

THE EFFECTS OF STOCKING DENSITY AND HOUSING ON FEED EFFICIENCY AND
GROWTH PERFORMANCE OF BROILER CHICKENS

By

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Agriculture (Animal Science)

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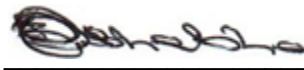
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Declaration

I, Netshipale Fhulufhelo, student number: 14014645, hereby declare that this dissertation is submitted in fulfilment of the requirement for the Master of Science in Agriculture in the Department of Animal Science at the Faculty of Science, Engineering and Agriculture, University of Venda, has not been previously in part or in its entirety been submitted to any university for any other degree. I further declare that this is my own work in design and execution and that all references material contained herein has been duly acknowledged.



Signature: Date:.....18-04-2025.....

Netshipale Fhulufhelo

Dedication

This dissertation is dedicated to my mom, E.M. Netshipale and my siblings M.R. Munyai, M. Munyai and L. Netshipale, thank you so much for your love and support and for always being there for me in everything. To my friends M. Makhamedzha and K.C. Moholola, thank you so much guys for your support and for your encouragement throughout, I wouldn't have made it this far without your help.

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Abstract

The poultry industry in South Africa is a significant contributor to the agricultural sector, with broiler production accounting for 80% of total broiler production within the Southern African Development Community. However, the industry faces challenges such as high input costs, particularly feed, and lack of domestically produced ingredients. To maximize broiler performance, producers should improve feed efficiency, which is crucial for profitability and long-term viability. Factors affecting feed efficiency include energy level of feed, temperature in the house, litter quality, feed wastage, and disease presence. Optimal growth performance is crucial, as it directly impacts the time it takes to bring products to market and the overall quality of the final product.

This study was to compare broiler performance under small scale production between fan exhaust houses and open-sided, naturally ventilated houses. The research aimed at determining the effects of stocking density and housing type on broiler performance, welfare, and economic implications. High stocking density is a strategy used by broiler farmers to maximize floor space, but it can have adverse effects on chickens, including lower growth rates, feed intake, and feed efficiency. High stocking densities can lead to diseases, increased litter moisture, higher temperatures, and increased competition for feed, affecting broiler growth. Lower stocking densities result in reduced oxidative stress and better growth performance.

Broiler houses are essential for optimal feed intake and feed efficiency in poultry farming. Natural ventilation systems, which control airflow and temperature, are common in small-scale productions, while mechanical ventilation systems require efficient fans. The choice of housing system and design significantly impacts the welfare and productivity of broilers. Stocking density and housing type significantly impact animal well-being and performance. The economic implications of stocking density and housing type are complex, requiring a careful equilibrium to maximize production costs, revenue, and total profitability in broiler chicken farming. Ethical

considerations, such as clean and disinfected pens and access to clean water and feed, are essential for broiler welfare and health.

The experiment involved a study on broiler houses with different designs, including natural ventilation and fan exhaust houses. A total of 300 Arbor Acre birds were housed in these houses, with half in naturally ventilated houses and the remaining in ventilated houses. Data collection began on day 8, and weekly feed intake was determined by subtracting left over feed from the total feed supplied for each seven-day interval. Feed conversion ratio was obtained by dividing the average weekly feed consumption per bird per replicate by the average weekly weight gain per bird per replicate. The results showed that broiler performance was not significantly affected by stocking density however housing type had a significant difference on feed intake in house 1 (H1) but not on feed efficiency. Overall stocking density and housing did not have any significant difference on broiler performance. For economic reasons farmers under small scale farming can use naturally ventilated houses.

Keywords: stocking density, housing type, feed efficiency, feed intake, broiler performance

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List of abbreviations

ABW	Average Body Weight
ABWG	Average Body Weight Gain
AFCR	Average Feed Conversion Ratio
AFI	Average Feed Intake
BW	Body Weight
IBW	Initial Body Weight
BWG	Body Weight Gain
CV	Coefficient of Variation
CI	Cost Index
EI	Economic Efficiency Index
FI	Feed Intake
FCR	Feed Conversion Ratio
SD	Stocking Density
H1	House number 1
H2	House number 2

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Chapter 1

1.1. Introduction and Background of the study

The poultry industry is the largest single contributor to the agricultural sector in South Africa. It is responsible for approximately 180 000 people who are employed either directly or indirectly in the industry. In 2022, the total gross value increased from 16% to 17.1% and 40.3 of animal product gross value steamed from poultry production (Nkukwana, 2019) . South Africa's broiler meat production represents less than 1.5% of the global output, although it contributes to about 80% of the total broiler production within the Southern African Development Community (SADC). The poultry industry is predominantly comprised of broiler production. Broiler output in South Africa has experienced an annual growth rate of 4% since 2000 (South Africa - Broiler Production and Consumption, n.d.).

Nevertheless, the industry encounters obstacles such as high input costs, which is the feed, which constitutes 75% of the overall production costs. South Africa lacks an adequate supply of domestically produced ingredients for feed manufacturing, while key exporting countries such as Brazil, the United States, and the European Union get subsidies. As a result, South Africa has become a country that imports more dark meat than it exports, and it purchases this meat at rates that are lower than the cost of producing it (Nkukwana, 2019).

The industry is comprised of a handful of major commercial producers and a significant number of small-scale farmers, with 1,554 small-scale farmers receiving government assistance to establish their operations. Despite the impressive performance of the industry since 2006, growth was negatively impacted by high costs and the 2007-2009 recession. Nevertheless, there is anticipation for a rise in demand as the economy rebounds (Mkhabela & Nyhodo, 2011).

