**BINDURA UNIVERSITY OF SCIENCE EDUCATION**

**FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE**

**DEPARTMENT OF ANIMAL SCIENCE**

# The Effects of Lactic Acid on Gut Health, Growth Performance and Feed Utilization In Post Weaned Piglets

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**The research project submitted as part of the requirements for the Bachelor of Agricultural Science with Honors degree in Animal Science and Technology (BAgSASc&T)**

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# Approval form

The signatory hereby attests that they comprehend and endorse the aforementioned research project entitled "Effects of Lactic Acid on Gut Health, Growth Performance, and Feed Utilization in Post-Weaned Piglets" in partial fulfillment of the specifications for the bachelor of agricultural science honor's degree in Animal Science and Technology.

## Supervisor

I affirm that I guided **CUTHBERT MUROMBA**'s research on "the effects of lactic acid on gut health, growth performance, and feed utilization in post-weaned piglets," submitted in partial fulfillment of the stipulations for the Honors Degree in Animal Science and Technology and endorse that it proceed for consideration.

MR M Dhliwayo ……………………………….

(Supervisor's name) (Date signed)

# ABSTRACT

Gut health is among the most important factors that influence weaner pig performance, health, and feed utilization. It is well established that pigs with a healthy gut have higher growth rates, feed conversion efficiency, weight gains, and are generally healthier. This study was conducted to investigate the possible effects of lactic acid inclusion in the drinking water of weaner piglets on gut health and growth performance. This research was conducted at the Pig Industry Board of Zimbabwe (Arcturus Station) in Mashonaland East. A total of 160 weaner pigs that were five weeks old were selected from the PIB commercial and breeding sections for the research, and only healthy pigs (without abnormalities) and those from the dams that were vaccinated were selected. The weaner piglets were assigned at random to one of the four treatments: treatment 1 (5.0 ph), treatment 2 (control), treatment 3 (4.0 ph), and treatment 4 (2.0 ph), each consisting of four replications (with 10 weaners per replicate). The production performance was recorded every day from day 35 until the completion of the study on day 56. The study results showed that piglets on lactic acid treatments had reduced FCR and scouring rate ($p<0.05$), and increased average daily gain ($p<0.05$), when compared to control piglets on water only treatment. The findings of this experiment indicated that supplementing lactic acid in the drinking water of post-weaned piglets does enhance gut health and improve performance in post-weaned pigs. As a result, the researcher recommended the use of lactic acid in drinking water of post-weaned piglets at an inclusion rate of 5.0 ph as it is cheaper compared to 2.0 ph and 4.0 ph.

**Key words:** Lactic acid, performance, weaner, scouring, gastro intestinal.

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# DEDICATION

I hereby dedicate this research project to my sister Gaudencia Muromba in appreciation of the support she provided up until its completion.

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# List of acronyms

| Acronyms | Explanation |
|---|---|
| ADG | Average daily gain |
| ADFI | Average daily feed intake |
| AHA | Alpha Hydroxyl Acid |
| CP | Clostridium perfringens |
| E.COLI | Escherichia coli |
| EW | Early weaning |
| FCR | Feed conversion ratio |
| GIT | Gastro intestinal tract |
| LA | Lactic acid |
| MEW | Medicated early weaning |
| PPV | Porcine Parvo Virus |
| PWD | Post Weaned Diarrhea |
| PH | Potential Hydrogen |
| SEW | Segregated early weaning |

# CHAPTER 1

## 1.0 Introduction

## 1.1Background to study

In order to increase annual sow productivity and profitability, Zimbabwean pig *farmers* are interested in lowering the weaning age(Chigede 2022) as a way of extending sow longevity to at least 6 to 8 parities and encouraging convenient farrowing indices like 2.3, which appears to reduce expenses and boost the production efficiency of pig operations and enhance sow obstetrics (Pietrosemoli and Tang 2020).However, soon after weaning, many farmers are experiencing great losses as a result of post-weaning mortality, which is normally due to scours, stress, and poor post-weaning management practices(Eriksen, Kudirkiene et al. 2021).Poor performance, frequently accompanied by diarrhea, a high FCR, and poor ADG in post-weaned piglets, is a common cause of huge losses as it delays production by increasing days to maturity and also mortality rates(Dowley 2022).

The weaning process exposes the pigs to various immunological problems; therefore, soon after weaning, the pigs will have a compromised immune system, and this expose them to various pathogenic infections (Jayaraman and Nyachoti 2017).The newly weaned pigs are more vulnerable to diseases and pathogenic infection which including *E Coli,* rotavirus, coccidiosis, and *Clostridium perfringens* type C during this time of weaning (Thomson and Friendship 2019). In a process to adjust to a new location and sometimes interact with new pen or cage mates, they might experience digestive issues as a result of the diet shift thereby experiencing a post-weaning lag phase marked by decreased growth performance, increased scouring rate, and increased mortality rate, especially within the first week of weaning (Boyle, Edwards et al. 2022).

Prophylactic doses of antimicrobial feed supplements, which include antibiotics, are frequently added to the diet of weaning pigs' in order to prevent post-weaning issues. For many years, antibiotics have been utilized in animal production (Suiryanrayna and Ramana 2015). Antibiotics have been shown to promote weight gain in pigs by 3.3 to 8.0% and increase feed efficiency by about 3% (Lourenco, Hampton et al., 2021). Nevertheless, there is growing worry that the usage of antibiotics in stock feed results in an increase in the number of resistant diseases that are resilient to antibiotics, increased issues with antibiotic residue in animal products, inhibition of the animal immune system, damage to the normal gut flora of animals, long withdrawal periods, and antibiotic drug resistance in humans (Ngangom, Tamunjoh et al. 2019).

