EFFECT OF PROBIOTICS ON GROWTH, CARCASS YIELD AND QUALITY CHARACTERISTICS, REPRODUCTIVE PERFORMANCE, HAEMATOLOGY AND SERUM BIOCHEMISTRY OF RABBITS

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ABSTRACT

This study was carried out to evaluate the effects of probiotics (Saccharomyces boulardii and Saccharomyces cerevisiae) supplementation on growth, carcass yield and quality characteristics, reproductive performance, haematology and serum biochemistry of rabbits. The study consists of two (2) experiments. Experiment one (1) was for the parent rabbits while their progenies were harvested for experiment two (2). Fourty five heteregenous growing rabbits were used each for experiment one and two and randomly distributed into five (5) treatment groups (T_1, T_2, T_3, $T_4$and T_5) with each treatment having three (3) replicates and three (3) rabbits per replicate. T_1(control) had no probiotics, while Saccharomyces boulardii was administered orally on the rabbits weekly at 80 x 10^6cfu/ml , 60 x 10^6cfu/ml, 40 x 10^6cfu/ml and 20 x 10^6cfu/ml forT_2, T_3, T_4,and T_5 respectively. Serial dilution method was used to determine the doses while the Saccharomyces cerevisieawas added to the feed at 0.2g/kg (2 x 10^8cfu/ml), 0.4g/kg (4 x10^8cfu/ml), 0.6g/kg(6 x 10^8cfu/ml), and 0.8g/kg (8 x 10^8cfu/ml), for T_2, T_3, T_4 and T_5 treatment groups for the two experiments, respectively. Blood samples were collected through the ear maginal vein for haematological and serum biochemical evaluation. Data were also collected on body weight, body weight gain, feed intake, feed conversion ratio and nutrient digestibility. At the end of the feeding trial, a total of fifteen
(15) rabbits were randomly selected, one from each of the replicates and slaughtered for meat yield and quality characteristics study. Also data were collected on reproductive performance (doe traits, birth traits, weaning traits and testicular morphometric).The results of haematology in experiment one at week one showed no significant ($p>0.05$) difference in red blood cells (RBCs), Haemoglobin (Hb), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) but white blood cells (WBC) and packed cells volume (PCV) were significantly ($p<0.05$) affected. However, at week eight, only WBC was significantly ($p<0.05$) affected. The results for serum biochemistry of experiment one at week one showed significant ($p<0.05$) difference in total protein, albumin, sodium and chloride but non significant ($p>0.05$) difference in potassium while at week eight, the result showed no significant ($p>0.05$) difference in all the serum parameters. In experiment two, the results revealed non significant ($p>0.05$) difference in all the haematological and serum biochemical parameters both at week one and at eight. The results also revealed non significant ($p>0.05$) difference in final body weight, total body weight gain, average daily body weight gain, total feed intake, average daily feed intake and feed conversion ratio in both experiment one and two. Apparent

nutrient digestibility also showed no significant (P>0.05) difference in dry matter, crude protein, crude fibre, ether extract, ash and nitrogen free extract. No significant (p>0.05) differences in live weight, slaughter weight, carcass length, eviscerated weight, dressing percentage, head, neck, pelts, fore limb, hind leg, ribs and loin were observed in both experiment one and two with the exception of hind leg where it was significantly (p<0.05) affected in experiment two. The viscera organs also showed no significant (p>0.05) difference in all the parameters in both experiment one and two. Furthermore, the proximate composition of rabbits meat in both the experiment one and two were not significantly (p>0.05) affected. The physical properties, the pH, cooking yield, cooking loss and water holding capacity of the meat in experiment one were not significantly (p>0.05) affected but thermal shortening was significantly(p>0.05) affected. Also in experiment two, the cooking yield, cooking loss and water holding capacity were not significantly (>0.05) affected but the pH and thermal shortening were significantly (p<0.05) affected. The reproductive performance of the does, birth and weaning traits showed no significant (p>0.05) difference in both the experiments. The testicular morphometric characteristics also showed no significant (p>0.05) difference in weight of the testes, circumference of the testes, diameter of the testes in experiment one except in experiment two,where volume of the testes revealed significant (p<0.05) difference. It can be concluded that the administration of probiotics (Saccharomyces boulardiiand Saccharomyces cerevisaeimproved health status, growth performance,rabbits ability to digest fibre and clearly demonstrate their beneficial effects on the reproductive performance of rabbits. The heavier weight (39.04) observed for kittens kindled by rabbits in treatment 4 (40 x 10^6cfu/ml of S. boulardii + 0.6 g/kg (6 x 10^8) cfu/ml of S. cerevisiae) underscore the potential of these probiotics to enhance fertility and reproductive outcomes in rabbit. Importantly, the study also confirms that these probiotics do not adversely affect testicular morphometry in male rabbits, suggesting their safety and effectiveness in improving reproductive health. The findings support the integration of probiotics into rabbits feeding practice, offering a promising strategy for optimising reproductive efficiency and productivity.

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ABBREVIATIONS, GLOSSARIES AND SYMBOLS

AAD – Antibiotic associated diarrhoea

AGPS –Antibiotics growth promoters

AMP - Antimcrobial peptides

AOAC– Association of Official Analytical Chemist

ARBA - American Rabbits Breeders Association

CAMP– Cyclic adenosine monophosphate

DC – Dendritic cells

CEC - Commission of european communities

CFUs - Colony forming units

COVID-19 - Coronavirus disease

CRD– Completely randomized design

FAO– Food and Agriculture Organization

FAOSTAT - Food and Agriculture Organisation Statistics

FCR– Feed conversion ratio

GDP -Gross domestic products

GI – Gastro intestinal

GRAS - Generally recognized as safe

HDL - High density lipoprotein

IBD– Inflammatory bowel disease

IBS–Irritable bowel syndrome

LAB - Lactic acid bacteria

LDL - Low density lipoprotein

LPS– Lipo polysaccharide

MCL– Myosine light chain

MCR–Mixed lymphocyte reaction

PAMP - Pathogen associated molecular pattern

PRP - Pathogen recognition pattern

SCFA - Short chain fatty acid

UC– Ulcerative colitis

USDA - United States Department of Agriculture

WHC – Water holding capacity

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Rabbits (*Oryctolagus cuniculus*) serve as an important protein source for human consumption, not only in Nigeria but also worldwide. Their production in tropical regions holds great promise in bolstering food security, alleviating poverty among farming communities, and addressing the increasing need for high-quality protein-rich foods (Christopher *et al*., 2023). Rabbits exhibit high prolificacy, reaching puberty early and boasting a relatively short gestation period, typically around 29-30 days. Their ability to thrive on forages alone contributes to cost-effective production (Okon *et al*., 2023). Similar to poultry and other livestock, the maintenance of rabbits relies on their consumption and efficient utilization of feed (Essien *et al*., 2022a).

Rabbit is a key source of animal protein in certain European, Asian, and North African countries, including Spain, Italy, the Czech Republic, France, China, and Egypt (El-Sabrout and Aggag, 2018). Rabbit meat has several nutritional benefits, including a high protein content and a low cholesterol level (El-Sabrout and Aggag, 2018). Domestic rabbits are one of the most efficient cellulose converter animal species, ensuring the high production of low-cost meat (Siddiqui *et al.,* 2023). Rabbit meat is healthy and has high nutritional value due to its low content of fat, cholesterol, calories, and sodium, as opposed to beef, chicken, and pork (Wafar *et al*., 2018). Global rabbit and hare meat production was valued at US$ 1.5 billion in 2021(FAOSTAT, 2021). Production is concentrated in Asia with China accounting for more than half (53.1%) of global rabbit and hare meat production in 2021(FAOSTAT, 2021).

Rabbit farming is one of the sustainable and profitable agricultural practices due to the higher fecundity, efficient feed conversion, and the ability of rabbits to adapt to a variety of environments as well as the lower initial investment and a small production area required to breed rabbits on the large scale (Wongnaa *et al*., 2023). Rabbit meat is a nutrient-rich product with a higher content of protein and polyunsaturated fatty acids while low levels of carbohydrates, sodium, and cholesterol, as well as energy levels comparable to many types of red meat that are commonly consumed (Siddiqui *et al*., 2023). Similarly, rabbit skin and hides are sustainable industrial raw materials for the production of high quality leather commercially (Sikiru *et al.,* 2020).

The meat from rabbit surpasses meat from other farm animals in protein content (Kumar *et al*., 2023). It also contains low cholesterol, fewer calories and a lower percentage of fat compared to beef, pork, chicken or lamb (Kumar *et al*., 2023). Rabbit meat is prescribed safe and healthy for consumers (Wang *et al*., 2020). the demand for animal protein in Nigeria has been on the decline inthe last 16 years. While Nigerians were able to consume 59g/caput/day of total protein thus meeting FAO/WHO daily RNI for total protein, the animal based protein consumption which stood at 6.7 g/caput/day as at 2020, is a far cry from the recommended value of 28 g/caput/day (FAO, 2023).

Since January 1, 2006, the use of antibiotics as growth promoters in livestock farming has been banned in Europe by the European Union Commision. To combat antibiotic resistance on one hand and unfair competition for European livestock farmers on the other, the EU extended this ban to third-country operators exporting animals or products of animal origin to the EU in EU regulation EU 2019/6. This resistance results from irrational use of antibiotics, which leads to bacterial resistance through mechanisms transmitted to humans and animals via the environment or food. On a global stage about 1.2 million people already die each year from infections caused by microbial agents

resistant to all antibiotics and about 10 million lives threatened by 2050 (Mathilde and Stephanie, 2025) As a result, this has led to the concept of using probiotics to replace antibiotics as growth promoting agent (Fuller,1997).

Probiotics have always been a vital component and commercial target for providing potential health benefits (Hamad *et al*., 2022). The term "probiotic" was first presented by Werner Kollath in 1953, which is known to be a derivative of the Latin word *pro* and the Greek word *βιο* meaning "for life." Kollath defined probiotics as active bodies with essential functions for promoting various health aspects (Gasbarrini *et al.,* 2016). Food and Agriculture Organization (FAO) and World Health Organization (WHO) described them as "live microbes when administered in adequate quantities, confer health benefits on host organisms" (Munir *et al*., 2022). Several bacteria belonging to the genera *Pediococcus, Lactococcus, Enterococcus, Streptococcus, Propioni bacterium* and *Bacillus* are considered potential microbes for probiotic status (Hamad *et al.,* 2022).

As is known, *Saccharomyces cerevisiae* var. *boulardii* (often simply referred to as *S. boulardii*) has received the most scientific attention and is traditionally recognized as theprobiotic yeast par excellence (Pais *et al*, 2020). *S. boulardii* has been studied more extensively than other probiotic yeast strains. Research suggests that yeast generally appears to be safefor most healthy individuals, and it may be effective in addressing issues like antibiotic associated diarrhea,traveler's diarrhea, acute infectious diarrhea, and even inflammatory bowel disease (Abid *et al. ,*2022). This is important for establishing a probiotic strain as a viable option for widespread use. Recent advancements in genetic engineering techniques are opening up possibilities for developing next-generation probiotic yeasts with enhanced probiotic properties or targeted functionalities (Sun *et al*., 2021).

Probiotic yeasts can interact synergistically with beneficial gut bacteria, promoting their growth and activity. Probiotic yeasts have the ability to work in concert with good gutbacteria to enhance their development and activity. Improved nutritional absorption mayresult from increased nutrient degradation. Additionally, this “teamwork” stimulates the synthesis of beneficial metabolites like short-chain fatty acids, which support gut health by nourishing the intestinal lining (Bastors *et al.,* 2020; Li *et a*l.*,* 2022).

Due to the ban on the usage of antibiotics as growth promoters (CEC, 2003), intensive research has focused on the development of alternative strategies with the aim of maintaining a high productivity and reducing the morbidity and mortality under intensive production. The application of probiotics as dietary supplements could serve as a possible solution.

Probiotics are mostly gram-positive bacteria but there are also gram-negative bacteria, yeast, and fungi. The most common probiotics used for animals are *Lactobacillus*, *Bifidobacterium*, *Lactococcus*, *Bacillus*, *Streptococcus*, and yeast, such as *Candida* and *Saccharomyces* (Arora, 2020).As a probiotic, yeast (*Saccharomyces)* has been known to improve growth performance in weanling pigs and rabbit (Combes *et al*., 2013). It also improved nitrogen metabolism, fibre digestion, milk production in ruminants and enhanced growth performance as well as signicantly confer well-being for the ruminant health (Elghandour *et al.,* 2020). However, studies on the use of yeast as a probiotic in rabbit does are scarce, but growing rabbits fed with *Aspergillus awamori* showed improvement in body weight, nutrient digestibility and enhanced oxidative responses (El-Deep *et al*., 2021).

1.2 Statement of the Research Problem

The world population is increasing rapidly. It is assumedto extend to over 9.8 billion people by 2050, United Nations Department of Economic and Social Affairs Population Division (2017). This growing population is imposing food security challenges worldwide. The demand for animal proteins by the soaring world population coupled with income growth and fast urbanisation is more evident in the developing countries. This is expected to continue at a faster rate in future years (FAO, 2023)

In Nigeria, the population growth is projected to hit 250 million by 2030, the challenges of food insecurity and hunger will be on the front burner more than ever before because of the increased demand for food, this increase will be mainly driven by population growth, urbanization and income improvements. With crop production being the main driver of the agricultural sector, meeting the demand for staples and vegetables might pose little or no challenge but sufficient supply of affordable animal protein will become most criticalin the Nigerian food basket crisis (Adebayo, 2024). According to the WHO/FAO, a country's economic development is normally accompanied by improvement in its food supply and the gradual elimination of dietary deficiencies; hence an obligatory demand for animal protein.

Agriculture is one of the major contributor to the GDP of the nation's economy, contributing an average of 25.96% over the last 5 years. According to the recently released 2023 GDP report by the National Bureau of Statistics, agriculture contributed 26.11% to the GDP; this is a decline of 1.32% over 2022 contribution (FAO, 2023). Crop production still remains the major driver of the agriculture sector, and it has been accounting for 89%of agriculture GDP in the last 5 years; the implication of this is that animal agriculture contribution to the nation's GDP is less than 1.16%, and is on the

decline; and this is reflected in the quantity of animal based protein that is being consumed by Nigerians (Adebayo, 2024)

The global meat products markets size was exibited at USD 1,730.56 billion in 2024 and is projected to hit around USD 2,710.39 billion by 2034. In 2023, global meat production was 371 million tonnes and consumptions is projected to increase to almost 73 percent by 2050 (FAO,2024). To meet such enormous demand, other alternatives from the traditional sources of meat production is desired.

The recommended daily animal protein intake by the World Health Organisation (WHO) is 13.5 g/day but in Nigeria, consumption remains low at 6.0 - 8.4 g/head/day (Egbunike *et al.,* 1997). This daily intake is grossly below the recommended daily allowance among Nigerian population (Mubarak *et al*., 2016). Rabbit production in Nigeria is largely traditional, non-commercial oriented, family-consumption targeted, and smallholder type comprising 2-7 does and 3 bucks on average (Mubarak *et al*., 2016). There are about 1.7 million rabbits population and between 3.4 - 5.2 % of Nigerian population keep rabbits (Mubarak *et al*., 2016). Rabbits are raised for meat, pets or as laboratory animal, and even for pelt as in Angora, fur or wool. Demographic data obtained showed that women, children and research institutes are the most involved in the routine management and are particularly tasked during the dry season when green forages is scarce (Mubarak *et al*., 2016)

The traditional source of animal protein; the cow, is being threatened by fast urbanisation and land grabbing and banditry. This is more evident in the developing countries like Nigeria as witnessed in the ongoing banditry. Furthermore, kidnapping and cattle rustling within the herders settlement, established farms and ranches has been on the increase, forcing farmers to lose interest and close down due to fear.

The heavy usage of antibiotics in the prevention of disease and growth development in farm animals has been shown to be behind the development of antibiotic resistant disease causing agents and antibiotics residues in animal end products which is of importance to the well being of the people. This led to the prohibition of the usage of antibiotics as growth promoters in the European Union by the Commission of European Communities (CEC, 2003). The ban came into effect in 2006. Due to this ban, coupled with increased demand for protein of animal origin resulting from increase in world population, there has been an interest in finding an alternative to antibiotics that could enhance livestock productivity in many Western Countries (Ahmed, 2006). Thus, this research seeks to look at ways of improving the reproductive performance of rabbits using one of such possible alternatives.

1.3 Justification for the Study

The rabbit is a good potential source as a solution to fulfil demand for animal proteins. Rabbits produce about 3 kg of meat from the same amount of feed and water used by cattle to produce just 0.45 kg (Mensah *et al.,* 2018). Rabbit meat is nutritious due to its high proportion of digestible proteins in comparison to other meats such as pork, beef, and chicken (Birolo *et al.,* 2022). Apart from the low-fat percentage, it is rich in healthy fats such as monounsaturated and polyunsaturated fats, making it healthy and suitable for old and diabetic people (Martinez-Alvaro *et al.,* 2018). While meat from domesticated rabbits is rich in vitamins B12 and E, it has fewer calories and cholesterol than poultry (Lorio *et al.,* 2023). Rabbit meat has a lower fat content than the popular meats, with 10.2% fat per pound compared to 11% fat in chicken and 28% fat in beef. It also has lower moisture, calories, and cholesterol per pound when compared to chicken (Rasinska *et al.,* 2019). It has been recommended that rabbit meat be used as an

alternative in all chicken recipes, as they have almost the same taste and nutritional value (Samuelsson, 2020).

Some of the methods of improving the protein deficit include improved breeding methods of domestic animals and the breeding of animals for food which were hitherto not very common as food. Some of these animals include rabbit because of their high efficiency in converting forage to meat, short gestation period and high prolificacy and relatively low cost of production. The high nutritional quality of rabbit meat which includes low fat, sodium and cholesterol levels and a high protein level of about 20.8 % are some of the other reasons ((Delport *et al.,* 2017). The breeding of these animals requires improved production methods and the use of breeding stock which will maximize the potential for accelerated multiplication. These animals are useful as sources of animal protein as they can quickly be multiplied and in large numbers if effective monitoring of their reproduction is well managed.

The herders-farmers conflicts, urbanization and land grabbing is motivating larger attention for the production of rapid growing animals like rabbits that require small space as compared to the large animals that requires larger space. Furthermore, there is no religious taboo against consuming rabbit meat and in the light of the need to save feed grains badly needed to fight against hunger, raising rabbit is an excellent choice.

There is the necessity to exploit practicable ways to bridge the protein deficiency gap through improved reproductive efficiency using natural products that meet end user demands to sustain good standard of superiority anticipated in rabbit meat. Probiotics is believed to stimulate the host defence mechanism, improve weight gain, feed conversion efficiency, promote growth and enhance production in farm animals (Ismat *et al.,* 2021). The probiotics yeast in the ruminant is known to improve feed intake, milk

production, digestion, the numbers of anaerobic and cellulolytic bacteria and alter the patterns of volatile fatty acids. Live yeast cultures were also reported to influence blood constituents through the remodelling of ruminal microbial populations, resulting in improvement in the health status of animals (Ismat *et al*., 2021).

The addition of probiotics yeast culture to feed has been shown to have positive effect on the absorption of some minerals, found to produce vitamins B, positively affect blood-cell forming processes as well as proved to be beneficial in managing several gastrointestinal disorders, thereby improving the metabolic health of animals. They are particularly effective in treatment of acute infectious diarrhea and antibiotics-associated diarrhea by restoring the balance of gut microbiota and producing antimicobial substances (Plaza-Diaz *et al.,* 2019). Probiotics does not have any residues in farm animal by- products compared to antibiotics that can have severe effect like drugs resistances and dangerous change in the bacterial counts in the gastro intestinal tract (Martins *et al.,* 2005). Studies on the effects of such probiotics on reproductive performance traits in rabbits is still relatively limited and, hence, the justification for the present study.

1.4 Aim and Objectives of the Study

The aim of this research is to determine the effect of probiotics on growth, reproductive performance, haematology and serum biochemistry of rabbits raised under intensive system of production.

