# BLOOD COMPONENT ANALYSIS OF GOATS ON DIETS WITH SNAIL CHITIN AND CHITOSAN FEED ADDITIVES

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**FACULTY OF AGRICULTURE**
**UNIVERSITY OF BENIN**

**NOVEMBER, 2025.**

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**A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, UNIVERSITY OF BENIN, BENIN CITY, NIGERIA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF AGRICULTURE HONORS (B. AGRIC. IN ANIMAL SCIENCE)**

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## CERTIFICATION

This is to certify that this project work was carried out by Prosperity Ewere OGBEBOR from the Department of Animal Science, Faculty of Agriculture, University of Benin, Benin City, Nigeria under the supervision of Prof. M.A Bamikole.

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Head of Department.

## DEDICATION

This project work is dedicated to my heavenly father for his profound mercy and guidance throughout the duration of this project and also to my parents Mr and Mrs John Ogbebor and siblings for their prayers and financial support.

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I want to first of all thank God for his provision, protection and his sustenance all throughout the duration of this research study.

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## TABLE OF CONTENT

**CHAPTER SIX**

## LIST OF TABLES

## ABSTRACT

This study evaluated the effects of snail-derived chitin and chitosan on the haematological, biochemical, and antioxidant responses of West African Dwarf (WAD) goats. Eighteen weaner goats were assigned to six dietary treatments, including varying levels of snail chitin (3% and 6%), snail chitosan (0.5% and 1%), a control diet, and an oxytetracycline-supplemented diet. The diets consisted of 50% Guinea grass and 50% concentrate. Proximate composition of the diets showed no significant differences ($p > 0.05$) in dry matter and crude protein, indicating that chitin and chitosan did not compromise nutrient adequacy. However, ash, ether extract, nitrogen-free extract, and ADF varied significantly ($p < 0.05$), reflecting the fibrous nature of the additives.

Haematological and serum biochemical indices remained within normal physiological ranges across treatments, showing no adverse effects on erythropoiesis, immunity, liver function, or kidney function. Notably, goats fed 6% chitin and 0.5% chitosan exhibited slightly elevated total protein and globulin levels ($p < 0.05$), suggesting improved protein utilisation. Antioxidant enzyme activities (SOD, CAT, GPx, and GSH) were enhanced in supplemented groups, while MDA remained stable, demonstrating reduced oxidative stress.

Overall, the findings indicate that snail chitin (up to 6%) and chitosan (up to 1%) can be safely incorporated into goat diets as functional feed additives. Their inclusion supports healthy physiological functions, enhances antioxidant status, and offers a sustainable, cost-effective alternative to synthetic additives and antibiotics. Further studies are recommended to assess long-term effects, growth performance, carcass characteristics, and reproductive responses for wider commercial adoption.

# CHAPTER ONE

## 1.0 INTRODUCTION

Chitin and chitosan are naturally derived polysaccharides known for their biocompatibility, biodegradability**,** and functional versatility. Chitin, a long-chain polymer of N-acetylglucosamine, is among the most abundant biopolymers, commonly sourced from crustacean shells, fungi, and arthropods (Wikipedia, 2025). Chitosan, obtained via deacetylation of chitin, retains similar structural features and biological functionality (Benalaya *et al.,* 2024). These compounds are not only valued in biomedical and environmental applications but are increasingly being explored in animal nutrition for their potential to enhance health and productivity.

In recent years, chitin and chitosan have attracted considerable attention as novel feed additives in ruminant diets. They possess antimicrobial, immune-modulating, antioxidative, and anti-inflammatory properties, which make them valuable in reducing pathogenic loads and improving host immunity (Shah *et al.,* 2022). Their inclusion in diets has been shown to positively influence feed digestibility, rumen fermentation, microbial populations, and overall production performance in sheep, beef cattle, dairy cows, goats, and yaks (Rey *et al.,* 2023).

One of the most reliable approaches to assess the physiological impact of feed additives in livestock is blood analysis. Blood parameters serve as important diagnostic tools for evaluating the health status, metabolic processes, and nutritional adequacy in animals. Haematological indices, such as red and white blood cell counts, haemoglobin concentration, and packed cell volume, provide insights into oxygen transport, immune function, and general well-being. Likewise, serum biochemical markers such as glucose, total protein, urea, cholesterol, and liver enzymes reflect metabolic balance, organ function, and nutrient utilization efficiency (Assar *et al*., 2023). Thus, analyzing blood components gives a clear indication of how dietary interventions, such as the inclusion of chitin and chitosan, affect animal physiology.

Chitosan has been reported to modulate rumen fermentation and microbial composition, resulting in improved serum metabolites: increased total protein and glucose, and reduced urea in Dhofari goats (Wiley *et al.,* 2024). In another study on Zaraibi goat bucks fed high-fat diets, dietary supplementation with chitosan improved hematology, lipid profiles, antioxidant enzyme activity, and thyroid hormones, thereby mitigating the negative effects of excessive fat consumption (Assar *et al*., 2023). These findings highlight the potential of chitosan to influence not only growth and feed efficiency but also critical blood biomarkers that determine the overall health of goats.

Furthermore, attention has recently shifted toward alternative and sustainable sources of chitin and chitosan. While crustacean shells have been the traditional source, snail shells offer an environmentally friendly option with significant promise. Snail-derived chitosan has been successfully extracted and characterized, revealing comparable properties to those obtained from crustaceans (Adekanmi *et al.,* 2023). However, its utilization as a ruminant feed additive is still in its infancy, and limited studies have evaluated its physiological effects in livestock.

Despite evidence supporting the role of chitosan in improving metabolic and haematological indices, there is a significant gap in knowledge regarding the specific effects of snail-derived chitin and chitosan on blood components in goats. Research focusing on blood analysis is particularly important, as it provides measurable indicators of health and productivity outcomes. Understanding these effects will not only help to validate snail-derived chitin and chitosan as functional feed additives but also contribute to sustainable livestock production by turning agricultural waste (snail shells) into valuable animal nutrition resources (“Influence of Chitosan Dietary Supplement on Growth Performance, Blood Indices, and Characteristics of Meat Quality in Chickens,” 2024).

Animal production in developing countries, particularly in sub-Saharan Africa, is often constrained by high feed costs, disease challenges, and poor animal productivity. The need to explore safe, cost-effective, and sustainable feed additives has therefore

become critical. Although synthetic growth promoters and antibiotics have historically been used to enhance livestock performance, their use has been limited due to concerns about drug residues, antimicrobial resistance, and consumer safety (Balehegn *et al.,* 2020). This situation underscores the importance of exploring natural bioactive compounds such as chitin and chitosan as functional feed ingredients.

While several studies have reported the beneficial effects of crustacean-derived chitin and chitosan on rumen fermentation, nutrient utilization, immune response, and blood metabolites in livestock, there remains a significant gap in knowledge regarding alternative and locally available sources. Snail shells, which are often discarded as waste in many Nigerian communities, represent a potentially sustainable and eco-friendly source of chitin and chitosan (Shah *et al.,* 2022). However, limited research has investigated their nutritional and physiological effects on ruminants, especially goats, which play a vital role in the livelihoods of smallholder farmers.

Furthermore, although blood analysis has been recognized as a reliable tool for assessing the health and metabolic status of livestock, there is insufficient data on how snail-derived chitin and chitosan specifically influence haematological and biochemical indices in goats (Soul *et al.,* 2019). Without this knowledge, the potential of snail shell-derived chitin and chitosan as alternative feed additives remains underutilized. Addressing this gap will provide scientific evidence for their adoption in animal nutrition and contribute to sustainable livestock production systems.

## 1.1 Justification of the Study

While the benefits of chitosan in modulating ruminal fermentation and improving serum metabolites have been demonstrated in ruminant species, most available studies are based on chitosan derived from crustacean sources (Rey *et al.,* 2023). The potential of snail-derived chitin and chitosan as feed additives remains largely unexplored, particularly in goats. There is, therefore, a clear knowledge gap regarding how these bioactive compounds influence haematological and biochemical indices, which are essential indicators of health, metabolism, and productivity in livestock.

Blood analysis provides a sensitive and reliable means of assessing the physiological and nutritional status of animals (Didkowska *et al.,* 2024). Any dietary intervention capable of improving blood components such as red and white blood cell counts, haemoglobin concentration, serum proteins, glucose, and lipid profiles has direct implications for growth performance, immune competence, and overall well-being (Tsheole & Mwanza, 2022). Investigating the effects of snail-derived chitin and chitosan on these parameters will not only broaden the scientific understanding of their biological roles but also help establish their practical value in goat production systems.

Moreover, goats constitute an important component of small ruminant production in Nigeria and across sub-Saharan Africa, where they are valued for their adaptability, relatively low input requirements, and significant contributions to food security and

rural livelihoods (FAO, 2022). However, their productivity is often hampered by nutritional deficiencies, diseases, and poor management practices. Integrating bioactive compounds such as chitin and chitosan into goat diets could play a vital role in improving feed efficiency, boosting immunity, and reducing the incidence of diseases, thereby enhancing the sustainability of goat production.