As a result, numerous parts of the world have been searching for substitute feed additives that might be employed to reduce the detrimental effects associated with the obliteration of antibiotics from stock feeds and enhance performance. The ability of acidifiers to reduce the gastrointestinal tract (GIT) pH has made them a desirable addition to diets for weaning pigs. This promotes the digestion of nutrients by weaner piglets and safeguards the GIT against pathogenic incursion and proliferation (Smits, Li et al., 2021). Additionally, due to poor pepsin secretion, poor conversion of gastric zymogens into enzymes, and an increased stomach pH level, higher levels of undigested protein entering the duodenum may hasten the growth of harmful bacteria like E. coli and parasites like coccidiosis in the lower GIT (Cheeke and Dierenfeld 2010).Furthermore, the increased quantities of undigested protein entering the duodenum may hasten pathogenic bacterial and parasitic (E. coli and coccidiosis) growth in the lower GIT, as observed in both poor growth performance and a high incidence of diarrhea in weanling pigs (Rodrigues, Wellington et al., 2022).

Dietary acidification involves adding acids to animals diets, and it is one of the solutions that have been used to address the gut pH-related problems in weaner pigs (Tugnoli, Giovagnoni et al. 2020) due to the fact that weaner piglets have an ill-equipped digestive and immune system and are also susceptible to various stressors and gastro-intestinal problems. Finding and evaluating viable, less expensive, and more potent substitutes for currently existing antibiotics is therefore of utmost importance, and such alternatives include lactic acid. This study's objective is to assess the possible impacts of lactic acid administration in drinking water on post-weaned piglets' average daily gain, fecal viscosity, and feed conversion ratio. The effects of lactic acid as a diarrhea prophylaxis will be observed on a daily basis, and its subsequent effect on growth parameters of the weaner piglets will be observable at day 56, at the end of the post-weaning phase.

## 1.1Problem statement

Most pig producers are experiencing great losses as a result of post-weaning deaths resulting from post-weaning diarrhea (PWD), especially within the first week of weaning from farrowing (Eriksen, Kudirkiene et al. 2021).This has negatively impacted pig production in terms of high mortalities, poor wean weights, poor growth rates, and poor FCR, thereby increasing the cost of production and making the enterprise unprofitable. This study therefore seeks to ascertain the possible impacts of adding lactic acid to drinking water on post-weaned piglet gut health, feed conversion ratio (FCR), average daily gain (ADG), and fecal viscosity.

## 1.2 Justification

Small-scale pig farmers are concerned about a high post-weaning mortality rate, a slow growth rate, and a high incidence of post-weaning diarrhea (PWD). Due to post-weaning issues, the pigs are taking an excessively long time to achieve their slaughter weight, which tends to increase production costs for small-scale farmers by requiring them to use more inputs than necessary to complete the pig production cycle. On the other hand, pig farmers are now turning to antibiotics to address post-weaning issues while, administering antibiotics to cure piglets and promote growth has resulted in the systematic emergence of antimicrobial resistance in both pigs and pork consumers (Liao and Nyachoti 2017). Consequently, the study's goal is to determine any potential lactic acid impacts on gut health, growth performance, scours reduction, and subsequent effects on feed conversion ratio. In order to reduce the issue of antibiotic resistance organic therapies can be used since they do not leave any residue in animal bodies after consumption, and lactic acid is one of those organic remedies and it is also less expensive than antibiotics.

## 1.5 Objectives

### 1.5.1 Main objective

To determine the effects of lactic acid on gut health, growth and feed utilization in post weaned piglets.

### 1.5.2Specific objectives

a) To determine the effects of lactic acid treatment on average daily gain.

b) To evaluate the effect of lactic acids treatment on lowering feed conversion ratio of post weaned piglets.

c) To ascertain the effect of Lactic acid treatment on fecal viscosity.

## 1.6 Hypothesis

**$H_1$**: Drinking water containing Lactic Acid has significant effect in increasing fecal viscosity.

**$H_1$**: Drinking water containing Lactic acid in post -weaned piglets has a significant effect in lowering FCR.

**$H_1$**: Drinking water containing Lactic acid in post-weaned piglets has a significant effect on average daily gain.

# CHAPTER 2

## 2.0 Literature review

## 2.1 Introduction

The intent of this chapter is to review both theoretical and speculative justifications for the production of weaner pigs. A review of the literature is presented in the first section, which also discusses weaning physiology, different weaning techniques, and the consequences of stress during weaning. The final section skips over to potential reasons for post-weaned piglets' mortality, national requirements for weaned piglets, and the background and potential use of lactic acid in the biochemical industry and as a prophylaxis for post-weaned piglets' diarrhea.

## 2.2Historical background

The domestic pig is among the first animals to be domesticated by man, and it originates from the wild boar ancestor (*Sus scrofa),* which originated from the European wild boar (hitherto) (De, Sawhney et al. 2023).These creatures were adopted by humans to survive in enclosed, gloomy, marshy environments after they evolved in damp, swampy forests and theologically pigs were domesticated as far back as 2000 BC. In many nations up to the middle of the 18th century, the "one family, one pig per year" practice predominated and was a major source of meat for humans for many years. Sus scrofa's physique and legs are built for moving in dense forests, while its snout, powerful head, and tusks are used for rooting and digging. Due to the aforementioned situation, the domesticated pigs were given access to leftover food from the household in addition to being able to go foraging for sustenance (Sillitoe 2021).