The goal of poultry producers is to maximize the number of kilograms of broilers per floor area while avoiding production losses due to overstock (Abudabos et al., 2013), however according to

(world poultry science association, 2021) farmer should improve the feed efficiency because higher feed efficiency indicate that lower amount of feed is require per unit space. Efficient feed utilization and optimal growth performance are essential factors in broiler production, as they have a direct influence on the industry's profitability and long-term viability. Feed efficiency, especially in broilers, is a crucial factor that evaluates the effectiveness of converting feed into meat (SINGHA, 2022). In broiler production, feed efficiency plays a critical role in growth performance, production costs, and environmental sustainability. It lowers production costs, increases body weight gain and growth rates, and encourages sustained intensification (Zampiga et al., 2021). Reduced dietary nitrogen, phosphorus, and trace mineral excretion results from improved feed efficiency, which lessens the environmental effect of broiler farming (Improving Broiler Performance - Trouw Nutrition, n.d.). Furthermore sophisticated nutrition plans and breeding techniques can improve feed efficiency even further. For sustainable broiler production and optimal feed use, a multifaceted strategy combining nutrition, genetics, and management techniques is required (Maximizing Growth and Quality: The Essentials of Broiler Feed, n.d.).

There are various factors that can impact feed efficiency, such as the energy level of the feed, temperature in the house, quality of the litter, feed wastage, and the presence of diseases. The energy level of the feed is an important consideration, as high-energy feeds are more efficient but also come with a higher price tag. The feed conversion of broilers is influenced by the surrounding temperature. When the temperature is at its optimal level, broilers can efficiently convert nutrients into growth, rather than expending energy to regulate their body temperature. Factors such as litter quality and feed wastage can have an impact on feed efficiency, while the presence of diseases and the need for culling can have a negative effect on broiler performance and broiler growth. Optimal growth performance is of utmost importance, as it directly impacts the time it takes to bring products to market and the overall quality of the final product. Broilers go through a period of rapid growth during their early development, which is then followed by a slower

rate of growth as they mature. It is crucial to maximize feed conversion during the early growth stages as broilers age, as feed efficiency tends to decrease (Rocha et al, 2022).

The use of feeds with different levels of homogeneity can also have an effect on broiler performance. Broiler performance can be negatively affected by feeds with a high coefficient of variation (CV), especially in the early growth stages. Experts in the field recommend aiming for a CV of 10% or lower to achieve the best possible performance in broiler production. The nutritional and energy levels in feeds play a crucial role in determining the performance and economic viability of broilers. Enhancing nutritional and energy levels has the potential to enhance feed intake, feed conversion ratio, production efficiency index, and breast yield (Martins et al., 2016). However, it is important to consider that this may result in higher feed costs, which could impact economic outcomes. The economic efficiency index (EEI) and cost index (CI) are crucial factors in determining the financial feasibility of various nutritional plans.

In addition, Poultry producers tend to increase the number of birds per unit of space to reduce housing, equipment and labour costs per unit of space. However, as producers increase stocking densities, welfare issues become more important and alternative stocking systems need to be considered. Stocking density is defined as body weight (kg) or number of birds per unit living space. High stocking densities can affect performance at the bird level due to high ambient temperatures and reduced airflow (Simitzis et al., 2012). On the other hand, lower stocking densities may lead to higher productivity per bird, but not in flocks. Commercial farmers are better able to control ambient temperature and air flow, and may be better able to cope with high stocking densities. Broilers in broiler houses that rely on natural ventilation generally do not grow well at high stocking densities. There is limited information on how open-sided and ventilated houses affect broiler performance in tropical conditions in Thohoyandou, Limpopo province, South Africa.

1.2. Statement of the research problem

In general, higher stocking densities lead to lower growth potential (Zuowei et al., 2011; Dozier et al., 2011). Higher bird densities may increase litter moisture, airborne ammonia, and microbes in houses (Jayalakshmi et al., 2009), thus limiting weight gain (Ghosh et al., 2012). According to (Robago et al., 2003), the rearing environment affects the performance of broilers, with higher rearing densities in natural airflow housing, especially in summer, due to higher ambient temperatures, reduced airflow, and increased levels of carbon dioxide and ammonia can lead to the accumulation of carbon dioxide and ammonia, as a result leading to reduced feed intake, reduced feed conversion, and some bird mortality. In summer, when cooling is provided solely by the fan and there is no air cooler to reduce the temperature, the exhaust casing of the fan can get very hot. Additionally, building and maintaining these houses is expensive, and, excessive overcrowding can suffocate some birds, making cannibalism more common.

1.3. Justification

This study determines whether under small scale production, there are significant bird density related differences in performance between broilers raised in fan exhaust houses and those raised in open sided, naturally ventilated houses. In addition, it will help producers in the locality or areas with similar climatic conditions on how many birds they should stock per unit area. The comparison of the open sided houses and fan exhaust houses will enable the investigation to determine which housing is best for broiler production under the prevailing conditions in Thohoyandou. The reason why it is essential to conduct this study is because it is easier to implement the fans in the houses and it is cost efficient, they cost less compared to those fully mechanized with fully controlled environment. Farmers can easily afford it just as with the naturally ventilated houses.

1.4. Research objectives

1.4.1. Aim of the study

- To determine the effects of stocking density and type of housing on broiler performance.

1.4.2. Specific objectives

To determine the impacts of the following parameters on broiler performance:

1.4.2.1. Stocking density

1.4.2.2. Housing type

1.4.2.3. Interaction between stocking density and housing type.

1.4.2.4. Welfare and health considerations.

1.4.2.5 Economic implications related to stocking density and housing type.

1.5. Null hypotheses

Stocking density and housing type will not have any significant effect:

1.5.1. Weight gain

1.5.2. Feed intake

1.5.3. Feed efficiency

1.5.4. Mortality rate and

1.5.5. The economy

CHAPTER 2

LITERATURE REVIEW

General introduction

High broiler stocking density is one of the strategies employed by broiler farmers to maximize floor space occupied by birds and thereby achieve high levels of efficiency. Apart from efficiency, maintaining high density in broilers has also been shown to have adverse effects on chickens, including lower growth rates, lower feed intake and feed efficiency, and reduced health and welfare of chickens. (Xiong et al., 2020). Broiler density can be defined as the number of chickens per square meter and the weight of chickens per square meter. In this chapter, various scientific

perspectives are examined to understand the relationship between high stocking density and broiler productivity, growth rate, feed consumption, mortality and weight gain.

The broiler chicken business is a capital-intensive business with high investment value. The capital costs of purchasing land, building broiler sheds and installing equipment are the largest fixed cost components of broiler operations. Given the high investment costs, broiler growers do their best to operate efficiently. They achieve this by, among other things, rearing broilers at a high density per square meter. (Gauche et al., 2012) stated that there are limited specific recommendations on stocking density for broilers reared under different climatic conditions.