The objectives of the research are to determine the effect of probiotics on:

i. Growth and reproductive performance of rabbit
ii. Haematological and Serum biochemistry of rabbit.
iii. Carcass yield and quality characteristics of rabbit.

iv. Growth and reproductive performance of the progeny.

v. Haematological and Serum biochemistry of the progeny.

vi. Carcass yield and quality characteristics of the progeny.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction to Rabbits Farming

Rabbits are small mammals in the family *Leporidae* and in the order *Lagomorpha.* Rabbits (*Oryctolagus cuniculus)* are reared to produce cholesterol-free meat for the consumption of man; the meat has a high level of protein and are also becoming popular as pets among families especially in urban areas. Rabbits exhibit shigh prolificacy, reaching puberty early and boasting a relatively short gestation period, typically around 29-30 days. Their ability to thrive on forages alone contributes to cost-effective production (Okon *et al*., 2023). Rabbits are unique micro livestock which have been recognised to have played an important role in the supply of animal protein in many developing countries including Nigeria (Makinde, 2016). They serve as flexible financial reserve for rural population and as well as play other socio-cultural roles in the customs and traditions in many societies. The prolific nature of rabbits coupled with its short gestation period and generation interval, makes it the animal of choice for multiplication and a short way for increasing animal protein intake (Mukaila *et al.,* 2022). It is the only agricultural animal whose progenies yield meat at the rate of 10 to 15 times or more the animal's own weights annually (Houessou *et al*., 2022)

2.2 Breeds of Rabbit

The United States Department for Agriculture (USDA) has classified rabbits according to size, weight and type of pelt. Small rabbits weigh about 1.4 - 2 kg at maturity, medium breeds 4 - 5.4 kg, and large breeds 6.4 - 7.3 kg (FAO, 2018). Based on this classification, two most popular breeds for meat production include the New Zealand White and the California White. These breeds are the most popular because they

combine white fur and good growth characteristics. These two breeds are also the most popular in commercial rabbit in the developed countries. The New Zealand rabbits are slightly larger than the Californian; 4 - 5.9 kg and 3.6 - 4.5 kg respectively. The two most popular rabbits for fur production are the Rex and the American Chinchilla. The Rex is slightly smaller than the American Chinchilla, 3.2 kg versus 4.5 kg (FAO, 2018).

At present, there are many breeds of rabbit used for both meat and skin production in developing countries. For example in Brazil, there are the New Zealand White, Californian, Chinchilla, Palomino, Hollander, Rex, Dalmatian, Flemish Giant, New Zealand Red, Barboleta, Champagne, d'Argent; In Ecuador, there are the New Zealand White, Blue Viennese, Silver German and Angora. In Malawi, there are the New Zealand White, Californian, Angora, Rex; In Nepal, there are the Californian Hybrids while in Ghana, there are the Thuringa, Blue Viennese, Flemish Giant, Checkered Giant, Lop, Californian, Alaska, and the Yellow Silver (FAO, 2018).

In Nigeria, the most common breeds include the New Zealand White, Californian, Angora, Dutch, Rex amongst others. All these breeds of domestic rabbits are descendants of the European wild rabbit, *Oryctolagus cuniculus.* Although many of these are breeding successfully in various countries, withthe various production traits such as fertility, growth and feed conversion rates when considered, under commercial conditions, New Zealand Whites and Californians are amongst the better breeds available for meat production (Rabbitfarm NG, 2024).

2.3 Characteristics of Common Breeds of Rabbit

As at 2017, there were at least 305 breeds of domestic rabbits in 70 countries around the world (FAO, 2018). A rabbit breed is a distinct variety created through natural selection or, more often, through selective breeding for specific characteristics,

including size, fur (length, quality, or colour), feed conversion ratio, climate adaptability, or temperament. Groups such as the American Rabbit Breeders Association (ARBA) and the British Rabbit Council (BRC) coordinate and standardize the desired qualities of their recognized breeds, through promotion and exhibition. Each rabbit breed is considered to benefit when a reputable breeder strives to emulate the purpose for the breed, often defined by the individual breed standard by which it may be judged (FAO, 2018). The global diversity of breeds reflects the breadth of the rabbit's unique qualities. Below are the characteristics of some of the rabbit breeds:

i. **Californian White:** White fur on the body but nose, ears, feets and tail may be dark or black. The breed has muscular body with full shoulders and hindquarters. It has a good dressing percentage and could weigh up to 4 kg.

ii. **Flemish Giant:** This breed is light greyish in colour or grey on white. It is one of the heavy breed for meat and could weigh up to 5.9 to 7.3 kg.

iii. **Chinchilla:** Erect ears and a plump body, soft, short to medium length fur. The fur covers the body and is usually black or greyish. Adult weigh up to 4.5 to 5 kg.

iv. **New Zealand:** It could be white or red in fur colour and weigh between 2.5 and 5 kg.

v. **Rex:** Long, erect ears and short necks. Short, smooth fur that is extremely dense and can be a variety of colours. Rexs generally have rounded backs with well-developed shoulder and weigh between 1.7 to 2.1 kg.

vi. **Dutch:** Very distinctive black and white colouring. They have dark ears and bottoms and white shoulders, belly, front legs—plus, a wedge of white fur up the front of their face. They weigh between 1.95 and 2.3 kg.

vii. **Checkered Giant:** This breed has short fur, erect ears. The colour is black (white with black markings), blue (white with gray markings). The mature rabbit weigh between 5.0 - 11.3 kg.

viii. **Dalmatian:** This breed is white with numerous little coloured patches of black, blue-brown, orange or fawn. The mature breed weigh between 2.7 - 3.6 kg.

ix. **Champagne d'Argent:** The breed has erect ears, short fur, creamy white with an orange cast and weigh between 4.1 - 5.4 kg.

x. **Palomino:** This breed has a golden lynx colour, short fur, erect ears and has a weight of between 4.5 - 5.0 kg.

xi. **Alaska:** This breed is pure black in colour and has short fur and also erect ears. The mature breed weigh between 3.2 - 4.1 kg.

xii. **Angora:** This breed has long fur, erect ears and is either albino or coloured. The mature breed weighs up to 4.5 kg.

xiii. **Crosses:** These could be crosses between Chinchilla and New Zealand breeds or crosses between Californian and Flemish giant etc. Most of the breeds found in Nigeria are crosses. At maturity the weight could be up to 3-4 kg. They vary in colour and size.

2.4 Reproduction in Male Rabbit

The reproductive system of the male rabbit consists of two sets of testes, epididymis, ampullae, vas deferences, urethra, penis and two sets of preputial glands and accessory gland. The rabbit presents this peculiarity in the external genitalia, like marsupials of well-developed scrotal sacs located cranial to the penis and the urogenital opening (Lukefahr *et al.,* 2022). The testicular position in the rabbits varies depending on factors such as how the body is positioned, the temperature of the body, the breeding activity,

the amount of food in the stomach and how much fat is around the abdomen (Capello and Lennox, 2006). The rabbit also can retract its oval-shaped testes from within the scrotum into the abdomen. They remain in communication with the abdominal cavity where they were at birth but descend into the scrotum at about 10 to 12 weeks of age. The rabbit canconstrict its testes when frightened or fighting with other males or if it is stressed. A rubber ring may be used to restrain the testes in some instances to prevent retraction. The male rabbit is used to mate multiple females, which significantly increases the impact of having a fertile and highly active male (Lukefahr *et al.,* 2022).

2.5 Reproduction in Female Rabbits

Female rabbits does not possess an oestrus cycle and is described as an induced ovulator, which simply means ovulation occur once copulation takes place. Reproductive activity in does is under the control of neuro-endocrine axes and can be modified by genetics, feeding and management factors. In rabbit does, ovulation is induced by coitus, and the female could be inseminated independently of their Sexual Receptivity (SR) which in turn is regular with the only exception being on the day of partum and immediately after weaning (Lukefahr *et al*., 2022). The rabbits have a cycle of mating receptivity of about 14 of every 16 days. A doe is most receptive when the vagina is red and moist. Does that are not receptive have a whitish pink vaginal color with little or no moisture. Naturally, when artificial insemination (AI) is used, the induction of ovulation is achieved by exogenous synthetic analouges of GnRH. Gestation period is typically 28-32 days and following this period, rabbit does give birth in a nest in early morning. The lactation period is 4-5 weeks. Commercial producers seeking a high intensive production, generally inseminate does during lactation, a time where the sexual receptivity is low. This fact negatively impacts reproductive performance, since low sexual receptivity hinders pregnancy. (Diane, 2020).

2.6 Definition of Probiotics

Probiotics have always been a vital component and commercial target for providing potential health benefits (Hamad *et al*., 2022). The term "probiotic" was first presented by Werner Kollath in 1953, which is known to be a derivative of the Latin word *pro* and the Greek word *βιο* meaning "for life." Kollath defined probiotics as active bodies with essential functions for promoting various health aspects (Gasbarrini *et al.,* 2016). Food and Agriculture Organization (FAO) and World Health Organization (WHO) described them as "live microbes when administered in adequate quantities, confer health benefits on host organisms" (Munir *et al*., 2022). Several bacteria belonging to the genera *Pediococcus, Lactococcus, Enterococcus, Streptococcus, Propioni bacterium*, and *Bacillus* are considered potential microbes for probiotic status (de Brito Alves *et al.,* 2016; Hamad *et al.,* 2022). Probiotics are mostlygram-positive bacteria but there are also gram-negative bacteria, yeast, and fungi. The most common probiotics used for animals are *Lactobacillus*, *Bifidobacterium*, *Lactococcus*, *Bacillus*, *Streptococcus*, and yeast, such as *Candida* and *Saccharomyces* (Park *et al.,*2016; Arora,2020).

Among the species of micro-organisms that are used for probiotic preparation are the lactic acid bacteria - Lactobacilli *(L. acidophilus, L. casei, L. bulgaricus, L. brevis, L. cellobiosus, L. curvatus, L. fermentum, L. lactis, L. plantarum, L. reuteri),* Streptococa*(streptococcus themophilus, S. diacetylactis, S. Intermidius),* Bifidobacteria *(B. bifidum, B. animalis, B. adolescentis, B. infantis. B. longum).* Others are Bacillus species *(Bacillus ladies),* yeast *(Saccharomyces cerevisiae and Saccharomyces boulardii)* and Filamentous Fungi *(Aspergillus oryzae)* (Arora, 2020).

For a long time, the discussion around probiotics has centeredon lactic acid bacteria (LAB) like*Lactobacillus*and *Bifidobacterium*. These bacteria have been extensively

studied and documented for their role in promoting a healthy gut microbiome, offering benefits like improved digestion, immune function, and even mental health (Luo *et al*., 2019; Gomaa 2020 and Singh *et al.,* 2023). However, a new frontier is emerging in the world of probiotics - the rise of probiotics yeasts. Many studies have suggested that certain yeast strains hold significant potential to join the ranks of established probiotic power houses (Staniszewski and Kordowska-Wiater, 2021).

2.7 Beyond Bacteria: Unveiling the Potential of Yeasts

In the last few decades, researchers have begun to explore the potential of yeast strains which have shown promise in supporting gut health (Gomaa, 2020).Though lactic acid bacteria (LAB) will continue to play a significant role, these interesting new opportunities seem to have a positive impact on the future of gut health. Yeasts have been gaining increasing attention as potential probiotic candidates in recent years. While bacteria have dominated the probiotic market for a long time, research suggests that specific yeast strains possess properties that could be beneficial for human health (Staniszewski and Kordowska-Wiater., 2021).

Probiotic yeasts are generating excitement because they have interesting characteristics from an application point of view:

(i) Unique Advantages: some probiotic yeasts might offer advantages over LAB in terms of survival. Studies suggest that certain yeast strains may be more resilient to the hostile environment of the stomach, reaching the intestines in higher numbers where they can exert their probiotic effects (Gomaa, 2020).

(ii) Diverse Functionality: early research indicates that probiotic yeasts might have a broader range of functionality compared to some LAB strains. For example, some yeasts may produce compounds that not only benefit their own growth but also

stimulate the growth of other beneficial bacteria in the gut (Gomaa, 2020). This synergistic effect could lead to a more efficient and diverse gut microbiome.

(iii) Appropriated applications: the discovery of various probiotic yeast strains opens doors for the development of more targeted probiotic interventions. Different yeast strainsmight be effective for addressing specific gut health concerns, offering a more personalized approach to probiotic supplementation (Afzaal *et al.,* 2022).

2.7 *Saccharomyces boulardii*

Saccharomyces boulardii is true probiotic yeast, it has potent beneficial effects on the body. *Saccharomyces boulardii* was discovered by a French microbiologist in 1920 in IndoChina when searching for new strains of yeast for fermenting processes. A cholera outbreak was happening at the time, and it was noticed that some people who were drinking a special tea did not get sick. The special tea was made from brewing the outer skins from leeches and mangos teen (tropical fruits). The French researcher was able to isolate the substance involved and named it *Saccharomyces. Saccharomyce sboulardii* has received the most scientific attention and is traditionally recognized as the probiotic yeast par excellence.*S. boulardii* has been studied more extensively than other probiotic yeast strains. Research suggests that this yeast generally appears to be safe and it may be effective in addressing issues like antibiotic associated diarrhea, traveler's diarrhea, acute infectious diarrhea, and even inflammatory bowel disease (Abid *et al*., 2022). This is crucial for establishing a probiotic strain as a viable option for widespread use. Recent advancements in genetic engineering techniques are opening up possibilities for developing next-generation probiotic yeasts with enhanced probiotic properties or targeted functionalities (Shingel *et al.,* 2018; Sun *et al.,* 2021).

Probiotic yeasts can interact synergistically with beneficial gut bacteria, promoting their growth and activity. Probiotic yeasts can work in concert with good gut bacteria to enhance their development and activity. Improved nutritional absorption may result from increased nutrient degradation. Additionally, this “teamwork” stimulates the synthesis of beneficial metabolites like short-chain fatty acids, which support gut health by nourishing the intestinal lining (Bastos *et al*., 2020; Li *et al.,* 2022)

Unlike *Saccharomyces cerevisiae*, however, *Saccharomyces boulardii*'s optimum growth temperature is 98.6 degrees Fahrenheit, the same as the body temperature, and it clusters together differently making it able to persist in the body longer, at least in mouse studies (McFarland *et al.,* 1995). This yeast is a probiotic that, when given orally, achieves a constant flow through the gastro-intestinal tract within 3 days and is cleared within 3-5 days after it is stopped. Therefore, it does not colonize the gastro-intestinal tract. Additionally, *Saccharomyces boulardii* is also able to tolerate low pH, like the low pH of the stomach, and survive bile acids, so taking it as a supplement means that most, if not all, of it reaches the intestines (Höchter *et al.,*1990). *Saccharomyces boulardii* belongs to the kingdom - Fungi, phylum - Ascomycota and subphylum - *Saccharomycotina.* It belongs to the class - *Saccharomycetes*, order - *Saccharomycetales* and the family -*Saccharomycetaceae*. *Saccharomyces boulardii* is of the genus *Saccharomyces.*

2.8 *Saccharomyces cerevisiae*

Saccharomyces cerevisiae (Yeast) is a very useful microorganism with broad range of industrial application, because of their unique genetics and physiology. Yeast cells have many useful metabolites - protein, and minerals, zinc and magnesium. During the last decades, probiotic yeast (*Saccharomyces cerevisiae)* has been extensively used as

ruminant health promoter (Vivian, 2024). S*accharomyces cerevisiae*has been modified to express enzymes that degrade quorum sensing molecules, thereby inhibiting the communication and virulence of pathogenic bacteria like *Pseudomonas aeruginosa*. The utilization of the naturally prepared yeast would be accelerated in coming years due to the nature-oriented mind set of the consumers. Therefore, research on the isolation of the nutritious rich yeast strains for preparation of probiotic products has rapidly increased (Li *et al.,* 2023). Yeast, an important single cell microorganism, belongs to fungus family and it multiplies by cell division. The genetics and physiology of the yeast are unique, and, therefore, a broad range of research work in biological sciences is being carried out on this microbe. The yeast cell size is 5 × 10 µm and the size of the baker's yeast genome is 12.1 Mb containing 16 chromosomes and 5400 coding genes approximately (Chenoll *et al*., 2019). Members of the order Saccharomycetales are mainly used for animal probiotics and serve as reliable and economical sources of essential amino acids, vitamins, carbohydrates, and minerals from yeast cells. Thiamin, riboflavin, niacin and biotin are present in yeast (Cox *et al*., 2015). The antagonistic ability of yeast to block bacterial pathogenicity also makes it very useful (Crossland *et al.,* 2018). Yeast cells competition for nutrients, pH changes in the medium, high concentrations of ethanol production, secretion of antibacterial compounds and release of antimicrobial compounds are major antagonistic steps. Yeast cells have many useful fermentation metabolites (protein, vitamins, carbohydrates) which make it an important microbial feed supplement. Yeasts are naturally present (1.3 X 10^5 yeasts ml-1) in rumen fluid. Literature showed that yeasts (*S. cerevisiae*) are not significant members of the rumen microbial flora, but mostly, eenters the rumen with fibrous feed (De Mulder *et al*., 2018). Therefore, the viable yeast rich diet improves its numbers and function inside the rumen. Nowadays, *Saccharomyces cerevisiae* has been extensively used as

animal probiotic to improve milk production and its composition. Many researchers have given different conclusions in relation to the mode of action of yeast and its impact on the host animal (De Mulder *et al*., 2018).

2.9 Mechanisms of Action of Probiotics Yeast

Mechanisms of action of probiotics are complex, diverse, heterogeneous, and often strain- and compound specific (Kleerebezem, 2019; Monteagudo-Mera, 2019).

Probiotics interact with both the host and the microbiome via molecular effectors present on the cell structure or secreted as metabolic products. Probiotic metabolites can act on the microbiota by cross feeding interactions, changes in the gastrointestinal micro environment (pH lowering), competition for nutrients and binding sites, and inhibition of growth viathe production of strain-specific antibacterial compounds including bacteriocins (Lebeer, 2018; Plaza-Diaz *et al.,*2019) Such microbiota-directed effects contribute to the ability of probiotics to mediate health benefits in pathogen overgrowth states such as vaginal and oral dysbioses (Monteagudo-Mera *et al*., 2019).

Regarding host cells, probiotic effect or molecules can interact directly with receptors in intestinal epithelial, entero- endocrine, and immune cells as well as vagal afferent fibres. These interactions produce local gut effects, such as enhancement of intestinal barrier integrity and inflammation (via Toll-like receptors), as well as systemic effects via host immune, endocrine, and nervous system mediators (Lebeer*,* 2018; Monteagudo-Mera *et al.,* 2019). Probiotics also perform enzymatic metabolism of host compounds such as bile salts and ingested xenobiotics (Plaza-Diaz *et al.,* 2019) Specific probiotic surface-associated effect or molecules include pili, lipoteichoic acids, exopolysaccharides, and various surface-layer proteins, many of which are strain-specific and therefore mediate the delivery of strain-specific effects (Lebeer, 2018; Monteagudo-Mera *et al.,* 2019).

Probiotics also regulate the innate and adaptive immune response modulating dendritic cells (DC), macrophages B and T lymphocytes. Probiotics also increase the production of anti-inflammatory cytokines while interacting with intestinal epithelial cells and attracting macrophages and mononuclear cells (Petruzziello *et al*., 2023). Furthermore, probiotics can produce neurotransmitters in the gut through the gut-brain axis. Specific probiotic strains can modulate the serotonin, gamma-aminobutyric acid (GABA), and dopamine levels, affecting mood, behavior, gut motility, and stress-related pathways (Gangaraju *et al*., 2022).

2.10 The Gut Micro Flora

There is in the guts a very complex population of micro-organism which interacts with each other and with their host animal. The number of non-pathogenic micro-organisms far exceeds the number of pathogenic micro-organisms and many of the pathogenic microbes are in fact useful, even essential for the continued existence of life. The beneficial groups of micro-organisms are those which inhabit the gastro-intestinal tract of animals. The gut microbiota has broad impacts, including effects on colonization, resistance to pathogens, maintaining the intestinal epithelium, metabolizing dietary and pharmaceutical compounds, controlling immune function, and even behavior through the gut–brain axis (Saxena and Sharma, 2016).

The gut flora are the microorganisms, including bacteria, archaea, fungi, and viruses, that live in the digestive tracts of animals. Somewhere between 300 and 1000 different species live in the gut, with most estimates at about 500 (Moszak *et al*., 2020). However, it is probable that 99% of the bacteria come from about 30 or 40 species. The four dominant bacterial phyla in the gut are *Bacillota, Bacteroidota, Actinomycetota*, and *Pseudomonadota*. Most bacteria belong to the genera *Bacteroides, Clostridium,*

Faecalibacterium, Eubacterium, Ruminococcus, Peptococcus, Peptostreptococcus, and *Bifidobacterium.*Other genera, such as *Escherichia* and *Lactobacillus*, are present to a lesser extent. Species from the genus *Bacteroides* alone constitute about 30% of all bacteria in the gut, suggesting that this genus is especially important in the functioning of the host. Fungal genera that have been detected in the gut include *Candida, Saccharomyces, Aspergillus, Penicillium, Rhodotorula, Trametes, Pleospora, Sclerotinia, Bullera*, and *Galactomyces,* among others. *Rhodotorula* is most frequently found in individuals with inflammatory bowel disease (Salvadori, 2024)

Due to the prevalence of fungi in the natural environment, determining which genera and species are permanent members of the gut mycobiome is difficult (Hallen-Adams *et al.,*2017). *Saccharomyces cerevisiae,* brewer's yeast, is known to reach the intestines after being ingested and can be responsible for the condition auto brewery syndrome in cases where it is overabundant. (Painter *et al.,* 2024)

2.11 The Role of Gut Flora

The gut flora community plays a direct role in defending against pathogens by fully colonising the space, making use of all available nutrients, and by secreting compounds known as cytokines that kill or inhibit unwelcome organisms that would compete for nutrients with it. Different strains of gut bacteria cause the production of different cytokines. Cytokines are chemical compounds produced by our immune system for initiating the inflammatory response against infections. Disruption of the gut flora allows competing organisms like *Clostridioides difficile* to become established that otherwise are kept in abeyance (Colella *et al*., 2023)

Some gut microorganisms benefit the host by fermenting dietary fiber into short-chain fatty acids (SCFAs), such as acetic acid and butyric acid, which are then absorbed by

the host. Intestinal bacteria also play a role in synthesizing certain B vitamins and vitamin K as well as metabolizing bile acids, sterols, and xenobiotics. The systemic importance of the SCFAs and other compounds they produce are like hormones and the gut flora itself appears to function like an endocrine organ. Dysregulation of the gut flora has been correlated with a host of inflammatory and autoimmune conditions (Saxena and Sharma, 2016).