Pigs were only kept at subsistence level, and they were solely used for domestic food after slaughter (Vretemark, STIKA et al. 2010), their meat was preferable to that of other animals due to its high fat content, which made it easy to preserve. Pig meat production and management needs were significantly impacted by the industrial (agricultural) revolution that began in the 19th century (Gadd, Myrdal et al. 2011). More pork was offered as fresh meat as a result of the develop ment of pig breeds that produced meat that was leaner and grow quickly than the original breeds(Martins, Fialho et al. 2020) . Pigs were discovered to be better feed converters than other livestock species, and as demand increased (as a result of population increase), pig production was increased by giving them specialized housing, a healthy diet, and enhanced genetics (Wu and Bazer 2019). The primary goal was to make it possible for the farmer to raise more pigs each year with more meat in the shortest amount of time (Chriki and Hocquette 2020)

The sustainability of pork production is mostly dependent on two elements, namely health and management. Even if output has increased in terms of the number of pigs produced each year, the age at slaughter, diarrhea and other ailments increase the financial burden on the pig industry. These diseases result in high mortality rates and slow development rates, which either reduce the number of pigs produced annually per sow, the number of pigs weaned per sow, the post-weaning weights and the age at slaughter.

## 2.3 Pig Weaning Physiology

The weaning process is defined as the withdrawal of access to milk; this process gradually accustoms the young to accepting an adult diet (Orihuela and Galina 2019). Weaning is one of the most challenging times for pigs because it is typically accompanied by slower growth and more frequent diarrhea (Eriksen, Kudirkiene et al., 2021). The piglet is more susceptible to gastrointestinal problems during this weaning phase due to reduced feed intake because the digestive and immune systems are still developing. The main consequences of underdeveloped gastrointestinal system in weaned pigs include altered intestinal shape, decreased activity of digestive enzymes, and decreased small intestine digesting (Metzler-Zebeli 2021). The weaning procedure exposes the pigs to a number of immunological issues; consequently, immediately after weaning, the pigs' immune systems will be impaired, making them vulnerable to a number of pathogenic infections (Amdi, Lynegaard et al. 2020). Pigs prefer to eat in groups and are highly social animals; therefore, sufficient feeder space must be supplied to facilitate this behavior, if the feeder area is insufficient, greater pig competition for feed may result in diminished growth potential.

Throughout the weaning phase, pigs experience a range of stresses that have a significant negative impact on their health and cause a drop in feed intake, which may result in undesirable morphological and functional alterations in the gut. One of the most harmful alterations in intestinal morphology is the shortening of the villi, which is accompanied by hyperplasia of crypt cells and an increase in epithelial cell mitosis (Ji, Wang, et al. 2019). Gut functions may be impaired as a result of these changes in gut morphology, which can reduce absorptive capacity and brush-border enzyme activity. Additionally, stress and low feed intake in piglets may result in a reduction in the integrity of the gut mucosa, which is supported by an increase in paracellular movement and a reduction in villous length; hence, performance is reduced (Wu, Liu, et al. 2018).

### 2.3.1Types of weaning

For newly weaned piglets, weaning is an emotionally draining process that has an impact on both their social and physiological development. Weaning is usually accompanied by significant growth checks and high mortalities, which have a significant impact on the performance of grower herds and a decline in profitability. Weaning can be done using three basic methods: standard or conventional weaning, early weaning, and specialized weaning ,however, the fewer days the lactation period, the more proficient the housing, nutrition, and management abilities necessary to nurse the newly weaned piglets( Blavi, L., et al. 2021)..

### 2.3.2 Conventional or standard weaning

This method of weaning involves weaning the piglets between three and five weeks of age, typically when they weigh between 5 and 10 kg (Bedford, A., et al. 2015). At this age, pigs are of the right size and age to survive in a standard farm environment, have gotten used to a solid diet, and are growing more resilient to stress and temperature changes. Five weeks after farrowing, the sow's milk supply will drastically decrease, making it futile to feed the piglets with sow milk. As a result, they must receive supplementary and additional feed and be separated from their dams (Kenyon, P., et al. 2019).

### 2.3.3Early weaning

This method of weaning involves weaning the piglets between the ages of 10 and 21 days normally at 4-5 kg body weight (Novais, A. K., et al. 2021). Piglets at this age have reached a phase in their development where their digestive systems have evolved to digest solid feeds, their immune and heat regulatory mechanisms are starting to work effectively, and their level of adaptability has also increased. The general aims of early weaning are to reduce sow weight losses during lactation, shorten farrowing intervals and lost days, and solve issues with starvation and layering in the farrowing house.

### 2.3.4Specialized weaning

This is a type of weaning in which the piglets are weaned at an early age (less than 14 days). This type of weaning is usually implemented using two basic methods: (SEW) segregated early weaning and (MEW) mediated early weaning (Martin, J. L. (2017).

#### 2.3.4.1Segregated early weaning (SEW)

This method involves weaning piglets at an "early" age, usually before 18 days from birth, or removing the piglets from the breeding population right away after weaning in order to eliminate, or at least minimize, the disease burden in pigs entering farrowing houses and weaner facilities.

#### 2.3.4. 2Medicated early weaning (MEW)

The MEW method is employed to get pigs free of certain endemic diseases that are common in the herd. The sow is given heavy doses of antibiotics when she enters the farrowing facility and continues to receive them until her piglets are weaned. The piglets are administered dosages from birth until around ten days of age with medications comparable to those administered to their dams. They are weaned at approximately five days of age and sent to a secluded early-weaning center (Gelderman, A. and J. Clapper 2013).