2.1. Stocking density

Stocking density is defined as body weight (kg) or number of birds per unit living space. The density at which broilers are stocked has a notable impact on their performance. Increased stocking densities typically result in decreased body weight increase, feed intake, and feed conversion ratio (FCR) in broilers. When broilers are kept in higher stocking densities (over 30-40 kg/m²), they tend to eat their food faster, resulting in an increase in gizzard size to accommodate the higher feed consumption. Nevertheless, this does not automatically result in enhanced feed efficiency (Abudabos et al., 2013).

During the initial phase, elevating the stocking density from moderate to high levels had a notable impact on broilers, leading to a considerable decline in body weight gain, feed intake, and a deterioration in feed conversion ratio (FCR) (Sarnino et al., 2022). The detrimental impact on performance was less prominent throughout the finishing period. Research consistently demonstrates that stocking densities exceeding 30-40 kg/m² have a detrimental effect on the growth rate, feed intake, and feed efficiency of broilers when compared to lower stocking densities. The diminished performance can be attributed to heightened stress, unfavorable environmental circumstances, and compromised bird welfare resulting from high population densities (Chepete et al., 2023). According to (Simitzis et al., 2012) higher stocking densities

have a significant impact on broiler growth performance. As a results when birds are reared in large numbers are prone to getting diseases such as foot fad, chest burns and other diseases, which leads to decreased feed intake and heightened mortality (Ghosh et al., 2012). High stocking densities often result in increased litter moisture, higher temperatures, and elevated levels of ammonia, which can contribute to bacterial loads and other health problems (Liu et al., 2023). Overcrowding also allows for diseases such as Marek's disease, Newcastle disease, and others can that can affect broilers to easily spread among the birds (Diseases of Broilers: Why Are They Dangerous?, n.d.) . To add on that, due to overpopulation, there is increased competition for feed and as a result only chickens that are more competitive will perform better and those that will be near the feeders will have better access to feed favoring them to grow faster and better. However lower stocking density result in reduced oxidative stress caused by high temperatures and over population thus leading to better growth performance.

The table below indicate the demand for feed intake as each bird grow, and this shows that the bigger the bird the more feed it requires. With higher stocking densities it becomes difficult to meet these demands.

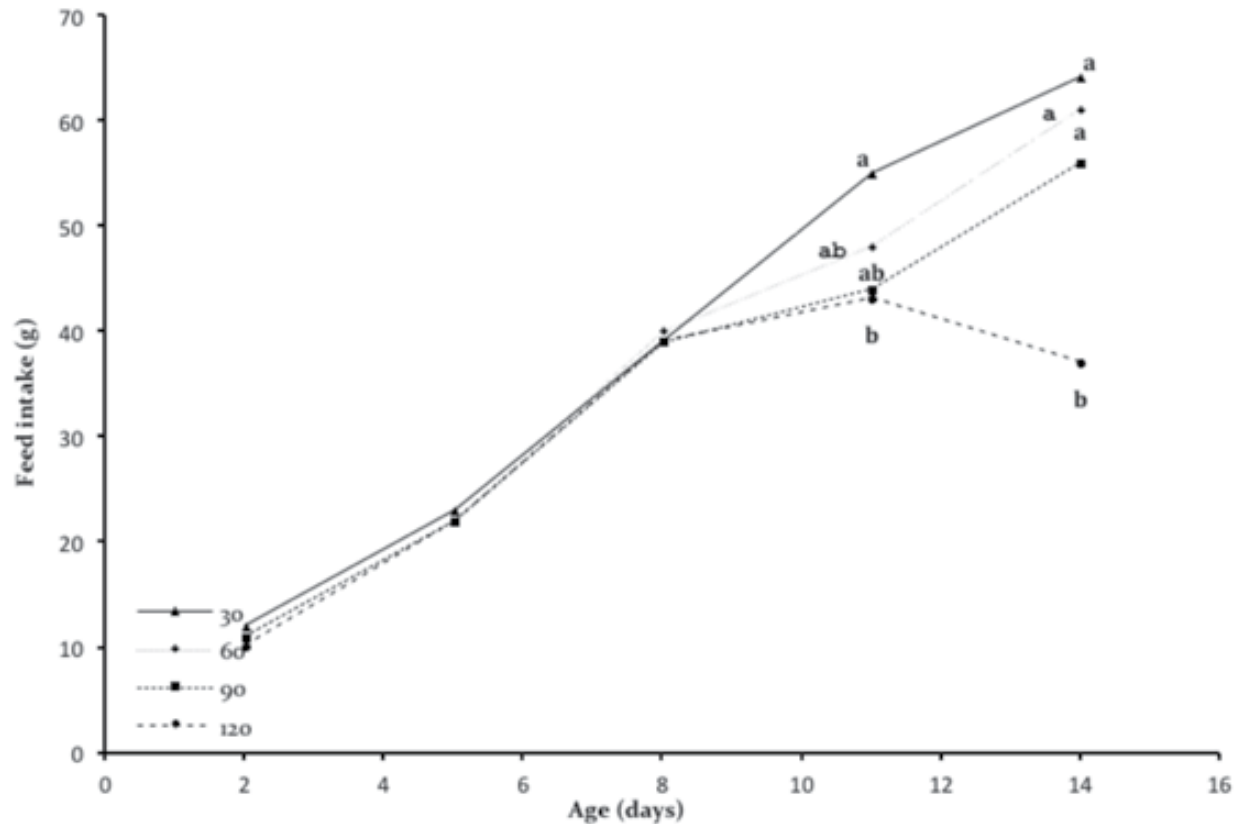


Figure 1. The effect of age and stocking density on the feed intake of broiler Chickens (SEM = 0.552)

Where 30, 60, 90 and 120 are the stocking densities in chicks/m²

Source: (Qaid et al. 2016).