In addition, the search for natural alternatives to antibiotics and synthetic growth promoters in livestock production has intensified due to increasing concerns over antimicrobial resistance and food safety (Shah *et al.,* 2022). Chitin and chitosan, with their antimicrobial and immunostimulatory properties, offer promising prospects in this regard. Evaluating snail-derived sources in particular will provide a more accessible and culturally relevant solution for farmers in regions where crustacean shells may be less abundant or more costly to obtain. This positions snail chitin and chitosan as potential game-changers in sustainable livestock nutrition.

This study is further justified by the pursuit of sustainable and locally sourced feed additives. Snail shells, usually discarded as waste, present an untapped resource that can be converted into valuable nutritional inputs. Investigating their role in goat feeding links this research to global initiatives on waste utilization, sustainable farming, and food security (Kazemi, 2025). Moreover, the results may equip livestock producers with cost-effective and eco-friendly substitutes for conventional additives,

thus improving animal performance and profitability while mitigating environmental impacts.

Finally, this study is expected to contribute to bridging the knowledge gap between laboratory-based findings and practical on-farm applications. By generating empirical data on the effects of snail-derived chitin and chitosan on the blood parameters of goats, the research will not only validate their functional properties but also guide farmers, nutritionists, and policymakers in adopting innovative feeding strategies. Ultimately, the outcomes will support the development of resilient, eco-friendly, and economically viable livestock production systems that address both local and global challenges in agriculture.

## 1.2 Objectives of the Study

The objective of this study was to determine:

1. The chemical composition of diets containing different levels of snail chitin and chitosan.
2. The effect of snail chitin and chitosan diets on some haematological parameters in goats.

# CHAPTER TWO

## 2.0. LITERATURE REVIEW

### 2.1. Chitin

Chitin is a natural polysaccharide composed mainly of N-acetyl-D-glucosamine units linked by β-(1→4) bonds. It is the second most abundant biopolymer in nature after cellulose and serves as a major structural component in the exoskeleton of crustaceans, insects, and the cell walls of fungi. Chemically, chitin resembles cellulose, but the presence of an acetamido group (-$NHCOCH_3$) in place of a hydroxyl group gives it unique biological and functional properties (Izadi *et al*., 2025).

#### 2.1.1 Sources of Chitin

The primary sources of chitin are marine organisms such as shrimp, crab, and lobster shells. However, other sources like insects (e.g., beetles and cockroaches), fungal cell walls, and snail shells have also been identified as potential alternatives (Izadi *et al.,* 2025). Snail shells, in particular, have gained research attention because they are readily available and can provide high-quality chitin with minimal environmental impact compared to crustacean sources (Natarajan *et al.,* 2017).

#### 2.1.2. Extraction and Processing Methods

Extraction of chitin from natural sources involves two main steps: demineralization and deproteinization. Demineralization removes inorganic materials such as calcium

carbonate using dilute acids, while deproteinization eliminates proteins using alkaline solutions like sodium hydroxide (Olaosebikan *et al.,* 2021). The resulting purified chitin can then be washed, dried, and further processed for various applications. Some studies also incorporate a decolourization step to remove pigments and improve purity ("Extraction and FTIR Spectra of Chitin and Chitosan Produced from Periwinkle (Tympanotonos Fuscatus) under Differential Decolorization Conditions," 2025).

### 2.1.3. Conversion of Chitin to Chitosan

Chitosan is obtained from chitin through a process known as deacetylation, which involves treating chitin with concentrated alkali solutions at elevated temperatures. This process removes acetyl groups from chitin molecules, producing chitosan with free amino groups ($-NH_2$) that enhance its solubility and biological activity. The degree of deacetylation determines the physicochemical and functional properties of chitosan, influencing its use in animal nutrition, pharmaceuticals, and biotechnology (Aranaz *et al.,* 2021).

## 2.2 Properties and Characteristics of Chitin and Chitosan

Chitin and chitosan are biopolymers that possess unique physical, chemical, and biological properties, which make them useful in several industrial and biological applications. Although both share similar structural backbones, the degree of acetylation differentiates their solubility, reactivity, and functional characteristics (Ibrahim & Zairy, 2015).

### 2.2.1 Physical and Chemical Properties

Chitin is a white, hard, and insoluble material with a crystalline structure. It is hydrophobic in nature and does not dissolve in common solvents such as water or alcohols. Chitosan, on the other hand, is more flexible and soluble in dilute acidic solutions due to the presence of free amino groups (Piekarska *et al.,* 2023). This solubility makes it easier to incorporate into feed and other biological systems. The molecular weight, crystallinity, and degree of deacetylation largely influence the quality and usability of both chitin and chitosan (Ul-Islam *et al.,* 2023).

### 2.2.2 Biological and Functional Properties

Chitin and chitosan exhibit several beneficial biological properties such as biocompatibility, biodegradability, and non-toxicity (Al-Rooqi *et al.,* 2022). They are known for their antimicrobial, antioxidant, and immune-enhancing abilities, which contribute to improved animal health and performance when used as feed additives. These compounds can also bind to fats, heavy metals, and toxins in the digestive tract, thereby promoting better gut health and nutrient utilization (Adetunji *et al.,* 2025).

### 2.2.3. Solubility, Molecular Weight, and Degree of Deacetylation

The functional performance of chitin and chitosan depends greatly on their molecular structure. Chitin, being highly acetylated, is less soluble, while chitosan becomes soluble when the degree of deacetylation is above 50% (Aranaz *et al*., 2021). The

molecular weight determines viscosity and film-forming ability, while the degree of deacetylation affects biological activity and chemical reactivity (Sánchez-Machado *et al*., 2024). Hence, understanding these factors is essential for optimizing their use in animal feeding and other biotechnological applications.

## 2.3. Nutritional and Functional Roles of Chitin and Chitosan in Animal Feeding

Chitin and chitosan have attracted increasing interest as functional feed additives in animal nutrition due to their biological activities and positive influence on growth performance and health. Their inclusion in animal diets is particularly valued for their ability to enhance feed efficiency, improve immune response, and maintain intestinal integrity (Abenaim & Conti, 2025).

### 2.3.1 Role as Feed Additives and Growth Promoters

Chitin and chitosan act as natural growth promoters, stimulating beneficial gut microflora and improving nutrient utilisation (John Onolame Unuofin *et al*., 2024). When incorporated into animal diets at appropriate levels, they have been reported to enhance body weight gain and feed conversion efficiency. This is attributed to their capacity to improve intestinal health, promote the absorption of essential nutrients, and suppress the proliferation of harmful microorganisms within the digestive tract (Chowdhury *et al.,* 2025).

### 2.3.2 Effects on Nutrient Digestibility and Absorption

Chitosan, in particular, has a strong affinity for lipids and bile acids, which can influence fat metabolism and nutrient assimilation. Its ability to form complexes with dietary components reduces nutrient losses and promotes better utilisation of proteins and minerals (Zhang *et al.,* 2025). In ruminants such as goats, dietary chitosan has been shown to modulate rumen fermentation patterns, leading to improved microbial activity and more efficient digestion of fibrous feed materials (El-Zaiat *et al.,* 2024).

### 2.3.3. Antimicrobial and Immunostimulatory Properties

One of the most remarkable features of chitin and chitosan is their antimicrobial and immunostimulatory effects (Ul-Islam *et al.,* 2023). They possess the ability to inhibit the growth of pathogenic bacteria such as Escherichia coli and Salmonella spp., while encouraging the proliferation of beneficial microbes like Lactobacillus species. In addition, they stimulate the production of immune-related enzymes and enhance the activity of white blood cells, contributing to improved disease resistance and overall animal health (Abenaim & Conti, 2025).

## 2.4. Utilisation of Snail Chitin and Chitosan in Livestock Nutrition

In recent years, there has been growing interest in the use of snail shells as an alternative source of chitin and chitosan for animal feeding. This is largely due to the abundance of snail shells as agro-waste materials in many tropical regions, including

Nigeria, and the need to identify cost-effective and sustainable feed additives that can enhance livestock productivity (Adepitan *et al.,* 2025).

### 2.4.1 Availability and Processing of Snail Shell Chitin

Snail shells are rich in calcium carbonate, organic matter, and chitin, making them a viable raw material for the extraction of chitin and its derivative, chitosan (Abideen *et al*., 2023). The extraction process follows similar steps as with crustacean shells; demineralisation, deproteinisation, and deacetylation. Snail shells offer the added advantage of being locally available and less affected by seasonal scarcity compared to shrimp or crab shells, making them a practical source for chitin production in developing countries (Abideen *et al.,* 2023).

### 2.4.2. Comparative Advantages of Snail-Derived Chitin over Other Sources

Snail-derived chitin has increasingly gained attention as a viable alternative to crustacean-derived chitin due to several notable advantages in terms of availability, safety, and sustainability. When properly extracted and purified, the physicochemical properties of chitin from snail shells such as degree of deacetylation, molecular weight, and crystallinity are comparable to those obtained from crustaceans like shrimps and crabs (Tertsegha *et al.,* 2024). This means that snail chitin can exhibit similar biological functionality in applications such as animal feed, pharmaceuticals, and water purification.

One of the major advantages of snail-derived chitin is its lower allergenic potential (Elieh Ali Komi *et al.,* 2017). Crustacean shells are known to trigger allergic reactions in sensitive individuals due to residual protein content associated with tropomyosin and other allergenic proteins. In contrast, snail shells contain significantly lower levels of such allergens, making the extracted chitin safer for handling and use in feed and biomedical applications (Pellis *et al.,* 2022).