## 2.4 Effects of stress at weaning

Weaning is one of the most stressful phases that causes digestive, immune, and behavioral changes. Stress is commonly described as any disturbance to an animal's homeostasis that causes behavioral changes. When a piglet is weaned from a sow, it encounters significant physiological, environmental, and social challenges that expose it to a variety of stressors during this period, which include separation from the dam, handling and transportation stress, food source change, social order stress, mixing with pigs from other litters, and changes in the physical environment. This increases exposure to pathogenic infections and dietary or environmental antigens (Upadhaya and Kim, 2021).

Weaning stress causes weaning anorexia, which is linked to serious gastrointestinal tract (GIT) disturbances marked by impaired digestive and absorptive capacity and, as a result, leads to an increase in pathogenic bacteria infestation. Additionally, stress caused by crowing and substandard housing reduces immune proficiency by reducing immune cell counts or increasing immunosuppressive mechanisms, as well as reducing growth rates and increasing the susceptibility to invasions by pathogenic organisms such as enterotoxigenic Escherichia coli (Gresse, Chaucheyras-Durand et al., 2021). Nevertheless, sufficient spacing should be provided in order to reduce stress during weaning, and the current recommended space allowance for weaned pigs is at least 0.34 m2 per pig in slatted pens; in antibiotic-free feeding regimens and unslatted pens, more space allowance might be required (Jensen, Nielsen et al. 2012).

### 2.5.1Weaner piglet nutritional requirements

One of the most challenging periods for a piglet is the weaning phase, due to the fact that they are exposed to so many changes, including being separated from the sow and other littermates, switching from milk to solid food suddenly, and being placed in a new environment (Choudhury, Middelkoop, et al., 2021). Due to this, it is usual to observe a post-weaning period of low and unpredictable feed intake, which frequently triggers a growth check that may persist for 7–10 days (Montagne, Gilbert et al., 2022). These stressors can alter the gastrointestinal tract's physiological function, leaving pigs vulnerable to post-weaning gastroenteritis and decreased feed intake, which can impair performance. Pre-weaning dietary requirements (weaner meal) and management should be enhanced in order to assist the newly weaned piglet in overcoming these obstacles. The newly weaned piglets should be given a highly formulated weaning diet that is high in energy, highly digestible, highly palatable, and high in protein. Therefore, weaner diet should consist of all nutrients in their proper quantities. As shown in Table 2.1 the diet should have all the required carbohydrates, fiber, vitamins, and minerals in the required quantities (Sherf Dagan, Goldenshluger et al. 2017) and the diet should be sufficient to provide enough energy for growth, maintenance, and immunological development. The water should be provided at adlib and they should be given clean and fresh water daily. In the first week following post-weaning, weaner pigs will drink more water to sate their hunger therefore the consumption of feed and water are correlated; therefore, having restricted access to fresh water can limit feed consumption (Nicolao 2022).

| Major nutrients | quantity | Minerals | quantity | Amino acid | quantity |
|---|---|---|---|---|---|
| Net energy(mj/kg) | 10.0-10.7 | Calcium (%) | 0.70-0.80 | Lysine (%) | 1.2-1.5 |
| Crude protein (%) | 19-22% | Digestible phosphorous (%) | 0.40-0.50 | Methionine(ratio) | 0.3-0.4 |
| Crude fiber (%) | 2.0-3.5% | Sodium (%), | 0.20-0.30 | Threonine | 0.65-0.70 |
| | | Copper(mh/kg) | 100-150 | Tryptophan(ratio) | 0.18-0.22 |
| | | | | Valine(ratio) | 0.65-0.70 |
| | | | | Histidine(ratio) | 0.35-0.45 |
| | | | | Isoleucine(ratio) | 0.55-0.66 |
| | | | | Methionine+ cysteine(ratio) | 0.58-0.65 |

Table2.1: showing the nutritional requirements of a post weaned piglet.

## 2.5.2Feeding physiology

Weaning is one of the most challenging and stressful stages of the pig production cycle as it exposes the animals to a variety of stressors that may result in morphological changes to the gastrointestinal tract, making them vulnerable to pathogens and some unfavorable homeostatic changes that may reduce feed intake (Pereg, Steffan et al., 2021). As indicated in Table 2.2 it is typical to have a post-weaning period of low and fluctuating feed intake, which frequently results in stunted growth and poor performance, particularly during the first week of weaning. Feed intake is generally low during the first week of weaning owing to stress and some GIT morphological development and gradually increases as the pigs approach the second week of weaning (Choudhury, Middelkoop et al., 2021). And also, the average weight gain is also correlated with feed intake in weaner pigs; that is, the ADG increases as feed intake increases. Limited access to fresh feed can also reduce the rate at which a weaner pig grows or gain weight.

| Age (days) | Body weight(kg) | Feed intake(kg/day) | Growth rate(g/day) | Feed gain(g/g) |
|---|---|---|---|---|
| 21-35 | 7-10.5 | 0.25 | 250 | 1.0 |
| 35-49 | 10.5-17 | 0.58 | 450 | 1.3 |
| 49-70 | 17-30 | 0.9 | 600 | 1.5 |
| 21-70 | 7-30 | 0.62 | 460 | 1.35 |
| 56-84 | 20-40 | 1.4 | 700 | 2.0 |

Table 2.2: describing the average daily gains and feed intake of post weaned piglets during the Various stages of weaning phase.