2.2. Housing types

Broilers are kept under intensive system, this is where birds are kept entirely indoors in broiler houses. The types of broiler houses that are commonly used is the natural ventilated housing system and the mechanical housing systems. Natural ventilation system is a ventilation system used in uncontrolled poultry environments. It is common in small-scale productions. It consists of ventilation directly with ambient air, controlling its intensity with curtains. It is useful in some regions, but in others, it can be difficult to apply, as it has been associated with high levels of gases in the shed air, such as NH₃ ammonia (Ventilation in Poultry Farming | Environment

Controlled Poultry Houses, 2021). The house should be oriented in a north-south direction, with the longer sides facing north and south and the shorter sides facing east and west.

This type of house depend on the wind for the airflow within the broiler house and depends on the sun for heating. (Uys, 2020). The other type of broiler housing design is the mechanical ventilation system, here fan selection is the first step which is most important and it is very much needed to choose fans which are performance-tested and also efficient in energy. In the enclosed of building where the poultry farm is confined air replacement system is needed sometimes they mix the two types of ventilation (natural and mechanical) for better air flow. Otherwise if the ventilation is poor it may change air composition. These results can increase the concentration of carbon dioxide, ammonia and many other harmful gases (Hightop, 2024) .

By improving air quality and controlling temperature and humidity levels, ventilation systems promote optimal bird growth, feed efficiency, and overall well-being. Numerous studies have been conducted on the impact of housing design on feed efficiency in the broiler production process. Variations in broiler housing systems can affect feed intake, growth rates, and overall performance. According to research, a number of elements, including the style of home, the location, and the surrounding environment, are important for feed efficiency (Admin, 2024) . For instance, certain dwelling designs, like as the Hoop-roofed house, have been demonstrated to support higher feed consumption and daily weight gain in hot climate zones because of the cooler temperatures, which can encourage birds to consume more and grow more body mass.

The way houses are designed has a big effect on how well broilers grow. Studies reveal that varying housing arrangements can impact the conduct, well-being, and productivity of rapidly expanding broiler flocks (Zhao, et al., 2014). According to studies, broilers kept indoors but having access to the outdoors engage in more natural activities than broilers kept indoors alone, including wandering, standing, exploring, dust-bathing, and preening. On the other hand, a higher fatality rate and subpar performance may result from this enhanced environment (Mesa

et al., 2017). Additionally, foot pad conditions and performance can be impacted by the flooring design in broiler housing, such as less contact with excreta. Overall, the choice of housing system and design plays a crucial role in the welfare and productivity of broilers.

2.3. The interaction between stocking density and housing type

The correlation between the density at which animals are kept and the sort of housing they are provided significantly impacts both their well-being and their performance. Studies suggest that the stocking density, which is the number of animals in a specific area, and the kind of housing might have a substantial effect on the results of animals (Qaid et al., 2023). Research on broiler chickens has demonstrated that the density at which they are stocked has an impact on their performance, mortality rates, and markers of their well-being. Increased stocking densities might result in limited mobility, which can impede growth and raise mortality rates, particularly among juvenile birds (Averós, et al., 2018). Furthermore, the housing system employed can have an impact on other aspects of poultry production, including as feed consumption, feed conversion ratio, dressing percentage, and carcass features (Ghanima et al., 2020). Hence, it is crucial to meticulously evaluate the stocking density and housing type in order to maximize animal welfare and performance in intense rearing situations.

High stocking density in naturally ventilated buildings can result in compromised air quality and elevated levels of ammonia and dust. A study revealed that increased stocking densities in houses with natural ventilation led to notably elevated levels of ammonia and dust. These elevated levels can have adverse effects on the health and performance of broiler chickens (Ghanima et al., 2020).

High stocking density in mechanically ventilated homes might provide challenges, but these can be effectively addressed by implementing appropriate environmental control measures. Research indicates that modern broilers have enhanced performance when provided with increased space,

resulting in improved body weight, feed conversion, mortality rates, carcass quality, and breast meat output, particularly when stocked at lower densities. (Broiler Production Systems: The Ideal Stocking Density, n.d.)

Nevertheless, the broiler farmer must find a compromise between stocking density and economic sustainability, as excessively low densities of 1-2 square feet per bird would not be economically viable. Effective ventilation, cooling, and environmental control become crucial when housing more birds in mechanically ventilated facilities in order to ensure the well-being and productivity of the animals.

Overall, a high stocking density has a detrimental effect on the health and performance of broilers in both naturally and mechanically ventilated houses. However, in mechanically ventilated houses, these negative effects can be reduced by implementing meticulous environmental control (Van Limbergen et al., 2020).

2.4. Welfare and health considerations

Elevating the stocking density beyond the acceptable limits is linked to elevated death rates, particularly during the initial week of life. Death serves as a crucial measure of substandard welfare (Van Limbergen et al., 2020). Overcrowding prohibits the natural behaviors like walking, standing, investigating, dust-bathing and preening. Lack of space and environmental enrichment leads to behavioral restrictions and frustration (Zhao et al., 2014)

According to (Goo, et al. 2019), greater stocking densities can lead to airborne infections, resulting in an increase in respiratory disorders, as well as other ailments such as ascites and contact dermatitis. They also reported that high stocking densities suppressed immunological responses. Birds housed at low stocking levels (10-14 birds/m²) exhibit higher antibody responses to Newcastle disease compared to birds housed at 18 birds/m².

Furthermore, (Greene, et al. 2021) discovered that high storage density influenced the litter microbial profile, Poor litter quality from overstocking can also cause contact dermatitis, hock burns and breast blisters. Wet, caked litter also increases dust levels which is a respiratory health risk (Diseases of Broilers: Why Are They Dangerous?, n.d.). These researchers also discovered that the number of molds in litter increased from 0.6 to 1.3 at chicken stocking levels of 10 and 17 birds per square meter, respectively. Furthermore, (Greene et al. 2021) discovered that inhaling toxins created by excessively contaminated bedding lowered levels of the enzymes lipase, amylase, trypsin, and chymotrypsin, resulting in poor protein, fat, and carbohydrate digestion and absorption. Furthermore Insufficient air quality caused by negative ventilation systems and overcrowding leads to increased rates of mortality and condemnation during the first week of slaughter. Accumulated trash releases ammonia, which harms the lungs (Van Limbergen et al., 2020) causing diseases such as air sac mites (are parasites that can be found in the entire respiratory tract, associated with high pitched noises and clicking, sneezing, tail bobbing and open mouth breathing) and avian influenza that easily spread amongst birds due to overcrowding.