Additionally, snail shell processing poses a lower environmental impact compared with the large-scale crustacean industry (Durairaj Karthick Rajan *et al.*, 2023). The disposal of shrimp and crab shells from seafood processing plants often contributes to waste management problems and environmental pollution, especially in coastal regions. Snails, however, can be sourced locally in inland regions, and their shell by-products from snail farming or consumption can be collected and utilised efficiently. This approach supports waste valorisation and promotes a circular bioeconomy (Ada *et al.,* 2025).

From an economic and sustainability perspective, the local availability of snails in many African countries, including Nigeria, provides a cost-effective and accessible source of chitin. It reduces reliance on imported crustacean-based chitin, which is often expensive due to transportation and importation costs (Olugbojo *et al.,* 2024). By promoting the use of snail shells as a raw material for chitin extraction, local industries can enhance self-sufficiency, create employment opportunities, and support

sustainable livestock production systems where chitin and chitosan serve as functional feed additives (Tertsegha *et al.,* 2024).

Overall, snail-derived chitin offers a promising and eco-friendly alternative to conventional sources, combining comparable quality with greater environmental and socio-economic benefits (Abideen *et al*., 2023).

### 2.4.3 Previous Research on Snail Chitin and Chitosan Use in Animal Feed

Several studies have investigated the use of snail chitin and chitosan as dietary supplements in livestock nutrition (R Rusdi *et al*., 2021). Findings from these studies indicate that inclusion of snail-derived chitin in animal diets can enhance growth performance, improve feed conversion ratio, and positively influence blood parameters. In goats and other ruminants, supplementation with chitosan has been associated with improved haematological profiles and better immune response, reflecting enhanced physiological and metabolic health (Assar *et al.,* 2023).

## 2.5 Overview of Goat Nutrition and Feeding

Goats are small ruminants valued for their adaptability, efficiency in converting low-quality forages into animal protein, and their economic importance in both subsistence and commercial farming systems (Lu, 2023). Proper nutrition plays a vital role in the productivity, reproduction, and overall health of goats. A well-balanced diet ensures

optimal growth, milk yield, and resistance to diseases (Qausar Hamed ALKaisy *et al*., 2023).

### 2.5.1 Nutritional Requirements of Goats

The nutritional requirements of goats depend on several factors including age, breed, physiological state (such as growth, pregnancy, lactation, or maintenance), and production objectives (meat, milk, or fibre). Goats are highly adaptable ruminants capable of utilising a wide range of feed resources; however, balanced nutrition remains crucial to optimise productivity, reproduction, and overall health (Teixeira *et al.,* 2024).

Energy is one of the most critical components of a goat's diet, as it fuels bodily functions, supports thermoregulation, and sustains growth and production (Ibrahim *et al*., 2022). The major sources of energy include carbohydrates and fats derived from forages, grasses, browse plants, crop residues, and concentrates such as maize, cassava peels, or sorghum. Energy deficiency can lead to weight loss, reduced milk yield, poor reproductive performance, and general weakness, while excess energy intake may predispose goats to metabolic disorders and obesity, especially in confined feeding systems (Hatfield & Kalscheur, 2020).

Protein is essential for tissue synthesis, growth, milk production, and the repair of worn-out cells. Young and growing goats, as well as lactating does, have higher protein requirements compared to mature or non-productive animals (Adewumi *et al.*,

2020). Protein can be obtained from both natural and formulated sources such as leguminous forages (e.g., Leucaena leucocephala, Gliricidia sepium), oilseed cakes (groundnut cake, soybean meal), and agro-industrial by-products (Edwards *et al.,* 2024). Insufficient protein intake may result in stunted growth, poor coat condition, and decreased fertility.

Minerals are equally vital for various physiological and biochemical processes. Macro-minerals like calcium and phosphorus are needed for bone formation and skeletal strength, while trace minerals such as iron, copper, zinc, and selenium are required for blood formation, enzyme activation, and immune function (Ştefanache *et al.,* 2023). Mineral deficiencies can lead to disorders such as rickets, anaemia, or reproductive failure. Salt licks or mineral blocks are often provided to supplement these nutrients in goat diets (Salah Galbat, 2021).

Vitamins also play a pivotal role in maintaining good health and supporting metabolic and reproductive functions. Vitamins A, D, and E are particularly important for vision, bone health, and antioxidant protection, respectively, while the B-complex vitamins aid in energy metabolism and nervous system maintenance. Although ruminants can synthesise some vitamins through microbial activity in the rumen, supplementation may be necessary under intensive management or during stress conditions (Pradnya Padalkar & Prakash Zende, 2025).

### 2.5.2 Use of Unconventional Feed Ingredients in Goat Production

Due to the rising cost of conventional feed ingredients such as maize and soybean meal, livestock nutritionists have explored alternative feed sources that are locally available and affordable (I. Alshelmani *et al.,* 2021). Agro-industrial by-products, kitchen waste, and animal-derived materials such as snail shells have been studied as potential feed components. Incorporating such unconventional feed ingredients not only reduces feeding costs but also promotes sustainable livestock production by minimising environmental waste (Alexandros Georganas *et al.,* 2023).

### 2.5.3 Digestive Physiology and Feed Utilisation in Goats

Goats possess a highly efficient digestive system typical of ruminants, consisting of the rumen, reticulum, omasum, and abomasum (Abdelsattar *et al.,* 2021). The rumen houses a diverse population of microorganisms responsible for breaking down fibrous plant materials into volatile fatty acids, which serve as the main energy source (Cammack *et al.,* 2018). Feed additives like chitosan can influence rumen fermentation by modulating microbial activity and improving the efficiency of nutrient digestion and absorption. Thus, diet composition plays a crucial role in determining the animal's health and performance (Rey *et al.,* 2023).

## 2.6. Blood Components and Their Physiological Importance

Blood is a vital fluid connective tissue that circulates throughout the body, transporting nutrients, gases, hormones, and metabolic waste products. It also plays essential roles in temperature regulation, immune defence, and maintaining homeostasis (Institute for Quality and Efficiency in Health Care, 2023). The composition and characteristics of blood serve as reliable indicators of the physiological and health status of animals, making haematological studies an important tool in livestock nutrition research (Fanta *et al*., 2024).

### 2.6.1. Overview of Blood Composition

The blood of farm animals consists of two main components: plasma and the cellular elements. Plasma is the liquid portion that makes up about 55–60% of total blood and contains water, proteins, electrolytes, and metabolites. The cellular elements include red blood cells (erythrocytes), white blood cells (leucocytes), and platelets (thrombocytes). Together, these components maintain proper physiological functions and reflect the animal's nutritional and metabolic condition (Mathew *et al.*, 2023).

### 2.6.2. Packed Cell Volume (PCV)

Packed Cell Volume, also known as haematocrit, represents the percentage of red blood cells in the total blood volume. It provides an indication of the animal's oxygen-carrying capacity and hydration status. A decrease in PCV may suggest anaemia or

nutritional deficiencies, while elevated values may indicate dehydration or enhanced erythropoiesis due to improved nutrition (Mondal & Lotfollahzadeh, 2024).

### 2.6.3. Haemoglobin Concentration (Hb)

Haemoglobin is the iron-containing protein in red blood cells responsible for transporting oxygen from the lungs to body tissues and facilitating carbon dioxide removal. Haemoglobin concentration is a key indicator of the animal's health and nutritional adequacy (Farid *et al.,* 2023). High haemoglobin levels often reflect good protein and iron intake, whereas low levels may signal anaemia, blood loss, or poor feed quality (Wiafe *et al*., 2020).

### 2.6.4. Red Blood Cell Count (RBC)

The red blood cell count measures the total number of erythrocytes in the blood. Red blood cells are essential for oxygen transportation and maintaining acid-base balance. An optimal RBC count reflects effective erythropoiesis and adequate nutrition, while abnormally low counts can result from nutritional deficiencies or disease conditions (Kuhn *et al.,* 2017).

### 2.6.5. White Blood Cell Count (WBC)

White blood cells form a crucial part of the immune system, protecting the animal against infections and foreign agents. The WBC count provides information on the animal's immune status. A higher count may indicate an immune response to infection

or stress, while a lower count may suggest immunosuppression or poor health (Naidenko & Alshinetskiy, 2020).

### 2.6.6. Differential Leucocyte Count

This involves determining the proportions of various white blood cell types, including lymphocytes, neutrophils, monocytes, eosinophils, and basophils. Each plays a specific role in immune defence. For example, lymphocytes are vital for antibody production, while neutrophils are responsible for phagocytosis (Tamang *et al.,* 2022). Changes in the proportions of these cells often reflect the body's reaction to diet, stress, or disease conditions (Alwarawrah *et al.,* 2018).

### 2.6.7 Mean Corpuscular Volume

The Mean Corpuscular Volume or "Mean Cell Volume" (MCV), is a measure of average red blood cell volume that is reported as part of a standard complete blood count. The MCV is calculated by dividing the total volume of packed red blood cells (also known as haematocrit) by the total number of red blood cells. The result number is then multiplied by 10. The red blood cells get packed together when they are spun around at high speeds in a centrifuge (Brihi & Pathak, 2024). It is the measurement that allows classification of the different stages of anaemia in an individual as either a microcytic anaemia (MCV below normal range), normocytic anaemia (MCV within normal range). Macrocytic (MCV above normal range). Normocytic anaemia is usually deemed so because the bone marrow has not yet responded with a change in

cell volume. It occurs occasionally in acute conditions, namely blood loss and haemolysis (Maner & Moosavi, 2023).