## 2.6 Causes of post weaning mortality

In pig production, particularly in the first two weeks after weaning, post-weaning mortality is a significant economic and animal welfare issue among various pig farmers. The mortality ranges from 3.6, which is considered normal, to 35%, which is excessive, mortality is a significant economic and animal welfare issue among various pig producers. The fact that weaning is the second development stage with the greatest mortality rate in comparison to other growth stages is one of the reasons why it concerns so many commercial pig producers (Camp Montoro, Manzanilla et al. 2020). A vast array of etiologies and risk factors with several interrelated effects combine to cause post weaning mortality. The etiology varies from infectious factors to non-infectious factors. With scours, hypothermia, and pneumonia being the common infectious factors causing post-weaning (Pietrosemoli Castagni, 2021).

## 2.7 Scours or diarrhea

Diarrhea is the most prevalent and serious disease affecting newly weaned piglets due to its high fatality rate and ability to cause dehydration (Thakor, Dinesh et al., 2022). Scours are usually caused by GIT dysfunctions, which include failure of pre-digestion of feed before it enters the small intestines, inability to absorb digested feed, water, and electrolytes in the small intestine resulting from reduced blood flow owing to chilling, bacterial toxins, and parasite impairment, outpouring of excessive fluids into the small intestines as a result of bacterial toxins, and failure to reabsorb fluid in the lower gut (Yadav, Gupta et al. 2022).

Scours are defined as an abnormally frequent discharge of semisolid or fluid fecal matter from the bowel (Sharma, Kumar et al. 2021). Scours are usually diagnosed by the rapid movement of fecal matter through the gastrointestinal tract(Dias, Morais et al. 2020) .Scours are usually associated with high mortality and a poor growth rate, and weaner pigs that survive diarrhea during weaning are typically linked to reduced growth rate and delayed slaughtering and marketing of pigs(Bonetti, Tugnoli et al. 2021) .Viruses, bacteria, and parasites are the three primary categories of pathogenic microorganisms that cause post-weaning scours.. The main viruses that cause post-weaning diarrhea include transmittable gastroenteritis, rotavirus, porcine epidemic diarrhea, and PRRS, while the most prevalent bacteria that causes scours are *Escherichia coli*, *Clostridia enteritis* ,*salmonella choleraesuis* and *brachyspira hampsonii* .Coccidia (*isospora suis* ) is the common parasite that causes scours in pigs(Augustino, Ochi et al. 2022). In order to prevent and minimize losses associated with diarrhea and its symptoms, which include cachexia, hypoglycemia, dehydration, and a high mortality rate, pig producers and feed manufacturers have developed a practice of using highly formulated, highly digestible, and highly palatable diets that include sub therapeutic levels of antibiotics in the feeds, the usage of probiotics and prebiotics, and acidified diet(Rahman, Fliss et al. 2022).Antibiotic use in pig production has significantly decreased high death rates and increased production effectiveness ,however, due to the cross-resistance of pathogens to antibiotics used in humans(Rahman, Fliss et al. 2022) this practice has caused concerns in recent years, leading to a ban on their use in the European Union in early 2006 .To reduce the effect of the removal of antibiotics, there has been a lot of interest in using organic solutions in disease treatments in order to reduce production and economic losses. Therefore, it is crucial to recognize and assess the available all-natural antibiotic alternatives, with lactic acid being one such treatment.

## 2.8. Lactic acid

### 2.8.1 Origin and properties of lactic acid

Lactic acid is an organic acid that is soluble in water and appears white in its solid state. Lactic acid has the chemical formula CH3CH (OH) COOH, and it produces an opaque solution when dissolved. The acid can either be produced synthetically or organically (Silva and Lidon 2016). Due to the incorporation of a hydroxyl group next to the carboxyl group, lactic acid is an alpha-hydroxyl acid (AHA) and therefore serves as a synthetic precursor in an array of organic biosynthesis industries as well as in numerous types of biochemical industries (Dewandre, Tenenbaum et al. 2020). Lactic acid, is widely accepted and recognized as safe, has been authorized by the Joint FAO/WHO Expert Committee on Food Additives. Karl Wilhelm Scheele, a Swedish chemist, isolated lactic acid from milk in the 1780s and discovered it in soggy milk (Mandal 2021).

Lactic acid was produced commercially for the first time in 1881. The acid was produced by fermenting carbohydrates like maize starch or beet sugar with bacteria including lactobacillus, streptococcus, bafidobacterium and enterococcus, and it was also synthesized during lactose or milk sugar fermentation (Kumar, Rattu et al., 2022). The molecular mass of lactic acid is 90.08 g/mol. Furthermore, for every 1 mm of lactic acid, the pH is 3.51, with melting and boiling temperatures of 530 and 1220 degrees Celsius, respectively (Pandey, S., et al., 2021).

Following the restrictions on antibiotics, organic acids have been more prevalent in pig diets as a means of boosting animal productivity and performance, reducing digestive issues, and promoting pig gut health (Rathnayake, Mun et al., 2021). Lactic acid is one of the top and most often used organic acidifiers, and various studies have found that these acids and their salts are among the best alternatives to the use of growth-promoting antimicrobial compounds in pig production. (Wang, Long, et al., 2022).