Although the majority of the literature suggests that increased stocking densities are detrimental to broiler production, several published research have demonstrated that this management strategy had no effect on broiler output. According to a report by (Johansen, 2019), raising the density to 10 or 12-14 birds/m² had no negative effect on chicken growth performance or bone development. Furthermore, (Thomas et al., 2004) discovered that broilers raised at densities of 10, 15, and 20 birds/m² exhibited comparable growth. (Keith. 2020) discovered that standard stocking densities (0.23 m²/bird) and low stocking densities (0.27 m²/bird) had no significant impact on growth performance.

It can be concluded that, overstocking and poor housing conditions are major risk factors for high mortality, contact dermatitis, respiratory issues, leg problems, immunosuppression and disease

in broilers. Providing adequate space, good litter, proper ventilation and environmental enrichment is crucial for broiler welfare and health

2.5. Economic implications related to stocking density and housing type

The economic consequences associated with broiler stocking density and housing type are important issues in broiler chicken production. Studies suggest that the number of animals per unit of space has an impact on the expenses and revenue associated with production. Increasing stocking densities can decrease variable costs of production by allowing for a higher number of chicks to be raised per unit of floor area, which has the potential to enhance profitability until a certain threshold is reached (Madilindi et al., 2018). Nevertheless, elevating the stocking density might result in diminished broiler performance, affecting variables like as growth rate, feed efficiency, and carcass quality. Research has indicated that when broilers are kept at high stocking densities, their growth rate may decrease, their feed conversion ratio (adjusted for mortality) may increase, and their carcass quality may be severely impacted (Abudaboos et al., 2013).

Furthermore, the specific housing design and location can also have an impact on the production of broilers and the economic results. The design of broiler housing, such as Gable- and See-saw-roofed homes, can affect aspects like as feed conversion efficiency and average daily gain (Chepete et al., 2023). These factors are important for economic considerations in broiler production. Furthermore, the selection of housing conditions, such as ventilation and environmental management, can impact the performance of broilers and the overall profitability of chicken production (Sarnino et al., 2022).

To summarize, the economic consequences of broiler stocking density and housing type are complex, requiring a careful equilibrium to maximize production costs, revenue, and total profitability in broiler chicken farming.

CHAPTER 3

3.1. Ethical considerations

The conditions and standards of care that was employed in this experiment was in accordance with the code of practice by the (South African Poultry Association., 2012). Birds were housed in clean and disinfected pens with fresh sawdust to prevent the accumulation of parasites and pathogens that could compromise bird health. Birds had ad lib access to clean water and feed. Ethical clearance of this experiment was provided by the University of Venda Ethics Committee and the ethical clearance number is: FSEA/22/ANS/1006.

3.2. Description of the study area

Experimental site

The study was carried out on an experimental farm at the Faculty of Agriculture, University of Venda (UNIVEN). The university is located in Thohoyandou, Limpopo Province, South Africa (22°58'32" S, 30°26'45" E, 596 meters above sea level). Temperatures vary between 25°C and 40°C in summer and between 12°C and 26°C in winter. Precipitation is highly seasonal, with 95% of it falling between October and March. Average precipitation is 800 mm, but it fluctuates temporarily (Mzezewa and Gwota, 2012).

3.3. Methods and materials

Housing and management

The experiment was conducted from June 7th to July 12th, 2021. Experiments were carried out on two of his broiler houses of different designs under test operation. One house relies on natural ventilation and another he uses fans for ventilation. Both sheds have automatic nipple drinkers and for heating when needed he uses a 175W infrared lamp, but feed distribution in both sheds is manual. Residential floors are disinfected with Viracid-TD® (Naruba, Alabama, Canada) and then covered with wood chips to a depth of approximately 20 mm, and when the wood chips get wet (mainly from water runoff), the floors get wet. Patches were replaced with fresh, dried chips.

Birds were housed in clean and disinfected pens with fresh sawdust to prevent the accumulation of parasites and pathogens that could compromise bird health. The pens inside the house were 2 squares metres were each pen was divided into 3 treatments of a square metre each. The diagrams below show the arrangements of pens and sub-pens within each house.