The bacterial flora of the small intestine aids in a wide range of intestinal functions. The bacterial flora provides regulatory signals that enable the development and utility of the gut. Overgrowth of bacteria in the small intestine can lead to intestinal failure. The microorganisms perform a host of useful functions, such as fermenting unused energy substrates, training the immune system via end products of metabolism like propionate and acetate, preventing growth of harmful species, regulating the development of the gut, producing vitamins for the host (such as biotin and vitamin K), and producing hormones to direct the host to store fats (Braune and Blaut, 2016).

It has been reported that an animal tolerates the presence of vast number of pathogenic micro-organisms within its gut because it has evolved a symbiotic relationship in which the bacteria get food and suitable environment for growth and the host animal acquire protection against some form of diseases (Bello *et al.,* 2018)

2.12 Characteristics of Efficient Probiotics

The major attribute of probiotics is their resilience in the gastrointestinal environment, where they must withstand challenges such as stomach acid and bile salts to be effective. For probiotics to be functionally effective, they must adhere to mucosal surfaces, allowing them to colonize the gut and interact with host cells (Sanders *et al.,* 2019). Effective probiotics should be non pathogenic, non-toxic and capable of exerting

a beneficial effect on the host. They should also be able to survive the passage through the digestive system, attach to the intestinal epithelia, maintain good viability and also be able to utilize nutrients and substrates in a normal diet (Collins *et al.,* 2020) Additionally, probiotics affect the synthesis of immunoglobulins and cytokines, which help modulate immune responses, promote immune balance, and potentially reduce inflammation. Moreover, many probiotics produce antimicrobial substances, such as hydrogen peroxide and lactic acid, inhibiting harmful bacteria's growth and enhancing overall gut health. Probiotics are generally considered safe when taken in appropriate amounts. Another key feature of an efficient probiotics is their ability to ferment dietary fibers, producing short-chain fatty acids (SCFAs) that have anti-inflammatory properties and supply energy to colon cells (Raghu *et al.,* 2020).

2.13 Importance of Haematology and Serum Biochemistry

Blood is the major transport system of the body and its constituent's changes in relation to the physiological condition of the animal. Haematological studies are a useful tool for the diagnosis of many diseases and investigation of the extent of damage to the blood (Ihedioha *et al.,* 2004). Serum biochemical analysis is used to determine the level of heart attack, liver and kidney damage. Blood examination reportedly gives the opportunity to investigate the presence of several metabolites as well as other constituents and thus help in detecting conditions of stress, which could be nutritional, environmental or physical and that physiological parameters (hormones, heart rate, immune reactions) when considered in relation with other parameters like behavior, morbidity and others can be used as a welfare indicator (Archetti *et al.,* 2008).

2.14 Effect of Probiotics on Serum Biochemical Properties

Probiotic feed supplements containing *Lactobacillus acidophilus*, *Bacillus subtilis*, and *Clostridium butyricum* can boost serum immunoglobulin levels and enhance IgA and IgM serum levels in chickens (Zhang and Kim, 2014). LAB (Lactic Acid Bacteria) can generate a broadrange of antimicrobial compounds to reduce pathogenicattacks. These include antimicrobial peptides (AMPs), such as defensins, organic acids, bacteriocins, ethanol, carbon dioxide, and diacetyl (Liao and Nyachoti, 2017). Organic acids like short-chain fatty acids, formic acids, and lactic acid have been proved to suppress potential harmful microbes of importance in farm animals. *Lactobacillus* bacteria generate lactic acid as the main glucose metabolism product (Russo *et al.,*2017). Organic acids work on the bacterial cell wall, cytoplasmic membrane, and precise metabolic functions such as replication and protein synthesis, which lead to the destruction and death of pathogenic microorganisms (Surendran, *et al.,* 2017). *Salmonella enteritidis*, *Lactobacillus monocytogenes*, and *Escherichia coli* could be effectively inactivated after exposure to 0.5% lactic acid for two hours (Wang *et al*., 2015).

2.15 Effect of Probiotics on Reproduction

Many studies have shown the positive effects of probiotics-based therapies on reproductive health in human and animal models (Dhanasekar *et al.,* 2019). Probiotics support reproductive tract eubiosis and the fertility of the host due to their antimicrobial, antioxidant, anti inflammatory, and immunomodulatory activities. In the field of human reproductive health, the use of probiotics either through oral or vaginal route of administration has proved its effectiveness against many reproductive disorders in women (vaginosis, polycystic ovary syndrome, and pre-term delivery). Similarly, probiotics show positive effects on male fertility and semen quality (Helli *et al.,* 2020)

In animal models, probiotics havebeen used to mitigate the negative effects of many reproductive disorders, specifically those impairing the immune-inflammatory system and/or due to the action of infectious diseasessuch as post-partum endometritis(Peter *et al.,* 2018). Probiotics can maintain and restore reproductive tract eubiosis through differentmechanisms. Probiotics have been found to produce bioactive molecules that have directeffects on reproductive tract microbiota, as these bioactive molecules can act as antimicrobial agents.

Probiotics can safely be used during pregnancy and breast feeding tooffer a unique opportunity to influence a range of important maternal and neonatal outcomes. Probiotics have also been found to improve the immune responses and inflammatory status of the reproductive tract. For instance, the administration of probiotics resulted in areduction of endometritic lesions through improving endometrial epithelial cells barrier function (Hashem and Gonzales-Bulnes, 2022).

Some probiotic species such as *Bifidobacterium infantis* and *Lactobacillus rhamnosus* (JB-1) and *farciminis* have been foundto exhibit anxiolytic effects and improve psychiatric-disorder-related behaviors, including anxiety, depression, acute stress disorders, and obsessive disorders (Cani *et al*., 2016). These effectswere developed through their influence on the HPA-axis, which can indirectly improve reproductive functions by attenuating negative effects of different environmental stresses on reproductive functions. Furthermore, some probiotic species can produce neuro transmitters such as dopamine, serotonin, and gamma-aminobutyric acid that interact with then ervous system (Almae *et al*., 2019).

Bacillus species serve as safe and effective feed additives which can improve the reproductive performance of farm animals (Mao *et al.,* 2015). *Gu et al.* (2019) found

that dietary supplementation with *Bacillus subtilis* and/or *Bacillus licheniformis* improved the lipid and protein metabolism profiles of sows, the placental antioxidant capacity, and placental efficiency that resulted in greater piglet birth weight. In sheep, the administration of monensin or *Saccharomyces cerevisiae* improved the metabolic status and ovarian steroid production of dams, as well as the growth performance of lambs, highlighting the possibility of using probiotic *Saccharomyces cerevisiae* as an alternative to the antibiotic monensin (Ahmadzadeh *et al.,* 2018). These evidence of the positive effects of probiotics on reproductive health and fertility of different mammalian species make them a suitable tool for reproduction and increasing reproductive efficiency.

2.16 The Application of Probiotics to Boost Animal Performance

Dietary supplementation of probiotics has attracted great attention due to their positive effects on gut microbiota and immunological systems in humans and livestock (Cheng, *et al.*, 2017). Probiotics are used as prophylaxis and for therapeutic purposes in both humans and farm animals (Abushelaibi *et al*., 2017), with probiotics being a safe and viable alternative to the use of antibiotics growth promotors which can result in antibiotic resistance in microbial population (Srinivas *et al*., 2017). Supplementation of probiotics in farm animals instead of antibiotics can improve growth performance, nutrient digestibility, and immune response and reduce the incidence of diseases (Srinivas *et al.,* 2017). In addition, probiotics increase the oxygen concentration in the gastrointestinal tract (GIT) in a multiplicity of ways including through depleting oxygen-scavenging compounds, such as nitrates. Moreover, probiotics secrete hydrolytic enzymes that can hydrolyze bacterial toxins and inactivate toxin receptors, decreasing toxin-mediated infections in farm animals. Probiotics decrease pathogenic microorganisms and establish a better microbial population in the GIT (Alayande *et*

al.,2020). Probiotics can also activate an immunologic response and assemble a series of immunoregulatory molecules. Some probiotics produce metabolites that can modulate metabolic pathways in the cell, such as bacteriocins, amines, and hydrogen peroxide. These metabolites can adjust cell apoptosis, proliferation, inflammation, and differentiation (Plaza-Diaz *et al*., 2019)

The microorganisms commonly used as probiotics in animal diets are principally bacteria, usually gram-positive bacteria. *Lactobacillus* and *Enterococcus* are natural flora in the alimentary tract of most animals and are usually present in amounts of 10^7-10^8 and 10^5-10^6 CFU/g, respectively. *Lactobacillus acidophilus (L. acidophilus), L. lactis, L. plantarum, L. bulgaricus, L. casei, L. helveticus, L. salivarius, Bifidobacterium* spp.*, Enterococcus faecium* (*Ent. faecium*)*, Ent. faecalis, Streptococcus thermophilus, Escherichia coli* are the most used probiotic bacteria in farm animals and probiotic fungi such as *Saccharomyces cerevisiae* and *Saccharomyces boulardii* are the most used probiotic fungi (Razavi *et al.,* 2019a). Of note, no other substances should be supplemented during the administration of probiotics such as antibiotics, disinfectants, and materials that interrupt the mechanism of action of probiotics. In addition, water used for dilution should not contain chlorine or disinfectants. Factors, such as the optimal selection of microbial strains, host species, and age are critical in the selection of probiotics (Mirzaei *et al*., 2020).

2.17 Effect of Probiotics in Animal Production

2.17.1 Effect of probiotics on growth

In animal nutrition, microorganisms used as probiotic were linked with a proven efficacy on the gut micro flora. Probiotics can increase the ruminants' body weight. For instance, a probiotic combination of *Lactobacillus reuteri* DDL 19, *Lactobacillus*

alimentarius DDL 48, *Enterococcus faecium* DDE 39, and *Bifidobacterium bifidum* DDBA collected from a healthy goat and fed to other goats for about two months. This caused an improvement in the goat's standard bodyweight by nine percent (Apas *et al.,*2010). *Bacillus subtilis* and *Bacillus amyloliquefaciens* upgrade intestinal maturation and growth competencyby stimulating GH/IGF-1 hormone (Du *et al.,* 2018). Administration of probiotic in feed significantly improves the feed intake, feed conversion ratio, daily weight gain and total body weight in pig, chicken, sheep, goat, cattle and equines (Samli *et al.,* 2007). Mudgal and Baghel (2010) worked on buffalo calves and found that supplementation of *Lactobacillus acidophilus* in their diet had positive effect on growth of calves (142 g/day in control vs 207 g/day in treatment). *Bifidobacterium animalis*and *Lactobacillus acidophilus*-rich feed additives enable the growth and lifespan of *Hypophthalmichthys molitrix* fingerlings (Noor *et al*., 2020).

2.17.2 Effect of probiotics on meat production

The demand for safe and quality meat in the market has considerably increased. The producers are eager to use natural and non-chemical supplements which positively affect the animal health, increase productivity and improve quality of the product. Probiotics improve the meat quality of the chicken. *Bacillus subtilis* can upgrade chicken meat quality (Mohammed *et al.,*2021). *Bifidobacterium bifidum* and *Bacillus toyonensis* can enhance the growth rate and meat quality in quails (Abou-Kassem *et al.,* 2021). Probiotics increased carcass output and water holding capacity and decreased meat hardness (Cesloyas *et al*., 2005). Probiotics reduced morbidity and mortality of growing rabbits during the fattening periods (Paulinus *et al*., 2006). *Lactobacillus casei* canelevate the high-density lipoprotein (HDL) level and mitigate the low-density lipoprotein (LDL) level in broiler chicken (Yulianto *et al.,*2020).

2.17.3 Effect of probiotics on milk production

The supplementation of animal feed with probiotics has a beneficial effect on subsequent milk yields, fat and protein content. Probiotics can enhance milk production in dairy ca

ttle. Probiotic microorganisms such as *Bacillus sublitis*, *Saccharomyces cerevisiae*, and *Enterococcus faecalis* enrich milk secretion (Ma *et al*., 2020),and *Bifidobacterium bifidum* inhibit milk allergy reaction (Jing *et al*., 2020). According to Nocek and Kautz (2006), probiotics containing *Ent. faecium* and *Sacc. cerevisiae* increases milk yield by 2.3 liters per dairy cattle daily. Another study showed that active yeast probiotics could enhance milk yield by nearly 1.2 g/kg of body weight in dairy cows and increase dry matter intake in the ruminant by about 0.44 g/kg of body weight but had no effects on milk protein percentage (Desnoyers *et al*., 2009).

In traditional milk products, microbes are selected for their ability to grow and produce organic acids in milk. In case of probiotic, microbes are mainly selected because of their potential health associated properties.

2.17.4 Effect of probiotics on miscellaneous animals

Probiotic feed supplements confer health values in farm animals such as sheep, lamb, pigs, rabbits, ducks, and turkeys. Scientists worldwide proposed different probiotic feed additives for safe production of meat, egg and milk, maintaining these animals' well-being. Probiotics can improve the health condition of sheep and lambs. *Bacillus licheniformis* and *Bacillus subtilis* can improve body weight, upgrade the intestinal microbiome, boost immunity, and preserve regular metabolic actions in two-month-old sheep and lambs (Devyatkin *et al.,*2021).

Probiotics can improve the health status of pigs. *Bacillus amyloliquefaciens*is considered a useful dietary supplement against antibiotics in pigs and piglets for fattening (Cao *et al*., 2020). Pigs face much trouble during weaning which leads to immune and intestinal system malfunctions, upsets the gut microbial environment, and hampers the growth rate of piglets. Duan-Nai-An, an engineered *Saccharomyces cerevisiae* strain, can significantly improve body weight, feed intake, and decrease the rate of diarrhea and death in early-weaned piglets (Xu *et al*., 2018).

Probiotics ameliorate the health condition of birds. Dietary feed supplements containing *Lactobacillus acidophilus* and *Lactobacillus casei* fed to white Pekin ducks increased total weight gain, protein content, intestinal enzyme activity, bactericidal activity, and decreased cholesterol, glucose, and cortisol level (Khattab *et al.,* 2021). In neonatal turkey birds, lactic acid bacteria can fight back against *Salmonella enteritis* and *Clostridium jejuni* and improve GIT condition (Yang *et al*., 2018).

2.17.5 Effect of probiotics on rabbits

Clostridium butyricum improves growth rate, gut microbial condition, and intestinal immunity in Rex rabbits. When healthy female rabbits were fed with *Clostridium butyricum*, it considerably ameliorated body weight, the action of digestive enzyme, improved the immune system by enhancing the abundance of beneficial bacteria (Lin *et al.,* 2019). *Bacillus subtilis* containing feed supplements improve growth performance, meat quality and immune response in rabbits brought up in a heated environment (Fathi *et al.,* 2017). Growing rabbits fed with *Aspergillus awamori* demonstrated improved body weight, nutrient digestibility, and better antioxidative responses (El-Deep *et al.,* 2021).

2.17.6 Antitoxin effects of probiotics

According to Czerucka *et al.* (2007), *Saccharomyces boulardii* secretes an enzyme 54 kDa protease, *in vivo*. This protease has been shown to degrade both toxins A and B, secreted from *Clostridium difficile,* and inhibit their cell from the probiotic yeasts. The hyper secretion of water and electrolytes (including chloride ions), caused by cholera toxin during a *Vibrio cholera* infection, can be reduced significantly with the introduction of *S. boulardii*. A 120 kDa protease secreted by *Saccharomyces boulardii* has been observed to influence enterocytes lining the large and small intestinal tract– inhibiting the stimulation of adenylatecyclase, which led to reduction in enterocytic cyclic Adenosine Monophosphate (CAMP) production and chloride secretion (Czerucka *et al.,* 2007). During an *Eschericia coli* infection, Myosin Light Chain (MLC) is phosphorylated leading to the degradation of the tight junctions between intestinal mucosa enterocytes. *Saccharomyces boulardii* has been shown to prevent this phosphorylation, leading to a reduction in mucosal permeability and thus a decrease in the translocation of the pathogenic bacteria (Dahan *et al.,* 2003). Polyamines (spermidine and spermine) have been observed to be released from *Saccharomyces boulardii* in the rat ileum. Polyamines have been theorized to stimulate the maturation and turnover of small intestine enterocytes. (Buts *et al.,* 1994)

2.17.7 Antimicrobial effects of probiotics

By restoring the balance of gut microbiota and producing antimicrobial substances, probiotics are particularly effective in the treatment of acute infectious diarrhea and antibiotic-associated diarrhea *Escherichia coli* and *Salmonella typhimurium* are pathogenic bacteria often associated with acute infectious diarrhoea. These organisms strongly adhere to mannose on the surface of *Saccharomyces boulardii* via lectin receptors (adhesions). Once the invading microbe is bound to *Saccharomyces boulardii*,

it is prevented from attaching to the brush border; it is then eliminated from the body during the next bowel movement (Mehendra *et al*., 2024). *Saccharomyces boulardii* help prevent traveller's diarrhoea. It also helps prevent and treat *Clostridium difficile* diarrhoea after antibiotics usage. It is very effective in the prevention and treatment of antibiotic-associated diarrhoea since it is not affected by antibiotics (Kotowska *et al.,* 2005).

Bifidobacterium infantis alleviate symptoms in irritable bowel symdrome by reducing inflammation and improving gut health. Additionally, probiotics, such as *Escherichia coli* have shown positive effects in maintaining remission in ulcerative colitis. Probiotics also offer benefits in relieving constipation and can serve as an adjunct therapy in eradicating *Helicobacter pylori* infections (Zhang *et al.,* 2015).

2.17.8 Anti-inflammatory effects of probiotics

Saccharomyces boulardii has been shown to decrease the secretion of IL-8 during an *E. coli* infection; *Saccharomyces boulardii* could have a protective effect in inflammatory bowel disease. Interleukin 8 (IL-8) is a pro- inflammatory cytokine secreted during an *E. coli* infection in the gut. Allergen-sensitized T cells produce various interleukins such as IL-1, IL-4, and IL-5, thus recruiting granular effector cells (mast cells, eosinophils, and basophils) toward the site of allergic inflammation. In addition, the interleukins switch B lymphocyte immunoglobulin isotype, which upsurges the circulating level of total and allergen-specific IgE (Galli *et al*., 2020).

Saccharomyces boulardii may exhibit part of its anti-inflammatory potential through modulation of dendritic cell phenotypes, function and migration by inhibition of their immune response to bacterial microbial surrogate antigens such as lipo polysaccharide (Galli*et al*., 2020). A recent study showed that culture of primary human myeloid

dendritic cells CD1c+CD11c+CD123- DC (mDC) in the presence of *Saccharomyces boulardii* culture supernatant (active component molecular weight < 3kDa as evaluated by membrane partition chromatography) significantly reduced expression of the co-stimulatory molecules CD40 and CD80 and the dendritic cell mobilization marker CC-chemokine receptor CCR7 (CD197) induced by the prototypical microbial antigen lipo polysaccharide (LPS). Moreover, secretion key pro-inflammatory cytokines like TNF-α and IL-6 were notably reduced, while the secretion of anti-inflammatory IL-10 did increase. Finally, *Saccharomyces boulardii* supernatant inhibited the proliferation of T-cells in a mixed lymphocyte reaction (MLR) with mDC (Thomas *et al.,* 2009).

Although the precise mechanism is not entirely known, it is expected that the probiotics improve mucosal barrier functions, stimulate the immune system, reduce leakage of antigen through the mucosa, produce anti-inflammatory cytokines, increase the production of secretory IgA (exclude antigens from intestinal mucosa), degrade dietary antigen and up-regulate anti-inflammatory cytokines such as IL-10 (Liang *et al*., 2022).

2.18 Benefits of Probiotics (*Saccharomyces)*

Probiotics yeasts have been gaining increasing attention as potential probiotic candidates in recent years. While bacteria have dominated the probiotic market for a long time, research suggests that specific yeast strains possess properties that could be beneficial for human health (Staniszewski and Kordowska*,* 2021). Probiotic yeasts are generating excitement because they have interesting characteristics from an application point of view. Some probiotic yeasts mightoffer advantages over LAB in terms of survival. Gomaa *et* al., (2020) suggest that certain yeast strains may be more resilient to the hostile environment of the stomach, reaching the intestines inhigher numbers where they can exert their probiotic effects. They also indicated that the diverse functionality

of probiotic yeasts might have a broaderrange of functionality compared to some LAB strains. For example, some yeasts may produce compounds thatnot only benefit their own growth but also stimulate the growth of other beneficial bacteria in the gut. This synergistic effect could lead to a more efficient and diverse gut microbiome (Gomaa *et al*., 2020). The discovery of various probiotic yeast strains opened doors for the development of more targeted probiotic interventions. Different yeast strains might be effective for addressing specific gut health concerns, offering a more personalized approach to probiotic supplementation (Afzaal *et al*., 2022).