The addition of lactic acid generally lowers the gut pH, provides buffering abilities in the gut, thus increasing gut acidity and nutrient digestibility, encourages the growth of beneficial microbes (lactic acid bacteria), and suppresses pathogenic and harmful microbes (Dittoe, Ricke, et al. 2018). It is known to have a metabolic alkalinizing impact and acts similarly to probiotics and antibiotics in terms of their mode of action. In addition, the acid can disrupt the bacterial cell wall and hinder the normal actions of certain types of bacteria, such as Salmonella species, *E. coli*, *Clostridia* species, Listeria species, and some coliforms, and it can also increase the activities of beneficial bacteria (bifidogenic effect), thereby preventing gut colonization by pathogens (Wan, Forsythe et al. 2019). Lactic acid (LA) is believed to enhance the performance of pigs by minimizing microbial competition with the pig for nutrients and by creating ideal conditions for digestion and absorption in the gastrointestinal tract (Terciolo, Dapoigny et al. 2019).

Lactic acid (LA) actually aids in the transformation of inactive pepsinogen into functional pepsin, prevents pathogenic bacteria colonization in the GIT, and promotes endogenous enzyme secretion, thereby enforcing efficient feed conversion, feed utilization, feed intake, and weight gain. The ideal pH range for weaning piglets is between 2.6 and 5.0, and this pH must be maintained for the animal's best digestion, development, and performance (Sotto 2019).

### 2.8.2 Other uses of lactic acid

- Lactic acid is mostly used to preserve foodstuff and flavor foodstuff.
- Lactic acid (LA) is also used in manufacturing of sour foods (pickles and sauerkraut).
- Lactic acid can be used in fabrics and some cosmetic products as a mordant, a substance that facilitates the uptake of color by fabric.
- Lactic acid is often used as an additive in livestock feed.
- Lactic acid is used to manufacture yogurt and cheese in the dairy industry.
- In the form of sodium or potassium lactate, lactic acid can be added to meat, fish, and poultry to increase shelf life, minimize salt, suppress harmful bacteria (thereby enhancing food safety), enhance and protect meat taste, and lengthen shelf life.
- Lactic acid is used as an acidulant, flavoring component, and pH stabilizer in beverages, fruit wine, and the meat industry.

# CHAPTER 3

## 3.0 Materials and methods

### 3.1Study site

The research was conducted at the Pig Industry Board of Zimbabwe (PIB), which is located in Arcturus, 25 kilometers off Murehwa Road, East of Harare. The farm is situated at a height of 1385 meters above the sea level, at 17 degrees 47' S and 31 degrees 19' E. Geographically, the farm is situated in Zimbabwe's agricultural farming region 11A, which includes a region with considerable rainfall. The region experiences annual rainfall averages of 900 to 1200 mm. The mean maximum and minimum temperatures vary from 19 to 23 ℃ and 10 to 13 ℃, respectively, with a mean yearly temperature range of 16 to 19 ℃ in between (Asamoah and Ansah-Mensah 2020). According to Zimbabwe's soil grading system, the soil type is largely red soil (mixed clay) within the Fersiallitic group, which originates in the Kaolintic order (Chinyama, Wenga et al., 2023).

### 3.2 Experimental animals

A total of 160 weaners weighing between six and nine kg were selected from both commercial and breeding sections of the pig industry board of Zimbabwe. The weaners were 35 days old at the start of the experiment, and the breeds used were Landrace, Duroc, Large White, and their crosses.

### 3.3 Housing and feeding of animals

The pigs were housed at the PIB weaner section in weaner cages measuring 1.61 meters by 3 meters. Each cage equipped with a working infrared lamp. As shown in Figure 3.1, the weaners were housed 10 per cage, with each cage containing all the mentioned breeds (Landrace, Duroc, Large White, and their crosses). Wheat straw was used as bedding, and the animals were given free access to standard weaner meal supplied through feeders and free choice access to fresh water and lactic acid treatments through water troughs. Feed was administered ad libitum, and clean water containing lactic acid was also given ad libitum. The water trough was cleaned every morning with clean water and rinsed with distilled water. The weaner meal diet was manufactured at the pig industry board milling section, and the weaner meal was formulated with premium and superior nutritional ingredients. The weaners were obtained from the sows that were vaccinated with Farrow Sure against Porcine Parvo Virus (PPV) and with Litter Guard vaccine against *E. coli* and CP type C. Biosecurity precautions were implemented to prevent the infiltration of diseases from outside the weaner cages; hence, footbaths filled with formalin-infused water were placed at the entrance of every experimental unit. The pens were cleaned, washed, and sprayed with formalin two weeks before the experiment. All pens were given a two-week rest before the commencement of the study.

Fig. 3.1 showing weaner pigs in weaner cages with the same conditions.

## 3.4 Experimental design

For the study, a completely randomized design (CRD) was employed. A total of 160 weaners weighing between six and nine kilograms were selected. The weaner pigs were first assigned to a stratum that had at least one trait in common with the general population (the same weight range). A sample size of 10 weaners per replication was then generated by randomly selecting weaners from the strata. As shown in Fig. 3.2, the design consisted of four treatments and four replicates, and the treatment groups were T1 (slightly acidic), 5.0 pH X4 replicates, and T2 (neutral), control (without lactic acid) X4 replicates; T3 (moderately acidic), 4.0 pH X4 replicates; and T4 (very acidic), 2.0 pH X4 replicates. Weaners were exposed to the same environment, such as the same type of housing, the same water source, the same feed, and the same stocking density, and they were given water containing lactic acid from day 35 up to day 56, while the control was given only water. Lactic acid was mixed with water, and a digital pH meter (pen type) was used to record the water pH among the four treatments. However, for all treatments, the weaners that were affected with scours were not treated with any antibiotics; hence, only the affected weaners in control were treated with an electrolyte supplement (stress pack).