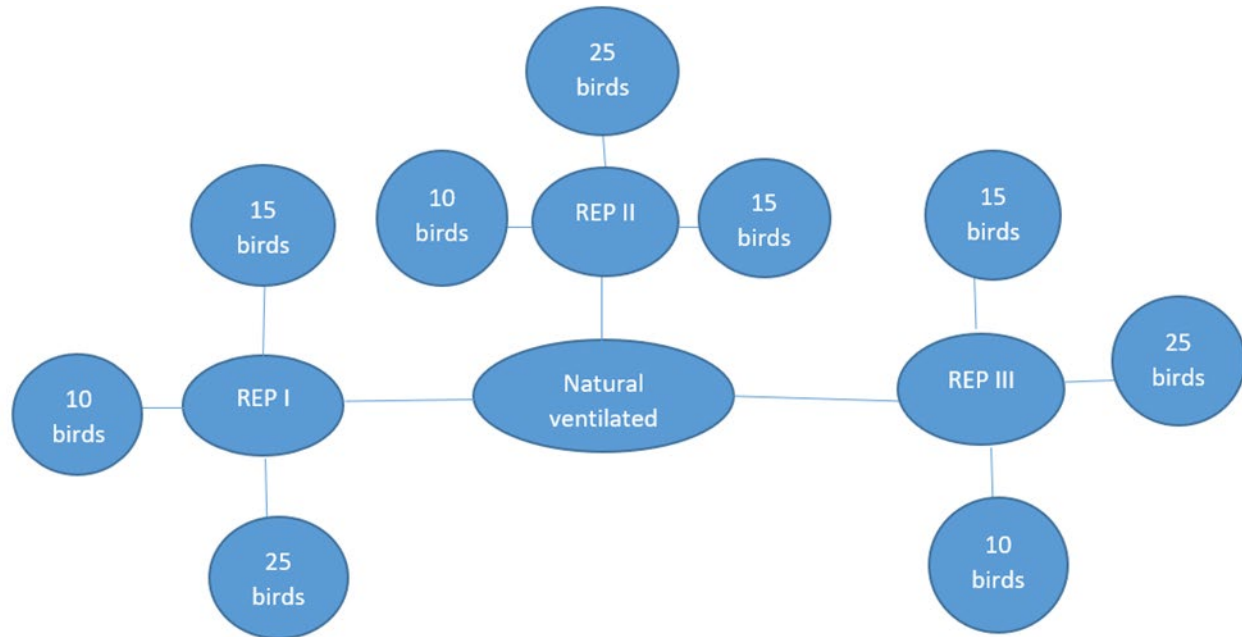


Figure 2: The arrangements of pens in the naturally ventilated house

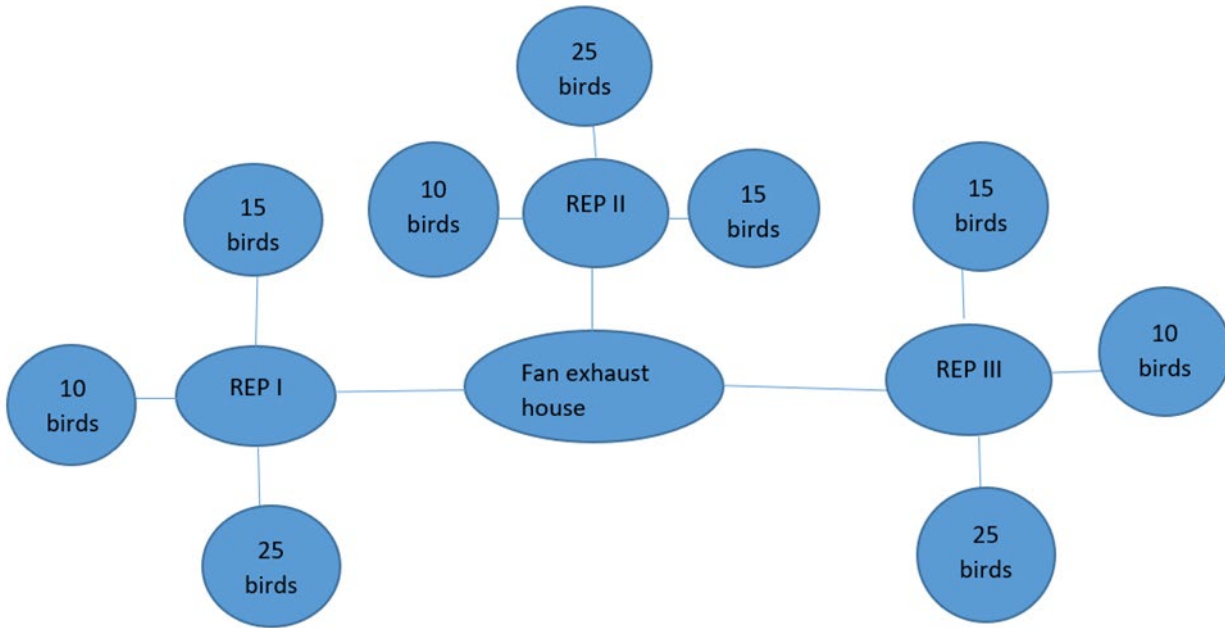


Figure 3: The arrangements of pens in the fan exhaust house

3.4. Experimental birds and management

A total of 300 Arbor Acre birds were used in this experiment. Half of the birds (150) were housed in naturally ventilated houses and the remaining 150 were housed in ventilated houses. Due to ethical reasons concerning the welfare and health issues of the bird only a limited number of birds was allowed for this type of experiment. The space that was available for this experiment was also limited hence only limited number of replicates was used to conduct this study. This study included three replicates per treatment where each replicate was a square metre in size and stocking densities that were kept in each square metre replica was 10, 15, and 25 birds per square meter. During his first 3 days after arrival, the bird was given a multivitamin solution (to adapt to the new environment and replenish his vitamins) and on day 18 he was given NOBILIS® GAMBORO D78. Chickens were fed commercial broiler starter crumbs from days 1 to 21, broiler grower pellets from days 22 to 35, and broiler finisher pellets from days 36 to 42. All feed was

purchased from an NTK partner company based in Muledane Thohoyandu. The bird was given his seven days to adapt to the environment, after which data collection began.

3.5. Data collection

Data collection began from day 8, wherein the initial body weight of the birds was determined as follows: On the 8th day and thereafter on every 7th day and until day 42, five birds were randomly selected from each replicate and weighed. Weekly feed intake per replicate was determined by subtracting the left over feed from the total feed supplied for each seven day interval.

Weekly weight gain

The weekly weight gain was calculated by subtracting the weight that was taken previously from the current weight. Eg. Week 2 weight – week 1 weight = weight gain

Feed conversion ratio was determined using the following formula:

$$FCR = \frac{\text{Average weekly feed consumption per bird per replicate}}{\text{Average weekly weight gain per bird per replicate}}$$

Mortality rate

Mortality records were kept on a daily basis and summed up for each seven day interval. The total mortality per replicate was then expressed as a percentage of the birds at the beginning of each seven day interval.

3.6. Mathematical and statistical analysis

Data was analyzed using the Generalized Linear Models procedure of the Minitab statistical software version 18 (Minitab, 2014).