2.18.1 Benefit of probiotics (*Saccharomyces)*on the immunity

Probiotics can enhance immunity in the host in many ways. Multiple studies have proven the immunostimulatory properties of probiotics (Punetha e*t al*.,2018; Kong *et al.,* 2020; Terada *et al*., 2020 and Bilal *et al*., 2021). Probiotics comprising *Lactobacillus fermentum* and *Saccharomyce scerevisiae* excited the gut T-cell immunity, highlighted by the enhanced yield of CD3+, CD4+, and CD8+ T-lymphocytes in the gastrointestinal tract of chickens (Bilal *et al.,*2021). In chicks of three-day and seven-day old, expression of CD3+, IL-2, and IFN-γ-genes were higher in the small intestine when provided food with probiotics *Lactobacillus jensenii* TL2937 and *Lactobacillus gasseri* TL2919 than without probiotics (Sato *et al*., 2009). Probiotics actively influence and regulate the host's immune system by triggering the activation of specific genes in localized host cells. They also modulate the release of gastrointestinal hormones and affect brain behavior through bidirectional neuronal communication, forming part of the gut-brain axis (Kristensen *et al*., 2016). *Saccharomyces boulardii* exhibits positive effects by the direct effects on pathogens or their toxins as well as by influencing the host's infection induced signaling cascades and its innate and adaptive immune system. The combination of these mechanism s results in the reduction of the

pathogens' ability for adhesion or colonisation and an attenuation of the overreacting inflamatory immune system (Heike and Stephan, 2016).

2.18.2 Benefits of probiotics (*Saccharomyces)* in the prevention of infections

Probiotic yeasts may compete with pathogenic bacteria for adhesion sites and nutrients, thereby inhibiting their growth and colonization. Additionally, they might produce antimicrobial compounds that directly eliminate harmful bacteria (Liu *et al*., 2022). The specific types of compounds identified so far can be categorized into two main groups: Killer toxins or Mycocins. Killer toxins are proteinaceous compounds produced by certain probiotic yeast strains, particularly those belonging to *S. cerevisiae* and *Debaryomyces* strains. Killer toxins target specific receptors on other yeast and fungal cells, creating pores that lead to cell death (Perez-Giraldo, 2018). Mycocins are another group of antimicrobial compounds produced by some probiotic yeasts. Mycocins are extracellular proteins with a broader target range, meaning they can inhibit β-glucan synthesis, affecting the growth of other yeasts and molds (Perez-Giraldo, 2018). In addition, mycocins produced by *Wickerhamomyces anomalus* (*Ascomycota, Saccharomycetes, Phaffomycetaceae)* exert antimicrobial activity against gram-negative bacteria such *Acinetobacter baumannii* (Junges *et al.,* 2020) and *Klebsiella pneumoniae* and gram-positive bacteria, such as *Staphylococcus aureus* (Calazans *et al.,* 2020)

2.18.3 Benefits of probiotics (*Saccharomyces)* in the prevention of inflammatory bowel disease (IBD)

i. *Saccharomyces boulardii* have a beneficial effect in the treatment of IBD as it limited, in vivo (in mice), the number of immune cells that respond to an inflamed colon. This limitation reduces the amplification of the inflammation response, resulting in less damage to the colon**.**

ii. It also helps to block secretion of the body's inflammation-causing chemicals

iii. In a pilot trial, 17 out of 24 patients obtained clinical remission of ulcerative colitis (UC) that was confirmed endoscopically. They used 250 mg of the yeast 3XD for 4 weeks during maintenance treatment with mesalazine.

iv. Patients with Crohn's disease had fewer relapses using mesalamine with *S. boulardii. (*Maupas *et al.,* 1983)

2.18.4 Benefit of *Saccharomyces* on digestion and nutrient absorption

Probiotics increase enzyme activity in the GIT and improve the digestibility and absorption of nutrients in the food eaten by the host. Probiotics boost the ileal digestibility of essential amino acids, with a 5 percent enhancement in chicken body weight (Zhang and Kim, 2014) and ameliorate the bioaccumulation of calcium in poultry. Maas *et al.* (2021), reported the impact of *Bacillus amyloliquefaciens* on digestion or metabolism following experiment with xylanase, phytase together with probiotics and found better calcium absorption and improved microorganisms' interactions in the gut. Another study in buffalo calves showed that feed containing probiotics *Lactobacillus acidophilus* ensures more dry matter intake, daily feed conversion efficiency, and apparent digestibility of nutrients compared to the control group (Sharma *et al*., 2018).

2.19 Medical Uses of *Saccharomyces*

There are numerous randomized, double-blind placebo-controlled studies showing the efficacy of *Saccharomyces boulardii* in the treatment and prevention of gastrointestinal disorders (Vandenplas *et al.,* 2009).

2.19.1 The use of probiotics (*Saccharomyces)* in the prevention and treatment of acute gastroenteritis

Probiotics have proven to be beneficial in managing several gastrointestinal disorders, including diarrhea, irritable bowel syndrome (IBS), inflammatory bowel disease (IBD), and constipation. They are particularly effective in treating acute infectious diarrhea and antibiotic-associated diarrhea by restoring the balance of gut microbiota and producing antimicrobial substances. Studies suggest that probiotic yeasts might be beneficial in preventing or alleviating symptoms of various gastrointestinal disorders, including diarrhea, constipation, and inflammatory bowel disease. Probiotic yeasts, specifically strains of *S. boulardii,* havedemonstrated potential in mitigating the duration and intensity of diarrhea associated withantibiotic use. They may also be beneficial in managing traveler's diarrhea and might improve bowel movement frequency in individuals with constipation (Mourey *et al.,* 2022).

2.19.2 The use of probiotics (*Saccharomyces)* in the treatment of recurrent Clostridium difficile infection

Administration of two 500 mg doses per day of *Saccharomyces boulardii* when given with one of two antibiotics (*Vancomycin* or *Metronidazole*) was found to significantly reduce the rate of recurrent *Clostridium difficile* (*Pseudo membranous colitis)* infection. No significant benefit was found for prevention of an initial episode of *Clostridium difficile*-associated disease (Santino *et al.,* 2014).

2.19.3 The use of probiotics (*Saccharomyces)* in the treatment of irritable bowel syndrome and diarrhoea (IBD)

Probiotic administration may alleviate IBD symptoms or help maintain remission by regulating the inflammatory response, enhancing barrier function to protect tight

junctions, and modulating gut microbiota composition and activity. The gastrointestinal tract plays a crucial role in protecting the body from toxic and infectious substances. However, factors such as stress, unhealthy diets, dysbiosis, and antibiotic treatments can compromise intestinal microbiota and barrier function, leading to increased permeability. This disruption may contribute to diseases like inflammatory bowel disease (IBD) and irritable bowel syndrome (IBS), as well as extra-intestinal conditions, such as heart disease, obesity, and type 1 diabetes (Aleman *et al.,* 2023).

An unidentified cause and an intensified immune reaction to the body's gastrointestinal (GI) microbiota, which mainly affects the colon and duodenum, are the hallmarks of inflammatory bowel disease (IBD). Usually, it is divided into two primary categories: ulcerative colitis (UC) and Crohn's disease (CD). Although previous research focused on adaptive immune responses as the main cause of these disorders, more recent research has brought attention to the important function of the innate immune system (So *et al*., 2023). The innate immune response can disrupt the balance between the gut's beneficial microbiome and commensal microflora, leading to dysbiosis. This imbalance can intensify inflammatory responses, thereby influencing the development of IBD (Roy *et al*., 2023)

2.19.4 The use of probiotics (*Saccharomyces)* in the treatment of aneamia

Hadadi *et al.* (2021), in their studies highlighted a significant connection between gut microbiota and iron deficiency. Their finding has illuminated the reciprocal relationship between iron deficiency and the composition of gut microbiota, as well as the beneficial impact of probiotic bacteria on enhancing iron absorption. A water-soluble B vitamin, folic acid essential for addressing and managing anemia, can be derived from probiotic microbes, such as *S. cerevisiae*, *L. lactis*, *L. cremoris*, *B. pseudocatenulatum*, *Candida*

famata, *B. adolescentis*, *Candida glabrata*, *Candida guilliermondii*, *Yarrowia lipolytica*, and *Pichia glucozyma*. These microbes enhance intestinal absorption of folic acid. Additionally, *P. denitrificans* and *P. shermanii* have proven useful in treating vitamin B12 deficiency. Lactic acid-fermented foods play a crucial role in increasing iron absorption andare often utilized in managing anemic patients. These foods help optimize the pH of the digestive tract and activate the enzyme phytase, which is important for nutrient absorption. Moreover, a combination of probiotic bacteria has been incorporated into food products to treat megaloblastic anemia, promoting colonic fermentation and counteracting the adverse effects of antibiotics (Hadadi *et al.,* 2021)

2.19.5 The use of probiotics in COVID-19

Probiotics may help the body produce more interferons and other antiviral cytokines, which help the body, fight viral infections, according to a few studies (Baud *et al*., 2022). Probiotics have attracted attention as supportive therapy in managing COVID-19 due to their capacity to modulate the immune system and reduce inflammation. Probiotics can aid in the restoration of dysbiosis caused by COVID-19, which further enhances immune system function in general and the gut microbiota in particular (Mak *et al*., 2020). They are thought to influence the gut-lung axis, which is vital for respiratory health, as it connects gut microbiota to immune responses in the lungs. Probiotic strains, particularly *Lactobacillus* and *Bifidobacterium*, may strengthen gut barrier function, decrease systemic inflammation, and boost antiviral defenses, potentially mitigating the severity of COVID-19 symptoms (Baud *et al*., 2022). Patients with COVID-19 who use probiotic supplements report less severe symptoms, shorter hospital stays, and a decreased risk of developing secondary bacterial infections (Deriu *et al*., 2021). Although the initial results are encouraging, more clinical research is required to identify the best probiotic strains and dosages for the treatment of COVID-

19. According to recent studies, probiotics can improve recovery and lessen consequences by modifying immunological and inflammatory pathways, even though they cannot prevent COVID-19 infection (Gutierrez-Castrellon *et al*., 2022)

2.20 Mode of Action of Probiotics

Probiotics exert their effectiveness through diverse mechanisms. Probiotics inhibit and control enteric pathogens along with improving the functioning and production capacity of animals (Chen *et al.,*2020a). Basic probiotic mode of action includes (a) inhibition of pathogen adhesion; (b) production of antimicrobial components (bacteriocins and defensins) (c) competitive exclusion of pathogenic microorganisms; (d) enhancement of barrier function; (e) reduction of luminal pH; and (f) modulation of the immune system. Probiotics promote health conditions by inhibiting harmful bacteria. For instance, *Lactobacillus rhamnosus*and *Lactobacillus plantarum* can avert *Escherichia coli* adhesion in the intestinal tract (Maldonado Galdeano *et al*., 2019). Bacteria commonly interact with host cells following the secretion of chemical signals that influence bacterial organisms' approach. This communication technique of bacteria with its host is called quorum sensing (Chen *et al.,*2020a; Deng *et al.,*2020a).

Probiotics can influence pathogenicity by modifying the communication process in pathogenic bacteria. Probiotics produce antibacterial substances and impede bacterial adherence and translocation. *Lactobacillus*, *Leuconostoc*, *Pediococcus*, *Lactococcus*, *Enterococcus*, *Streptococcus,* and *Bifidobacteria* can yield proteins or bacteriocins that minimize the development of closely linked bacterial organisms. These probiotics reduce the number of detrimental microorganisms from the gastrointestinal tract (Van Zyl *et al.,* 2020). Bacteriocins are bioactive antimicrobic peptides generated in the ribosome of many bacteria and stick to the pathogenic microorganism cells penetrating

through the phospholipid membranes. The basic pattern of bacteriocin- mediated pathogen reaction encloses the cytoplasmic membrane penetration of pathogenic bacteria that confers in DNA and RNA synthesis inhibition and cell leakages (Van Zyl *et al.,*2020). Bacteriocins restrict pathogen cells' capability of GIT colonization and combat antibiotic-resistant strains of bacteria (Kuebutornye *et al.,* 2020; Lajis, 2020).

Probiotics shape the cell-cell communication of bacteria and host and maintain cellular consistency by strengthening the intestinal barrier function. Such consistency is achieved through the modulation of cytoskeletal and tight junctional protein phosphorylation. *Lactobacilli* abide by the epithelial cells of the ileum of chickens (Jin *et al.,*1996). Probiotics competitively exclude pathogenic micro-organisms from the host intestine by strengthening this intestinal communication system. This anti-mechanism (competitive exclusion) demonstrates that bacterial species rigidly battle for attaching to receptors at a particular binding site in the GIT and might integrate antimicrobial substances secretion and competition for accessible nutrients (Van Zyl *et al.,* 2020).

2.20.1 Effect of probiotic on immunity

Probiotics improve the immunity of the host by modulating the immune system. The consumed probiotics play a crucial role in stimulating the mucosal immune system (MIS) and induce a network of signals. The reaction of diverse probiotic microbes on dendritic cells (DC) has been investigated in different experimental approaches. Dendritic cells are antigen-displaying cells that have crucial roles in innate and adaptive immunity. Dendritic cells can identify and react to bacterial components besides launching primary immune responses, which lead to the straight development of T- and B-cell responses. Probiotics directly govern intestinal dendritic cells with pathogen

recognition patterns (PRPs) displayed on the surface, which can precisely recognize the pathogen associated with molecular patterns (PAMPs) on the bacterial organism. This acknowledging method stimulates DC maturation regarding up-regulation of co-stimulatory molecular expression. As the immune system becomes active, cytokine secretion incites T-cell activation (Langenkamp *et al.,*2000). DC-originated signals ascertain the type of T-cells responses such as T helper cells polarization or T regulatory response, which determines the B-cell responses against pathogenicity (Kapsenberg, 2003).

2.20.2 Effect of probiotics on the immune system

Probiotics can enhance immunity in the host in many ways. Multiple studies have proven the immunostimulatory properties of probiotics (Terada *et al.,* 2020; Bilal *et al.,* 2021). Probiotics comprising *Lactobacillus fermentum* and *Saccharomyces cerevisiae* excited the gut T-cell immunity, highlighted by the enhanced yield of CD3+, CD4+, and CD8+ T-lymphocytes in the gastrointestinal tract of chickens (Bai *et al.,* 2013). In neonatal chicks three-day- and seven-day old expression of CD3+, IL-2, and IFN-γ-genes were higher in the small intestine when provided food with probiotics *Lactobacillus jensenii* TL2937 and *Lactobacillus gasseri* TL2919 than without probiotics (Sato *et al.,*2009).

Saccharomyces boulardii exhibits positive effects by the direct effects on pathogens or their toxins as well as by influencing the host's infection induced signaling cascades and its innate and adaptive immune system. The combination of these mechanism results in the reduction of the pathogens' ability for adhesion or colonisation and an attenuation of the over reacting inflamatory immune system (Heike and Stephan, 2016).

2.20.3 Effect of probiotics on the innate and adaptive immunity of the host

Several immune cell types, comprising granulocytes, dendritic cells, macrophages T lymphocytes, and B lymphocytes, are engaged with inflammatory responses, which are regulated by cytokines like TNFα, IL-8, IL-1β, IL-15, and IL-6 interleukins. The anti-inflammatory reactions are mediated by TGFβ, IL-10, IL-12 (Bilal *et al.,* 2021).

Innate immunity provides physical and chemical barriers against pathogens for the host organism. For example, intestinal epithelial cells (IECs) prevent the spread of harmful microbes so that infections do not occur. It has been reported that *Lactobacillus* bacteria such as *Lactobacillus gasseri*, *Lactobacillus salivarius*, *Lactobacillus fermentum*, and *Lactobacillus crispatus* can regulate favorably the secretion level of the pro- and anti-inflammatory interleukins IL-6, IL-8, and IL-10 to manage the inflammation and rebuild the physiological balance in animals (Rizzo *et al.,*2015).

Lactobacillus delbrueckii strain stimulate anti-inflammatory properties and capable of downregulating the pro-inflammatory cytokines IL-8 levels. These inflammatory responses were seen in *Aeromonas hydrophila* contaminated carp (*Cyprinus carpiohuanghe var*.) when supplemented with 1×10^7 CFU g/L *Lactobacillus delbrueckii* probiotics (Zhang *et al.,*2017). The adaptive immune response is dependent on B-lymphocytes and T-lymphocytes, which stimulate an antigen- specific response. In poultry, feed supplementation with 1×10^9 CFU/kg of *Lactobacillus acidophilus* LA5 elevated the amount of CD8+, CD4+, TCR1+ T-cell in the gastrointestinal tract as well as in the peripheral blood system (Asgari *et al*., 2016).

2.21 Role of Probiotics in Poultry

The world's poultry production now is five times higher than the poultry production of 50 years ago (FAOSTAT, 2016). Evaluation from the 2016 "Global Livestock

Environmental Assessment Model" FAO (2018) discloses that around 73 million tons of eggs and approximately 100 million tons of poultry meat have been required worldwide. Probiotics help improve the growth rates of broiler chicken. Probiotics can help to meet this massive need without exerting harmful effects (Abd El-Hack *et al.,* 2020).

When white Pekin ducks were given a dietary feed supplement containing *Lactobacillus acidophilus* and *Lactobacillucasei,* itincreased total weight gain, protein content, intestinal enzyme activity, bactericidal activity, and decreased cholesterol, glucose, and cortisol level (Khattab *et al.,* 2021). In Cherry Valley Pekin ducks, *Bacillus subtilis* and *Bacillus licheniformis* enhance LXRα and CYP7α1 enzyme activities in the liver and reduced lipid concentrations and fat deposition (Huang *et al.,*2015). In neonatal turkey birds, lactic acid bacteria fight back against *Salmonella enteritis* and *Clostridium jejuni* and improve GIT condition (Yang *et al.,*2018). Modified probiotic bacteria, *Escherichia coli* Nissle1917, secrete the antimicrobial peptide, Microcin J25 which diminishes *Salmonella enteritidis* in GIT of turkey (Forkus *et al.,*2017).

2.21.1 Effect of probiotics on digestibility in poultry

Probiotics increase the rate of digestion in animals. Probiotics ameliorate cecal microorganism constitution and nutrient digestion in broilers (Khalid *et al.,*2021). Probiotics boost the ileal digestibility of essential amino acids, with a 5 percent enhancement in chicken body weight and ameliorate the bioaccumulation of calcium in poultry. (Zhang and Kim 2014). Maas *et al*. (2021) experimented with enzymes xylanase, phytase together with probiotics. They reported the impact of *Bacillus amyloliquefaciens* on digestion or metabolism and found better calcium absorption and improved microorganisms' interactions in the gut. Probiotics increase enzyme activity in GIT and improve the digestibility of food eaten by the host. For example, a study in

buffalo calves showed that probiotic feed containing *Lactobacillus acidophilus* could ensure more dry matter intake, daily feed conversion efficiency, and apparent digestibility of nutrients compared to the control group (Sharma *et al*., 2018).

2.21.2 Effect of probiotics on laying performance of hens

Probiotics increase the laying performance of hens and egg quality. Lohmann pink laying hens which are nourished with *Clostridium butyricum*, *Saccharomyces boulardii*, and *Pediococcus acidilactici* have improved the gastrointestinal state and egg quality (Xiang *et al.,* 2019). When brown laying hens are given *Bacillus subtilis* ATCC PTA-6737 at 1×10^8CFU/kg feed, the laid eggs hadbetter yolk color, albumen quality, shell thickness, and breaking strength than eggs laid by control group hens (Sobczak and Kozłowski, 2015).

Probiotics can efficiently minimize the egg yolk cholesterol level. *Bacillus* spores, lactic acid bacteria, and yeast can minimize the cholesterol level of the egg yolk (Panda *et al.,* 2007). Probiotic supplementation in feed increased egg quality and egg production, reduced triglycerides, plasma cholesterol and egg contamination (Kurtoglu *et al.,* 2004). Probiotic supplementation also increased eggshell weight, shell thickness and serum calcium (Panda *et al.,* 2007). Kockaglu (2011) reported that probiotic supplementation increased hatchability.

2.21.3 Effect of probiotic on meat quality characteristics of poultry

Bacillus subtilis upgrade chicken meat quality (Mohammed *et al*.,2021). *Bifidobacterium bifidum* and *Bacillus toyonensis* enhance the growth rate and meat quality in quails (Abou-Kassem *et al.,* 2021). *Lactobacillus casei* elevate the high-density lipoprotein (HDL) level and mitigate the low-density lipoprotein (LDL) level in broiler chicken (Yulianto *et al.,* 2020). *Lactobacillus acidophilus* together with

Streptococcus faecium enhances the protein content in meat by lowering high-density lipoprotein levels and plasma protein concentrations (Pietras, 2001). Additional works based on *Lactobacillus spp.* supplementation offered similar results, with minimization in the whole cholesterol levels and low-density lipoprotein cholesterol levels (Taherpour *et al.,* 2009), as well as triglycerides level in blood serum of broilers (Kalavathy *et al.,*2003).