Fig. 3.2 showing how the water was prepared for all treatments during the experiment.

## 3.5. Measurement of feed conversion ratio (FCR).

The FCR was calculated as average feed consumed by pigs per pen divided by average weight gained by pigs per pen for a period of 21 days, that is, from day 35 up to day 56.

## 3.6Measurement of average daily weight gain (ADG).

The pigs were weighed once on the first day of the trials (day 35) to record their initial weights and once more at the end of the trial (day 56) to record their final weights. A hanging scale and a sack were used for the weighing process. Weight gain was obtained by subtracting the initial weight from the final weight, and ADG was obtained by dividing weight gained by the total number of days (final weight minus initial weight divided by total number of days).

## 3.7Measurement of fecal viscosity and scouring rate.

The scouring rate was recorded on a daily basis in all treatments for 21 days. The cases of diarrhea were recorded using expert knowledge and then entered on a Microsoft Excel spread sheet for every experimental unit. Scouring rate was obtained by dividing the number of pigs scoured per pen by the total number of pigs per pen (pigs' scoured/total number of pigs). Additionally, the texture and viscosity of the stools were described using a Bristol stool chart, as shown in Fig. 3.3.


Fig. 3.3 showing a Bristol stool chart used to describe the texture and viscosity of stool.

## 3.8Statistical analysis

Data on feed conversion ratio, average daily gain, and scouring rate was collected, processed, and compiled using Excel spreadsheet software. Analysis of data on FCR, ADG, and scouring rate was done using Genstat 18th edition in order to demonstrate the significance of lactic acid and water. Analysis of variance was performed at a 5% level of significance. The explanation of the data was provided through tables made from the analyzed data.

# CHAPTER 4

## 4.0 Results

### 4.1 Introduction

There was a significant ($p < 0.05$) difference in scouring rate, feed conversion ratio, and average daily gain between the weaner piglets that were given water containing lactic acid and the weaner piglets that were given water without lactic acid.

### 4.2 Effect of lactic acid on average daily gain (ADG).

The weaners that were given water containing lactic acid clearly reflected positive effects ($p < 0.05$) on increasing daily gain as compared to the weaners given water only as shown in Table 4.1.Weaners on lactic acid treatments showed a significantly higher average daily gain to weaners on water only. However weaners on different lactic acid levels showed no significant differences in average daily gain.

Table 4.1 Effect of lactic acid on average daily gain (A.D.G).

| Treatment | | Average daily gain (A.D.G) |
|---|---|---|
| | | |
| 3(4.0ph) | | $0.3620^{b}$ |
| | | |
| 4(2.0ph) | | $0.3540^{b}$ |
| | | |
| 1(5.0ph) | | $0.3230^{b}$ |
| | | |
| 2 (control) | | $0.2620^{a}$ |

$^{abc}$ Means within a column with different superscripts differ significantly ($P \leq 0.05$).

## 4.3 The effect of Lactic acid on feed conversion ratio (F.C.R).

The feed conversion ratio between the weaners given water containing lactic acid and those given water only was significantly different ($p<0.05$) as shown in Table 4.2. Weaners on lactic acid treatments demonstrated significantly lower feed conversion ratios to weaners on water only. However weaners on different lactic acid levels showed no significant differences in FCR, indicating that there is a maximum lactic acid or pH concentration that reduces FCR in weaners, beyond which there are no significant changes recorded. Whatever differences obtained are due to chance and are not repeatable.

Table 4.2 The effect of lactic acid on feed conversion ratio of weaned pigs.

| Treatment | | Feed conversion ratio(FCR) |
|---|---|---|
| 2 (control ) | | $1.905^{a}$ |
| | | |
| 1(5.0ph) | | $1.465^{b}$ |
| | | |
| 3(4.0ph) | | $1.250^{b}$ |
| | | |
| 4(2.0ph) | | $1.250^{b}$ |

$^{a-b}$ Means within a column with different superscripts differ significantly ($P \leq 0.05$).

## 4.4 Effects of lactic Acid on rate of Scouring in weaner Piglets.

The statistical analysis demonstrated that lactic acid had a significant effect on the scouring rate of weaner piglets ($p<0.05$) as presented in Table 4.3.Weaners on lactic acid treatments demonstrated significantly lower scouring rate to weaners on water only. However weaners on different lactic acid levels showed no significant differences in scouring rate, indicating that there is a maximum lactic acid or gut pH concentration that reduces scours in newly weaned piglets, beyond which there are no significant changes recorded. The differences obtained are due to chance and are not repeatable.

Table 4.3 Effect of lactic acid on scouring rate of post weaned piglets.

| Treatment | | Scouring rate |
|---|---|---|
| 2 (control) | | $0.850^{a}$ |
| | | |
| 1(5.0ph) | | $0.425^{b}$ |
| | | |
| 3(4.0ph) | | $0.350^{b}$ |
| | | |
| 4(2.0ph) | | $0.300^{b}$ |

$^{a\text{-}b}$ Means within a column with different superscripts differ significantly ($P \leq 0.05$).