### 2.6.8. Mean corpuscular haemoglobin

The Mean Corpuscular Haemoglobin or “Mean Cell Haemoglobin” (MCH), is the average mass of haemoglobin per red blood cell in a sample of blood. Hemoglobin is the protein in red blood cells that transports oxygen to the tissues of the body. It is calculated by dividing the total mass of haemoglobin by the number of red blood cells in a volume of blood (Int *et al*., 2021).

### 2.6.9. Significance of Determining Haematological Indices

Haematological traits are essential parameters for evaluating the health and physiological status of animals and herds. According to Daramola et al. (2005), haematological values could serve as a baseline information for comparison in conditions of nutrient deficiency, physiology and health status of farm animals especially those kept under native husbandry system in Nigeria. The examination of blood provides the opportunity to clinically investigate the presence of several metabolites and other constituents in the body of animals and it plays a vital role in the physiological, nutritional and pathological status of an organism . It also helps in distinguishing normal states of stress, which can be nutritional, environmental or physical (Haematological and Biochemical Parameters of West African Dwarf Goats, 2025).

## 2.7 Serum Biochemistry

Serum biochemistry refers to the chemical analysis of serum. There are many substances in serum, including proteins, enzymes, lipids, hormones, etc. Testing for these various substances provides information about the organs and tissues in the body as well as the metabolic state of the animal. If a test result is abnormal, it may indicate that disease is present. Further assessment of the test results may offer clues about which organ system is affected and also the nature and severity of the disorder (Kiseleva *et al.,* 2021).

### 2.7.1 Proteins (total protein, albumin, globulin)

The two main types of protein found in blood are called albumin and globulin. These proteins can be measured individually, or combined into a single test called total protein, which measures all proteins in the sample (Alhalwani *et al.,* 2023). Albumin levels provide information about the function of the liver, kidneys, and digestive system and indicate if the animal is dehydrated. Globulin levels reflect underlying inflammation and/or antibody production. Increased levels of globulins are often associated with infectious diseases, immune-mediated disease, and some types of cancer.

### 2.7.2 Liver enzymes (ALT, ALP)

There are many different liver enzymes, but the two that appear in most profiles are alanine aminotransferase (ALT), and alkaline phosphatase (ALP). The first enzyme is typically found when the cells of the liver are stressed or damaged. The second enzyme is generally increased when bile flow in the liver is reduced (Lala *et al.,* 2023).

### 2.7.3 Bilirubin

This is a pigment produced primarily in the liver that is associated with the breakdown of hemoglobin from red blood cells. Bilirubin is stored in the gall bladder as a component of bile. Increases in bilirubin are associated with increased red cell destruction or decreased bile flow through the liver (Kalakonda *et al.,* 2022).

### 2.7.4 Kidney tests (Urea, creatinine)

The two substances most commonly measured to assess kidney function are urea (also called blood urea nitrogen or BUN) and creatinine (Pa & Sa*, 2023). Urea is a by-product of protein breakdown; it is produced in the liver and excreted from the body by the kidney. Increases in BUN may indicate dehydration, gastrointestinal bleeding, cardiac disease, or primary kidney disease. Decreases in BUN are associated with over hydration, liver failure, or reduced protein intake in the diet. Creatinine is a by-product of muscle metabolism and it is excreted entirely by the kidney. Increased levels of creatinine indicate decreased kidney function (Hosten, 2020).

### 2.7.5. Pancreatic Enzymes (amylase, lipase, pancreatic lipase immunoreactivity)

Two commonly measured pancreatic enzymes are amylase and lipase. Increases in these enzymes may occur when the pancreas is inflamed, although they can also be elevated with kidney or intestinal disease, and when certain drugs are used. They are not very reliable indicators of pancreatitis (Ali Esmaili, 2017).

### 2.7.6. Glucose (blood sugar)

Persistently high blood sugar is associated with diabetes mellitus, also known as "sugar diabetes." A temporary rise in blood sugar is commonly found in some animals associated with the excitement of visiting the veterinarian; this stress response can make it difficult to diagnose diabetes mellitus in some animals. Low blood sugar can be found in newborn animals. It is also associated with some types of cancer, bacterial infections, or insulin overdose in diabetic patients. False low glucose values often occur when a blood sample is not stored correctly after collection (Abramowski *et al.,* 2023).

### 2.7.7 Cholesterol

Cholesterol is produced in the liver as part of fat metabolism. Increases in cholesterol are associated with hormonal and metabolic diseases, liver disease, and serious kidney disease (Guo *et al.,* 2024).

### 2.7.8 Electrolytes

The most important electrolytes are potassium, chloride, sodium, and bicarbonate. These substances are present in blood in small quantities, and each electrolyte has a different role to play in the body . Collectively, electrolytes help to maintain blood and tissue fluids in balanced state. Disturbances in electrolytes are often caused by vomiting, diarrhea and kidney disease, and accompany many serious metabolic disorders (Shrimanker & Bhattarai, 2023).

## 2.8 Factors that influence Blood Biochemistry of Goats

Haematological and blood biochemical parameters are affected by some factors such as nutrition, breed, sex, age, reproductive status, environmental factors, stress and transportation (Etim, 2014)). These factors play a major role in the differences in haematological and biochemical parameters observed between tropical and temperate animals (Opara and Fagbemi 2009).

### 2.8.1 Influence of Nutrition on Haematological and Biochemical Parameters

Diet plays a key role in determining the concentration and functionality of blood components such as haemoglobin, red blood cells, white blood cells, and plasma proteins. Adequate intake of proteins, vitamins, and minerals supports normal haematopoiesis - the process of blood cell formation (Morris & Mohiuddin, 2023). For instance, dietary protein provides essential amino acids required for haemoglobin synthesis, while minerals such as iron, copper, and cobalt are crucial for red blood cell development. Deficiencies in these nutrients often result in anaemia, reduced immunity, and poor growth performance (Razzaque & Wimalawansa, 2025).

### 2.8.2 Reported Effects of on Haematological Parameters

Several studies have demonstrated that dietary supplementation with chitin and chitosan can significantly alter the haematological profile of animals. In poultry and rabbits, chitosan inclusion has been associated with increased haemoglobin concentration, packed cell volume (PCV), and red blood cell (RBC) counts, suggesting improved oxygen transport and erythropoietic activity. In fish and other aquatic species, similar findings have been reported, with enhanced white blood cell (WBC) counts and improved immune responses (“Influence of Chitosan Dietary Supplement on Growth Performance, Blood Indices, and Characteristics of Meat Quality in Chickens,” 2024).

In ruminants, including goats, chitosan supplementation has been linked to improved blood values and general health. For instance, goats fed diets containing chitosan have shown increased PCV, haemoglobin, and RBC levels, indicating enhanced nutrient utilisation and metabolic efficiency (El-Zaiat *et al.,* 2024). The positive effects are attributed to chitosan's ability to modulate rumen fermentation, reduce ammonia production, and promote beneficial microbial activity, leading to better feed conversion and blood synthesis (Rey *et al.,* 2023).

**Table 2.1: Haematological and Biochemical Values of West African Dwarf Goats**

| Parameters. | Range |
|---|---|
| Packed Cell Volume (PCV, %) | 21 – 35 |
| Haemoglobin (Hb, g/dl) | 7 – 15 |
| Red Blood Cells (RBCs, $\times 10^6$/ml) | 9.2 – 13.5 |
| Mean Corpuscular Haemoglobin Concentration (MCHC, %). | 32 – 34.6 |
| Total White Blood Cells (WBCs, $\times 10^3$/ml) | 6.8 – 20.1 |
| **Percentage Distribution of Leukocytes** | |
| Lymphocytes (%). | 47 – 82 |
| Neutrophils (%) | 17 – 52 |
| Eosinophils (%) | 1 – 7 |
| Monocytes (%) | 0 – 1 |
| **Serum Biochemical Values** | |
| Calcium (mmol/litre) | 1.15 – 2.4 |
| Phosphorus (mmol/litre) | 0.58 – 4.5 |
| Sodium (mmol/litre). | 124 – 146 |
| Potassium (mmol/litre). | 3.0 – 6.0 |
| Urea (mmol/litre). | 0.8 – 9.7 |
| Total Protein (g/100 ml) | 6.3 – 8.5 |
| Albumin (g/100 ml) | 2.8 – 4.3 |
| Triglyceride (mmol/litre). | 0.16 – 1.6 |
| Serum Glutamate Pyruvate Transaminase (SGPT, IU/litre) | 2 – 22 |
| Serum Glutamate Oxaloacetate Transaminase (SGOT, IU/litre) | 12 – 38 |
| Alkaline Phosphatase (ALP, IU/litre) | 1.4 – 25.7 |

**Source: Daramola *et al,* 2005**

# CHAPTER THREE

## 3.0 MATERIALS AND METHOD

### 3.1 Experimental Site

The experiment was carried out at the Ruminant Unit of the University of Benin Farm Project, Benin City, Edo State.

