell weight, length and width, mouth width and length. This is further evident in the least values recorded for all the shell parameters measured in AF which is a small species.

5.10: Effects of Age on Organoleptic Properties of Fried Snail Meat from three Species

The age (young and mature) has no significant difference (P>0.05) in all the organoleptic properties measured.

5.11: Effects of Species on Organoleptic Properties of Fried Snail Meat from three Species

There was also no significant difference (P>0.05) within the three species for the sensory parameters that were measured. This report agrees with the work of Olatidoye and Sobowale (2016) who reported no difference in the colour, taste, flavor, appearance and crispiness of AA, AM and AF.

5.12: Interaction Effects between Species and Age on Organoleptic Properties of Fried Snail Meat

The interaction between age and species showed significant difference (P<0.05) in all themeasured organoleptic parameters of snail meat with AM recording highest values for colour, texture, flavor, tenderness, juiciness and overall acceptability. The least value (3.10) for general acceptability was recorded for AA even though they were similar (P<0.05)with that of the two other species.Olatidoye and Sobowale (2016) reported that*A. marginata* was most preferred to other species (P<0.05) irrespective of the processing method used. The highest mean score in colour, flavor, juicinessand tenderness in *A. marginata* over other species could be responsible for the highest mean score in general acceptability.

5.13 Effects of Age, Specie, Storage period and their Interaction on Microbial Count

Age effect significantly influenced (P<0.05) total aerobic count of fried snail meat with meat from growing snails recording the least (7.92×10^6 cfu/g) total aerobic count while the mature ones had the highest (10×10^6 cfu/g). These values are not above the borderline of satisfactory meat products as specified by the ICMSF (2002). This could be attributed to the fact that mature

snails increasingly feed on detritus: fallenLeaves, rotten fruit and humus which are usually having microbiological loads. Similarly, the total aerobic count of fried snail meat differs significantly ($P<0.05$) across the three species with *A. fulica* having the highest (9.63×10^6 cfu/g), followed by *A. marginata* (9.25×10^6cfu/g) and *A. achatina* (8×10^6 cfu/g), all of which are not above the satisfactory threshold stipulated by ICMSF(2002) and are comparable to the values reported by Samuel (2009) who stored gas dried and sun dried snail meat for a period of 15 days. When snail meat was stored, the total aerobic count increased with increase in storage days. At day 0 a total aerobic count of 6.17×10^6 was recorded, followed by 6.33×10^6 at day 7, 11×10^6 at the day 14 and (12.33×10^6 cfu/g) at day 21.This scenario was also seen in the report of Samuel (2009) who observed increased bacterial count in stored snail meat as storage days increases. This observation could be due to absorption of moisture by the samples which consequently increased water activity of the samples, with increasing water activity more microoganisms can survive and multiply leading to increased microbial loads over the storage period (Samuel, 2009). Engmann (2005) also reported higher microbial loads for bacteria and mold of samples at the end of thirty week storage period.

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATION

6.1 summary

The study find out the effects of species on the yield and quality of African giant snail meat. A total of 180 snails were sourced from Merchant Farms, Ibadan,Oyo State. Thirty (30) snails each from the young and mature of *Achatina achatina, Achatina fulica and Achachatina marginata* were used. Biometrics, proximate, sensory and microbial analyses were carried out.The result obtained indicated that the chemical composition of the three species at both young and mature stage were significantly different ($P<0.05$). Crude fiber was not found in all the three species at both age groups. Ether extract of *A. marginata* differs significantly from the other two species while *A. fulica* differed significantly in ash content. Similarly, age significantly influenced ether extract with mature ones recording the highest. However, the young snails have more ash content ($P<0.05$). There were significant differences in carcass weight, meat yield, yield of viscera and cooking loss with *A. marginata* recording highest in all the parameters Specie difference also significantly influenced shell weight, shell length, shell width, mouth length and mouth width with *A. marginata* recording the highest mean values in all the parameters ($P<0.05$). Results from organoleptic assessment showed that *A. marginata* at mature stage was most preferred by the panelist while at young stage, the panelists were indifferent. Age, species and storage days all significantly influenced the total aerobic count obtained i.e microbial load increases as storage days increases ($P<0.05$).

6.2 Conclusions

The following conclusions were made from the findings of this research:

a) That the chemical compositions of the three species of snail at both young and mature stage were significantly different. Comparison between the species showed that *A. marginata* had more ether extract than the other two species while *A. fulica* had more ash content. Also, the ether extract at mature stage was higher than at the young stage. However, the young snails have more ash content than the mature ones.

b) *A. marginata* at both young and mature stage had the highest carcass weight, visceral and shell characteristics, thus giving more yield than *A. achatina* and *A. fulica*

c) *A. marginata* at mature stage was more preferred by the panelist in comparison to the other two species.

d) Total aerobic counts obtained from this study at both young and mature stage throughout the storage period were not above the borderline (not greater than 10^6cfu/g) of the International Commission of Microbiological Standards for Foods (ICMSF). Snail meat can therefore be stored for up to 21 days and still remain wholesome for consumption provided it is properly processed.