# CHAPTER 5

## 5.1Discussion

The three main traits of economic importance that are essential for weaner pig performance are feed conversion ratio, weight gain, and mortality rate (Tugnoli, Giovagnoni, et al. 2020). It is proposed that dietary acidification can be used to enhance the performance of weaner pigs (Huting, Middelkoop et al., 2021). However, some authors (Upadhaya and Kim 2021) reviewed several beneficial effects showing improvements not only in growth performance and feed efficiency but also in the general health and wellbeing of animals. Dietary acidification is proposed to reduce harmful microbes and pathogens while enhancing the beneficial microbes' dominance in the gastro-intestinal tract (Tugnoli, Giovagnoni et al. 2020). The current study was done to ascertain the effect of giving lactic acid to the post-weaned piglets on average daily gain, feed conversion ratio, and scouring rate.

A higher average daily gain was observed in lactic acid treatments ($p<0.05$), which is analogous to the earlier study (Pearlin, Muthuvel et al. 2020) that found that pigs tend to gain more weight under dietary acidification and low gut ph. The increased average daily gain for lactic acid treatments could be brought about by the ability of lactic acid to lower the gastro-intestinal ph. A low gastric pH is essential for the conversion of pepsinogen to active pepsin, the conversion of the most important gastric proteolytic enzymes into their active forms, as well as enhancing feed digestion, absorption, and assimilation, hence increasing ADG (Fabay, Serrano Jr. et al., 2022). It could be due to the ability of lactic acid to initiate the buffering activities in the stomach and the gastro-intestinal tract by enhancing the activities of beneficial microbes and reducing the activities and multiplication of harmful microbes. (Tewari, David et al., 2019). Low GIT pH assists in the creation of the ideal environment for enzymatic actives, digestion, and assimilation of nutrients, hence an increase in weight gain (Pearlin, Muthuvel et al. 2020). According to other findings, dietary acidification in pigs increased daily gains by 6% (Huting, Middelkoop et al., 2021). The current study shows that weaner pigs were supplemented with water containing lactic acid. A reduced scouring rate in lactic acid could also be the reason why average daily gain increased with lactic acid treatment.

Feed conversion ratio was substantially positively influenced ($p < 0.05$) by the inclusion of lactic acid in drinking water, which goes hand in hand with other findings (Cullen, Lawlor et al. 2021) that discovered that feed conversion ratio was positively impacted by dietary acidification by 5–10% in pigs. Additionally, another study (Heyer, Wang et al., 2021) also demonstrated that dietary acidification boosted dry matter digestibility, feed consumption, and feed utilization by 0.82% in pigs. The current study showed that feed conversion ratios were lower and more efficient in lactic acid treatments as compared to water only ($p < 0.05$). The current study revealed that the lowest and most efficient feed conversion ratio was obtained in lactic acid treatments. This could be due to the ability of lactic acid to lower the gastro-intestinal ph, which contributes to the creation of a suitable environment for enzymatic reactions in the gastro intestinal tract, enhances digestion of protein and other nutrients, and enhances dry meter digestibility, hence efficient feed utilization (Pearlin, Muthuvel et al. 2020). The decrease in scouring rate within the lactic acid treatments could also contribute to efficient FCR in lactic acid treatments and also increased weight gain in lactic acid treatments might also contribute to an efficient feed conversion ratio in lactic acid treatments.

Lactic acid had an affirming impact on scouring rate ($p < 0.05$). These findings support earlier research (da Costa, Beechener et al., 2023) that claims that under stressful circumstances, organic acids in pig diets lower scouring rate and mortality rates while maintaining substantial growth performance. Another study (Blavi, Solà-Oriol et al., 2021) has also shown that the gastrointestinal pH of weaner pigs is considerably higher in contrast to that of mature pigs; therefore, in weaner pigs, this defensive mechanism can be improved by any lowering the gastrointestinal pH that results from dietary acidification. However, the current study demonstrated that lactic acid reduces the scouring rate. This may be because of lactic acid's capacity to reduce gut ph, establish an environment through the gut that is detrimental to E. coli as well as other pathogens, decrease pathogen survival throughout the digestive tract, improve the gut, and enhance nutrient digestion there by reducing the quantities of undigested protein entering the duodenum, which could speed up pathogenic bacterial development in the lower

GIT, as observed by poor growth rate and a high prevalence of diarrhea in weaned piglets (De Lange, Pluske et al. 2010).

# CHAPTER 6

## Conclusion and recommendations

### 6.1Conclusion

The scope of this experimental study sought to ascertain any potential impacts of (LA) lactic acid in drinking water on post-weaned piglets' ADG (average daily gain), FCR (feed conversion ratio), as well as diarrhea prophylaxis .According to the experimental results, weaner pigs given water containing lactic acid had a greater average daily weight gain (ADG), a lower feed conversion ratio (FCR), and a reduced scouring rate ($p< 0.05$) as compared to those given water without lactic acid. Therefore, the current study supports the benefits of using lactic acid in pig production.

### 6.2 Recommendation

The researcher hereby recommends pig producers use lactic acid at a rate of 5.0 pH in drinking water on post-weaned piglets (from day 35 to day 56) as a way of increasing average daily gain, feed convection ratio, growth performance, and scouring rate. This experiment has shown that the usage of lactic acid at the above-stated rate has effectively increased growth performance and reduced scouring rates, and the above-stated inclusion rate had no significant difference with other lactic acid inclusion rates (2.0 pH and 4.0 pH), therefore the researcher recommends a 5.0 pH inclusion rate as it is cheaper compared to 2.0 pH and 4.0 ph. The use of lactic acid in controlling scours and increasing growth performance helps minimize the cross-resistance of pathogens to antibiotics used in humans. More on that: lactic acid is a very cheap product that is locally available, and it is a weak organic acid that is safe for both handlers and animals.

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