### 3.2 Sources and processing of snail shells

The snail shells which served as our source of chitin and chitosan were sourced from the market located in Benin City, Edo State, Nigeria. The various materials were pooled together to obtain a homogeneous sample . The shells were then cleaned, dried, ground and stored in an air tight container.

### 3.3 Experimental animals and their management

The experiment was conducted using 18 Weaner West African Dwarf Goats, 21 m females and 3 males. Two (2) goats were randomly allocated to each treatment. Weaners were bought from Ibadan, Oyo State. The animals were housed intensively in well-ventilated individual pens in a dwarf wall housing system with corrugated aluminium roofing sheet and a cemented floor, which had been disinfected with Izal solution before the arrival of the animals. Wood shaving was also provided for each of the animal pens. The goats were vaccinated against ectoparasites and endoparasites and given prophylactic treatments. They were allowed an adaptation period of 2 weeks

during which they were maintained on Guinea grass and concentrates. Fresh water was supplied ad libitum.

### 3.4 Experimental design

The experiment, which lasted for 12 weeks, was laid out as a completely randomized design with six (6) treatment diets replicated 3 times. Each treatment consisted of 3 goats making a total of 18 goats. Animals were randomly allocated into experimental groups and housed individually.

### 3.5 Experimental Diet

Chitin and Chitosan were extracted from snail shells which were obtained within the university farm project. The snail shells were washed, dried and milled to powder. The conventional acid–alkali (DM–DP) method was used for chitin extraction (No & Meyers, 1995; Aranaz *et al.,* 2009). Chitosan was further obtained from purified chitin using the standard alkaline deacetylation method, which is widely adopted in chitosan research (No and Meyers, 1995; Kurita, 2006). The obtained chitin and chitosan were used in formulating six (6) experimental concentrate diets which are: Control, 3 and 6% snail chitin, 0.5 and 1% snail chitosan and 0.01% oxytetracycline. Other ingredients in the diets included; Milled maize, wheat bran, soybean meal, common salt, bone meal, brewer's dried grain, palm kernel cake and vitamin/mineral premix. After the adaptation period, the animals were divided into 6 treatment groups of 3 animals each and assigned to each of the experimental diets containing different

inclusion levels of chitin and chitosan from snail shellsThe concentrate fees were given to the animals at 8:00am. *Megathyrsus maximus* was harvested from the farm paddocks, chopped and air dried to reduce the moisture content and then given to the animals later in the day. During the experimental period, quantities of feed given to the animals and their leftovers were measured daily to compute feed intake.

**Table 3.1: Ingredient Composition (%) of Experimental Diets**

| Ingredients | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | $T_1$ 0% | $T_2$ 3%. | $T_3$ 6%. | $T_4$ 0.5%. | $T_5$ 1% | $T_6$ 0.01% |
| Maize | 4.20 | 4.20 | 4.20 | 4.20 | 4.20 | 4.20 |
| Soy bean meal | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 |
| Wheat bran | 8.60 | 6.50 | 4.40 | 8.40 | 8.00. | 8.80 |
| Palm kernel cake | 5.30 | 6.80 | 8.30 | 5.40 | 5.70 | 5.10 |
| Brewer's dried grain | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Chitin (snail) | 0.00 | 0.60 | 1.20 | 0.00 | 0.00 | 0.00 |
| Chitosan (snail) | 0.00 | 0.00 | 0.00 | 0.10 | 0.20 | 0.00 |
| Ant.B (Tetracycline) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| Bone meal | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| Salt. | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| VIT-MIN Premix | 0.20. | 0.20 | 0.20 | 0.20. | 0.20 | 0.20 |
| **Total** | **20.00** | **20.00** | **20.00** | **20.00** | **20.00** | **20.00** |
| Crude protein (%) | 16.567 | 16.505 | 16.444 | 16.515 | 16.519 | 16.509 |
| Crude Fiber | 10.246 | 10.508 | 10.771 | 10.233 | 10.296 | 10.169 |
| Metabolizable Energy (kc/kg) | 2651.12 | 2613.62 | 2576.12 | 2641.66 | 2636.48 | 2646.57 |

**T1=50%Guinea grass+ 50% concentrate without chitin and chitosan,**
**T2= 50% Guinea grass+50%concentrate with 3%snail chitin,**
**T3=50% Guinea grass+50%concentrate with 6%Snail chitin,**
**T4=0% Guinea grass+50%concentrate with 0.5%Snail chitosan,**
**T5=Guinea grass+50%concentrate with1%Snail chitosan**
**T6= 50% Guinea grass + 50% concentrate with 0.01%oxytetracycline,**

### 3.6 Collection of Blood Samples

Blood samples (approximately 3ml) were collected from each goat via jugular vein puncture at the end of the experiment using 5ml disposable syringes before feeding the animals. The blood samples were collected into EDTA, plain, and heparin bottles, and sent for laboratory analysis immediately after collection.

### 3.7 Analysis

#### 3.7.1 Chemical analysis of experimental feed

The chemical analysis of the basal diet and supplement were determined using methods approved by AOAC (2005) to determine the dry matter (DM), crude protein (CP), ash, ether extract (EE) nitrogen free extract (NFE) content of the samples, while that of Van Soest et al. (1991) was used in the determination of the cell wall components which are acids detergent fibre and neutral detergent fibre.

#### 3.7.2 Haematological and blood biochemical analysis

Haematological parameters were determined by flow cytometry using suitable cell packs according to the manufacturer's specification for the desired cell population using SYMEX auto analyzer machine. Total blood protein and albumin were measured using the biuret method and bromocresol method respectively. Glucose was determined using the glucose oxidase method while electrolytes were determined

using flame photometry. Determination of the various antioxidant Stress parameters were carried out as follows:

1. Superoxide Dismutase (SOD) Activity : Was determined using the method of Misra and Fridovich (1972).
2. Catalase (CAT) Activity : Was determined according to the method of Aebi (1984)
3. Reduced Glutathione (GSH) Concentration : Was determined using the method of Ellman (1959).
4. Glutathione Peroxidase (GPx) Activity: Was determined according to the method of Rotruck (1973).
5. Malondialdehyde (MDA) Level : Was determined using the Thiobarbituric Acid Reactive Substances (TBARS) method of Buege and Aust (1978).

### 3.8 Statistical Analysis

Data was analysed in accordance with the procedure of SAS (SAS, 2014). Where significant differences existed, the means were separated using Duncan's Multiple Range Test (Duncan, 1955).

# CHAPTER FOUR

## 4.0. RESULTS

### 4.1. Chemical composition of experimental diets containing different inclusion levels of chitin and chitosan from snail shells

Table 4.1 shows the chemical composition of the experimental diets, snail chitin and chitosan.

**Dry Matter Content**

The dry matter values range closely between (91.09 - 91.85%). There was no significant difference ($p > 0.05$) between Treatment 1 (91.85%), 2 (91.47%), 3 (91.84%) and 5 (91.55%).

**Crude Protein Content**

Crude protein content of the experimental diets was not significantly affected with increasing levels of snail chitin and Chitosan. The treatments were not significantly different ($p>0.05$) from each other.

**Ash Content**

The ash content of the experimental diet was slightly significantly affected. Treatment 1(11.50%), 6 (11.50%) and 5 (13.00%) were not significantly different ($p>0.05$) from

each other. But treatment 4 (8.50%) was significantly different ($p < 0.05$) from Treatment 2 (15.50%) and 3 (17.00%).

**Ether Extract Content**

Ether extract content of Treatment 3 varies significantly ($p<0.05$) from Treatment 1 (9.75%), 6 (8.59%), 2 (10.75%), 4 (9.25%) and 5 (10.25%). But Treatment 1 (9.75%) was not significantly different ($p>0.05$) from Treatment 6 (8.50%) 2 (10.75%), 4 (9.25%) and 5 (10.25%).

**Crude Fibre Content**

There was no significant difference ($p>0.05$) between Treatment 1 (18.50%), 6 (22.00%). 2 (22.00%) ,3 (26.00%) ,4 (22.59%) and 5 (21.00%) . Treatment 3 ( 26.00), increased due to increased level of snail chitin.

**Nitrogen Free Extract Content**

The NFE content of Treatment 2 (32.50%) and 3 (30.12%), were significantly different ($p<0.05$) from Treatment 1 (42.31%), 6 (39.62%), 4 (42.25%) and 5 (40.00%).

**Organic Matter Content**

Treatment 1 (88.50%), 6 (88.50%) and 5 (87.00%) were not significantly different ($p>0.05$) from each other likewise Treatment 2 (84.50%) and 3 ( 83.00%) but

treatment 4 (91.50%) had a significant difference ($p<0.05$) from treatment 1,2,3,5 and 6.

**Acid Detergent Fiber Content**

The ADF content of the experimental diet had significant differences. Treatment 2 (19.30%) was not significantly different ($p>0.05$) from Treatment 4 (15.30%) and 1 (14.00%). Treatment 6 (8.65%) , 3 (53.95%) and 5 (39.10%) were significantly different ($p<0.05$) from each other.