2.21.4 Effect of probiotics on the immune system of poultry

Probiotics enhance immunity in the host in many ways. Multiple studies have proven the immunostimulatory properties of probiotics (Terada *et al*., 2020; Bilal *et al*., 2021). Probiotics comprising *Lactobacillus fermentum* and *Saccharomyces cerevisiae* excited the gut T-cell immunity, highlighted by the enhanced yield of CD3+, CD4+, and CD8+ T-lymphocytes in the gastrointestinal tract of chickens (Bai *et al.*, 2013). In neonatal chicks of three days and seven days old expression of CD3+, IL-2, and IFN-γ-genes were higher in the small intestine when provided food with probiotics *Lactobacillus jensenii* TL2937 and *Lactobacillus gasseri* TL2919 than without probiotics (Sato *et al*., 2009).

2.21.5 Effect of probiotics on immunomodulatory responses in poultry

Probiotics supplementation helps broiler chickens to cope with stress conditions. Lactic acid bacteria (LAB) probiotics addition as a food supplement can rectify heat stress-relevant diseases in chickens (Abd El-Hack *et al.,* 2020). Lactic acid bacteria can improve antibody production and enhance immunitsy by increasing the Toll-like receptor (TLR) signaling. Toll-like receptors play a crucial role in the activation of T-cells in the intestinal immune system (Asgari *et al.,* 2018). *Lactobacillus fermentum* and *Saccharomyces cerevisiae* strengthen the degree of mRNA expression of TLR-2 and

TLR-4 in the foregut of the chickens in respect of those treated with or without an antibiotic (Bai *et al*., 2013).

2.22 Role of Probiotics in Ruminants

Rumen has an intricate microbial population. Host animals ingest carbohydrates and proteins, which are degraded by rumen microorganisms. The commonly used probiotics for ruminants are *Saccharomyces cerevisiae* (Elghandour *et al*., 2020), Lactic acid bacteria (Weimer, 2015); *Aspergillus oryzae, Bacillus* and *Enterococcus* (Uyeno *et al*., 2015) confer significant well-being for ruminant health.

2.22.1 Effect of probiotics on enhancement of milk production in dairy cattle.

Probiotic microorganisms such as *Bacillus sublitis*, *Saccharomyces cerevisiae*, and *Enterococcus faecalis* enrich milk secretion (Ma *et al*., 2020), and *Bifidobacterium bifidum* inhibit milk allergy reaction (Jing *et al.,* 2020). Cows supplemented with 5×10^9CFU of *Enterococcus faecium* and 2×10^9 CFU *Saccharomyces cerevisiae* cells enhanced milk production by 2.3 liters per cow each day. A rigorous quantitative study on yeast probiotics implications in ruminants demonstrated that ruminants fed with active yeast probiotics increased milk production by nearly 1.2 g/kg of body weight. Dry matter intake (DMI) by the farm animals was elevated by nearly 0.44 g/kg of bodyweight though there was no effect on milk protein content (Desnoyers *et al.,*2009).

2.22.2 Effect of probiotics on body weight of ruminants

Du *et al,* (2018) reported that probiotic combination of *Lactobacillus reuteri* DDL 19, *Lactobacillus alimentarius* DDL48, *Enterococcus faecium* DDE39, and *Bifidobacterium bifidum* DDBA collected from a healthy goat and fed to other goats for about two months greatly caused an improvement in the goat's standard body weight by nine

percent. *Bacillus subtilis* and *Bacillus amyloliquefaciens* upgrade intestinal maturation and growth competency by stimulating GH/IGF-1 hormone (Du *et al.,*2018)

2.22.3 Effect of probiotics on the increase of food digestibility in ruminants

Probiotics increase enzyme activity in GIT and improve the digestibility of food eaten by the host. For example, a study in buffalo calves showed that probiotic feed containing *Lactobacillus acidophilus* ensures more dry matter intake, daily feed conversion efficiency, and apparent digestibility of nutrients compared to the control group (Sharma *et al*., 2018). Using a mixture of *Lactobacillus acidophilus* NP51 and *Propioni bacterium freudenreichii* NP24 as cow feed improved the digestion of neutral detergent fiber, crude protein, and milk yield by nearly 7.6 percent (Boyd *et al*., 2011).

2.22.4 Effect of probiotics on the immune system of ruminants

The supplementation of *Lactobacillus acidophilus*, *Lactobacillus salivarius*, and *Lactobacillus plantarum* at a rate of 10^7– 10^8 CFU/g reduced the occurrence ofdiarrhea in juvenile calves. Nisin is an antimicrobial peptide generated from *Lactococcus lactis*. Nisin infusion in the intra-mammary glandtreats mastitis, which is caused by *Staphylococcus aureus* in dairy cows. *Lactobacillus* base teat spray improve mammary gland condition and strengthen the functions of the teat sphincter (Alawneh *et al.,*2020).

2.22.5 Effect of probiotics in alleviation of rumen acidosis

Probiotics alleviate rumen acidosis in cows, strengthen rumen fermentation and improve immunity in young, stressed calves. Multiple probiotic strains have been proved to yield antimicrobial components that can decrease zoonotic pathogens and control ammonia production. *Rhodopseudomonas palustris*, a photosynthetic bacterium, have been considered a feasible probiotic in the animal feed sector (Cheng *et al.,* 2017). Chen *et al.* (2020) reported that *Rhodopseudomonas palustris* containing feed supplements can

promote the viability of rumen microorganisms. They also noticed that *Rhodopseudomonas palustris* addition rendered high growth performance of rumen microorganisms and increased microbial fermentation to keep up the microbial balance. Application of *Megasphaera elsdenii* ameliorate butyrate production and improve dietary intake in newborn calves (Muya *et al.,* 2015)

2.23 Role of Probiotics in Aquaculture

In 2018, universal fish production was around 179 million tons, coupled with a total sale value estimated at USD 401 billion (FAO 2020). Antibiotics are extensively used to meet the increasing demand in aquaculture. However, this extensive use of antibiotics gives rise to the drug-resistant bacteria that transmit through the food web to humans (Banerjee and Ray, 2017).

2.23.1 Effect and benefits of probiotics to aqua animals

Probiotics promote the growth and reproduction of water-dwelling animals, safeguard from pathogens, strengthen immunity, help in digestion, improve water quality, and work as an alternative to antibiotics (Banerjee and Ray, 2017). Farmers use a broad range of probiotics in fish farming. *Bacillus subtilis* from *Bacillus* genera is frequently used in aquaculture (Olmos *et al.,* 2020). *Bacillus* probiotics alone can mitigate various harmful microorganisms in fish such as *Vibrio*, *Pseudomonas*, *Aeromonas, Clostridium, Streptococcus*, *Flavobacterium*, *Acinetobacter*, and white spot syndrome virus (Kuebutornye *et al.,* 2020).

2.23.2 Probiotics used in aquaculture

Other bacterial strains commonly used as probiotics in aquaculture are the LAB bacteria such as *Lactococcus lactis* (Balcazar *et al*., 2007) and *Lactobacillus plantarum* VSG-3. A broad range of gram-negative bacteria perform a vital role in fish farming. Several microalgae such as *Dunaliella tertiolecta*, *Dunaliella salina*, *Isochrysis galbana*, *Phaeodactylum tricornutum*, and *Tetraselmissu ecica* have enhanced the development and survival rate of aquatic animals. Yeast (*Saccharomyces cerevisiae*) has been proven useful for aquatic animals (Mo *et al.,* 2020; Wu *et al*., 2020).

2.24 Probiotics as Alternative to Antibiotics

Probiotics have attracted great attention due to their positive effects on gut microbiota and immunological systems in humans and livestock (Cheng *et al.,* 2017). Probiotics are used as prophylaxis and for therapeutic purposes in both humans and farm animals (Abushelaibi *et al.,* 2017) with probiotics being a safe and viable alternative to the use of antibiotics growth promotors which can result in antibiotic resistance in microbial population (Srinivas *et al.,* 2017). When used in farm animals instead of antibiotics dietary supplementation of probiotics improves growth performance, nutrient digestibility, and immune response and reduces the incidence of diseases (Srinivas *et al*., 2017). In addition, probiotics increase oxygen concentration in the gastrointestinal tract in a multiplicity of ways including through depleting oxygen-scavenging compounds, such as nitrates. Moreover, probiotics secrete hydrolytic enzymes that can hydrolyze bacterial toxins and inactivate toxin receptors, decreasing toxin-mediated infections in farm animals (Alayande *et al.,* 2020).

Antibiotics have been used commonly to change alimentary tract microorganism and increase productivity and animal growth. Prolonged use of antibiotics results in the

development of drug-resistant microbiota. Drug-resistant development in microbiota threatens consumers' health, causes a negative impact on the environment, and increases foodborne allergies (Deng *et al.,* 2020a). To confront these challenges, probiotics could be beneficial. Therefore, the use of probiotics as dietary supplementation has received great attention (Ahmadreza *et al.,* 2022)

2.25 Negative Effects of Probiotics

Probiotics have a long history of use without causing any illness in people. However, the safety of probiotic has not been thoroughly studied scientifically. Safety evaluation of probiotic strains is essential because probiotics might lead to adverse effects, such as transferring virulence factors and antimicrobial resistance, hemolytic potential, and production of toxic biochemicals (Lee *et al.,* 2017). Moreover, the potential risk of transmission of antimicrobial-resistant genes in the probiotic strain to other bacteria of the normal flora of GIT is more critical. Rarely, infectious diseases such as endocarditis, bacteremia, pneumonia, meningitis, and septic arthritis caused by *Lactobacillus* and *Enterococcus* are reported in immuno-compromised patients (Vankerckhoven *et al.,* 2008). Some authors discourage using *Enterococcus* as a probiotic because *Enterococcus* is more likely to develop vancomycin-resistant genes and can transfer to neighbouring pathogens and enhance the virulence of those pathogens (Alayande *et al*., 2020). Discovering the origin of GIT microbiota is necessary for ascertaining the source of a microorganism in the GIT. In addition, the possibility of probiotic supplementation that could contaminate the human food chain must be considered.

2.26 Probiotics: Now and the Future

The mechanism of action of probiotics is not yet fully known and is therefore, open for research. There are however, several hypotheses. There is increasing evidence to

suggest that probiotic act by stimulating the immune system of the host. The next-generation yeast probiotics are emerging as a powerful new approach in the field of live biotherapeutics (Tuliano, 2022). These modified yeast strains go beyond the fundamental idea of probiotics. By using genetic engineering, scientists are able to equip these tools with specialized capabilities. Compared to conventional probiotics, this enables them to more effectively target particular health issues. For the time being, *S. boulardii* is one of the most promising next-generation yeast probiotics (Murali and Mansell, 2024). Although this strain is currently utilized as a conventional probiotic, scientists are working to engineer it for additional uses (Shingel *et al.,* 2018). Yeasts can be engineered to produce specific molecules that benefit the gut environment. For instance, they can be programmed to synthesize short-chain fatty acids that promote gut health, or modifications can be made to allow the yeasts to reach specific areas of the gut where they can exert their desired effects. The hostile environment of the gut can be challenging for probiotics; however, scientists are engineering yeast strains that are better able to pass through the digestive system and establish themselves in the gut. Probiotics derived from next-generation yeast may revolutionize the way gastrointestinal disorders are treated and perhaps even other medical conditions. Though the field is still in its early stages, ongoing research and clinical trials are paving the way for the development of more effective and targeted treatments (Sun *et al*., 2021). Exploring the effects of probiotics on growth, feed conversion or production of farm animals to boost their economic contributions is a trend. Hence, their use is of potential economic benefits in the future.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Site

The study was conducted at the Teaching and Research Farm, Faculty of Veterinary Medicine, University of Abuja, Gwagwalada in Gwagwalada Area Council of the Federal Capital Territory, Abuja. Gwagwalada is located between latitude 6° 23' and 9° 13' North of the equator and longitudes 6º 45’ and 7º 39’ East of Greenwich meridian, respectively. It is characterized by arable farming and livestock keeping. Gwagwalada Area Council is characterized by four (4) climatic conditions. The hot and dry weather which occurs between the months of February to March and has a mean temperature of 32°C but generally oscillates between 20°C to 40°C, warm and wet weather which occurs between the months of April to September, with a temperature of 25°C, but which may fall to 20°C, warm and dry weather, occurs between October to mid November with average temperature of 25°C. Finally, the hamattan period which occur between mid November to February with a mean temperature of 22°C. Mean annual rainfall ranges from 1,100 mm to 1,600 mm, most of which fall between May and October with high relative humidity (HGAC, 2020).

3.2 Source of Probiotics

The probiotics used for the experiment were purchased from a reputable pharmaceutical company in Nigeria (Naza Pharmacy Nigeria Limited, Teaching Hospital Road, Phase 3, Gwagwalada, Abuja). The probiotics was marketed by Prisma Pharmaceutical Limited Jubilee House, Merrion Avenue, Stanmore, and Middlesex, U.K. It is a product of Bharat Biotech International Limited, Genome Valley, Shameerpet, Hyderabad, India

3.3 Probiotics Preparation, Bacterial Count and Administration

Serial dilution methods were used to get the required inclusion rates for the probiotics in 1 ml of the mixture as described by the manufacturer. After the preparation of probiotics concentration, 5 mls sterile plastic syringe was used to administer the concentration orally while a digital scale was used for the measurement of *Saccharomyces cerevisiea* for inclusion into the feed.

Serial dilution and bacterial count

One (1) sachet of *Saccharomyces* contains **250 mg** and **five (5) billion** colony forming units (cfu) of *Saccharomyces boulardii*

To calculate the required concentration therefore:

4 mg/ml = 4/250 x 5,000,000,000 = **80,000,000 cfu/ml**

3mg/ml = 3/250 x 5,000,000,000 = **60,000,000 cfu/ml**

2mg/ml = 2/250 x 5,000,000,000 =**40,000,000 cfu/ml**

1mg/ml = 1/250 x 5,000,000,000 =**20,000,000 cfu/ml**

Calculation of the required serial dilution rates to get the various concentration was done as follows:

80 x 10^6cfu/ml = 250/4 = 62.5ml

60 x 10^6cfu/ml = 250/3 = 83.33ml

40 x 10^6cfu/ml = 250/2 = 125ml

20 x 10^6cfu/ml =250/1 = 250ml

One (1) sachet of probiotics was diluted in distilled water for the various calculated volumes to get the required concentrations (colony forming units) of the probiotics. The doses of probiotics given to the rabbits is given in Table 3.1

3.4 Management of Experimental Rabbits

The grower rabbits were sourced from the National Veterinary Research Institute (N.V.R.I) Vom, Plateau State, and the National Animal Production Research Institute (NAPRI) Shika, Zaria, Kaduna State. They were fed with concentrates, forages and given clean drinking water *ad-libitum.* The concentrate was a commercially formulated pelletized grower mash (Vital feed) produced by Grand Cereals and Oil Mills Limited, Jos. The forages used were *Tridax, Stylosanthes* and cabbage waste. A day after their arrival, they were given Ivomectin at 0.3 ml subcutaneously against both ecto and endo-parasites. Fourty five (45) heterogenous grower rabbit of about four months old comprising fifteen (15) males and thirty (30) females were used for the experiment.

3.5 Experimental Design

Completely randomized design (CRD) was used for the research. The experiment consisted of five (5) treatments. In each treatment, there were three replicates, with each replicate having three rabbits. There was one (1) male and two (2) female rabbits in each replicate. Treatment one (T_1) represent zero level of probiotic, treatment two (T_2) represent 80 x 10^6cfu/ml of *S. boulardii* + 0.2 g/kg (2 x 10^8) cfu/ml of *S. cerevisiea,* treatment three (T_3) represent 60 x 10^6cfu/ml of *S. cerevisiae* + 0.4 g/kg (4 x 10^8)cfu/ml of *S. cerevisiea,* treatment four (T_4) represent 40 x 10^6cfu/ml of *S. boulardii* + 0.6 g/kg (6 x 10^8) cfu/ml of *S. cerevisiae* while treatment five (T_5) represent 20 x 10^6cfu/ml of *S. boulardii* + 0.8 g/kg (8 x 10^8) cfu/ml of *S. cerevisiae* respectively. The *Saccharomyces*

boulardii was administered orally using a syringe at 1 ml per rabbit once every week while the *Saccharomyces cerevisiae* was included in the diets and fed daily.

Table 3.1 Doses of probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae)* administered to rabbits

Treatments	Concentration (ml & gm)
T_1	Control (no probiotic)
T_2	80 x 10^6cfu/ml of *S. boulardii* + 0.2 g/kg (2 x 10^8) cfu/ml of *S. cerevisiea*
T_3	60 x 10^6cfu/ml of *S. cerevisiae* + 0.4 g/kg (4 x 10^8) cfu/ml of *S. cerevisiea*
T_4	40 x 10^6cfu/ml of *S. boulardii* + 0.6 g/kg (6 x 10^8) cfu/ml of S. *cerevisiae*
T_5	20 x 10^6cfu/ml of *S. boulardii* + 0.8 g/kg (8 x 10^8) cfu/ml of *S. cerevisiae*

3.6 Data Collection for Experiment 1 (Parent Rabbits)

Data were collected on the following parameters

3.6.1 Growth performance

3.6.1.1 Feed intake

Daily feed intake was obtained by calculating the difference between the quantity of feeds rejected from that supplied over a 24 hours duration. At the beginning of the experiment, using a weighing balance, a measured quantity of feed was given to the rabbits in each of the replicates and the measure of the remnants was also taken the following morning before the measure of new feed was made and given to the rabbit. A total of 100 g of feed/rabbit/day was shared into 50 g/rabbit from 8am - 4pm, and 50 g/rabbit from 4pm - 8am. This was increased to 120 g/rabbit/day in the reproductive phase and shared into 60 g in the morning and 60 g in the evening as was described by Togun *et al*. (2009). The records for each day and weekly feed intake for each of the treatment and mean weekly feed intake per treatment was calculated asfollows.

$$\text{Average feedintake} = \frac{\text{Quantity of feed given - quantity of feed left over (g)}}{\text{Number of rabbits}}$$

3.6.1.2 Body weight (g)

At the commencement of the growth performance study, the initial body weights of all the rabbits in each of the replicates were measured and weighed and afterwards at weekly intervals for 8 weeks period to monitor growth and development using a sensitive electronic balance (Mettler analytical balance, PM 400 model, Switzerland). The weights of each replicate were taken to obtain the average body weights.

3.6.1.3 Body weight gain (g)

This refers to the increase in the body mass of the rabbits and was measured in grams (g) It was determined by subtracting the initial body weights from the final body weights. The formula used for determining average body weight gain was;

Average body weight gain (g) = Mean final body weight − Mean initial body weight.

3.6.1.4 Feed Conversion Ratio (FCR)

To determine the FCR, average feed intake was divided by the average weight gain. It was expressed mathematically thus:

$$FCR = \frac{\text{Average feed intake (g)}}{\text{Average weight gain (g)}}$$

3.6.2 Digestibility trial

At the end of the feeding trial, a digestibility trial was conducted using 3 rabbits from each treatment group to assess the level of nutrients digestibility. The rabbits were kept in metabolic cages for two (2) days to acclimatize. Total faeces voided were collected for five (5) days. Feed intakes for the five (5) days period of faecal sample collection were noted. Faecal samples collected per day were dried at 60ºC until constant weights was obtained for each sample. The dried samples were weighed and stored in polythene bags. The daily feed intake and faecal samples were pooled for each replicate at the end of the five (5) days and representative samples were taken for proximate analysis. Digestibility coefficients was then calculated thus:

$$\text{Apparent nutrients Digestibility coefficients} = \frac{\text{Nutrient intake in feed} - \text{Nutrients voided in faeces}}{\text{Nutrient intake in feed}} \times 100$$

3.6.2 Determination of haematological parameters

The rabbits were bled through the ear marginal vein twice; at the beginning of the study, and at the eighth (8) week of the study. Two (2) ml of blood was collected and dispensed into bottles containing the anticoagulant Ethylene Diamine Tetra amine Acid (EDTA). The samples were taken to the Physiology and Biochemistry Laboratory, at the Faculty of Veterinary Medicine, University of Abuja, for the determination of red blood cell (RBC) count, white blood cell (WBC) count and haemoglobin concentration (Hb) using the improved Nuebaer haemocytometer method as described by Jain (1986). Packed cell volume (PCV) was determined using the Wintrobe Micro-Haematocrit method (Decie and Lewis,1991). Mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (MCHC) and mean cell haemoglobin (MCH) were calculated using the RBC, WBC, PCV and Hb values according to Jain (1986).

3.6.3 Determination of serum biochemistry

Two (2) mls of blood was collected from the rabbit through the ear marginal vein twice; at the beginning of the study and at the eighth (8) week. The blood samples were dispensed into anticoagulant free bottles. The samples were then transported to the Physiology and Biochemistry Laboratory, at the Faculty of Veterinary Medicine, University of Abuja, for analysis. In the laboratory, the blood was allowed to clot to obtain serum by allowing it to stand for 2 hours at room temperature and centrifuged using the high speed Wintrobes micro-haematocrit for ten minutes at 2000 rpm to separate the cells from the serum. Serum metabolites (total protein, albumin, sodium, potassium and chloride) were analysed using Sigma kits according to Benzie and Strain (1996).