The following statistical method was used:

$$Y_{ijkl} = \mu + M_i + P_j + W_k + (MP)_{ij} + (MPW)_{ijk} + \epsilon_{ijkl}$$

Where:

μ = overall mean

Y_{ijkl} = Measurement on the l^{th} observation from the i^{th} stocking density, j^{th} house type and k^{th} week
($Y=4$: Weekly feed intake, weekly weight gain, weekly feed conversion efficiency and weekly mortality rate)

M_i = effect of stocking density ($i=3$: 10, 15 & 25 bird/m²)

P_j = effect of type of housing ($j=2$: Naturally ventilated & forced fan circulation)

W_k = effect of age (in weeks) ($k=5$: week 2, 3, 4, 5 & 6)

$(MP)_{ij}$ = interaction between stocking density and type of house

$(MPW)_{ijk}$ = interaction between stocking density, housing and age in weeks

ε_{ijkl} = random error term. (Assumed to be normally and independently distributed with mean 0 and variance equal to σ^2)

Chapter 4

4.1. Results

Table 4.1.1. : The effect of stocking density and type of housing on feed efficiency and mortality of broiler chickens during the last two weeks of the starter phase (Day 7 to day 21)

Parameter		IBW(g)	BW21 (g)	BWG/b/d (g)	FI g/b/d	FCR	Mortality %
House means							
H1		163.8	1004.2 ^a	540.2 ^a	610.1	1.1 ^a	0.9
H2		168.9	909.8 ^b	422.2 ^b	613.8	1.5 ^b	0.0
SEM		4.51	15.90	16.50	29.81	0.10	0.30
Stocking density							
1		160.3	973.33	486.7	627.5	1.3	0.7
2		157.7	959.0	471.3	609.2	1.3	0.0
3		156.0	938.7	485.7	599.1	1.3	0.7
SEM		6.42	22.52	23.30	42.11	0.10	0.40
House type	Stocking density						
H1	1	153.3	1009.3	539.3	661.3	1.2	1.3
	2	154.0	984.0	500.0	595.0	1.2	0.0
	3	154.0	1019.3	581.3	574.0	1.0	1.3
H2	1	187.3	937.3	434.0	593.7	1.4	0.0
	2	161.3	934.0	442.7	623.4	1.4	0.0
	3	158.0	858.0	390.0	599.1	1.6	0.0
SEM		6.42	22.52	23.30	42.11	0.10	0.40
Significance level summary							
House type		NS	*	*	NS	*	NS
SD		NS	NS	NS	NS	NS	NS
H*SD		NS	NS	NS	NS	NS	NS

NOTES:

H1-House1 (natural ventilation); H2-House2 (exhaust fan house); IBW- initial body weight; BWG- body weight gain; BW- body weight; FI- Feed intake; SD- stocking density; H-House type; *- indicates means that are significantly different at $P < 0.05$; NS-Not significantly different ($P > 0.05$);

^{ab} For a given parameter, means in the column that do not share a common letter superscript are significantly different at $P < 0.05$; Stocking density: 1=25; 2=15; 3=10

The results in Table 4.1.1 show that the type of housing had significant effects on BW, BWG, and FCR but not on feed intake and daily mortality. The interaction between stocking density and housing had no significant difference on broiler performance. Stocking density had no significant effects on all the broiler performance parameters assessed during this phase.

Table 4.1.2. : The effect of stocking density and type of housing on feed efficiency and mortality of broiler chickens during the grower phase (Day 22 to day 35)

Parameter		IBW(g)	BW(35) (g)	BWG/b/d (g)	FI g/b/d	FCR	Mortality %
House means							
H1		1004.2 ^a	2211.3 ^a	634.9 ^a	1169.6	2.8	1.3
H2		909.8 ^b	1873.6 ^b	482.4 ^b	1211.9	1.9	1.7
SEM		15.90	29.61	27.4	33.6	0.22	0.63
SD							
1		973.3	2074.7	515.7	1205.1	2.7	1.3
2		959.0	2043.0	618.0	1166.2	2.0	0.0
3		938.7	2009.7	542.3	1201.0	2.4	3.2
SEM		22.51	41.80	38.80	47.41	0.31	0.87
House type	Stocking density						
H1	1	1009.3	2282.0 ^a	640.0	1163.3	1.8	2.7
	2	984.0	2156.7 ^{abc}	681.3	1133.9	1.7	0.0
	3	1019.3	2195.3 ^{ab}	583.3	1211.7	2.1	1.3
H2	1	937.3	1867.3 ^{bc}	391.3	1247.0	3.5	0.0
	2	934.0	1929.3 ^{bc}	554.7	1198.6	2.3	0.0
	3	858.0	1824.0 ^c	501.3	1190.3	2.6	5.0
SEM		22.51	41.80	38.80	47.41	0.31	0.87
Significance level summary							
House type		*	*	*	NS	NS	NS
SD		NS	NS	NS	NS	NS	NS
H*SD		NS	NS	NS	NS	NS	NS

NOTES: H1-House1 (natural ventilation)

NS-Not significant

H2-House2 (exhaust fan house)

IBW- initial body weight

BWG- body weight gain

BW- body weight

FI- Feed intake.

SD- stocking density

H-House type

*-indicates means that are significantly different at $P < 0.05$

^{abc} for a given parameter, means within a column that do not share a superscript letter (a, b, c)

are significantly different at $P < 0.05$ Stocking density: 1=25 ; 2= 15 ;3=10

Based on information in Table 4.1.2, housing had a significant effect ($P < 0.05$) on BW and BWG but did not have a significant effect on FI, FCR, and mortality. In house H2, birds kept at a stocking density of 15 birds/m² and 10 birds/m² had higher body weight gain compared to birds kept at a stocking density of 25 birds/m², while in house H1, birds kept at a stocking density of 15 birds/m² had higher BWG compared to the birds that were kept at 25 birds/m² and 10 birds/m².

Table 4.1.1: The effect of stocking density and type of housing on, feed efficiency, growth performance and mortality of broiler chickens during the finisher phase (Day 36 to day 42)

		IBW(g)	BW42(g)	BWG/b/d (g)	FI g/b/d	FCR	Mortality %
House means							
H1		2211.3 ^a	2695.1 ^a	483.8	1153.0	2.6	4.1
H2		1873.6 ^b	2303.3 ^b	429.8	1319.0	3.5	2.1
SEM		29.60	34.71	39.70	40.52	0.31	0.81
Stocking density							
1		2074.7	2502.0	427.3	1213.8	3.1	4.5
2		2043.0	2503.7	460.7	1211.7	3.3	1.3
3		2009.7	2492.0	482.3	1282.6	2.8	3.5
SEM		41.80	49.10	56.14	57.31	0.43	1.10
House type	Stocking density						
H1	1	2282.0 ^a	2697.3 ^{ab}	415.3	1140.1	3.2	9.0