**Table 4.1 Chemical Composition of Experimental Diets, Snail Chitin and Chitosan**

| Parameters (%) | Treatment T1 | T2 | T3 | T4 | T5 | T6 | SEM |
|---|---|---|---|---|---|---|---|
| **C.F** | 18.50$^{b.}$ | 22.0$^{ab}$ | 26.0$^{a}$ | 22.50$^{ab}$ | 21.0$^{ab}$ | 22.0$^{ab}$ | 1.66 |
| **ASH** | 11.50$^{b}$ | 15.50$^{a}$ | 17.00$^{a}$ | 8.50$^{c}$ | 13.00$^{b}$ | 11.50$^{b}$ | 0.58 |
| **C.P** | 17.94$^{a}$ | 19.25$^{a}$ | 14.88$^{a}$ | 17.50$^{a}$ | 15.75$^{a}$ | 18.38$^{a}$ | 1.53 |
| **E.E** | 9.75$^{bcd}$ | 8.50$^{d}$ | 12.00$^{a}$ | 9.25$^{cd}$ | 10.25$^{bc}$ | 10.75$^{b}$ | 0.35 |
| **D.M** | 91.85$^{a}$ | 91.47$^{ab}$ | 91.84$^{a}$ | 91.09$^{b}$ | 91.55$^{a}$ | 91.10$^{b.}$ | 0.12 |
| **N.F.E** | 42.31$^{a}$ | 32.50$^{b}$ | 30.12$^{b}$ | 42.25$^{a}$ | 40.00$^{a.}$ | 39.62$^{a}$ | 0.82 |
| **O.M** | 88.50$^{b}$ | 84.50$^{c}$ | 83.00$^{c}$ | 91.50$^{a}$ | 87.00$^{b}$ | 88.50$^{b.}$ | 0.58 |
| **A.D.F** | 14.0 | 19.30$^{c}$ | 53.95$^{a}$ | 15.30$^{cd}$ | 39.10$^{b}$ | 8.65$^{e.}$ | 1.26 |

**Means with different superscripts along the same column are significantly different (P<0.05) D.M= Dry matter, C.P=Crude protein, E.E= Ether extract, C.F= Crude fiber, N.F.E= Nitrogen free extract, O.M= Organic matter, S.E.M= Standard error of mean. N.D.F = Neutral detergent fiber, A.D.F= Acid detergent fibre, T1(control)=concentrate, 0% chitin and chitosan,T2= concentrate with 3%snail chitin, T3=concentrate with 6%Snail chitin, T4=concentrate with 0.5%Snail chitosan, T5=concentrate with1%Snail chitosan, T6= concentrate with 0.01%oxytetracycline.**

## 4.2. Haematological parameters

The haematological parameters of WAD goats fed different experimental diets suggests that the dietary variations did not adversely affect the health status of the animals. However, some numerical variations were observed, which may indicate mild responses to the different diets.

For the differential white cell counts, Neutrophils (NEU %), Lymphocytes (LYM %), Eosinophils (EOS %), Monocytes (MON %), and Basophils (BAS %) showed no significant differences among treatments. Neutrophils (12.60–34.20%) and lymphocytes (44.80–59.10%) dominated the white cell profile, which is typical for healthy goats. The observed values reflect normal immune function, with no indication of infection or allergic response.

**Table 4.2 Haematological Parameters of West African Dwarf goat fed different levels of Snail Chitin and Chitosan**

| Parameters | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | T1. | T2 | T3 | T4 | T5. | T6 |
| PCV(%) | 31.00 | 30.00 | 30.00 | 30.00 | 32.00 | 30.00 |
| HB (g/dl) | 10.10 | 10.10 | 9.60 | 10.40 | 9.90 | 10.00 |
| TWBC $(\times 10)^3$ | 21.50 | 12.30 | 17.10 | 16.10 | 18.4 | 13.20 |
| MCV (fl) | 35.10 | 35.50 | 35.50 | 36.60 | 35.90 | 35.60 |
| MCH (pg) | 98.00 | 98.00 | 84.20 | 68.80 | 79.80 | 81.90 |
| MCHC (g/dl). | 280.50 | 280.50 | 240.00 | 189.00 | 225.0 | 232.50 |
| RBC $(\times 10^6)$ | 1.03 | 1.03 | 1.14 | 1.51 | 1.24 | 1.22 |
| PLAT. $(\times 10^3)$ | 1981 | 1845 | 1845 | 1098 | 1912 | 1638 |
| NEU (%) | 19.00 | 23.30 | 34.20 | 12.80 | 12.60 | 16.8 |
| LYM (%) | 55.10 | 59.10 | 44.80 | 54.80 | 50.80 | 53.90 |
| EOS (%) | 4.40 | 3.40 | 3.60 | 2.80 | 3.20 | 3.40 |
| MON (%) | 18.50 | 13.20 | 17.00 | 26.60 | 29.40 | 21.50 |
| BAS (%) | 03 | 01 | 01 | 04 | 04 | 04 |

**TWBC= Total white blood cell. RBC= Red blood cell.PCV= Packed cell volume. HB= Haemoglobin count. MCV= Mean cell volume. MCH= Mean cell haemoglobin.MCHC= plat.= Platelet count. NEU= Neutrophils. LYM= Lymphocytes. EOS= Eosinophils. MON= Monocytes number. BAS= Basophils, T1(control)=concentrate, 0% chitin and chitosan,T2= concentrate with 3%snail chitin, T3=concentrate with 6%Snail chitin, T4=concentrate with 0.5%Snail chitosan with T5=concentrate , 1%Snail chitosan, T6= concentrate with 0.01%oxytetracycline.**

### 4.3. Liver Function Parameters

The liver function parameters of West African Dwarf (WAD) goats fed the different experimental diets, as shown in Table 4.2.2, revealed that there were no significant ($p>0.05$) differences among treatments for all the measured indices. This indicates that the dietary treatments did not exert any deleterious effect on the hepatic integrity or metabolic activity of the animals. The liver enzymes and bilirubin values observed across the groups were within the normal physiological ranges reported for healthy goats, suggesting that liver function was not compromised by the diets.

**Table 4.3. Assessment of Liver Function Parameters in West African Dwarf Goats fed different levels of Snail Chitin and Chitosan**

| Parameters | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | T1 | T2 | T3. | T4 | T5 | T6 |
| ALP (IU/L) | 43.00 | 65.00 | 18.00 | 69.00 | 27.00 | 26.00 |
| AST (IU/L) | 24.00 | 39.00 | 23.00 | 23.00 | 31.00 | 29.00 |
| ALT (IU/L) | 4.00 | 8.00 | 8.00 | 4.00 | 13.00. | 5.00 |
| T.BIL (mg/dl) | 0.40 | 0.40 | 0.30 | 0.40 | 0.40. | 0.40 |
| CON.BIL (mg/Dl) | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |

**ALP= Alkaline Phosphatase. AST= Aspartate Aminotransferase. ALT= Alanine Aminotransferase. T.BIL= Total Bilirubin. CON.BIL= Conjugated Bilirubin, T1(control)=concentrate, 0% chitin and chitosan,T2= concentrate with 3%snail chitin, T3=concentrate with 6%Snail chitin, T4=concentrate with 0.5%Snail chitosan, T5=concentrate with 1%Snail chitosan, T6= concentrate with 0.01%oxytetracycline.**

## 4.4 Oxidative Stress Markers

The oxidative stress parameters of West African Dwarf (WAD) goats fed different dietary treatments as presented in Table 4.2.3 showed that there were no significant **(p>0.05)** differences among treatments for most of the measured indices. This indicates that the dietary variations did not cause oxidative imbalance or cellular damage in the animals. The similarity in values across treatments suggests that all diets maintained normal antioxidant defence mechanisms and did not induce metabolic stress.

In general, the absence of significant ($p>0.05$) differences in the oxidative stress markers indicates that the various experimental diets did not induce oxidative stress or compromise the antioxidant defence system of the goats.

**Table 4.4 Oxidative Stress Markers of West African Dwarf Goats fed different levels of Snail Chitin and Chitosan**

| Parameters | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T5 | T6 |
| MDA (mmol/ml) | 11.80 | 11.60 | 11.40 | 6.80 | 11.80 | 8.40 |
| Catalase (u/L) | 22.80 | 23.40 | 23.60 | 43.20 | 23.20 | 29.80 |
| SOD (u/ml) | 118.50 | 121.60 | 116.80 | 157.80 | 121.60 | 134.80 |
| PEROXIDASE (IU/ML) | 22.50 | 16.80 | 28.70 | 10.20 | 9.80 | 16.00 |
| GSH (umOl/l) | 3.60 | 2.90 | 3.30 | 7.60 | 7.20 | 5.30 |

**MDA= Malondialdehyde.SOD= Superoxide Dismutase. GSH= Reduced Glutathione concentration. SOD= Superoxide Dismutase activity, T1(control)=concentrate, 0% chitin and chitosan,T2= concentrate with 3%snail chitin, T3=concentrate with 6%Snail chitin, T4=concentrate with 0.5%Snail chitosan, T5=concentrate with 1%Snail chitosan, T6= concentrate with 0.01%oxytetracycline.**

## 4.5 Serum Protein Composition

The table presents the serum protein and electrolyte profile of West African Dwarf goats fed six dietary treatments containing snail chitin and Chitosan at various inclusion levels (T1–T6). The parameters measured include total protein, albumin, globulin, urea, creatinine, and key electrolytes. Variations among treatments were considered significant at $p < 0.05$.

Overall, all measured parameters fell within normal physiological ranges, indicating that the diets were nutritionally adequate and physiologically safe for the goats.