3.6.4 Determination of female reproductive performance

A total of fourty five (45) rabbits were used for the reproduction study at the end of the feeding trial. Males were separated from the females between the 20th and 24th week for breeding purpose. Indelible marker and coat colour of the rabbits were used for their identification and proper record keeping. The does were weighed prior to mating, before and after parturition, and finally, at the end of the experiment. Parameters measured are as follows:

3.6.4.1 Does traits parameters

Weight at Mating (WM): The weight of the rabbits was taken at mating.

Conception Rate (CR): Conception rate was the proportion of females mated to those that actually conceived.

Gestation Lenght (GL): This is the time between mating and parturition. Records of mating and parturition dates were taken to obtained this.

Weight of Does Before Kindling (WDBK): The weights of does before kindling were measured

Weight of Does After Kindling (WDAK): Theweights of does after kindling were measured using a digital weighing balance

Weight of Does at Weaning (WDW): The weights of the does at weaning was recorded using a digital weighing balance

3.6.4.2 Birth traits parameters

Litter Size at Birth (LSB): Number of litters at parturition by each doe was taken.

Litter Weight at Birth (LWB: The weights of the litter at 1hour after parturition by each doe were taken.

Litter Size at Weaning (LSW): The number of litters that survived to weaning stage were counted.

Litter Weight at Weaning (LWW): This was determined by weighing all the litters at weaning using a Metler digital weighing balance.

Kindling Loss (KL): This was taken as the difference between the weights of the does a day before kindling and a day post partum.

Milking Capacity (MC): Milking capacity was calculated thus:

$$\text{Coefficient of milking capacity} = \frac{C2 - C1}{21 \times C1}$$

C1 = litter weight at birth

C2 = litter weight at 21 days post-partum

Mortality Rates (MR): This was determined by dividing the number of dead litters by those delivered within the study period multiplied by 100.

3.6.4.3 Weaning traits

This was evaluated at forty-two (42) days post-partum. Parameters evaluated were as follows:

Litter Size at Weaning (LSW): The number of weaners were counted

Litter Weight at Weaning (LWW): The weights of all the weaners per doe were taken.

Litter Weight Gain (LWG): The difference between the weights of the litter at birth and the weights of the litter at weaning was calculated.

Weaning Sex Ratio (WSR): The proportion of males to females at weaning was determined.

Survival Ratio (SR): The proportion of the litter kindled to those that survived to the weaning stage and was calculated thus:

$$SR = \frac{\text{Litter size at weaning}}{\text{Litter size at birth}} \times 100$$

These were determined according to the methods of Egena *et al.* (2012)

3.6.5 Determination of male reproductive performance

3.6.5.1 Evaluation of testicular morphometric traits

At the end of experiment one, ten (10) bucks (2 per treatment) were selected randomly and weighed to get the mean weight of bucks in each treatment group and were used for determination of morphometric traits. The bucks were euthanized, after which, the pairs of testes were carefully removed and freed of all adhering connective tissues. Using a Venier caliper, the circumference of the testes was measured. Similarly, the weights were measured using a Metler digital weighing balanceand the volume of the testes was also determined as described by Emmanuel *et al.* (2019). Using a vanier calipher, the lenght, widht and height of the testes were measured, and volume was then calculated as follows:

$$\text{Volume} = \text{Lenght} \times \text{width} \times \text{height} \times 0.52$$

3.6.6 Meat yield and meat quality characteristics of rabbits

In determining the meat yield and meat quality characteristics of rabbits, the method of Awosanya (1989) was adopted. After the conclusion of the experiment, 15 rabbits were randomly chosen from the five treatments (one rabbit from each replicate). Their final live weights were determined and recorded, then fasted overnight by allowing the animals access to water only. They were then slaughtered using a knife by means of cutting through the jugular vein and carotid artery around the atlas bone. The rabbits were suspended with the head facing down-ward to ensure complete bleeding. This was done for 20 minutes. The changes in the slaughtered weight and the weight after bleeding were taken as the blood loss. The rabbits were dressed by complete removal of skins (pelts); they were cut at the atlanto-occipital joint. The rear legs were cut at the junction linking the tibia calcaneus whilst the front legs were severed close to the carpal area and the tail (near the base) and removed, and their weights taken separately. Evisceration was accomplished by the removal of internal organs (heart, liver, kidneys, lungs, viscera and spleen), which were weighed individually and expressed as percentage of the carcass weight. The carcass length was determined using a tape rule, measuring from the anterior end of the 1st rib (close to the vertebra) to the anterior edge of the aitchbone of the pelvis (Awosanya, 1989).

The carcasses were evaluated according to the methods of Awosanya (1989) and Ahamefule (2005). The carcasses were first divided into two symmetrical halves as much as possible by splitting down the vertebral columns. Each half of the carcass was divided into the primal parts, following these reference points. Each shoulder was removed from the rest of the carcass by cutting between the 5th and the 6th ribs perpendicular to the back line. The rib was separated from the loin by cutting behind the 12th rib following its curvature. The loin was separated from the leg by cutting at the tip

of the ilium perpendicular to the chin- bone. By the time the loin was removed, the leg remained as a single entity. The weights of the primal parts were determined and recorded.

3.6.7 Evaluation of the fat deposits

The method of Awosanya (1989) was used in evaluating the peripheral fat deposit. These were the fats found on the internal ventral region of the carcass surrounding the kidneys down to the pelvic region after evisceration. The fats in this depot were removed, collected and their weight recorded.

3.6.8 Meat quality characteristics

3.6.8.1 pH of rabbit meat

A pH meter (Micro 600 pH meter) manufactured by Palintest, UK, was used following the method of Marchiori and deFelicio (2003). 10 g sample of meat was homogenized in 90 ml distilled water using a blending machine (model 242, Nakai, Japan) at speed 5. The pH meter was standardized by means ofbuffers 4 and 7, after which the pH reading of the meat samples were taken.

3.6.8.2 Water Holding Capacity (WHC)

The water holding capacity was calculated based on the technique of Suzuki *et al*. (1991). A 1g sample of meat was positioned in between two 9 cm Whatman No 1 filter papers (Model C Caver Inc. Wabash, U.S.A) and sandwiched in between 2 plexi glasses (10.2 x 10.2 cm^2), and pressed at around 35.3 kg/cm^3 absolute pressure for one minute by means of a vice. The meat samples were taken to the oven and dried at 105^0C for one day to ascertain the moisture level. The quantity of water liberated from the meat

samples was calculated by determining the size of titre paper wetted in relation to the area of the pressed meat samples.

Thus: $WHC = \frac{100-(Aw-Am) \times 9.47}{Wm \times Mc} \times 100$

Where,

Aw = Area of water released by meat samples (cm^2)

Am = Area of meat samples (cm^2)

Wm = Weight of meat samples (g)

Mc = Moisture content of meat samples (%)

9.47 = a constant factor

3.6.8.3 Cooking loss and thermal shortening

The cooking loss and thermal shortening of the meat samples were determined as reported by Omojola and Adesehinwa (2006). Meat samples from the hind limb of rabbit representing the various treatments were weighed and their length measured. They were put into a pot and boiled for 25 minutes between 60 – 80^0 C to an average temperature of 72^0C as determined with a skewer meat thermometer. The samples were allowed to cool to room temperature and were mopped of excess fluid with paper serviette after which their weights and lengths were retaken. The percentage of the difference between theinitial weight and length, and the final weight and length were recorded as the cooking loss, and thermal shortening of meat, respectively.

Thus:

$$\text{Cooking loss} = \frac{\text{Initial meat weight} - \text{Final meat weight}}{\text{Initial meat weight}}$$

$$\text{Thermal shortening} = \frac{\text{Initial meat length} - \text{Final meat length}}{\text{Initial meat length}} \times 100$$

3.6.8.4 Cooking yield of meat

Cooking yield of meat samples were determined according to the method of Okubanjo (1997). The percentage of the last weight of cooked meat and first weight of raw meat was determined as shown below.

$$\text{Cooking loss} = \frac{\text{Weight of cooked meat sample}}{\text{Weight of raw meat sample}} \times 100$$

3.6.9 Proximate Composition

Experimental diet and faecal samples collected during the digestibility trial were analyzed using the method of AOAC (2000). The parameters determined include: dry matter, crude protein, crude fibre, ash, nitrogen free extract and ether extract. The proximate composition of meat samples from the hind limb were determined for moisture, crude protein and ether extract.

3.6.10 Data analysis

Data obtained obtainedfrom both experiments were subjected to one-way analysis of variance using SPSS (2009). Where significant differences exist, means were separated by Duncan multiple range test ($p< 0.05$).

3.7 Data Collection for Experiment 2 (Progenies)

All the experiment, data collection and results analysis were carried out as done in experiment one (1).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results

4.1.1 Experiment 1 (Parent Rabbits)

4.1.2 Proximate composition of the experimental diet

The chemical content of the experimental diet on dry matter basis is shown in Table 4.1. The diet contained 93.20% dry matter, 20.50% crude protein, 4.00% crude fibre, 9.70% ether extract, 6.80% ash and 52.20% nitrogen free extract.

4.1.3 Week one haematology of rabbits administered probiotics

Presented in Table 4.2 are the results of haematological parameters at week one of the parent rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae*). The results revealed non-significant ($p>0.05$) effect on red blood cells count, haemoglobin concentration, mean corpuscular volume, mean corpuscular haemoglobin, and mean corpuscular haemoglobin concentration among the treated groups of rabbits. However, significant (<0.05) difference was observed in the white blood cells count and packed cells volume among the treated groups. The results of WBCs were statistically similar on T_3 (4.90%) and T_4 (5.20%). The highest value for the WBC was observed on T_5 (10.80%) and the least WBC was observed on T_2(3.25%). The result of the PCV on T_1 (31.00%), T_3 (30.50%) and T_4 (29.50%) were statistically similar. The highest value for PCV was observed on T_2 (42.00 %) while the least value was in T_4 (29.50 %).

Table 4.1 Proximate composition of the experimental diet (% dry matter), a pelletized grower mash (Vital® feeds)

Parameter	Composition (%)
Dry matter	93.20
Crude protein	20.50
Crude fiber	4.00
Ether extract	9.70
Ash	6.80
Nitrogen free extract	52.20

Table 4.2: Week one haematology of parent rabbits administered probiotics

Parameter	T1	T2	T3	T4	T5	SEM	P-VALUE
RBC ($x10^{12}$/l)	3.90	4.70	3.70	4.45	4.45	0.16	0.19
WBC ($x10^{9}$/l)	4.55^{b}	3.25^{b}	4.90^{ab}	5.20^{ab}	6.80^{a}	0.90	0.03
PCV (%)	31.00^{b}	42.00^{a}	30.50^{b}	29.50^{b}	36.00^{ab}	1.64	0.01
Hb (g/dl)	10.50	13.60	9.80	9.90	10.25	1.02	0.37
MCV (fl)	80.15	104.59	46.38	66.56	82.19	9.24	0.43
MCH (pg)	27.10	28.90	26.49	22.35	26.53	1.02	0.41
MCHC (%)	34.23	32.34	32.22	33.55	32.42	0.39	0.46

a,b:
Mean denoted by different superscript are significantly different ($P< 0.05$)

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S.cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S.* boulardii and 0.6 g/kg (6 x 10^8 cfu/ml) of *S.cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean, RBCs = Red Blood Cells,WBCs = White Blood Cells, PCV = Packed Cells Volume, Hb = Haemoglobin, MCV = Mean Corpuscular Volume, MCH = Mean Corpuscular Haemoglobin, MCHC = Mean Corpuscular Haemoglobin Concentration.

4.1.4 Week one serum biochemical properties of rabbits administered probiotics

The serum biochemical values of rabbit administered probiotics (*Saccharomyces boulardii* and *Sacchaaromyces cerevisiae*) are shown on Table 4.3. The results revealed no significant ($p>0.05$) differences in potassium among the treated groups. However, significant ($P<0.05$) differences were observed in total protein, albumin, sodium and chlorine among the treatment groups. The result of albumin was statistically similar in T_1 (3.40), T_2 (3.60), T_3 (3.40) and T_4 (3.80). The least value for albumin was observed in T_5 (2.30) and the highest in T_4 (3.80). The results further revealed that sodium was significantly ($P<0.05$) higher in the control group T_1 (142.00) and least in T_2 (120.00) but statistically similar to T_3 (137.00), T_4 (140.00) and T_5 (137.00).

4.1.5 Growth performance of rabbit administered probiotics

The growth performance of rabbit administered probiotics (*Saccharomyces bourladii* and *Saccharomyces cerevisiae)* is shown in Table 4.4. The result revealed non-significant ($P<0.05$) differences among all the treatment groups.

4.1.6 Apparent nutrient digestibility of rabbits administered probiotics

Table 4.5 shows the results of the apparent nutrient digestibility of rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiea*). The results revealed non-significant differences ($p>0.05$) in the digestibility of dry matter crude fibre, crude protein, either extract, ash and nitrogen free extract.

Table 4.3: Week one serum biochemical properties of parent rabbits administered probiotics

Parameter	T1	T2	T3	T4	T5	SEM	P-VALUE
Total protein (g/dL)	6.60^{ab}	6.90^{a}	6.50^{ab}	7.00^{a}	5.80^{b}	0.15	0.03
Albumin (g/dL)	3.40^{a}	3.60^{a}	3.40^{a}	3.80^{a}	2.30^{b}	0.18	0.01
Sodium (mmol/l)	142.00^{a}	120.00^{b}	137.00^{a}	140.00^{a}	137.00^{a}	2.69	0.01
Potassium (mmol/l)	4.90	4.05	3.90	4.00	3.85	0.16	0.15
Chloride (mmol/l)	103.50^{a}	91.50^{b}	99.00^{ab}	100.00^{ab}	97.00^{ab}	1.43	0.03

a,b:
Mean denoted by different superscript are significantly different (P< 0.05)

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S.* boulardii and 0.4 g/kg (4 x 10^8cfu/ml) of *S. cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S.* boulardii and 0.6 g/kg (6 x 10^8 cfu/ml) of *S.cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

Table 4.4: Growth performance of parent rabbits administered probiotics

Parameter (g)	T1	T2	T3	T4	T5	SEM	P-VALUE
Initial body weight	877.77	944.44	912.71	899.67	861.11	55.58	0.52
Final body weight	1832.6	1744.3	1761.11	1744	1786.7	32.38	0.93
Total body weight gain	954.90	799.90	839.10	844.33	941.77	34.38	0.59
Total feed intake	11246.66	10646.33	11203.67	10870.33	11206.66	0.13	0.23
Av. daily feed intake	200.77	190.03	200.03	194.53	200.08	1.71	0.19
Av. daily bdwt gain	17.04	14.28	14.98	15.07	16.81	0.61	0.59
FCR	12.05	13.47	13.93	12.95	11.92	0.21	0.71

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S.cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S, cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean, FCR = Feed Conversion Ratio.

Table 4.5: Apparent nutrient digestibility of parent rabbits administered Probiotics

Parameter (%)	T1	T2	T3	T4	T5	SEM	P-VALUE
Dry matter	86.17	83.59	84,45	84.53	85.15	0.58	0.65
Crude protein	81.83	77.98	78.23	79.76	80.65	0.84	0.61
Crude fibre	77.17	69.42	70.39	71.96	72.65	1.14	0.24
Ether extract	81.90	78.66	77.11	80.46	80.53	0.73	0.28
Ash	71.70	65.07	66.06	62.51	64.35	1.66	0.52
NFE	90.86	91.08	91.41	91.69	91.73	0.49	0.98

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii an*d 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and0.4 g/kg (4 x 10^8cfu/ml) of *S,cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S.cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard error of mean

NFE = Nitrogen free extract

4.1.7 Week eight haematology of rabbits administered probiotics

The results of the final haematological parameters of rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiea*) is shown in the Table 4.6. The results showed no significant (P>0.05) difference in red blood cells count, packed cell volume, haemoglobin, mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration of the rabbits'blood among all the treated groups. However, significant (P<0.05) differences were observed in the white blood cells count. The result of WBC in T_1 (5.00), T_3 (5.30) and T_4 (5.00) were statistically similar.

4.1.8 Week eight serum biochemical properties of rabbit administered probiotics

Presented in Table 4.7 are the results of the serum biochemical properties of rabbits Administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiea*). The results revealed no significant (P>0.05) difference in the total protein, albumin, sodium, potassium and chloride.

4.1.9 Characteristics of carcass cut-up parts of rabbits administered probiotics

Presented in Table 4.8 are the results of the carcass cut-up parts of rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiea).* The result revealed no significant (P>0.05) effect of treatment on live weight, carcass weight, slaughter weight, carcass cut up parts expressed in percentages of live-weight. Similarly, the result further revealed non-significant (p>0.05) effect on all the other parameters of the carcass cut up parts examined in the study.

Table 4.6: Week eight haematology of parent rabbits administered probiotics

Parameters	T1	T2	T3	T4	T5	SEM	P-VALUE
RBC ($x10^{12}$/L)	4.50	4.85	4.95	4.70	4.95	0.32	0.45
WBC ($x10^{9}$/L)	5.00^{ab}	4.00^{b}	5.30^{ab}	5.00^{ab}	8.55^{a}	0.12	0.03
PCV (%)	27.75	39.50	33.50	36.00	40.00	0.93	0.28
Hb (g/dL)	11.40	13.95	11.55	11.05	13.05	0.84	0.06
MCV(fl)	74.96	81.44	79.43	76.81	78.32	1.62	0.73
MCH (pg)	25.47	28.78	23.49	38.49	26.37	1.21	0.58
MCHC (%)	34.07	45.34	34.42	31.25	37.94	2.87	0.56

a,b:
Mean denoted by different superscript are significantly different ($P< 0.05$)

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardi* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and0.4 g/kg (4 x 10^8cfu/ml) of *S. cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S. cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean, RBCs = Red Blood Cells,WBCs = White Blood Cells, PCV = Packed Cells Volume, Hb = Haemoglobin, MCV = Mean Corpuscular Volume, MCH = Mean Corpuscular Haemoglobin, MCHC = Mean Corpuscular Haemoglobin Concentration.

.

Table 4.7: Week eight serum biochemical properties of parent rabbits administered probiotics

Parameter	T1	T2	T3	T4	T5	SEM	P-VALUE
Total protein (g/dL)	6.35	6.95	6.45	6.90	6.00	0.73	0.48
Albumin (g/dL)	3.50	3.75	3.70	4.00	3.50	0.33	0.54
Sodium (mmol/l)	143.50	127.50	139.00	141.00	137.50	13.18	0.13
Potassium (mmol/l)	4.75	3.90	3.95	3.95	4.50	0.21	0.39
Chloride (mmol/l)	103.00	96.10	98.53	101.50	98..50	8.29	0.37

T_1 = No probiotic (*Saccharomyces boulardii*and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S.cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S. cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii and* 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard rror of ean

Table 4.8: Characteristics of carcass cut-up parts of parent rabbits administered probiotics

Parameters	T1	T2	T3	T4	T5	SEM	P-VALUE
Liveweight (g)	1806.67	1750.34	1783.33	1759.67	1810.12	29.68	0.97
Slaughter weight (g)	1748.33	1690.42	1723.33	1723.33	1773.33	34.56	0.97
Carcass length (cm)	32.00	29.67	32.21	31.67	31.33	0.53	0.68
Eviscerated wt. (g)	895.83	910.34	893.33	930.21	916.67	20.99	0.99
Dressing (%)	49.38	51.06	49.46	51.76	50.66	0.51	0.57
Head (%)	16.49	15.68	16.46	15.39	15.51	0.26	0.56
Neck (%)	4.04	3.82	5.06	4.23	4.32	0.18	0.26
Pelts (%)	18.09	16.83	17.18	16.04	16.92	0.31	0.37
Fore limb (%)	10.74	8.73	9.98	9.78	9.44	0.27	0.18
Hind leg (%)	16.56	14.37	15.56	12.37	14.86	0.55	0.14
Rib (%)	4.33	5.28	5.35	4.82	5.27	0.17	0.24
Loin (%)	11.05	9.45	10.46	9.82	10.68	0.28	0.38

T_1 = No probiotic (*Saccharomyces boulardi* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S.cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S.cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii and* 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

4.1.10 Characteristics of visceral organs of parent rabbits administered probiotics

Presented in Table 4.9 are the results of the viscera organs characteristics of rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiea)*. The results revealed no significant (P>0.05) differences in abdominal fat, kidney, heart, liver, lungs, spleen, intestinal weght and intestinal length.

4.1.11 Proximate composition of meat from parent rabbits administered probiotics

The results of the proximate composition of meat from rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae*) are shown in Table 4.10. The result revealed that different concentration of the probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisae*) administered to the rabbits did not significantly (P>0.05) affect the moisture content, crude protein, ether extract, crude fibre,ash and nitrogen free extract of the rabbit's meat.