	2	2156.7 ^{abc}	2677.3 ^{ab}	520.7	1108.7	2.2	1.3
	3	2195.3 ^{ab}	2710.7 ^a	515.3	1210.3	2.5	2.0
H2	1	1867.3 ^{bc}	2306.7 ^{bc}	439.3	1287.51	3.1	0.0
	2	1929.3 ^{bc}	2330.0 ^{abc}	400.7	1314.7	4.5	1.3
	3	1824.0 ^c	2273.3 ^c	449.3	1354.93	3.0	5.0
SEM		41.80	49.10	56.14	57.31	0.43	1.10
Significance level summary							
House type		*	*	NS	NS	NS	NS
SD		NS	NS	NS	NS	NS	NS
H*SD		NS	NS	NS	NS	NS	NS

NOTES: H1-House1 (natural ventilation)

NS-Not significant

H2-House2 (exhaust fan house)

IBW- initial body weight,

BWG- body weight gain

BW- body weight

FI- Feed intake.

SD- stocking density

H- House type

*-indicates means that are significantly different at $P < 0.05$

^{abc} for a given parameter, means within a column that do not share a superscript letter(a,b,c) are significantly different at $P < 0.05$ Stocking density: 1= 25; 2=15; 3=10

According to Table 3, there is a significant ($P < 0.05$) difference in body weight with H1 birds stocked at 15 birds/m² having higher BW compared to the rest and at H2 birds kept at 10 birds/m² had high BW. Type of housing did not significantly affect BWG, FI, FCR and mortality rate.

Table 4.1.4. : The effect of stocking density and type of housing on feed efficiency, growth performance and mortality of broiler chickens from day 7 to day 42 (Overall performance)

Parameter		IBW(g)	ABW (g)	AWG/b/d (g)	FI g/b/d	FCR	Mortality %
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House means							
H1		163.8	1590.2 ^a	508.3 ^a	955.8	1.9 ^a	4.1
H2		168.9	1393.7 ^b	426.9 ^b	1015.7	2.4 ^b	2.1
SEM		4.51	13.70	7.15	26.30	0.077	0.80
Stocking density							
1		170.3	1519.13	466.3	984.6	2.1	4.5
2		157.7	1483.67	469.2	981.4	2.1	1.3
3		156.0	1472.13	467.2	991.1	2.2	3.5
SEM		6.38	19.30	10.10	37.20	0.11	1.10
House type	Stocking density						
H1	1	153.3	1620.1	508.8	968.0	1.9	9.0
	2	154.0	1555.5	504.7	932.3	1.8	1.3
	3	154.0	1595.7	511.3	967.0	1.8	2.0
H2	1	187.3	1418.1	423.9	1001.2	2.4	0.0
	2	161.3	1411.9	433.7	1030.7	2.4	1.3
	3	158.0	1349.2	423.1	1015.2	2.4	5.0
SEM		6.38	19.30	10.10	37.20	0.11	1.10
Significance summary							
House type		NS	*	*	NS	*	NS
SD		NS	NS	NS	NS	NS	NS
H*SD		NS	NS	NS	NS	NS	NS

NOTES: H1-House1 (natural ventilation)

NS-Not significant

H2-House2 (exhaust fan house)

IBW- initial body weight,

BWG- body weight gain

BW- body weight

FI- Feed intake.

SD- stocking density

H-House type

stocking density: 1=25; 2=15 3=10

*-indicates means that are significantly different at $P < 0.05$

Means that do not share a letter (a, b, c) are significantly different at $P < 0.05$

Overall, housing had significant ($P < 0.05$) effect on ABW, ABWG and FCR. On the other hand, stocking densities of 10, 15, and 25 birds per square metre did not significantly produce significant differences in ABW, ABWG and FCR.

4.2. Discussion

House type had a significant difference on broiler performance from the beginning of the study to the very end. All birds that were kept under natural ventilation showed a significant weight gain, feed intake and feed conversion ratio, this may be due to good environmental conditions within the house since there is enough airflow within the house these results are in correlations to the study that was conducted by (Qaid et al., 2023) that suggests that the kind of housing might have a substantial effect on the results of animals but that's not all there are other factors that affect feed efficiency such as litter quality, energy levels in the feed and diseases. In addition the quality of the fans in H2 might have also had an impact on the performance of these broilers.

However the feed intake in H1 was significantly higher than the feed intake in H2 which might have a negative economic impact since more feed will be used in H1 in production it is important to find the best optimum ways to have better production at lower costs. Stocking density, which is the number of animals kept per unit area showed no significant difference on broiler performance, These results are in agreement to the findings by (Thomas et al., 2004) and (Keith., 2020) who reported that stocking density had no significant difference on broiler performance. This study is further supported by the article written by (World Poultry., 2005) that stocking density has less impact on broiler production than the housing systems.

However, these results may have been affected due to a limited number of birds that were used in this study compared to other studies (Thomas et al., 2004). The geographical location of the study and the season in which the study took place may also have an impact on the results obtained. This study took place in winter while temperatures are too low, meanwhile other studies took place in summer when temperatures are high which results in high mortalities due to heat stress that weakens their immune system and their feathers also prevent the heat from escaping the body.

4.3. Conclusion

Most scholars concluded that high stocking density has a significant difference on broiler performance. However, this study showed that high stocking density does not have any significant difference on broiler performance. What may have affected these results could be the season in which the study took place, and the geographical location of the study. The lack of significant differences due to stocking density from this study suggests that the stocking density range investigated was not wide enough to negatively affect bird performance. Birds in the natural ventilated broiler house (H1) generally performed better than those in the fan ventilated broiler house (H2). Given that there were no facilities to measure temperature or humidity, it is possible that the fan ventilation system did not perform to expectations resulting in negative effects on bird performance. Based on the results it can be concluded that stocking density and housing systems has no significant difference on broiler performance.

4.4. Recommendations

Based on these findings, and all other factors being constant, the open sided broiler house and a stocking density of 25 birds per square metre is recommended under Thohoyandou or similar conditions. For farmer who like to use fan ventilate house types they should consider fan quality, and have proper equipment to measure factors such as temperature and humidity as they are very crucial.

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