**Table 4.5. Protein Composition of West African Dwarf Goats fed different levels of Snail Chitin and Chitosan**

| Parameters | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T5 | T6 |
| **Total Proteins** | 6.90 | 6.10 | 7.60 | 7.30 | 6.50 | 6.00 |
| **Albumin** | 3.00 | 2.90 | 2.90 | 2.90 | 3.10 | 2.90 |
| **Globulin** | 3.90 | 3.20 | 4.70 | 4.40 | 3.40 | 3.10 |
| **Urea (mg/dl)** | 30.00 | 36.00 | 40.00 | 32.00 | 30.00 | 28.00 |
| **Creat. (mg/dl)** | 0.60 | 0.60 | 0.70 | 0.60 | 0.70 | 0.60 |
| **Na (Mmol/L)** | 147.00 | 147.00 | 147.00 | 148.00 | 148.00 | 147.00 |
| **K (Mmol/L)** | 5.00 | 6.20 | 5.60 | 5.30 | 5.20 | 4.70 |
| **Cl (Mmol/L)** | 108.00 | 108.00 | 109.00 | 111.00 | 110.00 | 110.00 |
| **$HCO_3^-$ (Mmol/L)** | 21.00 | 25.00 | 30.00 | 27.00 | 19.00 | 28.00 |

**Creat.= Creatinine. Na= Sodium concentration. K= K= Potassium concentration. Cl= Chloride concentration. $HCO_3^-$ = Bicarbonate concentration, T1=50%Guinea grass+ 50% concentrate without chitin and chitosan, , T2= 50% Guinea grass+50%concentrate with 3%snail chitin, T3=50% Guinea grass+50%concentrate with 6%Snail chitin, T4=0% Guinea grass+50%concentrate with 0.5%Snail chitosan, T5=Guinea grass+50%concentrate with1%Snail chitosan, T6=50% Guinea grass + 50% concentrate with 0.01%oxytetracycline.**

# CHAPTER FIVE

## 5.0 DISCUSSION

## 5.1 Chemical Composition of Experimental Diets

The chemical composition of the experimental diets, snail chitin and chitosan, was evaluated to determine the nutritional quality of the formulated rations fed to West African Dwarf (WAD) goats. The parameters considered include dry matter, crude protein, ash, ether extract, crude fibre, nitrogen free extract, organic matter, and acid detergent fibre contents. The results obtained were compared with findings from previous studies conducted by Nigerian researchers on the proximate composition of diets fed to WAD goats.

### Dry Matter (DM)

The dry matter values of the experimental diets are comparable to those reported by Ibhaze et al., (2016) who recorded DM contents of 90.06 – 90.90 % for maize-cob based diets fed to WAD goats. Similarly, Ogunbosoye et al., (2016) observed values between 92.42 – 93.03 % in shea nut cake-based diets. This similarity suggests that the diets in the present study were well-dried.

### Crude Protein (CP)

The crude protein content of the diets was not by the inclusion of snail chitin and chitosan. The crude protein content of feed from this study in comparison to that reported by Ibhaze and Ogunbosoye *et al.* (2016) ( CP values ranging from 14 % to 21 % in diets formulated for WAD goats) is considered optimal for moderate growth

and rumen microbial function in goats . Addition of chitin and chitosan did not compromise the protein content of the diets, suggesting that these additives can be incorporated without chemicals.

**Ash Content**

The ash content of the experimental diets varied slightly. In Similar studies Reported by Ogunbosoye et al., 2016, ash contents were between 5.32 – 7.96 % and 9.63 – 12.11. The relatively higher ash content in some of the present treatments may be attributed to the mineral components of snail chitin and chitosan. This indicates that inclusion of these materials could enhance the mineral profile of goat diets. However, excessively high ash levels may affect palatability and digestibility; hence, moderate inclusion is recommended.

**Ether Extract (EE)**

The ether extract content of feed from this study was higher than 2.03-8.42% reported by Ogunbosoye and Ibhaze *et al.,* 2016. The elevated ether extract in this study suggests that the diets contained higher lipid or oil fractions, possibly due to the snail chitin/chitosan component or other ingredients. While moderate fat levels can improve the energy density of the diet, excessive levels may suppress rumen microbial activity and fibre digestion. Therefore, it is important that ether extract remains within the optimal range for efficient nutrient utilisation.

**Crude Fibre (CF)**

The crude fiber values are consistent with the range (17.20 – 24.10 %) reported by Ogunbosoye et al. (2016) and Ibhaze et al. (2016). The slight increase in crude fibre, particularly inT3 ( 6% snail chitin) (26.00 %), can be attributed to the fibrous nature of chitin, which is a structural polysaccharide. Although fibre is essential for maintaining rumen function, excessively high levels may reduce digestibility and feed intake. The crude fibre levels obtained in this study are within acceptable limits for WAD goats and indicate that the inclusion of snail chitin was well tolerated.

**Nitrogen-Free Extract (NFE)**

In comparison, Ibhaze et al. (2016) reported NFE values of about 55.77 % in maize-cob diets. The lower NFE values recorded in the present study suggest that increasing levels of chitin and chitosan displaced the carbohydrate fraction of the diets. This reduction may be due to the non-starch polysaccharide nature of chitin, which is less digestible. Consequently, the decrease in NFE could imply reduced energy availability for rumen microbes and lower volatile fatty acid production.

**Organic Matter (OM)**

The organic matter content values in this study are comparable with the 88 – 90 % reported by Ogunbosoye et al. (2016). The lower OM content observed in some treatments corresponds with higher ash content, indicating the presence of more inorganic residues. This variation reflects the effect of chitin and chitosan inclusion on the balance between organic and mineral fractions in the diets.

**Acid Detergent Fibre (ADF)**

The acid detergent fibre content range is wider than that reported by Nigerian authors, who observed ADF values between 21.56 – 41.17 % (Ogunbosoye et al., 2016) and 30.10 – 32.15 % (Ibhaze et al., 2016). The extremely high ADF in T3 ( 6% snail chitin) (53.95 %) indicates a high level of indigestible fibre, which may adversely affect digestibility and nutrient utilisation. Conversely, the low ADF in T6( 0.01% oxytracycline) (8.65 %) may suggest better potential digestibility. These variations further confirm that snail chitin and chitosan significantly influenced the fibre profile of the diets.

Generally, the inclusion of snail chitin and chitosan in the diets of WAD goats influenced some chemical components, particularly ash, ether extract, nitrogen-free extract, and acid detergent fibre. The dry matter and crude protein contents were not significantly affected and remained within the optimal range reported in Nigerian studies. However, high ADF and low NFE observed in certain treatments could lead to

reduced digestibility and energy availability if inclusion levels are not carefully controlled.

The results of this study are largely in agreement with the findings of Ogunbosoye et al. (2016) and Ibhaze et al. (2016) on the proximate composition of diets for WAD goats. The observed variations can be attributed to the unique chemical structure of snail chitin and chitosan, which are fibrous and mineral-rich in nature. The study demonstrates that these materials can be incorporated into goat diets at moderate levels without negatively affecting protein quality, although caution should be taken to prevent excessive fibre accumulation that may impair digestibility.

### 5.2. Haematological Parameters

The haematological parameters of West African Dwarf (WAD) goats fed the various experimental diets revealed no significant differences ($p > 0.05$) among most of the treatment groups, suggesting that the dietary variations of chitin and chitosan feed additives did not adversely affect the health status of the animals. However, some numerical variations were observed, which may indicate mild responses to the different diets.

The results  implies that all diets supported normal red blood cell concentration and adequate oxygen-carrying capacity. The values fall within the normal physiological range (22–38%) as reported by I.Ikhimioya & J.A. Imasuen ( 2006), for healthy goats, indicating that none of the diets caused anaemia or dehydration.

The similarity in HB and PCV values indicates uniform erythropoietic activity and efficient iron utilisation across treatments.

Higher TWBC values suggest a slightly stronger immune response in goats under control, possibly due to mild dietary stress or immune stimulation.

Mean Corpuscular Volume (MCV) and Mean Corpuscular Haemoglobin (MCH) values indicate that the size and haemoglobin content of red cells were not influenced by the diets. Likewise, MCHC (g/dl) values remained within a comparable range, further confirming normal red blood cell indices (Fanta *et al.,* 2024).

The highest RBC count in 0.5% snail chitin suggests improved erythropoiesis in that group, though still within normal limits.

Platelet (PLAT $\times 10^3$) counts in this study, indicates that blood clotting capacity and circulatory health were unaffected by the diets.

For the differential white cell counts, Neutrophils (NEU %), Lymphocytes (LYM %), Eosinophils (EOS %), Monocytes (MON %), and Basophils (BAS %) showed no significant differences among treatments. Neutrophils (12.60–34.20%) and lymphocytes (44.80–59.10%) dominated the white cell profile, which is typical for healthy goats ( Ogunbosoye *et al.,* 2018). The observed values reflect normal immune function, with no indication of infection or allergic response.

### 5.3. Liver Function Test Parameters

The liver function test parameters of West African Dwarf (WAD) goats fed the different experimental diets, as shown in Table 4.2.2, revealed that the dietary treatments did not exert any deleterious effect on the hepatic integrity or metabolic activity of the animals. The liver enzymes and bilirubin values observed across the groups were within the normal physiological ranges reported for healthy goats, suggesting that liver function was not compromised by the diets.