4.1.12 Meat quality characteristics from parent rabbit administered probiotics

Table 4.11 shows the results of the meat quality characteristics of meat obtained from rabbits administered probiotics (*Saccharomyces boulardii and Saccharomyces. cerevisiea)*. The result revealed that the pH, cooking yield, cooking loss and water holding capacity of rabbit's meat were not significantly (p>0.05) affected by the concentrations of probiotics (*S. boulardii* and *S. cerevisiae*) given. However, thermal shortening of rabbit meat was significantly (p>0.05) affected with higher values in T_1 (8.71 %) and the least value was obtained in T_3 (1.73%).

Table 4.9: Characteristics of visceral organs from parent rabbits administered probiotics

Parameter (%)	T1	T2	T3	T4	T5	SEM	P-VALUE
Abdominal fat	1.18	0.79	1.16	0.88	1.03	0.07	0.33
Kidney	0.51	0.59	0.63	0.49	0.54	0.02	0.21
Heart	0.16	0.18	0.21	0.20	0.18	0.01	0.37
Liver	2.51	2.61	2.79	2.49	2.65	0.11	0.92
Lungs	0.73	0.64	0.83	0.82	0.89	0.04	0.46
Spleen	0.06	0.06	0.06	0.06	0.06	0.00	0.62
Intestinal weight (g)	5.22	5.65	5.30	5.22	5.52	0.08	0.39
Intestinal length (cm)	425.00	364.00	433.00	440.00	438.00	1.96	0.10

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S.cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S.cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

Table 4.10: Proximate composition of meat from parent rabbits administered probiotics

Parameters	T1	T2	T3	T4	T5	SEM	P-VALUE
Moisture content	67.43	67.62	65.72	66.65	67.19	0.48	0.83
Crude Protein	28.80	27.90	29.94	28.51	29.08	0.55	0.90
Crude Fibre	1.03	1.06	1.37	1.09	1.19	0.05	0.22
Ash	1.7	1.72	2.67	11.76	2.14	1.99	0.51
Ether Extract	6.41	6.61	9.27	8.64	8.94	0.47	0.10
NFE	29.5	31.41	23.15	26.74	26.43	1.28	0.34

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S.cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii and* 0.6 g/kg (6 x 10^8 cfu/ml) of *S.cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Errow of the Mean

NFE = Nitrogen Free Extract

Table 4.11: Meat quality characteristics of meat obtained from parent rabbits administered probiotics

TREATMENT (%)	T1	T2	T3	T4	T5	SEM	P-VALUE
PH	6.74	6.67	6.74	6.72	6.69	0.02	0.62
Thermal shortening	8.71^{c}	2.13^{ab}	1.73^{b}	2.67^{a}	2.58^{a}	1.86	0.03
Cooking yield	70.7	72.97	72.08	73.65	73.91	0.70	0.66
Cooking loss	29.30	27.24	27.92	26.35	25.97	0.72	0.67
WHC	26.42	26.32	25.27	23.74	23.58	0.51	0.22

a,b,c:
Mean denoted by different superscript are significantly different ($P< 0.05$)

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S.cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S. cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii and* 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

WHC = Water Holding Capacity

4.1.13 Reproductive performance of rabbits (doe traits) administered probotics

Presented in Table 4.12 are the results of the reproductive performance of rabbit does administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae)*. The results revealed no significant ($p>0.05$) differences among all the treatment groups.

4.1.14 Reproductive performance of rabbits (birth and weaning traits) administered probiotics

Presented in Table 4.13 are the results of the reproductive performance of rabbit given probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae*).The results revealed no significant ($p>0.05$) differences among all the treatment groups for all the traits; litter weight at birth was significantly ($p<0.05$) influenced with heavier weights (39.04) observed for kittens kindled by rabbits in treatment 4 (40 x 10^6 cfu/ml of *S.boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S.cerevisiea*)

Table 4.12: Reproductive performance of rabbit does administered probotics

Parameters	T1	T2	T3	T4	T5	SEM	P-VALUE
Weight at mating(g)	1845.00	1790.50	1750.00	1800.00	1770.00	22.58	0.83
Conception Rate (%)	83.33	50.06	100.00	83.33	83.33	7.37	0.33
Gestation length (Day)	31.50	32.00	31.00	31.50	32.50	0.17	0.56
Weight Before kindling (g)	2090.51	1918.03	1920.32	1890.45	1904.51	38.83	0.56
Weight at kindling (g)	1738.23	1704.60	1667.50	1607.50	1672.50	30.06	0.82
Kindling loss (g)	352.52	214.02	252.50	482.55	172.31	24.01	0.11

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S.boulardii* and 0.4g/kg (4 x s10^8cfu/ml) of *S.cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S.boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S.cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

Table 4.13: Reproductive performance of rabbit (birth and weaning traits) administered probiotics

Treatment	T1	T2	T3	T4	T5	SEM	P - VALUE
Litter size at birth	10.50	6.50	6.50	7.00	4.50	0.88	0.33
Litter weight at birth (g)	32.95	27.01	33.13	39.04	32.25	38.95	0.00
Litter size at weaning	6.00	4.00	3.50	4.50	3.50	0.40	0.24
Liter weight at weaning (g)	300.98	326.40	314.25	309.17	323.25	7.45	0.89
Litter weight gain (g)	268.35	299.39	290.33	270.14	287.79	7.11	0.69
Mortality rate (%)	41.83	34.72	45.24	35.42	16.67	4.77	0.44
Survival rate (%)	51.17	65.28	54.76	64.58	83.33	6.74	0.67
Milking capacity	0.13	0.22	0.13	0.15	0.19	0.29	0.89
Weaning sex ratio	1.13	0.50	1.17	0.28	0.50	0.18	0.89

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii and* 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S.cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii and* 0.6 g/kg (6 x 10^8 cfu/ml) of *S. cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

4.1.15 Testicular and morphometric characteristics of parent rabbits administered probiotics

The results of testicular and morphometric characteristics of rabbits administered probiotics (*Saccharomyces boulardii and Saccharomyces cerevisiae)* are shown in Table 4.14. The result reveled no significant (P>0.05) differences on weight of the rabbit, weight of the testes, circumference of the testes, diameter of the testes as well as volume of the testes. The results further shows that weight of the rabbit, weight of the testes, circumference of the testes, diameter of the testes and volume of the testes had a similar trend with highest values in T_3 (1925.00g, 3.50g, 20.00, 6.36 and 46.93) respectively. The least value for weight of the testes was observed inT_4 (2.50g), circumference of the testes in T_2 (17.00), diameter of the testes in T_2 (5.41) and volume of the testes in T_4 (22.72) respectively.

Table 4.14: Testicular and morphometrics characteristics of parent rabbit administered probiotics

TREATMENT	T1	T2	T3	T4	T5	SEM	P-VALUE
Weight of rabbit (g)	1866.00	1865.00	1925.00	1745.00	1835.00	31.71	0.47
Weight of testes (g)	2.60	2.65	3.50	2.50	2.55	0.22	0.33
Circumference of testes	19.00	17.00	20.00	19.00	18.50	0.42	0.26
Diameter of testes	6.05	5.41	6.36	6.05	5.89	0.13	0.26
Volume of testes	45.34	23.15	46.93	22.72	23.50	5.19	0.29

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii and* 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S.cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii and* 0.6 g/kg (6 x 10^8 cfu/ml) of *S cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

4.2 Experiment 2 (Rabbit Progenies)

4.2.1 Proximate composition of the experimental diet

The chemical content of the experimental diet on dry matter basis is shown in Table 4.15. The diet contained 93.20% dry matter, 20.50% crude protein, 4.00% crude fibre, 9.70% ether extract, 6.80% ash and 52.20% nitrogen free extract. Same as experiment 1.

4.2.2 Haematology of rabbit's progenies administered probiotics at week one

The results of the haematology of the progenies of rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae*) at week one is shown in Table 4.16. The results show no significant ($p<0.05$) differences among all the treated parameters.

4.2.3 Serum biochemical properties of rabbits' progenies administered probiotics at week one

The results of serum biochemical properties of rabbit progenies administered probiotics at week one is shown in Table 4.17. The results revealed that probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae*) administered on rabbits' progenies had no significant ($P>0.05$) effect among the treated groups.

Table 4.15 Proximate composition of the experimental diet (% dry matter), a pelletized grower mash (Vital® feeds)

Parameter	Composition (%)
Dry matter	93.20
Crude protein	20.50
Crude fibre	4.00
Ether extract	9.70
Ash	6.80
Nitrogen free extract	52.20

Table 4.16: Haematology of rabbits'progenies administered probiotics at week one

Parameter	T1	T2	T3	T4	T5	SEM	P-VALUE
RBC ($x10^{12}$/L)	4.83	5.06	5.13	5.10	5.03	0.13	0.97
WBC ($x10^{9}$/dL)	4.73	4.73	4.7	4.97	5.20	0.14	0.85
PCV (%)	35.67	37.67	39.00	40.33	38.33	0.58	0.08
Hb (g/dL)	11.30	11.90	12.33	12.20	12.13	0.19	0.50
MCV (fl)	71.74	74.91	76.32	76.36	76.78	1.92	0.95
MCH (pg)	23.37	23.04	24.20	24.13	24.47	0.68	0.98
MCHC (%)	32.66	31.64	31.68	30.25	31.78	0.64	0.82

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S.cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S. cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean, RBCs = Red Blood Cells,WBCs = White Blood Cells, PCV = Packed Cells Volume, Hb = Haemoglobin, MCV = Mean Corpuscular Volume, MCH = Mean Corpuscular Haemoglobin, MCHC = Mean Corpuscular Haemoglobin Concentration.

Table 4.17 Serum biochemical properties of rabbits' progenies administered probiotics at week one

Parameters	T1	T2	T3	T4	T5	SEM	P-VALUE
Total protein (g/dL)	6.17	6.40	7.03	6.73	6.80	0.11	0.09
Albumin (g/dL)	3.56	4.03	4.23	3.90	3.93	0.12	0.55
Sodium (mmol/l)	105.33	100.00	101.00	98.33	93.33	2.66	0.77
Potassium (mmol/l)	4.90	4.43	4.83	4.53	5.27	0.17	0.47
Chloride (mmol/l)	98.57	95.43	99.42	98.75	99.20	0.88	0.67

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S. cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S. cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

4.2.4 Growth performance of rabbit progenies administered probiotics

Table 4.18 revealed the results of the growth performance of rabbit progenies administered probiotics **(***Saccharomyces boulardii* and *Saccharomyces cerevisiae***).** The results showed no significant (P>0.05) difference among all the treated groups.

4.2.5 Apparent nutrients digestibility of rabbits' progenies administered probiotics

Presented in Table 4.19 is the result of the apparent nutrients digestibility of the progenies of rabbits administered probiotics **(***Saccharomyces boulardii* and *Saccharomyces cerevisiae***).** The results revealed no significant (P>0.05) differences in the digestibility of dry matter, crude protein, crude fibre, ether extract, ash and nitrogen free extract.

4.2.6 Haematology of rabbits' progenies administered probiotics at week eight

Table 4:20 shows the result of haematology of rabbits'progenies administered probiotics **(***Saccharomyces boulardii* and *Saccharomyces cerevisiae***)** at week eight. The results revealed no significant (P>0.05) difference in all the haematological parameters.

Table 4.18: Growth performance of rabbits' progenies administered probiotics

Parameter (g)	T1	T2	T3	T4	T5	SEM	P-VALUE
Initial body weight (g)	683.33	650.00	695.00	683.33	699.67	9.63	0.57
Final body weight (g)	1933.33	1766.67	2050.00	1923.3	1900.00	36.46	0.18
Total body wt. gain (g)	1250.00	1116.67	1354.00	1240.0	1232.20	30.49	0.16
Total feed intake (g)	12.03	12.19	12.19	12.33	11.77	0.12	0.73
Av. daily feed intake(g)	214.76	217.62	217.62	220.15	210.11	2.22	0.73
Av. daily BDWT gain (g)	22.32	19.94	24.17	22.14	21.43	0.54	0.16
FCR	9.67	10.98	8.99	9.97	9.82	0.24	0.94

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S. cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S. cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

FCR = Feed Conversion Ratio

AV = Average

BDWT =Body weight

Table 4.19: Apparent nutrients digestibility of rabbits' progenies administered probiotics

Treatment (%)	T1	T2	T3	T4	T5	SEM	P-VALUE
Dry Matter	85.83	85.13	82.49	86.27	85.27	0.61	0.35
Crude Protein	82.31	82.21	77.40	80.97	79.34	0.77	0.24
Crude Fibre	83.17	71.09	70.40	74.87	75.34	1.85	0.18
Ether Extract	80.34	79.52	75.74	80.73	78.74	0.82	0.35
Ash	70.30	65.84	64.75	68.95	68.31	1.12	0.57
NFE	92.97	91.02	90.86	91.69	91.29	0.39	0.49

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*,

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S.cerevisiea*,

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S. cerevisiea*,

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*),

SEM = Standard Error of Mean,

NFE = Nitrogen Free Extract

Table 4.20: Haematology of rabbits' progenies administered probiotics

Parameters	T1	T2	T3	T4	T5	SEM	P-VALUE
RBC ($x10^{12}$/L)	5.07	5.10	5.45	5.60	5.43	0.10	0.39
WBC ($x10^{9}$/L)	4.83	4.70	4.80	4.97	4.43	0.12	0.77
PCV (%)	35.92	36.00	36.00	36.25	35.67	0.44	0.99
Hb (g/dL)	11.17	11.07	11.27	11.48	10.97	0.12	0.76
MCV (fl)	70.91	69.51	66.01	64.73	66.07	1.25	0.53
MCH (pg)	21.70	21.74	20.65	20.58	20.33	0.38	0.72
MCHC (%)	31.10	31.32	31.30	31.82	30.79	0.39	0.97

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S. cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S. cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean, RBCs = Red Blood Cells,WBCs = White Blood Cells, PCV = Packed Cells Volume, Hb = Haemoglobin, MCV = Mean Corpuscular Volume, MCH = Mean Corpuscular Haemoglobin, MCHC = Mean Corpuscular Haemoglobin Concentration.

4.2.7 Serum biochemical properties of rabbits'progenies administered probiotics at week eight

Table 4.21 shows the results of the serum biochemical properties of the progenies of rabbits administered probiotics **(***Saccharomyces boulardii* and *Saccharomyces cerevisiae*) at week eight. The result revealed no significant (P>0.05) difference in all the parameters (total protein, albumin, sodium, potassium and chloride).

4.2.8 Characteristics of carcass cut-up parts of rabbits' progenies administered probiotics

Presented in Table 4.22 are the results of the carcass cut-up parts of rabbits' progenies administered probiotics **(***Saccharomyces boulardii* and *Saccharomyces cerevisiae*). The results showed no significant (p>0.05) difference in the liveweight, slaughtered weight, carcass length, eviscerated weight and dressing percentage of carcass. Furthermore, the result of carcass revealed no significant (p>0.05) difference in the head, neck, pelts, shoulder, rib and loin. However, significant (p<0.05) differences were observed in the result of the hind leg between rabbits in the treatment groups. The result of hind leg was higher in T_5 (7.97 %) but statistically similar with T_1 (7.66 %) and T_2 (7.66 %).

4.2.9 Characteristics of visceral organs of rabbits' progenies administered probiotics.

The characteristics of visceral organs of rabbits' progenies administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae*) is shown in Table 4.23. The results showed no significant (P>0.05) differences among all the parameters.

Table 4.21: Serum biochemical properties of rabbit progenies administered probiotics at week eight

Parameters	T1	T2	T3	T4	T5	SEM	P-VALUE
Total protein (g/dL)	6.27	6.63	6.87	6.63	6.10	0.98	0.65
Albumin (g/dL)	3.50	3.87	3.50	3.37	3.90	0.11	0.46
Sodium (mmol/L)	82.00	102.83	101.33	105.33	109.67	6.80	0.80
Potassium (mmol/L)	4.50	4.50	4.77	4.60	5.33	0.16	0.45
Chloride (mmol/L)	101.75	96.83	101.37	99.00	100.33	0.97	0.55

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S.cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S.cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

Table 4.22: Characteristics of carcass cut-up parts of rabbit progenies administered probioticss

TREATMENT	T1	T2	T3	T4	T5	SEM	PVALUE
Live weight (g)	1960.00	1733.33	1966.66	1846.66	1800.00	47.83	0.52
Slaugter weight. (g)	1873.33	1663.33	1873.33	1780.00	1716.66	50.42	0.66
Carcass length (cm)	32.07	32.33	41.17	33.50	33.33	1.59	0.33
Eviscerated weight (g)	973.33	868.33	1013.33	973.33	878.33	31.12	0.55
Dressing percentage (%)	51.49	49.33	51.03	52.03	48.55	0.54	0.19
Head (%)	7.33	8.24	7.52	7.35	8.37	0.19	0.19
Neck (%)	2.05	1.99	2.05	2.14	2.18	0.09	0.97
Pelts (%)	8.02	9.45	9.25	9.09	9.07	0.13	0.53
Fore limb (%)	5.02	4.78	4.77	4.96	5.19	0.08	0.48
Hind leg (%)	7.66^{a}	7.66^{a}	7.56^{ab}	6.09^{b}	7.97^{a}	0.22	0.01
Rib (%)	2.19	2.71	2.46	2.84	2.76	0.12	0.48
Loin (%)	5.44	5.15	4.72	4.75	5.19	0.14	0.49

a,b:
Mean denoted by different superscript are significantly different (P< 0.05)

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii and* 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S. cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S. cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

Table 4.23: Characteristics of visceral organs of rabbit progenies administered probiotics

Parameter (%)	T1	T2	T3	T4	T5	SEM	P-VALUE
Abdominal fat	1.07	0.91	1.07	0.77	1.07	0.05	0.39
Kidney	0.42	0.63	0.55	0.53	0.62	0.03	0.16
Heart	0.14	0.19	0.19	0.21	0.17	0.01	0.33
Liver	2.47	2.67	2.46	2.79	2.75	0.09	0.75
Lungs	0.62	0.68	0.83	0.99	0.86	0.05	0.12
Spleen	0.05	0.06	0.05	0.05	0.06	0.00	0.53
Intestinal weight (g)	5.34	6.28	5.33	5.31	5.72	0.15	0.16
Intestinal length (cm)	420.33	439.67	434.33	440.00	441.67	3.15	0.18

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S.cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S.cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

4.2.10 Proximate composition of the meat from rabbits' progenies administered probiotics

Table 4:24 reveals the results of the proximate composition of the meat of the progeny of rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae*). The results revealed that different concentration of probiotics administered on the progenies of rabbits did not significantly ($P>0.05$) affect the moisture content, crude protein, crude fibre, ash and nitrogen free extract contents of the meat. However, the ether extract of the rabbit meat was significantly ($P<0.05$) affected by the different concentration of the probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae*).

4.2.11 Meat quality characteristics of the meat from rabbits' progenies administered probiotics

The results of the meat quality characteristics of the meat of rabbits' progenies are presented in Table 4.25. The results revealed that the cooking yield, cooking loss and water holding capacity were not significantly ($p>0.05$) affected by the various administration of the probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae*). The results however showed that the pH and thermal shortening were significantly ($p<0.05$) influenced by the different administration of the probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae*). The results showed that thermal shortening had the highest value in T_4 (26.30 %) and the least on T_1 (7.36 %). The result of thermal shortening also shows that T_2 (20.14 %), T_3 (16.80 %) and T_5 (20.00 %) are statistically similar ($p>0.05$).

Table 4.24: Proximate composition of the meat from rabbit progenies administered probiotics

Parameters	T1	T2	T3	T4	T5	SEM	P-VALUE
Moisture content	68.05	67.71	66.02	65.98	66.87	0.37	0.28
Crude Protein	29.36	28.56	28.54	28.62	29.32	0.22	0.66
Crude Fibre	0.67	0.82	0.74	0.68	0.98	0.13	0.96
Ash	1.59	1.61	1.99	2.10	1.54	0.17	0.83
Ether Extract	6.20^{ab}	5.92^{b}	8.09^{a}	8.08^{a}	7.59^{ab}	0.30	0.02
NFE	30.22	30.78	26.97	27.02	27.43	0.55	0.12

sa,b:
Mean denoted by different superscript are significantly different ($P < 0.05$)

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S.cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S.cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

NFE = Nitrogen Free Extract

Table 4.25: Quality characteristics of meat from rabbits' progenies administered probiotics

Parameter (%)	T1	T2	T3	T4	T5	SEM	P-VALUE
pH	6.78^{a}	6.65^{b}	6.76^{a}	6.71^{ab}	6.69^{ab}	0.01	0.01
Thermal shortening	7.36^{c}	20.14^{b}	16.82^{b}	26.30^{a}	20.00^{b}	1.68	0.00
Cooking yield	71.40	73.46	72.19	73.25	71.59	1.80	0.45
Cooking loss	28.59	26.54	27.81	26.42	27.74	0.67	0.87
WHC	25.14	24.93	22.18	23.54	23.73	0.49	0.35

a,b,c:
Mean denoted by different superscript are significantly different ($P< 0.05$)

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S.cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S. cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

WHC = Water Holding Capacity

4.2.12 Reproductive performance of rabbits' progenies (doe traits) administered probotics

The results of the reproductive performance (doe traits) of rabbits' progenies administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae*) are shown in Table 4.26. The results revealed non-significant ($p>0.05$) difference among all the treatment groups.