6.3 Recommendations

Based on the findings of this research, the following recommendations were made:

a. Consumers can go for the meat of AM for high protein and ether extract (fat) content while the meat of the smaller breeds (AF and young of other breeds) is most recommended for minerals.

b. For higher meat yield and optimum economic return, farmers should go for *A. marginata* as it gives higher meat yield and shell size at both young and mature stage.

c. Snail meat should be properly processed before eating to mitigate the level of microbial contamination that might affect meat quality.

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APPENDICES

Appendix i: Interaction Effects between Species and Age on Chemical Composition of Fresh Snail Meat

Age	Specie	Parameters (%)					
		Moisture	**Crude Protein**	**Crude fibre**	**Ether Extract**	**Ash**	**NFE**
Young	AA	76.12[a]	46.06[e]	0.00	1.54[e]	4.61[f]	47.80[a]
	AM	74.47[c]	53.74[b]	0.00	1.82[a]	7.35[b]	37.09[e]
	AF	75.35[b]	51.04[c]	0.00	1.44[f]	8.49[a]	39.03[d]
Mature	AA	71.90[e]	49.29[d]	0.00	1.63[d]	6.10[d]	42.99[b]
	AM	69.47[f]	57.56[a]	0.00	1.75[c]	5.35[e]	35.34[f]
	AF	74.15[d]	49.78[d]	0.00	1.80[b]	7.20[c]	41.26[c]
SEM		0.070	0.632	0	0.002	0.035	0.603

abcdef = means with different superscript within the same column differs significantly ($p<0.05$)
AA = Achatina achatina, AM = Archachatina marginata, AF = Achatina fulica, SEM = Standard Error of Mean.

Appendix ii: Interaction Effects between Specie and Age on Carcass Characteristics

Age	Specie	Parameters (%)				
		Live weight (g)	**Carcass weight (g)**	**Yield of Viscera (%)**	**Cooking loss (%)**	**Meat yield (%)**
Young	*AA*	81.20^{d}	23.80^{d}	21.68^{d}	30.42^{c}	30.18^{b}
	AM	143.00^{c}	47.25^{c}	12.99^{e}	18.02^{a}	33.12^{a}
	AF	20.40^{f}	5.40^{f}	25.15^{b}	39.14^{e}	24.75^{e}
Mature	AA	222.70^{b}	49.60^{b}	21.67^{d}	38.68^{d}	26.55^{d}
	AM	320.00^{a}	92.60^{a}	23.66^{c}	25.98^{b}	29.09^{c}
	AF	54.80^{e}	13.30^{e}	28.99^{a}	46.87^{f}	22.33^{f}
SEM		2.23	1.18	0.79	0.32	0.74

abcdef = means with different superscript within the same column differs significantly ($p<0.05$)
AA = Achatina achatina, AM = Archachatina marginata, AF = Achatina fulica, SEM = Standard Error of Mean.

Appendix iii: Interaction Effects between Age and Species on Shell Parameters of Snail

Age	Specie	Parameters (%)				
		Shell weight (g)	**Shell length (cm)**	**Shell width (cm)**	**Mouth length (cm)**	**Mouth width (cm)**
Young	*AA*	23.7^{d}	10.81^{d}	14.15^{b}	4.50^{d}	2.49^{c}
	AM	58.50^{c}	12.19^{c}	18.12^{a}	6.51^{c}	3.44^{bc}
	AF	6.10^{f}	7.27^{f}	10.80^{c}	3.14^{f}	2.02^{c}
Mature	AA	72.0^{b}	15.06^{b}	20.51^{a}	7.08^{b}	4.44^{b}
	AM	85.30^{a}	16.53^{a}	22.88^{a}	8.32^{a}	6.89^{a}
	AF	15.2^{e}	10.09^{e}	13.07^{bc}	4.03^{e}	2.80^{c}
SEM		1.56	0.14	1.37	0.04	0.85

abcdef = means with different superscript within the same column differs significantly ($p<0.05$)
AA = Achatina achatina, AM = Archachatina marginata, AF = Achatina fulica, SEM = Standard Error of Mean.

Appendix iv: Interaction Effects between Species and Age on Organoleptic Properties of Fried Snail Meat

Age	Specie	Parameters (%)					
		Colour	**Texture**	**Flavour**	**Tenderness**	**Juiciness**	**General Acceptability**
Young	AA	3.70^{ab}	3.70^{ab}	3.70^{a}	4.15^{a}	3.60^{ab}	3.60^{ab}
	AM	3.20^{b}	3.55^{b}	3.85^{a}	2.95^{c}	3.30^{b}	3.50^{ab}
	AF	3.65^{b}	3.40^{b}	3.55^{a}	3.45^{b}	3.25^{b}	3.60^{ab}
Mature	AA	3.20^{b}	3.00^{bc}	3.05^{b}	2.85^{c}	3.20^{b}	3.10^{b}
	AM	3.80^{a}	4.05^{a}	3.75^{a}	4.20^{a}	3.85^{a}	3.70^{a}
	AF	3.15^{bc}	3.45^{b}	3.65^{a}	3.50^{b}	3.70^{ab}	3.65^{ab}
SEM		0.27	0.23	0.25	0.24	0.27	0.29

abc = means with different superscript in the same column differs significantly ($p<0.05$)AA = Achatina achatina, AM = Archachatina marginata, AF = Achatina fulica, SEM = Standard Error of Mean.