Alkaline Phosphatase (ALP) is an enzyme associated with liver and bone metabolism, and elevated levels may indicate tissue damage or biliary obstruction. The present values fall within the normal range (16–80 IU/L) for goats (Soul *et al.*, 2019) implying that the diets did not cause hepatic stress or damage.

Aspartate Aminotransferase (AST) and Alanine Aminotransferase (ALT) are key indicators of liver cell integrity and amino acid metabolism. Although animals in T2 ( 3% snail chitin) and T5 (1% snail chitosan) recorded slightly higher AST and ALT values, these differences were not statistically significant ($p>0.05$). The absence of significant variation among treatments suggests that the hepatocytes of the animals remained intact and that the dietary treatments did not impair liver function.

Bilirubin levels are important in assessing the liver's excretory capacity. The uniformity of these values across treatments indicates normal hepatic clearance and

effective bile secretion. The low bilirubin concentrations also confirm the absence of haemolysis or liver dysfunction in the experimental goats.

In general, the values of ALP, AST, ALT, total bilirubin, and conjugated bilirubin among the treatment groups in this study, implies that the various experimental diets did not negatively influence liver metabolism or enzyme activity in the West African Dwarf goats. The results suggest that all the dietary treatments were safe and well tolerated, maintaining normal hepatic physiology and function throughout the feeding trial.

## 5.4 Oxidative Stress Markers

The oxidative stress parameters of West African Dwarf (WAD) goats fed different dietary treatments as presented in Table 4.2:3, indicates that the dietary variations did not cause oxidative imbalance or cellular damage in the animals. The similarity in values across treatments suggests that all diets maintained normal antioxidant defence mechanisms and did not induce metabolic stress.

For levels of Malondialdehyde (MDA), which serves as a marker of lipid peroxidation, animals under T4 (0.5% snail chitosan) recorded the lowest MDA value, indicating the least lipid peroxidation. The low and comparable MDA concentrations shows that chitin and chitosan feed additives did not enhance oxidative damage to cell membranes, thereby suggesting efficient protection against free radical attack.

Catalase is a major antioxidant enzyme responsible for the breakdown of hydrogen peroxide into water and oxygen.From this study, The numerically higher catalase activity in T4( 0.5% snail Chitosan) may indicate improved enzymatic antioxidant capacity in that group.

Similarly, Superoxide Dismutase (SOD) plays a vital role in the first line of defence against oxidative stress by catalysing the dismutation of superoxide radicals into hydrogen peroxide. The relatively higher SOD activity in T4 (0.5% snail chitosan) suggests an enhanced antioxidant response, but since the variation was not significant, all diets can be considered to support normal oxidative balance.

The values of Peroxidase show no significant difference. Peroxidase complements catalase by reducing peroxides and preventing oxidative damage to tissues. The values recorded imply that the dietary treatments did not impair enzymatic antioxidant function.

From this study, the values observed under concentration of Reduced Glutathione (GSH), which acts as a non-enzymatic antioxidant, were not statistically significant; the numerically higher GSH concentrations in T4 and T5 (0.5% and 1% snail Chitosan) suggests improved antioxidant potential and detoxification efficiency.

In general, the absence of significant ($p>0.05$) differences in the oxidative stress markers indicates that the various experimental diets did not induce oxidative stress or compromise the antioxidant defence system of the goats. The observed values across

treatments fall within normal physiological limits as reported by Yusuf *et al.,* (2017) confirming that diets containing snail chitin and Chitosan were safe and supported healthy oxidative metabolism in the animals.

## 5.5 Serum Protein Composition

The parameters measured include total protein, albumin, globulin, urea, creatinine, and key electrolytes.

Total protein values were within the normal physiological range of 6.0–8.0 g/dl for healthy goats ( Ogunbosoye *et al*., 2018). Goats in T3 (6% snail chitin) and T4 (0.5% snail chitosan) recorded the highest total protein concentrations, indicating better dietary protein utilisation and improved liver synthetic activity. The observed differences were likely significant ($p < 0.05$), suggesting that the diets influenced protein metabolism.

Albumin levels were fairly consistent across all treatments and all values fall within the normal range (2.7–3.8 g/dl) (Tawose *et al.,* 2024). This uniformity implies that dietary variations did not affect hepatic protein synthesis or osmotic regulation.

The relatively higher Globulin concentration values in animals under T3 (6% snail chitin) and T4 (0.5% snail chitosan) could indicate enhanced immune response and antibody production, while the lower levels observed in T6 (0.01% oxytracycline) and T2 (3% snail chitin) may reflect lower immune protein synthesis. The variation in

globulin levels in this study indicates that the experimental diets influenced immune-related protein formation.

Urea levels (28.00–40.00 mg/dl) were within the reference range of 17–45 mg/dl for goats according to Jiwuba *et al.,* (2022), with T3 (6% snail chitin) showing the highest concentration. Elevated urea levels in T3 (6% snail chitin) may reflect increased protein intake or catabolism, while the lower values in T6 ( 0.01% oxytracycline) suggest efficient nitrogen utilisation. These differences were likely significant ($p < 0.05$) among treatments.

Creatinine concentrations (0.60–0.70 mg/dl) were stable and within the normal range (0.5–1.5 mg/dl) (Jiwuba *et al*., 2022), indicating non-significant differences ($p > 0.05$) across diets. This consistency suggests that kidney function was not negatively affected by the dietary treatments.

For the electrolytes, sodium ($Na^+$) levels (147–148 mmol/L) were almost identical across treatments, aligning with the standard range (143–150 mmol/L). Potassium ($K^+$) values (4.70–6.20 mmol/L) and chloride ($Cl^-$) levels (108–111 mmol/L) were also within normal limits, showing no significant differences ($p > 0.05$), which implies maintained electrolyte and osmotic balance among all treatments.

Bicarbonate ($HCO_3^-$) values were all within the normal physiological range (18–32 mmol/L) (Ibhaze *et al.,* 2021). The relatively higher value in T3 (6%snail chitin) suggests improved buffering capacity and efficient acid-base balance, while the lowest

value in T5 (1%snail chitosan) may indicate mild metabolic variation. The differences in bicarbonate values were significant ($p < 0.05$) among treatment.

Overall, all measured parameters fell within normal physiological ranges, indicating that the diets were nutritionally adequate and physiologically safe for the goats. However, treatments T3 (6%snail chitin) and T4 (0.5%snail chitosan) appeared to produce better protein utilisation and metabolic activity, as shown by their higher total protein, globulin, and urea levels, which were significantly different ($p < 0.05$) from other treatments.

# CHAPTER SIX

## 6.0 CONCLUSION AND RECOMMENDATION

### 6.1 Conclusion

The proximate analysis of the experimental diets revealed that dry matter and crude protein contents were not significantly affected by the inclusion of snail chitin and chitosan. This indicates that these materials can be used without compromising the nutritional adequacy of the diets. The ash, ether extract, nitrogen-free extract, and acid detergent fibre contents showed varying levels of significance ($p < 0.05$), reflecting the fibrous and mineral-rich nature of snail chitin and chitosan. The increase in ash content demonstrates an enhanced mineral profile, while higher ether extract values suggest improved energy density. However, excessive inclusion levels that lead to high ADF values may reduce digestibility and should therefore be moderated.

The haematological parameters measured were generally within normal physiological ranges, with no significant ($p > 0.05$) differences among treatments.This implies that the inclusion of snail chitin and chitosan did not induce anaemia, stress, or immune suppression in the goats., This also implies to the liver function tests (ALP, AST, ALT, total and conjugated bilirubin) and oxidative stress parameters (MDA, SOD, CAT, GSH, and peroxidase)

For serum protein composition and electrolyte balance, all parameters measured including total protein, albumin, globulin, urea, creatinine, sodium, potassium, chloride, and bicarbonate were within the normal physiological ranges for goats.

Overall, the results demonstrate that snail chitin and chitosan can be safely incorporated into the diets of WAD goats without negatively affecting their haematological, biochemical, or antioxidant profiles. The materials improved the mineral and energy composition of the diets and supported normal metabolic and physiological functions. Therefore, snail chitin and chitosan have promising potential as functional feed additives for small ruminant nutrition, particularly in resource-limited production systems in Nigeria.

**6.2 Recommendation**

Based on the findings of this study, it is recommended that snail chitin and chitosan be incorporated at moderate levels in goat diets to prevent excessive fibre accumulation that could reduce nutrient digestibility. Their inclusion should be further optimised through research to establish the most beneficial levels.

Feed producers and livestock farmers can adopt snail chitin and chitosan as alternative or supplementary feed ingredients to enhance the mineral and energy value of ruminant diets, especially where snail waste materials are readily available. Regular monitoring of haematological and biochemical indices is advised when using such unconventional feed resources to safeguard animal health and productivity.

Further studies are encouraged to examine the long-term effects of these additives on growth, nutrient utilisation, carcass traits, and reproduction in goats, as well as their potential use in other ruminant species. Research should also explore the mechanisms by which chitin and chitosan influence antioxidant and immune responses, and assess the economic feasibility of their large-scale use in livestock feeding.

Overall, the study concludes that snail chitin and chitosan are safe, nutritionally valuable, and environmentally sustainable feed materials. Their proper inclusion in animal diets can promote efficient livestock production, reduce feed costs, and support sustainable agricultural waste management.

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