4.2.13 Reproductive performance of rabbits' progenies (birth and weaning traits) administered probiotics

The results of the reproductive performance (birth and weaning traits) of rabbits'progenies administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae*) are presented in Table 4.27. The results revealed non-significant ($p>0.05$) difference among all the parameters in the treatment groups.

4.2.14 Testicular and morphometrics characteristics of rabbit progenies administered probiotics

Presented in Table 4:28 are the results of the testicular and morphometric characteristics of the progenies of rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomycescerevisiae*).The result showed no significant ($p>0.05$) differences in the weight of the rabbits, weight of the testes, circumference of testes, and the diameter of the testes. The results however, revealed significant ($P<0.05$) difference in the volume of the testes.

Table 4.26: Reproductive performance (doe traits) of rabbits of testes administered probotics

Parameters	T1	T2	T3	T4	T5	SEM	P-VALUE
Weight at mating (g)	1916.66	1826.67	1880.00	1950.00	1883.3	22.18	0.55
Conception Rate (%)	61.11	49.99	66.66	61.11	44.44	6.47	0.86
Gestation length (Day)	31.33	31.66	31.33	31.33	31 33	0.13	0.66
Weight B/4 kindling (g)	2174.67	1982.00	2031.66	2139.33	2008.3	28.43	0.10
Weight at kindling (g)	1891.66	1783.33	1840.00	1896.66	1843.3	22.18	0.54
Kindling loss (g)	258.58	147.30	218.27	189.64	190.83	17.01	0.55

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S. cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S.cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

Table 4.27: Reproductive performance (birth and weaning traits) of rabbits progenies administered probotics

Parameters	T1	T2	T3	T4	T5	SEM	P - VALUE
Litter size at birth (g)	7.66	5.00	6.00	5.00	6.00	0.51	0.51
Litter weight at birth (g)	33.10	29.37	36.05	37.29	33.32	1.05	0.12
Litter size at weaning	4.65	3.33	34.33	3.67	3.67	0.33	0.76
Liter weight at weaning (g)	302.66	356.00	324.66	327.66	336.33	9.59	0.57
Litter weight gain (g)	269.57	326.62	288.29	290.38	303.01	9.95	0.52
Mortality rate (%)	37.95	31.94	28.97	18.89	37.30	3.59	0.50
Survival rate (%)	62.07	68.06	71.03	81.11	62.70	3.59	0.50
Milking capacity	0.12	0.18	0.19	0.18	0.15	0.01	0.20
Weaning sex ratio	1.13	0.50	1.17	0.28	0.50	0.18	0.89

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S. cerevisiea*

T_4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S.cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of Mean

Table 4.28: Testicular and morphometric characteristics of rabbit progenies administered probiotics.

TREATMENT	T1	T2	T3	T4	T5	SEM	P-VALUE
Weight of rabbit (g)	1890.00	1776.66	1976.67	1896.66	1850.00	30.33	0.35
Weight of testes (g)	3.47	2.87	3.60	2.97	3.60	0.14	0.30
Circumference of testes	18.66	18.00	20.33	19.00	18.00	0.37	0.25
Diameter of testes	6.10	5.93	6.43	5.97	6.10	0.70	0.16
Volume of testes	43.33^{ab}	38.00^{b}	44.66^{a}	38.00^{b}	39.66^{ab}	0.89	0.02

a,b:
Mean denoted by different superscript are significantly different ($p< 0.05$)

T_1 = No probiotic (*Saccharomyces boulardii* and *Saccharomyces cerevisea)*

T_2 = 1ml of 80 x 10^6 cfu/ml of *S. boulardii* and 0.2 g/kg (2 x 10^8 cfu/ml) of *S. cerevisiea*

T_3 = 1ml of 60 x 10^6 cfu/ml of *S. boulardii* and 0.4 g/kg (4 x 10^8cfu/ml) of *S. cerevisiea*

T4 = 1ml of 40 x 10^6 cfu/ml of *S. boulardii* and 0.6 g/kg (6 x 10^8 cfu/ml) of *S. cerevisiea*

T_5 = 1ml of 20 x 10^6cfu/ml of *S. boulardii* and 0.8 g/kg (8 x 10^8cfu/ml) of *S. cerevisiea*

SEM = Standard Error of the Mean

4.3 DISCUSSION

4.3.1 Proximate composition of the experimental diet for rabbits

The chemical component of the pelleted feed used in feeding the rabbits (parent and progenies) showed that the crude fibre and crude protein were within the values recommended by NRC (1977).

4.3.2 Haematological parameters of rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae)*

This result of the haematological parameters of parent rabbits showed non significant difference in all the haematological parameters with the exception of white blood cells count and packed cells volume at week 1, and at week 8 where it showed significant difference. This is in contrast with the results of Besseboua and Ayad (2021). The authors reported significanct difference in RBCs Hbs and MCV in rabbits fed diets containing *Saccharomyces.* The non-significant difference in the haematological parameters (RBC, WBC, PCV, MCV, Hb, MCH and MCHC) among the progenies of rabbit supplemented with *Saccharomyces* in the diet is in agreement with the result of Belhassan *et al*. (2016). The authors revealed non significant variations in haematological parameters of rabbits fed diets containing probiotics in the treatment groups, although they noted a slight rise in haemoglobin concentration. The significant results observed in the WBC and PCV of the rabbits supplemented with diet containing *Saccharomyces* is in contrast with the results of Seyidoglu *et al.* (2014), and Belhassan *et al*. (2016) who revealed no significant differences in haematological parameters among treated groups. In another investigation, Onifade *et al*. (1998), reported that Hb concentration MCV and MCH rose significantly (P>0.05) in rabbits supplemented with diets containing *Saccharomyces* and also that, a relationship exist between dietary levels

of *Saccharomyces* and haematological parameters considering that it could be a promoter of supplemental yeast in rabbits. This result show that *Saccharomyces* does not affect animal health. The significanct difference observed in WBC and PCV may be indicative of physiological or pathological conditions which may have been because of age of the rabbits, sex, nutrition, environment, and stress More research is needed to ascertain the appropriate immune modulation effect of *Saccharomyces* in rabbits.

4.3.3 Serum biochemical parameters of rabbit administerd probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae)*

The results of serum biochemical properties of the rabbit parent at week 1 showed that total protein, albumin, sodium and chloride were significantly different. This agrees with the results of Amber *et al*. (2014) who reported that serum total protein, albumin and globulin were significantly different with supplementation of probiotics (BIO-MOS BIO-plus), or their mix in diets. This result contradicts the report of Beshara *et al.* (2018). The authors reported non-significant difference in total protein and albumin in rabbits fed diets containing probiotics early from 3 weeks of age. The serum biochemcial parameters of the parent group of rabbits (at week 8 and week 1) and week 8 serum biochemical parameters of the progeny groups did not show any significant differences. These results agree with the observation of El-Shafel *et al.*(2019) who reported no significant effect of probiotics (*Lactobacillus plantarum*) on total protein and globulins in New Zealand rabbits. The results of Mohamed *et al*. (2017) partially agrees with the current result as no significant effect was reported on globulin, while significant difference was observed in the total protein of growing rabbits fed with diets containing probiotics (*Lactobacilllus acidophilus*). Fathi *et al*. (2017) also reported a slight increase in total protein and globulin with the highest dose of probiotics (*Bacillus subtalis*) in rabbits fed supplemented diets. Beshara *et al*. (2018) also reported no

significant difference in total protein and globulin in treated groups. The variations observed in the outcomes could be related to the environment, optimal health status of the rabbits, different doses of the probiotics used, as wells as different mechanism of action of the probiotics. Simone and Gisella (2021) reported that probiotics modulate the host's defences, increase the immunity response or exercise a direct effect on microorganisms (for example, pathogens), thereby reducing the host requirement of immune defences.

4.3.4 Growth performance of rabbit administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae)*

According to the results of this study, the body weight gain of rabbits was not significantly affected by dietary supplementation of *Saccharomyces boulardii* (orally) and *Saccharomyces cerevisiea* in the diet of both the parent rabbits and their progenies. This has comfirmed the previous findings of Belhassen *et al*. (2016), which reported no significant difference in the growth performance of rabbits fed rations containing *Saccharomyces* supplementation. Also, Besseboua and Ayad (2021) reported no significant difference in body weight gain in Algerian rabbits fed diets containing *Saccharomyces cerevisiea.* In another study, Beshara *et al*. (2017), reported that feeding probiotics to rabbits at 3 - 8 weeks of age affect body weight gain. The authors reported an improvement in growth and feed utilisation following the usage of 2 % concentration of yeast in the diets. The divergent differences of these results may be due to the doses or kind of yeast used, basal diet, environmental conditions, or the mechanisms of growth promotion by yeast culture in rabbits.

4.3.5 Apparent nutrients digestibility of rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae)*

The non-significant ($p>0.05$) differences observed in this study in apparent nutrient digestibility in terms of dry matter, crude protein, crude fibre and nitrogen free extract among the groups agrees with the reports of of Beshara *et al.* (2018). The authors reported no significant difference in all the digestibility coefficients apart from ether extracts where rabbits fed diets containing probiotics had significantly lower digestibility of ether extract than those fed the control diet. Also, Oso *et al*. (2013) in their study reported that, apparent nutrient digestibility values were not affected by dietary inclusion of probiotics in growing rabbits' diet. Similarly, the effects of probiotics on digestibility have been investigated by many scientists. Luicke *et al*. (1992) and Gippert *et al*. (1992), found no effect of dietary supplementation with *Saccharomyces* on digestibility in rabbits. Karma *et al.* (1995) also, did not find any effect on the degradation and utilization of feed in rabbits following oral administration of *Saccharomyces*. In contrast, El-Gaafary *et al*. (1992) reported higher crude protein and crude fibre digestibility. Also, Amber *et al*. (2014), using probiotics (Bio-plus 2B, *Bacillus subtalis* and *Bacillus licheniformis)* supplemented in the diet of rabbits of 3 - 13 weeks of age showed significantly higher crude protein, crude fibre and nitrogen free extract digestibility due to improved absorption of nutrients.

4.3.6 Characteristics of carcass cut parts of rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae)*

Significant effect of *Saccharomyces* suplementation was observed in the hind leg among the parent groups. The result is in agreement with the results obtained by Metzger *et al*. (2023) who reported that the hind and fore part of carcass are closely related to the locomotor activity and so increase at the expenses of immediate parts in pen-housed and

cage-housed rabbits. Similarly, Dal Bosco *et al*. (2014) found an increase in the portion of the hind part. In the same vein, Beshara *et al*. (2018), reported no significant differences in the carcass traits of rabbits fed diets containing probiotics.

4.3.7 Characteristics of viscera organs of rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae)*

No significant difference were observed in the percentage weight of kidney, lungs, heart, liver, spleen, abdominal fat, intestine and intestinal length of both the parent and their progenies following suplementation with the probiotics. This result is in agreement with the results of Ibrahim *et al*. (2022) who reported no significant difference in the internal organs (liver, kidney, lungs, intestine heart and pancease) of rabbits fed diets containing *Saccharomyces cerevisiae*. In another study by Ombasilor and Yacin (2008), the authors also reported no difference in the weight of kindey, heart, lungs, and small intestine of New Zealand white rabbits fed 1g of probiotics (Bioteksin^{TM})/Kg diet.

4.3.8 Meat quality characteristics of rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae)*

The result of meat quality characteristics showed no significant difference in the cooking yield, cooking loss and water holding capacity of both the parent and progenies of rabbits fed diet containing *Saccharomyces.* This agrees with the reports of Pelicano *et al*. (2003). The authors reported no significant differences in the water holding capacity and cooking loss among different levels of probiotics tested in rabbits' diets. The result is however at variance with the reports of Shahzad *et al*. (2024). The authors reported significant difference in the cooking loss and water holding capacity of rabbits fed diet containing probiotics. The authors further reported that a higher water holding capacity suggest that probiotics may enhance the meat's ability to retain moisture, which can

improve its texture and tenderness, thus influencing its overall sensory qualities. The result also shows a significant difference in pH among the parent groups and the progenies and significant difference in thermal shortening only among the progeny groups. These results agree with the findings of Bonai *et al*. (2008). The authors in a study using a different probiotic (*Bacillus cereus vartoyon*) reported pH values of 6.3 - 6.8 for rabbit meat which falls within the pH values obtained in the current study. A lower pH is indicative of meat that is more prone to spoilage, while a higher pH can lead to better meat quality and storage properties.

4.3.9 Proximate composition of the meat rabbit administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae)*

The results of the proximate composition of meat from the rabbits showed no significant difference in moisture content, crude protein and ether extract among the parent groups and the progeny groups; exception was observed in the composition of ether extract among the progeny groups where significant difference was observed in the values. The range of values of moisture content (65.72 - 65.62 %), crude protein (27.90 - 29.00 %) and ether extract (6.41 - 9.27 %) obtained among the parent groups, and 65.98 - 68.05 %, 28.55 % - 29.36 % and 5.92 % - 8.09 % obtained among the progeny groups respectively, falls within the values of 63.6% - 76.8 %, 20.38 % - 29.00 % and 0.33 - 14.60 % for moisture content, crude protein and ether extract respectively reported by Pla *et al*. (1996).

4.3.10 Female reproductive traits of rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae)*

The result of the reproductive performance showed no significant differences in all the parameters observed in both the parent rabbits groups, and the progenies groups. The

results on conception rate is in agreement with the report of Belhassen *et al.* (2016). The authors reported conception rates of 95.80 % and 66.70% for rabbits does and their progenies following supplementation with diets containing *Saccharomyces cerevisiae.* The gestation length of does range from 31-32 days which is like that reported by Yono *et al.* (1986) and Oyedemi (2011).The non-significant difference obseved in the parameters of the birth and weaning traits are in conformity with the results of Nicodemus *et al.* (2004), who found that probotics included at the rate of 0.29/kg of diet had no effect on these parameters at birth and weaning. But on the contrary, Maertens and De-Groote (1992) and Ayyat *et al.*(1996) observed a significant improvement in litter size and body weight at 21 days, and at weaning due to Paciflor® and *Lacto-Sacch* supplementation. The lower values recorded for litter size at weaning among the parent groups of rabbit in T_3 (3.50) and T_5 (3.50) and progeny groups in T_2 (3.33) is in agreement with the values of Isaac *et al.* (2010) who reported average litter size at weaning of 3.0, 2.3 and 3.5 for four breeds of rabbits (New Zealand white, American Chinchilla, Angora and California white). The higher values recorded for the litter size at weaning observed on T_1 (6.00), T_2 (4.5) and T_4 for the parents' group and T_1 (4.65), T_3 (4.33), T_4 (3.67) and T_5 (3.67) for the progenies, contradicts the values of Isaac *et al*. (2010). Litter size at birth (10.5) observed in this study for the parent groups and (7.66) for the progeny groups is higher than the 5.2 reported by Ola *et al*. (2012) and Odeyinka *et al.* (2008). This is an indication that *Saccharomyces* possesses substances that could increase ovulation rates and hence litter size. The result of improved reproductive performance obseveed in this study agrees with the findings of Odeyinka *et al.* (2008) and Ola *et al.* (2012).

4.3.11 Testicular morphometrics characteristics of rabbits administered probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae)*

Testicular morphometric parameters showed no significant difference in all the parameters among the parent rabbits'groups, and the progenies with the exception of volume of the testes where it showed signinficant difference in the progeny groups. This result (on testes volume of the progenies) is in contrast with the reports of Besseboua *et al*. (2021) The authors reported no significant difference in testicular volume in rabbits fed diets containing probiotics compared to the control. Fernandez *et al*. (2004) however, reported a significant difference in the scrotal circumference of rams fed diets containing probiotics. Similarly, Kheradmand *et al*. (2006) reported that both the testicular size and scrotal circumference of rams were influenced by the addition of probiotics to the diets of rams. The increase observed in the testicular volume in this study may be attributed to adequate nutrients supply and absorption occassioned by probiotics supplementation which is essential for testicular development and function. Also, probiotics may have influence hormone production including testosterone, which plays a crucial role in testicular development and functon. This study has established the fact that administration of probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiea)* did not adversely affect testicular morphometrics characteristic of rabbits.

CHAPTER FIVE

5.0 CONCLUSIONAND RECOMMENDATION

5.1 Conclusion

The findings of this study revealed the following: -

i. Administration of probiotics (*Saccharomyces bourlardii* and *Saccharomyces cerevisiae*) orally and in feed did not significantly ($p>0.05$) affect the growth and reproductive performance of parent rabbits except for litter weight at birth which was significantly ($p<0.05$) influenced.

ii. The administration of probiotics *Saccharomyces bourlardii* and *Saccharomyces cerevisiae* in feed shows significant difference ($p<0.05$) in white blood cells count and packed cells volume in week 1 and only white blood cells count in week 8 among the parent rabbits. The serum biochemical properties showed significant ($p<0.05$) differences in total protein, albumin, sodium and chloride at week 1 but however, no significant ($p>0.05$) effect was observed in all the serum metabolites of the parent rabbits at week 8.

iii. The study revealed that administration of probiotics (*Saccharomyces boulardii* and *Saccharomyces cerevisiae*) orally and in feed did not significantly ($p>0.05$) affect the carcass cut parts, visceral organs and proximate composition of meat of parent rabbits. It however shows significant ($p<0.05$) differences in thermal shortening.

iv. The administration of probiotics (*Saccharomyces bourlardii* and *Saccharomyces cerevisiae*) orally and in feed did not significantly ($p>0.05$) affect growth and reproductive performance of rabbits' progenies except for volume of the testes which was significantly ($p<0.05$) influenced.

v. The study revealed that the administration (*Saccharomyces bourlardii* and *Saccharomyces cerevisiae*) orally and in feed did not significantly ($p>0.05$) affect the haematological parameter at week 1 and at week 8 among the progeny groups. Also, it did not significantly ($p>0.05$) affect serum biochemical parameter at week 1 and at week 8.

vi. The administration of probiotics (*Sacchromyces bourlardii* and *Saccharomyces cerevisae*) orally and in feed showed no significant ($p>0.05$) differences in the carcass cut-up parts except for hind limb where significant ($p<0.05$) difference was observed among the progeny groups. Ether extract, pH and thermal shortening were also significant ($p<0.05$) influenced.

5.2 Recommendations

Considering the conclusion arrived in this research, it is therefore recommended as follows:

i. The significant ($p<0.05$) effect of *Sacchromyces boulardii* and *Sacchromyces cerevisae*s on white blood cells count confirms the positve potentials of these probiotics in the prevention of diseases by elimination of pathogens thereby supporting the function and development of the immune system.

ii. The significant ($p<0.05$) difference observed in serum metabolites (total protein, albumin, sodium and chloride), following the administration of *Sacchromyces boulardii* and *Sacchromyces cerevisae* on rabbits orally and in feed underscore their funtion in nutrients absorption and utilisation, proper liver and kidney function.

iii. *Sacchromyces boulardii* and *Sacchromyces cerevisae* should be added to the diet of rabbit for significant improvement in conception rates, gestation consistency and litter size both at birth and at weaning.

iv. Further research should continue in this area of probiotic supplementation. Focus should be on the technologies of the administration (microencapsulation, cell immobilization and continous fermentation), to ensure that these beneficial micro-organisms will reach, in high numbers, the target site of action.

v. The discovery of probiotics yeast constitutes an important development in the field of probiotics. The future of these probiotics is promising. Further research is needed to explore their application in many contexts:

   a. Mechanism elucidation to understand howthese yeasts interact with gut microbiodata (microbiome.)

   b. Strain specificity to know the most beneficial strain within each genus.

   c. Clinical trials are also needed to confirm the safety and effectiveness of the yeast strain.

5.3 Contributions to Knowledge

The following contribution to knowledge were made from the findinds of this study:

i. The study revealed that the haematological parameters of parent rabbits at T5 with white blood cells count of (8.55) at week 1 and (8.55) at week 8 and T2 with packed cells volume (42.00 %) ensures immune system function and overall health being.

ii. The serum biochemical of the parent rabbits' group had higher level of total protein at T4 (7.00 g/dL) and Albumin at T5 (3.80 g/dL) which indicates adequate nutrition, liver and kidney function.

iii. The study also confirmed that the sodium with higher values in T5 (140.00 mmom/l) and chloride with higher values in T1 (103.50 mmol/L) are essential electrolytes in ensuring the regulation of fluids balance, nerve and muscle function.

iv. The study showed significant ($P<0.05$) difference in hind leg in T3 (7.97 %) among the progeny group, which signifies adequate nutrients absorption and utilisation.

v. The significant ($P<0.05$) effect observed in thermal shortening of meat quality characteristics in T1 (8.71 %) and (7.36 %) among the parent groups and progeny groups respectively as well as pH in T2 (6.55) is an indication of overall meat quality and acceptability of cooked meat, safety and shelf life.

vi. The study showed that ether extractin T3 (8.09 %) is indicative of energy content and nutritional value and inpact onmeat quality.

vii. The study also confirmed that, the testicular morphormetry in T3 (44.66) is indicative of robust reproductive potentials with no underlying reproductive health issues.

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